ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

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DEVELOPMENT OF COMPRESSOR STATION AT RUPKHELIA

TENDER FOR HIRING OF COMPRESSOR STATION ON BOO BASIS For 3 YEARS EXTENDABLE TO ANOTHER 2 YEARS

Doc No. : P167-TEN-M001

Revision : TA

Technical Volume II of II

Issued : 26.10.2023

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Doc. No.: P167-MRR-M001

TA	26.10.2023	Issued With Tender	AS	RNR	AD
CA	23.10.2023	Issued For Client Review	AS	RNR	AD
IA	17.10.2023	Issued For Internal Review	AS	RNR	AD
REV.	**DATE**	**DESCRIPTION**	**ORG**	**REVIEW**	**APPROVED**

Content

DEVELOPMENT OF COMPRESSOR STATION AT RUPKHELIA

SCOPE OF WORK
SECTION A

Doc. No.: P167-SOW-M001

TA	26.10.2023	Issued With Tender	AS	RNR	AD
CA	23.10.2023	Issued For Client Review	AS	RNR	AD
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1. INTRODUCTION

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e., Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCM of gas per day.

Assam Gas Company Ltd. intends to Development of Compressor Station at Rupkhelia, Golaghat, Assam.

Pipeline Engineering Consultants Pvt. Ltd. has been appointed as an EPMC Consultant by M/s. Assam Gas Company Ltd. For Development of Compressor Station at Rupkhelia, Golaghat, Assam.

2. DEFINITIONS

PROJECT	Development Of Compressor Station At Rupkhelia
OWNER	Assam Gas Company Limited (AGCL)
EPMC	Pipeline Engineering Consultants Pvt. Ltd. (PLECO) is the agency to act for and on behalf of Owner for the Development of Compressor Station at Rupkhelia.
CONTRACTOR	Agency appointed by CLIENT/ OWNER/EPMC for the execution of assigned tasks
PURCHASER	Either of CLIENT, OWNER or EPMC
CONTRACTOR/MANUFACTURER	Party, which manufactures and supplies equipment services to the OWNER or to CONTRACTOR

3. BRIEF OPERATING PARAMETERS OF COMPRESSOR PACKAGE (FOR DETAILED PROCESS DESIGN REFER SECTION B)

Owner is looking to implement compressor package for natural gas compression on BOO (Build Own Operate) basis with following operating parameter:

SL. No	Description	Unit	Description
1	Location	-	Rupkhelia (Golaghat)
2	Type	-	Reciprocating
3	Driver	-	Gas engine driven
4	Quantity	-	3no’s (total) (2 Working + 1 Standby)
5	Suction Pressure	Kg/cm2g	8 - 12

6	Discharge Pressure	Kg/cm2g	42 - 65
7	Inlet gas Temperature	°C	35
8	Outlet Temperature	°C	52 (max)
9	Capacity	MMSCMD	0.25 (for each compressor package at the outlet)
6	Natural Gas Composition	:	Refer Process Section B

Remarks:

a) The battery limit shall be as indicated in the schematic (Refer Process Section B).

b) The Gas engine driven natural gas compressor package shall be skid mounted and will be equipped with all equipment such as coupling, compressor, interconnecting piping, valves, fittings, separators, dampner, inter after air cooled heat exchanger, lube oil system, safety valve, control panel and other instrumentation required.

c) The Compressor package shall have all the required utilities such as, instrument air, fuel gas conditioning skid etc.

d) Compressor package configuration shall be as listed below:

Number of Compressors	2 Working + 1 Standby
Stand by compressor capacity	50% of gross working capacity i.e. 0.25 MMSCMD

Gross working capacity is 0.5 MMSCMD.

e) The contractor should incorporate necessary facilities required to prevent entry of **free water / condensate / oil entrainment,** if any, in suction of compressors.

f) Providing adequate firefighting equipment viz. Fire extinguishers, sand buckets, portable trolleys etc. Water sprinkler system (Manually operated) is to be provided inside the compressor shed as per OISD-STD-189. Fire water shall be made available to the contractor by the Owner to hook up with compressor fire water line as and when ready. Meanwhile, contractor shall make arrangement of compressor fire water supply.

4. SPECIAL INSTRUCTIONS TO CONTRACTOR

Contractor to note the following instructions while submitting his proposal.

a) Contractor shall design/supply, install, commission, operate and maintain the compressor package within 06 months (01 No. Compressor in 2 months & remaining 2 No. Compressor in next 04 months) from the date of award of contract. Contractor must submit details covering Certificate/documentation including manufacturer's standard compressor datasheet or datasheet as per API 11P/ISO 13631, from the original equipment manufacturer (OEM)/packager covering the aspects for adequacy of gas compressor with respect to compressor sizing, compressor performance, its mechanical soundness, driver sizing & suitability of the offered compressor for the specified operating conditions along with the proposal.

b) Contractor shall undertake total single point responsibility for the complete scope of work as per bid document.

c) Exception / deviations to the bid document shall not be accepted. If there are exceptions /deviations bidder shall raise the deviation in the format enclosed with commercial volume and get the approval from Owner/ EPMC before submission of the bid documents. Exception/ deviation mentioned elsewhere in the bid other than the enclosed deviation form shall not be considered. If exceptions /deviations except the agreed deviations / exceptions during pre-bid reply or clarification specially provided by the Owner/EPMC are maintained in the bid, such conditional / non-conforming bids may be rejected.

d) Compressor package shall be designed, constructed and operated so as to meet the requirements of applicable safety codes / standards, Petroleum & Natural Gas Regulatory Board (PNGRB), Oil Industry Safety Directorate (OISD) of India – Standards, national / International codes / practices and other statutory code requirements etc.

e) All statutory permissions shall be obtained by the Owner. Contractor will provide necessary documents to get statutory approval.

f) All electrical apparatus, instruments items / systems shall be suitable for the hazardous area classification as per applicable National / International standards and Indian statutory regulations.

g) Owner/ EPMC shall have the right to inspect the facilities / equipment deployed by the contractor in the gas compressor package and if any deficiencies are observed by Owner/EPMC, the contractor shall remove such deficiencies promptly upon receipt of such instructions from Owner/ EPMC.

h) Contractor shall provide all documents of Compressor and its area to the 3rd party for its study of HAZOP, HAZID, QRA and SIL. Contractor equipment's and installation work shall meet these study requirements. Any recommendation during these studies shall be binding to Contractor.

i) Equipment & package design and engineering shall incorporate adequate safety features (as per applicable specifications of respective equipment as well as Health, Safety and Environment Codes & Standards applicable for the subject project) to provide protection to operating personnel, equipment and environment.

j) Local discharge of any process chemicals/oils etc., which may affect the environment or be hazardous to the plant, will not be allowed. All such discharges should be connected and terminated to the temporary condensate tank provided by Contractor and arrangement for the safe discharge/disposal after proper treatments as per the prevailing Indian Guidelines as per Owner Approval.

k) It is Contractor's responsibility to ensure that all necessary equipment, instruments or any material or service are available for smooth and safe operation of Compressor package satisfying the Basic process requirements as detailed out in P&ID / schematic/ scope of work and Compressor process data sheet attached in this document.

l) The compressor system should be designed / selected, constructed, installed, operated and maintained for uninterrupted continuous operation to supply compressed gas at the specified conditions so as to meet all tender requirements.

m) Any change in variation of compressor loading shall be done in consultation with Owner/ EPMC representative. However, if the compressor is operating at a reduced load due to any compressor malfunction, the contractor shall shift the malfunctioned compressor's load to the standby compressor for smooth operation and take immediate measures for repair and maintenance of the malfunctioned compressor. The whole load shifting process shall be accomplished within half hour.

n) **Experience and Qualification of the Crew:** To carry out round the clock operations of the plant by providing requisite competent manning, contractor may decide team size, however compliance of statutory requirements as applicable with regards to minimum level and their qualification etc. must be ensured. The bidder should indicate the number and type of persons to be deployed at compressor plant for smooth operation and maintenance along with the bid.

o) The bidder should confirm to deploy in each round the clock shift at least two persons (ITI/ trade Certificate) for operation & maintenance and minimum 1 person (Diploma) for maintenance in general shift. However, Contractor shall also appoint 1 person (B.E./B.Tech.) as per Owner requirement. Successful bidder to submit additional manpower proposed for regular maintenance of the equipment with details of all proposed manpower before mobilization.

p) The persons should have at least 2(two) years' experience in operation & maintenance of gas compressors/ Oil & gas processing/ Process units having gas engines and reciprocating gas compressors. The documentary evidence for experience of proposed O&M crew members is must for prior approval by Engineer in-charge before mobilization of compressor.

q) System UPTIME during the Contract period (Excluding downtime of redundant units) shall be 100%. In case of tripping of running equipment, re-start of same unit or start of standby unit and putting the system on full load shall be accomplished within half hour. Availability status of running as well as stand by equipment shall be logged and informed to Owner, daily.

r) Equipment Availability on monthly basis shall be more than 98% (since 2 + 1 configuration selected) on available flowrate of 0.25 MMSCMD to 0.5 MMSCMD.

$$\% \textbf{ Availablity} = \frac{[\textbf{Total hours} - (\textbf{Unplanned Down time} + \textbf{Planned Downtime})]}{\textbf{Total Hours}} \textbf{ x100}$$

s) In case percentage availability is lesser than 98% then fixed monthly rental charges shall be deducted by 20 % of fixed monthly rental charges of that month bill.

t) In case system downtime exceeds 6 hours beyond 2% of non-availability, then maximum fixed monthly rental charges shall be deducted by additional 10 % of fixed monthly rental charges of that month bill.

Note: Any maintenance shutdown shall be pre-planned & pre-approved by the EIC.

u) All civil & structural work including foundations, porta cabins, sheds, pipe supports etc required for installation and operation of Compressor package shall be in Contractor's Scope.

v) All costs for mobilization (transportation, supply, installation, commissioning), operation & maintenance, demobilization shall be included in Contract price. After the termination of contract, the Land shall be handed over back in condition as received during start of the contract from the Owner/EPMC.

w) All consumables (like lube oil etc.) and spares required for pre-commissioning, commissioning & operation & maintenance of compressor system shall be in scope of contractor at no extra cost to Owner/EPMC.

x) The Contractor should indicate manpower histograms showing manpower mobilization during all the phases (engineering/procurement/construction/commissioning) of the project and subsequently during operation & maintenance.

y) The contractor shall ensure maintaining of proper records for the daily Operation and maintenance. Daily Performance Report of compressor system in a mutually decided format signed by his authorized representative and obtain signature of Owner/EPMC's representative on daily basis.

z) The contractor shall follow all industrial labour laws for the deputed manpower.

aa) Operation and Maintenance of the complete compressor system including deployment of requisite skilled and experienced manpower, supply of all consumables, chemicals, lubricants, spare parts, tools & tackle and replacement of defective / faulty equipment, components parts etc. are in contractor's scope.

bb) Contractor shall maintain sufficient inventory of spare parts required for the continuous uninterrupted operation of the system for total duration of contract. Contractor shall also maintain the required consumables, chemicals, lubricants etc. for smooth operation of the compressor system. The list of such spares and consumables shall be submitted along with the proposal.

cc) The contractor should take sufficient care to safeguard its compressor system from any process upsets.

dd) Bidder proposed compressor packages shall have residual life of more than 7 to 10 years and the suitability & wellness for operation purpose of compressor package should be certified by a Chartered Engineer (to be hired by the bidder).

ee) In view of the urgency of the project, equipment offered should be available in India and the necessary proof in the form of CE certificate/TPI certificate clearly indicating the current location shall be provided along with the bid.

ff) Contractor shall coordinate with other agencies working on this project.

gg) The minimum delivery pressure shall be 42 bar(g) of the compressor for suction pressure of 8 - 1 2 bar(g) for the flowrate of 0.25 to 0.5 MMSCMD, failing which the rental value of the compressor will be NIL till the period minimum required delivery pressure is met and the equipment will not be considered available till that period.

hh) **Following Inter distance Criteria as per OISD 226 and PNGRB shall be met by Contractor for his facilities**

<u>Minimum Inter Distances For Various Station Facilities as per OISD 226:</u>

S.No.	From / To	1	2	3	4	5	6	7	8	9	10
1	Small Compressor / Pump House	-	15	15	15	16	30	15	15	15	16
2	Main Compressor House	15	-	15	15	30	30	15	15	30	30
3	Gas Handling System (PB/GC)	15	15	-	5	16	30	15	15	5	16
4	Equipment Room	15	15	5	-	-	30	15	15	5	16
5	Control Room / Office building	16	30	16	-	-	30	15	15	5	-
6	Fire Pump House / Fire water storage	30	30	30	30	30	-	-	30	12	-
7	Water Spray Deluge Valve	15	15	15	15	15	-	-	15	-	16
8	Cold Blow Down	15	15	15	15	15	30	15	-	5	30
9	Compound wall	15	30	5	5	5	12	-	5	-	5
10	Elect Substation,	16	30	16	16	-	-	16	30	5	-

5. DETAILED SCOPE OF WORK

The detailed scope of work includes but not limited to the following:

5.1 OVERALL SCOPE OF WORK

- The contractor is required to provide a suitable Reciprocating type Gas engine Driven Compressor system with configuration 2 working + 1 standby of capacity 0.25 MMSCMD each capable of compressing the natural gas with gross flow capacity of 0.5 MMSCMD available in the designated suction hook up point and delivering compressed gas quantity to the designated delivery hook up point at the specified conditions as per Clause 3.0 of this document, by providing all necessary facilities, equipment along with requisite manpower, consumables, lubricants, spare parts etc.

- The contractor's scope of work encompasses design / selection, supply, transportation, installation (including all civil, structural, piping and electrical & instrumentation works) and hook up, commissioning, operation and maintenance of a suitable compressor system complete in all respect. The detailed scope of work shall include supply (mobilization), installation, operation, maintenance, dismantling & demobilization compressor packages including utility packages and fire-fighting system at Rupkhelia (Assam, India) on BOO basis for a specified period of time.

- The scope of work detailed herein shall be read in conjunction with schematic, process data sheet enclosed with the bid package.

- Suitable material handling equipment shall be provided with the compressor package inside the compressor shed for ease of maintenance.

- Contractor shall mobilize crane as & when required for compressor maintenance.

- Civil & structural works including RCC foundation of proposed compressor system and shed with suitable structure and roof for the same.

- Porta Cabin for operators & other facilities, as required for Operation and Maintenance at location.

- Provision of protective covers for all equipment, electrical, instrumentation items as deemed necessary.

- Selection/design, supply, transportation, installation and hook up (with other facilities) of flame proof compressor system as per specifications including but not limited to, suction knock out drum, auxiliaries, inter and after stage air coolers, inter and after stage separators, inter and after stage dampner, utility systems (Instrument & plant air, Nitrogen skid (if required)), complete Firefighting system as per OISD norms, piping, inlet & discharge piping, valves, fittings, pressure vessels & associated instruments, instrumentation, cabling, control systems etc. and electrical items, electrical safeguarding systems, cabling, termination, earthling etc. Any other system required for making the compressor system complete in all respect for the purpose it is purported to be and hook up at a location provided by Owner/EPMC at the battery limit.

- Supply, transportation and Installation of any other process & Utility system as required.
- All high-pressure components such as pressure vessels, filters, cylinders, tubes etc. should be periodically inspected and tested. All pressure gauges, switches, relief valves, gas detectors etc. installed on the Compressor package should be periodically calibrated at NABL lab or as per the norms laid down by the statutory authorities by the Contractor at his own cost.
- The Contractor shall provide assistance, instruments, labour and materials as normally required for examining, measuring and testing any workmanship as may be selected and required by the Owner/EPMC.
- Contractor shall arrange for insurance of equipment, utility and personnel engaged for the complete tenure of Compressor Package in service with OWNER/EPMC.
- Offered compressor package should not be taken on lease from the banned/black-listed firms under banning orders issued by OWNER/EPMC debarring them from carrying on business dealings with OWNER/EPMC.
- Hook up of Contractor's compressor system to the following designated hook up points at a location provided by Owner/EPMC at the battery limit:

  i. Designated hook up point for supply of Inlet gas.

  ii. Designated hook up point for compressed Outlet gas. Refer enclosed schematic for more details.

  iii. Designated hook up point for Compressor package fire water supply.

5.2 MECHANICAL SCOPE OF WORK

5.2.1 EQUIPMENT SPECIFICATION

1. The offered compressor package including the driver i.e., Gas engine & associated item shall conform to applicable API 11P/ ISO 13631 -2002 standards.
2. The equipment supplier's standard data sheets / data sheet as per ISO/API must be duly signed and stamped by the Gas Compressor Manufacturer as well as the Contractor.
3. Air Cooled Heat Exchangers shall be designed as per API 661 and ASME SEC VIII DIV 1 and shall be provided for gas after cooler, lube oil cooler(s) for compressor and gas engine. The finned tube exchangers for all the streams shall be mounted in one compact cooler assembly with cooler fans being driven by separate electric motor or through V belt drive by Gas Engine.
4. Compressor package interconnecting piping shall be designed as per ASME B 31.3/ASME B 31.8 And Contractor to refer enclosed PMS for piping material.

5. It shall be contractor’s responsibility to supply & install air-cooled heat exchanger (including all piping and associated auxiliaries) within the compressor skid.

6. Contractor shall indicate the detailed requirement of electric power including motive power for compressor package/auxiliaries such as lube oil pumps, air cooled heat exchangers etc. Compressors package should be skid mounted and suitable for continuous operation on round the clock basis.

7. The material of construction of the compressor components & other auxiliary system shall be suitable for the process gas with proven track record / references & shall conform to the requirements specified in the process data sheet.

8. For Reciprocating machines, Pulsation suppressor connections shall be flanged and suction side suppressors shall be provided with drain lines. Pulsation dampeners / volume bottles shall be classified as per pressure vessel, inter and after stage separator shall be designed, fabricated, inspected and tested as per ASME Sec VIII Div 1.

9. Pulsation study of the compressor package shall be submitted during design /engineering stage for reciprocating machines.

10. It is preferred that the noise level from the gas compressor package (Driver + Driven Equipment + Auxiliary) shall not exceed 88 dBA when measured at 1 m distance from the skid in any direction.

11. In case of any malfunctioning in the compressor installation, contractor shall carryout a field survey to identify the cause of the problem and rectify the same.

12. Bidder shall furnish duly completed Annexure-2, 3 attached at the end of this section along with the proposal with complete supporting documentation.

13. The gas engine shall meet the requirements specified in relevant ISO/API standards. Fuel for the gas engine shall be the same of process gas which is being compressed and shall be provided by Owner/EPMC as free supply up to minimum guaranteed fuel quantity, however, the cost of fuel gas over and above the minimum guaranteed quantity shall be borne by the contractor. Facilities for tapping the process gas for the purpose of fuel for gas engine shall be arranged by the contractor within the gas compressor package skid along with latest standard metering instrument.

14. As a minimum, the gas Engine shall comprise of the following:

    - Engine air intake system
    - Engine ignition system
    - Compressed air start system for engine (suitable for black starting of gas engine) and associated facilities for compressed air start system.
    - Engine cooling system (air cooled heat exchanger based). The fan shaft of the air cooler

shall drive the power from Gas Engine itself.

- Fuel gas measurement system
- Engine exhaust system
- Gas conditioning
- Gas pressure boosting facility (if required)
- Acoustic enclosure
- Ventilation system for Enclosure
- Lube oil system
- Any other associated mechanical, electrical and instrumentation items as required.

15. Exhaust emission from the gas engine shall meet the statutory norms on emissions. Approvals from statutory authorities shall be arranged by the contractor. Exhaust from gas engine shall be routed to atmosphere in such a way that the same is not being sucked into the engine air intake system. Exhaust silencer shall be insulated with aluminium rockwool cladding & exhaust stack (if required) shall be provided by the contractor for meeting the noise limits & safe disposal of engine exhaust, respectively.

5.2.2 ASSOCIATED ITEMS OF COMPRESSOR PACKAGE:

- All associated electrical, instrumentation, inter-connecting piping, air cooled heat exchangers, separator(s) / knock-out drums / scrubbers shall meet the technical requirements specified in respective electrical, instrumentation, piping & static equipment section(s) of the tender document.

- Contractor shall make his own provision for Instrument air with an electric motor driven air compressor, receiver and air dryer system.

- Providing adequate firefighting equipment viz. Fire extinguishers, sand buckets, portable trolleys etc. Water sprinkler system (Manually operated) is to be provided inside the compressor shed as per OISD-STD-189. Fire water shall be made available to the contractor by the Owner to hook up with compressor fire water line as and when ready. Meanwhile, contractor shall make arrangement of compressor fire water supply.

- Items not covered above or in the tender document, shall meet supplier’s standard & field proven design requirements.

5.3 CIVIL (FOR DETAILED SCOPE OF WORK: REFER SECTION C)

a) Land for the installation of Compressor package shall be arranged by Owner/ EPMC.

b) Required earthwork, levelling (Finished ground level), site grading shall be in Owner scope. However, if required for equipment installation, Contractor shall do suitable site grading or filling / plot development within battery limit at no cost to the Owner.

c) All Civil, structural system including foundations, cabins/Compressor sheds, access, cable trenches, drainage system etc. required for installation & operation of compressor system including ancillary systems, Utility systems, firefighting system as required, shall be designed, procured, erected / constructed by the contractor.

d) Any additional requirement specifically not mentioned in this document but required for safe and efficient working of the Compressor System shall be in Contractor's scope.

5.4 PIPING (FOR DETAILED SCOPE OF WORK: REFER SECTION D)

a. Piping material shall generally be carbon steel / LTCS (as applicable) piping according to recognized standards, such as ASTM, All main gas piping shall be flanged/ welded. Screwed connections are not acceptable.

b. Contractor shall follow P&ID/schematic & datasheet attached with this document. For detail engineering work, list of all applicable codes & standards shall be strictly followed.

c. Piping facilities shall be designed and engineered primarily in accordance with the provisions of following codes:

   I. Gas Piping & fuel gas piping: ASME B-31.8

   II. Air & lube oil Piping: ASME B31.3

d. Discharge piping shall be designed with suitable damping devices to minimize vibrations.

e. Contractor shall carry out the dynamic and flexibility analysis of suction and discharge piping systems within battery limit and same to be submitted for OWNER/ EPMC's review. Contractor shall ensure that piping routing and supporting arrangement shall be such that no vibrations are produced in the proposed compressor & attached piping.

f. Contractor shall do the stress analysis of the complete compressor package upto the battery limit and same shall be to be submitted for OWNER/ EPMC's review. No extra load shall be transferred to the Owner /EPMC's piping upon hook-up.

g. All other regular incidental / auxiliary / ancillary / accessory/ equipment's like crane etc or any enabling work / materials not specifically mentioned in the specifications but necessary for the execution and completion of work shall be in the scope of the Contractor.

h. A minimum straight length of compressor suction pipe shall be provided as per OEM's recommendation.

i. Proper insulation (Hot / cold) of suction line / exhaust line piping wherever required shall be in contractor scope.

j. Suitable corrosion protection of system like primer, painting and finish coating of steel structure and pipe-work and equipment shall be performed by the Contractor wherever necessary.

5.5 INSTRUMENTATION (FOR DETAILED SCOPE OF WORK: REFER SECTION E)

The proposed compressor system should have the following features as a minimum:

a. Contractor shall be responsible for all instrumentation related activities including installation, field testing, calibration, pre commissioning, commissioning, etc.

b. Contractor shall ensure installation of dedicated control system for each compressor (Operational + Standby) for implementing its monitoring, controls, interlocks and shutdown parameters.

c. Contractor shall provide Pressure safety valve and a check valve on the discharge line.

d. Emergency Shut Down valves to be provided on Suction and Discharge lines. Blow down valve to be provided on discharge line which shall operate only after ESD on Suction and Discharge line operates.

e. The contractor shall ensure that all instrumentation equipment, instruments, apparatus, fittings, Explosion proof JBs etc provided / installed are intrinsically safe and suitable for the hazardous area classification as per applicable National / International standards and statutory regulations.

f. PSL & PSH on suction and discharge line respectively for alarm purpose and PSLL & PSHH on suction and discharge line respectively for safe trip of compressor shall be provided. Similarly, alarms for TSH & safe tripping for TSHH of discharge line is to be provided.

g. Alarm and safe tripping is to be provided for LLH & LLHH respectively for KOD at suction point.

h. HC Gas detectors shall be provided at each compressor unit with local display.

i. Contractor shall ensure that potential free contacts for the LEL parameters and Alarm points (High Level (HL) and High-High Level (HHL) Alarms) are provided at Junction Box.

j. Contractor shall provide Fuel meter along with Flow Computer in full compliance to applicable AGA and ISO standards. Complete fuel consumption in terms of SCM and energy is to be monitored and retransmitted to Owner/EPMC (in case of gas engine compressor).

k. Any additional signals required for monitoring of running compressor by the Owner/EPMC shall be covered in contractor’s scope.

l. Devices to monitor and trip in case of excessive vibration, speed, amperage, low lube oil pressure, seal oil differential pressure, high bearing temperature and high discharge temperature, etc. shall be as per system requirements. Contractor shall ensure additional instrumentation as per manufacturer’s recommendations.

m. All the instruments shall be capable for full range of operation. All instruments shall be calibrated and a copy of calibration certificates shall be submitted to the Owner/EPMC before commissioning.

n. Contractor shall be responsible for all kind of works in the local control room i.e. installation of contractor supplied panels/cabinets, MCT frame/blocks, cable laying, cable tray/ conduit erection/ installation, glanding and termination of cables, loop checking, pre- commissioning checks and final commissioning.

o. Potential free contacts and isolated 4-20 mA signal & communication port (for digital communication) shall be provided at junction box near the Compressor area for all instrument parameters and alarms to telemeter all the signals to new SCADA system of Owner/EPMC (By others).

p. Any additional requirement specifically not mentioned in this document but required for safe and efficient working of the Compressor System shall be in Contractor's scope.

q. CCTV system to be added for compressor area – Explosion Proof

r. F&G PLC

5.6 ELECTRICAL (FOR DETAILED SCOPE OF WORK : REFER SECTION F)

The electrical scope of work shall include but not limited to the following:

a. Contractor shall carry Electrical load calculation and shall make arrangement of reliable power supply. Owner/EPMC shall provide the power supply upto the battery limit.

b. Supply, laying & termination and testing of power & control cable(s) of required sizes & cores shall be the responsibility of the Contractor.

c. All erection and installation material like cable glands, cable lugs, connectors, cable supports, nuts, bolts and other required hardware shall be supplied by the Contractor. Cabling work shall include cable laying, end terminations, clamping, tagging etc.

The Contractor's scope of work encompasses the following:

- Providing, laying & termination of LT cable of required sizes & core from designated MCC Panel to cater various loads of Motor/Drives.
- Supply & installation of lighting equipment's for compressor unit, field cabin, store rooms etc.
- Providing area lighting which includes supply & installation of pole light as per area classification.
- Installation of Earth Pits / Earth Grid as per Standard Engineering Practices and IS:3043.
- Earthing of the Motor / Distribution Panel and other Electrical Fittings / Fixtures, lighting poles

including provision of equipment /foundations.

- Equipment/body/foundation earthing should be done at two sides opposite to each other.
- Providing rubber mattress of ISO standard, wherever required
- Health monitoring, periodic/predictive/breakdown maintenance along with supply of requisite spares/consumables.
- Availability of spares along with skilled/experienced manpower.
- UPS supply, if required to be arranged by the contractor.
- Temporary power supply (DG/GG) at the starting of contract, if required, shall be arranged by contractor.
- Installation of adequate nos. of emergency lights. This will keep the area illuminated during power failure.

d. The contractor shall ensure that all electrical equipment's / apparatus / instruments/fittings provided & installed are suitable as per applicable National / International standards and statutory regulations with respect to Area Classification.

e. Supply & installation of complete earthing system for the new equipment including supply of materials. Grounding and bonding of all equipment is included in the scope of work.

f. Main earth grid of bare 50X6 mm, GI strip will be used below ground. Above ground green /yellow PVC insulated copper conductors shall be used.GI Earth rod of 50 mm diameter 3m long shall be used. LV motors, cable trays, metallic equipment, enclosures etc. shall be connected to the main earth grid with 35 mm2, PVC insulated copper conductors. Joint is not allowed in cable for grounding/earthing purpose.

g. All the equipment shall be earthed from two points. —Double earthing system.

h. All equipment shall be grounded and bonded in accordance with the recommendations of IS: 3043 /IEEE-142 —Recommended practice for grounding of Industrial & Commercial power system.

AREA CLASSIFICATION AND EQUIPMENT REQUIREMENTS

i. Area Classification for Process Gas Compressor shall be done as per IS 5572 and Temperature Class-T3. However detailed area classification drawing shall be prepared by the contractor.

ii. The enclosure protection for various package equipment shall be minimum as follows:

- MV Motors: Ex (n)

- Local control stations: Ex (d)
- All electrical equipment installed in hazardous areas shall meet the requirements of relevant IS/IEC standards. Equipment suitable for safe/non-hazardous areas application shall not be used in Zone-1 / Zone- 2 hazardous area.

iii. Electrical equipment having flameproof enclosure protection shall conform to IS- 60079 (Part 1):2007/IEC-60079-1 (2007).

iv. Electrical equipment having enclosure protection Ex (n) i.e. non-sparking type (without prestart ventilation) shall conform to IS/IEC 60079-15 (2005).

v. All electrical equipment for hazardous areas shall be certified by CMRI or equivalent international testing agency and shall be CCOE/PESO approved for the service and area in which it could be used.

6. BATTERY LIMIT

Refer enclosed schematic in ANNEXURE-6 for battery limit.

7. MATERIALS TO BE SUPPLIED BY CONTRACTOR

i. All materials, including consumables, piping components, equipment required for installation, commissioning and operation of Compressor system & associated piping systems shall be procured and supplied by the Contractor for successful running of Compressor system under Contractor scope of work

ii. All materials, manpower, spares, tools & tackles (duly tested by authorized person) and consumables for carrying out pre-commissioning activities and during commissioning (including compressor, nitrogen required for achieving the specified criteria for piping inertization prior to declaring piping fit for commissioning) necessary piping and instrumentation connection for measuring flow rate, pressure, temperature etc., temporary facilities for blow down/ venting/ flaring along with necessary piping, valves & instrumentation as well as consumables and manpower required during pre-commissioning, commissioning, operation and maintenance.

iii. All spares for pre-commissioning and commissioning as required for all items supplied by Contractor for the entire piping system.

iv. All material, equipment, consumable for utility package systems like utility & plant air and nitrogen system required for installation, commissioning and smooth operation of compressor system.

v. All material, equipment, consumable for fire-fighting system.

vi. All Power arrangement till owner permanent power is installation completed. Also all Back up power arrangement is in Contractor scope.

vii. Drain Tank for collection of lube wastage from Compressor area.

viii. Fire water for Compressor area till Owner fire water pump and ring main completed.

ix. Any other material not specifically listed herein, but required for successful completion of the Work.

8. OWNER SCOPE OF WORK

i. Land including site grading & plot development. However, if required Contractor shall do suitable site grading or filling /plot development within battery limit for proper installation of all the equipment at no cost to the Owner.

ii. Process Piping system as per battery limit as shown in enclosed drawing

iii. Power supply at the battery Limit, temporary power arrangement shall be provided by the Contractor at the starting phase of the contract

iv. Fuel gas for proposed compressor package at battery limit.

v. HAZOP, SIL and PHA (Process Hazard Analysis) study (inputs to be provided by the Contractor). However, if any change required as per study, then contractor shall comply the requirement without any price implication.

vi. Fire water required for compressor fire water system. Temporary fire water arrangement shall be provided by the Contractor at the starting phase of the contract

9. GAS MEASUREMENT

a) The unit of gas measurement shall be in Standard Cubic Meter (SCM).

b) The gas compressed will be metered using the electronic flow computer (AGA3 and AGA9 compliant) having USM Type flow meter (Previous day and current day). Total monthly gas compressed shall be tabulated with daily readings by Contractor's supervisor. Log record to be maintained. The flow meter of Owner at the compressor upstream shall be treated as main meter and considered for invoicing purposes.

c) In the event of non-operation of Gas compressor package(s) due to any reason, other than Force Majeure, the same will be recorded by Contractor's supervisor/ personnel at site. Time period of non-availability of compression services as per this record will be liable for Liquidated Damages and/or Compensation for Non-compression and/or Termination under the respective clauses.

d) The meter reading will be noted on hourly basis along with equipment parameters of the Gas compressor package by Contractor's personnel and shall be given to Owner. The 0600 hrs. reading and 1800 hrs totalizer reading are to be given to the control room daily as soon as the readings are taken.

e) The records of measurement shall be reported to the Engineer-in-Charge in the form of daily report.

f) The records of measurement duly certified by the Engineer-in-Charge shall accompany the monthly bills of the Contractor.

10. DELIVERY PERIOD

Contractor shall supply 03 No. of compressors (02 Working + 01 Standby) of capacity 0.25 MMSCMD each, 01 No. Compressor in 2 months & remaining 2 No. Compressor in next 04 months from the date of award of contract.

11. INSTALLATION WORKS

a) Contract shall install compressor package along with all the piping, auxiliary items, utilities including fire water system, fuel gas conditioning, lube oil, instrument air etc as per SOW & battery limit.

b) Contractor shall obtain all necessary approvals and work permits from Owner for performing the Work. Contractor shall be required to carry out all the works as mentioned in the work permit and shall strictly complying with all stipulations/conditions/recommendations of the Company and providing all safety appliances, gas detectors, fire screens required during execution of the work as per the direction of Owner/EPMC.

c) All Welding/test records etc. pertaining to skid piping for all pre-fabricated spools shall be submitted for Owner/EPMC's review.

d) Hydro test and Radiographic testing for all process piping within Contractor's battery limit (site fabricated and pre- fabricated spools) shall be carried out at site before installation as per applicable standards.

e) All welding & NDT shall be carried out as per relevant code requirements. Piping welding shall be carried out by established WPS/PQR

f) All Piping weld shall be post weld stress relieved (PWHT) as per relevant construction code (ASME B31.8 / ASME B31.3).

g) All NDT shall be carried out after PWHT, if applicable.

h) Preparation of photographs, project records as per specification and instructions of the Owner/EPMC including furnishing of all Test Certificates/Inspection Reports for all materials used for Compressor Package installation.

i) Coordinating all activities with Owner/EPMC for movement of men, material, Equipment & tools shall be the responsibility of the Contractor.

12. PRE-COMMISSIONING AND COMMISSIONING

a) Contractor shall be responsible for pre-commissioning & commissioning of the compressor system, including supply of manpower, materials, equipment including nitrogen along with necessary piping and instrumentation connections for monitoring flow rate, pressure, temperature etc. temporary venting along with necessary piping, valves and instrumentation as well as consumables.

b) All process lines and utility lines shall be hydro-tested at a pressure 1.5 times the design pressure of the lines in which these are hooked up. All process piping within the battery limit shall be pneumatically tested at Maximum operating pressure.

c) All process lines within compressor shed shall be completely dried using N2 after completion of hydro-test. All other lines shall be dried by using dry air after hydro-test.

d) All works for locating and repair of minor/major leak/burst (occurred during testing) including necessary repairing/replacing/ cutting and removing out defective pipe length/weld joints shall be carried out by the contractor.

e) Contractor shall carry out repair of defective weld joints including cutting and welding, NDT of the welds, coating/insulation of the weld joints, clean up, retesting of piping including providing all pipe spools, blinds, equipment, manpower & consumables etc. All such activities shall be completed by contractor within contractual time schedule and without any extra cost to Owner.

f) The mechanical 48 hours test of continuous operation with gas of a pressure within the stated operating pressure range shall be performed by the contractor at site in consultation with the OEM/Packager/Owner/EPMC. During the test no faults of the equipment shall occur. Perfect operation of the devices and controls shall be verified. In case of any inconsistency observed during operation of supplied compressor package, contractor shall rectify all defects to the satisfaction of the Owner/EPMC. Guaranteed parameters shall be indicated by the Contractor in his proposal as per Annexure–1 of this document.

g) Successful commissioning of the compressor system in totality after demonstration of trouble free continuous 48 hrs performance test run and same shall be certified by Third Party Inspection Agency.

h) Contractor shall guarantee the total capacity of the compressor package (0.5 MMSCMD) with the given gas composition. The same shall be used to establish the capacity during performance test for full load four hours continuous operation.

i) The capacity for this performance test run will be measured through a flow meter to be provided by Owner at a suitable downstream location of the designated hook up point for compressed outlet gas.

13. DOCUMENTS TO BE SUBMITTED AT THE TIME OF BIDDING

Following information shall be furnished by the bidder with the Proposal: -

a) **Compliance to tender document**: - The bidder shall furnish confirmations for (i) complete Scope of Work, and (ii) Project Delivery Schedule as specified in the Tender document.

b) **Past track record** (Purchase order copy/Contract award copy and Performance certificate/Completion certificate etc.) indicating the execution of job of similar nature. Bidder shall submit the details in the format attached in Annexure-4.

c) The bidder should be certified to international quality management system (QMS) certifications like ISO 9001:2000/2008, ISO 14001:2015 or equivalent.

d) **Organogram**: Organogram shall clearly identify the team proposed to be deployed for work tendered in this document.

e) **CVs of key personnel**: - CVs of key personnel proposed to be deployed for the project execution shall be furnished and their availability shall be confirmed for the entire project duration. Contractor to ensure that only the personnel with relevant work experience are deployed.

f) **Project Schedule**: - The detailed project schedule shall be submitted by the Contractor addressing all critical activities.

g) Bidder shall necessarily furnish following documents also along with the bid without which the offer shall be considered incomplete:

- Supplier Standard or ISO/API Datasheet covering gas compressor, its driver & associated auxiliaries for finalized option.
- Filled in Guaranteed Parameters
- Compressor performance curves.
- The Completion time schedule for the work (including mobilization period).
- The Bidder is required to submit a Project Time Schedule in Bar Chart Form, along with the Bid. The Schedule shall cover all aspects like sub ordering, manufacturing and delivery.
- Package P&IDs & Schematic diagrams of proposed compressor package.
- Schematic Architectural drawings of BOO Compressor Shed showing Plan, Elevations and Cross Sections
- Past Track Record as per Annexure- 4
- Utilities requirements
- Electrical Load summary
- Catalogues of compressor, driver and instrumentation items etc.
- Organization chart for installation, testing and operation

- Past Performance Certificate issued by previous Owner.
- OEM inspection or testing certificates for equipment and materials supplied.
- List of critical spares.
- Acceptance & Deviation list considered while designed of the compressor.

14. POST ORDER DOCUMENT REVIEW AND APPROVAL

Upon receiving the LOI the contractor shall submit the following documents for review and approval:

a) Datasheet of Natural gas Compressor, Air compressor, Air cooled heat exchanger, inter and after stage separator/KOD, inter and after stage dampers, Gas engine etc.

b) P&ID of Gas system, Lube oil system, Gas engine water system, Gas engine start system etc.

c) Stress Analysis And Report For Process Piping.

d) Thickness Calculation For Pipe

e) Load Data For Fire Water Piping & Process Piping

f) Equipment Layout / key plan/ General Arrangement indicating size of proposed skids, center distance between skids and space required along with maintenance requirements.

g) Equipment GAD, Piping GAD For Process And Utility Piping

h) Fire Water Spray System Piping GAD For Compressor Area.

i) Fire Water Flange, Fittings, Valves & Spray Nozzle Datasheet For Compressor Area.

j) Architectural Drawings for BOO Compressor Shed.

k) Foundation & Super Structure Drawings for BOO Compressor Shed.

l) Foundation Drawing for BOO Compressor, Air Compressor, Pipe Supports (One of each type), Equipments (One of each type).

m) Operation & Maintenance manual of all the equipment.

n) Compressor Package QAP/ITP.

o) Inspection Reports.

p) Foundation drawing

q) Material testing and Inspection Reports

r) QA/QC Procedures

s) WPS, PQR, NDT procedures

t) Fabrication Drawings

15. CONTRACTOR'S RESPONSIBILITIES

Contractor's responsibilities, besides the scope of work to be performed defined earlier, shall also include the following:

a) Develop and submit Engineering Drawings, calculations, Fabrication drawings, QA/QC procedures, inspection and testing reports, as-built records etc for complete piping system for information to Owner/EPMC.

b) Furnishing and mobilizing at site(s) all construction equipment, manpower, tools and tackles, fully equipped and fully manned with other required support facilities etc.

c) Pre-commissioning & commissioning of Compressor package with the associated piping system.

d) Contractor shall carry out all testing and inspection of materials, equipment etc. in independent testing institutions, laboratories, if so desired by Owner/EPMC.

e) Disposal of surplus materials etc. as per local authority's/Owner/EPMC's requirements.

f) The Contractor is cautioned to exercise extreme care and take necessary precautions to prevent damage to the existing piping(s), facilities, electrical and other cables during execution of the entire works. Restoration/reconstruction of all structures/ facilities affected during installation and operation shall be carried out by Contractor upto the satisfaction of Owner/EPMC at no additional cost and time implication.

g) At the end of the contract, the Gas compressor package will be required to be decommissioned as per safety requirements such as blinding of flanges used for hook-up etc and cleaning of area utilized in placement and movement of Gas Compressor package by Contractor's personnel in presence of AGCL engineers.

h) Any other work not specifically listed but required for successful completion of entire piping system.

16. DISMANTLING AND DEMOLITION

It will be contractor's responsibility to arrange dismantling for safe transportation of Gas compressor package out from site either in one go or partwise within 4 weeks from the date of completion /closure/termination of the contract. Any delay beyond 4 weeks in transporting the Gas compressor package will entail application of charges similar to other charges as decided by Owner.

17. HEALTH SAFETY AND ENVIRONMENT

The Contract shall follow the HSE Policy of Owner during entire duration of the project. Broad HSE Requirements are listed below:

a) Contractor shall comply with all of its approved and/or AGCL's Quality Policy and standards while performing work /services /supplying material at any of AGCL facilities, location, or yards.

b) All work performed by Contractors shall be performed in a safe, environmentally –sensitive manner.

c) Contractor shall take all necessary precautions for the safety of all personnel at the worksite. This includes ensuring that all personnel at worksite are being appropriately trained in the job to be performed.

d) Contractor shall comply with all Owner and local safety/environmental laws, rules, and regulations.

e) Contractor shall provide all necessary safety equipment to the personnel at site and ensure their subcontractors have all necessary safety equipment.

f) Contractor shall provide sufficient fire-fighting equipment and maintain the same in good condition. They should take necessary steps to ensure that at least one person is always present who is competent to use the firefighting Equipments.

g) Contractor shall report all injuries and incidents (including property damages and near misses) in a timely manner to the Owner Personnel or designated alternate, as well as the appropriate authorities.

h) Caution shall be taken to avoid spills and releases.

i) Contractor shall provide first aid facilities at site and they should also ensure availability of the same.

j) Work Permit system and Work procedures shall be implemented in line with the existing system of Owner

k) Contractor shall conduct or attend a pre-job HSE meeting prior to commencing operations.

l) Contractor shall strictly adhere to Owner's Waste Management Plans prepared for wastes generated while on Owner's facility. If a waste is generated for which there is no Plan, a Owner Supervisor shall be notified prior to disposal.

m) Contractor shall prepare an emergency response plan for compressor station and get it approved from Owner.

n) Compressor station shall have an emergency shutdown system (ESD) connected to a control system that can detect abnormal conditions such as an unanticipated pressure drop or natural gas leakage. These emergency systems will automatically stop the compressor units and isolate and vent compressor station gas piping (sometimes referred to as a blow down).

o) Contractor shall conduct periodic audits and mock drills.

p) Contractor shall submit the project quality policy and QAP after award of contractor.

q) POLLUTION AND CONTAMINATION:

Notwithstanding anything to the contrary contained herein, the responsibility and liability of Contractor for pollution or contamination shall be as follows:

Contractor shall assume all responsibility and liability for cleaning up and removal of pollution or contamination which originates above the surface from spills of fuels, lubricants etc. wholly in Contractor’s possession and control and/or directly associated with Contractor’s equipment and facilities.

Contractor shall assume all responsibility and liability for all other pollution or contamination, howsoever caused including control and removal of same, which may occur during the term of or arising out of this contract and shall indemnify company from and against all claims, demands and causes of action of every kind and character arising from said pollution or contamination, including but not limited to that which may result from fire, seepage or any other uncontrolled flow of gas, water or other substance.

In the event of a third party commits an act of omission which results in pollution or contamination for which either the Contractor or Owner/EPMC, by whom such party is performing work is held to be legally liable, the responsibility shall be considered as between Contractor and Owner/EPMC, regardless of the party for whom the job was performed and liability as set forth in (a) and (b) above would be specifically applied.

ANNEXURE-1 GURANTEED PARAMETERS

S.NO	GENERAL	BIDDER's RESPONSE
1	Compressor Discharge Pressure at battery limit	
2	Compressor Discharge Temperature at battery limit	
3	Flow through Compressor (MMSCMD)	
4	Fuel gas consumption for proposed compressor package (MMBTU per MMSCM of gas compressed) Note-1	
5	Compressor efficiency	
6	Driver efficiency	
7	Noise level @ 1meter from enclosure (max 85dBA)	
8	Gas Composition Note-2	

Note-1: It shall be noted that in case fuel gas consumption is more than the above specified limit, then extra fuel consumed shall be charged per SCM cost of gas from the contractor. Charging cost shall be considered from the respective month cost of per SCM gas in the Assam state.

Note-2: Outlet Gas quality shall not be different from inlet gas composition.

ANNEXURE-2 COMPRESSOR DATA SHEET

DATASHEET FOR GAS COMPRESSOR AT RUPKHELIA STATION	
Project	Development of Compressor Station at Rupkhelia
Service	Natural Gas
Type	Reciprocating
Lubricating or Non-Lubricating	Lubricating
Type of Driver	Gas Engine
Working Machine Design flowrate Capacity	0.5 MMSCMD
No. of Stages	By Contractor
No. of compressor units	Three 3 number (2 W + 1 S) of units with equal flow capacity of 0.25 MMSCMD.

PROPERTIES OF NATURAL GAS AT COMPRESSOR SUCTION		
Composition	**Percent (%)**	
Methane	94.07729	
Ethane	3.584269	
Propane	0.2744034	
Isobutane	0.1932841	
N-butane	0.05908686	
Iso-pentane	0.04807066	
N-pentane	0.02103092	
Hexane	0.05007361	
CO2	0.6409422	
Nitrogen	1.051546	
Gross Flow rate	MMSCMD	0.5 Note -1
Corrosive Element	None	
Particle size of Erosive (If any)	None	

Design data / Pressure & Rating:		
Suction	150#	
Discharge	600#	
Suction Pressure	Kg/cm2g	8 - 12
Discharge pressure	Kg/cm2g	42 – 65
Inlet Temperature	Deg C	35
Discharge Temperature	Deg C	52 (Max.)
Compression Ratio	By Contractor	
Air Cooler by Contractor	Yes	
Max. discharge	Deg C	52
Suction, Inter and After Scrubber required	Yes	
Capacity Control Mode (Manual / Automatic)	Contractor to decide	
Mechanical Data (At Package Battery Limit)		
Upstream Design Pressure	Kg/cm2g	19
Upstream Design Temperature	Deg C	(-)29 / 65
Downstream Design Pressure	Kg/cm2g	65
Downstream Design Temperature	Deg C	(-)29 / 65
Utilities Available	None	
Cooling Medium	Ambient Air	

NOTES :

1. The compressor may have to be run continuously on reduced/full load for long duration.One driver with associated compressor is to be referred as one compressor unit.

2. Compressor downstream piping temperature shall be limited as per given conditions.
Contractor to provide suitable cooling arrangement.
Ambient air shall be used as cooling medium. All air-cooled inlet/intermediate/after/lube oil cooler, etc. shall be provided by contractor.

3. Safety valves at inter stage and discharge of compressor should be vented to safe location.

4. Contractor to suggest instrumentation requirement for safe, smooth and uninterrupted operation of compressor. All those instruments will be supplied by the contractor.

5. Contractor to provide adequate venting arrangement for purging the stagnant warm gases before the start up.

6. Pulsation damper and temporary suction strainer to be in contractor scope of supply.

7. Fuel conditioning skid to be provided by the contractor

8.Ambient Air Data : Min. : 10 Deg C
Max. : 45 Deg C
Altitude : 170 M above MSL

ANNEXURE-3 BRIEF DETAILS FOR COMPRESSOR PACKAGE

SL NO	DESCRIPTION	BIDDER's
1	Name & Address of the Bidder/Packager	
2	Whether past track record of the bidder /	
3	Confirm that the compressor, driver all accessories would be mounted on a common skid as fully self-contained package	Yes / No
4	Confirm suitability for continuous operation in tropical ambient conditions	Yes / No
5	Confirm suitability of complete compressor package for the specified electrical area class	Yes / No
6	Confirm that complete package would conform to relevant ISO / API standards (with deviations, if any)	Yes / No
7	Month and year of manufacturing original compressor	
8	Configuration of compressor	
9	Compressor delivered capacity (MMSCMD)	
10	Driver Guaranteed capacity (kW)	
11	Furnishing of Project Time Schedule in Bar	

ANNEXURE-4 PAST TRACK RECORD

S. No.	Project	Client Name	Award Date	Contract delivery date	Actual Completion Date	**Details of Compressor Package supplied**							
						Compressor make, model & type	Driver make & Model	Flow Volume	Suction Pressure	Discharge Pressure	Comp. Operating Envelope	Driver Type	Driver ISO Rating (MW)

ANNEXURE-5 RESPONSIBILTIY MATRIX FOR EQUIPMENT & SERVICES

The equipment machinery, tools, materials supplies, instruments, services and labour, including but not limited to those listed at the following terms shall be provided at the location by OWNER or contractor and the expenses of OWNER/EPMC or contractor as designated hereunder by ' ✓ 'mark in the appropriate column:

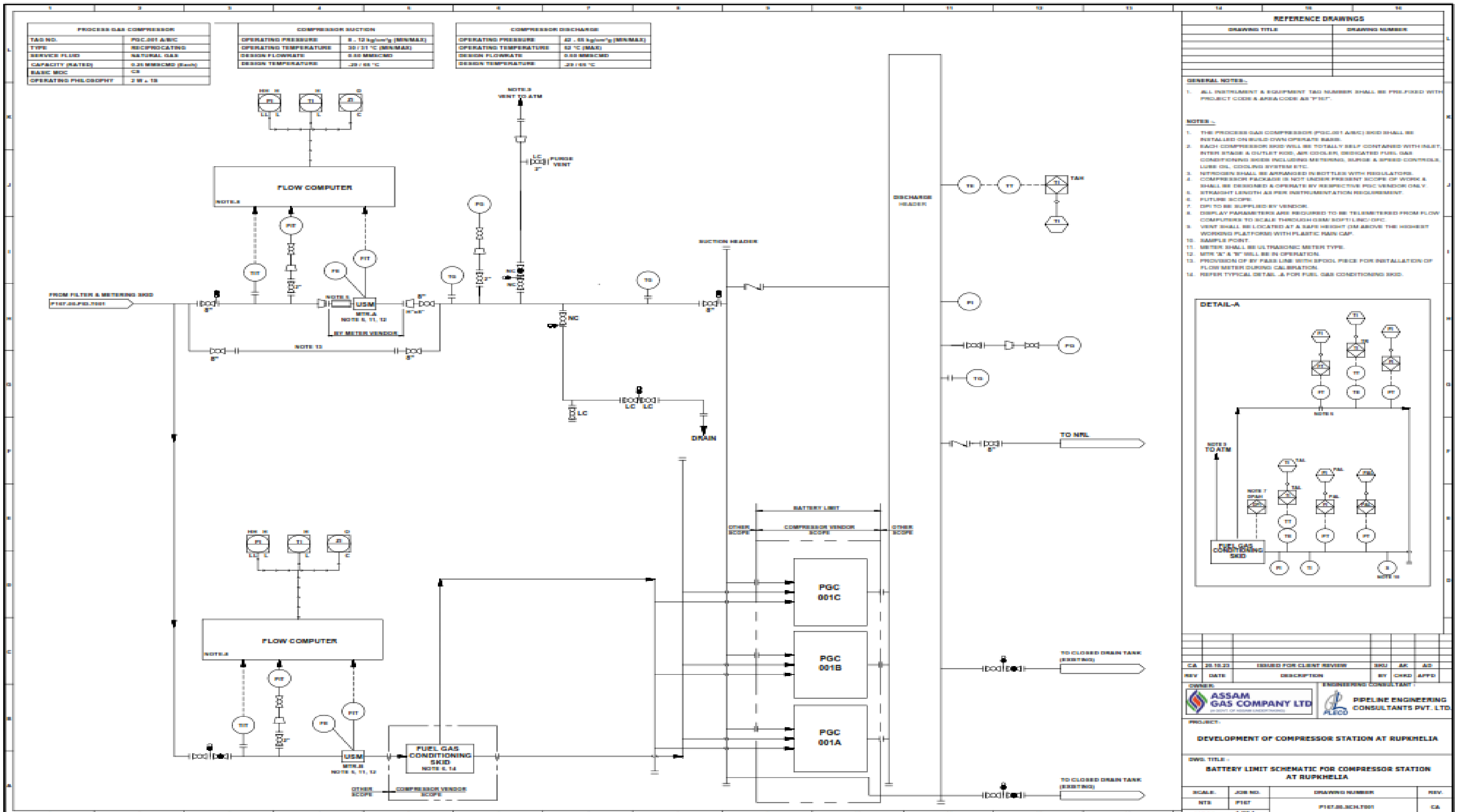
Sr. No.	DESCRIPTION	PROVIDED BY		AT COSTS OF	
		Contractor	OWNER	Contractor	OWNER
1	Transportation and handling of contractor material/ equipment between base camp and Location.	✓		✓	
2	Natural/Process Gas at Battery Limit for compression		✓		✓
3	Land for Installation of Compressor package		✓		✓
4	Required Site grading, Cutting filling, leveling etc. for the designated area at Rupkhelia station. However, if required Contractor shall do suitable site grading or filling /plot development within battery limit for proper installation of all the equipment at no cost to the Owner.		✓		✓
5	Performance of required Survey(s) for the designated area at Rupkhelia station	✓		✓	
6	Piping for suction and delivery lines, venting line, liquid drain line in Gas Compressor Station upto Battery Limit		✓		✓

Sr. No.	DESCRIPTION	PROVIDED BY		AT COSTS OF	
		Contractor	OWNER	Contractor	OWNER
7	Arranging for all the statutory approvals required for operation of the compressor package and contractor shall provide the necessary support for the same.		✓		✓
8	Safety System / Instrumentation/ Consumables	✓		✓	
9	Security Fencing/ boundary wall, if required for compressor package.		✓		✓
10	Skilled Manpower required for operation of the compressor station	✓		✓	
11	Transportation of contractor's personnel and equipment spares	✓		✓	
12	Equipments/ instruments required for the unit as per contract and spares for their maintenance.	✓		✓	
13	All personnel safety equipment for Contractor's personnel.	✓		✓	
14	Diesel, lube oil, chemicals, any other consumables etc. required at Gas Compressor Station	✓		✓	
15	All repairs to contractor's equipment.	✓		✓	

Sr. No.	DESCRIPTION	PROVIDED BY		AT COSTS OF	
		Contractor	OWNER	Contractor	OWNER
16	Contractor's office	✓		✓	
17	Office space for contractor's personnel.	✓		✓	
18	First-Aid treatment at site	✓		✓	
19	Arrangement of medical treatment for contractor's personnel including emergency hospitalization.	✓		✓	
20	Obtain, maintain all necessary permits, consents, licenses, and other certificates required for movement of contractor's equipment to and from worksite and to operate it.	✓		✓	
21	Passport, visas, and work permits and related documentation required to maintain contractor's personnel in India.	✓		✓	
22	All licenses and port charges for contractor's materials and equipment whilst import. Clearance of contractor's equipment/ material through customs after securing Essentiality Certificates from DGH	✓		✓	
23	All engineering and procurement services.	✓		✓	

Sr. No.	DESCRIPTION	PROVIDED BY		AT COSTS OF	
		Contractor	OWNER	Contractor	OWNER
24	Correcting deficiencies of Contractor's Equipment during mobilization.	✓		✓	
25	Utilities like Instrument & plant air, nitrogen, water etc., for plant operation & work place.	✓		✓	
26	Casual labour for handling Contractor's Equipment, material and supplies at base camp and compressor station	✓		✓	
27	Fire Fighting system as per PNGRB/OISD Norms	✓		✓	
28	Green Belt Development		✓		✓
29	Arrangement of electricity/power at proposed compressor station upto the battery limit		✓		✓
30	HAZOP, SIL and PHA (Process Hazard Analysis) study (inputs to be provided by the Contractor). However, if any change required as per study, then contractor shall comply the requirement without any price implication.		✓		✓
31	Boundary Wall		✓		✓

ANNEXURE 6 BATTERY LIMIT SCHEMATIC



ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF COMPRESSOR STATION AT RUPKHELIA

PROCESS SCOPE OF WORK

Doc No.: P167-SOW-T001

TA	25.10.2023	Issued with Tender	AS	AK	AD
CA	18.10.2023	Issued for Client review	AS	SV	AD
IA	10.10.2022	Issued IDC	AS	SV	AD
REV.	DATE	DESCRIPTION	ORG	REVIEW	APPROVED

CONTENTS

CONTENTS

1.0 INTRODUCTION

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e., Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCM of gas per day.

AGCL is planning to expand its Pipeline Network in Assam for increasing gas transportation capacity so they want to develop new Compressor Station at Rupkhelia (Assam).

Pipeline Engineering Consultants Pvt. Ltd. has been appointed as Engineering Consultant by AGCL for Consultancy Services Engineering, Procurement, RFP preparation and Project Management for the Project.

2.0 PURPOSE OF DOCUMENT

The Purpose of this document is to define the minimum technical requirements and Seller's scope of work to install a gas engine driven reciprocating compressor on BOO basis for this project.

3.0 DEFINITION

Where used in this document, the following terms shall have the meanings indicated below, unless clearly indicated by the context to this order.

PROJECT	Development of New Compressor Station at Rupkhelia Assam
CLIENT/ OWNER	Assam Gas Company Limited
EPMC	Pipeline Engineering Consultants Pvt. Ltd. (PLECO) the agency to act for and on behalf of OWNER for the Detailed Engineering Services and Project Management
CONTRACTOR	Agency appointed by CLIENT/ OWNER for execution of assigned tasks
PURCHASER	Either of CLIENT, OWNER or EPMC
VENDOR/ MANUFACTURER	Party, which manufactures and supplies equipment and services to the OWNER or to CONTRACTOR

4.0 PROJECT BRIEF

The Proposed facility at Rupkhelia, Assam shall have a compression package comprising of 3 X 0.25 MMSCMD (Engine driven) natural gas reciprocating compressors with a suction pressure of 8 -12 kg/cm^{2}g, and a discharge pressure of 42 – 65 kg/cm^{2}g. The compressor shall also have a provision for complete isolation of each individual package compressor including drain, flare, and vent etc. for any maintenance job.

The facility shall include the following components:

1. Compressor package (2W+1S, Engine driven) reciprocating compressors and its auxiliaries
2. Common inlet manifold
3. Common suction KOD
4. Common discharge KOD
5. Interstage air coolers
6. Compressors outlet manifold
7. Fuel gas conditioning skid including metering
8. Lube Oil system
9. Intermediate Blow down Vessel
10. Common Flash Vessel
11. Fire detection and suppression system
12. Integration with existing SCADA system
13. Plant lighting

5.0 DOCUMENT PRECEDENCE:

It shall be the responsibility of the Manufacturer/Vendor to inform the Purchaser of any errors, ambiguities, inconsistencies, discrepancies or conflict of information that may be found to exist in any document, specification or drawing submitted by the Purchaser.

In case of conflict, the order of precedence shall be as follows:

- Approved Datasheets, Specification and Drawings
- Scope of Work.
- Design Basis;
- International Codes & Standards.

As a general rule in the event of any discrepancy between technical matter and local laws/regulations (and documents above listed) the most stringent shall be applied.

Manufacturer/Vendor shall notify Purchaser of any apparent conflicts between MR, specifications, related datasheets, any code and standards and any other specifications noted herein. (Resolution and/ or interpretation precedence shall be obtained from Purchaser in writing before proceeding with the design/ manufacturer or completion of services.

6.0 CODES & STANDARDS

The equipment shall be designed, constructed and tested in accordance with the latest edition and amendments of the following codes and standards

Code	Name
API RP 520	Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries
API STD 618	Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services (5th Edition, December 2007)
API STD 661	Petroleum, Petrochemical and natural Gas Industries – Air cooled Heat Exchangers (7th Edition, July 2013)
ASME Sec VIII Div I	Rules for construction of Pressure Vessels (2019 Edition, July 2021)
ASME B31.8	Gas Transmission and Distribution Piping System
OISD – 226	Natural Gas Transmission Pipelines and City Gas Distribution Networks
PNGRB, T4S	For Natural gas Pipelines

7.0 SCOPE OF WORK

Vendor shall be completely responsible for supply and installation of below mentioned materials within the Compressor Package Equipment along with required accessories and services for satisfying the functional / operational requirements stated in this Scope of Work:

7.1 GENERAL

(1) The Compressor package should have maximum designed capacity 0.25 MMSCMD (Each Compressor) and it will be able to safely run at minimum 25% load of maximum full capacity i.e., capacity turndown will be between 25 to 100%. The compressor package shall be designed taking the extreme operating conditions. Bidders are required to furnish capacity availability and details like HP requirements of the package at different combinations.

(2) Engineering, Procurement, design, selection, manufacturing, shop inspection cum testing, painting, packing and forwarding, assembly, testing, transportation to project site, storage, erection and commissioning, performance testing of 3(three) no. of Reciprocating natural gas compressor package, including performance and mechanical guarantees against entire workmanship in all respects.

(3) Natural Gas will be available at Rupkhelia (Golaghat) compressor station at 8 - 12 Kg/Cm^{2}g and need to compress up to 42 - 65 Kg/Cm^{2}g. However, unit will be designed to operate at a minimum suction pressure of 8 -12 Kg/Cm2g depending upon the supply pressure available. Suction pressure may vary above/below standard suction pressure value based on field condition. Accordingly, package is to be designed in a way that it maintains desired flow in such fluctuating operating conditions also. Compressor will have minimum designed capacity of 0.25 MMSCMD (Each compressor) and should be operational at variable load of 25%,50%,75% and 100% at minimum suction pressure.

(4) The above duty conditions (capacities) are at normal operating speed and after considering other conditions/factors such as altitude, maximum gas temperature, ambient temperature etc. The gas pressures (both suction and discharge) for the units are likely to fluctuate by 30% of the figures given above and the compressor package shall be designed taking the extreme operating conditions. Bidders are required to furnish capacity availability and other details like HP requirement of the packages at different combinations. The requirement

against each duty of compressor may be increased/ decreased at the time of order placement.

(5) Perform a hydraulic study for the compressor upstream and downstream pipeline for estimation of increased throughput with addition of this new package if desired by AGCL for operational requirement if any in near future.

(6) Carryout HAZOP Study by engaging an approved third party.

(7) SIL study is to be performed by engaging an approved third party.

(8) 3D modeling of the complete package should be done using industry preferred modeling software like PDMS/Autoplant/Solidplant/Naviswork etc. AGCL will seek review at various completion stages.

(9) Finalization & submission of Project Execution Plan/Schedule considering all the aspects within the stipulated project completion time frame mentioned in tender document.

(10) Submission of any other relevant engineering drawing, technical specification of all equipment's for AGCL's review which need to comply with statutory requirements with special reference to OISD & PNGRB norms whichever applicable.

(11) Fire extinguishing system including water reservoir/tank, fire hydrant lines, water monitors, water sprinklers in compressor shed etc. as per OISD guidelines.

(12) Vendor shall be responsible for As-built documentation at the end of the job related to project scope of work.

(13) It is Vendor's responsibility to verify the selection of type of material of construction of each component as per the data mentioned in individual specifications / data sheets. Vendor shall stand guarantee for all items supplied by them, including his brought-out items.

(14) Vendor shall submit the mentioned below process deliverables as minimum but not limited to. Any additional deliverables required shall be prepared and submitted to meet the project intent, same shall be complied without any cost and schedule impact.

- Process Datasheets
- Piping & Instrumentation Diagram(P&IDs) of compressor package and associated utilities.
- Operation & Maintenance catalogue
- HAZOP & SIL reports
- Vent & Drain Philosophy, ESD Philosophy

ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF COMPRESSOR STATION AT RUPKHELIA

PROCESS DESIGN BASIS

Doc No: P167-DEB-T001_RTA

TA	25.10.2023	Issued with Tender	AS	AK	AD
CA	18.10.2023	Issued For Client Review	AS	AK	AD
IA	11.10.2023	Issued For IDC	AS	AK	SV
REV.	**DATE**	**DESCRIPTION**	**ORG**	**REVIEW**	**APPROVED**

ABBREVIATIONS

AG	Above Ground
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
AGCL	Assam Gas Company Limited.
BIS/IS	Bureau of Indian standards
CS	Carbon Steel
EPMC	Engineering Project Management Consultant
ESD	Emergency Shutdown
MMSCMD	Million Metric Standard Cubic Meter per Day
F&G	Fire and Gas
3LPE	Three Layer Polyethylene
RPM	Round Per Minute
FGS	Fire & Gas System
i.e.,	That is
LDS	Leak Detection System
LTCS	Low Temperature Carbon Steel
Ltd.	Limited
MAOP	Maximum Allowable Operating Pressure
Max	Maximum
Min	Minimum
MOC	Material of Construction
OISD	Oil Industry Safety Directorate
PSV	Pressure Safety Valve
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
TOP	Tap Off Point

CONTENTS

1. INTRODUCTION

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e., Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCM of gas per day.

AGCL is planning to expand its Pipeline Network in Assam for increasing gas transportation capacity so they want to develop new Compressor Station at Rupkhelia (Assam).

Pipeline Engineering Consultants Pvt. Ltd. has been appointed as Engineering Consultant by AGCL for Consultancy Services Engineering, Procurement, RFP preparation and Project Management for the Project.

2. DEFINITIONS

Where used in this document, the following terms shall have the meanings indicated below, unless clearly indicated by the context to this order.

PROJECT	Development of Compressor Station at Rupkhelia.
EPMC	Pipeline Engineering Consultants Pvt. Ltd. (PLECO) is the agency to act for and on behalf of OWNER for the Detailed Engineering Services and Project Management.
CONTRACTOR	Agency appointed by CLIENT/ OWNER for the execution of assigned tasks
PURCHASER	Either of CLIENT, OWNER or EPMC
VENDOR/MANUFACTURER	Party, which manufactures and supplies equipment services to the OWNER or to CONTRACTOR

3. SCOPE OF DOCUMENT

The scope of the document is to describe the basic information and design criteria which will be used under **“Development of Compressor Station at Rupkhelia Project”.**

The document provides facilities-related design information, including physical properties, environmental information and also provides inputs required for process design of facilities in this project scope.

4. PROJECT BRIEF

The proposed facility at Rupkhelia, Assam shall have a compression package comprising of 3 x 0.25 MMSCMD (Engine driven) natural gas reciprocating compressors with a suction pressure of 8 – 12 kg/cm^{2}g, and a discharge pressure of 42 - 65 kg/cm^{2}g. The compressor shall also have a provision for complete isolation of each individual package compressor including drain, flare, and vent etc. for any maintenance job.

The facility shall include the following components:

1. Compressor package (2W+1S, Engine driven) reciprocating compressors and its auxiliaries
2. Common inlet manifold
3. Common suction KOD
4. Common discharge KOD
5. Interstage air coolers
6. Compressors outlet manifold
7. Fuel gas conditioning skid including metering
8. Lube Oil system
9. Intermediate Blow down Vessel
10. Common Flash Vessel
11. Fire detection and suppression system
12. Integration with existing SCADA system
13. Plant lighting

5. PROJECT DESCRIPTION

5.1 COMPRESSOR PACKAGE AT RUPKHELIA (GOLAGHAT)

A new compressor station & associated facilities are proposed at Rupkhelia (Golaghat) station.

The compressor package shall be provided with necessary controls (including speed control) connected to the unit control panel. Compressor package shall also be provided with PSV, BDV, SDV and other instrumentation required for safe operation of the unit.

6. BATTERY LIMITS

Process Facility : **Upstream**

- From tie-in available at Golaghat premises.

: **Downstream**

- Rupkhelia Compressor station with Pipeline Receipt facilities.
- Rupkhelia to Numaligarh 8” x 33.5 km Pipeline.

Utilities : From the tie-in points with existing nearest available utility headers.

7. DESIGN CODES & STANDARDS

The list of applicable codes & standards for design of process facilities is as given below:

Code	Name
API RP 520	Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries
API STD 618	Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services (5th Edition, December 2007)
API STD 661	Petroleum, Petrochemical and natural Gas Industries – Air cooled Heat Exchangers (7th Edition, July 2013)
ASME Sec VIII Div I	Rules for construction of Pressure Vessels (2019 Edition, July 2021)
ASME B31.8	Gas Transmission and Distribution Piping System
OISD – 226	Natural Gas Transmission Pipelines and City Gas Distribution Networks
PNGRB, T4S	For Natural gas Pipelines

8. UNIT OF MEASUREMENT

Unit of measurement shall be metric except for the following:

Flow	:	MMSCMD
Pressure	:	Kg/cm^{2}g
Temperature	:	˚C

9. COMPRESSOR PACKAGE DETAILS

Process Gas compressors 001A, 001B and 001C is considered to compress the gas. Each compressor is of Reciprocating and two stage compression type, will operate in 2W + 1S configuration. These compressors shall use to compress the combined gas coming from Nambor GGS, Khoraghat and Haziragaun. This combined gas at Rupkhelia (Golaghat) station shall be collected in compressor inlet manifold of PGC which will operate at 8–12 kg/cm2g.The process gas shall be compressed to 42–65 kg/cm2g.

The Compressor package shall be design based on the following design criteria:

SL. No	Description	Unit	Condition
1	Location	-	Rupkhelia (Golaghat)
2	Type	-	Reciprocating
3	Driver	-	Gas engine driven
4	Quantity	-	3no's (total)
5	Operating Philosophy		2W + 1S
6	Suction Pressure	Kg/cm2g	8 - 12
7	Discharge Pressure	Kg/cm2g	42 - 65
8	Inlet gas Temperature	°C	30 - 31
9	Outlet Temperature	°C	52 (max)
10	Capacity	MMSCMD	0.25 (for each compressor package at the outlet)

- **FUEL GAS**

  Engine fuel gas supply tap-off shall be taken from the header at the outlet of common suction KOD. Vendor shall size the common suction KOD to ensure that the fuel gas taken from the outlet meets the requirement of the engine as per OEM recommendations.

SL. No	PARTICULARS	DESCRIPTION/VALUE
1	Type of fuel	Gas
2	Fuel Pressure Range	3.5 – 6 Kg/cm2g
3	Gas Temperature	45°C
4	Composition	Same as compressed gas
5	LHV	Vendor to estimate and use for engine design
6	Allowable solid particulate matter	< 5 microns (Vendor to confirm requirement)
7	Allowable oil/liquid carryover	< 10 microns (Vendor to confirm requirement)

10. SITE AND ENVIRONMENTAL DATA

**Environmental data for the process facilities considered under this project is as given below:

Max Ambient Temperature	45 ℃
Min Ambient Temperature	10 ℃
Max Ambient Air Temperature	40 ℃
Relative Humidity at 21℃	100 %
Relative Humidity at 32 ℃	95 %
Relative Humidity at 41 ℃	70 %
Elevation Above Mean Sea Level	170 meters
Yearly Average Rainfall	2528 mm

****Reference: AGCL Tender document 1**

11. FACILITIES AT COMPRESSOR STATION, RUPKHELIA

- A new compressor station & associated facilities are proposed at Rupkhelia (Golaghat) station.
- The compressor shall have Reciprocating type compressor.
- The compressor shall be totally self- contained type with inlet inter stage and outlet Knock out Drums, air coolers, dedicated fuel gas conditioning skid including metering, lube oil system, cooling systems etc.
- The compressor package shall be provided with necessary controls (including speed control) connected to the unit control panel. Compressor package shall also be provided with PSV, BDV, SDV and other instrumentation required for safe operation of the unit.
- The process conditions are as follow:
  - **Suction Pressure:** 8 - 12 Kg/cm2g.
  - **Discharge Pressure:** 42- 65 Kg/cm2g (max)
  - **Inlet gas temperature: (**30 – 31) °C
  - **Outlet temperature:** 52°C Max

12. HAZARDOUS AREAS

The Classification of hazardous areas is in accordance with IS 5572, PESO & PNGRB guidelines.

Electrical equipment shall be located outside the hazardous area unless the equipment is directly connected to the process. Equipment within the hazardous area shall be suitably rated for the area by PESO.

13. PRESSURE SAFETY DEVICES

Any equipment/skids containing Natural Gas in the form of trapped volume shall be protected against excessive pressure developed due to a rise in surrounding temperature by installing suitable safety relief valves.

Pressure safety valves of sufficient capacity and sensitivity and other safety devices/system (as applicable) shall be installed to ensure that the pressure inside the system/equipment does not exceed the prescribed limits.

For all critical equipment like KODs, the PSV shall be set for Fire case i.e. for 21% overpressure, so that the pressure inside the equipment does not exceed 21% of the Maximum Allowable Operating Pressure (MAOP) in any case.

All such safety relief valves shall have lock open type isolation valve upstream of the relief valve.

14. CONTROL SYSTEM

Gas Compressor Package vendor's, instrumentation scope includes the package instruments, the Unit Control Panel (UCP) to be located in control room and Local Control Panel (LCP) to be located at shelter. The LCP / UCP are envisaged to be interfaced with existing DCS / SCADA System. A dedicated Unit control panel (UCP) for each package shall be provided and the UCP shall be located in the Control Room which shall be using a SIL3 certified PLC system to monitor and control all integrated functions. The Local Control panel on / beside the package shall be provided with all the critical controls required for the operation from field and should have the facility for monitoring complete status of the equipment. The local control panel shall have necessary push button, display panel, relay, indication, hooter etc.

Following philosophy shall be used for the instrumentation and control of this pipeline:

a) Instrument and control signals at Compressor station at Rupkhelia shall be connected to respective Compressor PLC. Signals from PLC shall be further transmitted through FOC based network to the New SCADA/RTU system (By Others).

b) The fire and gas devices and ESD Devices shall be connected to the F&G system and ESD System Respectively at Compressor Station Control Room of Rupkhelia, subsequently these signals / alarms shall be made available to New SCADA/RTU system (By Others)

15. F&G

The Fire and Gas (F&G) detection system shall be designed as per the latest edition of the National Fire Alarm Code NFPA 72.

ANNEXURE-1

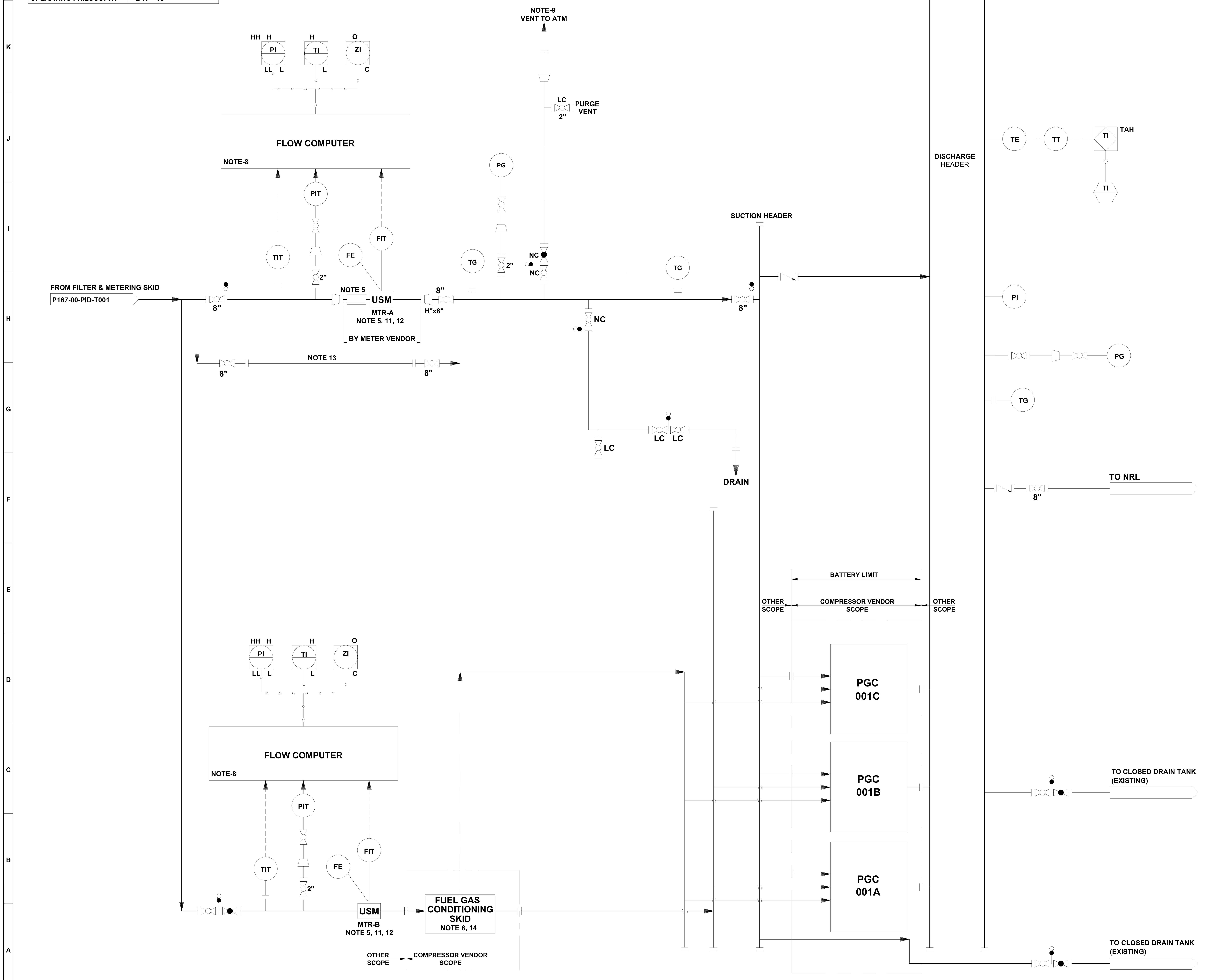
Gas Composition

Gas Component	Percent (%)
Methane	94.07729
Ethane	3.584269
Propane	0.2744034
Isobutane	0.1932841
N-butane	0.05908686
Iso-pentane	0.04807066
N-pentane	0.02103092
Hexane	0.05007361
CO2	0.6409422
Nitrogen	1.051546

PROCESS GAS COMPRESSOR	
TAG NO.	PGC-001 A/B/C
TYPE	RECIPROCATING
SERVICE FLUID	NATURAL GAS
CAPACITY (RATED)	0.25 MMSCMD (Each)
BASIC MOC	CS
OPERATING PHILOSOPHY	2 W + 1S

COMPRESSOR SUCTION	
OPERATING PRESSURE	8 - 12 kg/cm²g (MIN/MAX)
OPERATING TEMPERATURE	30 / 31 °C (MIN/MAX)
DESIGN FLOWRATE	0.50 MMSCMD
DESIGN TEMPERATURE	-29 / 65 °C

COMPRESSOR DISCHARGE	
OPERATING PRESSURE	42 - 65 kg/cm²g (MIN/MAX)
OPERATING TEMPERATURE	52 °C (MAX)
DESIGN FLOWRATE	0.50 MMSCMD
DESIGN TEMPERATURE	-29 / 65 °C



REFERENCE DRAWINGS

DRAWING TITLE	DRAWING NUMBER

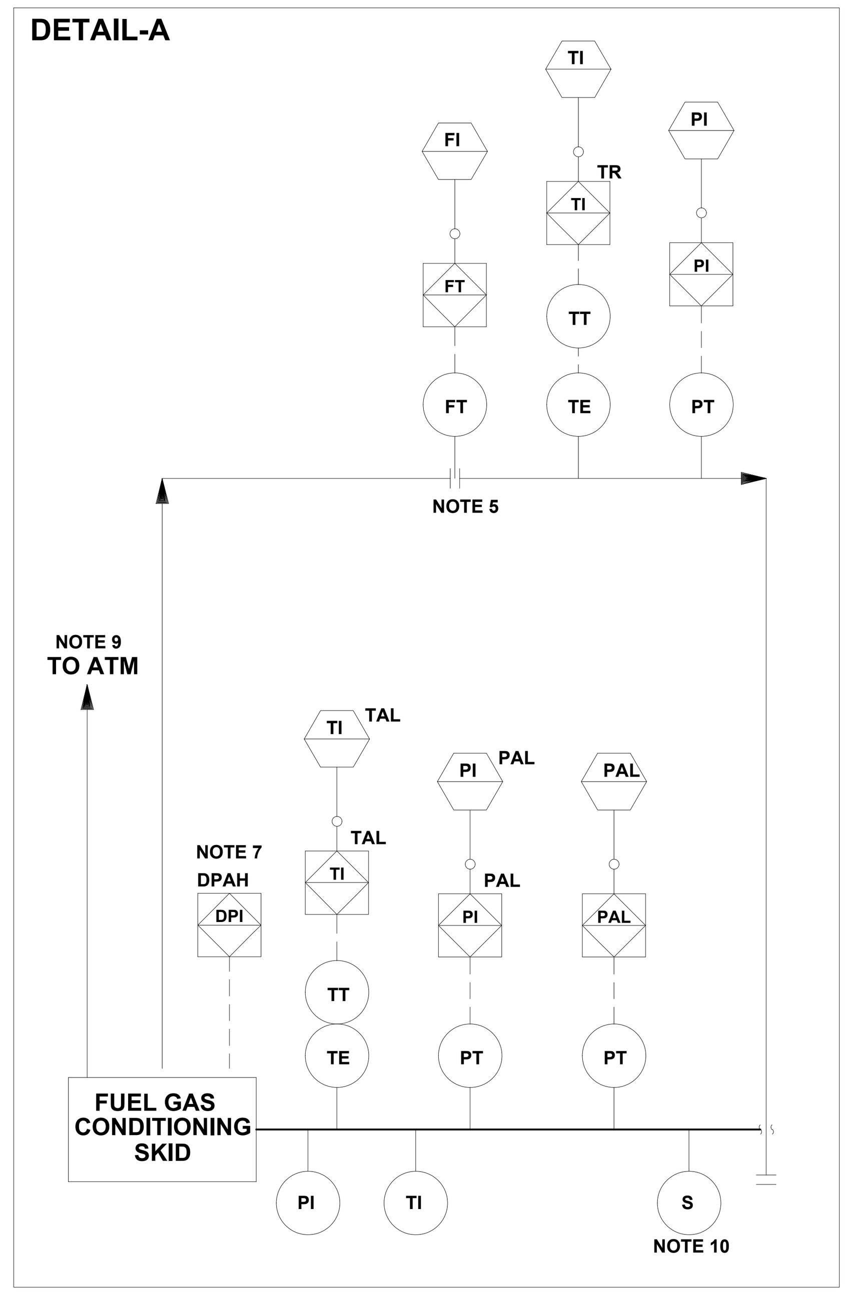
GENERAL NOTES:-

1. ALL INSTRUMENT & EQUIPMENT TAG NUMBER SHALL BE PRE-FIXED WITH PROJECT CODE & AREA CODE AS "P167".

NOTES :-

1. THE PROCESS GAS COMPRESSOR (PGC-001 A/B/C) SKID SHALL BE INSTALLED ON BUILD OWN OPERATE BASIS.
2. EACH COMPRESSOR SKID WILL BE TOTALLY SELF CONTAINED WITH INLET, INTER STAGE & OUTLET KOD, AIR COOLER, DEDICATED FUEL GAS CONDITIONING SKIDS INCLUDING METERING, SURGE & SPEED CONTROLS, LUBE OIL, COOLING SYSTEM ETC.
3. NITROGEN SHALL BE ARRANGED IN BOTTLES WITH REGULATORS.
4. COMPRESSOR PACKAGE IS NOT UNDER PRESENT SCOPE OF WORK & SHALL BE DESIGNED & OPERATE BY RESPECTIVE PGC VENDOR ONLY.
5. STRAIGHT LENGTH AS PER INSTRUMENTATION REQUIREMENT.
6. FUTURE SCOPE.
7. DPI TO BE SUPPLIED BY VENDOR.
8. DISPLAY PARAMETERS ARE REQUIRED TO BE TELEMETERED FROM FLOW COMPUTERS TO SCALE THROUGH GSM/ SOFT/ LINC/ OFC.
9. VENT SHALL BE LOCATED AT A SAFE HEIGHT (3M ABOVE THE HIGHEST WORKING PLATFORM) WITH PLASTIC RAIN CAP.
10. SAMPLE POINT.
11. METER SHALL BE ULTRASONIC METER TYPE.
12. MTR "A" & "B" WILL BE IN OPERATION.
13. PROVISION OF BY PASS LINE WITH SPOOL PIECE FOR INSTALLATION OF FLOW METER DURING CALIBRATION.
14. REFER TYPICAL DETAIL -A FOR FUEL GAS CONDITIONING SKID.

DETAIL-A



REV	DATE	DESCRIPTION	BY	CHKD	APPD
TA	25.10.23	ISSUED WITH TENDER	SKU	AK	AD
CA	20.10.23	ISSUED FOR CLIENT REVIEW	SKU	AK	AD

OWNER: ASSAM GAS COMPANY LTD (A GOVT. OF ASSAM UNDERTAKING)

ENGINEERING CONSULTANT : PIPELINE ENGINEERING CONSULTANTS PVT. LTD. PLECO

PROJECT:

DEVELOPMENT OF COMPRESSOR STATION AT RUPKHELIA

DWG. TITLE :

BATTERY LIMIT SCHEMATIC FOR COMPRESSOR STATION AT RUPKHELIA

SCALE.	JOB NO.	DRAWING NUMBER	REV.
NTS	P167	P167-00-SCH-T001	TA
SHEET	1 OF 1		

SHEET SIZE : A1 (841 mm x 594 mm)

ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF RUPKHELIA COMPRESSOR STATION

SECTION - C

CIVIL, STRUCTURAL & ARCHITECTURAL

DEVELOPMENT OF RUPKHELIA COMPRESSOR STATION

SCOPE OF WORK FOR CIVIL, STRUCTURAL & ARCHITECTURAL

DOCUMENT NO. P167-SOW-C001-RTA

TA	25.10.23	ISSUED WITH TENDER	AK/ SS	RBS	RKB
CA	20.10.23	ISSUED FOR CLIENT REVIEW	AK/ SS	RBS	RKB
IA	06.10.23	ISSUED FOR INTERNAL REVIEW	AK/ SS	RBS	RKB
Rev.	**Date**	**Purpose**	**Prepared by**	**Reviewed by**	**Approved by**

Contents

1.0 INTRODUCTION

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e., Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCMD of gas per day.

AGCL is planning to expand its Pipeline Network in Assam for increasing gas transportation capacity so they want to develop new Compressor Station at Rupkhelia (Assam).

Pipeline Engineering Consultants Pvt. Ltd. (PLECO) has been appointed as PMC by AGCL for Project Management for the Project.

2.0 PURPOSE

The purpose of this document is to specify the scope of civil, structural and architectural for the development of BOO natural gas compressor station with maintenance area and worker shed at Rupkhelia.

3.0 DEFINITION

Where used in this document, the following terms shall have the meanings indicated below, unless clearly indicated by the context to this order.

PROJECT	Development of Rupkhelia Compressor Station
PMC	Pipeline Engineering Consultants Pvt. Ltd. (PLECO) the party to act for and on behalf of OWNER for the Project Management.
CONTRACTOR	Agency appointed by CLIENT/ OWNER for executions of assigned tasks

4.0 SCOPE OF WORK

The scope of Civil, Structural & architectural works under this contract shall include design, drafting & detailing, fabrication, supply of all materials, execution and construction of BOO compressor shed along with the maintenance area shed and worker shed including all relevant Civil, Structural and Architectural works required for successful completion of **BOO Natural Gas Compressor Station** works as per the Drawing, Specifications, Standards enclosed with the bid document.

Major civil, structural & architectural works involved shall include, but not limited to the following:

1. Scope of work by the Contractor shall consist of Architectural design & detail engineering including preparation of Architectural construction drawings, construction including construction supervision & supply of all materials, labour, tools & tackles etc., obtaining approvals from statutory Authorities, supply of deliverables like drawings, documents, preparation of as-built drawings etc. and co-ordination with Consultant & the Owner etc., all complete for BOO compressor shed along with EOT/ Maintenance arrangement, maintenance area shed and worker shed as listed in subsequent clauses.
2. Contractor shall develop architectural drawings and respective documents as relevant up to Approved for Construction (AFC) status, taking due account of the detailed requirements of the bid drawings, Design Basis, Job specifications and Standards for architectural works for the scope of work covered under this Contract. Contractor shall not proceed with construction till those documents which are specifically listed at "Review" category are reviewed by OWNER /CONSULTANT.
3. Design, Drafting, Detailing, Fabrication, Supply and Construction of foundation and/ or superstructure for
    a. BOO compressor shed including EOT crane / Maintenance arrangement.
    b. BOO compressor foundations.
    c. Air compressor foundations.
    d. Maintenance Area shed.
    e. Worker shed.
    f. Pipe Supports & Equipment Foundations
    g. Cable Trenches, pipe trenches, pits, etc.
4. Preparation of Bar Bending Schedule for all RCC works before construction is taken up.
5. Design, Drafting, Detailing, Supplying, Fabricating and erection of Structural Steel works in superstructure including platforms, ladders around equipments, EOT crane/ maintenance arrangement supports, handrails, crossovers, pipe supports and operating platforms from grade.
6. Preparation of fabrication drawings for all structural steel works.
7. Providing Electroformed galvanized MS grating, Chequered plate and painted handrails on platforms/ stairs.
8. Painting on structural steel and coating of RCC works including shop primer shall be done as per Painting specification attached elsewhere in the bid document.
9. Piling works (Bored/ Driven Cast-in-situ), wherever required as per the recommendation of Soil Investigation report(s) shall be carried out by the

Contractor. Details of piling works along with technical specifications including pile testing shall be submitted by the Contractor to Owner/ Consultant for review & record before starting the construction activities.

10. Microplanning schedule of activity wise shall be furnished & taking necessary approvals from the related department before carrying out any activity in existing structure. Any statutory approval from authorities including submission of stability certificate after completion of construction, if required, shall also be taken.
11. PCC works including lean concrete below foundations of all types, Plinth beams, etc. at all depths below plinth level.
12. Documentation of **AS BUILT** drawings/ details for all works as specified elsewhere in this Bid package.
13. Any other Civil, Structural & Architectural works required/ directed by owner/ consultant for the satisfactory and successful completion of the project.
14. Initial plot plan is attached herewith in the bid document. Final plot plan shall be made available to the successful bidder after award of job.
15. Geotech Report and Topo Survey Report is attached herewith in the bid document.

5.0 SPECIFIC REQUIREMENTS TO BE FULFILLED BY CONTRACTOR

Apart from the conditions mentioned in the Specifications, the following shall be strictly adhered to.

1. The Shed shall be designed on the basis of following documents. In case of any irrevocable conflict, the most stringent provision or Owner/ Consultant's decision shall be followed.
    a) National Building Code of India
    b) State Factory Rules
    c) PNRGB (Petroleum & Natural Gas Regulation Board)
    d) BIS (Bureau of Indian Standards) Codes
    e) Indian Electricity Rules
    f) Local Municipality/ any other Authority Bye-Laws as applicable.
2. Ordinary Portland Cement (43 or 53 Grade)/ Portland Pozzolana Cement shall be used.
3. Contractor shall make necessary arrangement for placing the anchor bolts in position before concreting. Whenever there are more foundation bolts, these shall be fixed by using templates. In case bolts are not available at site at the time of casting of foundation, proper pockets shall be left as per direction of the Owner/ Consultant.

4. Contractor to ensure isolation of structures/ equipment with difference of temperature for free expansion while providing interconnecting platform and for connection to stair structures.
5. Contractor shall ensure lateral stability by providing box/built-up sections for columns wherever it is not feasible to provide vertical bracing in either direction.
6. All designs, detailing & construction shall strictly conform to enclosed standards, specifications & drawings.
7. Contractor shall depute his concerned Civil-Structural design engineer to Owner/Consultant review office as and when required for review of his documents. During such reviews involving computer aided analysis/design/drafting of structures, the Contractor shall make his own arrangement of Personal Computer (PC) in the form of Lap-top in the premises of Owner/ Consultant review office. This is required to expeditiously resolve all the comments including those involving the use of PC by Contractor in his submission. The Contractor shall ensure that these PCs are fully operational along with necessary software already loaded including the input/output/drawing files of the structures being reviewed. The Contractor shall revise and re-submit the analysis/design and drawings as required during review.
8. Verification of foundation loading data for all equipments/ structures/ stacks etc., which form part of the comprehensive packages supplied by the respective vendors, shall be entirely the responsibility of Contractor. Contractor shall ensure that wind/ seismic loadings are strictly in line with the basic wind pressures/ seismic condition enclosed in Engineering Design Basis and addendum with this bid package.
9. The Net Safe Bearing Capacity of Soil considered for the design of foundation shall be mentioned in drawings for all structures and equipments.
10. Contractor shall submit one set of design document/ AFC drawings for owners.

6.0 SCOPE OF SUPPLY

6.1 OWNER SCOPE OF SUPPLY

NIL

6.2 CONTRACTOR SCOPE OF SUPPLY

All materials (consumables/ non-consumables) including tools, tackles, plant machinery, workers/labors, etc. required for completion of the works as per Scope of work shall be in contractor’s scope of supply and shall be the responsibility of Contractor within the quoted rates.

7.0 LIST OF ATTACHMENTS

7.1 STANDARDS SPECIFICATIONS

S. NO.	TITLE	SPEC NO./ DOCUMENT NO.	NO. OF SHEETS	REV. NO.
1.	Civil & Structural Works- General Scope	C-SPC-101	04	0
2.	Civil & Structural Works- Materials	C-SPC-102	15	0
3.	Civil & Structural Works- Earthwork	C-SPC-103	13	0
4.	Civil & Structural Works- Plain & Reinforced Cement Concrete	C-SPC-104	29	0
5.	Civil & Structural Works- Structural Steel Works	C-SPC-106	24	0
6.	Civil & Structural Works Miscellaneous Steel Works	C-SPC-108	11	0
7.	Civil & Structural Works Miscellaneous Items	C-SPC-112	09	0
8.	Architectural Works – General	C-SPC-151	07	0
9.	White/ Colour Washing, Distempering, Painting and Polishing	C-SPC-157	14	0
10.	Geotechnical Investigation Report	-	-	-

11.	Topographical Survey Report	-	-	-

7.2 DRAWINGS

S. No.	TITLE	DRAWING NO.	NO. OF SHEETS	REV. NO.
1.	Indicative plot plan	P167-DWG-C001	1	CA

STANDARD SPECIFICATION

FOR

CIVIL & STRUCTURAL WORKS - GENERAL SCOPE

C-SPC-101

0	26.02.22	ISSUED FOR USE AS STANDARD	MK	ADh	RKB	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATION

IS	Indian Standard

1. These specifications establish and define the material and constructional requirements for CIVIL and STRUCTURAL WORKS.

2. Methods of measurements are indicated in these specifications; where not so specified, latest revision oflS: 1200 shall be applicable.

3. Providing and operating all necessary measuring and testing devices/ equipments including all materials and consumables are included in the scope of work. No separate measurement or payment for testing the quality of work and materials shall be made; rates quoted for various items shall be deemed to include the cost of such tests which are required to ensure achievement of specified quality.

4. All materials shall be of standard quality, manufactured by renowned concerns conforming to Indian Standards or equivalent, and shall have IS mark as far as possible unless otherwise approved by the Engineer-in-Charge. Vendor List attached in the Tender document shall be followed. The Contractor shall get all materials approved by the Engineer-in-Charge prior to procurement and use. The Contractor shall furnish manufacturer's certificates for the materials supplied by him when asked for. Further to that he shall get the materials tested from an approved test house if asked for by the Engineer-in- Charge. The cost for all the tests and test certificates for the material procured by the Contractor shall be borne by the Contractor. No separate payment shall be made for the testing. The Engineer-in-Charge shall have the right to determine whether all or any of the materials are suitable. Any materials procured or brought to site and not conforming to specifications and satisfaction of the Engineer-in-Charge shall be rejected and the Contractor shall have to remove the same immediately from site at his own expense and without any claim for compensation due to such rejection.

5. Wherever referred to in the tender document, only the latest revision of Specifications, Codes of Practice and other publications of Bureau oflndian Standards shall be applicable.

6. Wherever the Contractor executes civil and structural works involving buildings, equipment foundations, supporting structures, pipe racks, etc., the following works are deemed to have been included in the quoted rates for various works.

   - Marking of centre lines of foundations etc.
   - Establishing layout and levels of foundations and superstructure etc., including establishment of reference lines, bench marks on various floors, platforms etc.
   - General upkeep of the plant site.
   - Preparation of Fabrication drawings and getting approval from Engineer-in-Charge after incorporating all the comments.
   - Preparation of "As-Built" scheme of structural drawings indicating constructed details including levels, centre lines, layouts, member sizes etc. complete.

7. The provisions of Schedule of Rates, specifications and drawings shall be read in conjunction with each other and in case of conflict amongst them, clarification shall be obtained from the Engineer-in-Charge whose decision shall be final and binding. However, the following procedure may generally be followed:

- Description of items in schedule of rates shall be followed when provisions therein are different from those in specifications.

- Where the description of item does not call for some specific requirement but the same is given in specifications, the specifications shall be followed in addition to the requirement given in description of item.

- Where drawings call for requirements different from or additional to those given in item description and specifications, the decision of the Engineer-in-Charge shall be obtained as to what shall be followed.

STANDARD SPECIFICATION FOR CIVIL & STRUCTURAL WORKS - MATERIALS

C-SPC-102

0	26.02.22	ISSUED FOR USE AS STANDARD	MK	ADh	RKB	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATION

API	:	American Petroleum Institute
ASTM	:	American Society for Testing & Materials
BIS	:	Bureau of Indian Standards
BS	:	British Standard
C&D	:	Waste Construction and Demolition Waste
DIN	:	Deutsches Institut' flir Normung
EC	:	Emulsifiable Concentrate
IS	:	Indian Standards
PCC	:	Plain Cement Concrete
PVC	:	Poly Vinyl Chloride
RA	:	Recycled Aggregates
RCA	:	Recycled Concrete Aggregates
RCC	:	Reinforced Cement Concrete

CONTENTS

1.0 SCOPE

1.1 This specification establishes and defines the requirements of various materials to be used in Civil and Structural works.

1.2 Whenever any reference to BIS Codes is made, the same shall be taken as the latest revision (with all amendments issued thereto) as on the date of submission of the bid.

1.3 Apart from the BIS Codes mentioned in particular in the various clauses of this specification, all other relevant codes related to specific job under consideration regarding quality, tests, testing and/ or inspection procedures shall be applicable. Reference to some of the Codes in the various clauses of this specification does not limit or restrict the scope of applicability of other referred or relevant codes.

1.4 In case of any variation/contradiction between the prov1s1on of BIS Codes and this specification, the provision given in this specification shall be followed.

1.5 All materials shall be of standard quality and shall be procured from renowned sources/ manufacturers approved by the Engineer-in-Charge. It shall be the responsibility of the Contractor, to get all materials/ manufacturers approved by the Engineer-in-Charge prior to procurement and placement of order.

1.6 Whenever called for by the Engineer-in-Charge all tests of the materials as specified by the relevant BIS Codes shall be carried out by the Contractor in an approved laboratory and test reports duly authenticated by the laboratory, shall be submitted to the Engineer-in-Charge for his approval. If so desired by the Engineer-in-Charge, tests shall be conducted in the presence of the Engineer-in-Charge or his authorized nominee.

1.7 Quality and acceptability of materials not covered under this specification shall be governed by the relevant BIS Codes. In case BIS code is not available for the particular material, other codes e.g. BS or DIN or API/ ASTM shall be considered. The decision of Engineer-in-Charge, in this regard, shall be final and binding on the Contractor.

1.8 Whenever asked for, the Contractor shall submit representative samples of materials to the Engineer-in-Charge for his inspection and approval. Approval of any sample does not necessarily exempt the Contractor from submitting necessary test reports for the approved material, as per the specification/relevant BIS Codes.

1.9 The Contractor shall submit manufacturer's test reports on quality and suitability of any material procured from them and their recommendation on storage, application, workmanship etc. for the intended use. Submission of manufacturer's test reports does not restrict the Engineer-in-Charge from asking fresh test results from an approved laboratory of the actual material supplied from an approved manufacturer/ source at any stage of execution of work.

1.10 All costs relating to or arising out of carrying out the tests and submission oftest reports and or samples to the Engineer-in-Charge for his approval during the entire tenure of the work shall be borne by the contractor and included in the quoted rates.

1.11 Materials for approval shall be separately stored and marked, as directed by the Engineer-in-Charge and shall not be used in the works till these are approved.

1.12 All rejected materials shall be immediately removed from the site by the Contractor at his own cost.

2.0 REFERENCES

As mentioned in the respective clauses.

3.0 WATER

3.1 Water used in construction for all civil & structural works shall be clean and free from injurious amount of oil, acids, alkalies, organic matters or other harmful substances which may be deleterious to concrete, masonry or steel. The pH value of water sample shall be not less than 6. Potable water shall be considered satisfactory. Underground water can also be used with the prior approval of Engineer-in-Charge, if it meets all the requirements of IS:456.

3.2 Tests on water samples shall be carried out in accordance with IS:3025 and they shall fulfill all the guidelines and requirements given in IS:456.

3.3 The Engineer-in-Charge may require the Contractor to prove, that the concrete prepared with water, proposed to be used, shall have average 28 days compressive strength not lower than 90% of the strength of concrete prepared with distilled water.

3.4 The Engineer-in-Charge may require the Contractor to get the water tested from an approved laboratory before starting the construction work and in case the water contains any oil/ organic matter or an excess of acid, alkalies or any injurious amount of salts etc., beyond the permissible maximum limits given in IS:456, the Engineer-in-Charge may refuse to permit its use. In case the water is supplied by the owner, contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense. In case there is any change in source of water, water samples shall be tested again to meet the specified requirements.

3.5 Water shall be stored in tin barrels, steel tanks or water-tight reservoirs made with bricks / stone or reinforced concrete. Brick/ stone masonry reservoirs shall have RCC base slab and shall be plastered inside, with I part of cement and 4 parts of sand and finished with neat cement punning. These reservoirs shall be- of sufficient capacity to meet the water requirement, at any stage of construction.

3.6 Water for curing shall be of the same quality as used for concreting and masonry works. Sea water shall not be used for preparation of cement mortar, concrete as well as for curing of plain/reinforced concrete and masonry works. Sea water shall not be used for hydrotesting and checking the leakage of liquid retaining structures also.

4.0 AGGREGATE

4.1 General

4.1.1 Coarse and fine aggregates for Civil and Structural Works shall conform in all respects to IS:383 (Specification for coarse and fine aggregates for concrete). Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or a combination thereof or manufactured aggregates produced from other than natural sources. These shall be chemically inert, hard, strong, dense durable, clear and free from veins, adherent coatings, injurious amount of disintegrated pieces, alkalies, free lime, vegetable matter and other deleterious substances such as iron pyrites, coal, lignite, mica, shale, sea shells etc. Naturally occurring aggregates shall be obtained from an approved source known to produce the same satisfactorily.

Manufactured aggregates shall consists of Iron and Steel slag aggregates, Copper slag aggregates or aggregates made from Construction & Demolition (C&D) waste such as Recycled Aggregates (RA) and Recycled Concrete Aggregates (RCA). RA shall comprise of waste from concrete, brick, tiles, stone, etc. and RCA shall be derived from concrete after requisite processing. Extent of utilization of manufactured aggregates in RCC and PCC works shall be as per Table-I of IS:383.

4.1.2 Source and type of aggregates shall be got approved by the Engineer-in-Charge prior to procurement. Change in source and type of aggregates, at later stage, shall not be generally permitted; but under specific circumstances, Engineer-in-Charge can allow a change in source and type of aggregate. Contractor shall produce necessary test certificates from approved laboratories regarding the quality and suitability of the proposed aggregates and submit fresh mix design for approval of the Engineer-in-Charge. Any such change, if permitted by the Engineer-in-Charge, shall be without any time and cost implication to the owner.

4.1.3 Aggregates which may chemically react with alkalies of cement or might cause corrosion of the reinforcement, shall not be used. If so desired by the Engineer-in-Charge, the Contractor shall carry out alkali reactivity tests and submit the results to him for approval.

4.1.4 The maximum quantities of deleterious materials in the aggregates as determined in accordance with IS:2386 - Part II (Methods of Test for aggregates for concrete), shall not exceed the limits defined in IS: 383. No special test is required to prove the absence of such deleterious matters if the aggregates are from a known source with satisfactory prior data on the properties of concrete made with them. In case of newly developed quarry sites, the contractor shall submit necessary test results as per IS:383 and IS:2386 to the Engineer-in- Charge prior to his acceptance and approval. The method of Sampling shall be in accordance with the requirements given in IS:2430.

4.1.5 Coarse and fine aggregates shall be batched separately. All-in-aggregate shall be used only where specifically permitted by the Engineer-in-Charge.

Separate sieve analysis and grading curves shall be prepared by the Contractor for any/ all batches of coarse and fine aggregates, and submitted to the Engineer-in- Charge, whenever asked for, to ensure conformity with those submitted along with the mix design.

4.1.6 Whenever required by Engineer-in-Charge, the aggregates (coarse/ fine) shall be washed and/ or sieved by the contractor before use in the works to obtain clean and graded aggregate at no extra cost to the owner.

4.1.7 Aggregates not in conformity with the specifications shall be rejected and the Contractor shall immediately remove. them from the site of work.

4.2 Coarse Aggregates

4.2.1 Coarse aggregates are the aggregates, which are retained on 4.75 mm BIS Sieve. It shall have a specific gravity not less than 2.6 (saturated surface dry basis).

4.2.2 These may be obtained from crushed or uncrushed gravel or stone or may be manufactured from other than natural sources like RCA or RA from C&D waste and may be supplied as single sized or graded. The grading of the aggregates shall be as per IS:383 or as required by the mix design, to obtain densest possible concrete. For this purpose, the contractor shall submit to the Engineer-in-Charge at least three sets of mix design and test results, each with different gradings of coarse aggregates, proposed to be used. The Engineer-in-Charge may allow "All-in-aggregates" to be used provided they satisfy the requirements oflS:383.

4.3 Fine Aggregates

4.3.1 Fine aggregates are the aggregates which pass through 4.75 mm BIS sieve but not more than ten percent (10%) pass through 150 micron BIS sieve. These shall comply with the requirements of grading zones I, II and Ill of IS:383. Fine aggregates conforming to grade zone IV shall not be used for reinforced concrete works.

4.3.2 Fine aggregates shall consist of material resulting from natural disintegration of rock and which has been deposited by streams or glacial agencies, or crushed stone sand or gravel sand or manufactured from other than natural sources like RCA from C&D waste. Sand from sea shores, creeks or river banks affected by tides, shall not be used for filling or concrete works.

4.4 Sampling and Testing

The Contractor shall carry out all tests including mix designs of concrete, at his own expense, at the start of work as well as during any stage of construction as required by the Engineer-in-Charge. Test shall be carried out in accordance with IS:516 - Methods of test for strength of concrete and IS:2386 - Methods oftest for aggregates for concrete. Testing shall be carried out from laboratories approved by the Engineer- in-Charge. The method of sampling shall be in accordance with the requirements given in IS: 2430.

4.5 Storage of Aggregates

4.5.1 Storage of all types of aggregates at site of work shall be at contractor's expense and risk and shall be stored as specified in IS:4082. Aggregates shall in no case be stored near to the excavated earth or directly over ground surface.

4.5.2 The Contractor shall maintain sufficient quantities of aggregates, near to the place of work, required for the continuity of the work. Each type and grade of aggregate shall be stored separately on hard, firm surface having adequate slope for drainage of water.

4.5.3 Aggregates delivered at site in wet condition or becoming wet due to rain or any other means, shall not be used for atleast 24 hours. The Contractor shall obtain prior approval of the Engineer-in-charge for the use of such aggregates and shall adjust the water content in accordance with IS:2386 to achieve the desired mix. In the absence oftest results, and to allow variation in mass of aggregates and water content on account of moisture content, the Contractor can make suitable adjustment in the masses as per IS:456, for preparation of nominal mix concrete only.

5.0 SAND

5.1 Sand for Masonry Mortars

5.1. 1 The sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified in IS:2116.

5.1.2 The sand shall not contain any harmful impurities such as iron pyrites, alkalis, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shells in such form or in such quantities as to affect adversely the hardening, strength or durability of the mortar.

5.1.3 Unless found satisfactory as a result of further tests as may be specified by the Engineer-in-Charge, or unless evidence of such performance is offered which is satisfactory to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the sand, when tested in accordance with IS:2386, shall not be more than 5% by mass in natural sand, or crushed gravel sand or crushed stone sand. For organic impurities, when determined in accordance with IS:2386, colour of the liquid shall be lighter than that indicated by the standard solution specified in IS:2386.

5.1.4 Grading of Sand

The particle size grading of sand for use in mortars shall be within the limits as specified below:

GRADING OF SAND FOR USE IN MASONRY MORTARS

IS SIEVE DESIGNATION IS: 460 (PART I)	PERCENTAGE PASSING BY MASS	REF. TO METHOD OF
4.75mm	100	IS:2386 (Part I)
2.36mm	90 to 100	
1.18 mm	70 to 100	
600 micron	40 to 100	
300 micron	5 to 70	
150 micron	0 to 15	

In case of a sand whose grading falls outside the specified limits due to excess or deficiency of coarse or fine particles, this shall be processed to comply with the standard by screening through a suitably sized sieve and/or blending with required quantities of suitable sizes of natural sand particles or crushed stone screenings which are by themselves unsuitable. Based on test results and in the light of practical experience with the use of local materials, deviation in grading of sand may be considered by the Engineer-in-Charge. The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

5.1.5 Sampling and Testing

The method of sampling shall be in accordance with IS:2430. The amount of material required for each test shall be as specified in relevant parts of IS:2386. Any test which the engineer-in-charge may require in connection with this, shall be carried out in accordance with the relevant parts ofIS:2386.

If further confirmation as to the satisfactory nature of the material is required, compressive test on cement mortar cubes (l :6) may be made in accordance with IS:2250 using the supplied material in place of standard sand and the strength value so obtained shall be compared with that of another mortar made with a sand of acceptable and comparable quality.

5.2 Sand for Filling

Sand for filling shall meet the requirements of IS:383 and shall be natural sand, hard, strong, free from any organic and deleterious materials. Any sand proposed for filling, shall be used only after it is approved by the Engineer-in-Charge. Sand obtained from sea shores, creeks or river banks affected by tides, shall not be used for filling. Fine aggregates suitable for concreting works shall be suitable for filling also. No sand below grading zone-III as per IS:383 shall be allowed for filling.

6.0 CEMENT

Cement to be used for civil and structural works shall be one of the following. Specific requirement for the type of cement to be used shall be as shown in the drawings or as specified in the contract or as directed by the Engineer-in-Charge.

- Specification for 33 grade ordinary portland cement : IS:269
- Specification for 43 grade ordinary portland cement : IS:8112
- Specification for 53 grade ordinary portland cement: IS:12269
- Specification for portland slag cement : IS:455
- Specification for Portland pozzolana cement (fly ash based) : IS:1489 Pt.I
- Specification for Portland pozzolana cement (calcined clay based) : IS:1489 Pt.2
- Specification for Masonry Cement : IS:3466
- Specification for high alumina cement for structural use : IS:6452
- Specification for rapid hardening portland cement : IS:8041
- Specification for 43 grade ordinary portland cement : IS:8112
- Specification for 53 grade ordinary portland cement : IS:12269
- Specification for Sulphate Resisting Portland cement : IS:12330

6.1 Storage at Site

6.1.1 The storage of cement (lifted from the Owner's godown or procured by the Contractor himself) at the site of work shall be at contractor's expense and risk and shall meet the requirements of IS:4082. The cement shall be stored above ground in a suitable weather tight building or godown and in such a manner as to permit easy access for proper inspection and also to prevent deterioration due to moisture. In the event of any damage occurring to the quality of cement due to faulty storage or on account of negligence on the part of the contractor, such damages shall be borne by the contractor himself.

6.1.2 All approved cement shall be arranged in batches with type, brand and date of receipt flagged on them. A maximum of eight bags shall be stacked one over the other. Cement bags shall be used in the same order as received from the manufacturer/ owner. The contractor shall maintain a register, on day to day basis, giving the details of the receipt/ consumption, source of supply and type of cement etc. The register shall always be accessible to the Engineer-in-Charge for verification.

6.2 Tests after Delivery

Each consignment of cement supplied by Owner or contractor, shall, after delivery at site and at the discretion of the Engineer-in-Charge, be subjected to any or all of the tests and analyses, required by the relevant Indian Standard Codes. In case the cement is supplied by the owner, the contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense. The contractor shall carry out and bear the cost of all tests and analyses required to ensure quality of cement before using in actual works, irrespective of the fact whether the cement is supplied by the Owner or procured by him.

6.3 Rejection

The Engineer-in-Charge may reject at his discretion any cement, notwithstanding the manufacturer's certificate or failing to meet the requirements of relevant BIS Codes for testing of cement. He may similarly reject any cement which has deteriorated owing to inadequate protection from moisture or due to intrusion of foreign matter or any other cause. Any cement which is considered defective, shall not be used and shall be promptly removed from the site by the contractor.

7.0 STEEL

7.1 General

All steel bars, sections, plates, and other miscellaneous steel materials, etc shall be free from loose mill scales, rust as well as oil, mud, paint or other coatings. The materials, construction specifications such as dimensions, shape, weight, tolerances, testing etc, for all materials covered under this section, shall conform to respective BIS Codes. Steel sections shall be conforming to IS:808 or IS:12778.

7.2 Reinforcement Bars

Reinforcement bars, to be used for civil and structural works shall be one of the following or in combination thereof.

- Mild Steel and Medium Tensile Steel Bars and Hard-Drawn Steel Wire for Concrete Reinforcement **IS: 432**
- Specification for hard drawn steel wire fabric for concrete reinforcement **IS:1566**
- Specification for plain hard-drawn steel wire for prestressed concrete. **IS:1785**
- Specification for High strength deformed steel bars and wires for concrete reinforcement. **IS:1786**
- Specification for indented wire for prestressed concrete. **IS:6003**
- Specification for fusion bonded epoxy coated reinforcing bars **IS:13620**

7.3 Structural Steel

Structural steel to be used for general structural purposes shall be one of the following or in combination thereof.

Structural steel sections shall conform to following BIS Codes:

- Steel tubes for structural purposes. **IS:1161**
- Mild Steel Tubes, tubulars and other wrought steel fittings. IS:1239
- Steel for general structural purposes (Grade A/BR/BO). IS:2062
- Hollow steel sections for structural use. IS:4923

7.4 Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the following BIS Codes.

- Expanded Metal Steel Sheets for General purposes. **IS :412**
- Mild steel bars of anchor bolts, rungs, metal inserts, grating etc.) **IS :2062**
- Hexagonal headbolts, screws & nuts of product grade C. **IS:1363**
- Cold formed light gauge structural steel sections. **IS:811**
- Technical supply conditions for threaded steel fasteners. **IS:1367**
- Plain washers IS:2016
- Steel wire ropes for general engineering purposes **IS:2266**
- Thimbles for wire ropes. **IS:2315**
- Bulldog grips. **IS:2361**
- Mild Steel Tubes, tubulars and other wrought steel fillings. (For Hand rail tubular sections). **IS:1239**
- Drop forged sockets for wire ropes for general engineering purposes**. IS:2485**
- Steel chequered plates. **IS:3502**
- Hexagonal bolts and nuts (M42 to M150). **IS:3138**
- High Strength Structural Bolts **IS:3757**
- High Strength Bolts **IS:4000**

7.4.1 Anchor Bolts

Material for Anchor Bolts such as MS bars, washers, nuts, pipe sleeves and plates etc. shall be as per relevant BIS Codes mentioned above.

7.5 Storage

The storage of all materials at site of work shall be at the contractor's expense and risk and shall be done as per the requirements given in IS:4082. The contractor shall maintain the proper records of receipt/consumption. The records shall always be accessible to the Engineer-in-Charge for verification.

The reinforcement bars, structural steel sections and other miscellaneous steel materials etc, shall be stored in such a way as to avoid and prevent deterioration, corrosion, bending, twisting and wrapping. In case of any damage occurring to the material on account of faulty storage or negligence by the contractor, same shall be borne by the contractor himself.

7.6 Tests after Delivery

Materials supplied by the Owner or Contractor, shall, after delivery at site and at the discretion of Engineer-in-Charge, be subjected to any or all of the tests, required by the relevant BIS Codes. The Contractor shall carry out and bear the cost of such tests irrespective of the fact whether the material is procured by the Owner or the contractor. In case steel is supplied by the Owner, the Contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense.

7.7 Rejection

The Engineer-in-charge may reject at his discretion any material, not withstanding the manufacturer's certificate or failing to meet the requirements of relevant BIS Codes for testing of materials. He may similarly reject any material, which has deteriorated or corroded etc., due to improper storage, handling or transport. Defective materials shall not be used and removed from the site by the contractor at his own expense.

8.0 BRICK

8.1 General

All Bricks used for masonry works shall conform to the requirements of following BIS Codes:

- Common Burnt Clay Bricks- Specifications IS:1077
- Pulverized Fuel Lime Ash Bricks- Specifications IS:12894
- Burnt Clay Fly Ash Bricks- Specifications IS:13757

8.1.1 Common Burnt Clay Bricks

Bricks for masonry works shall conform to IS:I 077 - Specification for common burnt clay building bricks and shall be of class 5.0 (with minimum compressive strength of 5.0 N/mm2). Specific requirement for any other class of bricks shall be as shown in drawings or as described in the contract for a particular site or type of work. Physical requirements, quality, dimensions, tolerances etc. of common burnt clay building bricks shall conform to the requirements oflS:1077.

Bricks shall be hand - moulded or machine moulded and shall be made from suitable soils. The bricks shall have smooth rectangular faces with sharp comers and shall be well burnt, sound, hard, tough and uniform in colour. These shall be free from cracks, chips, flaws, stone or humps of any kind.

8.1.2 Fly Ash Lime Bricks (FALG Bricks)

The Fly Ash Lime Bricks (FALG Bricks) shall conform to IS 12894. Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage, flaws and organic matter. Fly ash shall conform to IS 3812.

8.1.3 Burnt Clay Fly Ash Bricks

The burnt clay fly ash bricks shall conform to IS 13757. The bricks shall be sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with sharp and square corners. The bricks shall be free from visible cracks, flaws, warpage, nodules of free lime and organic matter, the bricks shall be hand or machine moulded. The bricks shall have frog of 100 mm in length 40 mm width and 10 to 20 mm deep on one of its flat sides. If made by extrusion process may not be provided with frogs. Fly Ash shall conform to grade I or grade II ofIS 3812.

8.1.4 Mechanized Autoclave Fly Ash Lime Brick

These bricks shall be machine moulded and prepared in plant by appropriate proportion of fly ash and lime. The autoclave fly ash bricks shall conform to IS 12894. Visually, the bricks shall be sound, compact and uniform shape, free from visible cracks, warpage and organic matters. The brick shall be solid with or without frog, and of l00/80 mm in length, 40 mm width and 10 to 20 mm deep one of its flat side as per IS 12894. The brick shall have smooth rectangular faces with sharp corners and shall be uniform in shape and colour. Fly ash shall conform to IS 3812 and lime shall conform to class 'C' hydrated lime ofIS 712.

8.2 Tests after Delivery

The Contractor shall take samples of each type of brick as directed by the Engineer-in-Charge as per the requirements of IS:5454 and tests shall be carried out as per IS:3495. The cost for carrying out any or all the tests, shall be borne by the Contractor. The bricks, when tested, as per IS:3495 shall have a minimum average compressive strength, as given in the Code, for a particular class of brick. Water absorption shall not be more than 20% by its dry weight, when soaked in cold water for 24 hours.

Brick samples so approved, shall be deposited with the Engineer-in-Charge. All subsequent deliveries shall be upto the standards of the approved samples.

8.3 Stacking of Bricks

Bricks shall be stored at site as per the requirements given in IS:4082 and shall not be dumped at site. They shall be unloaded from trucks to a place on a levelled surface near to the work site. They shall be stacked in regular tiers even as they are unloaded, to minimise breakages and defacement of bricks. The supply of bricks shall be so arranged that as far as possible, at least two days' requirements of bricks are available at site at any time. Bricks, of different class & types, shall be stacked separately.

8.4 Local Bricks/ Class 3.5 Bricks.

Where shown on drawings, locally available bricks of non modular size (230 mm x 110 mm x 70 mm) in place of bricks of modular size (190 mm x 90 mm x 90 mm) can be used in case the bricks satisfy the other requirements of respective BIS codes. Minimum compressive strength of these bricks shall not be less than 3.5 N/mm^2•

8.5 Concrete Block Masonry

Concrete Block Masonry shall be as per PLECO Specification No. C-SPC-110.

9.0 STONE

9.1 General

All Stones used for masonry works shall conform to the requirements of following BIS Codes.

- Method of identification of natural building stones. **IS:1123**
- Recommendations for dimensions and workmanship of natural building stones for masonry work. **IS:1127**
- Recommendations for dressing of natural building stones **IS:1129**

9.2 Quality of Stones

Stones shall be of approved quality, hard, dense, strong, sound, durable, clean and uniform in colour. They shall also be free from veins, adherent coatings, injurious amount of alkalies, vegetable matters and other deleterious substances such as iron pyrites, coal, lignite, mica, sea shells etc. Unless otherwise approved, stones from one single quarry shall be used for any one work. The strength of stones should be adequate to carry the imposed load and shall meet all the requirements of IS:1905, taking into account the appropriate crushing strength of stone and type of the mortar used. The percentage of water absorption, when tested in accordance with IS:1124, shall not exceed 5 percent.

Stones normally used, shall be small enough to be lifted and placed by hand. The length of the stone shall not exceed 3 times the height. Width of stone on base shall not be less than 150 mm and in no case exceed 314th thickness of the wall. Height of the stone shall not be more than 300 mm.

9.3 Unloading/Stacking

The stones shall be unloaded from the trucks to a site near to the place of work as defined in IS:4082 and shall be stacked on a firm ground having adequate stope for drainage. The supply of stones shall be so arranged that as far as possible, at least two days' requirements of stone are available at site at any time.

10.0 ADMIXTURES

10.1 General Requirements for Admixtures

10.1.1 All concrete admixtures shall in general comply with the following BIS Codes unless otherwise stipulated in this specification.

- Specification for integral cement water proofing compounds. IS:2645
- Specification for other admixtures for concrete. IS:9103

10.1.2 Generally, admixtures shall have ISi certification marks. However, even in case of BIS certified admixtures, Engineer-in-Charge may require the Contractor to carry out and submit any or all the tests (as specified in relevant BIS Codes), from BIS approved laboratories, over and above the manufacturer's test certificate, before giving his final approval.

In case, admixtures certified by BIS are not available, the contractor shall submit to the Engineer-in-Charge the type and/or proprietary brand of the admixture from only reputed manufacturers along with necessary test certificates from BIS recognized/ BIS approved laboratories or any other document directed by Engineer-in-Charge for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Engineer-in-Charge for his selection. In case, both the names are rejected, the contractor shall submit a fresh list of two manufacturers for approval by the Engineer-in-Charge.

The Engineer-in-Charge may direct the contractor to submit test results as required by IS:2645 or IS:9 I03 for any admixture proposed to be used in the concrete in any approved laboratory at his discretion at any stage of the work. The cost of any/all tests required to satisfy compliance with this specification shall be borne by the Contractor.

In case of non-availability of any BIS code for testing and acceptability criteria, relevant American, British or German Code shall be applicable.

10.1.3 Prior approval of the Engineer-in-Charge shall be obtained while using water reducing admixtures in the concrete (PCC/ RCC) or mortar. Other type of admixtures such as accelerating admixtures, retarding admixtures or air entraining admixtures, shall not be used unless specified on the design drawings or prior approval taken from the design approving authority. Once approved, utmost care shall be exercised at site by the Contractor to maintain the consistency in the quality of admixture and the concrete/ mortar so produced.

10.1.4 The suitability and effectiveness of any admixture shall be verified by trial with the designed concrete mixes using cement, aggregates together with any other materials to be actually used in the works as per the direction of Engineer-in-Charge. If two or more admixtures are to be used simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved laboratory to show their interaction and compatibility. Any/all tests specified in BIS Codes shall be carried out only with the type of material and mix design, to be actually used in the work site.

10.1.5 No admixture shall impair the durability of the concrete nor combine with the ingredients to form harmful compounds nor increase the risk of corrosion of reinforcement. Use of admixtures shall not reduce the dry density of concrete. Once the proportion of admixture has been established, strict check shall be maintained not to alter the proportions of ingredients and water-cement ratio of the Design Mix during execution.

10.1.6 The chloride contents in admixtures shall not exceed 2% by mass of the admixture or 0.03% by mass of the cement.

I0.1.7 Admixtures which do not meet the requirements stipulated in this specification shall be rejected and shall not be used.

10.2 Water Proofing Compounds

10.2.1 Water proofing compounds shall be mixed with cement only.

10.2.2 The permeability of the specimen with the admixture shall be less than half of the permeability with similar specimen without the use of these compounds. These compounds shall be used in such proportion as recommended by manufacturer but in no case it shall exceed 3% by weight of cement.

10.2.3 The initial setting time of the cement with the use of these compounds shall not be less than 30 minutes and final setting time shall not be more than IO hours. Test shall be carried out in accordance with IS:4031.

10.2.4 Compressive strength of specimen at 3 days shall not be less than 160 kg/sq.cm nor 80% of the 3 days compressive strength of mortar cubes prepared with same cement and sand only, whichever is higher. Similarly compressive strength at 7 days shall not be less than 220 kg/sq.cm nor less than 80% of the 7 days compressive strength prepared with the same cement and sand only, whichever is higher. The test to determine the compressive strength shall conform to IS:4031.

11.0 WATER BARS (WATER STOPS)

11.1 PVC water bars shall be used in reinforced concrete construction of liquid retaining structures or any other structure to safeguard them from hydrostatic pressure and water leakage and any relative movement between two parts of the structure due to thermal loading shrinkage or differential movement of foundations. Wherever desired or shown in the drawings, they shall be used at expansion/contraction/construction joints. These shall be pre-formed and shall provide a permanent water tight seal along the entire joint in the poured concrete structures. These shall also be flexible enough to withstand deflection/displacements at joints arising due to variation of temperatures or settlement of foundations. The minimum thickness of water bar shall be as shown on drawings or described in the schedule of rates and unless otherwise mentioned, these shall be able to withstand a water head of at least 12 meters.

11.2 Performance requirements of PVC water bars shall meet the requirements ofIS:12200. These shall be of approved make and of ribbed/ serrated/ plane type with a bulb at the centre. The thickness and width of water bars shall be as per schedule of rates/ drawings but in no case the thickness shall be less than 5 mm and width less than 150 mm. The joining of the water bars shall be carried out by vulcanising strictly as per the manufacturer's specifications. Lapped joints shall not be allowed under any circumstances.

12.0 BITUMEN/BITUMINOUS MATERIALS

Bitumen to be used for various types of work shall meet all the requirements of relevant BIS Codes as given below:

- Specification of Paving Bitumen. **IS:73**
- Specification for bitumen mastic for flooring. **IS:1195**
- Specification for Bitumen felts for water proofing and damp proofing. **IS:1322**
- Specification for Bituminous compounds for water proofing and caulking purposes. **IS:1834**
- Specification for preformed fillers for expansion joint in concrete pavements and structures. **IS:1838**
- Specification for bitumen mastic for use in water proofing of roofs. **IS:3037**
- Specification for bitumen primer for use in water proofing and damp proofing**. IS:3384**
- Specification for Bitumen Mastic for Tanking and Damp proofing. **IS:5871**
- Specification for Glass fibre base coal tar pitch & bitumen felts. **IS:7193**
- Code of practise for damp proofing using bitumen mastic. **IS:7198**

- Specification for bitumen Mastic, Anti Static and electrically conducting grade. **IS:8374**

The type and grade shall be as shown on the drawings or as indicated in schedule of quantities or as directed by Engineer-in-Charge. Tests and acceptable criteria shall be as per relevant BIS Codes.

13.0 PVC PIPES

PVC Pipes shall conform to the requirements ofIS:4985.

14.0 WOOD/ TIMBER

14.1 Wood recommended for platforms of cold vessels or below cold vessels/ exchangers shall be hard and shall be of group A, grade I, and shall have safe permissible stress of 7 N/mm2 in compression, perpendicular to grains on outside location as per IS:883. General characteristics like durability, treatability etc. shall conform to IS:883 and IS:3629.

14.2 Timber required to be used for formwork shall be fairly dry before use. It should maintain its shape during the use and even when it comes into contact with moisture from the concrete. Storage of Wood/Timber shall be as per the requirements ofIS:4082.

For proper identification and selection of suitable timber for formwork, following codes shall be referred.

- Classification of commercial timbers and their zonal distribution **IS:399**
- Specification for ballies for general purposes **IS:3337**
- Specification for Ply wood for concrete shuttering work. **IS:4990**

15.0 PAINT

15.1 Refer PLECO Specification No. C-SPC-157 or the job specification whichever applicable.

16.0 ANTITERMITE COMPOUNDS

16.1 Chloropyrifos emulsifiable concentrates (1%) conforming to IS:8944 shall be used for treatment of soil for protection of buildings against attack by subterranean termites.

Generally I part of Chloropyrifos (EC 20) shall be mixed with 19 parts of water to prepare I% solution (chemical emulsion) or as specified by the Manufacturer.

17.0 POLYSULPHIDE SEALANTS

Polysulphide Sealants shall conform to IS:12118 and be of approved make. Test conditions and requirements shall be as given in the above referred BIS code.

STANDARD SPECIFICATION

CIVIL & STRUCTURAL WORKS

EARTHWORK

C-SPC-103

0	26.02.22	ISSUED FOR USE AS STANDARD	MK	ADh	RKB	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

CNS : Cohesive Non Swelling

CONTENTS

1.0 SCOPE

This specification deals with earth work in excavation and filling.

2.0 CLASSIFICATION OF SOIL

2.1 Ordinary Soil

2.1.1 Soft Soil/ Loose Soil

Generally any soil which yields to the ordinary application of pick and shovel, or to phawra, rake or other ordinary digging implements such as:

a) Sand, gravel, loam, clay, mud, black cotton soil

b) Vegetables or organic soil, turf, peats, soft shale or loose murrum

c) Mud concrete below ground level

d) Any mixture of soil mentioned above.

2.1.2 Hard/ Dense Soil

Generally any soil, which requires close application of picks or jumpers or scarifier and rippers to loosen the same, such as:

i) Stiff heavy clay, hard shale or compact murrum requiring grafting tool and/ or pick and shovel

ii) Shingle and river or nallah bed boulders

iii) Soling of roads, paths etc. and hard core

iv) Macadam surface of any description (water bound, grouted tarmac etc.)

v) Lime concrete, stone masonry in lime or cement mortar below ground level

vi) Soft conglomerate when the stone can be detached from the matrix with picks and shovels

2.2 Soft Rock

This is fissured/ disintegrated rocky strata, boulders (volume more than 0.028 m3 and less than

0.400 m3) and also which cannot be quarried/ excavated by using above manual tools but can be quarried/ excavated manually by using crow bars is classified as soft rock. Soft rock shall include all kinds of stiff and stratified rock, such as shales, thinly bedded philites, laterite hard conglomerate, lime stone, sand stone and unreinforced cement concrete below ground level. Soft rock may be quarried or split with crow bar or picks and can also be excavated by rippers, dozers and other mechanical equipment, but without the aid of blasting. If required and permitted, light blasting may be restored to, for loosening the materials, but this will not, in any way entitle the material to be classified as "Hard Rock".

2.3 Hard Rock

2.3.1 Hard Rock (Not Requiring Blasting)

This shall include all types of hard and compact rock, having closely spaced fissures or joints, on account of which blasting is not considered necessary and shall not be resorted unless permitted by the Engineer-in charge.

2.3.2 Hard Rock (Requiring General Blasting)

This shall include all types of hard and compact rock occurring in unfissured masses or similar foundations, boulders (volume more than 0.4 m3) for excavation in which blasting is considered necessary such as quartzite, granite, basalt stones, reinforced cement concrete (reinforcement to be cut through but not separated from concrete) below ground level and the like.

2.3.3 Hard Rock (Requiring Controlled Blasting (Explosive/ Non-explosive)

This type of excavation becomes necessary when excavation is done in formations, mentioned in Clause 2.3.2, in the vicinity of existing foundations/ structures. Mode of blasting shall be decided by Engineer-in-Charge, keeping in view the sensitivity of structures.

2.3.4 Hard Rock (Blasting Prohibited)

Hard rock requiring blasting as described in clause 2.3.2 above, but where blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging, pneumatic/ hydraulic/ electro-mechanical breaking by using splitter or by chemical means or any other agreed method.

The use of excavation shall not be considered as a reason for classification under hard rock requiring blasting unless clearly found necessary in the opinion of Engineer-in-Charge.

3.0 BACKFILLING MATERIAL

3.1 Suitable Materials:

3.1.1 Back filling suitable material shall be approved by the Engineer-in-charge. Additionally, they shall be free from refuse, large stones or rocks or other material which might prevent proper compaction or cause the compacted fill or embankment to perform inadequately or to have insufficient stability or bearing capacity for the superimposed loads to which it is likely to be subjected.

3.1.2 Back filling of excavation in trenches, foundations and elsewhere shall consist of one of the following materials as shown on drawing, or directed by the Engineer-in-charge.

i) Soil

ii) Selected earth from heaps or brought from borrow areas.

In case i) or ii) are not available, the Engineer-in-charge may approve use of any of the following:

iii) Stone/ Gravel

iv) Sand

v) CNS material.

3.1.3 The material shall be free from refuse, debris, roots, hard lumps and any other foreign organic material.

3.2 Unsuitable Materials

Unsuitable material shall include particles in excess of75 mm size and that which is:

a) Organic material, logs, stumps and perishable materials.

b) Material susceptible to spontaneous combustion

c) Materials with undefined properties

d) Materials having a moisture content greater than the maximum specified

e) Building rubble and domestic and industrial wastes

f) Soils and rock susceptible to deterioration/ change of their properties.

g) Clay, silt and other loose or soft soils not in accordance with compaction criteria.

h) Dredged material

i) Material containing gypsum or other soluble salts.

4.0 SETTING OUT

4.1 The Contractor shall be responsible for the true and proper setting out of the work in relation to original points, lines* and levels* of reference and for the correctness of the levels, dimensions and alignment of all parts of the work. If at any time during progress of the work any error appears or arises in the position of level, dimension, or alignment of part of the work, the Contractor at his own expense shall rectify such errors to the satisfaction of the Engineer-in-Charge. The checking of any line or level by the Engineer-in-Charge shall not in any way relieve the Contractor of his responsibilities.

4.1.1 Tolerances*

The grade shall be properly shaped to the required elevations and parallel to the required surface. The elevation of any point and the line of any edge or center of the earthworks shall conform to that shown on the drawings within the tolerances stated below:

	Tolerances from True Level	Tolerances from True Line
Basic Grading	-25mm	-75mm
Embankments	+75mm	+75mm

4.2 The Contractor shall lay out and construct one or more permanent bench marks in some central place before the start of the work, from which all important levels for the excavations will be set.

These permanent bench marks shall consist of masonry pillars with top neatly plastered and leveled as per the directions of the Engineer-in-Charge. Bench marks shall be well connected with triangular grid system or any other bench mark approved by the Engineer-in-Charge.

5.0 EARTHWORK IN EXCAVATION

5.1 Excavation shall be carried out in any material met on the site to the lines, levels and contours shown on the detailed drawings and the Contractor shall remove all excavated materials to spoil heaps on site or transport for use in filling on the site or stack them for reuse as directed.

5.2 Excavated material shall not be deposited within 1.5 m from the top edge of the excavation.

5.3 The sides of the excavation may be cut sloping, or shored and strutted to hold the face of earth as per site requirements and as directed by the Engineer-in- Charge.

5.4 Foundation pits/ trenches shall not be excavated to the full depth unless construction is imminent. The last 15 cm depth of the excavation shall not be done until concreting work is imminent. The full depth may at the discretion of the Engineer-in-Charge be excavated and the bed covered with a 50 mm (minimum) thick (or as indicated on drawing) layer of lean concrete l :5: l0 mix (1 cement : 5 coarse sand : l 0 crushed stone aggregate) or as specified in schedule of rates/ shown on drawing, after watering if required, and consolidating the bed.

5.5 If the bottom of any excavation has been left exposed by the Contractor and in the opinion of the Engineer-in-Charge, that has become badly affected by the atmosphere or by water, then the Contractor shall remove such portions of the deteriorated material as the Engineer-in-Charge may direct and shall make good with lean concrete l :5:l0 mix (l cement : 5 coarse sand : l 0 crushed stone aggregate). All expenses for such additional concrete and excavation shall be borne by the Contractor.

5.6 Where excavation is made in excess of the depth required, the Contractor shall, at his own expense, fill upto required level with lean concrete l :5:l0 mix (l cement : 5 coarse Sand : l 0 crushed stone aggregates) or as decided by Engineer-in-Charge.

5.7 The Contractor shall provide suitable drainage arrangement to prevent surface water from any source entering the foundation pits at his own cost.

5.8 The Contractor shall make all arrangements for dewatering during excavation and subsequent works, the accumulated water from any source (including subsoil water) in the excavated pits/trenches and keeping the excavated pits/ trenches dry for subsequent works.

5.9 The Contractor shall make necessary arrangements for lighting, fencing and other suitable measures for protection against risk of accidents due to open excavation.

5.10 Where the excavation is to be carried out below the foundation level of an adjacent structure, the precaution to be taken such as under pinning, shoring and strutting etc. shall be determined by the Engineer- in-Charge. No excavation shall be done unless such precautionary measures are carried out as per directions of the Engineer-in-Charge. The payment for such precautionary measures shall, however, be made separately.

5.11 Loose or soft bed ground encountered in excavation at the required depth shall on the Engineers-in-Charge's instructions be excavated to a firm bed and difference made up to the required level with lean concrete 1:5:10 mix (l cement: 5 coarse Sand: 10 crushed stone aggregates).

5.12 In those cases where during excavation, side slips occur for reasons not attributable to the Contractor (e.g. side slips which take place on their own but not due to surcharge of earth kept near the edge of excavation and cracking of excavation top strata due to clay drying out leading to collapse of excavation sides), the Engineer-in-Charge shall admit payment at his discretion.

5.13 Any obstacle encountered during excavation shall be reported immediately to the Engineer-in-Charge and shall be dealt with as instructed by him. Removal of buried pipes or cables shall not be done without prior permission of the Engineer-in-Charge and the Contractor shall provide all measures to protect the same. Cost of such protective measures are deemed to be included in the rates for various items of excavation.

5.14 The Contractor shall not undertake any concreting in foundation until the excavation pit/trench is approved by the Engineer-in-Charge.

5.15 The specification for earth work shall also apply to excavation in rock in general.

5.16 In case of hard rock requiring blasting, the provisions mentioned below shall be strictly followed.

5.16. 1 General

Where hard rock is met with and blasting operations are considered necessary, the Contractor shall intimate about the same to the Engineer-in-Charge, and obtain his approval in writing for resorting to blasting operation.

The Contractor shall obtain license from the district authorities for undertaking blasting work as well as for obtaining and storing the explosive as per the Explosive Rules 2008, corrected upto date. He shall purchase the explosives, fuses, detonators etc. only from a licensed dealer. He shall be responsible for the safe custody and proper accounting of the explosive materials. The Engineer-in-Charge or his authorised representative shall have the access to check the Contractor's store of explosive and his accounts.

In case where explosives are required to be transported and stored at site, relevant clauses of the Explosive Rules, 2008 as amended subsequently, shall apply.

The Contractor shall be responsible for any accident to workmen, public or property, due to blasting operations.

5.16.2 Precautions

Blasting operations shall be carried out under the careful superv1s1on of a responsible authorised and licensed blaster of the Contractor (referred subsequently as "blaster" only) during specified hours, as approved in writing by the Engineer-in-Charge. The blaster shall be fully conversant with the rules of blasting.

Proper precautions for safety of persons shall be taken. Red flags shall be prominently displayed around the area to be blasted and all the people on the work except those who actually light the fuses, shall withdraw to a safe distance of not less than 200 m from the blast. Precautions as per Explosive Rules 2008 with amendment shall be followed.

5.16.3 Fuses

All fuses shall be cut to the lengths required before being inserted into the holes. Joints in fuses shall be avoided. Where these are unavoidable, a semicircular niche shall be cut in one piece of fuse about 2 cm. deep from the end and the end of other piece inserted into this niche, and the two pieces then wrapped together with a string. All joints exposed to dampness shall be wrapped with rubber tape. Fuse and detonators shall be kept separated from the explosives.

5.16.4 Blasting with Gun Powder

Blasting shall normally be done with gun powder. Dynamite, gelatine or any other high explosive shall only be used in special cases with the written permission of the Engineer- in-Charge.

In case of blasting with gun powder, the position of all bore holes to be drilled shall be marked out in circles with white paint. The bore holes shall be jumped or drilled in the rock face. The depth of bore hole shall be about the same as that of the line of least resistance and its size shall be such that the cartridges can easily pass down to the bottom. The bore holes must be dried before being charged and these shall be inspected by the Contractor's agent.

Gun powder may be used in the form of pellet blasting cartridges or as powder or granules. Cartridges are provided with tapered central hole. One end of fuse is passed through the narrow end of the hole and a sufficient length of the fuse is doubled back so that when the fuse is pulled, it is held tight in the tapered hole of the cartridge. Other cartridges are then inserted in the fuse to make up the required charge. The cartridge along with the fuse is lowered down in the bore hole, placed in position and gently filled and pressed home with dry hay or turf. The rest of the bore shall then be filled with dry clay, which shall be tamped with copper or brass rod until it becomes compact. Care shall be taken to avoid any possibility ofan air space around the fuse. The safety fuses shall be taken to the required distance so as to allow the blasting to take place after the person lighting the fuse has withdrawn to a safe distance.

Where gun powder is used in the form of powder or granules it shall be introduced in the bore hole by means of funnel or copper tube. The bore holes shall be loaded with two thirds of the quantity of charge required, and safety fuse then directly introduced over the charge. Remaining one third charge shall then be introduced, and gently filled and pressed home with dry hay or turf. The rest of the bore hole shall be filled with dry clay in the same way as for cartridges, and the safety fuse taken to the required distance.

The charges shall be fired by igniting the fuse. The number of charges to be fired and the actual number of shots heard, shall be compared, and the Contractor's blaster shall satisfy himself by examination that all the charges have exploded, before workmen are permitted to approach the site. The charge which has not exploded, shall not be permitted to be withdrawn. The tamping and charge shall be flooded with water and the holes marked with a red cross (X) over it. Another hole shall be jumped at a distance of about 45 cm from the old hole and fired in the usual way. This operation shall be continued, till the original and any subsequent unfired charges are exploded.

5.16.5 Blasting with Dynamite or any other High Explosive

In case of blasting with dynamite or any other high explosive the position of all bore holes to be drilled shall be marked out in circle with white paint. These shall be inspected by the Contractor's blaster. Bore holes shall be of a size that the cartridge can easily pass down. After the drilling operation, the blaster shall re-inspect the holes to see that the holes marked out by him have been drilled. The Blaster shall then prepare all charges necessary for the bore holes. The bore holes shall be thoroughly cleaned before a cartridge is inserted. Wooden tamping rods (not pointed but cylindrical throughout) shall be used, in charging holes. Metal rods shall never be used for tamping. One cartridge shall be first placed in the bore hole, gently pressed and not rammed down. Other cartridges shall then be added as may be required to make up the necessary charge for the bore hole. The top most cartridge shall be connected to the detonator which shall in turn be connected to the safety fuse of required length.

The maximum of eight (8) bore holes shall be loaded and fired on each occasion. The charges shall be fired successively and not simultaneously.

Immediately before firing a blast, due warning shall be given and the blaster shall see that all persons have retired to a place of safety. The safety fuses of the charged holes shall be ignited in the presence of the blaster, who shall see that all the fuses are properly ignited.

Careful count shall be kept by him and others of each blast as it explodes. After the blast the blaster shall inspect the work and ascertain that all the charged holes have been exploded. In case of misfired holes, the Blaster shall inspect the same after half an hour and mark red crosses (X) over the holes. During this interval of half an hour, no body shall approach the misfired holes. None of the drillers shall work near such holes, until one of the two following operations has been done by the blaster.

a) Either the Contractor's blaster shall very carefully (when the tamping is of damp clay) extract the tamping with a wooden scraper and withdraw the fuse, primer and detonator, after which a fresh detonator, primer and fuse shall be placed in the misfired holes and fired.

OR

b) The hole shall be cleaned for 30 cm of tamping and its direction ascertained by placing a stick in the hole. Another hole shall then be drilled 15 cm away and parallel to it. This hole shall be charged and fired. The misfired hole should also explode along with the new one.

Before leaving the work, the blaster of one shift shall inform another blaster relieving him for the next shift, of any cases of misfire, and shall point out their positions denoted by red crosses and also state the action, if any, to be taken in the matter.

The Engineer-in-Charge shall also be informed by the blaster of all cases of misfire, their causes and steps taken in that connection.

5.16.6 Controlled Blasting (Explosive/ Non-explosive)

Whenever required by the Engineer-in-Charge, rock blasting shall be carefully controlled so that vibrations generated during the blasting do not cause damage to the buildings and installation around. Similarly, the rock pieces should not fly off and endanger the buildings and installations around. Apart from the general precautions mentioned in the preceding paragraphs, following protective measures and limits for use of explosive are suggested as guidelines. Bidders are requested to carefully check the site conditions and submit details of the scheme they propose to adopt for controlling the blast.

Following protective measures shall be adopted while carrying out blasting operations. The hole shall be covered with mild steel plate of minimum 12 mm thickness.

Reinforcement rod mesh not less than 20 mm dia. at 150 mm centre in both directions shall be placed over the steel plates.

Steel plate and reinforcement shall be inspected after every blasting operation and all twists shall be removed before reuse to the satisfaction of the Engineer-in-Charge.

Sand filled bags of 6 to 8 layers shall be placed over the mesh suitably covering the whole region under blasting operation.

The thickness of covering plate and the kind of dead weight is to be duly approved by the Engineer-in-Charge.

5.16.7 Hard rock requiring blasting as described under Clause 2.3.2 above, but where blasting is prohibited for any reason(s), breaking up of rock can be done by using Splitter and/or chemical substances of approved manufacturer mixed in an appropriate proportion. The method involves drilling holes into rock and then inserting Splitter (hydraulic/ pneumatic/ electro-mechanical) or injecting Chemical solvents into the holes. The breaking-up of rock takes place in a controlled fashion without much noise and spark. Any other method as agreed with Engineer-in-Charge may also be used.

5.17 Excavation in areas where existing under ground cables are envisaged, to be carried out carefully by manual means taking proper safety precautions.

The earth work machinery be deployed after ensuring from the trial pits that no cable is crossing the proposed area of excavation.

5.18 Payment (applicable for item rate tenders only)

5.18.1 The payment clause shall be operated only if the earthwork is to be measured separately as per relevant tender item.

5.18.2 Payment for earth work in excavation shall be made on cubic meter (m3) basis on the measurement of volume of pit/ trench of excavation with working space as per relevant Indian Standards (IS:1200) and slopes/ steppings as permitted by the Engineer-in-Charge. The rate shall include cost of all the operations of blasting with explosives & accessories, making of all arrangements for dewatering the accumulated water from any source in the excavated pit or trench, removal and disposal of surplus excavated soil within a lead of 100 m from construction areas. The rate shall also include setting out and line out work required for the excavation.

5.18.3 The following works shall not be measured separately and allowance for the same shall be deemed to have been made in the description of main item:

a) Setting out works, profiles, etc.;

b) Site clearance, such as cleaning grass and vegetation;

c) Unauthorized battering or benching of excavation;

d) Forming (or leaving 'dead men' or 'tell-tales' in borrow pits and their removal after measurements;

e) Forming (or leaving) steps in sides of deep excavation and their removal after measurements;

f) Excavation for insertion of planking and strutting;

g) Unless otherwise specified, removing slips or falls in excavations;

h) Bailing out or pumping of water in excavation from rains;

i) Bailing out or pumping of water in excavation from sub-soil water, and

j) Slinging or supporting pipes, electric cables, etc, met during excavation.

5.18.4 Special pumping other than what is included in 5.18.3 (h and i) and well point dewatering where resorted to, shall each be measured separately, unless otherwise stated, in Kilo Watt Hour against separate specific provision(s) made for the purpose.

5.18.5 The Contractor shall intimate to the Engineer-in-Charge as soon as different classification of soils are met with. The measurements of various soil classifications then shall be worked out by either of the following alternatives in the order of their decreasing importance.

a) Joint levels shall be taken as to the levels of different soil classifications and volume worked out on the basis oflevels only.

b) Where levels of different strata cannot be clearly marked and defined, the Contractor shall stack different soils of various classifications separately for measurement purpose and then dispose it off.

c) If the quantum of work involved in (b) above is extensively large & time consuming, then the total area may be divided into various zones and reasonably representative samples as in (b) above may be taken and quantities of soils of various classifications finalized for the entire zone based on the representative.

If soil of any classification other than that specified in the Schedule of Rates is met with during excavation, the decision of the Engineer-in-Charge as to the classification of soil, levels of the strata of different classifications and their location shall be binding.

In above case, the total quantity of excavation shall be computed from the measurement of the pit/ trench excavated. The hard rock and soft rock shall be measured separately from the relevant stacks and each shall be reduced by fifty percent for voids, and paid under the relevant items. The balance, that is the total quantity of excavation minus the reduced (for voids) quantity of excavation for rocks shall be paid as soft/ hard soil as per the direction of the Engineer-in-Charge (However, the maximum payment shall be limited to the volume of the excavated pit/ trench as approved by Engineer-in-Charge).

6.0 SHORING AND STRUTTING

6.1 The shoring and strutting of the sides to withhold the face of excavation pits/trenches shall be done when approved or directed by the Engineer-in-Charge.

6.2 The shoring shall be of close or open timbering type or by Sheet Piling, Soldier Piling, etc. depending upon the site requirements and as directed by the Engineer-in-Charge whose decision shall be final and binding as to the type of shoring to be used.

6.3 The arrangement of the shoring and strutting shall be sound and safe and shall be got approved from the Engineer-in-Charge before installation. The approval shall not absolve the Contractor of his responsibilities of safety and any other requirements of the contract.

6.4 The shoring and strutting shall be kept in position till all the relevant work in the excavated area is completed and approved. It shall be dismantled and removed only after the permission to do so is obtained from the Engineer-in-Charge.

6.5 Sheet Piling

The contractor shall design, supply and install hot rolled steel sheet piles including all associated structural steel members viz. waler & runner beams, strut, cross ties, vertical members, guide frames, suitable interlocks, suitable comer sections, splicing & cutting of sheet piling. The contractor shall also apply recommended· sealant for complete water tightness (as required) and ensure pre-drilling for installation into bedrock (as necessary), etc. as per site conditions.

The contractor shall mobilize/ demobilize all necessary tools & tackles, hammer (vibratory/ impact), crane(s) etc., shifting plant/ machinery and carryout all ancillary works (as required) and ensure subsequent removal of entire arrangement after completion of works.

6.6 Payment (applicable for item rate tenders only)

Payment for shoring and strutting by close and open timbering shall be made on square meter (m2) basis as separate items. In both the cases, the measurement shall be done on the basis of the surface area of the sides of the excavation actually shored and strutted.

The rate shall include all labour, materials, erection of the poling boards, wales, struts, ballies etc., fixing and keeping the same in position as required, dismantling and removing the same after the work is over as directed.

Payment for shoring and strutting by sheet piling shall be made on the basis of shoring area of sheet pile exposed after complete excavation.

The rate shall include all labour, design, supply and installation of hot rolled steel sheet piles including all associated structural steel members, application of recommended sealant, pre- drilling for installation into bedrock etc., mobilization/ demobilization of all necessary tools & tackles, hammer, crane(s) etc., shifting plant/ machinery & all ancillary works, fixing and keeping the sheet piling in position, dismantling and removing the same after the work is over, etc. all complete as directed by the Engineer-in-Charge.

No extra payment shall be made for cost of extraction and replacement for installing of sheet pile deviating the specification or rejected by Engineer-in-charge. Extracted sheet piles shall be contractor's property and contractor shall remove the same from site without any extra cost to client.

7.0 BACK FILLING AROUND FOUNDATIONS AND IN PLINTH

7.1 Back filling around completed foundations, structures, trenches and in plinth shall be done to the lines and levels shown on the drawings including any trimming of the surfaces, as may be necessary. This shall be done with selected and approved earth from excavation or otherwise with suitable materials described under Clause 3.1 as directed by the Engineer-in-Charge. Where sufficient suitable material is not available from the excavation, the Engineer-in-Charge may direct to import suitable earth from other sources. The filling shall be done in layers of thickness not exceeding 15 cm with watering, rolling and ramming by manual methods/ mechanical compactors to grade and level as shown on drawings to obtain 90% laboratory maximum dry density.

7.2 The Contractor shall not commence filling in and around any work until it has been permitted by the Engineer-in-Charge.

7.3 Backfilling around liquid retaining structures and pipes shall be done only after approval of the Engineer-in-Charge is obtained.

7.4 Payment (applicable for item rate tenders only)

Payment for backfilling with earth shall be based on volume in cubic meters (m3) of consolidated fill. This volume shall be derived from the difference between the volume of excavation and the structure or trenches as the case may be. The rate shall include cost of extracting suitable approved earth from available excavated soil from spoil heaps within a lead of l00 m, placing, watering, rolling, ramming compacting in layers, trimming and dressing finished surface and disposal of surplus material upto a lead of l00 m.

However, backfilling done with materials other than earth shall be paid separately under relevant items.

8.0 TRANSPORTATION OF SURPLUS EARTH

8.1 Surplus earth and soil from excavation shall be removed from construction area to the area demarcated by the Engineer-in-Charge.

8.2 Payment (applicable for item rate tenders only)

8.2.1 Payment shall be made only for the lead beyond initial 100 m from construction area Rate shall include re-excavation, loading, transportation, dumping, stacking or spreading (as per directions of the Engineer-in-Charge) the surplus earth and the soil in the area demarcated by the Engineer-in-Charge. Payment shall be made on cubic metre (m3) basis on the difference of measurements of the volume of the excavated pits and the measurement of the back filling. Quantity generated due to voids in back filled volume of earth shall also be removed by the Contractor at no extra cost and this disposal of earth shall not be measured and paid under any item.

8.2.2 In exceptional circumstances the Engineer-in-Charge may direct the Contractor to remove surplus earth, concrete debris or any other waste material from site to the areas of disposal on the basis of truck measurement. In such cases volume of material shall be calculated on the basis of truck volume reduced by 30% for voids in case of soft/hard soils and 50% for soft/ hard rock. All other provisions of disposal such as spreading, levelling, grading shall apply in this case also.

9.0 PROTECTION OF PROPERTY AND PERSONNEL

9.1 The Contractor shall protect all active utility lines shown on the drawings or encountered during the excavation Ifhe damages those lines, the Contractor shall repair or replace them. If existing utilities interfere with his work, the Contractor shall inform to the Engineer-in-charge and secure written instructions for further action.

9.2 The Contractor shall barricade open holes and depressions which he creates or exposes as part of this, and he shall post warning signs and lights on property adjacent to or with public access. He shall operate warning lights during hours from dusk to dawn each day and as otherwise required for safety.

9.3 The Contractor shall protect structures, utilities, pavements, and other facilities from damage caused by settlement, lateral movement, washout, and other hazards created by his operations.

9.4 The Contractor shall plan and execute all aspects of the earthwork so that the safety of personnel, the work and adjacent property is guaranteed and such that a minimum of inconvenience is caused.

10.0 CLEAN UP

Upon completion of work, the Contractor shall leave the project site clear of debris and surplus materials off plant limits in a manner meeting all location authority requirements.

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS
PLAIN AND REINFORCED CEMENT CONCRETE

C-SPC-104

0	26.02.22	ISSUED FOR USE AS STANDARD	MK	ADh	RKB	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

ACI	:	American Concrete Institute
ASTM	:	American Society for Testing and Materials
BS	:	British Standards
GI	:	Galvanized Iron
IS	:	Indian Standard
ISO	:	International Organization for Standardization
PVC	:	PolyVinyl Chloride
RCC	:	Reinforced Cement Concrete
SCC	:	Self Compacting Concrete
SWG	:	Standard Wire Gauge

CONTENTS

1.0 SCOPE

This specification is applicable for Concrete Grade up to M60 and establishes the requirements of materials, mix proportioning, placing, curing, etc. of all types of cast-in-situ and precast concrete (ref. section 1.6) used in foundations, underground and above ground structures, floors, pavements etc. Any special requirements as shown or noted on the drawings shall supersede the provisions of this specification.

1.1 Reference Codes and Specifications

Apart from this specification, construction of plain and reinforced concrete works shall be in accordance with the Indian Standard Code of Practice for "Plain and Reinforced Concrete" IS 456: 2000 along with all amendments till date and other relevant codes mentioned therein.

1.2 For Liquid Retaining Structures, PLECO Specification No. C-SPC-105 shall be applicable.

1.3 For Structural Steel works, PLECO Specification No. C-SPC-106 & 108 shall be applicable.

1.4 In case of conflict between the clauses mentioned in this specification and those in the Bureau oflndian Standards (BIS), this specification shall govern.

2.0 MATERIALS

2.1 Materials for concrete viz cement, Pozzolanas, Fly Ash, Ground Granulated Blast Furnace Slag, Sand, Coarse aggregate, Water, etc. shall be as described in PLECO Specification No. C-SPC-102.

2.2 Materials for all reinforcements, embedment, inserts, water bars etc. shall conform to PLECO Specification No. C-SPC-102.

2.3 Materials to be used as additive to concrete shall conform to PLECO specification No. C-SPC-102.

3.0 GRADES OF CONCRETE

Characteristic Compressive strength for different grades of concrete shall be as per Table- I.

TABLE-1 GRADES OF CONCRETE

Group	**Grade Designation**	**Specified Characteristic Compressive Strength of 150 mm cube at 28 days (N/mm^2)**
Ordinary Concrete	M10 M 15 M20	10 15 20
Ordinary Concrete	M1O M 15 M20	10 15 20
Standard Concrete	M25 M30 M35 M40	25 30 35 40

	M45	45
	M50	50
	M55	55
	M60	60

Note: The characteristic strength is defined as the strength of material below which not more than five (5) percent of the test results are expected to fall.

4.0 TYPE OF CONCRETE MIX

4.1 Unless otherwise noted on drawings, all lean/plain concrete shall be of Nominal Mix type and reinforced concrete shall be of Design Mix type.

4.2 Nominal Mix Concrete

This concrete shall be made (without preliminary tests) by adopting nominal concrete mix with proportions of materials as specified in Table 9 of IS: 456.

4.3 Design Mix Concrete

The mix shall be designed as per IS: I 0262 in an approved laboratory to produce the grade of concrete having the required workability and characteristic strength not less than appropriate values given in Table- I. The target mean strength of concrete mix shall be equal to the characteristic strength plus 1.65 times the standard deviation.

As long as the quality of materials does not change, a mix design done earlier but not prior to one year may be considered adequate for later work. However, in case the source & quality of materials changes or there is a break in the continuity of construction, the Engineer-in-Charge shall ask for a new design mix.

Irrespective of the grade of concrete required to be produced as per characteristic strength criteria, the minimum cement content and maximum water cement ratio in the design concrete shall be strictly maintained as stipulated in Table 5 of IS: 456.

5.0 CONCRETE MIX PROPORTIONING

Proportioning, as used in this specification, shall mea11 the process of determining the proportions of the various ingredients to be used to produce concrete of the required workability when fresh/green and strength, durability & surface finish, when hardened. The following information shall be collected prior to design of the concrete mix:

The Engineer-in-Charge shall verify the strength of the concrete mix, before giving his sanction of its use. However, this does not absolve the Contractor of his responsibility as regards achieving the prescribed strength of the mix. If during the execution of the work, cube tests show lower strengths than required, the Engineer-in-Charge shall order fresh trial mixes to be made by the Contractor. No claim to alter the rates of concrete work shall be entertained due to such changes in mix variations. Any variation in cement consumption shall be taken into consideration for material reconciliation. Preliminary mix designs shall be established well ahead of start of work.

5.1 Maximum Density

Suitable proportions of sand and the different sizes of coarse aggregates for each grade of concrete shall be selected to give as nearly as practicable the maximum density as per clause 10.2.3 of IS 456. This shall be determined by mathematical means, laboratory tests, field trials and suitable changes in aggregate gradation. The contractor shall ensure the same to the satisfaction of Engineer-in-Charge.

5.2 Consistency

The concrete shall have a consistency such that it shall be workable in the required position and when properly vibrated it flows around reinforcing steel, all embedded fixtures, etc.

5.3 Workability

"Workability of Concrete" shall be as per clause 7 of IS: 456.

5.4 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, low water-cement ratio and adequate cement content shall always be used. Workability of concrete shall be such that concrete can be completely compacted with the means available. Leak-proof formwork shall be used so as to ensure no loss of cement-slurry during pouring and compaction. Cover to reinforcement shall be uniform. Concrete mix design shall always take into account the type of cement, minimum cement content irrespective of the type of cement and maximum water cement ratio and minimum grade of concrete conforming to environmental exposure conditions (refer Table 3 ofIS 456) as given in Table 5 of IS: 456.

Generally, following types of cement shall be used for Plain and Reinforced concrete works:

a) 43 Grade Ordinary Portland Cement conforming to IS: 8112.

b) 53 Grade Ordinary Portland Cement conforming to IS: 12269.

c) Rapid hardening Portland Cement conforming to IS: 8041.

d) Portland Slag Cement conforming to IS: 455.

e) Portland Pozzolana Cement(fly ash based) conforming to IS:1489(Part 1)

f) Portland Pozzolana Cement (calcined clay based) conforming to IS: 1489(Part-2).

g) Sulphate Resisting Portland Cement conforming to IS: 12330

Sulphate Resisting Portland Cement shall be used only for specific requirements depending on environmental and process exposure conditions to which the structures may be subjected to like high Sulphate concentrations, processes involving Sulphur handling etc.

5.4.1 Water Cement Ratio

Once a mix, including its water cement ratio, has been determined and approved for use by the Engineer-in-Charge, that water cement ratio shall be maintained. The Contractor shall determine the water content of the aggregates frequently as the work progresses, and the amount of mixing water shall be adjusted so as to maintain the approved water cement ratio. Maximum water-cement ratio shall be as per Table 5 of IS: 456 for different exposure condition.

The minimum cement content as mentioned in Table 5 of IS: 456 shall be adjusted for aggregates other than 20mm nominal maximum size as defined in Table 6 of IS 456.

For maximum cement content refer Cl.8.2.4.2 ofIS: 456.

5.5 Limits to Deleterious Constituents

Careful selection of the mix and the constituent materials shall be made to limit the presence of deleterious constituents in concrete. The total acid soluble chloride content calculated from the mix proportion and the measured chloride content of each of the constituents shall not exceed 0.6 kg/m3 at the time of placing of concrete. The total water soluble Sulphate content of the concrete mix shall not exceed 4 percent by mass of the cement in the mix.

6.0 BATCHING

Refer clause 10.2 of IS: 456.

7.0 CONCRETE MIXING

7.1 Ready Mixed Concrete supplied by Ready Mixed Concrete Plants or from on/off-site batching plants (IS: 4926) shall be used for structural concrete.

All records and charts for the batching and mixing operations shall be prepared and maintained by the contractor in accordance with IS: 4926 or as per the instructions of Engineer-in-Charge.

In case Ready Mixed Concrete is not available, the mixing of concrete shall be strictly carried out in an approved type of mechanical concrete mixer. The mixer shall be fitted with water measuring devices. The mixing shall be continued until there is a uniform distribution of the material and the mass is uniform in colour and consistency. If there is segregation after unloading from the mixer, the concrete shall be remixed.

7.2 Mixer

7.2.1 Mechanical Mixers shall comply with IS: 1791 and 12119 and shall be maintained in satisfactory operating condition. These shall be used only for producing lean/ plain concrete and/ or nominal mix concrete wherever permitted.

7.2.2 Mixing Time

Mixing time shall be as indicated in the following Table-2. Excessive m,xmg reqmrmg additions of water shall not be permitted. Time shall start when all solid materials are poured in the revolving mixer drum, provided that all of the mixing water shall be introduced before one-fourth of the mixing time has elapsed. The Engineer-in-Charge may, however, direct a change in the mixing time, if he considers such a change necessary.

TABLE-2

MINIMUM MIXING TIME FOR MIXERS

Capacity of mixer	Minimum mixing time
2 m^3 or less	2 minutes
Above 2 m^3	3 minutes or as recommended by the mixer manufacturer.

7.3 Hand Mixing

Hand mixing of concrete shall not be permitted. However, for non-critical applications namely foundations for crossovers, isolated operating platforms etc., using concrete upto grade M20 and located at far away isolated places, this may be permitted by the Engineer- in-charge as a special case. Mixing shall be carried out on a water tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. No extra payment shall be made to the Contractor for mixing by hand or for using extra cement due to hand mixing.

7.4 Additives

Additive in concrete shall be used only with the prior approval of the Engineer-in-Charge and shall comply with Cl. 5.5 of IS: 456. Any additive used for obtaining proper workability or leak proofness of concrete or repair/rendering works of concrete due to non-conformance to the specifications, shall not be measured and paid for. All costs relating to such usage shall be borne by the Contractor.

8.0 TRANSPORTATION, PLACING AND COMPACTION

8.1 General

The entire concrete placing programme including transportation arrangements, deployment of equipment, layout, proposed procedures and methods, shall be submitted to the Engineer-in-Charge 24 hours prior to concreting for approval. No concreting shall be placed until his approval has been received. Approval of the Engineer-in-Charge for pouring concrete shall be taken as 'conveyed', when the concrete pour card is signed by him.

8.1.1 Chuting

The use of long troughs, chutes and pipes for conveying concrete from the mixer to the forms shall be permitted only on written authorization from the Engineer-in-Charge. In case an inferior quality of concrete is produced by the use of such conveyors, the Engineer-in-Charge may order discontinuance of their use and the substitution of a satisfactory method of placing the concrete. Open troughs and chutes shall be equipped with baffles and be in short lengths to avoid segregation. Chutes shall be designed so that the concrete is, to some extent, remixed at the lower end by passing down through a funnel shaped pipe or drop chute. Alternatively, they shall discharge into a storage hopper from which the concrete shall be transported to the point of placing by wheel barrows or other means. Where drop chutes are used, a sufficient number of these must be provided, so that the concrete discharged from the chute is not required to flow laterally more than 1.0 metre. Where a drop chute is swung from the vertical, the bottom two sections must be maintained in a vertical position to avoid segregation. The addition of water at any point in the system of transportation, to facilitate the movement of concrete shall not be permitted. All chutes, troughs and pipes, shall be kept clean and free from coatings of hardened concrete by thoroughly flushing them with water after each run; water used for flushing shall be discharged clear of the structure.

8.1.2 Vibrators

8.1.2.1 Concrete shall be compacted with mechanical vibrating equipment supplemented, if necessary to obtain consolidation, by hand spreading, rodding and tamping. The vibrators shall be of immersion type with operational frequency ranging between 8,000 to 12,000 vibrations per minute. All vibrators shall comply with IS: 2505. Screed board concrete vibrators or concreting vibrating tables or form vibrators conforming to IS: 2506, 2514 and 4656 respectively shall be used where specifically required and directed by Engineer-in-Charge.

8.1.2.2 Immersion type vibrators shall be inserted in a vertical position at intervals of about 600mm, depending upon the mix, the equipment used, and experience on work. The vibrators shall be withdrawn slowly. The spacing shall provide some overlapping of the area vibrated at each insertion. In no case shall vibrators be used to transport concrete inside the forms. Over vibration or under vibration shall not be permitted as both are harmful. Hand tamping in some cases may be allowed subject to the approval of the Engineer-in-Charge.

8.1.2.3 In placing concrete in layers which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, bonding and moulding of the concrete between the succeeding batches.

8.1.2.4 The vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

8.1.2.5 Care shall be taken to prevent contact of vibrators against all embedded reinforcing steel or inserts. Vibrators shall not be allowed to come in contact with forms.

8.1.2.6 The use of form vibrators shall not be permitted for compaction of in-situ concrete without specific authorization of the Engineer-in-Charge.

8.1.2.7 The use of surface vibrators of screed board type shall not be permitted for consolidation of concrete under ordinary conditions. However, for thin slabs (of thickness less than 200mm) surface vibration by such vibrators may be permitted, upon approval of the Engineer-in-Charge.

8.1.2.8 Whenever vibration has to be applied externally, the design of formwork and the dis.position of vibrators shall be carefully planned to ensure efficient compaction and to avoid surface blemishes.

8.2 Transportation

8.2.1 All concrete shall be conveyed from the mixer to the place of final deposit such as formwork as rapidly as possible using suitable buckets, dumpers, pumps, transit mixers containers or conveyors which shall be mortar leak tight. Care shall be taken to prevent the segregation or loss of the ingredients and maintaining the required workability. For structural concrete produced from Ready Mixed Concrete/ Batching Plants, concrete shall be transported from the plants to the sites only by transit mixers and Delivery Ticket for each delivery of concrete shall be maintained by the contractor.

8.2.2 During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted. All equipment used for transporting and placing of concrete shall be maintained in clean condition. All buckets, hoppers, chutes, dumpers and other equipment shall be thoroughly cleaned after each use.

8.3 Placing and Compaction

8.3.1 Before placing concrete, all soil surfaces upon which or against which concrete is to be placed shall be well compacted and free from standing water, mud or debris. Soft or yielding soil shall be removed and replaced, with lean concrete or with selected soils/sand and compacted to the density as directed by Engineer-in-Charge. The surface of absorptive soil (against which concrete is to be placed) shall be moistened thoroughly so that moisture is not drawn from the freshly placed concrete. Similarly, for concrete to be placed on formworks, all chippings, shavings and sawdust etc. shall be removed from the interior of the forms before the concrete is placed.

8.3.2 Concrete shall not be placed until the formwork, the placement of reinforcing steel, embedded parts; pockets etc. have been inspected and approved by the Engineer- in-Charge. Any accumulated water on the surface of the bedding layer shall be removed by suitable means before start of placement. No concrete shall be placed on a water covered surface.

8.3.3 Concrete shall be discharged by vertical drop only and the drop height shall not normally exceed 1.5 metre throughout all stages of delivery until the concrete comes to rest in forms. However, drop height can be relaxed by the Engineer-in-Charge as per the provisions given under Cl. 8.1.1. For continuous concreting operation windows of suitable size shall be kept in the formwork or chutes shall be used to avoid segregation of concrete.

8.3.4 Concrete shall be deposited as near as practicable in its final position to avoid rehandling. Concrete shall be placed in successive horizontal layers. The bucket loads, or other units of deposit, shall be placed progressively along the face of the layer with such over-lap as will facilitate spreading the layer of uniform depth and texture with a minimum of hand shoveling. Any tendency to segregation shall be corrected by shovelling coarse aggregates into mortar rather than mortar on the coarse aggregates. Such a tendency for segregation shall be corrected by redesign of mix, change in process or other means, as directed by the Engineer-in-Charge.

8.3.5 All struts, stays and braces (serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations) shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These shall not be buried in the concrete. Concrete shall be thoroughly compacted with vibrators and fully worked around the reinforcement, embedded fixtures and into comers of formwork before setting commences and shall not be subsequently disturbed. Methods of placing shall be such as to preclude segregation and avoid displacement of reinforcement or formwork. The formation of stone-pockets or mortar bondage in corners and against face forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for thorough bonding as directed by the Engineer-in-Charge. Care shall be taken to avoid displacement of reinforcement and embedded inserts or movement of formwork.

8.3.6 Unless otherwise approved, concrete shall be placed in single operation to the full thickness of foundation rafts, slabs, beams and similar members. Concrete shall be placed continuously until completion of the part of the work between approved construction joints or as directed by the Engineer-in-Charge.

8.3.7 The method of placing and compaction employed in any particular section of the work shall be to the entire satisfaction of the Engineer-in-Charge.

8.3.8 During hot weather (atmospheric temperature above 40 degree Celsius) or cold weather (atmospheric temperature below 5 degree Celsius, the concreting shall be done as per the procedure set out in IS: 7861).

8.3.9 Concrete that has set standing and becomes stiffened shall not be used in the work.

8.3.10 Continuous Concreting

Where called out on the drawings, continuous concreting shall be done in a single operation as per the requirements of IS: 456 and IS: 2974. Sufficient "Windows" shall be left in the formwork for pouring & compaction of concrete and inspection. These windows shall be fixed tight once the level of concrete reaches their levels.

8.3.11 Concreting under special conditions

a) Work in extreme weather conditions during hot or cold weather, the concreting shall be done as per procedure set out in IS: 786l(Part 1) or IS: 7861 (Part2).

b) Under water concreting shall be as per clause 14.2 of IS: 456.

8.4 Items Embedded in Concrete

8.4.1 Concreting shall not be started unless the electrical conduits, pipes, fixtures etc., wherever required, are laid by the concerned agency. The Contractor shall afford all the facilities and maintain co-ordination of work with other agencies engaged in electrical and such other works as directed by the Engineer-in-Charge.

8.4.2 Before concreting, the Contractor shall provide, fabricate and lay in proper position all metal inserts, anchor bolts, pipes etc. (which are required to be embedded in concrete members) as per relevant drawings and directions of Engineer-In-Charge.

8.4.3 All embedment, inserts etc. shall be fully held and secured in their respective positions by the concerned agencies to the entire satisfaction of Engineer-in-Charge so as to avoid any dislocation or displacement during the concreting operations. The Contractor shall take all possible care during concreting to maintain these embedment/inserts in their exact locations.

9.0 CONSTRUCTION JOINTS

9.1 Construction joints shall be provided in position as shown or described on the drawings or as directed by the Engineer-in-Charge. Such joints shall be kept to the minimum. These shall be straight and at right angles to the direction of main reinforcement and shall be placed at accessible locations to permit cleaning out of laitance, cement slurry and unsound concrete.

9.2 In a column, the joint shall be formed about I 00mm to 150mm below the lowest soffit of the beams framing into it. Concrete in a beam and slab shall be placed throughout without a joint but if the provision of a joint is unavoidable, the joint shall be vertical and located within 1/3 to 1/4 of the span, unless otherwise shown on the drawings.

9.3 When stopping the concrete on a vertical plane in slabs and beams, an approved stop board shall be placed with necessary slots for reinforcement bars. The construction joints shall be keyed by providing a triangular or trapezoidal fillet nailed on the stop board. Inclined joints shall not be permitted. Any concrete flowing through the joints of stop board shall be removed soon after the initial set. When concrete is stopped on a horizontal plane, the surface shall be roughened and cleaned after the initial set and a triangular or trapezoidal groove shall be provided for keying with the new concrete later.

9.4 When the work has to be resumed on a surface which has hardened, such surface shall be cleared of any foreign materials and roughened to expose the tips of the coarse aggregate. This may be done by manual chipping of concrete, with a high pressure water jet or by any other appropriate means as per Engineer-in-Charge's directions. It shall then be swept clean and thoroughly washed and wetted before any new concrete is poured. Any set mortar or concrete sticking to the exposed reinforcing rods in and around such joints shall be thoroughly removed. The reinforcements shall be wire brushed and washed just before pouring any cement slurry or mortar. For vertical joints neat cement slurry shall be applied on the surface before it is dry. For horizontal joints the surface shall be covered with a layer of mortar about 10 to 15mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix.. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing new concrete.

9.5 Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgement of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface layer of concrete not exceeding 150mm in thickness shall first be placed and shall be well rammed against old work, particular attention being paid to corners and close spots; work thereafter shall proceed in normal way.

10.0 SEPARATION JOINT

10.1 Separation joint shall be obtained by using an approved Alkathene sheet stuck on the surface against which concrete shall be placed. Adequate care shall be taken to cause no damage to the sheet.

11.0 EXPANSION JOINTS/ISOLATION JOINT

11.1 Expansion/ Isolation joints in structures shall be formed in the positions and to the shapes shown in the relevant drawings. Joints shall be filled with joint filling material as stipulated in the drawings/schedule of rates. Isolation joints shall be provided around all equipment foundations, columns, pedestals, trenches etc. on grade.

12.0 WATER STOPS

PVC water stops as per PLECO Specification No. C-SPC-102 for materials shall be accurately cut, fitted and integrally joined as per manufacturer's specifications to provide a continuous, watertight diaphragm at all points.

The water stops shall be located and embedded at expansion/contraction/ construction joints as indicated in the drawings or directed by the Engineer-in-Charge.

Adequate provision shall be made for the support and protection of water stops during the progress of the work. Damaged water stops shall be replaced and/or repaired as directed.

13.0 PROTECTION OF FRESHLY LAID CONCRETE

13.1 Newly placed concrete shall be protected, by approved means, from rain, sun and wind. Concrete placed below the ground level shall be protected from falling earth during and after placing. Surface shall be kept free from contact with such ground or with water draining from such ground during placing of concrete for a period of at least 3 days, unless otherwise directed by the Engineer-in-Charge. The ground water around newly poured concrete shall be kept to an·approved level by pumping or other approved means of drainage and adequate steps shall be taken to prevent floatation and flooding. Steps shall be taken to protect immature concrete from damage by debris, loading, vibration, abrasion, mixing with deleterious materials that may, in the opinion of the Engineer-in-Charge, impair the strength and/or durability of the concrete.

14.0 CURING

14.1 Concrete shall be cured by keeping it continuously moist wet for the specified period of time to ensure complete hydration of cement and its hardening. Curing shall be started after 8 hours of placement of concrete in normal weather, and in hot weather after 4 hours. The water used for curing shall be of the same quality as that used for making of concrete.

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances such as hose, sprinklers etc. A layer of sacking, canvas, hessian, or other approved material, which will hold moisture for long periods and prevent loss of moisture from the concrete, shall be used as covering. Type of covering which would stain, disfigure or damage the concrete, during and after the curing period, shall not be used. Only approved covering shall be used for curing.

Exposed surfaces of concrete shall be maintained continuously in a damp or wet condition for at least the first 7 days after placing of concrete.

The Contractor shall have all equipment and materials required for curing on hand and ready to use before concrete is placed.

For curing the concrete in pavements, floors, flat roofs or other level surfaces, the ponding method of curing shall be used. For the first 24 hours after concreting, the concrete shall be cured by use of wet sacking, canvas, hessian etc. The minimum water depth of 25mm for ponding shall be maintained. The method of containing the ponded water shall be approved by the Engineer-in-Charge. The ponded areas shall be kept continuously filled with water, and leaks, if any, shall be promptly repaired. Areas cured by ponding method shall be cleared of all debris and foreign materials after curing period is over.

Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing as soon as possible after the concrete has set. Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer so as to obtain an efficiency of 90% as specified by BS-8110. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Engineer-in-Charge may not allow curing by curing compounds for those surfaces where use of curing compound may be detrimental to application of future finishes over the concrete. Impermeable membranes such as polyethylene sheeting closely covering the concrete surface may also be used.

14.2 For concretes containing Portland pozzolana cement or Portland slag cement, the curing period as given in Cl. 14.1 shall be doubled. Curing by ponding shall, however, commence after the first 24 hours of concreting.

15.0 FIELD TESTS

15.1 Grading Test

Grading test on fine and coarse aggregates shall be carried out as per IS: 2386 at intervals specified by the Engineer-in-Charge.

The mandatory tests and their frequencies shall be done as given in Table-3A & 3B below:

TABLE-3A

(For Concrete prepared at site by using Mechanical mixers)
MANDATORY TESTS ON SAND & STONE AGGREGATES

S. No	MATERIAL	TEST	FIELD/ LAB TEST	MIN.QTY OF MATERIAL/ WORK FOR CARRYING OUT TEST	FREQUENCY OF TESTING*
1.	Sand	(a) Bulking of sand	Field Test	20 m^3	Every 20 m^3 or part thereof or more frequentlyas decided by the Engineer-in-Charge
		(b) Silt content	Field Test	20 m^3	
		(c) Particle size distribution	Field or Lab as decided by the Engineer-in-Charge	40 m^3	1) Every 40 m^3 of fine aggregate/sand requiredin RCC works only 2) Every 80 m^3 of fine aggregate/ sand required for other items
2.	Stone aggregate	a) Percentage of soft or deleterious materials	General visual inspection, laboratory test whererequired by Engineer -in-Charge or as specified	As required by Engineer-in-Charge	For all quantities
		b) Particle size distribution	Field or lab. as required by Engineer-in-Charge	45 m^3	For every 45 m^3 or partthereof as decided by Engineer-in-Charge
		c)Ten percent Finevalue	Laboratory	45 m^3	Initial test and subsequent test as & when required by Engineer-in-Charge

* Fresh testing is mandatory whenever there is change in Source of materials.

TABLE-3B

(Refer Cl. 4.4 & 4.6.1 of IS:4926)

(For Ready Mixed Concrete supplied by Ready Mixed Concrete Plants
or from on/off-site Batching Plants)

MATERIALS TESTING REQUIREMENTS

S. No	AGGREGATE PROPERTY/ PARAMETER	TYPE OF AGGREGATE	ASSESSMEN TOF TYPICAL PROPERTIES AND HIGH TEST RATE*	NORMAL MONITORING AND LOW TEST RATE*	REQUIREMENT FOR NORMAL MONITORING AND LOW TEST RATE
I.	**Grading**	Sand/Fine	Weekly	Monthly	Last 8 results conform toIS 383 or representative values
		Coarse-Singlesized/ Graded	Weekly	Monthly	
2.	**Particle density** -Oven Dry -Saturated Surface Dry -Apparent	All Types	Weekly	3 Monthly	Last 4 results ±0.04 percent
3.	**Absorption**	All Types	Weekly	3 Monthly	Last 4 results ±0.04 percent
4.	**Bulk Density** - **Loose** - **Compacted**	**All Types**	**Monthly**	**6 Monthly**	Last 4 results ± 75kg/m3
5.	**Fines(Silt) Content**	**Sand**	**Weekly**	**Monthly**	Last IO results <75 percent maximum allowed
		Coarse	**Monthly**	**3 Monthly**	
6.	**Aggregate Impact Value**	**Coarse**	**As specified**	**As specified**	-
7.	**10 % Fines**	**Coarse**	**Yearly**	**Yearly**	-
8.	**Flakiness**	**Coarse**	**2 Weekly**	**6 Monthly**	Last 3 results conform to standard
9.	**Chloride Content**	**All Types**	**Weekly**	**6 Monthly**	Last 3 results < 0.01 percent
10.	**Aggregate Abrasion Value (Los Angeles Method)**	**Coarse**	**-**	**Yearly/ Source Change**	-
11.	**Soundness**	**Fine and Coarse**	**-**	**Yearly/ Source Change**	-
12.	**Potential Alkali Aggregate Reactivity Including Petrography**	**Fine and Coarse**	**-**	**5 Yearly/ Source Change**	-
13.	**Petrographic Description (General)**	**All Types**	**-**	**5 Yearly**	-

*Note: The high- or low-test rates apply in accordance with the following conditions:

a) High test rate

i) To establish the typical characteristics of an aggregate, and

ii) When significant changes in properties occur outside the tolerances for low test rates given.

b) Low test rate

i) When the typical characteristics of the aggregate have been established, and

ii) When subsequent tests lie within the tolerances for low test rates given

15.2 Compaction Factor Test /Slump Test of Concrete

15.2.1 For structural quality concrete (excluding pavements, flooring etc.) at least one Slump Test shall be made for every compressive strength test carried out. More frequent tests shall be made if there is a distinct change in working conditions or if required by the Engineer-in-Charge.

In case of Ready Mixed Concrete, provisions of IS: 4926 shall be followed.

15.2.2 For structural quality concrete for pavements & floorings, measurement of workability shall be by determination of compacting factor. Value of compacting factor of 0.75 to 0.8 shall generally be acceptable.

15.3 Strength Test of Concrete

15.3.1 Samples from fresh concrete shall be taken as per IS: 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS: 516.

15.3.2 In order to get a relatively quicker idea of the quality of concrete, optional tests on beams for modulus of rupture at 72±2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values shall be arrived at based on actual testing. In all cases, the 28 days compressive strength specified in Table- I shall alone be the criterion for acceptance or rejection of the concrete in accordance with clause 15.3.9.

15.3.3 Sampling Procedure

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested that is, the sampling should be spread over the entire period of concreting and cover all mixing units.

15.3.4 Frequency of Sampling

The minimum frequency of sampling of concrete for each grade shall be in accordance with Table-4.

TABLE-4

(Refer Cl. 15.2.2 of IS:456)

FREQUENCY OF CONCRETE SAMPLING

Quantity of concrete in the work (m^3)	Number of samples
1-5	l
6-15	2
16-30	3
31-50	4

51 & above	4 plus one additional sample for each additional 50m^3 or part thereof.

At least one sample shall be taken from each shift.

When concrete is produced at continuous production units such as ready mixed concrete/ batching plants, atleast one sample shall be taken for every 50m3 of concrete or after every 50 batches, whichever occurs at a greater frequency or as decided by the Engineer-in- Charge. Samples shall be avoided from the first and the last cubic metre of concrete mix in a lot.

15.3.5 Test Specimen

Three test specimens shall be made for each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork or to check the testing error. Additional samples may also be required for testing samples cured by accelerated methods as described in IS: 9013. The specimen shall be tested as described in IS: 516.

15.3.6 Identification mark on concrete test cubes:

The following numbering system shall be adopted on each 150mm cube:

First line: ZZ	(Alpha code assigned by the Engineer -in-Charge to the Contractor for a particular contract starting with AA and progressing to AB, AC and so on).
Second line: XXXX	(Unique integer in ascending order starting from I).
Third line: DD-MM-YY	(Date of casting of cube)

15.3.7 Test Results of Sample

The test results of the sample shall be the average of the strength of three specimens. The individual variation should not be more than ± 15 percent of the average. If more, the test results of the sample shall be considered invalid.

15.3.8 Standard Deviation

Standard deviation for each grade of concrete shall be calculated separately. Standard deviation based on test results of samples:

a) The total number of test samples required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts shall be made to obtain the 30 samples, as early as possible, when a mix is used for the first time.

b) For design of mix in the first instance, the value of standard deviation given in Table 8 of IS: 456, Amendment No. 4 may be assumed.

c) As soon as sufficient results of samples are available, actual calculated standard deviation shall be used and the mix design shall be revised/ updated. However, when adequate past records for a similar grade exist and justify to the designer a value of standard deviation different from that shown in Table 8 of IS: 456, Amendment No. 4, it shall be permissible to use that value.

d) For additional requirement on standard deviation refer clause 9.2.4 of IS : 456.

15.3.9 Acceptance Criteria

15.3.9.1 Compressive Strength

The concrete shall be deemed to comply with the strength requirement when both the conditions as given in col. 2 & col.3 of Table-5 for that particular grade of concrete are simultaneously met. For working out standard deviation compressive test result of date wise serially logged 30 sample test result shall be used.

15.3.9.2 Flexural Strength

The concrete shall be deemed to comply with flexural strength requirements when both the following conditions are simultaneously met:

a) The mean strength determined from any group of four non-overlapping consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm2.

(For non overlapping consecutive compressive test result any one alternate set of four samples shall be used for verification of compliance to clause no. 16.1.a of IS 456)

b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm2

Table-5

(Refer Cl. 16.1 & 16.3 of IS:456)

Characteristic Compressive Strength Compliance Requirement

Specified Grade	**Mean of the Group of 4 Non-Overlapping Consecutive Test Results in N/mm²**	**Individual Test Results in N/mm²**
M15 or above	$\geq f_{ck}$ + 0.825 x established standard deviation(rounded off to nearest 0.5N/mm²) or $\geq f_{ck}$ + 3 N/mm², Whichever is greater	$\geq f_{ck}$ - 3 N/mm²
NOTE : 1) In the absence of established value of standard deviation, the values given in Table 8 of IS:456, Amendment No. 4, may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation. 2) For concrete of quantity 30 m³ (where the number of samples to be taken is less than four as per the frequency of sampling given in cl. 15.3.4, Table 4), the mean of test results of all such samples shallbe t k + 4 N/mm², minimum and the requirement of individual test results shall be fck - 2 N/mm². minimum. However, when the number of sample is only one as per Table 4. the requirement shall be fck + 4 N/mm².		

15.3.9.3 Quantity of Concrete Represented by Strength Test Results

The quantity of concrete represented by group of four consecutive test results shall include the batches from which first and last samples were taken together with all intervening batches. Acceptance of concrete shall be applicable for serially logged 30 samples. In case serially logged samples are less than 30 then standard deviation of adjoining previous sample sets will be used for establishing acceptance criteria as per clause 16.1.a ofIS: 456.

For the individual test result requirements given in col. 3 of Table-5 or in item (b) of 15.3.9.2, only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified, the maximum quantity of concrete that four consecutive test results represent shall be limited to 60m3.

15.3.9.4 If the concrete is deemed not to comply pursuant to Cl. 15.3.9.1 or 15.3.9.2, the structural adequacy of the parts affected shall be investigated and any consequential action as needed shall be taken (Refer Cl. 16.0).

15.3.9.5 Concrete of each grade shall be assessed separately.

15.3.9.6 Concrete is liable to be rejected if it is porous or honey-combed, its placing has been interrupted without providing a proper construction joint, the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures and tests to the fullest satisfaction of the Engineer-in-Charge.

15.3.9.7 Tolerance in leveling of concrete surface at foundation/ pedestal top level where grouting is to be done:

Maximum Plan Dimension	**≤ 2m**	**>2m but ≤4m**	**>4m**
Tolerance in leveling	+ 10mm	+ 10mm	+ 10mm
	- 10mm	-20 mm	-25mm

15.3.9.8 Tolerance in dimensions of pocket:

20mm overall maximum tolerance on the size of pocket.

For pockets, chemically dissolvable moulds shall be preferred. Smooth removal of moulds without affecting the pocket size shall be ensured.

16.0 INSPECTION AND TESTING OF STRUCTURES

16.1 Inspection

To ensure that the construction complies with the design, an inspection procedure shall be set up by the contractor and duly approved by the Engineer-in Charge covering materials used, receipt of materials, their test results, records, workmanship and construction etc.

Contractor shall ensure that the surface which is to receive the grout is at proper level and so are the openings for pockets as per Cl. 15.3.9.7 & 15.3.9.8.

16.2 Immediately after stripping the formwork, all concrete shall be carefully inspected and any defective work or small defects either removed or made good before concrete has thoroughly hardened.

16.3 Testing

In case of doubt regarding the grade or soundness of concrete used, either due to poor workmanship or based on results of cube strength, compressive strength tests of concrete on the basis of clause 17.4 of IS: 456 and/or load test as per clause 17.6 of IS: 456 shall be carried out.

The Engineer-in-Charge shall be the final authority for interpreting the results of all tests and shall decide upon the acceptance or otherwise. The decision of the Engineer-in-Charge shall be final and binding on the contractor. In case the results of the tests are unsatisfactory, the Engineer-in-Charge may instruct the contractor to demolish and reconstruct the structure or part thereof without any extra cost to the Owner.

16.4 Members other than Flexural Members

Members other than flexural members like columns etc. shall be referred to the designer to investigate the structural adequacy. The decision of the designer shall be final and binding on the contractor.

16.5 Non-destructive Tests

Non-destructive tests using Ultrasonic Pulse Velocity and Rebound Hammer methods shall be resorted to for checking the soundness of concrete placed and shall be as per the directions of Engineer-in-Charge. The testing shall be based on IS: 13311, Part-I. However, the Rebound Hammer test (IS: 13311, Part-2) shall only be used in combination with other tests (Destructive or Non-Destructive) for checking the concrete quality.

17.0 FINISHING OF CONCRETE

17.1 On striking the formwork, all surface defects such as bulges, ridges and honey-combing etc. observed shall be brought to the notice of the Engineer-in-Charge. The Engineer-in-Charge may, at his discretion allow rectification by necessary chipping and packing or grouting with concrete or cement mortar. However, if honey-combing or sagging is of such extent as being undesirable, the Engineer-in-Charge may reject the work totally and his decision shall be binding. No extra payment shall be made for rectifying these defects, demolishing and reconstructing the structure. However, quantity of cement actually used for this purpose may be considered for reconciliation of materials. All burrs and uneven faces shall be rubbed smooth with the help of carborundum stone.

The surface of non-shuttered faces shall be smoothened with a wooden float to give a finish similar to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as from the formwork except that honey-combed surface shall be made good as specified above. The top faces of slabs not intended to be covered shall be levelled and floated to a smooth finish to the rises or falls shown on the drawings or as directed. The floating shall not be executed to the extent of bringing excess fine materials to the surface. The top faces of slabs intended to be covered with screed, granolithic or similar finishes, shall be left with a rough finish.

17.2 Repair and Replacement of Unsatisfactory Concrete

17.2.1 Repair shall be made as soon as possible after the forms are removed and before the concrete becomes too hard with prior permission from the Engineer-in-Charge, in writing. Stone pockets, segregation patches and damaged areas shall be chipped out and the edges undercut slightly to form a key. All loose material shall be washed out before patching. No excess water shall be left in the cavity, but the concrete shall be damp. A good bond between the patch and parent concrete shall be obtained by sprinkling dry cement on the wet surface or by throwing mortar with force on to the wetted concrete, or by brush in a coat of thick cement grout of about 1:1 (1 cement:1 sand) just before applying the patching material. Before this has dried, the remainder of the patch shall be filled with mortar or concrete, depending on the extent of the repair.

17.2.2 Cement concrete/mortar used in repair of exposed surfaces shall be made with cement from the same source as that used in concrete and blended with sufficient amount of white Portland cement to produce the same colour as in the adjoining concrete. The proportions of ingredients shall be same as those used in parent concrete. The mortar shall be as dry as possible and well compacted into the cavity. All filling shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the filling has been cured and dried.

17.2.3 For larger repairs to hardened concrete, necessary formwork bearing tightly at the edges of the cavity shall be provided. Concrete shall be chipped out to a depth of at least 100mm and preferably 150mm. Mortar shall be scrubbed into all surfaces with a wire brush before placing the concrete. Damaged reinforcement shall be adequately spliced with new steel so as to maintain the original strength. Additional reinforcement, if required in the patch, shall be provided as per the instructions of Engineer-in-Charge.

17.2.4 In case, in the opinion of the Engineer-in-Charge, defects in the concrete is excessive or beyond repair, the contractor shall either redo the structure or take other remedial measures as instructed by the Engineer-in-Charge. The decision of the Engineer-in-Charge shall be final and binding to all in this respect.

17.2.5 Approved epoxy formulation for bonding fresh concrete used for repairs with already hardened concrete shall be used by the Contractor if asked by the Engineer-in-Charge. Epoxy shall be applied in strict accordance with PLECO Specification No. C-SPC-104 and the instructions of the manufacturer.

17.2.6 All repair works due to non-conformance or non-adherence to specification, if allowed by the Engineer-in-Charge, shall be carried out free of cost to the owner.

17.3 Curing of Patched Work

Immediately after patching is completed, the patched area shall be covered with an approved non-staining water saturated material which shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the patched area shall be kept continuously wet by a fine spray or sprinkling for not less than 10 days.

18.0 WATERPROOF CEMENT PAINT

Wherever specified, concrete elements (whether cast-in-situ or precast) exposed to atmosphere shall be provided with three coats of cement based waterproof paint as per IS:5410 provided these surfaces shall not contain any protective coating. Prior to application of the paint, the surface shall be prepared to remove all foreign particles, loose materials, extra deposited concrete lumps, etc. using appropriate mechanical/ manual means.

19.0 FORM WORK

19.1 General

19.1.1 Forms for concrete shall be of plywood conforming to IS: 6461 (Part-5) or steel or as directed by the Engineer-in-Charge and shall give smooth and even surface after removal thereof.

19.1.2 If it is desired by Engineer-In-Charge, the Contractor shall prepare, before commencement of actual work, design and drawings for formwork and get them approved by the Engineer-in-Charge. For details regarding design, detailing etc., reference may be made to IS: 14687.

19.1.3 Form work and its supports shall maintain their correct position and be to correct shape and profile so that the final concrete structure is within the limits of dimensional tolerances specified below, unless required otherwise, for functional/aesthetic reasons. The decision of the Engineer-in-Charge shall be final and binding in this regard.

(a) Deviation from specified dimensions of cross section of columns and beams	- 5mm to+ 10mm
(b) Deviation from dimensions of footings (see Note below)	
i) Dimensions in plan	-10mm to +50mm
ii) Eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50mm.
iii) Thickness	-l0mm to +50mm or ±0.05 times the specified thickness, whichever is less

Note: These tolerances apply to Cast-in-situ concrete dimensions only, not to positioning of vertical reinforcing steel or dowels.

(c) Deviation in length (major dimension of single unit)

upto 3m	±6mm
3m to 4.5m	±9mm
4.5m to 6m	±12mm
Additional deviation for every subsequent 6m.	±6mm

(d) Deviation in straightness or bow (deviation from specified line) for a single or continuous member) e.g. beam, column or slab edge.

upto 3m	6mm
3mto6m	9mm
6m to 12m	12mm
additional for every subsequent 6m.	6mm

(e) Deviation in squareness shall be measured taking the longer of two adjacent sides as the base line.

The shorter side shall not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions exceeds 6mm. For this purpose, any error due to lack of straightness shall be ignored. Squareness shall be checked with respect to the straight lines that are most nearly parallel with the features being checked. When the nominal angle is other than 90 degree, the included angle between check lines shall be varied accordingly.

(f) Deviation in twist shall be within a limit such that any comer shall not be more than the limit given below from the plane containing other three comers:

upto 600mm wide and upto 6m in length	6mm
over 600mm wide and for any length	12mm

(g) Maximum deviation in flatness from a 1.5m straight edge placed in any position on a nominally plain surface shall not exceed 6mm.

(h) Tolerance in leveling of concrete surface at foundation/ pedestal top level where grouting is to be done	As per Cl. 15.3.9.7

19.2 Form Requirement

19.2.1 The formwork shall be true, rigid and adequately braced both horizontally as well as diagonally. The forms shall have smooth and even surface and be sufficiently strong to carry, without deformation, the dead weight of the green concrete, working load, wind load and also the side pressure exerted by the green concrete. As far as practical, clamps shall be used to hold the forms together. Where use of nails is unavoidable minimum number of nails shall be used. Projected part of nail shall not be bent or twisted for easy withdrawal.

19.2.2 Where through tie rods are required to be put to hold the formwork and maintain accurate dimension, they shall always be inserted through a precast concrete block (of same mix proportion as is to be used for concreting) with a through hole of bigger diameter. The Precast block shall tightly fit against in inner faces of formwork. The holes left after the withdrawal of tie rods shall be fully grouted with cement-sand mortar of same proportion as that used for concrete. However, use of such precast block shall in no case impair the desired appearance or durability of the structure. No such tie rods shall be used in any liquid retaining or basement structure.

19.2.3 Tie wires shall be permitted only upon approval of the Engineer-in-Charge and shall be cut off flush with the face of the concrete or counter sunk, filled and finished in the manner specified in clause 17.

19.2.4 Form joints shall not permit any leakage. The formwork shall be strong enough to withstand the effect of vibrations practically without any deflection, bulging, distortion or loosening of its components.

19.2.5 Forms for beams and slabs (span more than 6.0m) shall have camber of 1 in 500 so as to offset the deflection and assume correct shape and line after deposition of concrete. For cantilevers, the camber at free end shall be 1/100th of the projected length. Where architectural considerations and adjunctive work are critical, smaller form cambers shall be adopted as decided by the Engineer-in-Charge.

19.2.6 All vertical wall forms may be designed and constructed for the following mm1mum pressure. The pressures listed in Table-6 are intended as guide only and the Contractor shall ensure that the formwork is adequately strong and sturdy.

TABLE-6

MINIMUM DESIGN PRESSURE FOR WALL FORMWORK

Rate of pour in meter/hour	Pressure in KN/m^2	
	at 10° (in Celsius)	at 24° (in Celsius)
0.6	36.0	29.0
0.9	40.0	32.0
1.2	44.0	35.0
1.5	46.0	37.0

All horizontal forms shall be designed and constructed to withstand the dead load of the green concrete, reinforcement, equipment, material, embedment and a minimum live load of 2.0 kN/m^2.

19.3 Inspection of Forms

Temporary openings shall be provided at the base of column and wall forms and other places necessary to facilitate cleaning and inspection. Before concrete is placed, all forms shall be carefully inspected to ensure that they are properly placed, sufficiently rigid and tight, thoroughly cleaned, properly treated and free from foreign material. The complete form work shall be inspected and approved by the Engineer-in-Charge before the reinforcement bars are placed in position. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the work shall be stopped until the defects have been rectified as per the instructions of the Engineer-in-Charge.

19.4 Cleaning and Treatment of Formwork

The surfaces of forms that would come in contact with concrete shall be well treated with approved non-staining form release agents such as soft soap, oil, emulsions etc. Release agents shall be applied so as to provide a thin uniform coating to the forms without coating the reinforcement.

19.5 Chamfers and Fillets

All comers and angles shall be fonned with 45 degree mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfers and fillets, unless otherwise detailed or specified shall be 25x25mm. For heavier work chamfers or fillets shall be 50x50mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

19.6 Reuse of forms

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired and retreated, before resetting. Formwork shall not be reused, if declared unfit or un-serviceable by the Engineer-in-Charge.

19.7 Removal of Forms/Stripping Time

In the determination of time for removal of forms, consideration shall be given to the location and character of the structures, the weather and other conditions including the setting and curing of the concrete and material used in the mix.

Forms and their supports shall not be removed without the approval of the Engineer-in-Charge. Forms shall not be released until the concrete has achieved a strength of at least twice the stress to which the concrete may be subjected at the time of removal. The formwork shall be removed without shock and methods of form removal likely to cause over stressing or damage to the concrete shall not be adopted. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In normal circumstances when average air temperature exceeds 15 degree Celsius during the period under consideration after pouring of concrete and where ordinary Portland cement is used, forms may generally be removed after expiry of following periods.

(a)	Walls, columns and vertical faces of all structural members	16 to 24 hours as may be decided by the Engineer-in-Charge.
(b)	Slabs (props left under)	3 days
(c)	Beam Soffits (props left under)	7 days
(d)	Removal of props under slabs	
	Spanning upto 4.5m	7 days.
	Spanning over 4.5m	21 days
(e)	Removal of props under beams and arches:	
	Spanning upto 6m	14 days.
	Spanning over 6m	21 days

(f) Cantilever Construction Formwork shall remain till structures for counter acting or bearing down have been erected and have attained sufficient strength (minimum 14 days).

Notes:

i) For other cements, the stripping time recommended for ordinary Portland cement shall be suitably modified as per the instructions of the Engineer- in-Charge.

ii) The number of props left under, their sizes, supporting arrangement, and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

iii) Where the shape of the element is such that the formwork has re-entrant angles, the form work shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

iv) For rapid hardening cement, 3/7 of the above mentioned periods shall be considered subject to a minimum of 16 hours.

v) For Portland pozzolana or low heat cement, 10/7 of the above mentioned periods shall be considered.

19.8 Staging/Scaffolding

19.8.1 Staging/Scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. The Contractor shall get it reviewed by Engineer-in-Charge before commencement of work. While designing and during erection of scaffolding/staging, the following measures shall be considered:

(a) Sufficient sills or underpinnings in addition to base plates shall be provided particularly where scaffolding is erected on soft grounds.

(b) Adjustable bases to compensate for uneven ground shall be used.

(c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

(d) Horizontal braces shall be provided to prevent the scaffolding/staging from rocking.

(e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

(f) The scaffolding/staging shall be checked at every stage for plumb line.

(g) Wherever the scaffolding/staging is found to be out of plumb line it shall be dismantled and re-erected afresh and effort shall not be made to bring it in line with a physical force.

(h) All nuts and bolts shall be properly tightened and care shall be taken that all clamps/couplings are firmly tightened to avoid slippage

(i) Erection work of a scaffolding/staging under no circumstances shall be left totally to semi-skilled or skilled workmen and shall be carried out under the supervision of a technically qualified civil engineer of the Contractor.

19.8.2 For smaller works or works in remote areas, wooden ballies may be permitted for scaffolding/staging by the Engineer-in-Charge at his sole discretion. The contractor must ensure the safety and suitability of such works as described under clause 19.8. l above.

20.0 EXPOSED/ARCHITECTURAL CONCRETE WORK

20.1 Form Work

Other things remaining same as per clause 19.0, formwork shall be of high quality. Care shall be taken to arrange the forms so that the joints between forms correspond with the pattern indicated in the drawings. The forms shall be butting with each other in straight lines, the corners of the boards being truly at right angles. The joints between the forms shall cross in the two directions at right angles. The size of forms shall be so selected as to exactly match with the pattern of forms impression on the concrete face indicated in the drawings. Maximum care shall be taken to make the form work watertight. Burnt oil shall not be used for treatment of forms. The Contractor shall be permitted reuse of forms brought new on the work place only if forms are properly cared for, stored and treated after each use.

The Engineer-In-Charge may, at his absolute discretion, order removal of any forms considered unsuitable for use in the work.

20.2 Finishing

Repairing to exposed concrete work shall be avoided. Rendering and plastering shall not be done. Minor repairing, if unavoidable shall be done as specified in clause 17.0 with the written permission of the Engineer-in-Charge.

21.0 REINFORCEMENT

21.1 The Contractor shall develop the bar bending schedule for all RCC structures/ structural parts at no extra cost to the Owner and shall get it reviewed by the Engineer-in-charge. Reinforcement shall be cut and bent to shape as per dimensions shown in the bar bending schedule/ drawings.

If protective fusion bonded epoxy coating is required to be applied on reinforcement bars, the same shall be done as per IS: 13620. All repairs to applied protective coating required due to mishandling and/ or bending of reinforcement bars shall also be done as per relevant clauses ofIS:13620.

21.2 Straightening, Cutting and Bending

Procedure for cutting and bending shall be as given in IS: 2502. Bars shall be bent in a slow and regular movement to avoid fractures by mechanical means only. In case bars are supplied in coils, they shall be smoothly straightened without any kinks.

Cold twisted deformed bars shall be bent cold. Bars larger than 25mm in size (except cold twisted deformed bars) may be bent hot at cherry red heat to a temperature not exceeding 850° Celsius as per the instructions of the Engineer-in-Charge. The bars shall be allowed to cool gradually without quenching.

Bars shall be cut & bend in a Bar Bending Machine. Bars which develops cracks or splits after bending shall be rejected. A second bending of reinforcement bars shall be avoided but when reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care should be taken to ensure that at no time is radius of the bend less than 6 times bar diameter for high strength deformed bars. Care shall also be taken when bending back the dowel bars to ensure that concrete around the bars is not damaged. All bars shall be properly tagged for easy identification.

21.3 Placing and Fixing

All reinforcement shall be cleaned to ensure freedom from loose mill scale, loose rust, oil, form releasing agents, grease or any other harmful material before placing them in position. Reinforcement shall not be surrounded by concrete unless it is free from all such materials. Rough handling and dropping of reinforcement from a height shall be avoided.

All reinforcement shall be fixed in the correct position and shall be properly supported to ensure that displacement will not occur when the concrete is placed and compacted.

The uncoated reinforcement bars shall be tied at every intersection by two strands of 16 SWG black soft annealed binding wire. The Epoxy coated reinforcement bars shall be tied with 2 strands of PVC coated GI 18 SWG wire at every intersection. Crossing bars shall not be tack welded for assembly of reinforcement. The reinforcement bars shall be kept in position by using the following methods:

a) In case of beam and slab construction, precast cover blocks (having the same sand contents as the concrete which shall be placed) of size 40 x 40 mm and thickness equal to the specified covers shall be placed firmly in between the bars and forms so as to secure and maintain the specified covers over the reinforcement.

   When reinforcement bars are placed in two or more layers in beams, the vertical distance between the horizontal bars shall be maintained by introducing spacer bars at 1 to 1.2m centre to centre.

b) In case of thick rafts & pile caps having two or multi layers of reinforcement, the vertical distance between the horizontal bars shall be maintained by introducing suitable chairs, spacers, etc.

c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them. The templates shall be removed after the concreting has been done below it.

d) Exposed portions of reinforcement bars shall not be subjected to impact or rough handling and workmen will not be permitted to climb on extending bars until the concrete has attained sufficient strength so that no movement of the bars in the concrete is possible.

21.4 Special requirements for Handling, Stacking, Placing of Epoxy coated Reinforcing bars.

Epoxy coated reinforcing bars shall be carefully handled and it shall be ensured that these do not rub on any hard surface or against another epoxy coated/uncoated reinforcing bar whether during conveying/transportation, stacking or placing.

During transportation and while stacking the epoxy coated reinforcing bars shall be placed on wooden planks not spaced farther than 600mm. When placed in stacks the epoxy coated reinforcing bars shall be neatly tied in bundles using PVC binding material.

The cut ends of bars shall be touched up with special touch up material of specifications as provided by the coating agency. After cutting of the bar the application of touch up material shall be completed within four hours.

While bending the bars the pins of work bench(s) shall be provided with a PVC or plastic sleeve. Each bending operation on epoxy coated reinforcing bar shall be completed in time not less than 90 seconds.

Epoxy coated reinforcing steel bar shall not be directly exposed to sun rays or rain, and shall be protected with opaque polyethylene sheets or similar means as approved by the Engineer in Charge.

While doing concreting the workmen or machinery shall not rest or move on the epoxy coated reinforcing bars. Wooden planks shall suitably be placed to create proper gang-way.

21.5 Splicing/Overlapping

Only bars of full length shall be used as shown in the drawings. But where this cannot be done, overlapping of bars shall be done as directed by the Engineer-in-Charge. The overlapping bars shall be tied with two strands of 16 SWG black soft annealed binding wire. The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is maximum.

21.6 Welded Joints

Welding of reinforcing bars shall not be permitted without the written permission of the Engineer-in-Charge. Where welding of reinforcing bars is permitted, it shall be in accordance with the recommendations of IS: 2751 and IS: 9417. Welded joints shall be located at suitable staggered positions. Tests shall be made as directed by the Engineer-in-Charge to prove that the joints are of the full strength of the bars. Maximum one welded joint shall be allowed per bar.

21.7 Mechanical Connections (upto Seismic Zone-III as per IS:1893 Part-I)

The mechanical splices in reinforcement by means of couplers, clamps etc. shall be used (as per manufacturer's specifications) with the written approval of the Engineer-in-Charge.

Following tests, at the minimum, shall be conducted in advance to prove efficiency of the coupled joint before putting them in actual use:

Name of the Test	**Testing Requirement**	**Code of conformance**
Static Tension &Compression Test	Each connection shall develop at least 125% of the specified yield strength of the reinforcing bar	ASTM A370/ ACI 318/ ISO 15835
Permanent Elongation (Slip)	Permanent elongation across the coupled Joint shall be less than 0.1mm After loading at 60% of the yield strength of the reinforcing bar	BS 8110/ ISO 15835
Moderate Oligocyclic (Seismic) Test (Cyclic Tension & Compression Test)	Deformation across the coupled joint shall be less than 0.3mm after subjecting the joint to a series of 20 cycles with 90% tension as well as 50% compression of the yield strength of the reinforcing bar	ISO 15835

All operations relating to reinforcement coupling shall be done by using manufacturer's patented machine/ equipment in the presence of Engineer-in-Charge. Mechanical connections shall be placed away from points of high stress and shall be staggered.

21.8 Tolerances on Placing of Reinforcement

Unless otherwise directed by the Engineer-in-Charge, reinforcement shall be placed within the following tolerances:

a) For effective depth 200mm or less ± 10mm

b) For effective depth more than 200mm ± 15mm

21.9 Substitution

When indicated diameter of reinforcement bar is not available, the Contractor shall use other diameter of reinforcement bars on written approval of the Engineer-In-Charge.

21.10 Tolerance to Cover

The actual concrete cover shall not deviate from the required nominal cover by + 10mm measured over the steel reinforcement including links.

22.0 PAYMENT

22.1 Plain and Reinforced Concrete

22.1.1 Payment for plain and reinforced cement concrete (cast- in-situ) shall be made on cubic metre basis of the volume of the actual finished work done or as per approved construction drawings, whichever is less and shall be inclusive of providing pockets, openings, recesses of all sizes, chamfers, fillets, grooves, separation/ expansion/ isolation/ construction/ movement joints, curing by normal moist curing or using curing compound etc. as directed by Engineer-in-Charge etc. The rates shall be deemed to include complete cost of getting the respective mix designs approved, making and testing concrete cubes and carrying out other tests including tests of various ingredients, as per specifications and as directed by Engineer-in-Charge. Payment shall, however, be separately made for tests on concrete cubes done by accelerated methods of curing as defined in IS: 9013.

22.1.2 No separate payment shall be made for any additive/ admixture/ Plasticizer/ Fibres used by the contractor for accelerating or retarding the strength of concrete or for achieving specified workability. The rate quoted shall be deemed to be inclusive of all costs related to any such additive/admixture/ Plasticizer/ Fibres.

22.1.3 The rate shall however be exclusive of reinforcement, metal inserts, pipe sleeves, formwork water stops and any filler material in expansion/isolation joints.

22.1.4 Where the strength of concrete mix as indicated by tests, lies in between the strengths of any two grades given in Table- I and it is accepted by the Owner/Engineer-in-Charge, such concrete shall be classified as a grade belonging to the lower of the two grades between which it lies. In case the cube strength shows higher results than those specified for the particular grade of the concrete, it shall not be placed in the higher grade nor shall the Contractor be entitled for any extra payment on such account. The concrete giving lower strength than specified may be accepted at reduced rates after satisfying the safety of the structure by checking it with tests as specified or rejected entirely at the discretion of the Engineer-in- Charge. The rejected concrete shall be dismantled at no extra cost to the owner and no payment or extension of time shall be granted for the concrete so rejected and the formwork and reinforcement used for the same. Cost of any material supplied by the Owner free of cost shall be recovered from the Contractor at double the prevailing market rate. In case the concrete of lower strength can be improved by carrying out some strengthening measures entirely at the discretion of the Engineer-in-Charge, then the said measures including all related tests shall be carried out by Contractor at his own cost. If the Contractor is able to make up the strength to the required grade by such improvement measures to the entire satisfaction of Engineer-in-Charge, payment shall be made for the grade achieved. However, if the strength of concrete is not made up to the strength of required grade, payment shall be made only for the lower strength if such concrete is accepted by the Engineer-in-Charge.

22.1.5 Deductions for openings, pockets etc. shall be as specified in relevant parts of IS 1200.

22.1.6 Payment under continuous concreting item in the schedule of rates shall be made only where the total quantity of concrete between two consecutive construction joints specifically called-out on the drawings exceeds 250 cubic metres. For any foundation/structure involving concrete quantity upto

250 cubic metres between two consecutive construction joints shown on drawings, the concrete shall not be measured or paid for under this category (i.e. continuous concreting), even though the same is required to be constructed in single pour. The rate quoted against this item shall be inclusive of all extra cost related to labour, shuttering, staging and making all other arrangements for such continuous casting e.g. provisions for adequate movement and storage spaces, special gangways, scaffolding, additional construction equipments, adequate lighting and supervision while the work continues round the clock etc. The rate shall also be inclusive of all costs related to concreting in any thickness, shape and position and at any height or depth so as to avoid any cold joint between specified construction joints.

22.1.7 Form Work

Unless otherwise specified, payment for form work shall be on square metre basis of the actual area in contact with the concrete cast. The rates shall be inclusive of keeping the formwork for th full period as specified in the above clauses and removing the same after the period is over. No extra payment shall be made for providing scaffolding/ staging/ access/ stairways/ ladders etc.

The rates shall be inclusive of any prov1s1on to be made or kept m the formwork for providing dowels, inserts etc.

Superior quality formwork for exposed/architectural concrete work shall be measured and paid separately under the relevant item in the schedule of rates.

22.2 Reinforcement

22.2.1 Payment for plain round mild steel reinforcement bars, high strength deformed steel bars and epoxy coated reinforcing steel bar shall be on the basis of weight of bare steel irrespective of any coating applied in metric tons. The weight of the bar shall be derived from the sizes and corresponding nominal unit weight given in Table- I of IS: 1786. In case actual unit weight of the bars is less than nominal unit weight, but within permissible tolerances, the weight of reinforcement shall be calculated on the basis of actual unit weight. In case actual unit weight of the bars is more than nominal unit weight, the payment shall be made on the basis of nominal unit weight. Standard hook lengths, chairs, spacer bars and authorized laps only shall be included in the weight calculated. Binding wire shall not be weighed nor otherwise measured. Measurements for weight shall not include cutting allowance etc.

22.2.2 Rate quoted for reinforcement shall include cost of supplying, decoiling, straightening, cleaning, cutting, bending, placing, binding, welding (if required) and providing necessary cover blocks of concrete.

22.2.3 Payment for a mechanical threaded coupler/ clamp shall be made by measuring the Lap length of the respective rebar on which coupler/ clamp is used. The rate shall include supply of complete assembly, fixing, testing etc. all complete.

22.3 Water Stops/Water Bars & Expansion/Isolation Joints

22.3.1 Payment for PVC water bars shall be made on running metre (RM) basis of the water stops provided in position. Rate shall include supplying cutting, fixing, jointing by vulcanising or any other approved method, wastage, etc. complete.

22.3.2 Payment for filler materials in Expansion/Isolation joints shall be made on running metre basis of the joint provided. For boards provided at expansion/isolation joints, the measurement shall be made on square metre basis. Rate shall be inclusive of supply, cutting, fixing, jointing, wastage etc. complete.

22.4 Waterproof Cement Paint

22.4.1 Payment for waterproof cement paint as per Cl. 18.0 shall be made separately on Sqm basis.

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS
STRUCTURAL STEEL WORKS

C-SPC-106

0	26.02.22	ISSUED FOR USE AS STANDARD	MK	ADh	RKB	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AFC	:	Approved For Construction
AWS	:	American Welding Society
BIS	:	Bureau of India Standards
IS	:	Indian Standard

CONTENTS

1.0 SCOPE

This specification describes the information to be included in a Project Specification and also covers the requirements for material, storage, preparation of fabrication drawings, fabrication, assembly, tests/examinations, transportation, erection and painting of all types of bolted and/or welded structural steel works for general construction work. Fabrication of structures shall also include fabricating:

(a) Built up sections/plate girders made out of rolled section and/or plates.

(b) Compound sections made out of rolled sections.

2.0 REFERENCES

2.1.1 BIS Codes

IS: 800, 808, 816, 819, 822, 919, 1024, 1261, 1323, 1477, 1852, 2074, 7205, 7215, 7307,

7310, 7318, 9595, 12778 and other relevant BIS Codes.

SP: 6(1)

2.1.2 International Standard

AWSDI.1

2.2 PLECO Specifications

C-SPC-102- Materials

6-79-0020 (or relevant Job Specification)- Surface preparation & protective coating (New construction)

2.3 In case of conflict between the clauses mentioned in this specification and those in the Indian Standards, this specification shall govern. Any special provision as shown or noted on the design drawings or any project specific specification specified elsewhere shall govern over the provisions of this specification.

3.0 MATERIALS

3.1 General

All materials shall conform to their respective specifications given in PLECO Specification no. C-SPC-102. The use of equivalent or alternative materials shall be permitted only in very special cases and for all such cases prior written approval of the Engineer-in-Charge shall be obtained.

3.2 Receipt & Storing of Materials

3.2.1 Each section shall be marked for identification and each lot shall be accompanied by manufacturer's quality certificate, chemical analysis and mechanical characteristics.

3.2.2 All sections shall be checked, sorted out and arranged by grade and quality in the store. Any instruction given by the Engineer-in-Charge in this respect shall be strictly followed.

3.2.3 All material shall be free from surface defects such as pitting, cracks, laminations, twists etc. Defective material shall not be used and all such rejected material shall be immediately removed from the store/site. The decision of the Engineer-in- Charge in this regard shall be final and binding.

3.2.4 Welding wires and electrodes (packed in their original cartons) shall be stored separately by quality and lots inside a dry and enclosed room in compliance with IS:9595 and as per the instructions given by the Engineer-in-Charge. Electrodes shall be kept perfectly dry to ensure satisfactory operation and weld metal soundness.

3.2.5 Each lot of electrodes, bolts, nuts etc. shall be accompanied by manufacturer's quality/test certificates.

3.2.6 All bolts (including nuts & washers) shall be checked, sorted out and arranged diameter-wise by grade and quality in the store.

3.3 Material Tests

3.3.1 The Contractor shall submit manufacturers' quality certificates for all the materials supplied by him. In case, quality certificates are not available or are incomplete or when material quality differs from standard specifications, such materials shall not be used in the construction. However, the Contractor shall get all appropriate tests conducted in approved test houses for such materials as directed by the Engineer-in-Charge, at no extra cost, and submit the same to Engineer-in-Charge for his approval. The Engineer-in-Charge may approve the use of such materials entirely at his discretion.

3.3.2 The Contractor shall ensure that all materials brought to site are duly approved by the Engineer-in-Charge. Rejected materials shall not be used and shall be removed from site forthwith. Any material of doubtful quality for which specific tests are to be carried out as per the instruction of the Engineer-in-Charge shall be separately stacked and properly identified and shall not be used. These shall be removed from site forthwith.

4.0 FABRICATION DRAWINGS

4.1 Fabrication and erection drawings shall be prepared by the Contractor on the basis of "Approved for Construction" (AFC) design drawings, PLECO Standards issued to the Contractor. These drawings shall be prepared by Contractor or by an agency engaged by the contractor using TEKLA or AUTODESK Advance Steel or equivalent 3D Modeling software and approved by the Engineer-in-Charge.

4.2 Fabrication and erection drawings shall be thoroughly checked, stamped "Approved for Construction" and signed by the Contractor's own responsible Engineer irrespective of the fact that such drawings are prepared by the Contractor or his approved agency, to ensure accuracy and correctness of the drawings. Unchecked and unsigned drawings shall not be used for the purpose of proceeding with the work. The Contractor shall proceed with the fabrication and erection work only after thoroughly satisfying himself in this regard.

4.3 All fabrication and erection drawings shall be issued for construction by the Contractor directly to his work- site. Six copies of such drawings shall simultaneously be submitted to the Engineer-in-Charge who may check/ review some or all such drawings at his sole discretion and offer his comments for incorporation in these drawings by the Contractor.

However, the Contractor shall not proceed with the fabrication of such structures whose fabrication drawings are required to be reviewed before taking up the fabrication work as noted on "Approved for Construction (AFC)" design drawings issued to the Contractor or as conveyed by the Engineer-in-Charge. The fabrication of such structures shall be done only as per the reviewed fabrication drawings.

The review of such drawings by PLECO shall be restricted to the checking of the following only:

i) Structural layout, orientation and elevation of structures/members.

ii) Sizes of members.

iii) Critical joint details.

4.4 Fabrication drawings shall be drawn to scale and shall convey the information clearly and adequately. Following information shall be furnished on such drawings:

i) Reference to design drawing number (along with revision number) based on which fabrication drawing has been prepared.

ii) Structural layout, elevations & sections (with distinct erection marking of all members).

iii) Framing plans, member sizes, orientation and elevations.

iv) Layout and detailing of rain water pipes and gutters showing all necessary levels, connections and provisions wherever required.

v) Detailing of shop/field joints, connections, splices, for required strength and erection.

vi) Location, type, size and dimensions of welds and bolts.

vii) Shapes and sizes of edge preparation for welding.

viii) Details of shop and field joints/welds.

ix) Bill of materials/D.O.D. Lists.

x) Quality of structural steel, plates etc., welding electrodes, bolts, nuts and washers to be used.

xi) Erection assemblies identifying all transportable parts and sub-assemblies with special erection instructions, if required.

xii) Method of erection and special precautions to be taken during erection as required.

xiii) Details of holes and fittings in components necessary for safe lifting and erection purpose.

4.5 The Contractor shall additionally ensure accuracy of the following and shall be solely responsible for the same:

i) Provision for erection and erection clearances.

ii) Marking of members

iii) Cut length of members

iv) Matching of joints and holes.

v) Provision kept in the members for other interconnected members.

vi) Bill of materials/D.O.D. Lists.

4.6 Connections, splices and other details where not shown on the design drawings shall be suitably designed and shown on the fabrication drawings based on good engineering practice developing full member strength. Design calculations for such connections/ splices shall be submitted to the Engineer-in-Charge alongwith the fabrication drawings.

4.7 Any substitution or change in section shall be allowed only when prior written approval of the Engineer-in-Charge has been obtained. Fabrication drawings shall be updated incorporating all such substitutions/changes by the Contractor at no extra cost to the Owner.

4.8 In case during execution of the work, the Engineer-in-Charge on review of drawings considers any modifications/ substitutions necessary to meet the design parameters/ good engineering practice, these shall be brought to the notice of the Contractor who shall incorporate the same in the drawings and works without any extra cost to the owner. The Contactor will be totally responsible for the correctness of the detailed fabrication drawings and execution of the work.

4.9 Contractor shall incorporate all the revisions made in the design drawings during the course of execution of work in his fabrication drawings, and resubmit the drawings at no extra cost to the Owner. All fabrication shall be carried out only as per the latest AFC design drawings and corresponding fabrication drawings.

4.10 The Contractor shall supply two prints each of the final/as built drawings alongwith their native soft file to Engineer-in-Charge for reference and record. The rates quoted shall include for the same.

5.0 FABRICATION

5.1 General

5.1.1 Fabrication of structures shall be done strictly as per "Approved for Construction" fabrication drawings (prepared by the Contractor based on the latest design drawings) and in accordance with IS:800, 9595 & other relevant BIS Codes and BIS Hand Book SP:6(1).

5.1.2 Prior to commencement of structural fabrication, undulations in the fabrication yard, if any, shall be removed and area levelled and paved by the Contractor.

5.1.3 Any defective material used in the work shall be replaced by the Contractor at his own expense. Necessary care and precautions shall be taken so as not to cause any damage to the structure during any such removal and replacement.

5.1.4 Any faulty fabrication pointed out at any stage of work by the Engineer-in- Charge, shall be made good or replaced by the Contractor at his own cost.

5.1.5 Tolerances for fabrication of steel structures shall be as per IS:7215.

5.2 Fabrication Procedure

5.2.1 Straightening & Bending

5.2.1.1 All materials shall be straight and, if necessary, before being worked shall be straightened and/or flattened (unless required to be of curvilinear form) and shall be free from twists.

5.2.1.2 Bending of rolled sections and plates shall be done by cold process to shape/s as shown on drawings.

5.2.1.3 After completion of bending or straightening, welds within the area of bending or straightening shall be thoroughly visually inspected. Nondestructive tests required to be carried out for such locations shall be done only after straightening or bending activity.

5.2.2 Clearances

The erection clearance for cleated ends of members shall be not greater than 2mm at each end. The erection clearance at ends of beams without web cleats and end plates shall be not more than 3mm at each end but where for practical reasons, greater clearance is necessary, suitably designed seatings approved by the Engineer-in-Charge shall be provided.

5.2.3 Cutting

5.2.3.1 Prior to cutting, all members shall be properly marked showing the requisite cut length/width, connection provisions e.g. location and dimensions of holes, welds, cleats etc. Marking for cutting shall be done judiciously so as to avoid wastages or unnecessary joints as far as practicable. Marking shall be done by placing the members on horizontal supports/pads in order to ensure accuracy. Marking accuracy shall be limited to+ 1mm.

5.2.3.2 Cutting may be affected by shearing, cropping or sawing. Gas cutting by mechanically controlled torch shall be permitted for mild steel. Hand flame cutting may be permitted subject to the approval of the Engineer-in-Charge.

5.2.3.3 Except where the material is subsequently joined by welding, no loads shall be transmitted into metal through a gas cut surface.

5.2.3.4 Shearing, cropping and gas cutting shall be clean, square, free from any distortion & burrs, and should the Engineer-in-Charge find it necessary, the edges shall be ground afterwards, to make the same straight and uniform at no extra cost to the Owner.

5.2.4 Holing

5.2.4.1 Holes for bolts shall not be formed by gas cutting process.

5.2.4.2 Holes through more than one thickness of material of members such as compound stanchions and girder flanges shall, where possible, be drilled after the members are assembled and tightly clamped/bolted together. Punching may be permitted before assembly, provided the thickness of metal is less than 16mm and the holes are punched 3mm less in diameter than the required size and reamed, after assembly, to the full diameter. Punching shall not be adopted for dynamically loaded structures.

5.2.4.3 Holes may be drilled in one operation through two or more separable parts and burrs removed from each part after drilling.

5.2.4.4 Holes in connecting angles and plates, other than splices, also in roof members and light framing, may be punched full size through material not over 12mm thick, except where required for close tolerance bolts or barrel bolts.

5.2.4.5 All matching holes for black bolts shall register with each other so that a gauge of 2mm less in diameter than the diameter of hole shall pass freely through the assembled members in the direction at right angle to such members. Finished holes shall be not more than 2mm in diameter larger than the diameter of the black bolt passing through them, unless otherwise specified by the Engineer- in-Charge.

5.2.4.6 Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to HS tolerance specified in IS:919. Parts to be connected with close tolerance or barrel bolts shall be firmly held together by tacking bolts or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all the thicknesses in one operation shall be drilled to a smaller size and reamed out after assembly. Where this is not possible, the parts shall be drilled and reamed separately.

5.2.4.7 To facilitate grouting, holes shall be provided in column bases or seating plates exceeding 300mm in width for the escape of air.

5.2.4.8 To avoid accumulation of water in gussetted column bases of laced, battened or box type stanchions, suitable reverse U-type holes shall be provided at the junction of base plate and column section in the vertical gussets for draining out of any water.

5.2.4.9 Slotted holes shall be punched or formed by drilling two holes and completed by cutting.

5.2.5 Assembly

The component parts shall be assembled and aligned in such a manner that they are neither twisted nor otherwise damaged, and shall be so prepared that the required camber, if any, is provided. Proper clamps, clips,jigs and other fasteners (bolts and welds) shall be placed in a balanced pattern to avoid any distortion in the members and to ensure their correct positioning (i.e. angles, axes, nodes etc.). Any force fitting, pulling/stretching of members to join them shall be avoided. Proper care shall be taken for welding shrinkage & distortion so as to attain the finished dimensions of the structure shown on the drawings.

5.2.6 Welding

5.2.6.1 General

a) All joints shall be welded unless noted otherwise on the design drawings.

b) Welding shall be in accordance with IS:816, IS:819, IS:1024, IS:1261, IS:1323 and IS:9595 as appropriate.

c) The Contractor shall make necessary arrangement for providing sufficient number of welding sets of the required capacity, all consumables, cutting and grinding equipment with requisite accessories/ auxiliaries, equipment & materials required for carrying out various tests such as dye penetration, magnetic particle, ultrasonic etc.

d) Adequate protection against rain, dust, snow & strong winds shall be provided to the welding personnel and the structural members during welding operation. In the absence of such a protection no welding shall be carried out.

e) It shall be the responsibility of the Contractor to ensure that all welding is carried out in accordance with the terms of this specification and relevant BIS codes. The Contractor shall provide all the supervision to fulfil this requirement.

5.2.6.2 Preparation of Member for Welding

a) Edge Preparation

Edge preparation/bevelling of fusion faces for welding shall be done strictly as per the dimensions shown in the drawings. In case, the same are not indicated, edges shall be prepared (depending on the type of weld indicated in the drawing) as per the details given in IS:9595. Bevelling of fusion faces shall be got checked and approved by the Engineer- in-Charge. The tolerances on limits of gap, root face & included angle shall be as stipulated in IS:9595.

b) Cleaning

Welding edges and the adjacent areas of the members (extending upto 20mm) shall be thoroughly cleaned of all oil, grease, scale and rust and made completely dry. Gaps between the members to be welded shall be kept free from all foreign matter.

c) Preheating

Preheating of members, shall be carried out as per IS:9595 when the base metal temperature is below the requisite temperature for the welding process being used. Preheating shall be done in such a manner that the parts, on which the weld metal is being deposited, are above the specified minimum temperature for a distance of not less than 75mm on each side of the weld line. The temperature shall be measured on the face opposite to that being heated. However, when there is access to only one face, the heat source shall be removed to allow for temperature equalization (1 minute for each 25mm of plate thickness) before measuring the temperature.

d) Grinding

i) Column splices & butt joints of struts and compression members (depending on contact for load transmission) shall be accurately ground and close-butted over the whole section with a tolerance not exceeding 0.2mm locally at any place. In column caps & bases, the ends of shafts together with the attached gussets, angles, channels etc., shall be accurately ground so that the parts connected butt over minimum 90% surface of contact. In case of connecting angles or channels, care shall be taken so that these are fixed with such accuracy that they are not reduced in thickness by grinding by more than 2mm.

ii) Ends of all bearing stiffeners shall be ground to fit tightly at both top and bottom. Similarly bottom of the knife edge supports along with the top surface of column brackets shall be accurately ground to provide effective bearing with a tolerance not exceeding 0.2mm locally at any place.

iii) Slab bases and caps shall be accurately ground over the bearing surfaces and shall have effective contact with the ends of stanchions. Bearing faces which are to be grouted direct to foundations need not be ground if such faces are true & parallel to the upper faces.

iv) Tack welding shall be thoroughly removed by grinding or gouging such that subsequent welding shall be done properly.

5.2.6.3 Welding Processes

Welding of various materials under this specification shall be carried out using one or more of the following processes.

Manual Metal Arc Welding Process (MMAW) Submerge Arc Welding Process (SAW)

Gas Metal Arc Welding Process (GMAW) Flux Cored Arc Welding Process (FCAW)

The welding procedure adopted and consumables used shall be specifically approved by the Engineer-in-Charge. A combination of different welding processes or a combination of electrodes of different classes/makes may be employed for a particular joint only after qualifying the welding procedures to be adopted and obtaining the written approval of the Engineer-in-Charge.

5.2.6.4 Approval & Testing of Welders

The Contractor shall satisfy the Engineer-in-Charge that the welders are suitable for the work upon which they will be employed. For this purpose the welders shall have satisfied the relevant requirements of IS:7318 or AWS D1.1. If the welders will be working to approved welding procedures, they shall have satisfied the relevant requirements of IS:7310 orAWSDl.1.

Adequate means of identification shall be provided to enable each weld to be traced to the welder by whom it was made. The Contractor shall intimate the Engineer-in-Charge sufficiently in advance, the commencement of tests, to enable him to be present to witness the same.

5.2.6.5 Approval & Testing of Welding Procedures

The Contractor shall carry out procedure tests in accordance with IS:7307 or AWS D1.1 to demonstrate by means of a specimen weld of adequate length on steel representative of that to be used, that he can make welds with the welding procedure to be used for the work to the complete satisfaction of the Engineer- in-Charge. The test weld shall include weld details from the actual construction and it shall be welded in a manner simulating the most unfavourable instances of fit-up, electrode condition etc., which are anticipated to occur on the particular fabrication. Where material analysis is available, the welding procedure shall be carried out on material with the highest carbon equivalent value.

After welding, but before the relevant tests given in IS:7307 or AWS D1.1 are carried out, the test weld shall be held as long as possible at room temperature, but in any case not less than 72 hours, and shall then be examined for cracking. The examination procedure shall be sufficiently rigorous to be capable of revealing significant defects in both parent metal and weld metal.

After establishing the welding method, the Contractor shall finally submit to the Engineer-in-Charge for his approval the welding procedure specification in standard format given in IS:9595 before starting the fabrication.

5.2.6.6 Sequence of Welding

a) As far as practicable, all welds shall be made in a sequence that will balance the applied heat of welding while the welding progresses.

b) The direction of the general progression in welding on a member shall be from points where the parts are relatively fixed in position with respect to each other towards points where they have a greater relative freedom of movement.

c) All splices in each component part of a cover-plated beam or built up member shall be made before the component part is welded to other component parts of the member.

d) Joints expected to have significant shrinkage shall be welded before joints expected to have lesser shrinkage.

e) Welding shall be carried continuously to completion with correct number of runs.

f) The Contractor shall choose the welding sequence after carefully studying each case such as to minimize distortion and shrinkage & submit the same to the Engineer-in-Charge for comments and approval.

5.2.6.7 Welding Technique

a) After the fusion faces are carefully aligned and set with proper gaps, the root pass of butt joints shall be executed properly so as to achieve full penetration with complete fusion of the root edges.

b) On completion of each run, all slag and spatters shall be removed and the weld and the adjacent base metal shall be cleaned by wire brushing and light chipping. Visible defects such are cracks, cavities and other deposition faults, if any, shall be removed to sound metal before depositing subsequent run of weld.

c) All full penetration butt welds shall be completed by chipping/gouging to sound metal and then depositing a sealing run of weld metal on the back of the joints. Where butt welding is practicable from one side only, suitable backing steel strip shall be used and joint shall be arranged in such a way as to ensure that complete fusion of all the parts is readily obtained.

d) While welding is in progress care shall be taken to avoid any kind of movement of the components, shocks, vibrations to prevent occurrences of weld cracks.

e) Any deviation desired from the recommended welding technique and electrodes shall be adopted only after obtaining written approval of the Engineer-in-Charge.

5.2.6.8 Inspection & Testing of Welds

The method of inspection shall be according to IS:822 and extent of inspection and testing shall be in accordance with the relevant applicable standard or, in the absence of such a standard, as specified by the Engineer-in-Charge. Welds shall not be painted or otherwise obscured until they have been inspected, approved and accepted.

The Engineer-in-Charge or his representative shall have access to the Contractor's work at all reasonable times and the Contractor shall provide him with all facilities necessary for inspection during all stages of fabrication and erection with, but not limited to, the following objectives.

i) To check the conformity with the relevant standards and suitability of various welding equipments and their performance.

ii) To witness/approve the welding procedure qualification.

iii) To witness/approve the welders performance qualification.

iv) To check whether shop/field welding being executed is in conformity with the relevant specifications and codes of practice.

Inspection and testing of all fabricated structures shall be carried out by the Contractor by any, or, a combination of all the following methods as directed by the Engineer-in-Charge and no separate payment shall be made, unless otherwise mentioned, for inspection and testing of welds/fabricated structures:

A. Visual Inspection

All finished welds (i.e. 100 percent) shall be visually inspected for identification of the following types of weld defects & faults.

a) Weld defects occurring at the surface such as blow holes, exposed porosity, unfused welds etc.

b) Surface cracks in the weld metal or in the parent metal adjacent to it.

c) Damages to the parent metal such as undercuts, burning, overheating etc.

d) Profile defects such as excessive convexity or concavity, overlapping, unequal leg lengths, excessive reinforcement, incompletely filled grooves, excessive penetration beads, root grooves etc.

e) Distortion due to welding i.e., local shrinkage, camber, bowing, twisting, rotation, wariness etc.

f) Linear eccentric, angular and rotational misalignment of parts.

g) Dimensional errors.

B. Mechanical Tests

The mechanical testing (such as tensile load tests, bend tests, impact tests etc.) shall be done in accordance with the relevant standards and as per the instructions of the Engineer-in-Charge.

C. Magnetic Particle/Dye Penetration/Ultrasonic Examination

The examination shall be done at random as directed by the Engineer-in-Charge. Whenever such tests are directed, the tests shall be carried out on joints chosen by him. The tests shall be carried out by employing approved testing procedure in accordance with IS:822.

D. Radiographic Examination

Radiographic examination shall be carried out only in special cases for random joints as directed by the Engineer-in-Charge. The Contractor shall be paid extra for such examination except for penalty radiographic tests for which the cost shall be borne by him. The Contractor shall make necessary arrangement at his own expense for providing the radiographic equipment, films and all other necessary materials required for carrying out the examination. The tests shall be carried in the presence of the Engineer-in-Charge by employing approved testing procedure in accordance with IS:822. The Contractor shall fulfill all the statutory safety requirements while handling X-ray and Gamma-ray equipment and provide the Engineer- in-Charge all the necessary facilities at site such as dark room, film viewer etc., to enable him to examine the radiographs.

5.2.6.9 Repair of Faulty Welds

No repair of defective welds shall be carried out without proper permission of the Engineer-in-Charge and his approval for the corrective procedure.

Welds not complying with the acceptance requirements (as specified by BIS Codes & the Engineer-in-Charge), as revealed during inspection & testing of welds or erection or in-situ condition, shall be corrected either by removing & replacing or as follows:

a) Excessive convexity	- Reduced to size by removal of excess weld metal.
b) Shrinkage cracks, cracks in in parent plates and craters	- Defective portions removed down to sound metal and re-welded.
c) Under cutting.	- Additional weld metal deposited.
d) Improperly fitted/ misaligned parts	- Welding cut & edges suitably prepared and parts.

.e) Members distorted by the heat of welding	- Member straightened by mechanical means or careful application of limited amount of heat, temperature of such area not to exceed 650 degree Centigrade (dull red heat).

In removing defective parts of a weld, gouging, chipping, oxygen cutting or grinding shall not extend into the parent metal to any substantial amount beyond the depth of weld penetration, unless cracks or other defects exist in the parent metal. The weld or parent metal shall not be undercut in chipping, grinding, gouging or oxygen cutting.

Any fabricated structure or its component which, in the opinion of Engineer- in-Charge, is defective and/or beyond any corrective action shall be removed forthwith from the site as instructed by the Engineer-in-Charge without any extra claim. The owner reserves the right to recover any compensation due to any loss arising out of such rejections.

5.2.7 Bolting

5.2.7.1 All bolts shall be provided such that no part of the threaded portion of the bolts is within the thickness of the parts bolted together. Washers of suitable thickness shall be used under the nuts to avoid any threaded portion of the bolt being within the thickness of parts bolted together.

5.2.7.2 The threaded portion of each bolt shall project through the nut at least one thread.

5.2.7.3 Flat washers shall be circular and of suitable thickness. However, where bolt heads/nuts bear upon the bevelled surfaces, they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

5.2.7.4 Different bolt grades of the same diameter shall not be used in the same structure, except if agreed otherwise by the Engineer-in-Charge.

5.2.7.5 Bearing type bolts shall be used (unless noted otherwise) and tightened firmly by available means.

5.2.8 Splicing

5.2.8.1 Splicing of built up/compound/latticed sections shall be done in such a fashion that each component of the section is joined in a staggered manner.

5.2.8.2 Where no butt weld is used for splicing, the meeting ends of two pieces of joist/channel/built up section shall be ground flush for bearing on each other and suitable flange and web splice plates shall be designed and provided for the full strength of the flange/ web of the section and welds designed accordingly.

5.2.8.3 Where full strength butt weld is used for splicing (after proper edge preparation of the web and flange plates) of members fabricated out of joist/ channel/ angles/ built up section, additional flange and web plates shall be provided, over and above the full strength butt welds, to have 40% strength of the flange and web.

5.2.8.4 Where a cover plate is used over a joist/channel section the splicing of the cover plate and channel/joist sections shall be staggered by minimum 500mm. Extra splice plate shall be used for the cover plate and joist/channel section as per clause 5.2.8.2 or 5.2.8.3.

5.2.8.5 Prior approval shall be obtained by the Contractor for locations of splices where not shown on design drawings. For members upto a length of 7m, generally no splice shall be allowed but in exceptional cases one splice shall be allowed at approved location. Maximum two numbers of splices shall be allowed for members exceeding this length.

5.2.9 Machining & Grinding

5.2.9.1 All slab bases and slab caps shall be accurately machined over the bearing surfaces and shall be in effective contact with the ends of column sections (shafts).

5.2.9.2 For slab bases and slab caps, ends of column shafts shall be accurately machined. However, for gussetted bases and caps, the column shafts shall be ground flush for effective contact with parts connected together.

5.2.9.3 Gussetted bases and caps shall be ground flush for effective contact with ends of column sections.

5.2.9.4 End of all bearing stiffeners shall be machined or ground to fit tightly at top and bottom without any air gap.

5.2.9.5 While machining or grinding care shall be taken so that the length or thickness of any part does not get reduced by more than 2.0mm.

5.2.9.6 For all machining or grinding works for gassetted base and cap plates, the clearance between the parts joined shall not exceed 0.2mm at any location.

6.0 MARKING FOR IDENTIFICATION

6.1 Each component shall be distinctly marked (with paint) before delivery in accordance with the marking diagrams and shall bear such other marks as will facilitate erection. Components which are identical in all respects may have the same erection mark.

6.2 For small members which are delivered in bundles or crates, the required marking shall be done on small metal tags securely tied to the bundle.

7.0 SHOP ERECTION

The steel work shall be temporarily shop erected complete or as directed by the Engineer-in-Charge, so that the accuracy of fit may be checked before despatch.

8.0 INSPECTION & TESTING OF STRUCTURES

8.1 The Engineer-in-Charge (or his authorised representative) shall have free access at all times to those parts of the Contractor's works which are concerned with the fabrication of the steel work and shall be provided with all reasonable facilities for satisfying himself that the fabrication is being undertaken in accordance with the provisions of these specifications & other relevant BIS Codes.

8.2 Should any structure or part of a structure be found not to comply with any of the provisions of this specification (or relevant BIS Codes as referred to), it shall be liable to rejection. No structure or part of the structure, once rejected shall be resubmitted for inspection, exception cases where the Engineer-in-Charge or his authorised representative considers the defect as rectifiable.

8.3 Defects which may appear during/after fabrication/ erection shall be made good only with the consent of the Engineer-in-Charge and procedure laid down by him.

8.4 All necessary gauges and templates shall be supplied free to the Engineer-in-Charge by the Contractor whenever asked for during inspection. The Engineer-in- Charge, may at his discretion, check the test results obtained at the Contractor's works by independent tests at a test house, and the cost of such tests shall be borne by the Contractor.

9.0 SHOPPAINTING

9.1 All components and members of steel work shall be given one shop coat of primer, as specified in the tender, immediately after the surfaces have been properly prepared (i.e. degreased, derusted, descaled & cleaned) in accordance with the job specifi ation or 6-79-0020, as applicable.

The primer coat shall be applied over completely dry surfaces (using brushes of good quality) in a manner so as to ensure a continuous and uniform film without "holidaying". Special care shall be taken to cover all the crevices, comers, edges etc. However, in areas which are difficult to reach by brushing, daubers/mops shall be used by dipping the same in paint and then pulling/ pushing them through the narrow spaces. The primer coat shall be air dried and shall have the thickness as per PLECO Specification no. C-SPC-157 or the relevant job specification.

9.2 Surfaces which are inaccessible after shop assembly, shall receive the full specified protective treatment before assembly (this shall not apply to the interior of sealed hollow sections).

9.3 Steel surfaces shall not be painted within a suitable distance of any edges to be welded if the paint specified would be harmful to welders or impair the quality of the welds.

9.4 Welds and adjacent parent metal shall not be painted prior to deslagging, inspection and approval by the Engineer-in-Charge.

9.5 Parts to be encased in concrete shall have only one coat of primer and shall not be painted after erection.

10.0 PACKING

10.1 All items shall be suitably packed in case these are to be despatched from the fabrication shop to the actual site of erection so as to protect them from any damage/distortion or falling during transit. Where necessary, slender projecting parts shall be temporarily braced to avoid warping during transportation.

10.2 Small parts such as gussets, cleats etc., shall be securely wired on to their respective main members.

10.3 Bolts, nuts washers etc. shall be packed in crates.

11.0 TRANSPORTATION

Loading and transportation shall be done in compliance with transportation rules. In case, certain parts can not be transported in the lengths stipulated on the drawings, the position details of such additional splice joints shall be gqt approved by the Engineer-in- Charge.

12.0 SITE (FIELD) ERECTION

12.1 Plant & Equipment

The suitability and capacity of all plant and equipment used shall be to the complete satisfaction of the Engineer-in-Charge.

12.2 Storing & Handling

All steel work shall be so stored and handled at site so that the members are not subjected to surface abrasion, excessive stresses and any damage.

12.3 Setting Out

Prior to setting out of the steel work, the Contractor shall get himself satisfied about the correctness of levels, alignment, location of existing concrete pedestals/columns/brackets and holding down bolts/pockets provided therein. Any minor modification in the same including chipping, cutting and making good, adjusting the anchor bolts etc., if necessary, shall be carried out by the Contractor at his own expense. The positioning and levelling of all steel work including plumbing of columns and placing of every part of the structure with accuracy shall be in accordance with the drawings and to the complete satisfaction of the Engineer-in-Charge.

12.4 Tolerances

Tolerances for erection of steel structures shall be as per Annexure 'A'

13.0 SAFETY & SECURITY DURING ERECTION

13.1 The contractor shall comply with IS:7205 for necessary safety and adhere to safe erection practices and guard against hazardous as well as unsafe working conditions during all stages of erection.

13.2 During erection, the steel work shall be securely bolted or otherwise fastened and when necessary, temporarily braced/guyed to provide for all loads to be carried by the structure during erection till the completion, including those due to the wind, erection equipment & its operation etc. at no extra cost to the owner. For the purpose of guying, the Contractor shall not use other structure in the vicinity without prior written permission of the Engineer-in-Charge.

13.3 No permanent bolting or welding shall be done until proper alignment has been achieved.

13.4 Proper access, platform and safety arrangement shall be provided for working and inspection, (at no extra cost to the owner) whenever required.

14.0 FIELD CONNECTIONS

14.1 Field Bolting

Field bolting shall be carried out with the same care as required for shop bolting.

14.2 Field Welding

All field assembly and welding shall be executed in accordance with the requirements for shop assembly and welding. Holes for all erection bolts - where removed after final erection shall be plugged by welding. Alternatively erection bolts may be left and secured.

15.0 GROUTING

15.1 Prior to positioning of structural columns/girders/ trusses over the concrete pedestals/columns/brackets, all laitance & loose material shall be removed by wire brushing & chipping. The bearing concrete surfaces shall be sufficiently levelled, hacked with flat chisels to make them rough, cleaned (using compressed air) and made thoroughly wet. All pockets for anchor bolts shall also be similarly cleaned and any excess water removed. Thereafter, the structural member shall be erected, aligned & plumbed maintaining the base plates/shoe plates at the levels shown in the drawings, with necessary shims/pack plates/wedges.

15.2 After final alignment and plumbing of the structure, the forms shall be constructed allround and joints made tight to prevent leakage. Grouting (under the base plates/shoe plates including grouting of sleeves & pockets) shall be done with non-shrink grout having compressive strength (28 days) not less than 40N/sq.mm Non shrink grout shall be of free flow premix type and of approved quality and make. It shall be mixed with water in proportion as specified by the manufacturer. Ordinary 1:2 cement/sand mortar grout shall be used only for small, isolated structures e.g. operating platforms not supporting any equipment, pipe supports, crossovers, stairs & ladders. The thickness of grout shall be as shown on the drawings but not less than 25 mm nor more than 40mm in any case.

15.3 The grout mixture shall be poured continuously (without any interruption till completion) by grouting pumps from one side of the base plate and spread uniformly with flexible steel strips and rammed with rods, till the space is filled solidly and the grout mixture carried to the other side of the base plate.

15.4 The grout mixture shall be allowed to harden for a period as decided by the Engineer-in-Charge. At the end of this period, the shims/wedges/pack plates may be removed and anchor bolts tightened uniformly. The alignment of the structure shall now be rechecked and if found correct, the voids left by the removal of shims/wedges/pack plates (if removed) must be filled up with a similar mixture of grout. In case after checking, serious misalignment is indicated, the grout shall be removed completely and fresh grouting done after making appropriate correction of alignment.

16.0 SCHEME AND SEQUENCE OF ERECTION

The Contractor shall furnish the detailed scheme and sequence of erection to match with the project schedule and get the same approved by the Engineer-in- Charge. All necessary co-ordination and synchronization shall be done with the Civil contractor where Civil works are not included in the scope of structural contractor at no extra cost so as to match with the project schedule.

17.0 PAYMENT

This clause shall apply to Item Rate tender only.

17.1 Payment for structural steel works shall be made on the basis of admissible weight in metric tons (determined as described in clause 17.2 and 17.3) of the structure accepted by the Engineer-in-Charge. The rate shall include supplying (as per supply conditions given in the Tender) fabricating, erecting in position (at all levels & locations), testing/examining (excluding radiography only) of bolted and/or welded structural steel works of all types (including all built up/compound sections made out of rolled sections and/or plates) including all handling, transporting, storing, straightening if required, cutting, edge preparation, preheating, bolting and welding of joints (including sealing the joints of box sections with continuous welding), finishing edges by grinding/machining as shown, fixing in line & level with temporary staging & bracing and removal of the same after erection, grouting with non-shrink/ordinary grout as specified, preparation of fabrication & erection drawings, & erection schedule and getting them reviewed, preparation and submission of as built drawings, preparing the surfaces for painting, and applying the primer as specified after fabrication, return of surplus materials to owner's stores and material reconciliation in the case of materials supplied by the owner as per relevant contract conditions etc. all complete for all the operations mentioned in the foregoing clauses.

17.2 The weight for payment shall be determined from the fabrication drawings and respective bill of materials prepared by the Contractor. The bill of materials shall be checked and approved by the Engineer-in-Charge before making the payment. The Contractor shall prepare full scale template in order to supplement/verify the actual cutting dimensions where so directed by the Engineer-in-Charge. The weight shall be calculated on the basis of BIS Hand Book wherever applicable. In case sections used are different from BIS sections, then Manufacturers' Hand Book shall be adopted. No allowance in weight shall be made for rolling tolerances.

17.3 Welds, bolts, nuts, washers, shims, pack plates, wedges, grout and shop painting shall not be separately measured. The quoted rate shall be deemed to include the same.

17.4 The rate shall include all expenses related to safety & security arrangements during erection and all plants & tools required for fabrication, transportation & erection.

18.0 PAINTING AFTER ERECTION

18.1 General

18.1.1 The scope of painting after erection shall be at the sole discretion of the Engineer-in-Charge and the Contractor shall obtain written instruction in this regard sufficiently prior to taking up any procurement of paint and execution of painting work after erection of steel structures.

18.1.2 The Contractor shall carry out the painting work in all respects with the best quality of approved materials (conforming to relevant PLECO Specification no. C-SPC-157 or the job specification, as applicable) and workmanship in accordance with the best engineering practice. The Contractor shall furnish characteristics of paints (to be used) indicating the suitability for the required service conditions. The paint manufacturer's instructions supplemented by Engineer-in-Charge's direction, if any, shall be followed at all times. Particular attention shall be paid to the following:

- Proper storage to avoid exposure & extremes of temperature.
- surface preparation prior to painting.
- Mixing & thinning.
- Application of paint and the recommended limit on time intervals between consecutive coats.

18.1.3 Painting shall not be done in frost or foggy weather, or when humidity is such as to cause condensation on the surfaces to be painted.

18.1.4 Surface which shall be inaccessible after site assembly shall receive the full specified protective treatment before assembly.

18.1.5 Primers & finish coat paints shall be from the same manufacturer in order to ensure compatibility. Painting colour code shall be as per Annexure-'B' or the job specification.

18.2 Rub Down & Primer Application

The shop coated surfaces shall be rubbed down thoroughly with emery/abrasive paper to remove dust, rust, other foreign matters and degreased, if required, in accordance with PLECO specification no. C-SPC-157 or the job specification, as applicable, cleaned with warm fresh water and air dried. The portions, from where the shop coat has peeled off, shall be touched up and allowed to dry.

Primer coat as per PLECO specification no. C-SPC-157 or the job specification, as applicable, shall be applied by brushing/ spraying over the shop coat in a manner so as to ensure a continuous and uniform film throughout. Special care shall be taken to cover all the crevices, comers, edges etc. The final primer coat shall be air dried and shall have a minimum film thickness as per PLECO Specification no. C-SPC-157 or job specification after drying, as applicable.

In case a different cleaning procedure & primer specifications are specified m the drawing/Tender, the same shall be adopted.

18.3 Final Paint Application

After the primer is hard dry, the surfaces shall be dusted off and the paint as per PLECO specification no. C-SPC-157 or the job specification, as specified, shall be applied by brushing/spraying so that a film free from "holidaying" is obtained. The colour & shade of first coat of paint shall be slightly lighter than the second coat in order to identify the application of each coat. The second coat of paint shall be applied after the first coat is hard dry. The minimum thickness of each film shall be 20 microns (± 10% tolerance) after drying. ·

In case a different type of paint & painting procedure are specified in the drawing/tender, the same shall be adopted.

18.4 Inspection & Testing of Painting Works

18.4.1 All painting materials including primers & thinners brought to site by the Contractor for application shall be procured directly from reputed and approved manufacturers and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates shall not be accepted.

18.4.2 The Engineer-in-Charge at his discretion may call for additional tests for paint formulations. The Contractor shall arrange to have such tests performance including batch wise test of wet paints for physical & chemical analysis. All costs shall be borne by the Contractor.

18.4.3 The painting work shall be subject to inspection by the Engineer in-Charge at all times. In particular, the stage inspection will be performed and Contractor shall offer the work for inspection and approval at every stage before proceeding with the next stage. The record of inspection shall be maintained. Stages of inspection are as follows:

(a) Surface preparation

(b) Primer application

(c) Each coat of paint

18.4.4 Any defect noticed during the various stages of inspection shall be rectified by the Contractor to the entire satisfaction of the Engineer-in-Charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work the Contractor shall be responsible for making good any defects found during final inspection/guarantee period/defect liability period, as defined in General Conditions of Contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat. The thickness shall be measured at as many locations as decided by the Engineer-in-Charge. The Contractor shall provide standard thickness measuring instrument such as elkometer (with appropriate range for measuring dry film thickness of each coat) free of cost to the Engineer-in-Charge whenever asked for.

18.5 Payment

Payment for painting of structural steel works shall be made on the basis of admissible weight in metric tons of the painted structures accepted by the Engineer-in-Charge.

The rate shall include supplying & applying the paint, specified in the tender, of approved quality and shade over the primer, specified in the tender, over the shop primer already applied to structural steel works of all types/shapes at all levels, locations & positions including storage, surface preparation, degreasing, cleaning, drying, touching up of shop primer coat, providing temporary staging, testing etc. all complete to the entire satisfaction of the Engineer-in-Charge.

ANNEXURE-'A'
(CLAUSE 12.4)

Maximum Permissible Erection Tolerances

A. Columns

1. Deviation of column axes at foundation top level with respect to true axes.

    i) In longitudinal direction ±5mm

    ii) In lateral direction ±5mm

2. Deviation in the level of bearing surface of columns at foundation top with respect to true level

    ±5mm

3. Out of plumb (Verticality) of column axis from true vertical axis, as measured at top:

    i) Upto and including 30m height whichever is less ± H/1000 or± 25 mm

    ii) Over 30m height ± H/1200 or± 35 mm whichever is less

4. Deviation in straightness in longitudinal & transverse planes of column at any point along the height.

    ± H/1000 or ± 10 mm whichever is less.

5. Difference in the erected positions of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance. ± 5 mm

6. Deviation in any bearing or seating level with respect to true ± 5 mm level.

7. Deviation in difference in bearing levels of a member on adjacent pair of columns both across & along the building. ± 5 mm

B. Trusses

1. Shift at the centre of span of top chord member with respect to the vertical plane passing through the centre of bottom chord.

    ± 1/250 of height of truss in mm at centre of span or± 15mm whichever is less.

2. Lateral shift of top chord of truss at the centre of span from the vertical plane passing through the centre of supports of the truss.

    ± 1/1500 of span of truss in mm or ± 10mm Whichever is less.

3. Lateral shift in location of truss from its true position ± 10mm

4. Lateral shift in location of purlin from true position. ±5mm

5. Deviation in difference of bearing levels of truss from the true level.

   ± 1/1200 of span of truss in mm or 20mmwhichever is less

C. Gantry Girders & Rails

1. Shift in the centre line of crane rail with respect to centre line of web of gantry girder.

   $\pm \left[\frac{\{\text{web thickness (mm)}\}+2}{2}\ \text{mm}\right]$

2. Shift of alignment of crane rail (in plan) with respect to true axis of crane rail at any point.

   ± 5mm

3. Deviation in crane track gauge with respect to true gauge.

   i) For track gauge upto and including 15 m. ± 5mm.

   ii) For track gauge more than 15m. ± [5 + 0.25 (S-15)]

   Subject to maximum± 10mm, where S in metres is true gauge.

4. Deviation in the crane rail level at any point from true level. ± 10mm.

5. Difference in level between crane track rails (across the bay) at

   i) Supports of gantry girders 15mm.

   ii) Mid span of gantry girders 20mm

6. Relative shift of crane rail surfaces (at a joining) in plan and elevation. 2mm.

ANNEXURE –'B'
(CLAUSE 18.1)

PAINTING COLOUR CODE FOR STRUCTURAL STEEL

1	GANTRY GIRDER & MONORAIL	DARK GREEN
2	GANTRY GIRDER & MONORAIL STOPPER SIGNAL	RED
3	BUILDING STRUCTURAL STEEL COLUMNS, BRACKETS, BEAMS, BRACINGS, ROOF TRUSS PURLINS, SIDEGIRTS, LOUVERS, STRINGERS	DARK ADMIRALITY GREY
4	PIPE RACK STRUCTURE & TRESTLE	DARK ADMIRALITY GREY
5	CHEQUERED PLATE (BOTH FACES)	BLACK
6	GRATING	BLACK
7	LADDER RUNGS	BLACK
8	HAND RAILING	VERTICALS & CAGE RED
	HANDRAIL, MIDDLE RAIL, TOE PLATE	SIGNAL RED
	VERTICAL POST	BLACK

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS
MISCELLANEOUS STEEL WORKS

C-SPC-108

0	26.02.22	ISSUED FOR USE AS STANDARD	MK	ADh	RKB	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AFC	:	Approved for Construction
BIS	:	Bureau of Indian Standards
IS	:	Indian Standard
M.S.	:	Mild Steel
PCC	:	Plain Cement Concrete
RCC	:	Reinforced Cement Concrete

CONTENTS

1.0 GENERAL

1.1 All materials supplied by the Contractor shall conform to specifications given m PLECO Standard Specification No. C-SPC-102.

1.2 The Contractor shall furnish test certificates for all materials prior to their use in the works. Structural steel materials not supported by mill test certificates may be used after confirming their quality by carrying out appropriate tests in accordance with the method specified in IS:1608.

1.3 Other requirements not covered under this specification shall be in accordance with PLECO Standard Specification No. C-SPC-102.

2.0 REFERENCES

As mentioned in the respective clauses.

3.0 MATERIAL

As mentioned in the respective clauses.

4.0 ANCHOR BOLTS

4.1 Material

Materials for anchor bolts, nuts, lockouts, washers, pipe sleeves and anchor plates shall conform to their respective clauses given in PLECO Standard Specification No. C-SPC-102.

4.2 Fabrication

Fabrication of anchor bolts and their complete assemblies shall be strictly in compliance with the specifications and drawings/standards.

4.3 Placement

Anchor bolt assemblies shall be placed in position strictly as per drawings and securely held during pouring and vibrating of concrete with necessary templates and other dummy structures to prevent their dislocation.

4.4 Tolerances

Tolerances allowed for anchor bolts positioning shall be as below:

a) For sleeved bolts, one tenth of the bolt nominal diameter.

b) For bolts without sleeves, one twentieth of the bolt nominal diameter.

4.5 Protection

The exposed surfaces of bolts shall be properly covered (after greasing of bolts and packing of sleeves) with jute cloth so as to protect them from damage till final erection of structure/ equipment is over.

4.6 Payment

4.6.1 Payment shall be made on the basis of actual weight in metric tons of the anchor bolt/anchor bolt assembly. The rate shall include supply (as per scope of supply conditions given in the tender) of all materials, handling, transporting, fabrication, turning from available size to required diameter, threading, welding, fixing in position at all levels and locations, providing necessary templates, greasing, packing of sleeves, covering with jute cloth and other protective measures etc. all complete.

4.6.2 The rate shall cover bolt of any diameter and nomenclature.

4.6.3 Payment for fixing anchor bolt assembly (already fabricated and supplied by the Owner as free issue) in position shall be made on the basis of actual weight of anchor bolts/bolt assemblies in metric tons. The rate shall include handling, transporting, fixing in position at all levels and locations, welding if required, providing necessary templates, greasing, packing of sleeves, covering with jute cloth and other protective measures etc. all complete.

4.6.4 No separate payment shall be made for templates, dummy structures, supports etc. and the rate quoted shall be inclusive of all cost related to such provision required for correct and accurate installation of anchor bolts/anchor bolt assembly.

5.0 METAL INSERTS

5.1 Material

Materials required for fabricating metal inserts shall conform to their respective specification given in PLECO Standard Specification No. C-SPC-102.

5.2 Fabrication

Fabrication of inserts shall be done strictly as per drawings/standards and in compliance with the requirements given in PLECO Standard Specification No. C-SPC-106.

5.3 Placement

Metal inserts shall be correctly embedded (in plain concrete/ reinforced concrete) as per their location shown on the drawings. Care shall be taken that these are securely held in position and do not get disturbed during concreting. Where necessary, these may be welded to the reinforcement bars. Suitable templates, spacers, dummy structures and temporary staging shall be provided. Necessary cutting in the formwork and adjustment of reinforcement bars shall be done for the placement of metal inserts where required.

5.4 Painting

The exposed surfaces of metal inserts shall be cleaned and given one coat of primer as per PLECO Standard Specification No. C-SPC-157 or job specification (wherever applicable), as specified, after fabrication.

5.5 Payment

Payment shall be made on the basis of actual weight in metric tons of the metal inserts. The rate shall include supply (as per supply conditions given in the tender) of all materials, handling, transporting, fabrication, welding, fixing in position at all levels and locations, providing necessary templates, spacers, dummy structures, adjusting the formwork and reinforcement, staging, preparation of surface for painting, applying one coat of primer as per PLECO Standard Specification No. C-SPC-157 or job specification (wherever applicable), as specified, etc. all complete.

6.0 CHEQUERED PLATES

6.1 Material

Material required for chequered plates shall conform to the specifications given in PLECO Standard Specification No. C-SPC-102. Chequering shall be closed or open-ended or of any other pattern as shown on drawings.

6.2 Fabrication Drawings

As per the requirements given in PLECO Standard Specification No. C-SPC-106.

6.3 Fabrication

Chequered plates shall be fabricated as per the "Approved for Construction" fabrication drawings (prepared by the Contractor based on design drawings). These shall be perfectly flat and without any dents/deformations and shall be cut to the required size and shape. Holes/ notches/ openings of the required size, if any, shown on drawings shall be made. Nosing for staircase treads shall be made by cold bending of chequered plates. All edges shall be made smooth and even. All chequered plate units shall be given distinct erection marks in accordance with the marking drawings. Stiffeners of any description shall be welded with the chequered plates where shown on drawings.

6.4 Erection/Fixing

Chequered plates shall be fixed to the bearing members by welding/ bolting/ screwing as shown on drawings. All bolts/ screws shall be of counter-sunk type so that the heads remain flush with the top of plate. Where welding is used for fixing, stitch welds of minimum 50mm length with a pitch of 150 mm shall be used. Continuous sealing run of weld shall be provided along the junction of two consecutive chequered plates parallel to the span. For removeable flooring, details as shown on drawings shall be followed.

6.5 Painting

Chequered plates shall be cleaned (both the surfaces) and given one coat of primer/ galvanization as per PLECO Standard Specification No. C-SPC-157 or job specification, as specified, on both surfaces.

6.6 Payment

6.6.1 Payment shall be made on the basis of actual weight in metric tons of the chequered plate. If any stiffening sections are provided below the chequered plates for strengthening,.the same shall be separately measured & paid under Structural Steel item (Refer PLECO Standard Specification No. C-SPC-106).

6.6.2 The rate shall include supplying (as per supply conditions given in the tender), fabricating, erecting M.S. chequered plates including transporting, handling, straightening if required, cutting to required size and shape, making holes/ notches/ opening of required size and nosing, smoothening the edges, fixing by welding/bolting/screwing, at all levels and locations, preparing detailed fabrication drawings, surface cleaning, removal of rust, scale, grease and applying one coat of primer/ galvanization as per PLECO Standard Specification No. C-SPC-108 or job specification (wherever applicable), as specified, etc. all complete.

6.6.3 Welds, bolts, nuts, screws, washers, clips shall not be measured. The quoted rate shall be deemed to include the same.

7.0 GRATINGS

7.1 Categories

The electro forged galvanized gratings shall be either Type-I or Type-II as per PLECO Standard No. C-SPC-005 and shall be procured from approved manufacturers as per Vendor List.

7.2 Material

Materials for fabrication and fixing of Gratings shall conform to specifications given in PLECO Standard Specification No. C-SPC-102.

7.3 Fabrication Drawings

As per the requirements given in PLECO Standard Specification No. C-SPC-106.

7.4 Fabrication

The gratings shall be manufactured by electroforging process strictly as per the "Approved for Construction" fabrication drawings prepared by the Contractor based on PLECO standard. All units shall be given distinct erection marks in accordance with the marking drawing. The Contractor shall submit sample gratings for inspection and approval by the Engineer-in-Charge whenever asked for.

7.5 Erection/Fixing

Gratings shall be fixed to the bearing members by welding/ clamping and bolting as indicated in the Standard.

7.6 Galvanisation

Gratings and the fixing clamps, bolts, nuts shall be cleaned with wire brush and galvanization shall be done in accordance with IS: 2629 and tested as per IS: 2633 & 6745. Quantity of zinc coating shall be minimum 900 gm/sq.m. of surface area (0.12mm uniform thickness).

7.7 Payment

7.7.1 Payment shall be made on the basis of actual weight in metric tons of the gratings manufactured in accordance with PLECO Standard and accepted by the Engineer-in-Charge.

The weight.for payment shall also include the weight of galvanization and welding.

7.7.2 The rate shall include supplying, fabricating, erecting electroforged galvanized gratings (of the specified category) including transporting, handling, cutting to required size and shape, making holes/ notches/ openings, smoothening the edges, fabricating clamps, fixing by welding/ clamping/ bolting, at all levels and locations, preparing detailed fabrication drawings, surface cleaning, removal of rust, scale, grease and carrying out galvanization, all complete.

7.7.3 Bolts, clamps, nuts and washers shall not be measured. The quoted rate shall be deemed to include the same.

8.0 TUBULAR HAND RAILING

8.1 Material

Materials for fabrication and fixing of Tubular Hand Railing shall confirm to specification given in PLECO Standard Specification No. C-SPC-102.

8.2 Fabrication Drawings

As per the requirements given in PLECO Standard Specification No. C-SPC-106.

8.3 Fabrication

8.3.1 Hand railing shall be fabricated strictly as per the "Approved for Construction" fabrication drawings prepared by the Contractor based on design drawings and standards. All tubes shall be straight and without any dents/ deformations. Tubes shall be cut and ends shall be prepared to a neat and workman-like finish. All elements shall be directly welded. All welded joints shall be cleaned and filed or ground smooth, if required, to have a smooth surface and aesthetically pleasant appearance. Splicing of top rail shall not be allowed. Tubes shall be cold bent to shape and curvature in case of discontinuous ends of handrails. Ripples, kinks and/ or dents at bends shall not be accepted.

8.3.2 Lower ends of vertical posts shall be cut and splayed (for grouting in pockets in the concrete members). For removable type of hand railing, suitable base plates (with provision for bolting) shall be welded to the lower end of vertical posts. All units shall be given distinct erection marks in accordance with the marking drawing.

8.4 Erection/ Fixing

Hand railing, shall be fixed to the bearing members by welding/ bolting/ grouting as indicated on the drawings. Local notching shall be made in the floor plate/ grating to accommodate vertical posts/ their base plates which shall always be welded to the main supporting member. When the posts are to be fixed in concrete members, suitable pockets shall be made in concrete for grouting as shown on drawings/standards.

8.5 Painting

Tubes shall be cleaned with wire brush and given coat of primer as per table 29 of IS: 800, as specified, after fabrication.

8.6 Payment

8.6.1 Payment shall be made on the basis of measured length in meters (m) of top rail only (Horizontal and/or inclined lengths). The rate shall include preparation of fabrication drawings, supply of all materials, handling, transporting, straightening if required, cutting to required size, bending, welding, bolting, fixing in position at all levels and locations, grouting with 1:2 (cement:sand) mortar, surface cleaning, removal of rust, scale, grease and applying coat of primer as per table 29 of IS: 800, as specified, after fabrication etc. all complete.

8.6.2 The rate shall include making suitable notches in floor plates/ gratings and pockets m concrete structures for fixing the vertical posts.

9.0 MILD STEEL RUNGS

9.1 Material

All materials shall conform to specifications given in PLECO Standard Specification No. C-SPC-102.

9.2 Fabrication

Rungs shall be fabricated as per standards/drawings. Mild steel bars shall be straightened if required, cut, bent to shape and given coat of primer on exposed portions.

9.3 Fixing

Rungs shall be fixed in position as per detailed drawing and firmly tied/welded with reinforcement to prevent their displacement during vibration of concrete.

9.4 Payment

Payment shall be made on the basis of actual weight in kilogram (Kg) of the M.S. rungs. The rate shall include supply of all materials, handling, transporting, straightening if required, cutting to required size, bending to shape, tying/welding with reinforcement bars, fixing at all levels and locations, adjustment of formwork, applying coat of primer as per table 29 of IS: 800, as specified, and two coats of anti-corrosive paint or any other paint, as specified, on the exposed portion of rungs etc. all complete.

10.0 LIGHT GAUGE STEEL STRUCTURAL SECTIONS

10.1 Material

All materials required for fabrication and fixing in position of Light Gauge Steel Structural Sections shall conform to PLECO Standard Specification No. C-SPC-102.

10.2 Fabrication Drawings

As per the requirements given in PLECO Standard Specification No. C-SPC-106.

10.3 Fabrication

10.3.1 Fabrication of members shall be done strictly as per the "Approved for Construction" fabrication drawings prepared by the Contractor based on the latest design drawings and in accordance with IS 800, IS 801 and other relevant BIS Codes.

10.3.2 All members shall be straight and free from any dents/deformations/ twists. Members shall be cut to the required sizes and ends prepared to a neat and workman like finish. Holes (for sag rods and cleat bolts) of appropriate size shall be drilled and all members/ components shall be given distinct erection marks in accordance with the marking drawings. Holes shall not be formed by gas cutting process.

10.4 Erection

Structural members shall be erected in proper sequence and aligned properly without causing any twist. Permanent bolting/ welding shall be done only after proper alignment has been achieved. Proper access, working platforms and safety arrangements shall be provided by the Contractor for working and inspection.

10.5 Painting

All structural components shall be cleaned thoroughly and given coat of primer as per table 29 of IS: 800, as specified, after fabrication.

10.6 Payment

10.6.1 Payment shall be made on the basis of admissible weight in metric tons of the structure accepted by the Engineer-in-Charge. The weight for payment shall include all structural members, cleats, splices, gussets and sag rods and shall be determined from the fabrication drawings along with respective bill of materials prepared by the Contractor. The bill of materials shall be checked and approved by the Engineer-in-Charge before making the payment. The weight shall be calculated as per IS 808/ IS 1161. BIS Handbook/ Manufacturer's catalogues/ charts shall be adopted in case relevant weights of sections used are not covered in IS 808/ IS 1161. No allowance in weight shall be made for rolling tolerances. In case of any doubt, actual weight of the section shall be measured at site.

The rate shall include supplying, fabricating, erecting, at all levels and locations, testing of bolted and/ or welded Light Gauge structural steel works including cleats, crook bolts, splices/ sleeves, all other fixtures and accessories, straightening if required, cutting, edge preparation, welding and bolting of joints, fixing in line and level with temporary staging and removal of the same after final alignment, handling, transporting, storage, preparation of detailed fabrication drawings and getting them reviewed by the Engineer-in-Charge, surface cleaning, removal of scale, rust, oil or grease and painting as per clause no. 8.5 above etc., all complete.

10.6.2 All welds, bolts, nuts, washers, fixtures and accessories shall not be measured. The quoted rate shall be deemed to include the same.

11.0 EXPANSION FASTENERS

11.1 Material

Expansion fasteners (medium and heavy duty) shall be of mild steel/ high tensile steel with rust proof coating.

11.2 Classification

The expansion fasteners shall be designated as medium and heavy duty depending on their usage. The broad classification is given below for general guidance.

11.2.1 Medium Duty (Mild steel/ High tensile steel) for:

a) Ladders and stairs supports.

b) Cables and cable trays supports.

c) Electrical panels and fixtures.

d) Hangers for pipes and cable trays.

e) Pipe supports.

11.2.2 Heavy Duty (Mild steel/ High tensile steel) for:

a) Platform supports (beam and columns)

b) Knee brackets for pipes/ multi tiers cable trays/ walkways etc.

Note:- Expansion fasteners shall not be used for:

1. Members supporting equipment and pipes subjected to vibrations.
2. Cantilever connections designed to cater for effective cantilever spans greater than 1,000 mm and 1,000 Kg of concentrated load at the free end.

11.3 Selection

The Contractor shall procure the expansion fasteners from the approved manufacturers as per Vendor List.

11.4 Testing

If so desired by the Engineer-in-Charge, the Contractor shall carry out all the requisite tests (pullout test, torque test etc.) of specimen expansion fasteners (representative of those to be used) from approved laboratory/ test house and submit the report to him for approval. The decision of the Engineer-in-Charge regarding the adequacy of strength and load carrying capacity of the expansion fastener shall be final and binding to all. The cost of all such tests shall be borne by the Contractor.

11.5 Installation

The Contractor shall install the expansion fasteners at their correct location (to suit the requirement of fixtures as shown in drawings) as per the procedure laid down by the manufacturer. Location of all holes shall be pre-marked on the concrete surfaces and then holes drilled carefully with an electric drill to the correct recommended size and depth. Holes shall be exactly round and true perpendicular to the concrete surface. Edge distance and pitch of fasteners shall be as recommended by the manufacturer. The contractor shall suitably shift the hole with the approval of the Engineer-in-Charge in case any reinforcement bar is met with while drilling the hole in RCC structure. Necessary staging shall be provided for working and the Contractor shall take requisite safety precautions so as not to cause any damage to the existing structure/ equipment. Any damage done while executing the job shall be made good by the Contractor at his cost.

11.6 Protection

The exposed surfaces of expansion fasteners shall be properly greased & covered with jute cloth so as to protect the from damage.

11.7 Payment

Payment for installing rust proof expansion fasteners shall be made on number basis (each). The rate shall include supply of complete assembly, handling, transporting, providing necessary temporary staging, installing (as per manufacturer's specifications) in PCC/ RCC structures, at all levels and locations, testing, drilling, cleaning, covering with jute cloth, relocating and re-drilling in case of any obstruction, making good any damage done to the structure, grouting the abandoned holes and any gap left between the contact surfaces of PCC/ RCC and fixtures to be added, etc. all complete.

12.0 CHEMICAL ANCHORS AND DOWELS

12.1 Material

Chemical Anchors shall be of high tensile steel rods of minimum grade 5.8 galvanised to at least 5 microns.

Grade of Rebars for chemical anchoring shall be as per the General Notes of the project.

12.2 Selection

The Contractor shall select the chemical anchors based on the parameters such as Loads and rebars for dowels as specified in the AFC drawings/ documents. The chemical anchors shall be procured from the approved manufacturers as per Vendor List.

12.3 Testing

The Contractor shall carry out, at the work place, the requisite tests like pull out test, shear test, etc. for chemical anchors and pull out test for dowels. The chemical anchors shall withstand the load specified in the drawing/ documents and the Dowels shall be tested for full tensile capacity of the rebars. The decision of the Engineer-in-Charge regarding the adequacy of strength and load carrying capacity of the anchors/ dowels shall be final and binding to all. The cost of all such tests shall be borne by the Contractor.

12.4 Installation

The Contractor shall install the chemical anchors/ dowels at their correct location (to suit the requirement of fixtures as shown in drawings) as per the procedure laid down by the manufacturer. Location of all holes shall be pre-marked on the concrete surfaces and then holes drilled carefully with an electric drill to the correct recommended size and depth. Holes shall be exactly round and true perpendicular to the concrete surface. Edge distance and pitch of fasteners shall be as recommended by the manufacturer. The contractor shall suitably shift the hole with the approval of the Engineer-in-Charge in case any reinforcement bar is met with while drilling the hole in RCC structure. Necessary staging shall be provided for working and the Contractor shall take requisite safety precautions so as not to cause any damage to the existing structure/ equipment. Any damage done while executing the job shall be made good by the Contractor at his cost.

12.5 Payment

Payment for installing chemical anchors shall be made on number basis (each). The rate shall include supply of complete assembly i.e. chemical anchors along with chemical foils as per manufacturer specifications.

Payment for installing chemical dowels shall be made on number basis (each). The rate shall include fixing of dowels by drilling/ cleaning hole and injecting odourless chemical as per manufacturer specifications. Rebars used as dowels shall be paid separately under relevant SOR item.

For chemical anchors/ dowels, the rate shall be inclusive of handling, transporting, providing necessary temporary staging, installing (as per manufacturer's specifications) in PCCI RCC structures to a required depth with a specified hole diameter, at all levels and locations, testing, drilling holes, cleaning, covering with jute cloth, relocating and re-drilling in case of any obstruction, making good any damage done to the structure, grouting the abandoned holes and any gap left between the contact surfaces of PCC/ RCC and fixtures to be added, etc. all complete.

STANDARD SPECIFICATION

CIVIL & STRUCTURAL WORKS

MISCELLANEOUS ITEMS

C-SPC-112

0	26.02.22	ISSUED FOR USE AS STANDARD	MK	ADh	RKB	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

BIS	:	Bureau of Indian Standards
DPC	:	Damp Proof Course
FGL	:	Finished Ground Level
IS	:	Indian Standard
RCC	:	Reinforced Cement Concrete

CONTENTS

1.0 SCOPE

The scope shall be as specified separately for different items below.

2.0 REFERENCES

2.1 BIS Codes

1. IS:73 Paving bitumen - specification
2. IS:383 Specification for coarse and fine aggregates from natural sources for Concrete
3. IS:6313 Code of practice for Anti-termite measures in buildings

2.2 PLECO specifications

C-SPC-102: Materials

C-SPC-104: Plain and Reinforced Cement Concrete

3.0 MATERIALS

The materials shall be as specified separately for different items below.

4.0 GENERAL REQUIREMENTS

The Contractor shall test the materials, wherever applicable, in approved laboratory as required by the Engineer-in-Charge and furnish test certificates for materials and obtain the approval of the Engineer-in-Charge prior to the use of such materials in the works. All tests shall be in accordance with relevant Indian Standards.

5.0 PRE-CONSTRUCTIONAL ANTI-TERMITE TREATMENT

5.1 Scope

This specification establishes the materials and method of accomplishing pre-constructional anti-termite treatment of soil for protection of buildings against attack by subterranean termites with the usage of chemical emulsions in accordance with the procedure laid down.

5.2 Materials

Refer PLECO Specification No. C-SPC-102.

5.3 Procedure for Treatment

5.3.1 The treatment shall be carried out by an approved agency specialized in the field. Apart from this specification, the work shall be carried out in compliance with IS:6313. In case of any contradiction, this specification shall govern.

5.3.2 Site Preparation

Prior to start of Anti Termite treatment, area(s) shall be made free from logs, stumps, timber offcuts, leveling pegs, roots of plants/ trees etc. Soil treatment shall start when foundation trenches/ pits are ready to take concrete/ masonry in foundations and plinth area ready for laying the subgrade. Treatment shall not be carried out when it is raining or the subsoil water level is at the same or higher than the level of treatment. In the event of water-logging of foundations, the water shall be pumped out and the chemical emulsion applied when the soil is absorbent

5.3.3 Treatment of the excavated pits/ trenches and backfill for Foundations

a) The bottom surface and the lower 300 mm side surfaces of the excavated pits/ trenches for foundations of masonry works and RCC plinth beams supporting such masonry works, shall be treated with specified chemical emulsion @ 5 litres/m2 of the surface area. However, no such treatment shall be required in case of pits/ trenches made for RCC foundations supporting RCC walls and/ or columns.

b) On completion of construction of masonry foundations, the backfill in immediate contact with the substructure shall be treated in layers, of300 mm, with emulsion@ 7.5 litres/m2 of the vertical surface of the substructure (i.e. 7.5 x 0.3 = 2.25 litres/meter of perimeter) for each side. The treatment shall be given after ramming of each layer of soil, by rodding the earth at 150 mm centres close to the wall surface and working the rod backward and forward (parallel to the wall surface) and then spraying the specified dosage of emulsion. The emulsion shall be directed towards the masonry surfaces so that the soil in contact with these surfaces is well treated with the chemical. After the treatment, the soil shall be tamped back into place. This shall be done for full depth of the fill.

c) For RCC walls and columns, the treatment as specified in (b) shall start from a depth 500 mm below the finished ground level, and shall be done upto the FGL.

5.3.4 Treatment of Plinth/ Basement and Apron

a) The top surface of the consolidated earth below the non-suspended floor slabs and the peripheral aprons of widths upto 750 mm, the bottom surface and side surfaces of the excavated pits for the basements shall be treated with chemical emulsion @ 5 litres/m2 of the surface area. Holes 50 mm to 75 mm deep at 150 mm centre, both ways, shall be made on the surface with 12 mm diameter mild steel rod and then emulsion shall be sprayed uniformly over the area. At expansion joint locations, anti-termite treatment shall be supplemented by treating through the expansion joint @ 2.0 litres per linear metre of joint after the sub-grade has been laid.

b) Treatment of Junctions of plinth filling and wall/column faces shall be done after making a small channel 30 mm x 30 mm, by making rod holes 150 mm apart (upto the ground level) in the channel and then by moving the rod backward and forward to break up the earth. The chemical emulsion shall be poured along the channel @ 7.5 litres/m2 of the vertical wall/column surface so as to soak the soil right to the bottom. The soil shall be tamped back into place after the treatment.

5.3.5 Treatment of Soil along External Perimeter of Building

After the building is complete, the earth along the external perimeter shall be rodded at intervals of 150 mm and to depth of 300 mm. The rod shall be moved backward and forward parallel to the wall to break up the earth and chemical emulsion poured along the wall@7.5 litres/m2 of vertical surface (i.e. 7.5 x 0.3 = 2.25 litres/metre of perimeter). After the treatment, the earth shall be tamped back into place.

5.4 Payment

This clause shall apply to Item Rate tender only.

Payment for pre-constructional anti-termite treatment shall be made on square metre (sq.m.) basis of plinth area of the building at ground floor only.

The rate shall include supplying all materials, spray pumps, tools, tackles & other accessories, labour, site preparation, rodding, tamping, mixing, spraying the specified chemical emulsion at prescribed dosage, storage facilities, handling, transporting etc. all complete as directed & specified.

6.0 ANTI-CORROSIVE LAYER

6.1 Scope

This specification covers the requirement of materials. method of preparation and procedure for laying an anticorrosive layer over top surface of tank foundations for protection of bottom plates of steel tanks against corrosion attack.

6.2 Materials

6.2.1 Sand shall be clean, dry, coarse, hard, angular, free from coatings of clay, dust and mix of vegetable and organic matter and shall conform to IS:383 - Grade III.

6.2.2 Bitumen shall be of grade VGI0 conforming to IS:73.

6.3 Mixing and Laying

The bitumen shall be heated till it melts. 3% kerosene may be added if required. Sand shall be thoroughly mixed with bitumen (8% to 10% by volume) in a mixing drum to give a uniform mixture and shall be laid over clean and dry surface of tank foundation to line, grade and levels as shown on the drawings and directed by the Engineer-in-Charge. Bitumen shall not be heated beyond the specified temperature limits. The layer shall be tamped to form hard mass of specified compacted thickness.

6.4 Payment

This clause shall apply to Item Rate tender only.

The payment shall be made on square metre (sq.m.) basis of the area covered with the anticorrosive layer.

The rate shall include supplying all materials, tools, plants, labour, transportation, handling, heating, mixing, laying, tamping etc. all complete as specified.

7.0 DRESSING & TRIMMING

7.1 Scope

This specification covers the procedure for dressing, trimming and paving with earth the peripheral area around the completed building/ structure.

7.2 Procedure

The ground all around the completed building/structure for 3 metres width or as specified by the Engineer-in-Charge, shall be cleaned and dressed to suitable slope. Over the prepared ground a layer of approved earth shall be spread, watered and well consolidated so as to achieve an average thickness of 75 mm.

7.3 Payment

This clause shall apply to Item Rate tender only.

Payment shall be made on square metre (sq.m.) basis of the actual area dressed and paved with earth.

The rate shall include supplying all materials, labour including cleaning, dressing the ground to required slope, spreading of earth, watering, ramming, consolidating etc. all complete as directed.

8.0 BREAKING PILE HEADS

8.1 Scope

This specification covers procedure for breaking pile heads of RCC piles.

8.2 Procedure

8.2.1 Head of already cast/ driven RCC piles shall be broken after 28 days of casting up to a length and elevation as shown on the drawing by chiseling or by approved mechanical means taking all necessary safety precautions. Care shall be taken that pile reinforcement is not cut or damaged during chiseling operation. All debris and loose or cracked concrete in the pile shall be removed and disposed off within the plant boundary as per the directions of the Engineer-in-Charge and site shall be left clean for casting of pile caps. The surface of reinforcement bars shall be cleaned, if required by wire brushing, so that no old concrete sticks to them.

8.3 Payment

This clause shall apply to Item Rate tender only.

Payment shall be made per pile basis for the actual number of pile heads broken.

The rate shall include supplying all tools and tackles, labour including disposal of debris, bending the pile reinforcements for proper anchorage within the pile cap etc. all complete as directed.

9.0 BUILDING-UP PILE HEADS

9.1 Scope

This specification covers requirements of materials and procedure for building-up of RCC Pile Heads.

9.2 Materials

9.2.1 Concrete shall be of the same grade & PLECO specification shall be same as that for the pile.

9.2.2 Reinforcement shall be of the same grade as that for the pile.

9.2.3 Type of cement shall be same as that used for the pile.

9.3 Procedure

Concrete in ex1stmg piles shall be chiseled off minimum upto the lap-length of the reinforcements in the pile. In cases where reinforcements are longer than the concreted piles, the top concrete of the existing piles shall be chiseled or by approved mechanical means upto a length of 800 mm.

Concrete surface and reinforcement of pile shall be cleaned of any dirt, grease, debris etc. and concrete surface shall be made rough by hacking. Reinforcement shall be lapped/ welded as per the direction of the Engineer-in-Charge. Neat cement slurry shall be applied on top surface of concrete and using approved formwork, concreting shall be done upto the level shown on the drawing and as directed by the Engineer-in-Charge.

9.4 Payment

This clause shall apply to Item Rate tender only.

Payment shall be made on cubic metre basis for the total quantity of concrete actually poured for achieving the level as shown on drawings.

The rate shall include supply of all materials (except reinforcement which shall be paid separately as per respective item) labour, cleaning, welding, shuttering, vibrating, finishing, curing etc. all complete. Cutting of pile heads and excavation including backfilling shall be paid separately as per respective item.

10.0 HARD CORE

10.1 Scope

This specification covers the requirements of materials and procedure for laying of hard core.

10.2 Materials

Hard core shall consist of broken/ crushed stones of 150 mm and down size. Stones shall be sound, angular, hard and free from flakes, dust and other impurities.

10.3 Procedure

Hard core shall be laid to the grade, level and thickness as shown on the drawing. Broken stones of required height shall be vertically placed and blinded with approved murrum/ sand and consolidated with roller including watering, dressing etc. However, areas inaccessible by roller may be compacted by hand rammer.

10.4 Payment

This clause shall apply to Item Rate tender only.

The hard core shall be measured on the basis of volume in cubic metres (cu.m.) of the compacted hard core laid. The rate shall include all labour, materials, consolidation by rammer/ roller, watering, dressing etc. all complete.

11.0 SAND FILLING IN PLINTH/FOUNDATIONS

11.1 For specification of sand to be used for filling, reference shall be made to PLECO Specification No. C-SPC-002.

11.2 Filling shall be carried out in layers not exceeding 150 mm and shall be compacted mechanically or by saturation to specified grade and level and to obtain 90% laboratory maximum dry density or as specified in schedule of rates.

11.3 Compaction by flooding may be accepted at the discretion of the Engineer-in-Charge, provided the required compaction is achieved.

11.4 The Contractor shall not commence filling in and around any work until it has been permitted by the Engineer-in-Charge.

11.5 Payment

This clause shall apply to Item Rate tender only.

Payment shall be made on cubic metre (cu.m.) basis of the finished compact volume. The rate shall include cost of sand for any compacted thickness, wastage if any, all handling, transport for all leads, tamping, watering, flooding, dressing etc. Any brick work required for ponding shall be paid separately under relevant item.

12.0 DAMP PROOF COURSE - (DPC)

12.1 All materials used for Damp Proof Course shall comply with PLECO Specification No. C-SPC-102.

12.2 The 40 mm thick Damp Proof Course shall consist of plain cement concrete of the same grade as used for RCC work.

12.3 The Damp Proof Course shall be laid at plinth level of masonry walls, flush with the floor surface and shall not be carried across doorways.

12.4 Before laying, the top surface of wall shall be thoroughly cleaned and watered. The DPC shall be laid in layers of 20 mm thickness retaining the edges by necessary formwork and shall be well tamped and troweled to smooth finish. The layer shall be cured by keeping the surface wet for 40 hours and after it has dried, two coats of hot bitumen of grade VG10 conforming to IS:73 shall be applied over it at the rate of 1.7 kg/m2• Over this, the second layer of 20 mm thick concrete shall be laid and cured as described in case of the first layer and two coats of hot bitumen at the rate of 1.7 kg/m2 shall be applied again in a similar manner. Over this, dry sharp sand shall be sprinkled evenly before hardening of second coat of bitumen paint.

12.5 Payment

This clause shall apply to Item Rate tender only.

Payment shall be made on square metre (sq.m.) basis of the area laid. The rate shall be inclusive of formwork, curing, providing and laying bitumen, supplying and spreading sand over bitumen etc. complete.

STANDARD SPECIFICATION
FOR
ARCHITECTURAL WORKS - GENERAL
C-SPC-151

0	26.02.22	ISSUED FOR USE AS STANDARD	MK	ADh	RKB	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

BIS	:	Bureau of Indian Standard
ASTM	:	American Society for Testing and Materials
BS	:	British Standards

CONTENTS

1.0 GENERAL

This specification establishes and defines various aspects of specifications of Architectural works such as codes, references, manufacturer, conflicts and contradictions, materials, workmanship, packaging, shipping, delivery and storage, testing, submittals and measurement etc. and shall be applicable for all the Architectural specifications.

2.0 DEFINITIONS

2.1 Contractor

The party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of the Project. Contractor includes its approved Manufacturers, Vendors, Suppliers, and subcontractor's. Requirements of this specification shall be enforced at all levels of the Contractor's design, engineering, procurement, construction process.

2.2 Subcontractor

The party which is engaged by the "Contractor" and carries out all or part of the design, engineering, procurement, construction of the system (s).

2.3 Manufacturer/ Supplier/ Vendor

The party which manufactures and/or supplies equipment, materials, technical documents/ drawings and services to perform the duties specified by the "Contractor".

2.4 Shall

Indicates a mandatory requirement.

2.5 Should

Indicates a strong recommendation to comply with the requirements of this document.

3.0 CODES & SPECIFICATIONS

Codes and standards as indicated in the specifications form a part of specifications. When an edition date is not indicated for a code or standard, the latest edition and addendum or amendment in force at time of contract award shall apply.

Alternate codes and standards meeting the requirements of the referenced codes and standards may be used with the approval of the competent authority.

It shall be Contractor's responsibility to be, or to become, knowledgeable of the requirements of any referenced codes and standards.

4.0 MANUFACTURER

Manufacturers listed for particular item in the specifications are the acceptable Manufacturers for that particular item. Products by other Manufacturers which are of equal quality and performance may be considered for approval upon review of information as required and submitted to the competent authority. However the contractor to ensure that the time schedule is adhered to in any case.

Product data sheet, specifications, performance data, installation instructions and other recommendations of such listed or approved Manufacturers also form part of the specifications subject to compliance with other requirements specified.

Materials, installation method and other requirements for execution of any item if required by Manufacturer's installation instructions, recommendations and requirements shall also form part of the specifications whether specified or not.

Specifications which are based on one particular manufacturer's product are for reference to maintain the quality.

5.0 CONFLICTS & CONTRADICTIONS

Specifications, Scope of Work, Schedule ofrates and drawings for a particular Tender shall be read in conjunction with each other. In case of conflicts/ contradictions amongst them, the clarification shall be obtained from the Engineer-In-Charge whose decision shall be final & binding. Following procedure shall be followed for the necessary clarification.

A. Item description shall prevail over specifications for item rate tenders when provisions therein are different from those in specifications. Whenever any requirement is not covered in item description but are covered in specifications, the specifications shall be followed in addition to the requirements of item description .No extra payment shall be made to the Contractor for executing such item as per specification.

B. Whenever drawings call for requirements different from or additional to those in item description and specification, the decision of the Engineer-In-Charge shall be obtained in writing. However no extra payment shall be made to the Contractor for executing any work incorporating requirements additional to those in item description and specification but covered in applicable drawings or standards attached to the tender.

6.0 MATERIALS

All materials shall be of standard quality conforming to the specifications & IS or equivalent such as ASTM, BS etc and shall be obtained from the approved Manufacturer.

The Contractor shall get the samples of materials approved by the Engineer-In-Charge before ordering & procurement. Such approved samples shall be properly marked/ identified as approved sample and shall be kept as record for future reference. The Contractor shall furnish necessary test certificates etc. as asked by the Engineer-In-Charge. Further to that he shall get the materials tested from approved test house if and as asked by the Engineers-In-Charge & submit the test certificate at his own cost for which no extra payment shall be made to him.

The Engineer-In-Charge shall have the right to reject all or any of the materials intended to be used and such materials shall be immediately removed from the site by the Contractor at his own cost without any claim for compensation etc. due to such rejection.

7.0 WORKMANSHIP

Workmanship shall conform to the highest standards of construction practice. All work shall be executed to the complete satisfaction of Engineer-in-charge in regard to its quality and the order in which it is carried out.

Workmanship shall be in accordance with relevant codes or in accordance with Manufacturer's recommendations if not mentioned otherwise.

All works shall be undertaken by qualified Contractor's who have adequate equipment and skilled workers. All specialized items of work (e.g. Aluminium Doors and Windows, Waterproofing, Underdeck and Overdeck Insulation, Precoated roof sheeting/ cladding, False ceiling, False Flooring, Partitioning and Panelling, Expansion joint sealing, Fire Check Doors, Structural Glazing, Aluminium Composite

Panels etc.) shall be got executed by the Contractor only through authorised applicators/ sub contractors of approved manufacturer/ vendor.

All precaution and protection shall be taken during & after completion of work to prevent damages to work being done and other works. Any damages done shall be rectified.

Work area shall be cleaned after completion of each work and shall be kept clean and protected till final acceptance by the competent authority.

8.0 PACKAGING, SHIPPING, DELIVERY & STORAGE

All material shall be delivered in Manufacturer's original package bearing the name of the Manufacturer, product colour and pattern name, identification number and other related information.

All materials shall be stored, preserved and protected to safeguard against all adverse environments such as humidity, moisture, rain, dust, dirt, sand, mud, salt air, salt spray and sea water.

Specific requirement of packaging, shipping, storage and preservation and safety of materials/ items if any as per Manufacturer's recommendation shall also be ensured by Contractor.

Materials damaged in handling and storage shall not be used. In the event that any material for use deteriorates and become unusable due to inadequate and poor storage they shall be removed from site as instructed by Engineer-in-charge and replaced at the Contractor's expenses.

9.0 SUBMITTALS

If not mentioned otherwise, Contractor shall submit the following for various items.

9.1 Samples

Samples for all materials, components, accessories and complete range of finishing/ shades/ colours for verification as well as acceptance of pattern, colour and finish as applicable. Samples shall be re-submitted until approved. Approved samples shall be retained to serve as a basis for checking delivery to site and standard for subsequent work.

9.2 Test and BIS Certificates

All applicable tests as per relevant codes & standards shall be conducted by the Contractor at no extra cost. Test Certificates shall be submitted for review/ approval of the Engineer-in- charge. If the material/ product is BIS certified/ approved, valid document pertaining to the same shall be submitted.

9.3 Shop Drawings

Shop drawings indicating large scale details, lay-out, connections, anchoring, fastening, bracing, finishes etc. as applicable for review/ approval.

9.4 Product Information and Manuals

A. Product information (Technical)

B. Manufacturer's recommended installation instructions

9.5 List of applicators/ Sub contractors

Contractor shall submit list of authorized applicators/ sub contractors of specialized items of works for review/ approval before execution of such items.

9.6 Maintenance manuals

10.0 MEASUREMENT

Mode of measurement is generally specified in each Specification. Whenever mode of measurement is not specified, IS: 1200 shall be applicable.

STANDARD SPECIFICATION
FOR
WHITE/ COLOUR WASHING, DISTEMPERING, PAINTING AND POLISHING
C-SPC-157

0	27.02.22	ISSUED FOR USE AS STANDARD	MK	ADh	RKB	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

IS	:	Indian Standard
ASTM	:	American Society for Testing and Materials
BS	:	British Standards

CONTENTS

1.0 GENERAL

Reference shall be made to the following Indian Standards for further information etc. not covered in the specification. In case of conflict/contradictions provisions of the specification shall override.

IS 6278	Code of practice for white washing and colour washing.
IS 2395	Code of practice for painting concrete, masonry and plaster surfaces. Specification for building limes.
IS 712	Specification for Ultramarine blue for paints. Specification for whiting for paint and putty.Distemper (dry), colour as required.
IS 55	Distemper (Oil Bound), colour as required. Specification for plastic Emulsion paint for interior use.
IS 63	Code of practice for finishing of wood, and wood based materials.Part-1 : Operations & workmanship
IS 427	Code of practice for finishing of wood, and wood based materials.Part-2 : Schedule
IS 428	Cement paint, colour as required.
IS 5411	Code of practice for painting non ferrous metals in buildings. Part-1 : Pretreatment
IS 2338 Part-1	Code of practice for painting non ferrous metals in buildings.Part-2 : Painting
IS 2338 Part-2	Code of practice for painting ferrous metals in buildings.Part-1 : Pretreatment
IS 5410	Code of practice for painting ferrous metals in buildings.Part-1 : Painting
IS 2524 Part-1	Brushes, paints and varnishes, flat.
IS 2524 Part-2	Brushes, sash, tool, for paints and varnishes.
IS 1477 Part-1	Ready mixed paint, brushing, grey filler enamels for use over primers.Paste filler for colour coats.
IS 1477 Part-2	Wood filler, transparent liquid.
IS 384	Ready mixed paint, aluminium brushing priming water resistant forwood work.
IS 486	Code of practice for white washing and colour washing.
IS 110	Code of practice for painting concrete, masonry and plaster surfaces. Specification for building limes.

IS 426	Specification for Ultramarine blue for paints. Specification for whiting for paint and putty.Distemper (dry), colour as required.
IS 345	Distemper (Oil Bound), colour as required. Specification for plastic Emulsion paint for interior use.
IS 110	Ready mixed paint, brushing, grey filler for enamels for use over primers
IS 106	Ready mixed paint, brushing, priming for enamels, for use on metals.
IS 2395 Part- I	Painting of concrete, masonry & plastered surface, code of practice Part- I : Operations and workmanship
IS 2395 Part-2	Painting of concrete, masonry & plastered surface, code of practice Part-2 : Schedule

All materials required for the execution of painting work shall be obtained direct from approved manufacturers and shall be brought to the site in makers drums, bags etc. with seals unbroken.

In case of ready mixed paints, thinning if necessary, the brand of thinner shall be as per recommendations of the manufacturer.

Paint shall be applied by brushing or spraying. The brushing operations are to be adjusted to the spreading capacity advised by the manufacturer. During painting, every time after the paint has been worked out of the brush bristles, the bristles shall be opened up by striking the brush suitably.

Spray machine used may be of high pressure type or low pressure depending on the nature and location of work. After work, the brushes shall be completely cleaned of paint and shall be hung in a thinner if intended to be used afterwards. The spray guns shall be cleaned thoroughly after every break in work. The paint containers, when not used shall be kept close and free from air.

After the finishing of work, the adjacent surfaces not intended to be washed/ distempered/painted/polished shall be thoroughly cleaned of all paint patches and shall be finished in accordance with surface finishing of such surfaces.

2.0 WHITE WASHING

White washing in general shall conform to IS 6278.

2.1 Workmanship

2.1.1 Scaffolding

Wherever scaffolding is necessary, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be white/ colour washed. For white washing of ceiling, proper stage scaffolding shall be erected.

2.1.2 Preparation of Surfaces

The surface shall be thoroughly cleaned of all dirt, dust, mortar dropping and other foreign matter before white wash is to be applied. Surfaces already white/colour washed shall be broomed down to remove all dust, dirt, loose scales of lime wash or other foreign matters.

All damaged portions of the surface plaster shall be removed to full depth of plaster in rectangular patches and plastered again after raking the joints in masonry properly. Such portions shall be wetted and allowed to dry before any operation.

All holes, cracks, patches etc. not exceeding 0.1 sq. m. in area shall be made good with material similar to that of the surface. Surfaces affected by efflorescence, moss, fungi, algae, lichen etc. shall be treated in accordance with IS: 2395.

2.1.3 Preparation of White Wash

The fat lime conforming to IS: 712 shall be slaked at site and shall be mixed and stirred with about 5 litres of water for 1 kg. of unslaked lime to make thin cream. This shall be allowed to stand for a period of 24 hours and then shall be screened through a clean coarse cloth. 4 kg of gum dissolved in hot water shall be added to each cubic metre of lime cream. Approved quality ultramarine blue conforming to IS 55 @ 3 gram per kg. of lime shall also be added to the solution. The whole solution shall be stirred thoroughly before use.

2.1.4 Application

White wash shall be applied with "MOONJ" brush to the specified number of coats. The operation for each coat shall consist of stroke of the brush from the top to down wards, another from the down to upwards over the first stroke, similarly one stroke horizontally from right and another stroke from the left. Each coat shall be allowed to dry before the next coat is applied. The white washing on ceiling should be done prior to that on walls.

2.1.5 Protective measures

Surfaces of doors, windows, floors etc. which are not to be white washed shall be protected from being splashed upon. Such surfaces shall be cleaned of white wash splashed if any.

3.0 COLOUR WASHING

3.1 Workmanship

3.1.1 Scaffolding

Wherever scaffolding is necessary, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be white/ colour washed. For white washing of ceiling, proper stage scaffolding shall be erected.

3.1.2 Preparation of Surface

Surface shall be thoroughly cleaned of all dirt, dust, mortar dropping and other foreign matter before white wash is to be applied. Surfaces already white/colour washed shall be broomed down to remove all dust, dirt, loose scales of lime wash or other foreign matters.

All damaged portions of the surface plaster shall be removed to full depth of plaster in rectangular patches and plastered again after raking the joints in masonry properly. Such portions shall be wetted and allowed to dry before any operation.

All holes, cracks, patches etc. not exceeding 0.1 sq. m. in area shall be made good with material similar to that of the surface. Surfaces affected by efflorescence, moss, fungi, algae, lichen etc. shall be treated in accordance with IS: 2395.

3.1.3 Preparation of Colour Wash

Sufficient quantity of colour wash enough for the complete job shall be prepared in one operation to avoid any difference in colour. The basic white wash solution shall be prepared in accordance with clause 2.1.3. Mineral colours of approved shade and quality not affected by lime shall be added to the white wash solution in proportions as directed by Engg.in-charge Solid lumps etc. in the colour powder shall be ground to fine powder, sieved and mixed evenly and thoroughly to the white wash solution.

3.1.4 Application of Colour Wash

Colour wash shall be applied with "MOONJ" brush to the specified number of coats. The operation for each coat shall consist of stroke of the brush from the top to down wards, another from the down to upwards over the first stroke, similarly one stroke horizontally from right and another stroke from the left. Each coat shall be allowed to dry before the next coat is applied. The white washing on ceiling should be done prior to that on walls.

3.1.5 Protective Measure

Surfaces of doors, windows, floors etc. which are not to be white washed shall be protected from being splashed upon. Such surfaces shall be cleaned of white wash splashed if any.

4.0 DRY DISTEMPERING

4.1 Workmanship

4.1.1 Scaffolding

Wherever scaffolding is necessary, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be white/ colour washed. For white washing of ceiling, proper stage scaffolding shall be erected.

4.1.2 Preparation of Surface

The surface shall be thoroughly brushed free from dust, dirt, grease, mortar droppings, other foreign matter and shall be made smooth by sand papering.

In case of distempering over existing distempered surface, the existing distempering shall be scraped by steel scrapers leaving a clean surface.

All nails shall be removed. Pitting in plaster shall be made good with plaster-of-paris mixed with dry distemper of colour to be used. The surface then shall be rubbed down again with a fine grade sand paper and made smooth. A coat of distemper shall be applied over the patches. The surface shall be allowed to dry thoroughly before the regular coat of distemper is allowed.

The surface affected by moss, fungus, algae, efflorescence shall be treated in accordance with IS: 2395.

4.1.3 Priming Coat

A priming coat of whiting conforming to IS 63 shall be applied over the prepared surface. The priming coat shall be prepared by mixing 2.5 kg. of whiting and one litre of glue solution (prepared by mixing 250 gm. glue conforming to IS: 852 with boiling water) together and placing it in a covered vessel with enough water to cover the mixture which shall be left to cool until it becomes a jelly.

Priming coat shall be applied with "MOONJ" brush to the specified number of coats. The operation for each coat shall consist of stroke of the brush from the top to down wards, another from the down to upwards over the first stroke, similarly one stroke horizontally from right and another stroke from the left. Each coat shall be allowed to dry before the next coat is applied. The white washing on ceiling should be done prior to that on walls.

4.1.4 Preparation of Distemper

The dry distemper of approved shade and quality conforming to IS: 427 shall be stirred slowly in clean warm water using 0.6 litres of water per kg. of distemper. It shall be allowed to settle for at least 30 minutes before applying. The mixture shall be well stirred before and during use to maintain an even consistency.

4.1.5 Application of Distemper

After the priming coat has dried for at least 48 hours, the surface shall be lightly sand papered and dusted off avoiding rubbing off of the priming coat. Prepared distemper shall then be applied in minimum two coats with proper distemper brushes in horizontal strokes immediately followed by vertical ones which together shall constitute one coat. The subsequent coats shall be applied only after the previous coat has dried. The finished surface shall be even and uniform without patches, marks, distemper drops etc. The application of a coat in each room shall be finished in one operation. After each day's work, brushes shall be thoroughly washed in hot water and hung down to dry.

4.1.6 Protective Measure

Surfaces of doors, windows, floors etc. which are not to be white washed shall be protected from being splashed upon. Such surfaces shall be cleaned of white wash splashed if any.

5.0 OIL BOUND DISTEMPERING

5.1 Workmanship

5.1.1 Scaffolding

Same as in clause no. 2.1.1

5.1.2 Preparation of Surface

Preparation of surface shall in general be in accordance with clause no. 4.1.2 except that any unevenness shall be made good by applying putty made of plaster of Paris mixed with water including filling up the undulation and then sand papering the same after it is dry.

5.1.3 Primer Coat

The primer coat shall be alkali resistant primer or distemper primer and shall be of the same manufacture as oil bound distemper.

If the wall surface plaster has not dried completely, alkali resistant primer otherwise distemper primer shall be applied. The mixture of alkali resistant primer shall be prepared as per approved manufacturer's instructions.

The application of primer coat shall be in accordance with 2.1.4

5.1.4 Preparation of Oil Bound Distemper

The distemper shall conform to IS: 428 and shall be diluted with water or any other prescribed thinner recommended by the manufacturer.

5.1.5 Application of Distemper

After the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered and dusted off avoiding rubbing off of the primer coat. Minimum two coats of distemper shall be applied with brushes in horizontal strokes followed by immediate vertical strokes which together shall constitute one coat. The subsequent coats shall be applied after at least 24 hours between consecutive coats to permit proper drying of the preceding coat. The finished surface shall be even and uniform without patches, brush marks drops etc. Application of a coat in each room shall be finished in one operation. 14 cm double bristled distemper brushes shall be used. After each day's work brushes shall be thoroughly washed in hot water with soap solution and hung down to dry.

5.1.6 Protective Measures

Same as in clause no. 2.1.5

6.0 WATERPROOF CEMENT PAINT

6.1 Workmanship

6.1.1 Scaffolding

Same as in clause 2.1.1

6.1.2 Preparation of Surface

Preparation of surface shall be in accordance with clause no. 2.1.2. The surface so prepared shall be thoroughly wetted with clean water before the paint is applied.

6.1.3 Preparation of Paint

Waterproof cement paint of approved make shall be mixed with water and stirred to obtain a thick paste which shall then be diluted to brushable consistency. The proportion of mixture shall be as per manufacturer's recommendation. The paint shall be mixed in such quantity which can be used up within an hour of mixing to avoid setting and thickening of the paint.

6.1.4 Application of Paint

The surface shall be treated with minimum two coats of waterproof cement paint. No less than 24 hours shall be allowed between two coats and subsequent coats shall be applied only after the preceding coat has become hard to resist marking by subsequent brushing.

The finished surface shall be even and uniform in shade without patches, brush marks, paint drops etc. Cement paints shall be applied with a brush with relatively short stiff hog or fibre bristles.

6.1.5 Curing

Curing shall be started after the paint has hardened. Curing shall be done by sprinkling with water two or three times a day. This shall be done between coats and for at least two days following the final coat.

6.1.6 Protective Measure

Same as in clause in 2.1.5

7.0 PLASTIC EMULSION PAINTING

7.1 Workmanship

7.1.1 Scaffolding

Same as in clause 2.1.1

7.1.2 Preparation of Surface

Same as in clause 5.1.2 under specification of oil bound distempering.

7.1.3 Preparation of Paint

Plastic emulsion paint shall conform to IS 5411 (Part-1) and shall be of approved shade. Preparation of paint shall be as per manufacturer's instructions.

7.1.4 Application of Paint

The paint mix shall be continuously stirred while applying for maintaining uniform consistency. Number of coats shall be as specified. The painting shall be laid evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard at first, then brushing alternately in opposite direction 2 to 3 times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks, no hair marks no clogging of paint puddles shall be permitted. The full process of crossing and laying off will constitute one coat. The paint shall be applied by means of brush or roller.

Before starting painting with plastic emulsion paint, the prepared surface shall be treated with two coats of primer consisting of cement, primer, whiting and plastic emulsion paint shall start only after the preceding coat has become sufficiently hard to resist brush marking. Subsequent coats of plastic emulsion paint shall also be started after the preceding coat is dried by evaporation of water content.

The surface on finishing shall present a flat, velvety smooth finish, even and uniform shade without patches, marks, paint drops etc.

7.1.5 Precautions

A. Brushes shall be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the paint from hardening on the brush. Old brushes, if used shall be completely dried of turpentine/oil paints by washing in warm soap water.

B. No oil base putties shall be used in filling cracks/holes.

C. Washing of painted surface shall not be done within 3-4 weeks of application.

7.1.6 Protective Measores

Same as in clause 2.1.5

8.0 ACRYLIC COPOLYMER AGGREGATE FINISH

8.1 Material

It shall be an acrylic based textured wall coating consisting of quartz and silica aggregate, inorganic pigments and other additives to form a crack free, flexible, tough, waterproof coating.

8.2 Preparation of Surface

The surface to be coated shall be cleaned and all dirt, dust, grease and loose particles shall be removed. Any old textured surface shall be removed with removing agent as per manufacturer's instructions.

8.3 Application

Bonding agent and water shall be mixed first. Then the flakes/granules shall be added and mixed thoroughly and kneaded till no lumps are found. The dough shall be left for 20-30 minutes before starting application. The bonding agent, flakes/granules and water shall be mixed in different ratios for different finishes as per manufacturer's specifications.

The first application shall be by steel trowel. It shall be smoothened, if the specified finish requires, by a plastic trowel.

9.0 ACRYLIC BASED EXTERIOR EMULSION PAINT

9.1 Material

It shall be an acrylic based wall coating for exterior surfaces consisting of pure acrylic resin and additives to form a crack free, flexible, tough, alkali resistant, UV resistant waterproof coating.

9.2 Preparation of Surface

The surface to be coated shall be cleaned and all dirt, dust, grease and loose particles shall be removed. Any old paint shall be removed with removing agent as per manufacturer's instructions. The surface affected by moss, fungus, algae, efflorescence shall be treated in accordance with IS: 2395.

9.3 Application

A primer coat of similar shade shall be applied as per manufacturer's specifications. The paint shall be stirred to a uniform consistency. Two coats shall be applied over the primer coat by brush or roller. Each coat shall be applied after the previous coat has dried completely. The coverage of paint and application shall be strictly as per manufacturer's specifications.

10.0 PAINTING OF WOOD WORK

10.1 Preparation of surface

Preparation of wood surface shall conform to IS: 2338 (Part-I) in general. All woodwork shall be dry and free from any foreign matter. Nails shall be punched well below the surface. The surface shall be smoothened off with abrasive paper used across the grain prior to painting, with the grain prior to the staining. Any knots, resinous or bluish sap wood, cutting out of which is not justified shall be covered with red lead conforming to IS: 103.

Plywood and block board shall be treated in the same manner as for wood work.

Particle board's surface shall be filled with a thin brushable filler and finished as for solid wood.

10.2 Priming

Priming shall be in accordance with IS: 2338 (Part I and II). Dirt or any other extraneous material on the surface shall be removed and the priming shall be applied by brushing.

Priming shall be done on all exposed and unexposed surfaces. Unless specified otherwise all joinery work intended to be painted shall receive atleast 2 coats of primer. Type of primer shall be in accordance with Table-I and Table-2 ofIS: 2338 (Part-II).

10.3 Stopping and Filling

Stopping and filling shall be done after priming. Stopping shall be made to the consistency of stiff paste and shall be used to fill holes and cracks. Filler shall be used to level up slight irregularities of the surface. Filler shall be applied with a putty knife and subsequently rubbed down to a level surface with abrasive paper.

The filler coat shall be allowed to fully flatten and harden before subsequent coat is applied.

10.4 Application of Undercoat

Under coat shall be applied after the surface has been primed, stopped and filled, and rubbed down to a smooth surface. Under coat may be brushed or sprayed. After drying the coat shall be carefully rubbed down and wiped clean before the next coat is applied.

The type of undercoat shall be depending upon the finishing and in accordance with Table I and Table-2 of IS: 2338 (Part II).

10.5 Finishing

The finishing paint shall be as specified and shall be applied either by the brush or by spraying.

Reference shall be made to the Table-I and Table-2 ofIS: 2338 (Part-II)

10.6 Application of Clear Finishes

For the application of clear finishes, the following procedures shall generally be adopted in accordance with IS: 2338 (Part-I)

A. Filling

B. Staining

C. Sealing

D. Finishing

10.6.1 Filling

Fillers shall be applied to prevent the excessive penetration of the finish to the surface for obtaining a smooth finish. Fillers shall be conforming to IS: 345.

Fillers shall be heavily applied to the wood surface by hand, using hessian or jute rag across the grain. It shall be rubbed when still wet to get better penetration. After 5-10 minutes it shall be wiped off by hand across the grain followed by a light wipe with the grain. The filled surface shall be dried preferably over night and smoothened with abrasive paper.

10.6.2 Staining

10.6.2.1 Spirit Stains

Spirit stains are solutions of spirit soluble dyes in Industrial methylated spirit.

10.6.2.2 Oil Stains

Oil stains are solutions of oil soluble dyes in linseed oil, but, usually consist of insoluble, semi-transparent pigments ground in linseed oil and thinned with turpentine or other solvent.

10.6.2.3 Preparation of Wood for Staining

Surface intended for staining shall be kept scrupulously clean and free from greasy finger marks. It shall be prepared by careful smoothing with fine abrasive paper used in the direction of the grain. Small cracks/nail holes shall be stopped with plastic wood/fine plaster of Paris. The stopping shall be rubbed down with fine abrasive paper when hard and touched with a thinned knotting before staining. In case of oil staining stopping shall be done after staining using tinted putty or wood filler.

10.6.2.4 Application of Stains

Stains shall be applied by brushing and wiping or by spraying. The stain shall be so thinned that it can be applied fairly, liberally without over staining and over lapping.

10.6.3 Sealing

A suitable sealer shall be applied on the filled and sanded surface to prevent absorption by the wood of the succeeding coats of finish and to seal stain and filler and thus preclude their bleeding into the finish coat.

Sealer may be sprayed on taking care not to flood the surface and it shall be allowed to dry hard. When fully dry the surface shall be sanded taking care not to cut through at comers and edges. Dust shall be blown off and surface wiped with a clean rag.

10.6.4 Finishing

The stained surface shall be varnished, wax-polished or French polished as required after it is dried.

10.6.4.1 Varnishing

Varnishing of wood and wood based material shall be in accordance with IS: 2338 (Part-I).

Surfaces to be varnished shall be prepared to produce a smooth, dry and matt surface and all dust and dirt shall be removed from the surface.

The Varnish shall be applied liberally with a brush and spread evenly over a portion of the surface with short light strokes to avoid frothing. It shall be allowed to flow out while the next section is being laid in. Excess Varnish shall be scraped out of the brush and then the first section be crossed, re- crossed and laid off lightly. The Varnish, once it has begun to set, shall not be retouched. In case of any mistake, the Varnish shall be removed and the work shall be started afresh.

Where two coats of varnish are applied, the first coat shall be a hard drying under coating or flatting varnish which shall be allowed to dry hard and then be flatted down before applying the finishing coat. Sufficient time shall be allowed in between two coats.

When flat varnishing is used for finishing, a preparatory coat of hard drying undercoating of flatting varnish shall first be applied and shall be allowed to harden thoroughly. It shall then be lightly rubbed down before the flat varnish is applied. On larger areas, the flat varnish shall be applied rapidly, and the edges of each patch applied shall not be allowed to set, but shall be followed up whilst in free working conditions.

10.6.4.2 French Polish

French polish shall conform to IS :348. Suitable pigments shall be added to get the required colour.

The surface to be French polished shall be rubbed down to smoothness with sand paper and shall be well dusted. Pores in the surface shall be filled up with fillers.

A pad of woollen cloth covered by a fine cloth shall be used to apply the finish. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles applying the polish sparingly but uniformly over the entire area to give an even surface. A trace of linseed oil may be used on the face of the pad for the purpose. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cloth, slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

11.0 PAINTING OF STEEL AND OTHER METAL SURFACE

11.1 General

Reference shall be made to IS :2524 and IS:1447.

11.2 Preparation of Surface

The surface, before painting, shall be cleaned of all rust, scale, dirt and other foreign matter with wire brushes, steel wool, scrappers, sand paper etc. The surface shall then be wiped finally with mineral turpentine which shall then be removed of grease etc. The surface then shall be allowed to dry.

In case of GI surface, surface so prepared shall be treated with Mordant solution (5 litre for about 100 sq.m.) by rubbing the solution generously with brush. After about half an hour, the surface if required shall be retouched and washed down thoroughly with clean cold water and allowed to dry.

11.3 Application of Priming and Paints

Approved quality primer and paint in specified numbers of coats shall be applied as per manufacturer's recommendations either by brushing or spraying. Each subsequent coat shall be applied only after the preceding coat has dried.

DRAFT REPORT
MARCH-2023

ASSAM GAS COMPANY LIMITED
DULIAJAN. DIST DIBRUGARH , ASSAM
PIN - 786 602 (Assam).

GEOTECHNICAL SOIL INVESTIGATION REPORT ON THE SOIL CONDITIONS AT RUPKHELIA TERMINAL

(GOLAGHAT TO BCPL LAKWA GAS PIPELINE)

Village : Da Chamua / Borpotarua, Tehsil : Golaghat, District : Golaghat , State : Assam

SURVEY AGENCY:

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ISO 9001:2015

Report Prepared By		
Venkat **Assistant Technical Manager**	Signature ……………………………………	Date:

Rev No.:	REPORT REVISED (response to significant changes in client requirements, Corrections etc).			
REV-3 (Draft Report)	**Comments from .:** Pipeline Engineering Consultants Pvt. Ltd. (PLECO)	Signature ………………	Date: 17-03-2023	Nature of revision: As per requested from client
REV-2	**Comments from .:** Pipeline Engineering Consultants Pvt. Ltd. (PLECO)	Signature ………………	Date: 06-03-2023	Nature of revision: Values/ Parameters mentioned in bore log data & used in calculations are not matching with each other.
REV-1	**Comments from .:** Pipeline Engineering Consultants Pvt. Ltd. (PLECO)	Signature ………………..	Date: 27-02-2023	Nature of revision: As per requested from client
REV-0	**Comments from .:** Pipeline Engineering Consultants Pvt. Ltd. (PLECO)	Signature ………………	Date: 17-02-2023	Nature of revision: As per requested from client

DOC. NO.: SKP - AGCL - DR - RUPKHELIA TERMINAL	**FILE. NO.:** SKP - AGCL - DR - 17-03-2023

LIST OF CONTENTS

ANNEXURE

ABBREVIATIONS

EGL	Existing Ground Level
SPT	Standard Penetration Test
GWT	Ground Water Table
BH	Bore Hole
MSL	Mean Sea Level
mm	Millimeter
m^3	Cubic Meter
N	Observed standard penetration resistance
N_O	'N_O' corrected for overburden
N_D	'N_D' corrected for Dilatancy in saturated silty sand/fine sand only
N_C	Corrected 'N' for design
R	SPT Refusal
t/ m	Ton per meter
t/ m^2	Ton per square meter
C	Cohesion
RL	Reduced Level
PI	Plasticity Index
LL	Liquid Limit
IS	In Sufficient
NP	Not Possible
NA	Not Applicable

1.0 INTRODUCTION

Assam Gas Company Ltd., a Govt. of Assam Undertaking was incorporated on March 31,1962 in Shillong as a limited company wholly owned by the Government of Assam to carry out all kinds of business related to natural gas in India. The first gas transportation business started in the year 1967 with supply of natural gas to Namrup Thermal Power Station of ASEB. Subsequently, the company grew from strength to strength and stands today as one of the premier natural gas distribution companies in India.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e. Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCM of gas per day.

Besides other sources, AGCL is going to transport Natural Gas from the gas fields of ONGCL in Khoraghat region of Golaghat District bordering Nagaland through its 12" & 8" NB 100 km Nambor Golaghat Numaligarh (Letekujan) gas pipeline(N-G-N). Company is expecting additional transportation of around 130,000 SCMD of Natural gas from the above-mentioned Pipeline. AGCL is planning to supply this additional gas to Brahmaputra Cracker and Polymer Limited (BCPL) through Proposed Golaghat to BCPL Lakwa Gas Pipeline.

AGCL wants to extend its existing N-G-N pipeline network from Golaghat to BCPL Lakwa Terminal. This project foresees transportation of 1,30,000 SCMD Gas via new 12" x 112.5 km (approx.) pipeline.

AGCL has entrusted **SKP Projects Pvt. Ltd.**, the job of carrying out "Survey works at CNG Mother Station at Duliajan" vide WORK ORDER No: **AGCL/CNG/RB/SKP/33/14** Date:07.05.2022.

2.0 SCOPE OF THE WORK

The work includes drilling boreholes to determine the probable sub-surface conditions such as stratification, denseness of the strata, position of ground water table and conducting various field tests (field tests include standard penetration tests at required depths), collection of the soil samples (Disturb and undisturbed) from the field for laboratory testing, conducting standard penetration tests and the preparation of soil investigation report.

The samples thus collected from the field are subjected to various laboratory tests and report is generated for the results obtained.

With reference to the work order, the scope of this present report covers the details of **RUPKHELIA TERMINAL** is drilling of land boreholes for Geo-technical Investigation, includes 06 numbers of Standard Soil Investigation bores.

The present report covers the details of **RUPKHELIA TERMINAL** for deviated portion carried out along the pipeline route to obtain Geo-technical properties of soil and visual engineering classification of soil which are to be specified in data sheet for design and engineering of various facilities required along the pipeline route of GOLAGHAT TO BCPL LAKWA Gas Pipeline.

The termination criteria for the bore holes as per the given scope of work is 15mtrs drilling of each bore hole.

3.0 LOCATION

The proposed project is located at **RUPKHELIA TERMINAL**

Village : Da Chamua / Borpotarua**, Tehsil :** Golaghat**, District :** Golaghat **,**

State : Assam.

Sr. No.	Name of Location	Bore Hole No.	Terminated Depth (m)	G.W.T. Below G.L (m)	Ground RL's (m)
1	**RUPKHELIA TERMINAL**	BH-1	15.00	2.50	110.93
2		BH-2	15.00	1.70	107.71
3		BH-3	15.00	0.20	109.31
4		BH-4	15.00	2.10	111.90
5		BH-5	15.00	0.50	108.70
6		BH-6	15.00	2.10	111.30

Sr. No.	Bore Hole Name	Co-ordinate		Remarks
		Easting	Northing	
1	BH-1	596848.00	2928171.00	-
2	BH-2	596816.00	2928179.00	-
3	BH-3	596787.00	2928101.00	-
4	BH-4	596827.00	2928089.00	-
5	BH-5	596697.00	2928149.00	-
6	BH-6	596714.00	2928195.00	-

4.0 FIELD INVESTIGATION

A. Bore hole planning

The Bore Hole location showing the position of the bore holes in the proposed alignment of the selected portion of the pipeline route is to be prepared. The existing Earth Ground Levels (EGL) i.e., Reduced levels (RL 'S) at the location and coordinates of the bore hole was given by the survey team and the in-situ test depth is mentioned according to RL.

B. Standard Penetration Tests

The field investigations were carried out using Calyx Boring drilling rigs. This method of boring using the standard equipment is as per the standard methods suggested in IS- 1892.This is a 150mm diameter bores and in this, casing was also used to support the walls of the bore hole such that there is no wall collapse. Standard Penetration Tests (SPT) were conducted at required depth intervals, using manual drop head system for accuracy of workmanship and quality of results, in each bore hole as per IS-2131. Disturbed soil samples were also collected at various depths, using single tube samplers to evaluate the geo-technical parameters if required. In general, all the methods and the precaution taken are in accordance with IS-1892.

C. Core Drilling in Rock

Core drills shall be so designed that in sound rock, continuous recovery of core is achieved. Water is circulated down the hollow rods, which returns outside them, carrying the rock cuttings to the surface as sludge. These shall be retained as samples in traversing friable rock where cores can't be recovered. It is important to ensure that boulders or layers of cemented soils are not mistaken for bed rock.

This necessitates core drilling to a depth of at least 3m in bed rock in areas where boulders are known to occur. For shear strength determination, a core with diameter to height ratio of 1:1 is required. Rock pieces may be used for determination of specific gravity and classification.

D. Rock Core Recovery

This is the ratio of the length of core recovered to length of core run and is expressed as a percentage. The parameter provides a useful guide to the quality of drilling operation.

Total Rock core recovery defined as the quotient:

$TCR = (l_{\text{sum of pieces}}/l_{\text{total core run}})$

lsum of pieces = Sum of length of core pieces

ltotal core run = Total length of core run

E. Rock Quality Designation

This is the total length of those pieces of core, which is 10cm in length or longer, expressed as a percentage of the run length. This provides a good indication of the quality of the rock mass.

RQD is defined as the quotient:

RQD = (lsum of length of core pieces>=100mm/ ltotal core run)

$l_{\text{total core run}}$ = Total length of core run

F. Standing Ground Water Level

Records shall be maintained of the level at which water is struck and the level of any rapid inflow shall also be recorded. On reaching such level the borehole shall be left open for a period of two hours to observe the rise of water in the casing. Bore hole can be continued, thereafter, up to the end of the day.

The level of water in the casing at the end of the day and at the beginning of the next day shall be recorded properly. For studying the ground water table no drilling mud will be permitted for stabilizing the hole.

G. Laboratory Tests

Laboratory tests shall be conducted on selected samples collected from site to establish the physical and chemical properties of soil. Following tests shall be done as appropriate in accordance with latest relevant Indian code of practice.

- **i.** Sieve Analysis
- **ii.** Hydrometer Analysis
- **iii.** Atterberg Limits
- **iv.** Natural Moisture Content
- **v.** Specific Gravity (Soil)
- **vi.** Direct Shear Test
- **vii.** Free Swell Index
- **viii.** Swelling Pressure Test
- **ix.** Consolidation Test
- **x.** Tri-axial Test
- **xi.** Shrinkage Limit Test
- **xii.** UCS Test (Soil)
- **xiii.** Chemical Test on soil & Water
- **xiv.** Specific Gravity (Rock)
- **xv.** Uni-axial Compressive Strength of Rock

5.0 SUB-SOIL PROFILE

Soil investigation work was conducted for six boreholes. The layer wise soil profile is as follows:

i. **At Bore Hole-1**, as per bore log the soil profile consists of 5.00m thick Soft Brownish Colour Silty Clay, followed by 3.00m thick Stiff Brownish Colour Clay, followed by 3.00m thick Medium Dense Grayish Colour Fine Grained Sand, followed by 4.00m thick Dense Grayish Colour Fine Grained Sand, where the borehole was terminated on reaching termination criteria as per the scope of work.

ii. **At Bore Hole-2**, as per bore log the soil profile consists of 3.50m thick Soft Brownish Colour Silty Clay, followed by 4.00m thick Stiff Deep Grayish Colour Clay, followed by 7.50m thick Stiff to Very Stiff Grayish Colour Clay, where the borehole was terminated on reaching termination criteria as per the scope of work.

iii. **At Bore Hole-3**, as per bore log the soil profile consists of 6.50m thick Soft Brownish Grayish Colour Clay, followed by 4.50m thick Medium Dense Brownish Grayish Colour Silty Sand, followed by 4.00m thick Dense Grayish Colour Fine Grained Sand, where the borehole was terminated on reaching termination criteria as per the scope of work.

iv. **At Bore Hole-4**, as per bore log the soil profile consists of 3.50m thick Soft Brownish Grayish Colour Clay, followed by 3.00m thick Stiff Brownish Grayish Colour Clay, followed by 3.00m thick Stiff Deep Grayish Silty Clayey, followed by 5.50m thick Dense Deep Grayish Colour Fine Grained Silty Sand, where the borehole was terminated on reaching termination criteria as per the scope of work.

v. **At Bore Hole-5**, as per bore log the soil profile consists of 5.00m thick Soft Brownish Colour Silty Clay, followed by 1.50m thick Loose to Very Loose Grayish colour Fine Grained Sand as Containing Silts as Fines, followed by 3.50m thick Medium Dense Grayish colour Fine Grained Sand as Containing Silts as Fines, followed by 4.00m thick Dense Grayish Brownish colour Fine

Grained Sand, followed by 1.00m thick Stiff Grayish Colour Clay, where the borehole was terminated on reaching termination criteria as per the scope of work.

vi. **At Bore Hole-6**, as per bore log the soil profile consists of 6.50m thick Soft Brownish Yellowish Colour Sandy Clay, followed by 3.50m thick Medium Dense Grayish colour Fine to Medium Grained Sand, followed by 5.00m thick Dense Grayish colour Fine to Medium Grained Sand, where the borehole was terminated on reaching termination criteria as per the scope of work.

6.0 SOIL DENSITY BASED ON SPT 'N' VALUE

The field data and the laboratory classification reveal that, the entire strata comprises of Soft Sandy Clay, Medium Dense Fine to Medium Grained Sand, Dense Fine to Medium Grained Sand, up to the depth of Termination. Detailed sub-soil profile is mentioned in the Bore log. The relevance of sub soil deposition is mentioned in table-1.

Table 1: Deposition State of Sub Soil

S. No.	SPT N-Value	State of consolidation for Non-Cohesive soils	Consistency of Cohesive soils
1	< 10	Loose to Very Loose	Soft
2	10 to 30	Medium Dense	Stiff
3	30 to 50	Dense	Very Stiff
4	> 50	Very Dense	Hard

7.0 GEOLOGICAL INFORMATION

Geology of Assam:

The State of Assam is occupied by rocks belonging to, (a) Proterozoic Gneiss Complex, (b) Shillong Group of Meso-Palaeo Proterozoic age, (c) Granite Plutons of Neo-Proterozoic-Lower Paleozoic age, (d) Lower Gondwana sedimentary rocks of Permo-carboniferous age (e) Alkali Complexes of Samchampi, Borpung and volcanic rocks represented by Sylhet Trap of Cretaceousage, (f) Lower Tertiary (Paleocene-

Eocene) shelf sediments of the Jaintia Group extending along the southern and eastern flanks of Mikir Hills and geosynclinal sediments of Disang Group in parts of the North Cachar Hills, (g) Upper Tertiary (Oligocene to Pliocene) shelf and geo-synclinal sediments covering the southern flanks of Mikir Hills, the North Cachar Hills and the hills of the Cachar district in the Surma valley area. These rocks are also exposed along the northern foothills of Naga- Patkai range bordering the southern margin of Sibsagar, Jorhat and Dibrugrah districts. Along the southern foothills of Eastern Himalaya facing the northern border of Assam a narrow strip of Siwalik rocks are exposed (h) the Quaternary deposits comprising of Older and Newer Alluvium occur in flood plains and terraces of the Brahmaputra valley, Surma valley and other river basins of Assam.

Geological structures generally act either as conduits or as barrier to flow of groundwater. Lineaments representing faults, fractures, shear zones etc. are the structural features that control the occurrence and movement of ground water in hard rock terrain. The important geological structures reported are faults inferred to have cut across the valley fill of Quaternary alluvium. Some fractures show semi-circular pattern as in the Fatalist area.

8.0 Seismic Hazard

Seismic Hazard refers to the study of expected earthquake ground motions at the earth's surface, and its likely effects on existing natural conditions and man-made structures for public safety considerations; the results of such studies are published as seismic hazard maps, which identify the relative motion of different areas on a local, regional or national basis. With hazards thus determined, their risks are assessed and included in such areas as building codes for standard buildings, designing larger buildings and infrastructure projects, land use planning and determining insurance rates. The seismic hazard studies also may generate two standard measures of anticipated ground motion, both confusingly abbreviated MCE; the simpler probabilistic Maximum Considered Earthquake (or Event), used in standard building codes, and the more detailed and deterministic Maximum Credible Earthquake incorporated in the design of larger buildings and civil infrastructure like dams or bridges. Both the occurrence of earthquakes in the past in and around India, the country is divided into five seismic zones.

- **Zone V:** Covers the areas liable to seismic intensity IX and above on Modified Mercalli Intensity Scale. This is the most severe seismic zone and is referred here as Very High Damage Risk Zone.
- **Zone IV:** Gives the area liable to MM VIII. This, zone is second in severity to zone V. This is referred here as High Damage Risk Zone.
- **Zone III:** The associated intensity is MM VII. This is termed here as Moderate Damage Risk Zone.
- **Zone II:** The probable intensity is MM VI. This zone is referred to as Low Damage Risk Zone.
- **Zone I:** Here the maximum intensity is estimated as MM V or less. This zone is termed here as Very Low Damage Risk Zone.

Based on this zoning, about 60% of India's land area is under moderate seismic threat or more, i.e., under seismic zone III or above.

Largest Earthquake in Assam 12 June 1897 - Near Rangjoli, Assam, M8.0

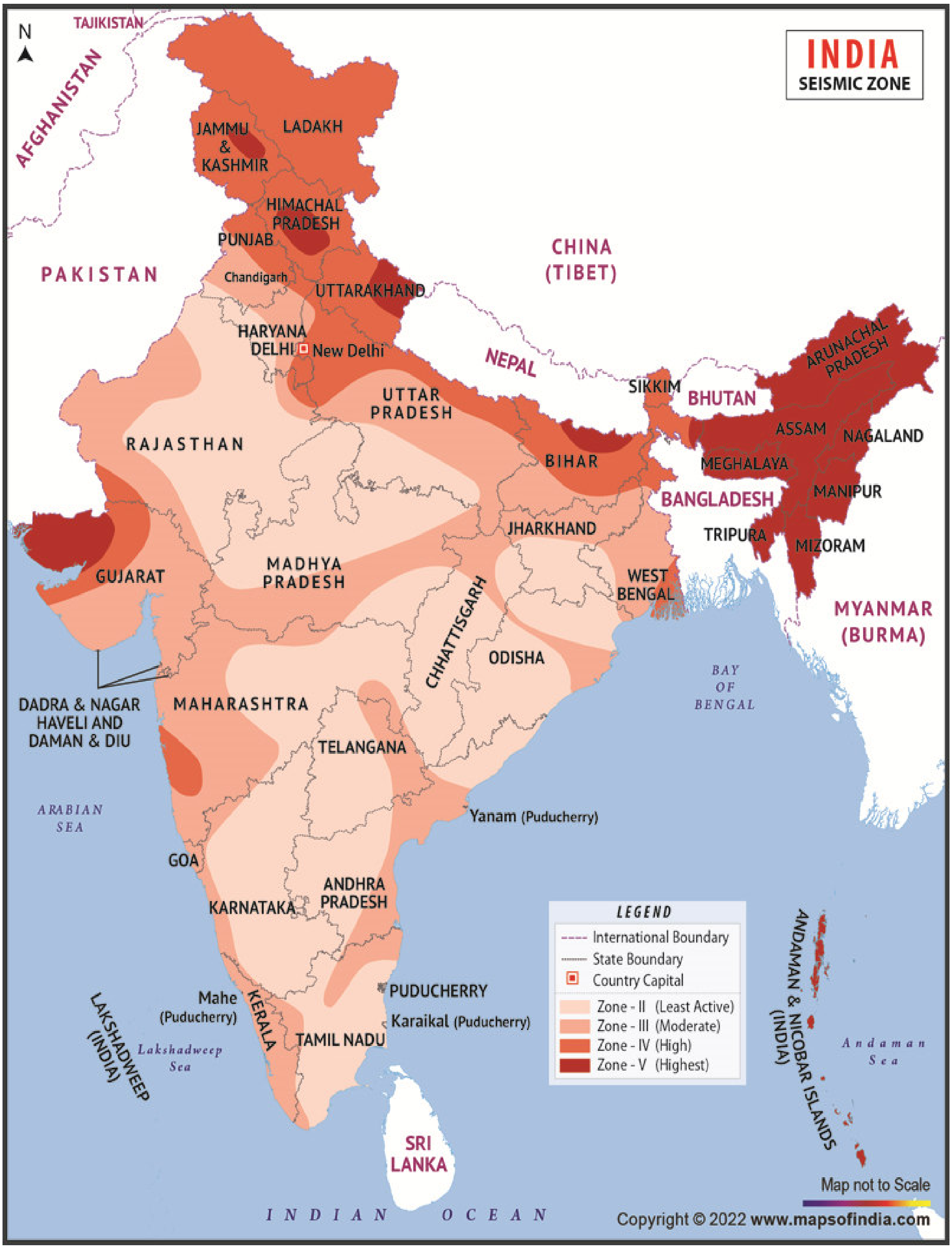
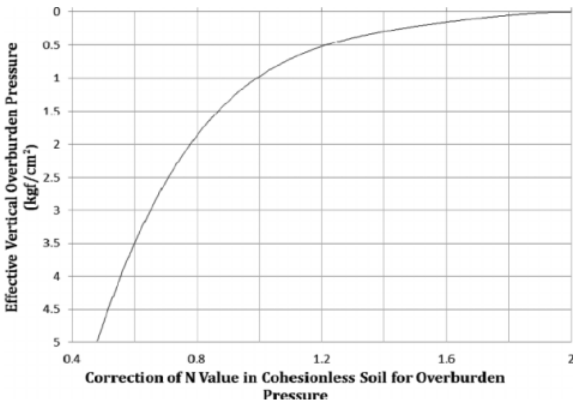


Figure 1 SEISMIC ZONATION MAP OF INDIA

(This seismic zonation map is identical to map shown in IS:1893- 2016)

9.0 CORRECTIONS TO STANDARD PENETRATION RESISTANCE

The corrections for the cohesion less soils are carried out using the Peck, Hansen and Thornburn equation and the chart as per IS 2131:1981.Value of N Corrected for over burden,



$N_o = C_N \times N$

Where $C_N = 0.77 \log_{10} \left(2000/\sigma_o' \right)$

σ_o' = Effective over burden pressure in KN/m^2 at depth where "N" is recorded.

Dilatancy correction is applied as saturated fine sand and silty sand strata are present at the construction site. Corrected "N" value in Clayey Gravel is restricted to 50 for bearing capacity evaluation, whenever N value exceeded 50 or Refusal is recorded. In SDR strata, corrected N value is restricted to 50 & 60 whenever corrected value of N_o or over burden exceeded 50 & Refusal is recorded, respectively.

$N_D = 15 + \frac{1}{2}(N_o - 15)$ (If N <=15; N_D = N_o)

I. For BH-1:

Depth RL (m)	*SPT*			
	N	*N_O*	*N_D*	*N_C*
109.43	4	5.76	NA	5.76
107.93	6	7.24	NA	7.24
106.43	8	8.57	NA	8.57
104.93	16	15.59	NA	15.59
103.43	20	17.99	NA	17.99
101.93	23	20.18	17.59	17.59
100.43	26	21.47	18.23	18.23
98.93	33	25.76	20.38	20.38
97.43	37	27.41	21.20	21.20
95.93	46	32.43	23.72	23.72

II. For BH-2:

Depth RL (m)	*SPT*			
	N	*N_O*	*N_D*	*N_C*
106.21	5	7.20	NA	7.20
104.71	7	8.45	NA	8.45
103.21	10	10.71	NA	10.71
101.71	11	10.72	NA	10.72
100.21	19	17.09	NA	17.09
98.71	27	23.69	NA	23.69
97.21	32	26.42	NA	26.42
95.71	36	28.10	NA	28.10
94.21	41	30.37	NA	30.37
92.71	55	38.78	NA	38.78

III. For BH-3:

Depth RL (m)	*SPT*			
	N	*N_O*	*N_D*	*N_C*
107.81	3	4.32	NA	4.32
106.31	4	4.83	NA	4.83
104.81	5	5.36	NA	5.36
103.31	6	5.85	NA	5.85
101.81	12	10.80	10.80	10.80
100.31	14	12.29	12.29	12.29
98.81	18	14.86	14.86	14.86
97.31	31	24.20	19.60	19.60
95.81	34	25.18	20.09	20.09
94.31	38	26.79	20.90	20.90

IV. For BH-4:

Depth RL (m)	*SPT*			
	N	*N_O*	*N_D*	*N_C*
110.40	6	8.64	NA	8.64
108.90	7	8.45	NA	8.45
107.40	17	18.21	NA	18.21
105.90	24	23.39	NA	23.39
104.40	28	25.19	NA	25.19
102.90	31	27.20	NA	27.20
101.40	33	27.24	21.12	21.12
99.90	36	28.10	21.55	21.55
98.40	40	29.63	22.31	22.31
96.90	43	30.32	22.66	22.66

V. For BH-5:

Depth RL (m)	*SPT*			
	N	*N_O*	*N_D*	*N_C*
107.20	3	4.32	NA	4.32
105.70	5	6.04	NA	6.04
104.20	6	6.43	NA	6.43
102.70	7	6.82	6.82	6.82
101.20	12	10.80	10.80	10.80
99.70	25	21.94	21.94	21.94
98.20	31	25.59	25.59	25.59
96.70	36	28.10	28.10	28.10
95.20	46	34.07	34.07	34.07
93.70	18	12.69	12.69	12.69

VI. For BH-6:

Depth RL (m)	*SPT*			
	N	*N_O*	*N_D*	*N_C*
109.80	5	7.37	NA	7.37
108.30	4	4.83	NA	4.83
106.80	10	10.71	NA	10.71
105.30	13	12.67	NA	12.67
103.80	18	16.19	15.60	15.60
102.30	21	18.43	16.71	16.71
100.80	30	24.77	19.88	19.88
99.30	33	25.76	20.38	20.38
97.80	39	28.89	21.94	21.94
96.30	46	32.43	23.72	23.72

10.0 SUMMARY OF ANALYSIS

A. SAFE BEARING CAPACITY:

Based on the field and laboratory test data allowable bearing capacity is derived for open Footing. The bearing capacity is derived based on minimum achieved value from shear failure.

TABLE-A-1: SAFE BEARING CAPACITY(BH-1)

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-1) (SPT-1)	1.5m x 1.5m	1.0m below EGL	9.69
		2.0m x 2.0m		9.41
		3.0m x 3.0m		9.12
		1.5m x 1.5m	1.5m below EGL	10.26
		2.0m x 2.0m		9.84
		3.0m x 3.0m		9.41

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-1) (SPT-2)	1.5m x 1.5m	2.0m below EGL	11.17
		2.0m x 2.0m		10.58
		3.0m x 3.0m		10.00
		1.5m x 1.5m	2.5m below EGL	11.76
		2.0m x 2.0m		11.03
		3.0m x 3.0m		10.29
		1.5m x 1.5m	3.0m below EGL	12.35
		2.0m x 2.0m		11.47
		3.0m x 3.0m		10.58

TABLE-A-2: SAFE BEARING CAPACITY(BH-2)

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-2) (SPT-1)	1.5m x 1.5m	1.0m below EGL	9.09
		2.0m x 2.0m		8.82
		3.0m x 3.0m		8.55
		1.5m x 1.5m	1.5m below EGL	9.62
		2.0m x 2.0m		9.22
		3.0m x 3.0m		8.82

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-2) (SPT-2)	1.5m x 1.5m	2.0m below EGL	10.50
		2.0m x 2.0m		9.94
		3.0m x 3.0m		9.39

		1.5m x 1.5m	2.5m below EGL	11.05
		2.0m x 2.0m		10.36
		3.0m x 3.0m		9.67
		1.5m x 1.5m	3.0m below EGL	11.60
		2.0m x 2.0m		10.77
		3.0m x 3.0m		9.94

TABLE-A-3: SAFE BEARING CAPACITY(BH-3)

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-3) (SPT-1)	1.5m x 1.5m	1.0m below EGL	10.00
		2.0m x 2.0m		10.00
		3.0m x 3.0m		10.00
		1.5m x 1.5m	1.5m below EGL	10.58
		2.0m x 2.0m		10.58
		3.0m x 3.0m		10.58

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-3) (SPT-2)	1.5m x 1.5m	2.0m below EGL	10.83
		2.0m x 2.0m		10.83
		3.0m x 3.0m		10.83
		1.5m x 1.5m	2.5m below EGL	11.40
		2.0m x 2.0m		11.40
		3.0m x 3.0m		11.40
		1.5m x 1.5m	3.0m below EGL	11.97
		2.0m x 2.0m		11.97
		3.0m x 3.0m		11.97

TABLE-A-4: SAFE BEARING CAPACITY(BH-4)

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-4) (SPT-1)	1.5m x 1.5m	1.0m below EGL	9.69
		2.0m x 2.0m		9.41
		3.0m x 3.0m		9.12
		1.5m x 1.5m	1.5m below EGL	10.26
		2.0m x 2.0m		9.84
		3.0m x 3.0m		9.41

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-4) (SPT-2)	1.5m x 1.5m	2.0m below EGL	11.85
		2.0m x 2.0m		11.23
		3.0m x 3.0m		10.60
		1.5m x 1.5m	2.5m below EGL	12.47
		2.0m x 2.0m		11.69
		3.0m x 3.0m		10.91
		1.5m x 1.5m	3.0m below EGL	13.10
		2.0m x 2.0m		12.16
		3.0m x 3.0m		11.23

TABLE-A-5: SAFE BEARING CAPACITY(BH-5)

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-5) (SPT-1)	1.5m x 1.5m	1.0m below EGL	11.83
		2.0m x 2.0m		11.50
		3.0m x 3.0m		11.22
		1.5m x 1.5m	1.5m below EGL	13.02
		2.0m x 2.0m		12.48
		3.0m x 3.0m		12.00

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-5) (SPT-2)	1.5m x 1.5m	2.0m below EGL	17.58
		2.0m x 2.0m		16.67
		3.0m x 3.0m		15.80
		1.5m x 1.5m	2.5m below EGL	18.84
		2.0m x 2.0m		17.69
		3.0m x 3.0m		16.58
		1.5m x 1.5m	3.0m below EGL	20.10
		2.0m x 2.0m		18.71
		3.0m x 3.0m		17.36

TABLE-A-6: SAFE BEARING CAPACITY(BH-6)

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-6) (SPT-1)	1.5m x 1.5m	1.0m below EGL	20.93
		2.0m x 2.0m		20.47
		3.0m x 3.0m		20.23
		1.5m x 1.5m	1.5m below EGL	23.72
		2.0m x 2.0m		22.89
		3.0m x 3.0m		22.26

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Bearing Capacity, T/m^2
RCC Isolated Footing	(BH-6) (SPT-2)	1.5m x 1.5m	2.0m below EGL	35.34
		2.0m x 2.0m		33.78
		3.0m x 3.0m		32.63
		1.5m x 1.5m	2.5m below EGL	38.08
		2.0m x 2.0m		35.73
		3.0m x 3.0m		33.56
		1.5m x 1.5m	3.0m below EGL	41.50
		2.0m x 2.0m		38.57
		3.0m x 3.0m		35.82

B. NET SAFE SETTLEMENT PRESSURE,q_{nssp}in kN/m2 :

$$Q_{nssp} = 1.385\,(N-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\, S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

R_W = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in ‘mm’

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure (q_{nssp}).

Based on the field and laboratory test data allowable bearing Pressure is derived for open Footing. The bearing Pressure is derived based on minimum achieved value from shear failure and settlement analysis.The typical Calculations Sheets are placed at **Annexure – VII(A)**

TABLE-B-1: SETTLEMENT FOR BH-1

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-1) (SPT-1)	1.0m x 1.0m	1.0m below EGL	4.04	8.08
		1.5m x 1.5m		3.44	6.88
		2.0m x 2.0m		2.76	5.53
		2.5m x 2.5m		2.40	4.80
		3.0m x 3.0m		2.17	4.34
		1.0m x 1.0m	1.5m below EGL	4.04	8.08
		1.5m x 1.5m		2.87	5.73
		2.0m x 2.0m		2.37	4.74
		2.5m x 2.5m		2.10	4.20
		3.0m x 3.0m		1.93	3.85

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-1) (SPT-2)	1.0m x 1.0m	2.0m below EGL	4.65	9.30
		1.5m x 1.5m		3.52	7.05
		2.0m x 2.0m		3.03	6.07
		2.5m x 2.5m		2.76	5.52
		3.0m x 3.0m		2.59	5.18
		1.0m x 1.0m	3.0m below EGL	3.10	6.20
		1.5m x 1.5m		2.64	5.29
		2.0m x 2.0m		2.43	4.85
		2.5m x 2.5m		2.30	4.60
		3.0m x 3.0m		2.22	4.44

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-1) (SPT-3)	1.0m x 1.0m	4.0m below EGL	4.07	8.15
		1.5m x 1.5m		3.47	6.94
		2.0m x 2.0m		3.19	6.38
		2.5m x 2.5m		3.02	6.05
		3.0m x 3.0m		2.92	5.83

TABLE-B-2: SETTLEMENT FOR BH-2

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-2) (SPT-1)	1.0m x 1.0m	1.0m below EGL	5.22	10.45
		1.5m x 1.5m		3.84	7.68
		2.0m x 2.0m		3.25	6.49
		2.5m x 2.5m		2.92	5.84
		3.0m x 3.0m		2.71	5.43
		1.0m x 1.0m	1.5m below EGL	3.69	7.37
		1.5m x 1.5m		2.97	5.93
		2.0m x 2.0m		2.64	5.29
		2.5m x 2.5m		2.46	4.93
		3.0m x 3.0m		2.35	4.69

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-2) (SPT-2)	1.0m x 1.0m	2.0m below EGL	3.99	7.97
		1.5m x 1.5m		3.40	6.79
		2.0m x 2.0m		3.12	6.24
		2.5m x 2.5m		2.96	5.92
		3.0m x 3.0m		2.85	5.71
		1.0m x 1.0m	3.0m below EGL	3.99	7.97
		1.5m x 1.5m		3.40	6.79
		2.0m x 2.0m		3.12	6.24
		2.5m x 2.5m		2.96	5.92
		3.0m x 3.0m		2.85	5.71

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-2) (SPT-3)	1.0m x 1.0m	4.0m below EGL	5.64	11.28
		1.5m x 1.5m		4.81	9.61
		2.0m x 2.0m		4.41	8.83
		2.5m x 2.5m		4.19	8.37
		3.0m x 3.0m		4.04	8.08

TABLE-B-3: SETTLEMENT FOR BH-3

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-3) (SPT-1)	1.0m x 1.0m	1.0m below EGL	0.97	1.93
		1.5m x 1.5m		0.82	1.65
		2.0m x 2.0m		0.76	1.51
		2.5m x 2.5m		0.72	1.43
		3.0m x 3.0m		0.69	1.38
		1.0m x 1.0m	1.5m below EGL	0.97	1.93
		1.5m x 1.5m		0.82	1.65
		2.0m x 2.0m		0.76	1.51
		2.5m x 2.5m		0.72	1.43
		3.0m x 3.0m		0.69	1.38

Type	Location	Size in m	Depth in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-3) (SPT-2)	1.0m x 1.0m	2.0m below EGL	1.34	2.68
		1.5m x 1.5m		1.14	2.28
		2.0m x 2.0m		1.05	2.09
		2.5m x 2.5m		0.99	1.99
		3.0m x 3.0m		0.96	1.92
		1.0m x 1.0m	3.0m below EGL	1.34	2.68
		1.5m x 1.5m		1.14	2.28
		2.0m x 2.0m		1.05	2.09
		2.5m x 2.5m		0.99	1.99
		3.0m x 3.0m		0.96	1.92

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-3) (SPT-3)	1.0m x 1.0m	4.0m below EGL	1.73	3.45
		1.5m x 1.5m		1.47	2.94
		2.0m x 2.0m		1.35	2.70
		2.5m x 2.5m		1.28	2.56
		3.0m x 3.0m		1.24	2.47

TABLE-B-4: SETTLEMENT FOR BH-4

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-4) (SPT-1)	1.0m x 1.0m	1.0m below EGL	8.25	16.50
		1.5m x 1.5m		6.09	12.19
		2.0m x 2.0m		5.00	10.01
		2.5m x 2.5m		4.41	8.82
		3.0m x 3.0m		4.04	8.07
		1.0m x 1.0m	1.5m below EGL	6.60	13.20
		1.5m x 1.5m		4.92	9.84
		2.0m x 2.0m		4.20	8.39
		2.5m x 2.5m		3.80	7.59
		3.0m x 3.0m		3.54	7.09

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-4) (SPT-2)	1.0m x 1.0m	2.0m below EGL	4.39	8.77
		1.5m x 1.5m		3.62	7.25
		2.0m x 2.0m		3.28	6.55
		2.5m x 2.5m		3.08	6.15
		3.0m x 3.0m		2.95	5.90
		1.0m x 1.0m	3.0m below EGL	3.99	7.97
		1.5m x 1.5m		3.40	6.79
		2.0m x 2.0m		3.12	6.24
		2.5m x 2.5m		2.96	5.92
		3.0m x 3.0m		2.85	5.71

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-4) (SPT-3)	1.0m x 1.0m	4.0m below EGL	11.13	22.25
		1.5m x 1.5m		9.48	18.96
		2.0m x 2.0m		8.71	17.41
		2.5m x 2.5m		8.26	16.52
		3.0m x 3.0m		7.97	15.93

TABLE-B-5: SETTLEMENT FOR BH-5

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-5) (SPT-1)	1.0m x 1.0m	1.0m below EGL	0.97	1.93
		1.5m x 1.5m		0.82	1.65
		2.0m x 2.0m		0.76	1.51
		2.5m x 2.5m		0.72	1.43
		3.0m x 3.0m		0.69	1.38
		1.0m x 1.0m	1.5m below EGL	0.97	1.93
		1.5m x 1.5m		0.82	1.65
		2.0m x 2.0m		0.76	1.51
		2.5m x 2.5m		0.72	1.43
		3.0m x 3.0m		0.69	1.38

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-5) (SPT-2)	1.0m x 1.0m	2.0m below EGL	2.22	4.45
		1.5m x 1.5m		1.89	3.79
		2.0m x 2.0m		1.74	3.48
		2.5m x 2.5m		1.65	3.30
		3.0m x 3.0m		1.59	3.18
		1.0m x 1.0m	3.0m below EGL	2.22	4.45
		1.5m x 1.5m		1.89	3.79
		2.0m x 2.0m		1.74	3.48
		2.5m x 2.5m		1.65	3.30
		3.0m x 3.0m		1.59	3.18

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-5) (SPT-3)	1.0m x 1.0m	4.0m below EGL	2.51	5.02
		1.5m x 1.5m		2.14	4.28
		2.0m x 2.0m		1.96	3.93
		2.5m x 2.5m		1.86	3.72
		3.0m x 3.0m		1.80	3.59

TABLE-B-6: SETTLEMENT FOR BH-6

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-6) (SPT-1)	1.0m x 1.0m	1.0m below EGL	6.39	12.79
		1.5m x 1.5m		4.72	9.44
		2.0m x 2.0m		3.88	7.75
		2.5m x 2.5m		3.42	6.83
		3.0m x 3.0m		3.13	6.26
		1.0m x 1.0m	1.5m below EGL	5.11	10.23
		1.5m x 1.5m		3.81	7.63
		2.0m x 2.0m		3.25	6.50
		2.5m x 2.5m		2.94	5.88
		3.0m x 3.0m		2.75	5.49

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-6) (SPT-2)	1.0m x 1.0m	2.0m below EGL	1.47	2.94
		1.5m x 1.5m		1.22	2.43
		2.0m x 2.0m		1.10	2.20
		2.5m x 2.5m		1.03	2.07
		3.0m x 3.0m		0.99	1.98
		1.0m x 1.0m	3.0m below EGL	1.34	2.68
		1.5m x 1.5m		1.14	2.28
		2.0m x 2.0m		1.05	2.09
		2.5m x 2.5m		0.99	1.99
		3.0m x 3.0m		0.96	1.92

Type	Location	Size in m	Assumed Depth of Footing in m	Safe Settlement Pressure (t/m^2)	
				25mm	50mm
RCC Isolated Footing	(BH-6) (SPT-3)	1.0m x 1.0m	4.0m below EGL	5.64	11.28
		1.5m x 1.5m		4.81	9.61
		2.0m x 2.0m		4.41	8.83
		2.5m x 2.5m		4.19	8.37
		3.0m x 3.0m		4.04	8.08

C. Settlement Analysis for soil, as per IS: 8009 (Part- I)-1976,

i. Immediate Settlement **(S_i)** = $\dfrac{pB(1-\mu^2)I_f}{E_s}$

Where,

P = net foundation pressure

B = Width of the foundation

μ = Poisson's Ratio

E = Young s's modulus

If = Influence Factor

ii. Consolidation Settlement **(S_c)** = $\dfrac{C_c H_c}{1+e_o}\log(\dfrac{P_o+\Delta P_o}{P_o})$

Where,

H_t = Thickness of the layer

C_c = Compression Index

P_o = Initial effective pressure at mid-height of layer, T/m2

ΔP = Pressure increment, T/m2

e_o = Void ratio

The typical Calculations Sheets are placed at **Annexure – VII(B)** .

Based on the bore log, sub soil conditions

Table No. B-1 Bearing Capacity Based on Settlement Criteria

Bore Hole No.	Depth below EGL (m)	Width of foundation (m)	Vertical Load (t/m^2) (Given)	Total Expected Settlement (mm)	Permissible Settlement** (mm)	Net Safe Settlement Pressure(t/m^2)	
						25mm	50mm
01	1.00	2.00 x 2.00	5.50	29.10	50.00	4.73	9.45
	1.50	2.00 x 2.00	5.50	23.21	50.00	5.93	11.85
02	1.00	2.00 x 2.00	5.50	34.77	50.00	3.95	7.91
	1.50	2.00 x 2.00	5.50	27.41	50.00	5.02	10.03
03	1.00	2.00 x 2.00	5.50	34.85	50.00	3.95	7.89
	1.50	2.00 x 2.00	5.50	27.48	50.00	5.00	10.01
04	1.00	2.00 x 2.00	5.50	35.93	50.00	3.83	7.65
	1.50	2.00 x 2.00	5.50	28.27	50.00	4.86	9.73
05	1.00	2.00 x 2.00	5.50	37.91	50.00	3.63	7.25
	1.50	2.00 x 2.00	5.50	29.70	50.00	4.63	9.26
06	1.00	2.00 x 2.00	5.50	31.94	50.00	4.31	8.61
	1.50	2.00 x 2.00	5.50	25.21	50.00	5.45	10.91

****Note: -** Permissible settlement values are, as per IS: 1904-1986.

D. PILE BEARING CAPACITY :

The diameter of the pile has been taken into consideration as per IS: 2911(Part1/Sec2). Here looking to the soil strata, **IS 2911 Part.2/ Section.2 – Bored Cast in situ piles (R2010)** has been followed for Bored Cast in Situ Pile Foundation. Vertical Axial Compression Capacity, uplift capacity and allowable lateral load capacities are furnished. The typical Calculations Sheet are placed at **Annexure – V & Annexure – VI** .

11.0 RECOMMENDATION

- Generally Four layer sub-soil profiles have been noticed in the boreholes and the detailed description of soil layers is made in tabular form.

In View of the these findings & results obtained during the field and laboratory investigations and the analysis carried out there after, following general recommendations are being made for the foundation design of the proposed Golaghat to BCPL Lakwa Terminal.

12.0 CONCLUSION

- ✓ Final recommend safe bearing capacity for designing the foundation for shear/settlement criteria are equal to least of the value from Safe Bearing Capacity (Shear) - (i.e., Table: A-2) and Safe Settlement Pressure - (i.e., Table: B-2) capacity at any desired depth of foundation**.**
- ✓ Soil investigation Analysis propose shallow depth of foundation for pipe line structures.
- ✓ We propose to have foundation depth in the range of 3.0mtr below EGL comparing the strata available . If during excavation the quantity of sub- soft soil is higher than it is recommended to have helical type of foundation for pipe line structures
- ✓ Raft foundation and Pile Foundation may be anticipated under circumstances of heavy industrial loading condition anticipated by structural design engineering team.(both raft and pile foundations are used when soil conditions or the loads on a structure make shallow foundations impractical or impossible).
- ✓ The diameter of the pile has been taken into consideration as per IS: 2911(Part1/Sec2).
- ✓ As per the requirement of client, R.C.C. Bored Cast-in-situ piles (as per IS 2911, Part I - Sec – 2) for foundation system has been calculated. The values of safe Vertical Capacity of various nominal diameters of R.C.C. Bored Cast-in-situ Piles having a cut-off level and tip level as indicated in the following table may be considered. Regarding the 'diameter and configuration' of the pile thereof shall be taken by the designer depending upon the magnitude of load transfer.

Pile capacity and Lateral Load

Sl .No	Borehole Number	Cut-Off Level (m)	Length of pile (m)	Diameter of Pile (mm)	Vertical load Carrying capacity of Pile (Ton)	Uplift Load (Ton)	Lateral Load (Ton) (1% of the dia of the Pile)	
							Free End Pile	Fixed End Pile
01	01	1.50	15.0	450	116.56	43.35	0.65	1.70
				500	138.47	48.66	0.80	2.10
02	03	1.50	15.0	450	86.51	36.55	0.61	1.60
				500	102.27	41.09	0.76	1.97
03	04	1.50	15.0	450	115.16	42.27	0.58	1.50
				500	136.88	47.46	0.72	1.88
04	05	1.50	15.0	450	86.71	30.15	0.51	1.32
				500	65.45	23.45	0.62	1.63
05	06	1.50	15.0	450	109.80	40.08	0.69	1.79
				500	130.61	45.02	0.84	2.18

- ✓ As per clause 6.9 of IS-2911 (Part 1-Sec 2), a maximum permissible safe load of a pile as arising out of wind loading is 25%. In case of loads arising out of earthquake effects, the increase of safe load on a single pile shall be limited to the provisions contained in IS 1893 (Part 1). For transient loading arising out of superimposed loads, no increase is permitted and shall be taken care of by the Structural Engineer and seismic forces are not being taken into consideration.
- ✓ The decision regarding the 'configuration of the pile' shall be taken by the Structural designer depending upon the magnitude of load transfer envisaged. It may be noted that pile capacity depends on piling methodology, equipment used and experience of piling agency. Therefore, care should be taken to ensure quality

control and provisions of relevant BIS codes should be followed. Pile capacity should be verified by the load test following the BIS code.

- ✓ Initial and Routine Pile load tests shall be carried out as per IS-2911 (Part IV) for confirmation of pile capacity prior to installation of actual piles for the proposed structure and after pile installation. The maximum test load should be two and a half times and one and half times the safe load for initial and routine pile load tests respectively.
- ✓ Choice of foundation as discussed above depends on the superstructure loading and hence it lies with the Structural Designer.
- ✓ Every precautionary measure as laid down in the relevant I.S. codes and as applicable for the particular type of foundation is to be adopted here must be taken during the execution of the foundation work. Due consideration should be particularly given towards the safety of nearly existing structures or any other water bodies, if any. Proper dewatering system must be designed during construction.
- ✓ Precaution shall be taken for slope of excavation during execution of work.
- ✓ For back-filling purpose, SP - SM(Poorly graded Sand as containing Silts as fines) as along with murrum or sandy soil or sandy gravel or Granular soil alike material for better efficiency.
- ✓ For the purpose of proportion of mix 2:1 (Murrum:Clay) is mostly applicable for shallow foundation back filling purpose.
- ✓ For the purpose of boundary wall of brick work generalized calculations made as follows (2000kg/m^3 x 1.50mtr height x 1.0m length)(approx - 3 t/m weight).for lesser load we recommend shallow foundation.
- ✓ Base of footing shall be compacted efficiently before laying PCC.

13.0 REFERENCES

- ❖ IS 1892-1979: Code of Practice for Subsurface Investigation for Foundations, Bureau of Indian Standards, New Delhi.
- ❖ IS 2131-1981: Method of Standard Penetration Test, Bureau of Indian Standards, New Delhi.

- SP 36 (Part 1) - Compendium of Indian Standards on Soil Engineering, Laboratory Testing of Soils for Civil Engineering Purposes, Bureau of Indian Standards, New Delhi.
- SP 36 (Part 2) - Compendium of Indian Standards on Soil Engineering, Field Testing of Soils for Civil Engineering Purposes, Bureau of Indian Standards, New Delhi.
- IRC 78-2000 - COP for Road Bridges, Indian Roads Congress, applied in scour depth calculations A Text Book of Soil Chemical Analysis, RR Hesse, CBS Publishers & Distributors, New Delhi.
- IS 2720 - Compendium of Indian Standards on Laboratory Testing of Soils for Civil Engineering Purposes .

14.0 LIMITATION

The results made in the report are valid only for these tests locations. However, if there is any change in sub soil conditions and properties at place beyond chosen test locations, the soil consultants be contacted for further guidance.

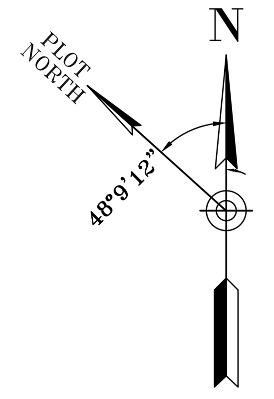
15.0 ACKNOWLEDGEMENT

We record our thanks to Assam Gas Company Ltd officials for their excellent co-operation and guidance during field work & preparation of this report.

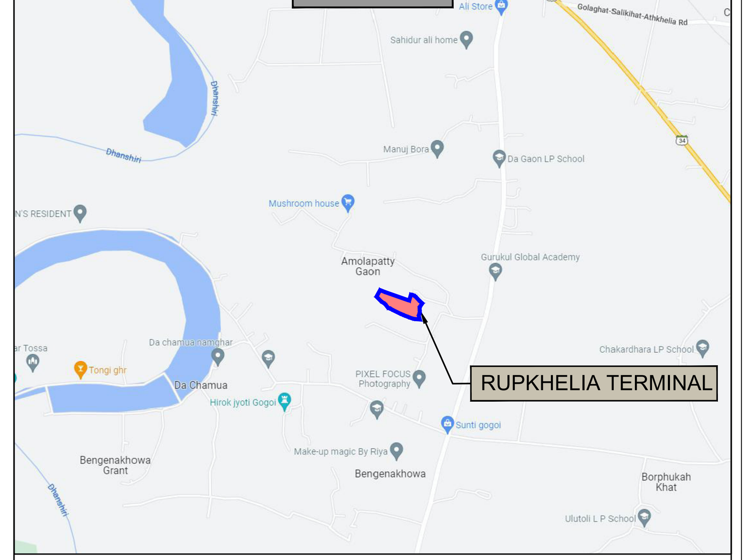
For SKP Projects Pvt. Ltd.

Authorized Signatory

Annexure - I
(LOCATION MAP)



KEY MAP



● HFL AS PER LOCAL INQUIRY : 111.02M

STATEMENT OF REFERENCE BENCH MARK & DGPS

PILLER NO	EASTING	NORTHING	MEAN SEA LEVEL
TBM–105	596860.19	2928285.13	109.83
TBM–106	596920.72	2928262.81	109.83
TBM–197	596795.21	2928200.02	110.79

STATEMENT OF REFERENCE BORE HOLE

BH NO	EASTING	NORTHING	MEAN SEA LEVEL
BH–1	596848.00	2928171.00	110.93
BH–2	596816.00	2928179.00	107.71
BH–3	596787.00	2928101.00	109.31
BH–4	596827.00	2928089.00	111.90
BH–5	596697.00	2928149.00	108.70
BH–6	596714.00	2928195.00	111.30

STATEMENT OF REFERENCE PILLAR

PILLER NO	EASTING	NORTHING	MEAN SEA LEVEL
P1	596814.25	2928204.73	110.07
P2	596838.58	2928193.88	110.21
P3	596871.31	2928161.81	109.74
P4	596855.20	2928078.43	111.36
P5	596804.01	2928089.23	109.98
P6	596783.30	2928097.61	109.89
P7	596705.23	2928135.27	109.72
P8	596688.94	2928150.54	108.60
P9	596683.21	2928158.64	108.52
P10	596664.16	2928172.36	108.50
P11	596680.23	2928210.93	110.51
P12	596713.04	2928198.67	111.00
P13	596799.28	2928177.41	110.50
P14	596805.49	2928176.26	110.54
P15	596653.91	2928152.10	111.50
P16	596617.44	2928159.96	109.67
P17	596653.75	2928231.64	110.97
P18	596659.11	2928244.07	111.00
P19	596687.62	2928238.19	111.00

STATEMENT OF REFERENCE FENCING POINTS BETWEEN PILLAR POINTS

PILLER NO	EASTING	NORTHING	MEAN SEA LEVEL
F1	596836.62	2928195.46	110.05
F2	596853.69	2928177.91	110.62
F3	596858.77	2928172.55	110.83
F4	596825.74	2928081.74	111.52
F5	596814.58	2928084.89	109.88
F6	596751.82	2928111.12	110.44
F7	596750.47	2928111.64	110.49
F8	596749.51	2928112.28	110.40
F9	596740.73	2928117.12	109.66
F10	596705.94	2928134.90	109.71
F11	596693.32	2928143.96	108.94
F12	596681.66	2928161.07	108.51
F13	596677.98	2928164.39	108.50
F14	596679.56	2928211.06	110.50
F15	596746.76	2928186.23	111.00
F16	596748.47	2928186.77	110.99
F17	596750.13	2928191.78	110.67

LEGEND

Proposed PipeLine	IP21/1 TP21		
Road		Building	
Cart Track		Settlements	
Culvert		Temple	
River		Well	W
Nala		Tube Well	
Canal		Other Tree	
Bench Mark	TBM	Lamp Pole	
Mango Tree		Power Line	FP
DGPS		Pillar	P1
Major Contour	100.00	Sport Levels	100.50
Minor Contour	100.50	Fancing	F1

REV	DATE	REVISION	BY	CHKD	APRD	PROJ ENGR
1	23/02/2023	ISSUED FOR CLIENT REVIEW	Arti	Ramesh		
0	03/10/2022	ISSUED FOR CLIENT REVIEW	Arti	Ramesh		

Note:–

1. ALL DIMENESION & LEVEL ARE IN METER
2. REF. BENCH MARK MSL VALUE TBM–105 "110.58" MARK ON ROAD EDGE,CONTOUR INTERVAL 0.50 M
3. 48°9'12" ANGLE BETWEEN TRUE NORTH & MAGNETIC NORTH.
4. WGS–84/UTM ZONE 46 CO–ORDINATES SYSTEM.

PROJECT :– SURVEY OF PIPELINE ROUTE AND STATIONS FOR GOLAGHAT TO BCPL LAKWA GAS PIPELINE PROJECT

CLIENT: – ASSAM GAS COMPANY LTD (A GOVT. OF ASSAM UNDERTAKING)

SURVEY AGENCY: – SKP
201–205, Sai Samarth Complex, Near Maneja Crossing
Makarpura Road, Vadodara – 390 010.
Phone= 7228940501/7228940502
(ANISO 9001:2015 CERTIFIED COMPANY)

TITLE:–

TOPOGRAPHICAL SURVEY DRAWING OF RUPKHELIA TERMINAL
SURVEY AREA:19094.786SQM(4.718ACRES)

SCALE:– 1M 0 1 2 3 4 5 6 7M
SCALE: 1:500 OR 1CM = 05M
CONTOUR INTERVAL = 0.5

DATE:– OCT 2022	RIV :–	CAD FILENAME:– SKP/RUPKHELIA TERMINAL	Page 36

Annexure - II
(BORE LOGS)

BORE LOG DATA SHEET

Bore Hole No	BH-1		
Sheet No	1	of	1
Client:	ASSAM GAS COMPANY LTD	Depth of Boring, m:	15.00
Project :	GOLAGHAT - BCPL LAKWA GAS PIPELINE PROJECT	Date of Execution	28-09-2022
Site Location:	Rupkhelia Terminal	Date of Completion:	29-09-2022

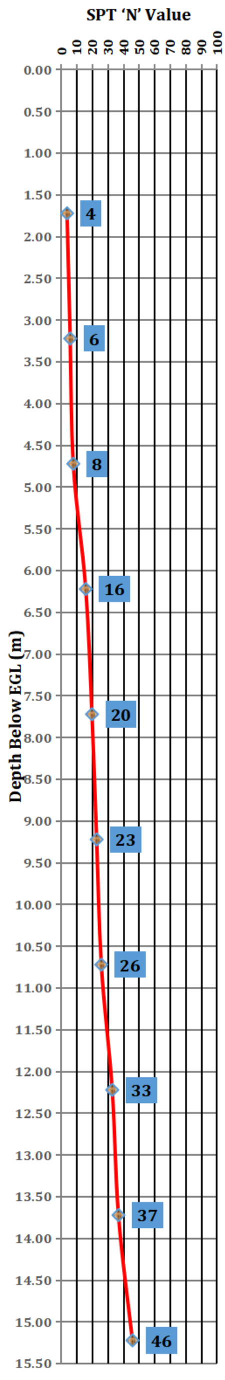
Co-Ordinates:					
Northing	2928171	Ground RL (m) (MSL)	110.93	Diameter of Boring,mm:	150.00
Easting	596848	Ground Water Table(m)	2.50	Type of Boring:	Calyx Boring

Depth below G.L. in (m): 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5

Existing Ground Level

Thickness, m	Description of Strata	Ground Water Table	Sampling: Sample Type	No	Depth w.r.t RL (m)	Lab. No.	SPT Blows/cm 0 - 15	15-30	30-45	SPT "N" value	Core Length (cm)	Core Recovery (%)	RQD (%)
5.00	Soft Brownish Colour Silty Clay (SC-Sandy Clay)		DS	1	110.93 / 109.43	AGCL-BH-1-1							
			SPT	1	109.43 / 108.98	AGCL-BH-1-2	1	2	2	4	-	-	-
		2.50m	DS	2	109.43 / 107.93								
			SPT	2	107.93 / 107.48	AGCL-BH-1-3	2	2	4	6	-	-	-
			DS	3	107.93 / 106.43								
			SPT	3	106.43 / 105.98	AGCL-BH-1-4	2	3	5	8	-	-	-
3.00	Stiff Brownish Colour Clay (CH-High Compressiblity Clay)		DS	4	106.43 / 104.93								
			SPT	4	104.93 / 104.48	AGCL-BH-1-5	4	7	9	16	-	-	-
			DS	5	104.93 / 103.43								
			SPT	5	103.43 / 102.98	AGCL-BH-1-6	6	9	11	20	-	-	-
3.00	Medium Dense Grayish Colour Fine Grained Sand (SM-SC - Silty Sand as Containing Clay as fines)		DS	6	103.43 / 101.93								
			SPT	6	101.93 / 101.48	AGCL-BH-1-7	6	10	13	23	-	-	-
			DS	7	101.93 / 100.43								
			SPT	7	100.43 / 99.98	AGCL-BH-1-8	8	11	15	26	-	-	-
4.00	Dense Grayish Colour Fine Grained Sand (SP-SM - Poorly Graded Sand as Containing Silts as fines)		DS	8	100.43 / 98.93								
			SPT	8	98.93 / 98.48	AGCL-BH-1-9	8	14	19	33	-	-	-
			DS	9	98.93 / 97.43								
			SPT	9	97.43 / 96.98	AGCL-BH-1-10	10	13	24	37	-	-	-
			DS	10	97.43 / 95.93								
			SPT	10	95.93 / 95.48	AGCL-BH-1-11	13	19	27	46	-	-	-

SPT Curve



Borehole Terminated.

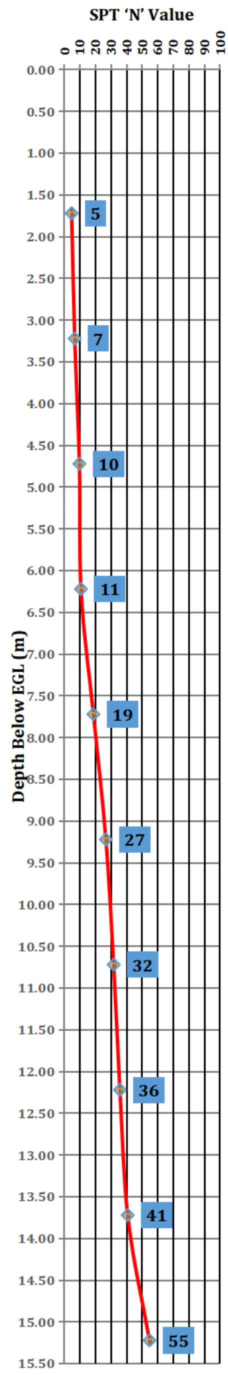
Abbreviation:

UDS : Undisturbed Sample DS : Disturbed Sample SPT : Standard Penetration Test RQD : Rock Quality Designation RCS : Rock Core Sample

JOB NO.: SKP/AGCL/BH-01/22-23

SKP	# BORE LOG DATA SHEET	Bore Hole No	BH-2
		Sheet No	1 of 1
Client:	ASSAM GAS COMPANY LTD	**Depth of Boring, m:**	15.00
Project :	GOLAGHAT - BCPL LAKWA GAS PIPELINE PROJECT	**Date of Execution**	25-09-2022
Site Location:	Rupkhelia Terminal	**Date of Completion:**	26-09-2022
Co-Ordinates:	**Northing** 2928101 — **Ground RL (m) (MSL)** 107.71	**Diameter of Boring,mm:**	150.00
	Easting 596787 — **Ground Water Table(m)** 1.70	**Type of Boring:**	Calyx Boring

Depth below G.L. in (m)	Thickness, m	Description of Strata	Legend	Ground Water Table	Sampling: Sample Type	Sampling: No	Sampling: Depth w.r.t RL (m)	Sampling: Lab. No.	SPT Details: Blows/cm 0 - 15	SPT Details: Blows/cm 15-30	SPT Details: Blows/cm 30-45	SPT "N" value	Core Details: Core Length (cm)	Core Details: Core Recovery (%)	RQD (%)	SPT Curve
0.0	Existing Ground Level															
0.5 1.0	3.50	Soft Brownish Colour Silty Clay (SC-Sandy Clay)			DS	1	107.71 106.21	AGCL-BH-2-1								
1.5 2.0				1.70 m	SPT	1	106.21 105.76	AGCL-BH-2-2	1	2	3	5	-	-	-	
2.5					DS	2	106.21 104.71									
3.0 3.5					SPT	2	104.71 104.26	AGCL-BH-2-3	1	3	4	7	-	-	-	
4.0	4.00	Stiff Deep Grayish Colour Clay (SC-Sandy Clay)			DS	3	104.71 103.21									
4.5 5.0					SPT	3	103.21 102.76	AGCL-BH-2-4	2	4	6	10	-	-	-	
5.5					DS	4	103.21 101.71									
6.0 6.5					SPT	4	101.71 101.26	AGCL-BH-2-5	4	4	7	11	-	-	-	
7.0					DS	5	101.71 100.21									
7.5 8.0	7.50	Stiff to Very Stiff Grayish Colour Clay (CH-High Compressiblity Clay)			SPT	5	100.21 99.76	AGCL-BH-2-6	6	8	11	19	-	-	-	
8.5					DS	6	100.21 98.71									
9.0 9.5					SPT	6	98.71 98.26	AGCL-BH-2-7	8	12	15	27	-	-	-	
10.0					DS	7	98.71 97.21									
10.5 11.0					SPT	7	97.21 96.76	AGCL-BH-2-8	10	14	18	32	-	-	-	
11.5					DS	8	97.21 95.71									
12.0 12.5					SPT	8	95.71 95.26	AGCL-BH-2-9	12	16	20	36	-	-	-	
13.0					DS	9	95.71 94.21									
13.5 14.0					SPT	9	94.21 93.76	AGCL-BH-2-10	18	19	22	41	-	-	-	
14.5					DS	10	94.21 92.71									
15.0 15.5					SPT	10	92.71 92.26	AGCL-BH-2-11	19	24	31	55	-	-	-	
Borehole Terminated.																



Abbreviation:

UDS : Undisturbed Sample DS : Disturbed Sample SPT : Standard Penetration Test RQD : Rock Quality Designation RCS : Rock Core Sample

JOB NO.: SKP/AGCL/BH-02/22-23

BORE LOG DATA SHEET

Bore Hole No	BH-3	Sheet No	1 of 1
Client:	ASSAM GAS COMPANY LTD	Depth of Boring, m:	15.00
Project :	GOLAGHAT - BCPL LAKWA GAS PIPELINE PROJECT	Date of Execution	21-09-2022
Site Location:	Rupkhelia Terminal	Date of Completion:	21-09-2022
Co-Ordinates: Northing	2928179	Ground RL (m) (MSL)	109.31
Co-Ordinates: Easting	596816	Ground Water Table(m)	0.20
		Diameter of Boring,mm:	150.00
		Type of Boring:	Calyx Boring

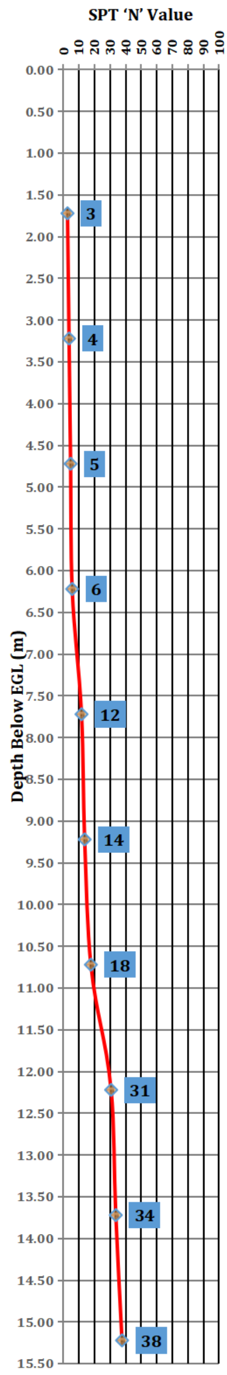
Depth below G.L. in (m): 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5

Existing Ground Level

Ground Water Table: 0.20 m

Thickness, m	Description of Strata	Sample Type	No	Depth w.r.t RL (m)	Lab. No.	SPT Blows/cm 0 - 15	15-30	30-45	SPT "N" value	Core Length (cm)	Core Recovery (%)	RQD (%)
6.50	Soft Brownish Grayish Colour Clay (CH-High Compressiblity Clay)	DS	1	109.31 / 107.81	AGCL-BH-3-1							
		SPT	1	107.81 / 107.36	AGCL-BH-3-2	1	1	2	3	-	-	-
		DS	2	107.81 / 106.31								
		SPT	2	106.31 / 105.86	AGCL-BH-3-3	1	2	2	4	-	-	-
		DS	3	106.31 / 104.81								
		SPT	3	104.81 / 104.36	AGCL-BH-3-4	2	2	3	5	-	-	-
		DS	4	104.81 / 103.31								
		SPT	4	103.31 / 102.86	AGCL-BH-3-5	2	3	3	6	-	-	-
4.50	Medium Dense Brownish Grayish Colour Silty Sand (SM- Silty Sand)	DS	5	103.31 / 101.81								
		SPT	5	101.81 / 101.36	AGCL-BH-3-6	4	6	6	12	-	-	-
		DS	6	101.81 / 100.31								
		SPT	6	100.31 / 99.86	AGCL-BH-3-7	4	6	8	14	-	-	-
		DS	7	100.31 / 98.81								
		SPT	7	98.81 / 98.36	AGCL-BH-3-8	6	8	10	18	-	-	-
4.00	Dense Grayish Colour Fine Grained Sand (SP-SM - Poorly Graded Sand as Containing Silts as fines)	DS	8	98.81 / 97.31								
		SPT	8	97.31 / 96.86	AGCL-BH-3-9	10	13	18	31	-	-	-
		DS	9	97.31 / 95.81								
		SPT	9	95.81 / 95.36	AGCL-BH-3-10	12	14	20	34	-	-	-
		DS	10	95.81 / 94.31								
		SPT	10	94.31 / 93.86	AGCL-BH-3-11	15	18	20	38	-	-	-

SPT Curve



Borehole Terminated.

Abbreviation:

UDS : Undisturbed Sample DS : Disturbed Sample SPT : Standard Penetration Test RQD : Rock Quality Designation RCS : Rock Core Sample

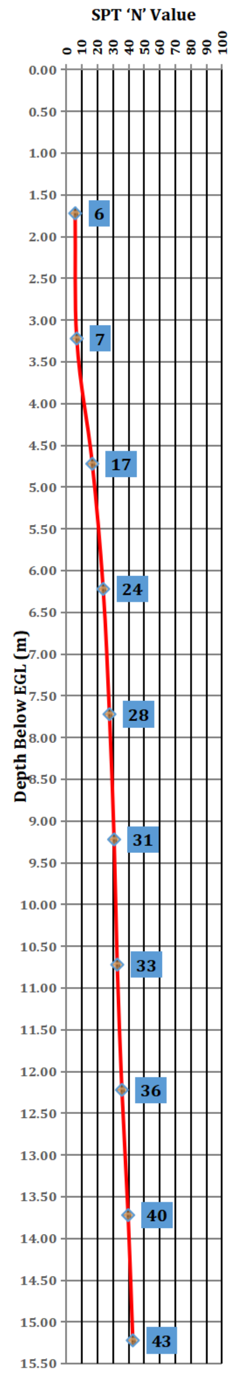
JOB NO.: SKP/AGCL/BH-03/22-23

BORE LOG DATA SHEET

Bore Hole No	BH-4				
Sheet No	1 of 1				
Client:	ASSAM GAS COMPANY LTD			Depth of Boring, m:	15.00
Project :	GOLAGHAT - BCPL LAKWA GAS PIPELINE PROJECT			Date of Execution	27-09-2022
Site Location:	Rupkhelia Terminal			Date of Completion:	28-09-2022
Co-Ordinates:	Northing 2928089	Ground RL (m) (MSL)	111.90	Diameter of Boring,mm:	150.00
	Easting 596827	Ground Water Table(m)	2.10	Type of Boring:	Calyx Boring

Depth below G.L. in (m)	Thickness, m	Description of Strata	Legend	Ground Water Table	Sampling: Sample Type	No	Depth w.r.t RL (m)	Lab. No.	SPT Details: Blows/cm 0 - 15	15-30	30-45	SPT "N" value	Core Details: Core Length (cm)	Core Recovery (%)	RQD (%)	SPT Curve
0.0	Existing Ground Level															
0.5 – 3.5	3.50	Soft Brownish Grayish Colour Clay (SC-Sandy Clay)		2.10 m	DS	1	111.90 / 110.40	AGCL-BH-4-1								
					SPT	1	110.40 / 109.95	AGCL-BH-4-2	2	2	4	6	-	-	-	
					DS	2	110.40 / 108.90									
					SPT	2	108.90 / 108.45	AGCL-BH-4-3	2	2	5	7	-	-	-	
4.0 – 6.5	3.00	Stiff Brownish Grayish Colour Clay (SC-Sandy Clay)			DS	3	108.90 / 107.40									
					SPT	3	107.40 / 106.95	AGCL-BH-4-4	3	7	10	17	-	-	-	
					DS	4	107.40 / 105.90									
					SPT	4	105.90 / 105.45	AGCL-BH-4-5	5	10	14	24	-	-	-	
7.0 – 9.5	3.00	Stiff Deep Grayish Silty Clayey (SM-SC - Silty Sand as Containing Clay as fines)			DS	5	105.90 / 104.40									
					SPT	5	104.40 / 103.95	AGCL-BH-4-6	7	11	17	28	-	-	-	
					DS	6	104.40 / 102.90									
					SPT	6	102.90 / 102.45	AGCL-BH-4-7	8	12	19	31	-	-	-	
10.0 – 15.5	5.50	Dense Deep Grayish Colour Fine Grained Silty Sand (SP-SM - Poorly Graded Sand as Containing Silts as fines)			DS	7	102.90 / 101.40									
					SPT	7	101.40 / 100.95	AGCL-BH-4-8	9	12	21	33	-	-	-	
					DS	8	101.40 / 99.90									
					SPT	8	99.90 / 99.45	AGCL-BH-4-9	11	14	22	36	-	-	-	
					DS	9	99.90 / 98.40									
					SPT	9	98.40 / 97.95	AGCL-BH-4-10	12	16	24	40	-	-	-	
					DS	10	98.40 / 96.90									
					SPT	10	96.90 / 96.45	AGCL-BH-4-11	15	17	26	43	-	-	-	
Borehole Terminated.																

Depth scale (m): 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5



Abbreviation:

UDS : Undisturbed Sample DS : Disturbed Sample SPT : Standard Penetration Test RQD : Rock Quality Designation RCS : Rock Core Sample

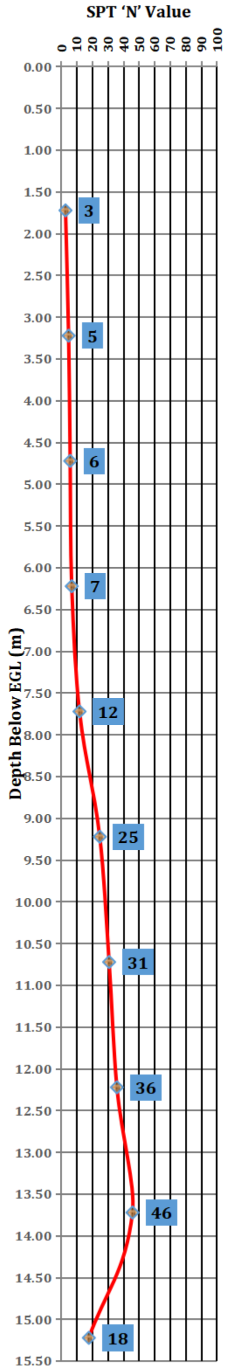
JOB NO.: SKP/AGCL/BH-04/22-23

BORE LOG DATA SHEET

Bore Hole No	BH-5		
Sheet No	1	of	1
Client:	ASSAM GAS COMPANY LTD	Depth of Boring, m:	15.00
Project :	GOLAGHAT - BCPL LAKWA GAS PIPELINE PROJECT	Date of Execution	22-09-2022
Site Location:	Rupkhelia Terminal	Date of Completion:	23-09-2022
Co-Ordinates: Northing	2928149	Ground RL (m) (MSL)	108.70
Diameter of Boring,mm:	150.00		
Co-Ordinates: Easting	596697	Ground Water Table(m)	0.50
Type of Boring:	Calyx Boring		

Depth below G.L. in (m)	Thickness, m	Description of Strata	Legend	Ground Water Table	Sampling: Sample Type	Sampling: No	Sampling: Depth w.r.t RL (m)	Sampling: Lab. No.	SPT Details: Blows/cm 0 - 15	SPT Details: Blows/cm 15-30	SPT Details: Blows/cm 30-45	SPT "N" value	Core Details: Core Length (cm)	Core Details: Core Recovery (%)	RQD (%)
0.0	Existing Ground Level														
0.5, 1.0	5.00	Soft Brownish Colour Silty Clay (MH-High Plasticity Silts)		0.50 m	DS	1	108.70 / 107.20	AGCL-BH-5-1							
1.5, 2.0					SPT	1	107.20 / 106.75	AGCL-BH-5-2	1	1	2	3	-	-	-
2.5					DS	2	107.20 / 105.70								
3.0, 3.5					SPT	2	105.70 / 105.25	AGCL-BH-5-3	2	2	3	5	-	-	-
4.0					DS	3	105.70 / 104.20								
4.5, 5.0					SPT	3	104.20 / 103.75	AGCL-BH-5-4	2	2	4	6	-	-	-
5.5	1.50	Loose to Very Loose Grayish colour Fine Grained Sand as Containing Silts as Fines (SP-SM - Poorly Graded			DS	4	104.20 / 102.70								
6.0, 6.5					SPT	4	102.70 / 102.25	AGCL-BH-5-5	2	2	5	7	-	-	-
7.0	3.50	Medium Dense Grayish colour Fine Grained Sand as Containing Silts as Fines (SP-SM - Poorly Graded Sand as Containing Silts as fines)			DS	5	102.70 / 101.20								
7.5, 8.0					SPT	5	101.20 / 100.75	AGCL-BH-5-6	3	5	7	12	-	-	-
8.5					DS	6	101.20 / 99.70								
9.0, 9.5					SPT	6	99.70 / 99.25	AGCL-BH-5-7	6	10	15	25	-	-	-
10.0					DS	7	99.70 / 98.20								
10.5, 11.0	4.00	Dense Grayish Brownish colour Fine Grained Sand (SM - Silty Sand)			SPT	7	98.20 / 97.75	AGCL-BH-5-8	9	13	18	31	-	-	-
11.5					DS	8	98.20 / 96.70								
12.0, 12.5					SPT	8	96.70 / 96.25	AGCL-BH-5-9	10	15	21	36	-	-	-
13.0					DS	9	96.70 / 95.20								
13.5, 14.0					SPT	9	95.20 / 94.75	AGCL-BH-5-10	14	20	26	46	-	-	-
14.5	1.00	Stiff Grayish Colour Clay (SC-Sandy Clay)			DS	10	95.20 / 93.70								
15.0, 15.5					SPT	10	93.70 / 93.25	AGCL-BH-5-11	4	8	10	18	-	-	-

SPT Curve



Borehole Terminated.

Abbreviation:
UDS : Undisturbed Sample DS : Disturbed Sample SPT : Standard Penetration Test RQD : Rock Quality Designation RCS : Rock Core Sample

JOB NO.: SKP/AGCL/BH-05/22-23

BORE LOG DATA SHEET

Bore Hole No	BH-6	Sheet No	1 of 1
Client:	ASSAM GAS COMPANY LTD	Depth of Boring, m:	15.00
Project :	GOLAGHAT - BCPL LAKWA GAS PIPELINE PROJECT	Date of Execution	24-09-2022
Site Location:	Rupkhelia Terminal	Date of Completion:	24-09-2022
Co-Ordinates: Northing	2928195	Ground RL (m) (MSL)	111.30
Co-Ordinates: Easting	596714	Ground Water Table(m)	2.10
Diameter of Boring,mm:	150.00	Type of Boring:	Calyx Boring

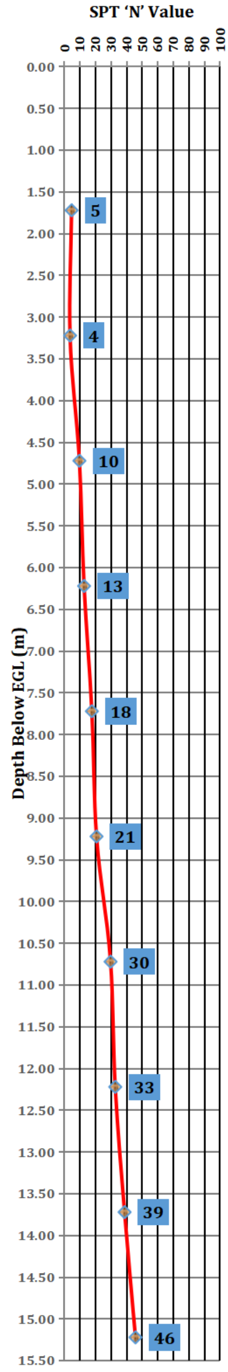
Depth below G.L. in (m): 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5

Existing Ground Level

Ground Water Table: 2.10 m

Thickness, m	Description of Strata	Sample Type	No	Depth w.r.t RL (m)	Lab. No.	Blows/cm 0 - 15	Blows/cm 15-30	Blows/cm 30-45	SPT "N" value	Core Length (cm)	Core Recovery (%)	RQD (%)
6.50	Soft Brownish Yellowish Colour Sandy Clay (SC-Sandy Clay)	DS	1	111.30 / 109.80	AGCL-BH-6-1							
		SPT	1	109.80 / 109.35	AGCL-BH-6-2	1	2	3	5	-	-	-
		DS	2	109.80 / 108.30								
		SPT	2	108.30 / 107.85	AGCL-BH-6-3	1	2	2	4	-	-	-
		DS	3	108.30 / 106.80								
		SPT	3	106.80 / 106.35	AGCL-BH-6-4	2	4	6	10	-	-	-
		DS	4	106.80 / 105.30								
		SPT	4	105.30 / 104.85	AGCL-BH-6-5	4	5	8	13	-	-	-
3.50	Medium Dense Grayish colour Fine to Medium Grained Sand (SP-SM - Poorly Graded Sand as Containing Silts as fines)	DS	5	105.30 / 103.80								
		SPT	5	103.80 / 103.35	AGCL-BH-6-6	4	8	10	18	-	-	-
		DS	6	103.80 / 102.30								
		SPT	6	102.30 / 101.85	AGCL-BH-6-7	6	9	12	21	-	-	-
5.00	Dense Grayish colour Fine to Medium Grained Sand (SM - Silty Sand)	DS	7	102.30 / 100.80								
		SPT	7	100.80 / 100.35	AGCL-BH-6-8	7	12	18	30	-	-	-
		DS	8	100.80 / 99.30								
		SPT	8	99.30 / 98.85	AGCL-BH-6-9	10	14	19	33	-	-	-
		DS	9	99.30 / 97.80								
		SPT	9	97.80 / 97.35	AGCL-BH-6-10	13	17	22	39	-	-	-
		DS	10	97.80 / 96.30								
		SPT	10	96.30 / 95.85	AGCL-BH-6-11	15	19	27	46	-	-	-

SPT Curve



Borehole Terminated.

Abbreviation:

UDS : Undisturbed Sample DS : Disturbed Sample SPT : Standard Penetration Test RQD : Rock Quality Designation RCS : Rock Core Sample

JOB NO.: SKP/AGCL/BH-06/22-23

Annexure - III

(LAB TEST RESULTS)

SUMMARY OF LABORATORY TEST RESULTS

Project:	**Laboratory testing of samples collected from geotechnical investigation at RUPKHELIA TERMINAL for AGCL**	**JOB NO.:**	**SKP/AGCL-1/22-23**
Client:	***AGCL***	*Nature of samples:*	***Soil and Rock Samples***
Borehole No:	***BH-1***	*Quantity of sample:*	***Sufficient***
Location:	***RUPKHELIA TERMINAL***	*Packing/Container:*	***Polybag***

LABORATORY TEST RESULTS

SAMPLE IDENTIFICATION					***SOIL***																			***Rock***	
						Grain size analysis					**Atterberg Limits**			**Direct shear test (UU)**		**Consoloidation Test**			**Chemical tests**						
Strata of the sample	**Lab No**	***Sample location (From***	***& To)***	**Sample No**	**Natural Moisture Content**	**Gravel**	**Sand**	**Silt**	**Clay**	**Specific gravity**	**Liquid limit**	**Plastic limit**	**Plasticity Index**	**Cohesion**	**Angle of Internal friction (ϕ)**	**Compression Index (Cc)**	**Void Ratio (eo)**	**Free Swell Index**	**pH**	**Chloride**	**Sulphate**	**Carbonate**	**Organic matter**	**Uniaxial Compressive strength (UCS)**	**Point Load Test**
		(m)			**(%)**	**(%)**	**(%)**	**(%)**	**(%)**		**(%)**	**(%)**		**kg/cm2**	**(°)**	**(%)**	**(%)**	**(%)**		**(%)**	**(%)**	**(%)**	**(%)**	**(Mpa)**	**(Mpa)**
Soft Brownish Colour Silty Clay	AGCL-BH-1-1	110.93	109.43	DS-1	43.26	0.00	52.36	30.26	17.38	2.701	36.52	20.62	15.90	0.32	0.00	IS	IS	30	7.96	0.02	0.26	0.35	2.01		
	AGCL-BH-1-2	109.43	108.98	SPT-1	41.35	0.00	54.73	27.64	17.63	2.721	33.77	18.96	14.81	0.32	0.00	IS	IS	20	7.64	0.03	0.24	0.34	1.85		
	AGCL-BH-1-3	107.93	107.48	SPT-2	40.59	0.00	53.69	31.11	15.20	2.715	30.29	16.36	13.93	0.33	0.00	IS	IS	20	7.34	0.01	0.25	0.38	1.54		
	AGCL-BH-1-4	106.43	105.98	SPT-3	39.80	0.00	50.62	29.70	19.68	2.736	33.87	19.64	14.23	0.33	0.00	IS	IS	30	7.79	0.02	0.23	0.32	1.64		
Stiff Brownish Colour Clay	AGCL-BH-1-5	104.93	104.48	SPT-4	41.23	0.00	49.68	32.56	17.76	2.719	37.52	19.72	17.80	0.36	0.00	IS	IS	30	7.46	0.03	0.28	0.25	1.75		
	AGCL-BH-1-6	103.43	102.98	SPT-5	41.08	0.00	46.00	46.95	7.05	2.615	34.15	18.07	16.08	0.37	0.00	IS	IS	30	7.64	0.01	0.24	0.29	1.59	**NA**	
Medium Dense Grayish Colour Fine Grained Sand	AGCL-BH-1-7	101.93	101.48	SPT-6	40.29	0.00	60.38	36.10	3.52	2.653	26.23	12.36	13.87	0.26	17.12	IS	IS	NP	7.47	0.02	0.27	0.33	1.45		
	AGCL-BH-1-8	100.43	99.98	SPT-7	40.35	0.00	53.60	36.55	9.85	2.661	27.36	16.84	10.52	0.24	13.26	IS	IS	NP	7.25	0.01	0.24	0.28	1.56		
Dense Grayish Colour Fine Grained Sand	AGCL-BH-1-9	98.93	98.48	SPT-8	40.59	0.00	66.41	30.86	2.73	2.659	25.69	18.25	7.44	0.00	19.38	IS	IS	NP	7.11	0.02	0.22	0.27	1.58		
	AGCL-BH-1-10	97.43	96.98	SPT-9	30.07	0.00	63.84	30.72	5.44	2.698	20.39	12.31	8.08	0.00	21.26	IS	IS	NP	7.01	0.02	0.29	0.37	1.60		
	AGCL-BH-1-11	95.93	95.48	SPT-10	29.11	0.00	60.25	30.98	8.77	2.662	23.65	13.72	9.93	0.00	23.00	IS	IS	NP	7.09	0.01	0.26	0.24	1.64		

SUMMARY OF LABORATORY TEST RESULTS

Project:	Laboratory testing of samples collected from geotechnical investigation at RUPKHELIA TERMINAL for AGCL		JOB NO.:	SKP/AGCL-2/22-23
Client:	*AGCL*	*Nature of samples:*	***Soil and Rock Samples***	
Borehole No:	*BH-2*	*Quantity of sample:*	***Sufficient***	
Location:	*RUPKHELIA TERMINAL*	*Packing/Container:*	***Polybag***	

LABORATORY TEST RESULTS

SAMPLE IDENTIFICATION					*SOIL*																				*Rock*	
						Grain size analysis					Atterberg Limits			Direct shear test (UU)		Consoloidation Test			Chemical tests						
Strata of the sample	Lab No	Sample location (From	& To)	Sample No	Natural Moisture Content	Gravel	Sand	Silt	Clay	Specific gravity	Liquid limit	Plastic limit	Plasticity Index	Cohesion	Angle of Internal friction (ϕ)	Compression Index (Cc)	Void Ratio (eo)	Free Swell Index	pH	Chloride	Sulphate	Carbonate	Organic matter	Uniaxial Compressive strength (UCS)	Point Load Test
		(m)			(%)	(%)	(%)	(%)	(%)		(%)	(%)		kg/cm2	(°)	(%)	(%)	(%)		(%)	(%)	(%)	(%)	(Mpa)	(Mpa)
Soft Brownish Colour Silty Clay	AGCL-BH-2-1	107.71	106.21	DS-1	43.28	0.00	52.56	29.64	17.80	2.756	45.26	22.63	22.63	0.36	0.00	IS	IS	20	7.10	0.02	0.14	0.30	1.29		
	AGCL-BH-2-2	106.21	105.76	SPT-1	40.33	1.29	49.38	29.64	19.69	2.763	43.78	28.95	14.83	0.30	0.00	IS	IS	10	7.25	0.03	0.13	0.31	1.27		
	AGCL-BH-2-3	104.71	104.26	SPT-2	35.24	0.00	54.67	30.27	15.06	2.750	40.92	24.64	16.28	0.31	0.00	IS	IS	10	7.32	0.02	0.12	0.30	1.27		
Stiff Deep Grayish Colour Clay	AGCL-BH-2-4	103.21	102.76	SPT-3	32.69	0.00	56.36	29.63	14.01	2.768	43.78	28.98	14.80	0.33	0.00	IS	IS	20	7.98	0.01	0.22	0.32	1.30		
	AGCL-BH-2-5	101.71	101.26	SPT-4	30.24	0.00	59.46	27.98	12.56	2.772	47.25	26.33	20.92	0.35	0.00	IS	IS	IS	7.01	0.03	0.32	0.35	1.36		
Stiff to Very Stiff Grayish Colour Clay	AGCL-BH-2-6	100.21	99.76	SPT-5	29.68	2.29	46.56	36.95	14.20	2.764	44.51	26.62	17.89	0.32	0.00	IS	IS	30	7.11	0.01	0.39	0.36	1.26	**NA**	
	AGCL-BH-2-7	98.71	98.26	SPT-6	28.31	3.15	49.93	30.54	16.38	2.758	46.32	26.31	20.01	0.34	0.00	IS	IS	30	7.85	0.03	0.40	0.32	1.89		
	AGCL-BH-2-8	97.21	96.76	SPT-7	26.39	0.00	50.36	39.61	10.03	2.761	37.68	24.28	13.40	0.31	0.00	IS	IS	20	7.65	0.01	0.49	0.37	2.01		
	AGCL-BH-2-9	95.71	95.26	SPT-8	24.59	1.27	53.69	29.02	16.02	2.659	35.15	20.36	14.79	0.30	0.00	IS	IS	30	7.23	0.02	0.50	0.38	2.26		
	AGCL-BH-2-10	94.21	93.76	SPT-9	20.09	0.00	59.64	29.46	10.90	2.721	30.38	19.62	10.76	0.30	0.00	IS	IS	IS	7.69	0.01	0.54	0.40	2.65		
	AGCL-BH-2-11	92.71	92.26	SPT-10	24.35	2.36	51.29	29.09	17.26	2.770	29.28	16.44	12.84	0.30	0.00	IS	IS	IS	7.95	0.01	0.49	0.34	2.34		

SUMMARY OF LABORATORY TEST RESULTS

Project:	**Laboratory testing of samples collected from geotechnical investigation at RUPKHELIA TERMINAL for AGCL**		**JOB NO.:**	**SKP/AGCL-3/22-23**
Client:	***AGCL***	*Nature of samples:*	***Soil and Rock Samples***	
Borehole No:	***BH-3***	*Quantity of sample:*	***Sufficient***	
Location:	***RUPKHELIA TERMINAL***	*Packing/Container:*	***Polybag***	

LABORATORY TEST RESULTS

SAMPLE IDENTIFICATION					***SOIL***																			***Rock***	
						Grain size analysis					**Atterberg Limits**			**Direct shear test (UU)**		**Consoloidation Test**			**Chemical tests**						
Strata of the sample	**Lab No**	***Sample location (From***	***& To)***	**Sample No**	**Natural Moisture Content**	**Gravel**	**Sand**	**Silt**	**Clay**	**Specific gravity**	**Liquid limit**	**Plastic limit**	**Plasticity Index**	**Cohesion**	**Angle of Internal friction (ϕ)**	**Compression Index (Cc)**	**Void Ratio (eo)**	**Free Swell Index**	**pH**	**Chloride**	**Sulphate**	**Carbonate**	**Organic matter**	**Uniaxial Compressive strength (UCS)**	**Point Load Test**
		(m)			**(%)**	**(%)**	**(%)**	**(%)**	**(%)**		**(%)**	**(%)**		**kg/cm2**	**(°)**	**(%)**	**(%)**	**(%)**		**(%)**	**(%)**	**(%)**	**(%)**	**(Mpa)**	**(Mpa)**
	AGCL-BH-3-1	109.31	107.81	DS-1	32.69	0.00	56.25	26.45	17.30	2.658	43.27	26.41	16.86	0.35	0.00	IS	IS	20	7.65	0.03	0.24	0.19	1.29		
	AGCL-BH-3-2	107.81	107.36	SPT-1	34.67	0.00	49.62	34.19	16.19	2.621	40.29	25.14	15.15	0.33	0.00	IS	IS	10	7.64	0.01	0.12	0.25	1.27		
Soft Brownish Grayish Colour Clay	AGCL-BH-3-3	106.31	105.86	SPT-2	37.29	0.00	45.25	37.81	16.94	2.614	39.62	22.35	17.27	0.32	0.00	IS	IS	20	7.25	0.02	0.56	0.35	1.29		
	AGCL-BH-3-4	104.81	104.36	SPT-3	28.39	0.00	43.26	35.25	21.49	2.625	36.28	21.14	15.14	0.36	0.00	IS	IS	20	7.35	0.01	0.15	0.30	1.30		
	AGCL-BH-3-5	103.31	102.86	SPT-4	30.20	0.00	58.79	27.11	14.10	2.637	35.27	19.17	16.10	0.32	0.00	IS	IS	IS	7.00	0.03	0.12	0.37	1.85		
	AGCL-BH-3-6	101.81	101.36	SPT-5	25.68	0.00	61.62	32.65	5.73	2.659	37.52	20.34	17.18	0.22	11.65	IS	IS	NP	7.54	0.01	0.36	0.29	1.59	**NA**	
Medium Dense Brownish Grayish Colour Silty Sand	AGCL-BH-3-7	100.31	99.86	SPT-6	27.61	0.00	66.29	30.72	2.99	2.614	29.81	19.14	10.67	0.16	13.64	IS	IS	NP	7.68	0.01	0.34	0.40	1.87		
	AGCL-BH-3-8	98.81	98.36	SPT-7	26.43	0.00	70.36	19.82	9.82	2.608	26.38	19.30	7.08	0.18	17.28	IS	IS	NP	7.75	0.02	0.32	0.39	1.62		
	AGCL-BH-3-9	97.31	96.86	SPT-8	22.53	0.00	75.63	20.36	4.01	2.710	20.92	14.64	6.28	0.00	19.11	IS	IS	NP	7.24	0.04	0.49	0.40	1.58		
Dense Grayish Colour Fine Grained Sand	AGCL-BH-3-10	95.81	95.36	SPT-9	21.38	0.00	78.76	19.67	1.57	2.654	19.46	10.25	9.21	0.00	21.68	IS	IS	NP	7.65	0.03	0.35	0.35	1.29		
	AGCL-BH-3-11	94.31	93.86	SPT-10	23.65	0.00	81.29	18.65	0.06	2.635	17.62	9.18	8.44	0.00	23.96	IS	IS	NP	7.51	0.02	0.39	0.35	1.37		

SUMMARY OF LABORATORY TEST RESULTS

Project:	Laboratory testing of samples collected from geotechnical investigation at RUPKHELIA TERMINAL for AGCL	**JOB NO.:**	SKP/AGCL-4/22-23
Client:	*AGCL*	*Nature of samples:*	*Soil and Rock Samples*
Borehole No:	*BH-4*	*Quantity of sample:*	*Sufficient*
Location:	*RUPKHELIA TERMINAL*	*Packing/Container:*	*Polybag*

LABORATORY TEST RESULTS

SAMPLE IDENTIFICATION					*SOIL*																			*Rock*	
						Grain size analysis					Atterberg Limits			Direct shear test (UU)		Consoloidation Test			Chemical tests						
Strata of the sample	Lab No	Sample location (From	& To)	Sample No	Natural Moisture Content	Gravel	Sand	Silt	Clay	Specific gravity	Liquid limit	Plastic limit	Plasticity Index	Cohesion	Angle of Internal friction (ϕ)	Compression Index (Cc)	Void Ratio (eo)	Free Swell Index	pH	Chloride	Sulphate	Carbonate	Organic matter	Uniaxial Compressive strength (UCS)	Point Load Test
		(m)			(%)	(%)	(%)	(%)	(%)		(%)	(%)		kg/cm2	(°)	(%)	(%)	(%)		(%)	(%)	(%)	(%)	(Mpa)	(Mpa)
Soft Brownish Grayish Colour Clay	AGCL-BH-4-1	111.90	110.40	DS-1	41.26	1.28	55.21	30.63	12.88	2.765	46.28	23.14	23.14	0.33	0.00	IS	IS	10	7.56	0.01	0.25	0.39	1.98		
	AGCL-BH-4-2	110.40	109.95	SPT-1	42.69	0.00	56.24	35.41	8.35	2.736	48.62	26.35	22.27	0.32	0.00	IS	IS	IS	7.47	0.03	0.26	0.32	1.78		
	AGCL-BH-4-3	108.90	108.45	SPT-2	48.65	2.00	53.36	35.26	9.38	2.705	41.25	23.24	18.01	0.35	0.00	IS	IS	10	7.53	0.01	0.00	0.35	1.65		
Stiff Brownish Grayish Colour Clay	AGCL-BH-4-4	107.40	106.95	SPT-3	47.68	2.63	53.20	33.73	10.44	2.786	39.25	20.11	19.14	0.37	0.00	IS	IS	20	7.97	0.03	0.30	0.26	1.54		
	AGCL-BH-4-5	105.90	105.45	SPT-4	41.26	0.00	56.06	36.25	7.69	2.727	35.26	18.36	16.90	0.35	0.00	IS	IS	IS	7.64	0.02	0.27	0.23	1.27		
Stiff Deep Grayish Silty Clayey	AGCL-BH-4-6	104.40	103.95	SPT-5	30.21	0.00	58.62	35.32	6.06	2.746	31.02	18.98	12.04	0.29	0.00	IS	IS	IS	7.82	0.02	0.21	0.38	1.26	NA	
	AGCL-BH-4-7	102.90	102.45	SPT-6	25.63	0.00	60.21	38.64	1.15	2.701	29.11	15.64	13.47	0.24	0.00	IS	IS	IS	7.65	0.02	0.22	0.27	1.34		
Dense Deep Grayish Colour Fine Grained Silty Sand	AGCL-BH-4-8	101.40	100.95	SPT-7	22.36	0.00	60.28	36.53	3.19	2.651	24.35	17.24	7.11	0.20	13.65	IS	IS	NP	7.54	0.01	0.28	0.29	1.54		
	AGCL-BH-4-9	99.90	99.45	SPT-8	23.35	4.63	67.24	25.62	2.51	2.632	23.67	18.24	5.43	0.19	15.26	IS	IS	NP	7.00	0.03	0.29	0.24	1.67		
	AGCL-BH-4-10	98.40	97.95	SPT-9	19.26	1.23	73.15	24.36	1.26	2.663	22.08	12.05	10.03	0.22	12.68	IS	IS	NP	7.69	0.01	0.27	0.25	1.48		
	AGCL-BH-4-11	96.90	96.45	SPT-10	20.20	2.36	77.21	16.32	4.11	2.674	21.33	14.25	7.08	0.20	11.71	IS	IS	NP	7.84	0.01	0.26	0.36	1.64		

SUMMARY OF LABORATORY TEST RESULTS

Project:	**Laboratory testing of samples collected from geotechnical investigation at RUPKHELIA TERMINAL for AGCL**	**JOB NO.:**	**SKP/AGCL-5/22-23**
Client:	***AGCL***	*Nature of samples:*	***Soil and Rock Samples***
Borehole No:	***BH-5***	*Quantity of sample:*	***Sufficient***
Location:	***RUPKHELIA TERMINAL***	*Packing/Container:*	***Polybag***

LABORATORY TEST RESULTS

SAMPLE IDENTIFICATION					***SOIL***																				***Rock***	
						Grain size analysis					**Atterberg Limits**			**Direct shear test (UU)**		**Consoloidation Test**			**Chemical tests**						
Strata of the sample	**Lab No**	***Sample location (From***	***& To)***	**Sample No**	**Natural Moisture Content**	**Gravel**	**Sand**	**Silt**	**Clay**	**Specific gravity**	**Liquid limit**	**Plastic limit**	**Plasticity Index**	**Cohesion**	**Angle of Internal friction (ϕ)**	**Compression Index (Cc)**	**Void Ratio (eo)**	**Free Swell Index**	**pH**	**Chloride**	**Sulphate**	**Carbonate**	**Organic matter**	**Uniaxial Compressive strength (UCS)**	**Point Load Test**
		(m)			**(%)**	**(%)**	**(%)**	**(%)**	**(%)**		**(%)**	**(%)**		**kg/cm2**	**(°)**	**(%)**	**(%)**	**(%)**		**(%)**	**(%)**	**(%)**	**(%)**	**(Mpa)**	**(Mpa)**
Soft Brownish Colour Silty Clay	AGCL-BH-4-1	108.70	107.20	DS-1	37.25	2.65	58.63	30.24	8.48	2.710	48.36	24.18	24.18	0.25	11.25	IS	IS	30	7.97	0.03	0.37	0.24	1.54	**NA**	
	AGCL-BH-4-2	107.20	106.75	SPT-1	32.36	0.00	55.42	35.83	8.75	2.712	45.24	26.24	19.00	0.21	10.24	IS	IS	IS	7.89	0.02	0.38	0.26	1.27		
	AGCL-BH-4-3	105.70	105.25	SPT-2	30.42	0.00	60.72	35.03	4.25	2.751	40.27	21.40	18.87	0.30	9.64	IS	IS	20	7.78	0.01	0.24	0.27	1.28		
	AGCL-BH-4-4	104.20	103.75	SPT-3	31.25	1.25	59.64	29.64	9.47	2.763	39.29	21.25	18.04	0.26	10.12	IS	IS	10	7.64	0.02	0.28	0.24	1.34		
Loose to Very Loose Grayish colour Fine Grained Sand as Containing Silts as Fines	AGCL-BH-4-5	102.70	102.25	SPT-4	28.25	0.00	61.25	35.21	3.54	2.710	35.22	18.16	17.06	0.00	18.25	IS	IS	NA	7.15	0.01	0.24	0.29	1.34		
Medium Dense Grayish colour Fine Grained Sand as Containing Silts as Fines	AGCL-BH-4-6	101.20	100.75	SPT-5	25.33	0.00	63.66	31.02	5.32	2.661	33.65	18.35	15.30	0.00	21.27	IS	IS	NA	7.25	0.03	0.29	0.24	1.57		
	AGCL-BH-4-7	99.70	99.25	SPT-6	26.38	0.00	65.49	29.36	5.15	2.658	29.54	17.44	12.10	0.00	22.31	IS	IS	NA	7.76	0.02	0.27	0.23	1.54		
Dense Grayish Brownish colour Fine Grained Sand	AGCL-BH-4-8	98.20	97.75	SPT-7	25.36	0.00	68.36	30.25	1.39	2.662	26.83	14.31	12.52	0.00	24.15	IS	IS	NA	7.68	0.01	0.24	0.34	1.64		
	AGCL-BH-4-9	96.70	96.25	SPT-8	22.99	0.00	70.25	26.98	2.77	2.659	27.24	16.32	10.92	0.00	26.38	IS	IS	NA	7.64	0.01	0.24	0.34	1.54		
	AGCL-BH-4-10	95.20	94.75	SPT-9	20.01	0.00	72.22	24.36	3.42	2.658	23.65	13.83	9.82	0.00	27.00	IS	IS	NA	7.01	0.01	0.33	0.40	1.76		
Stiff Grayish Colour Clay	AGCL-BH-4-11	93.70	93.25	SPT-10	18.27	2.36	63.26	27.98	6.40	2.762	41.28	25.63	15.65	0.31	0.00	IS	IS	NA	7.25	0.03	0.39	0.41	1.65		

SUMMARY OF LABORATORY TEST RESULTS

Project:	**Laboratory testing of samples collected from geotechnical investigation at RUPKHELIA TERMINAL for AGCL**	**JOB NO.:**	**SKP/AGCL-6/22-23**
Client:	***AGCL***	*Nature of samples:*	***Soil and Rock Samples***
Borehole No:	***BH-6***	*Quantity of sample:*	***Sufficient***
Location:	***RUPKHELIA TERMINAL***	*Packing/Container:*	***Polybag***

LABORATORY TEST RESULTS

SAMPLE IDENTIFICATION					***SOIL***																			***Rock***	
						Grain size analysis					**Atterberg Limits**			**Direct shear test (UU)**		**Consoloidation Test**			**Chemical tests**						
Strata of the sample	**Lab No**	***Sample location (From***	***& To)***	**Sample No**	**Natural Moisture Content**	**Gravel**	**Sand**	**Silt**	**Clay**	**Specific gravity**	**Liquid limit**	**Plastic limit**	**Plasticity Index**	**Cohesion**	**Angle of Internal friction (ϕ)**	**Compression Index (Cc)**	**Void Ratio (eo)**	**Free Swell Index**	**pH**	**Chloride**	**Sulphate**	**Carbonate**	**Organic matter**	**Uniaxial Compressive strength (UCS)**	**Point Load Test**
		(m)			**(%)**	**(%)**	**(%)**	**(%)**	**(%)**		**(%)**	**(%)**		**kg/cm2**	**(°)**	**(%)**	**(%)**	**(%)**		**(%)**	**(%)**	**(%)**	**(%)**	**(Mpa)**	**(Mpa)**
Soft Brownish Yellowish Colour Sandy Clay	AGCL-BH-4-1	111.30	109.80	DS-1	42.62	0.00	58.63	27.68	13.69	2.709	46.91	24.65	22.26	0.22	15.39	IS	IS	15	7.20	0.01	0.13	0.31	1.26	**NA**	
	AGCL-BH-4-2	109.80	109.35	SPT-1	46.90	0.00	56.36	25.65	17.99	2.727	42.73	23.71	19.02	0.27	14.15	IS	IS	20	7.65	0.03	0.14	0.33	1.29		
	AGCL-BH-4-3	108.30	107.85	SPT-2	45.85	0.00	52.62	34.28	13.10	2.714	38.62	20.25	18.37	0.24	18.64	IS	IS	IS	7.81	0.02	0.13	0.35	1.28		
	AGCL-BH-4-4	106.80	106.35	SPT-3	37.68	0.00	57.65	31.27	11.08	2.715	36.36	19.84	16.52	0.29	11.27	IS	IS	20	7.23	0.03	0.23	0.31	1.30		
	AGCL-BH-4-5	105.30	104.85	SPT-4	31.26	0.00	60.25	30.35	9.40	2.759	32.58	17.00	15.58	0.27	13.33	IS	IS	30	7.12	0.03	0.42	0.36	1.07		
Medium Dense Grayish colour Fine to Medium Grained Sand	AGCL-BH-4-6	103.80	103.35	SPT-5	29.65	0.00	63.62	30.25	6.13	2.699	28.75	17.93	10.82	0.00	19.67	IS	IS	NA	7.26	0.02	0.43	0.37	1.00		
	AGCL-BH-4-7	102.30	101.85	SPT-6	25.36	0.00	62.65	29.36	7.99	2.681	26.54	17.25	9.29	0.00	20.26	IS	IS	NA	7.91	0.01	0.49	0.39	1.98		
Dense Grayish colour Fine to Medium Grained Sand	AGCL-BH-4-8	100.80	100.35	SPT-7	22.63	0.00	66.31	30.29	3.40	2.682	24.35	18.25	6.10	0.00	21.38	IS	IS	NA	7.58	0.02	0.52	0.42	2.10		
	AGCL-BH-4-9	99.30	98.85	SPT-8	20.36	0.00	67.24	26.66	6.10	2.648	19.67	10.25	9.42	0.00	27.36	IS	IS	NA	7.99	0.03	0.51	0.42	2.22		
	AGCL-BH-4-10	97.80	97.35	SPT-9	17.92	0.00	63.77	28.65	7.58	2.658	20.31	11.62	8.69	0.00	24.37	IS	IS	NA	7.80	0.01	0.51	0.41	2.36		
	AGCL-BH-4-11	96.30	95.85	SPT-10	18.63	0.00	63.65	27.88	8.47	2.645	17.96	9.68	8.28	0.00	28.65	IS	IS	NA	7.71	0.02	0.52	0.39	2.39		

Annexure - IV

(SAFE BEARING CAPACITY CALCULATIONS)

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-01**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square		
Depth of footing, D (m)	1.00	1.00	1.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.50	2.50	2.50
Ratio Zw/B	1.00	0.75	0.50
Water Table Factor	1.00	0.88	0.75
Effective Surcharge over EGL, m	0.00	m	
Overburden Pressure, =	***2.40***	t/m^2	

Moisture Content, w	41.35 %
Cohesion, C	0.320 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.721
Bulk Density, γ_b	2.404 gm/cc
Sat. Density, γ_{Sat}	2.076 gm/cc
Sub. Density, γ_{Sub}	1.076 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.701 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$
	e_0 = 0.600

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$

= 0.00

Mode of Failure =	***Intermediate Shear Failure***

Nc" = 5.140	*Nc* = 5.140	*Nc'* = 5.140
Nq" = 1.000	*Nq* = 1.000	*Nq'* = 1.000
Nγ" = 0.000	*Nγ* = 0.000	*Nγ'* = 0.000
Sc = 1.300	*dc* = 1.133	*ic* = 1.000
Sq = 1.200	*dq* = 1.000	*iq* = 1.000
Sγ = 0.800	*dγ* = 1.000	*iγ* = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 BγNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 BγN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 BγN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***24.23*** ***t/m^2***
= ***23.52*** ***t/m^2***
= ***22.81*** ***t/m^2***

Net Safe Bearing Capacity (qs)
= ***9.69*** ***t/m^2***
= ***9.41*** ***t/m^2***
= ***9.12*** ***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**					
					L	**B**	***D***
0.00	**0.00**	**9.69**	***t/m^2***	***for***	***1.50***	***1.50***	***1.00***
					L	**B**	***D***
0.00	**0.00**	**9.41**	***t/m^2***	***for***	***2.00***	***2.00***	***1.00***
					L	**B**	***D***
0.00	**0.00**	**9.12**	***t/m^2***	***for***	***3.00***	***3.00***	***1.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-01**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square		
Depth of footing, D (m)	1.50	1.50	1.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.50	2.50	2.50
Ratio Zw/B	0.67	0.50	0.33
Water Table Factor	0.83	0.75	0.67
Effective Surcharge over EGL, m	0.00	m	

Moisture Content, w	41.35 %
Cohesion, C	0.320 *kg/sq.cm*
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.721
Bulk Density, γ_b	2.404 gm/cc
Sat. Density, γ_{Sat}	2.076 gm/cc
Sub. Density, γ_{Sub}	1.076 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.701 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

Overburden Pressure, = ***3.61*** t/m²

$e_0 =$ 0.600

$\phi' = Tan^{-1}\left(0.67\ tan(\emptyset)\right)$

= 0.00

Mode of Failure =	***Intermediate Shear Failure***

Nc'' = 5.140	Nc = 5.140	Nc' = 5.140
Nq'' = 1.000	Nq = 1.000	Nq' = 1.000
$N\gamma''$ = 0.000	$N\gamma$ = 0.000	$N\gamma'$ = 0.000
Sc = 1.300	dc = 1.200	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	***0.00***	***t/m²***
Net Safe Bearing Capacity (qs)	=	***0.00***	***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	***0.00***	***t/m²***
Net Safe Bearing Capacity (qs)	=	***0.00***	***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	***25.66***	***t/m²***
	=	***24.59***	***t/m²***
	=	***23.52***	***t/m²***
Net Safe Bearing Capacity (qs)	=	***10.26***	***t/m²***
	=	***9.84***	***t/m²***
	=	***9.41***	***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**					
					L	**B**	***D***
0.00	***0.00***	***10.26***	***t/m²***	*for*	***1.50***	***1.50***	***1.50***
					L	**B**	***D***
0.00	***0.00***	***9.84***	***t/m²***	*for*	***2.00***	***2.00***	***1.50***
					L	**B**	***D***
0.00	***0.00***	***9.41***	***t/m²***	*for*	***3.00***	***3.00***	***1.50***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-01**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.00	2.00	2.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.50	2.50	2.50
Ratio Zw/B	0.33	0.25	0.17
Water Table Factor	0.67	0.63	0.58
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = ***4.81*** t/m^2

Moisture Content, w	40.59 %
Cohesion, C	0.330 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.715
Bulk Density, γ_b	2.407 gm/cc
Sat. Density, γ_{Sat}	2.081 gm/cc
Sub. Density, γ_{Sub}	1.081 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.712 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

$e_0 =$ *0.586*

$\phi' = Tan^{-1}\left(0.67\ tan(\emptyset)\right)$
= 0.00

Mode of Failure =	*Intermediate Shear Failure*

Nc" = 5.140	*Nc* = 5.140	*Nc'* = 5.140
Nq" = 1.000	*Nq* = 1.000	*Nq'* = 1.000
$N\gamma$" = 0.000	$N\gamma$ = 0.000	$N\gamma$' = 0.000
Sc = 1.300	*dc* = 1.267	*ic* = 1.000
Sq = 1.200	*dq* = 1.000	*iq* = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***27.93*** ***t/m²***
= ***26.46*** ***t/m²***
= ***24.99*** ***t/m²***

Net Safe Bearing Capacity (qs)
= ***11.17*** ***t/m²***
= ***10.58*** ***t/m²***
= ***10.00*** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
0.00	***0.00***	***11.17***	***t/m²***	*for*	***1.50***	***1.50***	***2.00***
					L	**B**	**D**
0.00	***0.00***	***10.58***	***t/m²***	*for*	***2.00***	***2.00***	***2.00***
					L	**B**	**D**
0.00	***0.00***	***10.00***	***t/m²***	*for*	***3.00***	***3.00***	***2.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-01**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.50	2.50	2.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.50	2.50	2.50
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = ***6.02*** t/m^2

Moisture Content, w	40.59 %
Cohesion, C	0.330 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.715
Bulk Density, γ_b	2.407 gm/cc
Sat. Density, γ_{Sat}	2.081 gm/cc
Sub. Density, γ_{Sub}	1.081 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.712 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

$e_0 =$ *0.586*

Mode of Failure =	***Intermediate Shear Failure***

$\phi' = Tan^{-1}\left(0.67\ tan(\emptyset)\right)$

= 0.00

Nc'' = 5.140	Nc = 5.140	Nc' = 5.140
Nq'' = 1.000	Nq = 1.000	Nq' = 1.000
$N\gamma''$ = 0.000	$N\gamma$ = 0.000	$N\gamma'$ = 0.000
Sc = 1.300	dc = 1.333	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γS γd γi γ W'

Ultimate Bearing Capacity (qu)
= ***29.40*** ***t/m^2***
= ***27.56*** ***t/m^2***
= ***25.73*** ***t/m^2***

Net Safe Bearing Capacity (qs)
= ***11.76*** ***t/m^2***
= ***11.03*** ***t/m^2***
= ***10.29*** ***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**					
					L	**B**	***D***
0.00	***0.00***	***11.76***	***t/m^2***	*for*	***1.50***	***1.50***	***2.50***
					L	**B**	***D***
0.00	***0.00***	***11.03***	***t/m^2***	*for*	***2.00***	***2.00***	***2.50***
					L	**B**	***D***
0.00	***0.00***	***10.29***	***t/m^2***	*for*	***3.00***	***3.00***	***2.50***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-01**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	3.00	3.00	3.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.50	2.50	2.50
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = ***6.56*** t/m^2

Moisture Content, w	40.59 %
Cohesion, C	0.330 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.715
Bulk Density, γ_b	2.407 gm/cc
Sat. Density, γ_{Sat}	2.081 gm/cc
Sub. Density, γ_{Sub}	1.081 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.712 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

$e_0 =$ 0.586

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$
= 0.00

Mode of Failure =	*Intermediate Shear Failure*

$Nc'' =$ 5.140	$Nc =$ 5.140	$Nc' =$ 5.140
$Nq'' =$ 1.000	$Nq =$ 1.000	$Nq' =$ 1.000
$N\gamma'' =$ 0.000	$N\gamma =$ 0.000	$N\gamma' =$ 0.000
$Sc =$ 1.300	$dc =$ 1.400	$ic =$ 1.000
$Sq =$ 1.200	$dq =$ 1.000	$iq =$ 1.000
$S\gamma =$ 0.800	$d\gamma =$ 1.000	$i\gamma =$ 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γS γd γi γ W'

Ultimate Bearing Capacity (qu)
= ***30.87*** ***t/m^2***
= ***28.67*** ***t/m^2***
= ***26.46*** ***t/m^2***

Net Safe Bearing Capacity (qs)
= ***12.35*** ***t/m^2***
= ***11.47*** ***t/m^2***
= ***10.58*** ***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
0.00	***0.00***	***12.35***	***t/m^2***	*for*	***1.50***	***1.50***	***3.00***
0.00	***0.00***	***11.47***	***t/m^2***	*for*	***2.00***	***2.00***	***3.00***
0.00	***0.00***	***10.58***	***t/m^2***	*for*	***3.00***	***3.00***	***3.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-02**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square			Moisture Content, w	40.33 %
Depth of footing, D (m)	1.00	1.00	1.00	Cohesion, C	0.300 *kg/sq.cm*
Width of footing, B (m)	1.50	2.00	3.00	Angle of Int.Friction, ϕ	0.00 °
Length of footing, L (m)	1.50	2.00	3.00	Specific Gravity, G	2.763
				Bulk Density, γ_b	2.390 gm/cc
Depth of Water Table, d (m)	1.70	1.70	1.70	Sat. Density, γ_{Sat}	2.087 gm/cc
Ratio Zw/B	0.47	0.35	0.23	Sub. Density, γ_{Sub}	1.087 gm/cc
Water Table Factor	0.73	0.68	0.62	Inclination Angle, α	0
Effective Surcharge over EGL, m	0.00	m		Factor of Safety	2.5
				Surcharge Density, γ_{Sur}	1.000 gm/cc
				Dry Density, γ_d	1.703 gm/cc
Overburden Pressure, =	***2.39***	t/m²		Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$
					e_0 = 0.622

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$
= 0.00

Mode of Failure =	***Intermediate Shear Failure***

Nc" = 5.140	*Nc* = 5.140	*Nc'* = 5.140
Nq" = 1.000	*Nq* = 1.000	*Nq'* = 1.000
Nγ" = 0.000	*Nγ* = 0.000	*Nγ'* = 0.000
Sc = 1.300	*dc* = 1.133	*ic* = 1.000
Sq = 1.200	*dq* = 1.000	*iq* = 1.000
Sγ = 0.800	*dγ* = 1.000	*iγ* = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***22.72*** ***t/m²***
= ***22.05*** ***t/m²***
= ***21.38*** ***t/m²***

Net Safe Bearing Capacity (qs)
= ***9.09*** ***t/m²***
= ***8.82*** ***t/m²***
= ***8.55*** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**					
					L	**B**	**D**
0.00	**0.00**	**9.09**	**t/m²**	*for*	***1.50***	***1.50***	***1.00***
					L	**B**	**D**
0.00	**0.00**	**8.82**	**t/m²**	*for*	***2.00***	***2.00***	***1.00***
					L	**B**	**D**
0.00	**0.00**	**8.55**	**t/m²**	*for*	***3.00***	***3.00***	***1.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-02**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square		
Depth of footing, D (m)	1.50	1.50	1.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	1.70	1.70	1.70
Ratio Zw/B	0.13	0.10	0.07
Water Table Factor	0.57	0.55	0.53
Effective Surcharge over EGL, m	0.00	m	

Moisture Content, w	40.33 %
Cohesion, C	0.300 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.763
Bulk Density, γ_b	2.390 gm/cc
Sat. Density, γ_{Sat}	2.087 gm/cc
Sub. Density, γ_{Sub}	1.087 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.703 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

Overburden Pressure, = ***3.58*** t/m^2

$e_0 =$ 0.622

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$

= 0.00

Mode of Failure = ***Intermediate Shear Failure***

Nc'' = 5.140	Nc = 5.140	Nc' = 5.140
Nq'' = 1.000	Nq = 1.000	Nq' = 1.000
$N\gamma''$ = 0.000	$N\gamma$ = 0.000	$N\gamma'$ = 0.000
Sc = 1.300	dc = 1.200	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***24.06*** ***t/m²***
= ***23.05*** ***t/m²***
= ***22.05*** ***t/m²***

Net Safe Bearing Capacity (qs)
= ***9.62*** ***t/m²***
= ***9.22*** ***t/m²***
= ***8.82*** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
0.00	**0.00**	**9.62**	***t/m²***	***for***	***1.50***	***1.50***	***1.50***
0.00	**0.00**	**9.22**	***t/m²***	***for***	***2.00***	***2.00***	***1.50***
0.00	**0.00**	**8.82**	***t/m²***	***for***	***3.00***	***3.00***	***1.50***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-02**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.00	2.00	2.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	1.70	1.70	1.70
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = **4.27** t/m^2

Moisture Content, w	35.24 %
Cohesion, C	0.310 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.750
Bulk Density, γ_b	2.321 gm/cc
Sat. Density, γ_{Sat}	2.092 gm/cc
Sub. Density, γ_{Sub}	1.092 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.716 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

$e_0 =$ 0.603

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$

= 0.00

Mode of Failure =	***Intermediate Shear Failure***

Nc'' = 5.140	Nc = 5.140	Nc' = 5.140
Nq'' = 1.000	Nq = 1.000	Nq' = 1.000
$N\gamma''$ = 0.000	$N\gamma$ = 0.000	$N\gamma'$ = 0.000
Sc = 1.300	dc = 1.267	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγS γd γi γ W'

Ultimate Bearing Capacity (qu) = **0.00** t/m^2

Net Safe Bearing Capacity (qs) = **0.00** t/m^2

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γS γd γi γ W'

Ultimate Bearing Capacity (qu) = **0.00** t/m^2

Net Safe Bearing Capacity (qs) = **0.00** t/m^2

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γS γd γi γ W'

Ultimate Bearing Capacity (qu)
= **26.24** t/m^2
= **24.86** t/m^2
= **23.48** t/m^2

Net Safe Bearing Capacity (qs)
= **10.50** t/m^2
= **9.94** t/m^2
= **9.39** t/m^2

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	Local Shear Failure	Intermediate Shear Failure			L	B	D
0.00	0.00	10.50	t/m^2	for	1.50	1.50	2.00
0.00	0.00	9.94	t/m^2	for	2.00	2.00	2.00
0.00	0.00	9.39	t/m^2	for	3.00	3.00	2.00

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-02**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.50	2.50	2.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	1.70	1.70	1.70
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = **4.82** t/m^2

Moisture Content, w	35.24 %
Cohesion, C	0.310 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.750
Bulk Density, γ_b	2.321 gm/cc
Sat. Density, γ_{Sat}	2.092 gm/cc
Sub. Density, γ_{Sub}	1.092 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.716 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

$e_0 = 0.603$

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$
= 0.00

Mode of Failure =	***Intermediate Shear Failure***

$Nc'' = 5.140$	$Nc = 5.140$	$Nc' = 5.140$
$Nq'' = 1.000$	$Nq = 1.000$	$Nq' = 1.000$
$N\gamma'' = 0.000$	$N\gamma = 0.000$	$N\gamma' = 0.000$
$Sc = 1.300$	$dc = 1.333$	$ic = 1.000$
$Sq = 1.200$	$dq = 1.000$	$iq = 1.000$
$S\gamma = 0.800$	$d\gamma = 1.000$	$i\gamma = 1.000$

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = **0.00** ***t/m²***

Net Safe Bearing Capacity (qs) = **0.00** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = **0.00** ***t/m²***

Net Safe Bearing Capacity (qs) = **0.00** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= **27.62** ***t/m²***
= **25.89** ***t/m²***
= **24.17** ***t/m²***

Net Safe Bearing Capacity (qs)
= **11.05** ***t/m²***
= **10.36** ***t/m²***
= **9.67** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			L	B	D
0.00	**0.00**	**11.05**	t/m^2	*for*	***1.50***	***1.50***	***2.50***
					L	B	D
0.00	**0.00**	**10.36**	t/m^2	*for*	***2.00***	***2.00***	***2.50***
					L	B	D
0.00	**0.00**	**9.67**	t/m^2	*for*	***3.00***	***3.00***	***2.50***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-02**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square			
Depth of footing, D (m)	3.00	3.00	3.00	
Width of footing, B (m)	1.50	2.00	3.00	
Length of footing, L (m)	1.50	2.00	3.00	
Depth of Water Table, d (m)	1.70	1.70	1.70	
Ratio Zw/B	0.00	0.00	0.00	
Water Table Factor	0.50	0.50	0.50	
Effective Surcharge over EGL, m	0.00	m		
Overburden Pressure, =	***5.36***	t/m^2		

Moisture Content, w	35.24 %	
Cohesion, C	0.310	***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00	^{o}
Specific Gravity, G	2.750	
Bulk Density, γ_b	2.321	gm/cc
Sat. Density, γ_{Sat}	2.092	gm/cc
Sub. Density, γ_{Sub}	1.092	gm/cc
Inclination Angle, α	0	
Factor of Safety	2.5	
Surcharge Density, γ_{Sur}	1.000	gm/cc
Dry Density, γ_d	1.716	gm/cc
Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$		
e_0 =	0.603	

$\phi' = Tan^{-1}\left(0.67\, tan(\emptyset)\right)$

= 0.00

Mode of Failure =	*Intermediate Shear Failure*

Nc'' = 5.140	Nc = 5.140	Nc' = 5.140
Nq'' = 1.000	Nq = 1.000	Nq' = 1.000
$N\gamma''$ = 0.000	$N\gamma$ = 0.000	$N\gamma'$ = 0.000
Sc = 1.300	dc = 1.400	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN''cScdcic + q(N''q-1) Sqdqiq + 0.5 B γN''γS γd γi γ W'

Ultimate Bearing Capacity (qu)
= ***29.00*** ***t/m^2***
= ***26.93*** ***t/m^2***
= ***24.86*** ***t/m^2***

Net Safe Bearing Capacity (qs)
= ***11.60*** ***t/m^2***
= ***10.77*** ***t/m^2***
= ***9.94*** ***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**					
					L	**B**	***D***
0.00	***0.00***	***11.60***	***t/m^2***	***for***	***1.50***	***1.50***	***3.00***
					L	**B**	***D***
0.00	***0.00***	***10.77***	***t/m^2***	***for***	***2.00***	***2.00***	***3.00***
					L	**B**	***D***
0.00	***0.00***	***9.94***	***t/m^2***	***for***	***3.00***	***3.00***	***3.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-03**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square		
Depth of footing, D (m)	1.00	1.00	1.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	0.20	0.20	0.20
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Moisture Content, w	34.67 %
Cohesion, C	0.330 *kg/sq.cm*
Angle of Int.Friction, ϕ	0 °
Specific Gravity, G	2.621
Bulk Density, γ_b	2.297 gm/cc
Sat. Density, γ_{Sat}	2.055 gm/cc
Sub. Density, γ_{Sub}	1.055 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.706 gm/cc
Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$	
$e_0 =$	0.536

Overburden Pressure, = ***1.30*** t/m^2

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$
= 0.00

Mode of Failure =	*General Shear Failure*

Nc'' = 0.000	Nc = 5.140	Nc' = 5.140
Nq'' = 0.000	Nq = 1.000	Nq' = 1.000
$N\gamma''$ = 0.000	$N\gamma$ = 0.000	$N\gamma'$ = 0.000
Sc = 1.300	dc = 1.133	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***24.99*** t/m^2 ; ***24.99*** t/m^2 ; ***24.99*** t/m^2

Net Safe Bearing Capacity (qs) = ***10.00*** t/m^2 ; ***10.00*** t/m^2 ; ***10.00*** t/m^2

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** t/m^2

Net Safe Bearing Capacity (qs) = ***0.00*** t/m^2

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** t/m^2

Net Safe Bearing Capacity (qs) = ***0.00*** t/m^2

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
10.00	**0.00**	**0.00**	t/m^2	*for*	***1.50***	***1.50***	***1.00***
10.00	**0.00**	**0.00**	t/m^2	*for*	***2.00***	***2.00***	***1.00***
10.00	**0.00**	**0.00**	t/m^2	*for*	***3.00***	***3.00***	***1.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-03**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square		
Depth of footing, D (m)	1.50	1.50	1.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	0.20	0.20	0.20
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Moisture Content, w	34.67 %
Cohesion, C	0.330 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0 °
Specific Gravity, G	2.621
Bulk Density, γ_b	2.297 gm/cc
Sat. Density, γ_{Sat}	2.055 gm/cc
Sub. Density, γ_{Sub}	1.055 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.706 gm/cc
Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$	

Overburden Pressure, = ***1.83*** t/m^2

$e_0 =$ *0.536*

$\phi' = Tan^{-1}(0.67\, tan(\emptyset))$
= 0.00

Mode of Failure =	***General Shear Failure***

Nc" = 0.000	*Nc* = 5.140	*Nc'* = 5.140
Nq" = 0.000	*Nq* = 1.000	*Nq'* = 1.000
Nγ" = 0.000	*Nγ* = 0.000	*Nγ'* = 0.000
Sc = 1.300	*dc* = 1.200	*ic* = 1.000
Sq = 1.200	*dq* = 1.000	*iq* = 1.000
Sγ = 0.800	*dγ* = 1.000	*iγ* = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 BγNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***26.46*** ***t/m²*** ; ***26.46*** ***t/m²*** ; ***26.46*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***10.58*** ***t/m²*** ; ***10.58*** ***t/m²*** ; ***10.58*** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 BγN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 BγN"γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	Local Shear Failure	Intermediate Shear Failure			L	B	D
10.58	***0.00***	***0.00***	***t/m²***	*for*	***1.50***	***1.50***	***1.50***
10.58	***0.00***	***0.00***	***t/m²***	*for*	***2.00***	***2.00***	***1.50***
10.58	***0.00***	***0.00***	***t/m²***	*for*	***3.00***	***3.00***	***1.50***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-03**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.00	2.00	2.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	0.20	0.20	0.20
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Moisture Content, w	37.29 %
Cohesion, C	0.320 *kg/sq.cm*
Angle of Int.Friction, ϕ	0 °
Specific Gravity, G	2.614
Bulk Density, γ_b	2.360 gm/cc
Sat. Density, γ_{Sat}	2.061 gm/cc
Sub. Density, γ_{Sub}	1.061 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.719 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

Overburden Pressure, = ***2.38*** t/m^2

$e_0 =$ 0.521

$\phi' = Tan^{-1}(0.67\,tan(\emptyset))$
= 0.00

Mode of Failure =	***General Shear Failure***

Nc" = 0.000	Nc = 5.140	Nc' = 5.140
Nq" = 0.000	Nq = 1.000	Nq' = 1.000
Nγ" = 0.000	Nγ = 0.000	Nγ' = 0.000
Sc = 1.300	dc = 1.267	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
Sγ = 0.800	dγ = 1.000	iγ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 BγNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***27.08*** t/m^2, ***27.08*** t/m^2, ***27.08*** t/m^2

Net Safe Bearing Capacity (qs) = ***10.83*** t/m^2, ***10.83*** t/m^2, ***10.83*** t/m^2

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 BγN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** t/m^2

Net Safe Bearing Capacity (qs) = ***0.00*** t/m^2

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 BγN"γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** t/m^2

Net Safe Bearing Capacity (qs) = ***0.00*** t/m^2

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	Local Shear Failure	Intermediate Shear Failure			L	B	D
10.83	0.00	0.00	t/m^2	for	1.50	1.50	2.00
10.83	0.00	0.00	t/m^2	for	2.00	2.00	2.00
10.83	0.00	0.00	t/m^2	for	3.00	3.00	2.00

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-03**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.50	2.50	2.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	0.20	0.20	0.20
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = ***2.91*** t/m^2

Moisture Content, w	37.29 %
Cohesion, C	0.320 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0 °
Specific Gravity, G	2.614
Bulk Density, γ_b	2.360 gm/cc
Sat. Density, γ_{Sat}	2.061 gm/cc
Sub. Density, γ_{Sub}	1.061 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.719 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

$e_0 =$ *0.521*

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$
= 0.00

Mode of Failure =	***General Shear Failure***

Nc" = 0.000	*Nc* = 5.140	*Nc'* = 5.140
Nq" = 0.000	*Nq* = 1.000	*Nq'* = 1.000
$N\gamma$" = 0.000	$N\gamma$ = 0.000	$N\gamma$' = 0.000
Sc = 1.300	*dc* = 1.333	*ic* = 1.000
Sq = 1.200	*dq* = 1.000	*iq* = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

		28.51	***t/m^2***
Ultimate Bearing Capacity (qu)	=	***28.51***	***t/m^2***
		28.51	***t/m^2***
		11.40	***t/m^2***
Net Safe Bearing Capacity (qs)	=	***11.40***	***t/m^2***
		11.40	***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	***0.00***	***t/m^2***
Net Safe Bearing Capacity (qs)	=	***0.00***	***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	***0.00***	***t/m^2***
Net Safe Bearing Capacity (qs)	=	***0.00***	***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	Local Shear Failure	Intermediate Shear Failure			L	B	D
11.40	***0.00***	***0.00***	*t/m^2*	*for*	*1.50*	*1.50*	*2.50*
11.40	***0.00***	***0.00***	*t/m^2*	*for*	*2.00*	*2.00*	*2.50*
11.40	***0.00***	***0.00***	*t/m^2*	*for*	*3.00*	*3.00*	*2.50*

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-03**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	3.00	3.00	3.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	0.20	0.20	0.20
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = ***3.44*** t/m^2

Moisture Content, w	37.29 %
Cohesion, C	0.320 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0 °
Specific Gravity, G	2.614
Bulk Density, γ_b	2.360 gm/cc
Sat. Density, γ_{Sat}	2.061 gm/cc
Sub. Density, γ_{Sub}	1.061 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.719 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

$e_0 =$ 0.521

$\phi' = Tan^{-1}(0.67\,tan(\emptyset))$
= 0.00

Mode of Failure =	*General Shear Failure*

Nc'' = 0.000	Nc = 5.140	Nc' = 5.140
Nq'' = 0.000	Nq = 1.000	Nq' = 1.000
$N\gamma''$ = 0.000	$N\gamma$ = 0.000	$N\gamma'$ = 0.000
Sc = 1.300	dc = 1.400	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

		29.94	***t/m²***
Ultimate Bearing Capacity (qu)	=	***29.94***	***t/m²***
		29.94	***t/m²***
		11.97	***t/m²***
Net Safe Bearing Capacity (qs)	=	***11.97***	***t/m²***
		11.97	***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	***0.00***	***t/m²***
Net Safe Bearing Capacity (qs)	=	***0.00***	***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	***0.00***	***t/m²***
Net Safe Bearing Capacity (qs)	=	***0.00***	***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
11.97	***0.00***	***0.00***	***t/m²***	*for*	***1.50***	***1.50***	***3.00***
11.97	***0.00***	***0.00***	***t/m²***	*for*	***2.00***	***2.00***	***3.00***
11.97	***0.00***	***0.00***	***t/m²***	*for*	***3.00***	***3.00***	***3.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-04**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square			Moisture Content, w	42.69 %
Depth of footing, D (m)	1.00	1.00	1.00	Cohesion, C	0.320 *kg/sq.cm*
Width of footing, B (m)	1.50	2.00	3.00	Angle of Int.Friction, ϕ	0.00 °
Length of footing, L (m)	1.50	2.00	3.00	Specific Gravity, G	2.736
				Bulk Density, γ_b	2.443 gm/cc
Depth of Water Table, d (m)	2.10	2.10	2.10	Sat. Density, γ_{Sat}	2.086 gm/cc
Ratio Zw/B	0.73	0.55	0.37	Sub. Density, γ_{Sub}	1.086 gm/cc
Water Table Factor	0.87	0.78	0.68	Inclination Angle, α	0
Effective Surcharge over EGL, m	0.00	m		Factor of Safety	2.5
				Surcharge Density, γ_{Sur}	1.000 gm/cc
				Dry Density, γ_d	1.712 gm/cc
Overburden Pressure, =	*2.44*	t/m^2		Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$
				e_0 =	0.598

$\phi' = Tan^{-1}(0.67\ tan(\phi))$
= 0.00

Mode of Failure =	*Intermediate Shear Failure*

Nc" = 5.140	*Nc* = 5.140	*Nc'* = 5.140
Nq" = 1.000	*Nq* = 1.000	*Nq'* = 1.000
$N\gamma$" = 0.000	$N\gamma$ = 0.000	$N\gamma$' = 0.000
Sc = 1.300	*dc* = 1.133	*ic* = 1.000
Sq = 1.200	*dq* = 1.000	*iq* = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***24.23*** ***t/m²***
= ***23.52*** ***t/m²***
= ***22.81*** ***t/m²***

Net Safe Bearing Capacity (qs)
= ***9.69*** ***t/m²***
= ***9.41*** ***t/m²***
= ***9.12*** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	Local Shear Failure	Intermediate Shear Failure			L	B	D
0.00	**0.00**	**9.69**	**t/m²**	***for***	***1.50***	***1.50***	***1.00***
0.00	**0.00**	**9.41**	**t/m²**	***for***	***2.00***	***2.00***	***1.00***
0.00	**0.00**	**9.12**	**t/m²**	***for***	***3.00***	***3.00***	***1.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-04**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square		
Depth of footing, D (m)	1.50	1.50	1.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10
Ratio Zw/B	0.40	0.30	0.20
Water Table Factor	0.70	0.65	0.60
Effective Surcharge over EGL, m	0.00	m	
Overburden Pressure, =	**3.66**	t/m^2	

Moisture Content, w	42.69 %
Cohesion, C	0.320 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.736
Bulk Density, γ_b	2.443 gm/cc
Sat. Density, γ_{Sat}	2.086 gm/cc
Sub. Density, γ_{Sub}	1.086 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.712 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$
	$e_0 =$ 0.598

$\phi' = Tan^{-1}\left(0.67\ tan(\emptyset)\right)$
= 0.00

Mode of Failure =	***Intermediate Shear Failure***

Nc'' = 5.140	Nc = 5.140	Nc' = 5.140
Nq'' = 1.000	Nq = 1.000	Nq' = 1.000
$N\gamma''$ = 0.000	$N\gamma$ = 0.000	$N\gamma'$ = 0.000
Sc = 1.300	dc = 1.200	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	**0.00**	t/m^2
Net Safe Bearing Capacity (qs)	=	**0.00**	t/m^2

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	**0.00**	t/m^2
Net Safe Bearing Capacity (qs)	=	**0.00**	t/m^2

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

	=	**25.66**	t/m^2
Ultimate Bearing Capacity (qu)	=	**24.59**	t/m^2
	=	**23.52**	t/m^2
	=	**10.26**	t/m^2
Net Safe Bearing Capacity (qs)	=	**9.84**	t/m^2
	=	**9.41**	t/m^2

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	Local Shear Failure	Intermediate Shear Failure					
					L	B	D
0.00	0.00	10.26	t/m^2	for	1.50	1.50	1.50
					L	B	D
0.00	0.00	9.84	t/m^2	for	2.00	2.00	1.50
					L	B	D
0.00	0.00	9.41	t/m^2	for	3.00	3.00	1.50

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-04**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square			Moisture Content, w	48.65 %
Depth of footing, D (m)	2.00	2.00	2.00	Cohesion, C	0.350 *kg/sq.cm*
Width of footing, B (m)	1.50	2.00	3.00	Angle of Int.Friction, ϕ	0.00 °
Length of footing, L (m)	1.50	2.00	3.00	Specific Gravity, G	2.705
				Bulk Density, γ_b	2.558 gm/cc
Depth of Water Table, d (m)	2.10	2.10	2.10	Sat. Density, γ_{Sat}	2.085 gm/cc
Ratio Zw/B	0.07	0.05	0.03	Sub. Density, γ_{Sub}	1.085 gm/cc
Water Table Factor	0.53	0.53	0.52	Inclination Angle, α	0
Effective Surcharge over EGL, m	0.00	m		Factor of Safety	2.5
				Surcharge Density, γ_{Sur}	1.000 gm/cc
				Dry Density, γ_d	1.721 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

Overburden Pressure, = ***5.12*** t/m^2

e_0 = *0.572*

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$
= 0.00

Mode of Failure =	***Intermediate Shear Failure***

Nc'' = 5.140	Nc = 5.140	Nc' = 5.140
Nq'' = 1.000	Nq = 1.000	Nq' = 1.000
$N\gamma''$ = 0.000	$N\gamma$ = 0.000	$N\gamma'$ = 0.000
Sc = 1.300	dc = 1.267	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN''cScdcic + q(N''q-1) Sqdqiq + 0.5 B γN''γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***29.62*** ***t/m²***
= ***28.06*** ***t/m²***
= ***26.51*** ***t/m²***

Net Safe Bearing Capacity (qs)
= ***11.85*** ***t/m²***
= ***11.23*** ***t/m²***
= ***10.60*** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**					
					L	**B**	**D**
0.00	**0.00**	**11.85**	**t/m²**	*for*	***1.50***	***1.50***	***2.00***
					L	**B**	**D**
0.00	**0.00**	**11.23**	**t/m²**	*for*	***2.00***	***2.00***	***2.00***
					L	**B**	**D**
0.00	**0.00**	**10.60**	**t/m²**	*for*	***3.00***	***3.00***	***2.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-04**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.50	2.50	2.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = ***5.81*** t/m^2

Moisture Content, w	48.65 %
Cohesion, C	0.350 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.705
Bulk Density, γ_b	2.558 gm/cc
Sat. Density, γ_{Sat}	2.085 gm/cc
Sub. Density, γ_{Sub}	1.085 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.721 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

$e_0 =$ 0.572

Mode of Failure = ***Intermediate Shear Failure***

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$

= 0.00

Nc" = 5.140	*Nc* = 5.140	*Nc'* = 5.140
Nq" = 1.000	*Nq* = 1.000	*Nq'* = 1.000
Nγ" = 0.000	*Nγ* = 0.000	*Nγ'* = 0.000
Sc = 1.300	*dc* = 1.333	*ic* = 1.000
Sq = 1.200	*dq* = 1.000	*iq* = 1.000
Sγ = 0.800	*dγ* = 1.000	*iγ* = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 BγNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 BγN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 BγN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***31.18*** ***t/m^2***
= ***29.23*** ***t/m^2***
= ***27.28*** ***t/m^2***

Net Safe Bearing Capacity (qs)
= ***12.47*** ***t/m^2***
= ***11.69*** ***t/m^2***
= ***10.91*** ***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
0.00	***0.00***	***12.47***	***t/m^2***	*for*	***1.50***	***1.50***	***2.50***
0.00	***0.00***	***11.69***	***t/m^2***	*for*	***2.00***	***2.00***	***2.50***
0.00	***0.00***	***10.91***	***t/m^2***	*for*	***3.00***	***3.00***	***2.50***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-04**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	3.00	3.00	3.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = ***6.35*** t/m^2

Moisture Content, w	48.65 %
Cohesion, C	0.350 ***kg/sq.cm***
Angle of Int.Friction, ϕ	0.00 °
Specific Gravity, G	2.705
Bulk Density, γ_b	2.558 gm/cc
Sat. Density, γ_{Sat}	2.085 gm/cc
Sub. Density, γ_{Sub}	1.085 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.721 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

$e_0 = 0.572$

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$

= 0.00

Mode of Failure = ***Intermediate Shear Failure***

Nc'' = 5.140	Nc = 5.140	Nc' = 5.140
Nq'' = 1.000	Nq = 1.000	Nq' = 1.000
$N\gamma''$ = 0.000	$N\gamma$ = 0.000	$N\gamma'$ = 0.000
Sc = 1.300	dc = 1.400	ic = 1.000
Sq = 1.200	dq = 1.000	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.000	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***32.74*** ***t/m^2***
= ***30.40*** ***t/m^2***
= ***28.06*** ***t/m^2***

Net Safe Bearing Capacity (qs)
= ***13.10*** ***t/m^2***
= ***12.16*** ***t/m^2***
= ***11.23*** ***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**					
					L	**B**	***D***
0.00	***0.00***	***13.10***	***t/m^2***	***for***	***1.50***	***1.50***	***3.00***
					L	**B**	***D***
0.00	***0.00***	***12.16***	***t/m^2***	***for***	***2.00***	***2.00***	***3.00***
					L	**B**	***D***
0.00	***0.00***	***11.23***	***t/m^2***	***for***	***3.00***	***3.00***	***3.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-05**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square		
Depth of footing, D (m)	1.00	1.00	1.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	0.50	0.50	0.50
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	
Overburden Pressure, =	***1.67***	t/m^2	

Moisture Content, w	32.36 %
Cohesion, C	0.210 ***kg/sq.cm***
Angle of Int.Friction, ϕ	10.24 °
Specific Gravity, G	2.712
Bulk Density, γ_b	2.262 gm/cc
Sat. Density, γ_{Sat}	2.079 gm/cc
Sub. Density, γ_{Sub}	1.079 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.709 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$
	e_0 = 0.587

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$
= 6.90

Mode of Failure =	***Intermediate Shear Failure***

Nc'' = 8.240	Nc = 8.476	Nc' = 7.197
Nq'' = 2.425	Nq = 2.541	Nq' = 1.912
$N\gamma''$ = 1.188	$N\gamma$ = 1.289	$N\gamma'$ = 0.743
Sc = 1.300	dc = 1.160	ic = 1.000
Sq = 1.200	dq = 1.080	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.080	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***29.58*** ***t/m²***
= ***28.76*** ***t/m²***
= ***28.06*** ***t/m²***

Net Safe Bearing Capacity (qs)
= ***11.83*** ***t/m²***
= ***11.50*** ***t/m²***
= ***11.22*** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC								
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**						
					L	**B**	**D**
0.00	**0.00**	**11.83**	**t/m²**	***for***	***1.50***	***1.50***	***1.00***
					L	**B**	**D**
0.00	**0.00**	**11.50**	**t/m²**	***for***	***2.00***	***2.00***	***1.00***
					L	**B**	**D**
0.00	**0.00**	**11.22**	**t/m²**	***for***	***3.00***	***3.00***	***1.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-05**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square		
Depth of footing, D (m)	1.50	1.50	1.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	0.50	0.50	0.50
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Moisture Content, w	32.36 %
Cohesion, C	0.210 *kg/sq.cm*
Angle of Int.Friction, ϕ	10.24 °
Specific Gravity, G	2.712
Bulk Density, γ_b	2.262 gm/cc
Sat. Density, γ_{Sat}	2.079 gm/cc
Sub. Density, γ_{Sub}	1.079 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.709 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

Overburden Pressure, = ***2.21*** t/m²

e_0 = *0.587*

$\phi' = Tan^{-1}(0.67\, tan(\emptyset))$

= 6.90

Mode of Failure =	***Intermediate Shear Failure***

Nc'' = 8.240	Nc = 8.476	Nc' = 7.197
Nq'' = 2.425	Nq = 2.541	Nq' = 1.912
$N\gamma''$ = 1.188	$N\gamma$ = 1.289	$N\gamma'$ = 0.743
Sc = 1.300	dc = 1.239	ic = 1.000
Sq = 1.200	dq = 1.120	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.120	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	***0.00***	***t/m²***
Net Safe Bearing Capacity (qs)	=	***0.00***	***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu)	=	***0.00***	***t/m²***
Net Safe Bearing Capacity (qs)	=	***0.00***	***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

	=	***32.54***	***t/m²***
Ultimate Bearing Capacity (qu)	=	***31.21***	***t/m²***
	=	***30.01***	***t/m²***
	=	***13.02***	***t/m²***
Net Safe Bearing Capacity (qs)	=	***12.48***	***t/m²***
	=	***12.00***	***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L / B / D**		
0.00	***0.00***	***13.02***	***t/m²***	*for*	***1.50***	***1.50***	***1.50***
0.00	***0.00***	***12.48***	***t/m²***	*for*	***2.00***	***2.00***	***1.50***
0.00	***0.00***	***12.00***	***t/m²***	*for*	***3.00***	***3.00***	***1.50***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-05**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.00	2.00	2.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	0.50	0.50	0.50
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = ***2.71*** t/m^2

Moisture Content, w	30.42 %
Cohesion, C	0.300 ***kg/sq.cm***
Angle of Int.Friction, ϕ	9.64 °
Specific Gravity, G	2.751
Bulk Density, γ_b	2.203 gm/cc
Sat. Density, γ_{Sat}	2.075 gm/cc
Sub. Density, γ_{Sub}	1.075 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.689 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

e_0 = 0.629

Mode of Failure = ***Intermediate Shear Failure***

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$
= 6.49

Nc" = 7.755	*Nc* = 8.216	*Nc'* = 7.045
Nq" = 2.182	*Nq* = 2.405	*Nq'* = 1.839
Nγ" = 0.974	*Nγ* = 1.165	*Nγ'* = 0.680
Sc = 1.300	*dc* = 1.316	*ic* = 1.000
Sq = 1.200	*dq* = 1.000	*iq* = 1.000
Sγ = 0.800	*dγ* = 1.000	*iγ* = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 BγNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 BγN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 BγN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***43.96*** ***t/m^2***
= ***41.68*** ***t/m^2***
= ***39.50*** ***t/m^2***

Net Safe Bearing Capacity (qs)
= ***17.58*** ***t/m^2***
= ***16.67*** ***t/m^2***
= ***15.80*** ***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC								
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**						
					L	**B**	**D**
0.00	**0.00**	**17.58**	**t/m^2**	*for*	**1.50**	**1.50**	**2.00**
0.00	**0.00**	**16.67**	**t/m^2**	*for*	**2.00**	**2.00**	**2.00**
0.00	**0.00**	**15.80**	**t/m^2**	*for*	**3.00**	**3.00**	**2.00**

SKP

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-05**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.50	2.50	2.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	0.50	0.50	0.50
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Moisture Content, w	30.42 %
Cohesion, C	0.300 ***kg/sq.cm***
Angle of Int.Friction, ϕ	9.64 °
Specific Gravity, G	2.751
Bulk Density, γ_b	2.203 gm/cc
Sat. Density, γ_{Sat}	2.075 gm/cc
Sub. Density, γ_{Sub}	1.075 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.689 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

Overburden Pressure, = ***3.25*** t/m^2

$e_0 =$ *0.629*

Mode of Failure =	***Intermediate Shear Failure***

$\phi' = Tan^{-1}\left(0.67\, tan(\emptyset)\right)$
= 6.49

$Nc'' =$ 7.755	$Nc =$ 8.216	$Nc' =$ 7.045
$Nq'' =$ 2.182	$Nq =$ 2.405	$Nq' =$ 1.839
$N\gamma'' =$ 0.974	$N\gamma =$ 1.165	$N\gamma' =$ 0.680
$Sc =$ 1.300	$dc =$ 1.395	$ic =$ 1.000
$Sq =$ 1.200	$dq =$ 1.000	$iq =$ 1.000
$S\gamma =$ 0.800	$d\gamma =$ 1.000	$i\gamma =$ 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γS γd γi γ W'

Ultimate Bearing Capacity (qu)
= ***47.11*** ***t/m^2***
= ***44.23*** ***t/m^2***
= ***41.45*** ***t/m^2***

Net Safe Bearing Capacity (qs)
= ***18.84*** ***t/m^2***
= ***17.69*** ***t/m^2***
= ***16.58*** ***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
0.00	**0.00**	**18.84**	**t/m^2**	*for*	***1.50***	***1.50***	***2.50***
					L	**B**	**D**
0.00	**0.00**	**17.69**	**t/m^2**	*for*	***2.00***	***2.00***	***2.50***
					L	**B**	**D**
0.00	**0.00**	**16.58**	**t/m^2**	*for*	***3.00***	***3.00***	***2.50***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-05**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	3.00	3.00	3.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	0.50	0.50	0.50
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Moisture Content, w	30.42 %
Cohesion, C	0.300 *kg/sq.cm*
Angle of Int.Friction, ϕ	9.64 °
Specific Gravity, G	2.751
Bulk Density, γ_b	2.203 gm/cc
Sat. Density, γ_{Sat}	2.075 gm/cc
Sub. Density, γ_{Sub}	1.075 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.689 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

Overburden Pressure, = ***3.79*** t/m^2

$e_0 =$ 0.629

$\phi' = Tan^{-1}\left(0.67\ tan(\emptyset)\right)$

$= 6.49$

Mode of Failure =	***Intermediate Shear Failure***

$Nc'' =$ 7.755	$Nc =$ 8.216	$Nc' =$ 7.045
$Nq'' =$ 2.182	$Nq =$ 2.405	$Nq' =$ 1.839
$N\gamma'' =$ 0.974	$N\gamma =$ 1.165	$N\gamma' =$ 0.680
$Sc =$ 1.300	$dc =$ 1.474	$ic =$ 1.000
$Sq =$ 1.200	$dq =$ 1.000	$iq =$ 1.000
$S\gamma =$ 0.800	$d\gamma =$ 1.000	$i\gamma =$ 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γS γd γi γ W'

Ultimate Bearing Capacity (qu)
= ***50.26*** ***t/m²***
= ***46.78*** ***t/m²***
= ***43.41*** ***t/m²***

Net Safe Bearing Capacity (qs)
= ***20.10*** ***t/m²***
= ***18.71*** ***t/m²***
= ***17.36*** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
0.00	**0.00**	**20.10**	t/m²	*for*	***1.50***	***1.50***	***3.00***
0.00	**0.00**	**18.71**	t/m²	*for*	***2.00***	***2.00***	***3.00***
0.00	**0.00**	**17.36**	t/m²	*for*	***3.00***	***3.00***	***3.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-06**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square		
Depth of footing, D (m)	1.00	1.00	1.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10
Ratio Zw/B	0.73	0.55	0.37
Water Table Factor	0.87	0.78	0.68
Effective Surcharge over EGL, m	0.00	m	
Overburden Pressure, =	***2.52***	t/m^2	

Moisture Content, w	46.9 %
Cohesion, C	0.270 *kg/sq.cm*
Angle of Int.Friction, ϕ	14.15 °
Specific Gravity, G	2.727
Bulk Density, γ_b	2.518 gm/cc
Sat. Density, γ_{Sat}	2.085 gm/cc
Sub. Density, γ_{Sub}	1.085 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.714 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$
e_0 =	*0.591*

Mode of Failure =	***Intermediate Shear Failure***

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$
= 9.59

Nc'' = 10.054	Nc = 10.533	Nc' = 8.197
Nq'' = 3.425	Nq = 3.690	Nq' = 2.396
$N\gamma''$ = 2.150	$N\gamma$ = 2.407	$N\gamma'$ = 1.156
Sc = 1.300	dc = 1.171	ic = 1.000
Sq = 1.200	dq = 1.086	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.086	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 BγNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** t/m^2

Net Safe Bearing Capacity (qs) = ***0.00*** t/m^2

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 BγN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** t/m^2

Net Safe Bearing Capacity (qs) = ***0.00*** t/m^2

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 BγN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***52.34*** t/m^2
= ***51.19*** t/m^2
= ***50.58*** t/m^2

Net Safe Bearing Capacity (qs)
= ***20.93*** t/m^2
= ***20.47*** t/m^2
= ***20.23*** t/m^2

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
0.00	**0.00**	**20.93**	t/m^2	*for*	***1.50***	***1.50***	***1.00***
0.00	**0.00**	**20.47**	t/m^2	*for*	***2.00***	***2.00***	***1.00***
0.00	**0.00**	**20.23**	t/m^2	*for*	***3.00***	***3.00***	***1.00***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-06**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square		
Depth of footing, D (m)	1.50	1.50	1.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10
Ratio Zw/B	0.40	0.30	0.20
Water Table Factor	0.70	0.65	0.60
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = ***3.78*** t/m^2

Moisture Content, w	46.9 %
Cohesion, C	0.270 ***kg/sq.cm***
Angle of Int.Friction, ϕ	14.15 °
Specific Gravity, G	2.727
Bulk Density, γ_b	2.518 gm/cc
Sat. Density, γ_{Sat}	2.085 gm/cc
Sub. Density, γ_{Sub}	1.085 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.714 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

e_0 = *0.591*

Mode of Failure = ***Intermediate Shear Failure***

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$

= 9.59

Nc'' = 10.054	Nc = 10.533	Nc' = 8.197
Nq'' = 3.425	Nq = 3.690	Nq' = 2.396
$N\gamma''$ = 2.150	$N\gamma$ = 2.407	$N\gamma'$ = 1.156
Sc = 1.300	dc = 1.257	ic = 1.000
Sq = 1.200	dq = 1.128	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.128	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN''cScdcic + q(N''q-1) Sqdqiq + 0.5 B γN''γS γd γi γ W'

Ultimate Bearing Capacity (qu)
= ***59.31*** ***t/m²***
= ***57.22*** ***t/m²***
= ***55.66*** ***t/m²***

Net Safe Bearing Capacity (qs)
= ***23.72*** ***t/m²***
= ***22.89*** ***t/m²***
= ***22.26*** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
0.00	***0.00***	***23.72***	***t/m²***	*for*	***1.50***	***1.50***	***1.50***
0.00	***0.00***	***22.89***	***t/m²***	*for*	***2.00***	***2.00***	***1.50***
0.00	***0.00***	***22.26***	***t/m²***	*for*	***3.00***	***3.00***	***1.50***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-06**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.00	2.00	2.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10
Ratio Zw/B	0.07	0.05	0.03
Water Table Factor	0.53	0.53	0.52
Effective Surcharge over EGL, m	0.00	m	
Overburden Pressure, =	***4.96***	t/m^2	

Moisture Content, w	45.85 %
Cohesion, C	0.240 ***kg/sq.cm***
Angle of Int.Friction, ϕ	18.64 °
Specific Gravity, G	2.714
Bulk Density, γ_b	2.481 gm/cc
Sat. Density, γ_{Sat}	2.074 gm/cc
Sub. Density, γ_{Sub}	1.074 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.701 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$
	$e_0 =$ 0.596

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$

$= 12.73$

Mode of Failure =	***Intermediate Shear Failure***

$Nc'' =$ 12.873	$Nc =$ 13.783	$Nc' =$ 9.789
$Nq'' =$ 5.172	$Nq =$ 5.731	$Nq' =$ 3.274
$N\gamma'' =$ 4.043	$N\gamma =$ 4.645	$N\gamma' =$ 2.002
$Sc =$ 1.300	$dc =$ 1.371	$ic =$ 1.000
$Sq =$ 1.200	$dq =$ 1.186	$iq =$ 1.000
$S\gamma =$ 0.800	$d\gamma =$ 1.186	$i\gamma =$ 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γSγdγiγ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γSγdγiγ W'

Ultimate Bearing Capacity (qu)
= ***88.34*** ***t/m^2***
= ***84.45*** ***t/m^2***
= ***81.56*** ***t/m^2***

Net Safe Bearing Capacity (qs)
= ***35.34*** ***t/m^2***
= ***33.78*** ***t/m^2***
= ***32.63*** ***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	Local Shear Failure	Intermediate Shear Failure			L	B	D
0.00	0.00	35.34	t/m^2	for	1.50	1.50	2.00
0.00	0.00	33.78	t/m^2	for	2.00	2.00	2.00
0.00	0.00	32.63	t/m^2	for	3.00	3.00	2.00

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-06**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	2.50	2.50	2.50
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Moisture Content, w	45.85 %
Cohesion, C	0.240 *kg/sq.cm*
Angle of Int.Friction, ϕ	18.64 °
Specific Gravity, G	2.714
Bulk Density, γ_b	2.481 gm/cc
Sat. Density, γ_{Sat}	2.074 gm/cc
Sub. Density, γ_{Sub}	1.074 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.701 gm/cc
Void Ratio,	$e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$
	$e_0 =$ 0.596

Overburden Pressure, = ***5.64*** t/m^2

Mode of Failure =	***Intermediate Shear Failure***

$\phi' = Tan^{-1}\left(0.67\ tan(\emptyset)\right)$
= 12.73

Nc'' = 12.873	Nc = 13.783	Nc' = 9.789
Nq'' = 5.172	Nq = 5.731	Nq' = 3.274
$N\gamma''$ = 4.043	$N\gamma$ = 4.645	$N\gamma'$ = 2.002
Sc = 1.300	dc = 1.464	ic = 1.000
Sq = 1.200	dq = 1.232	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.232	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m²***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m²***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN''cScdcic + q(N''q-1) Sqdqiq + 0.5 B γN''γS γd γi γ W'

Ultimate Bearing Capacity (qu)
= ***95.20*** ***t/m²***
= ***89.34*** ***t/m²***
= ***83.90*** ***t/m²***

Net Safe Bearing Capacity (qs)
= ***38.08*** ***t/m²***
= ***35.73*** ***t/m²***
= ***33.56*** ***t/m²***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			L / B / D		
0.00	***0.00***	***38.08***	***t/m²***	*for*	***1.50***	***1.50***	***2.50***
0.00	***0.00***	***35.73***	***t/m²***	*for*	***2.00***	***2.00***	***2.50***
0.00	***0.00***	***33.56***	***t/m²***	*for*	***3.00***	***3.00***	***2.50***

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403(Edition 2002)

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-06**
Station	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square		
Depth of footing, D (m)	3.00	3.00	3.00
Width of footing, B (m)	1.50	2.00	3.00
Length of footing, L (m)	1.50	2.00	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10
Ratio Zw/B	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50
Effective Surcharge over EGL, m	0.00	m	

Overburden Pressure, = ***6.18*** t/m^2

Moisture Content, w	45.85 %
Cohesion, C	0.240 ***kg/sq.cm***
Angle of Int.Friction, ϕ	18.64 °
Specific Gravity, G	2.714
Bulk Density, γ_b	2.481 gm/cc
Sat. Density, γ_{Sat}	2.074 gm/cc
Sub. Density, γ_{Sub}	1.074 gm/cc
Inclination Angle, α	0
Factor of Safety	2.5
Surcharge Density, γ_{Sur}	1.000 gm/cc
Dry Density, γ_d	1.701 gm/cc

Void Ratio, $e_0 = \frac{G*\gamma_w}{\gamma_d} - 1$

$e_0 =$ 0.596

Mode of Failure =	***Intermediate Shear Failure***

$\phi' = Tan^{-1}(0.67\ tan(\emptyset))$

= 12.73

Nc'' = 12.873	Nc = 13.783	Nc' = 9.789
Nq'' = 5.172	Nq = 5.731	Nq' = 3.274
$N\gamma''$ = 4.043	$N\gamma$ = 4.645	$N\gamma'$ = 2.002
Sc = 1.300	dc = 1.557	ic = 1.000
Sq = 1.200	dq = 1.279	iq = 1.000
$S\gamma$ = 0.800	$d\gamma$ = 1.279	$i\gamma$ = 1.000

for general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 B γNγS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 B γN'γS γd γi γ W'

Ultimate Bearing Capacity (qu) = ***0.00*** ***t/m^2***

Net Safe Bearing Capacity (qs) = ***0.00*** ***t/m^2***

for intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

qu = cN"cScdcic + q(N"q-1) Sqdqiq + 0.5 B γN"γS γd γi γ W'

Ultimate Bearing Capacity (qu)
= ***103.74*** ***t/m^2***
= ***96.43*** ***t/m^2***
= ***89.55*** ***t/m^2***

Net Safe Bearing Capacity (qs)
= ***41.50*** ***t/m^2***
= ***38.57*** ***t/m^2***
= ***35.82*** ***t/m^2***

Result :-

Net Safe Bearing Capacity (qs), SBC							
General Shear Failure	**Local Shear Failure**	**Intermediate Shear Failure**			**L**	**B**	**D**
0.00	***0.00***	***41.50***	***t/m^2***	*for*	***1.50***	***1.50***	***3.00***
0.00	***0.00***	***38.57***	***t/m^2***	*for*	***2.00***	***2.00***	***3.00***
0.00	***0.00***	***35.82***	***t/m^2***	*for*	***3.00***	***3.00***	***3.00***

Annexure - V

(PILE BEARING CAPACITY- 450mm DIA CALCULATIONS)

PILES IN COHESIVE SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Q_u = \left(A_p N_c C_p \right) + \sum_{i=1}^{n} \propto_i C_i A_{si}$$

Bore Hole No = 1

Diameter of the Pile Shaft	=	D	=	450	mm	=	0.45	m					
cross-sectional area of pile tipShaft	=	Ap	=	159107.14	mm^2	=	0.15910714	m^2					
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3					
Ground water Table	=	GWT	=	2500.00	mm	=	2.50	m					
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)								
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3								
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)								
Thickness of the Pile Cap	=	t	=	0.80	m	(Given)							
Length of Pile for consideration of Effective overburden	=	15D	=	6750.00	mm	=	6.75	m					

Estimation of Lateral capacity(Annexure C of I.S.2911-Part1/Sec.2)

Characteristic Compressive strength of Concrete	=	fck	=	30	N/mm2								
Modulus of Elasticity of Pile Material	=	E	=	5000*(fck)^(0.5)	=	27386.12788	N/mm2	=	27386127.88	kN/m2			
Permissible deflection	=	y	=	1% of the diameter of the pile	=	4.50	mm	=	0.45	cm	(as per IRC:78 :2011)		
Horizontal Modulus of Subgrade reaction	=	K1	=	7000.00	kN/m3	Top layer is Soft Clay	As per annex.c of IS 2911/Table-4 pg.14						
			=	0.00700	N/mm3								
Moment of Inertia of the Pile	=	I	=	(πD^4)/64	=	0.0020137	m^4	=	2013699776.7857	mm^4			
Rigidity factor	=	R	=	(EI/KB)^(1/4)	=	2.51	m	K = (K1/1.5)*(0.3/B)	As per Annex.c of IS 2911/Cl:2.3.2				
					=	250.52	cm	= 3111.11 kN/m2					
Application of the lateral load level (approximately) at 1.0m above the pile cap	=	L1	=	100.00	cm	=	1.00	m					
	=	e/R	=	0.40									
Lf/R	=	Zf/R	=	1.85	(approx.)from Fig.4 of Annexure - C, of I.S.2911 [For Fixed piles in Preloaded clays]			=	1.55	[For Free end piles in Preloaded clays]			
		Zf	=	463.47	cm	=	4.63	m	388.31	cm			
Lateral deflection,	=	y	=	$\frac{Q(e+Zf)^3}{12EI}$				y	=	$\frac{Q(e+Zf)^3}{3EI}$			
Hence, lateral load	=	Q	=	$\frac{12EIy}{(e+Zf)^3}$	=	16.65	kN	=	1.70 (For Fixed End Pile)	Tonnes	=	6.39 kN	0.65 Tonnes (For freeEnd Pile)

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Cohesion C (kN/m2)	Nc as per IS 2911 Part-1/Sec-2 (Annexure -B)	End Bearing Capacity in kN (qub)	ᾱ i Adhesion factor for the ith layer depending on the consistency of soil as per IS 2911 (Annexure -B)	Asi Surface Area of Pile for ith layer, (m2)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingc apacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
1	0.80	1.95	1.15	Clay	4	31.381	9	44.94	1	1.63	51.151	51.15	96.09	9.60	3.84	1.93
2	1.95	3.45	1.5	Clay	6	32.362	9	46.34	1	2.12	68.607	119.76	166.10	16.46	6.58	2.81
3	3.45	4.95	1.5	Clay	8	32.362	9	46.34	1	2.12	68.607	188.37	234.71	23.09	9.23	3.17
4	4.95	6.45	1.5	Clay	16	35.304	9	50.55	1	2.12	74.844	263.21	313.76	30.78	12.31	3.75
5	6.45	7.95	1.5	Clay	20	36.285	9	51.96	1	2.12	76.923	340.13	392.09	38.40	15.36	4.18

PILES IN COHESIVE-LESS SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Qu = Ap\left(\frac{1}{2}D\gamma\, N\gamma + PdNq\right) + \sum_{i=1}^{i=n} Ki\, Pdi\, tan\delta i\, Asi$$

Diameter of the Pile Shaft	=	D	=	450	mm	=	0.45	m
cross-sectional area of pile tipShaft	=	Ap	=	159107.14	mm^2	=	0.159	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	2500.00	mm	=	2.50	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap(Pile Cut Off level (m) from EGL)	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	6750.00	mm	=	6.75	m
Dry Density of soil	=	γd	=	17.46	kN/m3	=	1.75	gm/cc
Bulk Density of soil	=	γb	=	18.246	kN/m3	=	1.82	gm/cc

Bore Hole No = 1

S.No	Depth of layer below ground (m)		Thickness of Layer (m)	Soil type	SPT(No)	Submerge density, of the soil at pile tip, in (kN/m3) (γ)	Effective Overburden pressure at pile tip, in kN/m2 limited upto 15D -GWT@EGL (kN/m3)(Pdi)	δ (Degree) angle of friction @pile stem	Nq	Nγ	Asi	Ki (IS:2911)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	End Bearing Capacity in kN (qub)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingcapa city of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
	From (m)	To (m)							IS 2911	IS 6403	Surface Area of Pile for ith layer, (m2)	value for earth pressure coefficient							
6	7.95	9.45	1.5	Sand	23	8.2457	65.14	33.9	43.4	42.39	2.12	1.195	110.89	451.03	477.50	928.53	92.72	37.09	17.26
7	9.45	10.95	1.5	Sand	26	8.2457	71.33	34.8	48.8	47	2.12	1.24	130.32	581.34	584.50	1165.84	116.54	46.62	22.05
8	10.95	12.45	1.5	Sand	33	8.2457	77.51	36.75	72.75	69.51	2.12	1.3375	164.12	745.46	942.58	1688.04	169.41	67.76	27.99
9	12.45	13.95	1.5	Sand	37	8.2457	83.69	37.75	85.75	81.79	2.12	1.3875	190.62	936.08	1195.30	2131.37	214.24	85.69	34.84
10	13.95	15.45	1.5	Sand	46	8.2457	89.88	40	115	109.41	2.12	1.5	239.83	1175.90	1715.99	2891.90	291.40	116.56	43.35

PILES IN COHESIVE SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)
Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Q_u = \left(A_p N_c C_p \right) + \sum_{i=1}^{n} \propto_i C_i A_{si}$$

Bore Hole No = 03

Diameter of the Pile Shaft	=	D	=	450	mm	=	0.45	m	
cross-sectional area of pile tipShaft	=	Ap	=	159107.14	mm^2	=	0.15910714	m^2	
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3	
Ground water Table	=	GWT	=	200.00	mm	=	0.20	m	
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)				
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3				
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)				
Thickness of the Pile Cap	=	t	=	0.80	m	(Given)			
Length of Pile for consideration of Effective overburden	=	15D	=	6750.00	mm	=	6.75	m	

Estimation of Lateral capacity(Annexure C of I.S.2911-Part1/Sec.2)

Characteristic Compressive strength of Concrete	=	fck	=	30	N/mm2							
Modulus of Elasticity of Pile Material	=	E	=	5000*(fck)^(0.5)	=	27386.12788	N/mm2	=	27386127.88	kN/m2		
Permissible deflection	=	y	=	1% of the diameter of the pile	=	4.50	mm	=	0.45	cm	(as per IRC:78 :2011)	
Horizontal Modulus of Subgrade reaction	=	K1	=	6500.00	kN/m3	Top layer is Soft Clay	As per annex.c of IS 2911/Table-4 pg.14					
			=	0.00650	N/mm3							
Moment of Inertia of the Pile	=	I	=	(πD^4)/64	=	0.0020137	m^4	=	2013699776.7857	mm^4		
Rigidity factor	=	R	=	(EI/KB)^(1/4)	=	2.55	m		K = (K1/1.5)*(0.3/B)	As per Annex.c of IS 2911/Cl:2.3.2		
					=	255.21	cm		= 2888.89	kN/m2		
Application of the lateral load level (approximately) at 1.0m above the pile cap	=	L1	=	100.00	cm	=	1.00	m				
	=	e/R	=	0.39								
Lf/R	=	Zf/R	=	1.86	(approx.)from Fig.4 of Annexure - C, of I.S.2911 [For Fixed piles in Preloaded clays]			=	1.56	[For Free end piles in Preloaded clays]		
		Zf	=	474.69	cm	=	4.75	m	398.13	cm		
Lateral deflection,	=	y	=	$\frac{Q(e+Zf)^3}{12EI}$				y	=	$\frac{Q(e+Zf)^3}{3EI}$		
Hence, lateral load	=	Q	=	$\frac{12EIy}{(e+Zf)^3}$	=	15.69	kN	=	1.60 (For Fixed End Pile)	Tonnes	= 6.02 kN	0.61 Tonnes (For freeEnd Pile)

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Cohesion C (kN/m2)	Nc as per IS 2911 Part-1/Sec-2 (Annexure -B)	End Bearing Capacity in kN (qub)	ἀ i Adhesion factor for the ith layer depending on the consistency of soil as per IS 2911 (Annexure -B)	Asi Surface Area of Pile for ith layer, (m2)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingc apacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
1	0.80	1.95	1.15	Clay	3	32.360	9	46.34	1	1.63	52.747	52.75	99.09	9.91	3.96	1.99
2	1.95	3.45	1.5	Clay	4	31.380	9	44.94	1	2.12	66.526	119.27	164.21	16.26	6.51	2.73
3	3.45	4.95	1.5	Clay	5	35.300	9	50.55	1	2.12	74.836	194.11	244.66	24.10	9.64	3.38
4	4.95	6.45	1.5	Clay	6	31.380	9	44.94	1	2.12	66.526	260.63	305.57	29.94	11.98	3.46

PILES IN COHESIVE-LESS SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Qu = Ap\left(\frac{1}{2}\,D\gamma\,N\gamma + PdNq\right) + \sum_{i=1}^{i=n} Ki\,Pdi\,tan\delta i\,Asi$$

Bore Hole No = 03

Diameter of the Pile Shaft	=	D	=	450	mm	=	0.45	m
cross-sectional area of pile tipShaft	=	Ap	=	159107.14	mm^2	=	0.159	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	200.00	mm	=	0.20	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap(Pile Cut Off level (m) from EGL)	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	6750.00	mm	=	6.75	m
Dry Density of soil	=	γd	=	17.06	kN/m3	=	1.71	gm/cc
Dry Density of soil	=	γb	=	17.828	kN/m3	=	1.78	gm/cc

S.No	Depth of layer below ground (m)		Thickness of Layer (m)	Soil type	SPT(No)	Submerge density, of the soil at pile tip, in (kN/m3) (γ)	Effective Overburden pressure at pile tip, in kN/m2 limited upto 15D -GWT@EGL (kN/m3)(Pdi)	δ (Degree) angle of friction @pile stem	Nq	Nγ	Asi	Ki (IS:2911)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	End Bearing Capacity in kN (qub)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingcapacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
	From (m)	To (m)							IS 2911	IS 6403	Surface Area of Pile for ith layer, (m2)	value for earth pressure coefficient							
5	6.45	7.95	1.5	Sand	12	7.8277	50.10	30.60	23.60	25.48	2.12	1.03	64.69	325.33	204.37	529.70	52.43	20.97	12.62
6	7.95	9.45	1.5	Sand	14	7.8277	55.97	31.20	27.20	28.55	2.12	1.06	76.17	401.50	260.43	661.93	65.54	26.22	15.58
7	9.45	10.95	1.5	Sand	18	7.8277	61.84	32.40	34.40	34.70	2.12	1.12	93.18	494.68	360.61	855.29	84.89	33.95	19.11
8	10.95	12.45	1.5	Sand	31	7.8277	67.71	36.25	66.25	63.38	2.12	1.3125	138.14	632.82	754.17	1386.99	138.72	55.49	24.17
9	12.45	13.95	1.5	Sand	34	7.8277	73.58	37.00	76.00	72.58	2.12	1.35	158.69	791.51	936.07	1727.58	173.07	69.23	29.92
10	13.95	15.45	1.5	Sand	38	7.8277	79.45	38.00	89.00	84.86	2.12	1.4	184.24	975.75	1179.23	2154.98	216.28	86.51	36.55

PILES IN COHESIVE SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Q_u = (A_p N_c C_p) + \sum_{i=1}^{n} \propto_i C_i A_{si}$$

Bore Hole No = 4

Diameter of the Pile Shaft = D = 450 mm = 0.45 m

cross-sectional area of pile tipShaft = Ap = 159107.14 mm^2 = 0.15910714 m^2

Effective Unit weight of water = γw = 1.00 gm/cc = 10.00 kN/m3

Ground water Table = GWT = 2100.00 mm = 2.10 m

Factor of Safety = FS1 = 2.50 (Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)

Density of M30(Assumption) grade Concrete = γc = 25.00 kN/m3

Factor of Safety for uplift capacity = FS2 = 3.00 (Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)

Thickness of the Pile Cap = t = 0.80 m (Given)

Length of Pile for consideration of Effective overburden = 15D = 6750.00 mm = 6.75 m

Estimation of Lateral capacity(Annexure C of I.S.2911-Part1/Sec.2)

Characteristic Compressive strength of Concrete = fck = 30 N/mm2

Modulus of Elasticity of Pile Material = E = 5000*(fck)^(0.5) = 27386.12788 N/mm2 = 27386127.88 kN/m2

Permissible deflection = y = 1% of the diameter of the pile = 4.50 mm = 0.45 cm (as per IRC:78 :2011)

Horizontal Modulus of Subgrade reaction = K1 = 6000.00 kN/m3 Top layer is Soft Clay As per annex.c of IS 2911/Table-4 pg.14

= 0.00600 N/mm3

Moment of Inertia of the Pile = I = (πD^4)/64 = 0.0020137 m^4 = 2013699776.7857 mm^4

Rigidity factor = R = (EI/KB)^(1/4) = 2.60 m

= 260.37 cm

K = (K1/1.5)*(0.3/B) As per Annex.c of IS 2911/Cl:2.3.2

= 2666.67 kN/m2

Application of the lateral load level (approximately) at 1.0m above the pile cap = L1 = 100.00 cm = 1.00 m

= e/R = 0.38

Lf/R = Zf/R = 1.87 (approx.)from Fig.4 of Annexure - C, of I.S.2911 [For Fixed piles in Preloaded clays] = 1.57 [For Free end piles in Preloaded clays]

Zf = 486.89 cm = 4.87 m — 408.78 cm

Lateral deflection, = y = $\frac{Q(e+Zf)^3}{12EI}$ — y = $\frac{Q(e+Zf)^3}{3EI}$

Hence, lateral load = Q = $\frac{12EIy}{(e+Zf)^3}$ = 14.73 kN = 1.50 Tonnes (For Fixed End Pile) = 5.65 kN 0.58 Tonnes (For freeEnd Pile)

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Cohesion C (kN/m2)	Nc as per IS 2911 Part-1/Sec-2 (Annexure -B)	End Bearing Capacity in kN (qub)	ᾱ i Adhesion factor for the ith layer depending on the consistency of soil as per IS 2911 (Annexure -B)	Asi Surface Area of Pile for ith layer, (m2)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingc apacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
1	0.80	1.95	1.15	Clay	6	31.381	9	44.94	1	1.63	51.151	51.15	96.09	9.60	3.84	1.93
2	1.95	3.45	1.5	Clay	7	34.323	9	49.15	1	2.12	72.765	123.92	173.07	17.17	6.87	2.95
3	3.45	4.95	1.5	Clay	17	36.285	9	51.96	1	2.12	76.923	200.84	252.80	24.93	9.97	3.45
4	4.95	6.45	1.5	Clay	24	34.323	9	49.15	0.7	2.12	50.936	251.78	300.93	29.47	11.79	2.93
5	6.45	7.95	1.5	Clay	28	28.439	9	40.72	0.7	2.12	42.204	293.98	334.70	32.55	13.02	3.00
6	7.95	9.45	1.5	Clay	31	23.536	9	33.70	0.4	2.12	19.958	313.94	347.64	33.50	13.40	2.61

PILES IN COHESIVE-LESS SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Qu = Ap\left(\frac{1}{2}D\gamma\, N\gamma + PdNq\right) + \sum_{i=1}^{i=n} Ki\, Pdi\, tan\delta i\, Asi$$

Diameter of the Pile Shaft	=	D	=	450	mm	=	0.45	m
cross-sectional area of pile tipShaft	=	Ap	=	159107.14	mm^2	=	0.159	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	2100.00	mm	=	2.10	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap(Pile Cut Off level (m) from EGL)	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	6750.00	mm	=	6.75	m
Dry Density of soil	=	γd	=	17.65	kN/m3	=	1.77	gm/cc
Bulk Density of soil	=	γb	=	18.444	kN/m3	=	1.84	gm/cc

Bore Hole No = 4

S.No	Depth of layer below ground (m) From (m)	Depth of layer below ground (m) To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Submerge density, of the soil at pile tip, in (kN/m3) (γ)	Effective Overburden pressure at pile tip, in kN/m2 limited upto 15D -GWT@EGL (kN/m3)(Pdi)	δ (Degree) angle of friction @pile stem	Nq IS 2911	Nγ IS 6403	Asi Surface Area of Pile for ith layer, (m2)	Ki (IS:2911) value for earth pressure coefficient	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	End Bearing Capacity in kN (qub)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingcapacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
7	9.45	10.95	1.5	Sand	33	8.44	79.38	36.75	72.75	69.51	2.12	1.3377	168.12	482.06	964.68	1446.73	145.18	58.07	18.68
8	10.95	12.45	1.5	Sand	36	8.44	85.71	37.50	82.50	78.72	2.12	1.375	191.71	673.77	1177.03	1850.79	186.00	74.40	25.56
9	12.45	13.95	1.5	Sand	40	8.44	92.04	38.50	95.50	91.00	2.12	1.425	221.18	894.95	1458.64	2353.59	236.89	94.76	33.44
10	13.95	15.45	1.5	Sand	43	8.44	98.38	39.25	105.25	100.20	2.12	1.4625	249.21	1144.15	1713.56	2857.71	287.91	115.16	42.27

PILES IN COHESIVE SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Q_u = \left(A_p N_c C_p \right) + \sum_{i=1}^{n} \propto_i C_i A_{si}$$

Bore Hole No = 5

Diameter of the Pile Shaft	=	D	=	450	mm	=	0.45	m		
cross-sectional area of pile tipShaft	=	Ap	=	159107.14	mm^2	=	0.15910714	m^2		
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3		
Ground water Table	=	GWT	=	500.00	mm	=	0.50	m		
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)					
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3					
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)					
Thickness of the Pile Cap	=	t	=	0.80	m	(Given)				
Length of Pile for consideration of Effective overburden	=	15D	=	6750.00	mm	=	6.75	m		

Estimation of Lateral capacity(Annexure C of I.S.2911-Part1/Sec.2)

Characteristic Compressive strength of Concrete	=	fck	=	30	N/mm2							
Modulus of Elasticity of Pile Material	=	E	=	5000*(fck)^(0.5)	=	27386.12788	N/mm2	=	27386127.88	kN/m2		
Permissible deflection	=	y	=	1% of the diameter of the pile	=	4.50	mm	=	0.45	cm	(as per IRC:78 :2011)	
Horizontal Modulus of Subgrade reaction	=	K1	=	5000.00	kN/m3	Top layer is Soft Clay	As per annex.c of IS 2911/Table-4 pg.14					
			=	0.00500	N/mm3							
Moment of Inertia of the Pile	=	I	=	(πD^4)/64	=	0.0020137	m^4	=	2013699776.7857	mm^4		
Rigidity factor	=	R	=	(EI/KB)^(1/4)	=	2.73	m	K = (K1/1.5)*(0.3/B)	As per Annex.c of IS 2911/Cl:2.3.2			
					=	272.51	cm	= 2222.22	kN/m2			
Application of the lateral load level (approximately) at 1.0m above the pile cap	=	L1	=	100.00	cm	=	1.00	m				
	=	e/R	=	0.37								
Lf/R	=	Zf/R	=	1.88	(approx.)from Fig.4 of Annexure - C, of I.S.2911 [For Fixed piles in Preloaded clays]			=	1.58	[For Free end piles in Preloaded clays]		
		Zf	=	512.32	cm	=	5.12	m	430.56	cm		
Lateral deflection,	=	y	=	$\frac{Q(e+Zf)^3}{12EI}$				y	=	$\frac{Q(e+Zf)^3}{3EI}$		
Hence, lateral load	=	Q	=	$\frac{12EIy}{(e+Zf)^3}$	=	12.97	kN	=	1.32	Tonnes	=	4.98 kN = 0.51 Tonnes
									(For Fixed End Pile)			(For freeEnd Pile)

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Cohesion C (kN/m2)	Nc as per IS 2911 Part-1/Sec-2 (Annexure -B)	End Bearing Capacity in kN (qub)	ᾱ i Adhesion factor for the ith layer depending on the consistency of soil as per IS 2911 (Annexure -B)	Asi Surface Area of Pile for ith layer, (m2)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingc apacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
1	0.80	1.95	1.15	Clay	3	20.594	9	29.49	1	1.63	33.568	33.57	63.06	6.23	2.49	1.34
2	1.95	3.45	1.5	Clay	5	29.420	9	42.13	1	2.12	62.370	95.94	138.07	13.60	5.44	2.59
3	3.45	4.95	1.5	Clay	6	25.497	9	36.51	1	2.12	54.054	149.99	186.50	18.17	7.27	2.68

PILES IN COHESIVE-LESS SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$\mathbf{Qu} = \mathbf{Ap}\left(\frac{\mathbf{1}}{\mathbf{2}}\,\mathbf{D}\gamma\, N\gamma + PdNq\right) + \sum_{i=1}^{i=n} Ki\; Pdi\; tan\delta i\; Asi$$

Diameter of the Pile Shaft	=	D	=	450	mm	=	0.45	m
cross-sectional area of pile tipShaft	=	Ap	=	159107.14	mm^2	=	0.159	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	500.00	mm	=	0.50	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap(Pile Cut Off level (m) from EGL)	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	6750.00	mm	=	6.75	m
Dry Density of soil	=	γd	=	17.35	kN/m3	=	1.74	gm/cc
Bulk Density of soil	=	γb	=	18.131	kN/m3	=	1.81	gm/cc

Bore Hole No = 5

S.No	Depth of layer below ground (m)		Thickness of Layer (m)	Soil type	SPT(No)	Submerge density, of the soil at pile tip, in (kN/m3) (γ)	Effective Overburden pressure at pile tip, in kN/m2 limited upto 15D -GWT@EGL (kN/m3)(Pdi)	δ (Degree) angle of friction @pile stem	Nq	Nγ	Asi	Ki (IS:2911)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	End Bearing Capacity in kN (qub)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingcapacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
	From (m)	To (m)							IS 2911	IS 6403	Surface Area of Pile for ith layer, (m2)	value for earth pressure coefficient							
4	4.95	6.45	1.5	Sand	7	8.13	39.84	29.4	18.8	21.02	2.12	0.97	46.16	196.16	132.82	328.97	32.33	12.93	7.87
5	6.45	7.95	1.5	Sand	12	8.13	45.94	30.6	23.6	25.48	2.12	1.03	59.32	255.48	189.03	444.52	43.74	17.50	10.25
6	7.95	9.45	1.5	Sand	25	8.13	52.04	34.5	47	45.47	2.12	1.225	92.88	348.36	418.65	767.01	76.25	30.50	13.77
7	9.45	10.95	1.5	Sand	31	8.13	58.13	36.25	66.25	63.38	2.12	1.3125	118.61	466.97	653.93	1120.90	111.96	44.78	18.17
8	10.95	12.45	1.5	Sand	36	8.13	64.23	37.5	82.5	78.72	2.12	1.375	143.67	610.64	894.24	1504.88	150.74	60.30	23.41
9	12.45	13.95	1.5	Sand	46	8.13	70.33	40	115	109.41	2.12	1.5	187.67	798.31	1357.88	2156.19	216.77	86.71	30.15

PILES IN COHESIVE SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Q_u = (A_p N_c C_p) + \sum_{i=1}^{n} \propto_i C_i A_{si}$$

Bore Hole No = 6

Diameter of the Pile Shaft	=	D	=	450	mm	=	0.45	m	
cross-sectional area of pile tipShaft	=	Ap	=	159107.14	mm^2	=	0.15910714	m^2	
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3	
Ground water Table	=	GWT	=	2100.00	mm	=	2.10	m	
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)				
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3				
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)				
Thickness of the Pile Cap	=	t	=	0.80	m	(Given)			
Length of Pile for consideration of Effective overburden	=	15D	=	6750.00	mm	=	6.75	m	

Estimation of Lateral capacity(Annexure C of I.S.2911-Part1/Sec.2)

Characteristic Compressive strength of Concrete	=	fck	=	30	N/mm2								
Modulus of Elasticity of Pile Material	=	E	=	5000*(fck)^(0.5)	=	27386.12788	N/mm2	=	27386127.88	kN/m2			
Permissible deflection	=	y	=	1% of the diameter of the pile	=	4.50	mm	=	0.45	cm	(as per IRC:78 :2011)		
Horizontal Modulus of Subgrade reaction	=	K1	=	7450.00	kN/m3	Top layer is Soft Clay	As per annex.c of IS 2911/Table-4 pg.14						
			=	0.00745	N/mm3								
Moment of Inertia of the Pile	=	I	=	(πD^4)/64	=	0.0020137	m^4	=	2013699776.7857	mm^4			
Rigidity factor	=	R	=	(EI/KB)^(1/4)	=	2.47	m	K = (K1/1.5)*(0.3/B)	As per Annex.c of IS 2911/Cl:2.3.2				
					=	246.65	cm	= 3311.11 kN/m2					
Application of the lateral load level (approximately) at 1.0m above the pile cap	=	L1	=	100.00	cm	=	1.00	m					
	=	e/R	=	0.41									
Lf/R	=	Zf/R	=	1.84	(approx.)from Fig.4 of Annexure - C, of I.S.2911 [For Fixed piles in Preloaded clays]			=	1.54	[For Free end piles in Preloaded clays]			
		Zf	=	453.84	cm	=	4.54	m	379.84	cm			
Lateral deflection,	=	y	=	$\frac{Q(e+Zf)^3}{12EI}$				y	=	$\frac{Q(e+Zf)^3}{3EI}$			
Hence, lateral load	=	Q	=	$\frac{12EIy}{(e+Zf)^3}$	=	17.53	kN	=	1.79	Tonnes	=	6.74 kN	0.69 Tonnes
									(For Fixed End Pile)				(For freeEnd Pile)

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Cohesion C (kN/m2)	Nc as per IS 2911 Part-1/Sec-2 (Annexure -B)	End Bearing Capacity in kN (qub)	ᾱ i Adhesion factor for the ith layer depending on the consistency of soil as per IS 2911 (Annexure -B)	Asi Surface Area of Pile for ith layer, (m2)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingc apacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
1	0.80	1.95	1.15	Clay	5	26.478	9	37.92	1	1.63	43.159	43.16	81.07	8.07	3.23	1.66
2	1.95	3.45	1.5	Clay	4	23.536	9	33.70	1	2.12	49.896	93.06	126.76	12.45	4.98	2.17
3	3.45	4.95	1.5	Clay	10	28.439	9	40.72	1	2.12	60.291	153.35	194.07	18.94	7.58	2.89
4	4.95	6.45	1.5	Clay	13	26.478	9	37.92	0.7	2.12	39.293	192.64	230.56	22.30	8.92	2.54

PILES IN COHESIVE-LESS SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$\mathrm{Qu} = \mathrm{Ap}\left(\frac{1}{2}\mathrm{D}\gamma\, N\gamma + PdNq\right) + \sum_{i=1}^{i=n} Ki\, Pdi\, tan\delta i\, Asi$$

Diameter of the Pile Shaft	=	D	=	450	mm	=	0.45	m
cross-sectional area of pile tipShaft	=	Ap	=	159107.14	mm^2	=	0.159	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	2100.00	mm	=	2.10	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap(Pile Cut Off level (m) from EGL)	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	6750.00	mm	=	6.75	m
Dry Density of soil	=	γd	=	17.68	kN/m3	=	1.77	gm/cc
Bulk Density of soil	=	γb	=	18.476	kN/m3	=	1.85	gm/cc

Bore Hole No = 6

S.No	Depth of layer below ground (m)		Thickness of Layer (m)	Soil type	SPT(No)	Submerge density, of the soil at pile tip, in (kN/m3) (γ)	Effective Overburden pressure at pile tip, in kN/m2 limited upto 15D -GWT@EGL (kN/m3)(Pdi)	δ (Degree) angle of friction @pile stem	Nq	Nγ	Asi	Ki (IS:2911)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	End Bearing Capacity in kN (qub)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingcapacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
	From (m)	To (m)							IS 2911	IS 6403	Surface Area of Pile for ith layer, (m2)	value for earth pressure coefficient							
5	6.45	7.95	1.5	Sand	18	8.4756	54.24	32.4	34.4	34.7	2.12	1.12	81.74	274.38	319.84	594.22	59.00	23.60	10.89
6	7.95	9.45	1.5	Sand	21	8.4756	60.60	33.3	39.8	39.32	2.12	1.165	98.32	372.69	409.76	782.45	77.83	31.13	14.60
7	9.45	10.95	1.5	Sand	30	8.4756	66.96	36	63	60.31	2.12	1.3	134.07	506.76	711.05	1217.82	121.84	48.74	19.52
8	10.95	12.45	1.5	Sand	33	8.4756	73.31	36.75	72.75	69.51	2.12	1.3375	155.23	662.00	894.59	1556.58	156.01	62.40	25.16
9	12.45	13.95	1.5	Sand	39	8.4756	79.67	38.25	92.25	87.93	2.12	1.4125	188.08	850.07	1227.53	2077.61	208.76	83.50	31.91
10	13.95	15.45	1.5	Sand	46	8.4756	86.03	40	115	109.41	2.12	1.5	229.55	1079.62	1646.43	2726.06	274.49	109.80	40.08

Annexure - VI

(PILE BEARING CAPACITY- 500mm DIA CALCULATIONS)

PILES IN COHESIVE SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Q_u = \left(A_p N_c C_p \right) + \sum_{i=1}^{n} \propto_i C_i A_{si}$$

Bore Hole No = 1

Diameter of the Pile Shaft	=	D	=	500	mm	=	0.5	m			
cross-sectional area of pile tipShaft	=	Ap	=	196428.57	mm^2	=	0.19642857	m^2			
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3			
Ground water Table	=	GWT	=	2500.00	mm	=	2.50	m			
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)						
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3						
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)						
Thickness of the Pile Cap	=	t	=	0.80	m	(Given)					
Length of Pile for consideration of Effective overburden	=	15D	=	7500.00	mm	=	7.50	m			

Estimation of Lateral capacity(Annexure C of I.S.2911-Part1/Sec.2)

Characteristic Compressive strength of Concrete	=	fck	=	30	N/mm2						
Modulus of Elasticity of Pile Material	=	E	=	5000*(fck)^(0.5)	=	27386.12788	N/mm2	=	27386127.88	kN/m2	
Permissible deflection	=	y	=	1% of the diameter of the pile	=	5.00	mm	=	0.50	cm	(as per IRC:78 :2011)
Horizontal Modulus of Subgrade reaction	=	K1	=	7000.00	kN/m3	Top layer is Soft Clay	As per annex.c of IS 2911/Table-4 pg.14				
			=	0.00700	N/mm3						
Moment of Inertia of the Pile	=	I	=	(πD^4)/64	=	0.003069196	m^4	=	3069196428.5714	mm^4	
Rigidity factor	=	R	=	(EI/KB)^(1/4)	=	2.78	m	K = (K1/1.5)*(0.3/B)	As per Annex.c of IS 2911/Cl:2.3.2		
					=	278.36	cm	= 2800.00	kN/m2		
Application of the lateral load level (approximately) at 1.0m above the pile cap	=	L1	=	100.00	cm	=	1.00	m			
	=	e/R	=	0.36							
Lf/R	=	Zf/R	=	1.89	(approx.)from Fig.4 of Annexure - C, of I.S.2911 [For Fixed piles in Preloaded clays]	=	1.59	[For Free end piles in Preloaded clays]			
		Zf	=	526.10	cm	=	5.26	m	442.59	cm	
Lateral deflection,	=	y	=	$\frac{Q(e+Zf)^3}{12EI}$			y	=	$\frac{Q(e+Zf)^3}{3EI}$		
Hence, lateral load	=	Q	=	$\frac{12EIy}{(e+Zf)^3}$	=	20.55	kN	=	2.10 Tonnes (For Fixed End Pile)	=	7.89 kN = 0.80 Tonnes (For freeEnd Pile)

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Cohesion C (kN/m2)	Nc as per IS 2911 Part-1/Sec-2 (Annexure -B)	End Bearing Capacity in kN (qub)	ᾱ i Adhesion factor for the ith layer depending on the consistency of soil as per IS 2911 (Annexure -B)	Asi Surface Area of Pile for ith layer, (m2)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingc apacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
1	0.80	1.95	1.15	Clay	4	31.381	9	55.48	1	1.81	56.800	56.80	112.28	11.20	4.48	2.17
2	1.95	3.45	1.5	Clay	6	32.362	9	57.21	1	2.36	76.374	133.17	190.39	18.82	7.53	3.18
3	3.45	4.95	1.5	Clay	8	32.362	9	57.21	1	2.36	76.374	209.55	266.76	26.16	10.46	3.63
4	4.95	6.45	1.5	Clay	16	35.304	9	62.41	1	2.36	83.317	292.87	355.28	34.73	13.89	4.32
5	6.45	7.95	1.5	Clay	20	36.285	9	64.15	1	2.36	85.632	378.50	442.64	43.18	17.27	4.85

PILES IN COHESIVE-LESS SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$\mathrm{Qu} = \mathrm{Ap}\left(\frac{1}{2}\,\mathrm{D}\gamma\, N\gamma + PdNq\right) + \sum_{i=1}^{i=n} Ki\, Pdi\, tan\delta i\, Asi$$

Diameter of the Pile Shaft	=	D	=	500	mm	=	0.5	m
cross-sectional area of pile tipShaft	=	Ap	=	196428.57	mm^2	=	0.196	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	2500.00	mm	=	2.50	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap(Pile Cut Off level (m) from EGL)	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	7500.00	mm	=	7.50	m
Dry Density of soil	=	γd	=	17.46	kN/m3	=	1.75	gm/cc
Bulk Density of soil	=	γb	=	18.246	kN/m3	=	1.82	gm/cc

Bore Hole No = 1

S.No	Depth of layer below ground (m)		Thickness of Layer (m)	Soil type	SPT(No)	Submerge density, of the soil at pile tip, in (kN/m3) (γ)	Effective Overburden pressure at pile tip, in kN/m2 limited upto 15D -GWT@EGL (kN/m3)(Pdi)	δ (Degree) angle of friction @pile stem	Nq	Nγ	Asi	Ki (IS:2911)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	End Bearing Capacity in kN (qub)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingcapacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
	From (m)	To (m)							IS 2911	IS 6403	Surface Area of Pile for ith layer, (m2)	value for earth pressure coefficient							
6	7.95	9.45	1.5	Sand	23	8.2457	65.14	33.9	43.4	42.39	2.36	1.195	123.45	501.95	593.31	1095.25	109.26	43.70	19.44
7	9.45	10.95	1.5	Sand	26	8.2457	71.33	34.8	48.8	47	2.36	1.24	145.07	647.01	725.82	1372.83	137.10	54.84	24.82
8	10.95	12.45	1.5	Sand	33	8.2457	77.51	36.75	72.75	69.51	2.36	1.3375	182.70	829.71	1169.91	1999.62	200.55	80.22	31.48
9	12.45	13.95	1.5	Sand	37	8.2457	83.69	37.75	85.75	81.79	2.36	1.3875	212.20	1041.91	1483.00	2524.91	253.64	101.46	39.14
10	13.95	15.45	1.5	Sand	46	8.2457	89.88	40	115	109.41	2.36	1.5	266.98	1308.88	2128.31	3437.20	346.19	138.47	48.66

PILES IN COHESIVE SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)
Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Q_u = (A_p N_c C_p) + \sum_{i=1}^{n} \propto_i C_i A_{si}$$

Bore Hole No = 03

Diameter of the Pile Shaft	=	D	=	500	mm	=	0.5	m
cross-sectional area of pile tipShaft	=	Ap	=	196428.57	mm^2	=	0.19642857	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	200.00	mm	=	0.20	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	7500.00	mm	=	7.50	m

Estimation of Lateral capacity(Annexure C of I.S.2911-Part1/Sec.2)

Characteristic Compressive strength of Concrete = fck = 30 N/mm2

Modulus of Elasticity of Pile Material = E = 5000*(fck)^(0.5) = 27386.12788 N/mm2 = 27386127.88 kN/m2

Permissible deflection = y = 1% of the diameter of the pile = 5.00 mm = 0.50 cm (as per IRC:78 :2011)

Horizontal Modulus of Subgrade reaction = K1 = 6500.00 kN/m3 Top layer is Soft Clay As per annex.c of IS 2911/Table-4 pg.14

= 0.00650 N/mm3

Moment of Inertia of the Pile = I = (πD^4)/64 = 0.003069196 m^4 = 3069196428.5714 mm^4

Rigidity factor = R = (EI/KB)^(1/4) = 2.84 m

= 283.57 cm

K = (K1/1.5)*(0.3/B) As per Annex.c of IS 2911/Cl:2.3.2

= 2600.00 kN/m2

Application of the lateral load level (approximately) at 1.0m above the pile cap = L1 = 100.00 cm = 1.00 m

= e/R = 0.35

Lf/R = Zf/R = 1.90 (approx.)from Fig.4 of Annexure - C, of I.S.2911 [For Fixed piles in Preloaded clays] = 1.60 [For Free end piles in Preloaded clays]

Zf = 538.77 cm = 5.39 m 453.70 cm

Lateral deflection, = y = $\frac{Q(e+Zf)^3}{12EI}$ y = $\frac{Q(e+Zf)^3}{3EI}$

Hence, lateral load = Q = $\frac{12EIy}{(e+Zf)^3}$ = 19.35 kN = 1.97 Tonnes = 7.43 kN 0.76 Tonnes

(For Fixed End Pile) (For freeEnd Pile)

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Cohesion C (kN/m2)	Nc as per IS 2911 Part-1/Sec-2 (Annexure -B)	End Bearing Capacity in kN (qub)	α i Adhesion factor for the ith layer depending on the consistency of soil as per IS 2911 (Annexure -B)	Asi Surface Area of Pile for ith layer, (m2)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingc apacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
1	0.80	1.95	1.15	Clay	5	32.360	9	57.21	1	1.81	58.572	58.57	115.78	11.56	4.62	2.23
2	1.95	3.45	1.5	Clay	7	31.380	9	55.48	1	2.36	74.057	132.63	188.10	18.59	7.44	3.10
3	3.45	4.95	1.5	Clay	8	35.300	9	62.41	1	2.36	83.308	215.94	278.34	27.34	10.93	3.87
4	4.95	6.45	1.5	Clay	11	31.380	9	55.48	1	2.36	74.057	289.99	345.47	33.73	13.49	4.00

PILES IN COHESIVE-LESS SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Qu = Ap\left(\frac{1}{2}\,D\gamma\,N\gamma + PdNq\right) + \sum_{i=1}^{i=n} Ki\,Pdi\,tan\delta i\,Asi$$

Diameter of the Pile Shaft	=	D	=	500	mm	=	0.5	m
cross-sectional area of pile tipShaft	=	Ap	=	196428.57	mm^2	=	0.196	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	200.00	mm	=	0.20	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap(Pile Cut Off level (m) from EGL)	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	7500.00	mm	=	7.50	m
Dry Density of soil	=	γd	=	17.06	kN/m3	=	1.71	gm/cc
Dry Density of soil	=	γb	=	17.828	kN/m3	=	1.78	gm/cc

Bore Hole No = 03

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Submerge density, of the soil at pile tip, in (kN/m3) (γ)	Effective Overburden pressure at pile tip, in kN/m2 limited upto 15D -GWT@EGL (kN/m3)(Pdi)	δ (Degree) angle of friction @pile stem	Nq IS 2911	Nγ IS 6403	Asi Surface Area of Pile for ith layer, (m2)	Ki (IS:2911) value for earth pressure coefficient	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	End Bearing Capacity in kN (qub)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingcapacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
5	6.45	7.95	1.5	Sand	12	7.8277	50.10	30.60	23.60	25.48	2.36	1.03	72.02	362.01	254.54	616.56	60.91	24.36	14.24
6	7.95	9.45	1.5	Sand	14	7.8277	55.97	31.20	27.20	28.55	2.36	1.06	84.79	446.80	324.02	770.83	76.19	30.48	17.57
7	9.45	10.95	1.5	Sand	18	7.8277	61.84	32.40	34.40	34.70	2.36	1.12	103.73	550.53	448.23	998.77	98.97	39.59	21.54
8	10.95	12.45	1.5	Sand	31	7.8277	67.71	36.25	66.25	63.38	2.36	1.3125	153.78	704.32	936.62	1640.93	163.98	65.59	27.22
9	12.45	13.95	1.5	Sand	34	7.8277	73.58	37.00	76.00	72.58	2.36	1.35	176.65	880.97	1161.99	2042.96	204.51	81.81	33.67
10	13.95	15.45	1.5	Sand	38	7.8277	79.45	38.00	89.00	84.86	2.36	1.4	205.09	1086.06	1463.27	2549.33	255.68	102.27	41.09

PILES IN COHESIVE SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Q_u = \left(A_p N_c C_p\right) + \sum_{i=1}^{n} \propto_i C_i A_{si}$$

Bore Hole No = 4

Diameter of the Pile Shaft	=	D	=	500	mm	=	0.5	m		
cross-sectional area of pile tipShaft	=	Ap	=	196428.57	mm^2	=	0.19642857	m^2		
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3		
Ground water Table	=	GWT	=	2100.00	mm	=	2.10	m		
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)					
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3					
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)					
Thickness of the Pile Cap	=	t	=	0.80	m	(Given)				
Length of Pile for consideration of Effective overburden	=	15D	=	7500.00	mm	=	7.50	m		

Estimation of Lateral capacity(Annexure C of I.S.2911-Part1/Sec.2)

Characteristic Compressive strength of Concrete	=	fck	=	30	N/mm2							
Modulus of Elasticity of Pile Material	=	E	=	5000*(fck)^(0.5)	=	27386.12788	N/mm2	=	27386127.88	kN/m2		
Permissible deflection	=	y	=	1% of the diameter of the pile	=	5.00	mm	=	0.50	cm	(as per IRC:78 :2011)	
Horizontal Modulus of Subgrade reaction	=	K1	=	6000.00	kN/m3	Top layer is Soft Clay	As per annex.c of IS 2911/Table-4 pg.14					
			=	0.00600	N/mm3							
Moment of Inertia of the Pile	=	I	=	(πD^4)/64	=	0.003069196	m^4	=	3069196428.5714	mm^4		
Rigidity factor	=	R	=	(EI/KB)^(1/4)	=	2.89	m	K = (K1/1.5)*(0.3/B)	As per Annex.c of IS 2911/Cl:2.3.2			
					=	289.30	cm	= 2400.00	kN/m2			
Application of the lateral load level (approximately) at 1.0m above the pile cap	=	L1	=	100.00	cm	=	1.00	m				
	=	e/R	=	0.35								
Lf/R	=	Zf/R	=	1.90	(approx.)from Fig.4 of Annexure - C, of I.S.2911 [For Fixed piles in Preloaded clays]			=	1.60	[For Free end piles in Preloaded clays]		
		Zf	=	549.66	cm	=	5.50	m	462.87	cm		
Lateral deflection,	=	y	=	$\frac{Q(e+Zf)^3}{12EI}$				y	=	$\frac{Q(e+Zf)^3}{3EI}$		
Hence, lateral load	=	Q	=	$\frac{12EIy}{(e+Zf)^3}$	=	18.39	kN	=	1.88 (For Fixed End Pile)	Tonnes	= 7.07 kN	= 0.72 Tonnes (For freeEnd Pile)

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Cohesion C (kN/m2)	Nc as per IS 2911 Part-1/Sec-2 (Annexure -B)	End Bearing Capacity in kN (qub)	ᾱ i Adhesion factor for the ith layer depending on the consistency of soil as per IS 2911 (Annexure -B)	Asi Surface Area of Pile for ith layer, (m2)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingc apacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
1	0.80	1.95	1.15	Clay	6	31.381	9	55.48	1	1.81	56.800	56.80	112.28	11.20	4.48	2.17
2	1.95	3.45	1.5	Clay	7	34.323	9	60.68	1	2.36	81.003	137.80	198.48	19.65	7.86	3.34
3	3.45	4.95	1.5	Clay	17	36.285	9	64.15	1	2.36	85.632	223.43	287.58	28.28	11.31	3.95
4	4.95	6.45	1.5	Clay	24	34.323	9	60.68	0.7	2.36	56.702	280.14	340.82	33.25	13.30	3.41
5	6.45	7.95	1.5	Clay	28	28.439	9	50.28	0.7	2.36	46.982	327.12	377.40	36.53	14.61	3.53
6	7.95	9.45	1.5	Clay	31	23.536	9	41.61	0.4	2.36	22.218	349.34	390.94	37.46	14.99	3.14

PILES IN COHESIVE-LESS SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Qu = Ap\left(\frac{1}{2}D\gamma\,N\gamma + PdNq\right) + \sum_{i=1}^{i=n} Ki\,Pdi\,tan\delta i\,Asi$$

Diameter of the Pile Shaft	=	D	=	500	mm	=	0.5	m
cross-sectional area of pile tipShaft	=	Ap	=	196428.57	mm^2	=	0.196	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	2100.00	mm	=	2.10	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap(Pile Cut Off level (m) from EGL)	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	7500.00	mm	=	7.50	m
Dry Density of soil	=	γd	=	17.65	kN/m3	=	1.77	gm/cc
Bulk Density of soil	=	γb	=	18.444	kN/m3	=	1.84	gm/cc

Bore Hole No = 4

S.No	Depth of layer below ground (m)		Thickness of Layer (m)	Soil type	SPT(No)	Submerge density, of the soil at pile tip, in (kN/m3) (γ)	Effective Overburden pressure at pile tip, in kN/m2 limited upto 15D -GWT@EGL (kN/m3)(Pdi)	δ (Degree) angle of friction @pile stem	Nq	Nγ	Asi	Ki (IS:2911)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	End Bearing Capacity in kN (qub)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingcapacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
	From (m)	To (m)							IS 2911	IS 6403	Surface Area of Pile for ith layer, (m2)	value for earth pressure coefficient							
6	9.45	10.95	1.5	Sand	33	8.444	79.38	36.75	72.75	69.51	2.36	1.3377	187.15	536.49	1197.25	1733.74	173.89	69.56	21.07
7	10.95	12.45	1.5	Sand	36	8.444	85.71	37.50	82.50	78.72	2.36	1.375	213.41	749.90	1460.25	2210.15	222.01	88.80	28.77
8	12.45	13.95	1.5	Sand	40	8.444	92.04	38.50	95.50	91.00	2.36	1.425	246.22	996.12	1809.04	2805.16	282.21	112.88	37.59
9	13.95	15.45	1.5	Sand	43	8.444	98.38	39.25	105.25	100.20	2.36	1.4625	277.42	1273.54	2124.58	3398.12	342.20	136.88	47.46

PILES IN COHESIVE SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Q_u = \left(A_p N_c C_p \right) + \sum_{i=1}^{n} \propto_i C_i A_{si}$$

Bore Hole No = 5

Diameter of the Pile Shaft	=	D	=	500	mm	=	0.5	m				
cross-sectional area of pile tipShaft	=	Ap	=	196428.57	mm^2	=	0.19642857	m^2				
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3				
Ground water Table	=	GWT	=	500.00	mm	=	0.50	m				
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)							
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3							
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)							
Thickness of the Pile Cap	=	t	=	0.80	m	(Given)						
Length of Pile for consideration of Effective overburden	=	15D	=	7500.00	mm	=	7.50	m				

Estimation of Lateral capacity(Annexure C of I.S.2911-Part1/Sec.2)

Characteristic Compressive strength of Concrete	=	fck	=	30	N/mm2							
Modulus of Elasticity of Pile Material	=	E	=	5000*(fck)^(0.5)	=	27386.12788	N/mm2	=	27386127.88	kN/m2		
Permissible deflection	=	y	=	1% of the diameter of the pile	=	5.00	mm	=	0.50	cm	(as per IRC:78 :2011)	
Horizontal Modulus of Subgrade reaction	=	K1	=	5000.00	kN/m3	Top layer is Soft Clay	As per annex.c of IS 2911/Table-4 pg.14					
			=	0.00500	N/mm3							
Moment of Inertia of the Pile	=	I	=	(πD^4)/64	=	0.003069196	m^4	=	3069196428.5714	mm^4		
Rigidity factor	=	R	=	(EI/KB)^(1/4)	=	3.03	m	K = (K1/1.5)*(0.3/B)	As per Annex.c of IS 2911/Cl:2.3.2			
					=	302.79	cm	= 2000.00	kN/m2			
Application of the lateral load level (approximately) at 1.0m above the pile cap	=	L1	=	100.00	cm	=	1.00	m				
	=	e/R	=	0.33								
Lf/R	=	Zf/R	=	1.92	(approx.)from Fig.4 of Annexure - C, of I.S.2911 [For Fixed piles in Preloaded clays]	=	1.62	[For Free end piles in Preloaded clays]				
		Zf	=	581.35	cm	=	5.81	m	490.52	cm		
Lateral deflection,	=	y	=	$\frac{Q(e+Zf)^3}{12EI}$				y	=	$\frac{Q(e+Zf)^3}{3EI}$		
Hence, lateral load	=	Q	=	$\frac{12EIy}{(e+Zf)^3}$	=	15.94	kN	=	1.63	Tonnes	=	6.12 kN = 0.62 Tonnes
									(For Fixed End Pile)			(For freeEnd Pile)

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Cohesion C (kN/m2)	Nc as per IS 2911 Part-1/Sec-2 (Annexure -B)	End Bearing Capacity in kN (qub)	ᾱ i Adhesion factor for the ith layer depending on the consistency of soil as per IS 2911 (Annexure -B)	Asi Surface Area of Pile for ith layer, (m2)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingc apacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
1	0.80	1.95	1.15	Clay	3	20.594	9	36.41	1	1.81	37.275	37.28	73.68	7.27	2.91	1.51
2	1.95	3.45	1.5	Clay	5	29.420	9	52.01	1	2.36	69.431	106.71	158.72	15.59	6.24	2.94
3	3.45	4.95	1.5	Clay	6	25.497	9	45.08	1	2.36	60.174	166.88	211.96	20.57	8.23	3.08

PILES IN COHESIVE-LESS SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Qu = Ap\left(\frac{1}{2}D\gamma N\gamma + PdNq\right) + \sum_{i=1}^{i=n} Ki\,Pdi\,tan\delta i\,Asi$$

Diameter of the Pile Shaft	=	D	=	500	mm	=	0.5	m
cross-sectional area of pile tipShaft	=	Ap	=	196428.57	mm^2	=	0.196	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	500.00	mm	=	0.50	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap(Pile Cut Off level (m) from EGL)	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	7500.00	mm	=	7.50	m
Dry Density of soil	=	γd	=	17.35	kN/m3	=	1.74	gm/cc
Bulk Density of soil	=	γb	=	18.131	kN/m3	=	1.81	gm/cc

Bore Hole No = 5

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Submerge density, of the soil at pile tip, in (kN/m3) (γ)	Effective Overburden pressure at pile tip, in kN/m2 limited upto 15D -GWT@EGL (kN/m3)(Pdi)	δ (Degree) angle of friction @pile stem	Nq IS 2911	Nγ IS 6403	Asi Surface Area of Pile for ith layer, (m2)	Ki (IS:2911) value for earth pressure coefficient	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	End Bearing Capacity in kN (qub)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingcapa city of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
4	4.95	6.45	1.5	Sand	7	8.13	39.84	29.4	18.8	21.02	2.36	0.97	51.39	218.27	165.84	384.11	37.67	15.07	8.90
5	6.45	7.95	1.5	Sand	12	8.13	18.29	30.6	23.6	25.48	2.36	1.03	26.30	244.57	107.49	352.06	33.95	13.58	10.25
6	7.95	9.45	1.5	Sand	25	8.13	24.39	34.5	47	45.47	2.36	1.225	48.47	293.04	265.68	558.71	54.57	21.83	12.34
7	9.45	10.95	1.5	Sand	31	8.13	30.49	36.25	66.25	63.38	2.36	1.3125	69.25	362.28	453.21	815.50	80.29	32.12	15.15
8	10.95	12.45	1.5	Sand	36	8.13	36.59	37.5	82.5	78.72	2.36	1.375	91.10	453.39	663.02	1116.40	110.51	44.21	18.69
9	12.45	13.95	1.5	Sand	46	8.13	42.69	40	115	109.41	2.36	1.5	126.80	580.18	1061.67	1641.85	163.63	65.45	23.45

PILES IN COHESIVE SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$Q_u = \left(A_p N_c C_p \right) + \sum_{i=1}^{n} \propto_i C_i A_{si}$$

Bore Hole No = 6

Diameter of the Pile Shaft	=	D	=	500	mm	=	0.5	m	
cross-sectional area of pile tipShaft	=	Ap	=	196428.57	mm^2	=	0.19642857	m^2	
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3	
Ground water Table	=	GWT	=	2100.00	mm	=	2.10	m	
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)				
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3				
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)				
Thickness of the Pile Cap	=	t	=	0.80	m	(Assuming)			
Length of Pile for consideration of Effective overburden	=	15D	=	7500.00	mm	=	7.50	m	

Estimation of Lateral capacity(Annexure C of I.S.2911-Part1/Sec.2)

Characteristic Compressive strength of Concrete	=	fck	=	30	N/mm2						
Modulus of Elasticity of Pile Material	=	E	=	5000*(fck)^(0.5)	=	27386.12788	N/mm2	=	27386127.88	kN/m2	
Permissible deflection	=	y	=	1% of the diameter of the pile	=	5.00	mm	=	0.50	cm	(as per IRC:78 :2011)
Horizontal Modulus of Subgrade reaction	=	K1	=	7450.00	kN/m3	Top layer is Soft Clay	As per annex.c of IS 2911/Table-4 pg.14				
			=	0.00745	N/mm3						
Moment of Inertia of the Pile	=	I	=	(πD^4)/64	=	0.003069196	m^4	=	3069196428.5714	mm^4	
Rigidity factor	=	R	=	(EI/KB)^(1/4)	=	2.74	m	K = (K1/1.5)*(0.3/B)	As per Annex.c of IS 2911/Cl:2.3.2		
					=	274.06	cm	= 2980.00	kN/m2		
Application of the lateral load level (approximately) at 1.0m above the pile cap	=	L1	=	100.00	cm	=	1.00	m			
	=	e/R	=	0.36							
Lf/R	=	Zf/R	=	1.89	(approx.)from Fig.4 of Annexure - C, of I.S.2911 [For Fixed piles in Preloaded clays]	=	1.59	[For Free end piles in Preloaded clays]			
		Zf	=	517.97	cm	=	5.18	m	435.75	cm	
Lateral deflection,	=	y	=	$\frac{Q(e+Zf)^3}{12EI}$			y	=	$\frac{Q(e+Zf)^3}{3EI}$		
Hence, lateral load	=	Q	=	$\frac{12EIy}{(e+Zf)^3}$	=	21.37	kN	=	2.18 Tonnes (For Fixed End Pile)	=	8.20 kN = 0.84 Tonnes (For freeEnd Pile)

S.No	Depth of layer below ground (m) From (m)	To (m)	Thickness of Layer (m)	Soil type	SPT(No)	Cohesion C (kN/m2)	Nc as per IS 2911 Part-1/Sec-2 (Annexure -B)	End Bearing Capacity in kN (qub)	ᾱ i Adhesion factor for the ith layer depending on the consistency of soil as per IS 2911 (Annexure -B)	Asi Surface Area of Pile for ith layer, (m2)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingc apacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
1	0.80	1.95	1.15	Clay	5	26.478	9	46.81	1	1.81	47.925	47.93	94.73	9.42	3.77	1.87
2	1.95	3.45	1.5	Clay	4	23.536	9	41.61	1	2.36	55.545	103.47	145.08	14.20	5.68	2.47
3	3.45	4.95	1.5	Clay	10	28.439	9	50.28	1	2.36	67.117	170.59	220.86	21.48	8.59	3.32
4	4.95	6.45	1.5	Clay	13	26.478	9	46.81	0.7	2.36	43.742	214.33	261.14	25.13	10.05	2.97

PILES IN COHESIVE-LESS SOILS(LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS)

Allowable Bored Cast in Situ Concrete Pile Capacities based on IS 2911 Part.1/Sec.2 (R2010)

$$\mathrm{Qu} = \mathrm{Ap}\left(\frac{1}{2}\,\mathrm{D}\gamma\, N\gamma + PdNq\right) + \sum_{i=1}^{i=n} Ki\ Pdi\ tan\delta i\ Asi$$

Diameter of the Pile Shaft	=	D	=	500	mm	=	0.5	m
cross-sectional area of pile tipShaft	=	Ap	=	196428.57	mm^2	=	0.196	m^2
Effective Unit weight of water	=	γw	=	1.00	gm/cc	=	10.00	kN/m3
Ground water Table	=	GWT	=	2100.00	mm	=	2.10	m
Factor of Safety	=	FS1	=	2.50	(Assuming Vibratory/ Impact /Heavy Loads are expected due power plant construction)(given in ANNEXURE-B)			
Density of M30(Assumption) grade Concrete	=	γc	=	25.00	kN/m3			
Factor of Safety for uplift capacity	=	FS2	=	3.00	(Cl:6.3.2- The recommended factor of safety is 3.0 in the absence of any pullout test results and 2.0 with pullout test results)			
Thickness of the Pile Cap(Pile Cut Off level (m) from EGL)	=	t	=	0.80	m	(Given)		
Length of Pile for consideration of Effective overburden	=	15D	=	7500.00	mm	=	7.50	m
Dry Density of soil	=	γd	=	17.68	kN/m3	=	1.77	gm/cc
Bulk Density of soil	=	γb	=	18.476	kN/m3	=	1.85	gm/cc

Bore Hole No = 6

S.No	Depth of layer below ground (m)		Thickness of Layer (m)	Soil type	SPT(No)	Submerge density, of the soil at pile tip, in (kN/m3) (γ)	Effective Overburden pressure at pile tip, in kN/m2 limited upto 15D -GWT@EGL (kN/m3)(Pdi)	δ (Degree) angle of friction @pile stem	Nq	Nγ	Asi	Ki (IS:2911)	Skin Friction Capacity in kN	Cumulative Skin Friction at every 1.5 m layer depthwise, kN (fs)	End Bearing Capacity in kN (qub)	Ultimate load capacity, kN (Qu)	Total load capacity, (tonnes) (Qu)	Vertical load Carryingcapacity of Pile, (tonnes) (Qn)	Safe Uplift Capacity (tonnes)
	From (m)	To (m)							IS 2911	IS 6403	Surface Area of Pile for ith layer, (m2)	value for earth pressure coefficient							
5	6.45	7.95	1.5	Sand	18	8.4756	54.24	32.4	34.4	34.7	2.36	1.12	90.99	305.32	398.02	703.33	69.76	27.90	12.31
6	7.95	9.45	1.5	Sand	21	8.4756	60.60	33.3	39.8	39.32	2.36	1.165	109.45	414.76	509.44	924.20	91.82	36.73	16.48
7	9.45	10.95	1.5	Sand	30	8.4756	66.96	36	63	60.31	2.36	1.3	149.25	564.01	883.31	1447.33	144.70	57.88	22.00
8	10.95	12.45	1.5	Sand	33	8.4756	73.31	36.75	72.75	69.51	2.36	1.3375	172.81	736.82	1110.73	1847.55	185.04	74.02	28.33
9	12.45	13.95	1.5	Sand	39	8.4756	79.67	38.25	92.25	87.93	2.36	1.4125	209.37	946.19	1523.45	2469.64	248.01	99.20	35.89
10	13.95	15.45	1.5	Sand	46	8.4756	86.03	40	115	109.41	2.36	1.5	255.54	1201.72	2042.56	3244.29	326.52	130.61	45.02

Annexure - VII(A)

(SAFE SETTLEMENT PRESSURE CALCULATIONS)

(Based on SPT 'N' Values)

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-01**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square				
Depth of footing, D (m)	1.00	1.00	1.00	1.00	1.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.50	2.50	2.50	2.50	2.50
Ratio Zw/B	1.50	1.00	0.75	0.60	0.50
Water Table Factor	1.00	1.00	0.88	0.80	0.75

Corrected Spt 'N' Value 5.76

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N} - 3)\left(\frac{B + 0.3}{2B}\right)^2 R_W \; S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in ‘mm’

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng’s equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	25mm	50mm	25mm	50mm
1.00	1.00	1.00	40.38	80.75	4.04	8.08
	1.50	1.50	34.40	68.81	3.44	6.88
	2.00	2.00	27.65	55.29	2.76	5.53
	2.50	2.50	23.98	47.95	2.40	4.80
	3.00	3.00	21.68	43.36	2.17	4.34

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-01**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square				
Depth of footing, D (m)	1.50	1.50	1.50	1.50	1.50
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.50	2.50	2.50	2.50	2.50
Ratio Zw/B	1.00	0.67	0.50	0.40	0.33
Water Table Factor	1.00	0.83	0.75	0.70	0.67

Corrected Spt 'N' Value 5.76

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	50mm
1.50	1.00	1.00	40.38	80.75	4.04	8.08
	1.50	1.50	28.67	57.34	2.87	5.73
	2.00	2.00	23.70	47.39	2.37	4.74
	2.50	2.50	20.98	41.96	2.10	4.20
	3.00	3.00	19.27	38.54	1.93	3.85

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-01**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing: Square

Depth of footing, D (m)	2.00	2.00	2.00	2.00	2.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00

Depth of Water Table, d (m)	2.50	2.50	2.50	2.50	2.50
Ratio Zw/B	0.50	0.33	0.25	0.20	0.17
Water Table Factor	0.75	0.67	0.63	0.60	0.58

Corrected Spt 'N' Value 7.24

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where
N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	50mm
2.00	1.00	1.00	46.52	93.04	4.65	9.30
	1.50	1.50	35.23	70.47	3.52	7.05
	2.00	2.00	30.34	60.67	3.03	6.07
	2.50	2.50	27.62	55.25	2.76	5.52
	3.00	3.00	25.91	51.81	2.59	5.18

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-01**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square				
Depth of footing, D (m)	3.00	3.00	3.00	3.00	3.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.50	2.50	2.50	2.50	2.50
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 7.24

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	$25mm$	$50mm$	$25mm$	50mm
3.00	1.00	1.00	31.01	62.03	3.10	6.20
	1.50	1.50	26.43	52.85	2.64	5.29
	2.00	2.00	24.27	48.54	2.43	4.85
	2.50	2.50	23.02	46.04	2.30	4.60
	3.00	3.00	22.21	44.41	2.22	4.44

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-01**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-03**

Shape of footing	Square				
Depth of footing, D (m)	4.00	4.00	4.00	4.00	4.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.50	2.50	2.50	2.50	2.50
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 8.57

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	25mm	50mm	25mm	50mm
4.00	1.00	1.00	40.74	81.48	4.07	8.15
	1.50	1.50	34.72	69.43	3.47	6.94
	2.00	2.00	31.88	63.76	3.19	6.38
	2.50	2.50	30.24	60.48	3.02	6.05
	3.00	3.00	29.17	58.34	2.92	5.83

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-02**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square				
Depth of footing, D (m)	1.00	1.00	1.00	1.00	1.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	1.70	1.70	1.70	1.70	1.70
Ratio Zw/B	0.70	0.47	0.35	0.28	0.23
Water Table Factor	0.85	0.73	0.68	0.64	0.62
Corrected Spt 'N' Value	7.20				

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(N-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	50mm
1.00	1.00	1.00	52.23	104.45	5.22	10.45
	1.50	1.50	38.39	76.78	3.84	7.68
	2.00	2.00	32.45	64.91	3.25	6.49
	2.50	2.50	29.19	58.37	2.92	5.84
	3.00	3.00	27.13	54.26	2.71	5.43

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-02**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square				
Depth of footing, D (m)	1.50	1.50	1.50	1.50	1.50
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	1.70	1.70	1.70	1.70	1.70
Ratio Zw/B	0.20	0.13	0.10	0.08	0.07
Water Table Factor	0.60	0.57	0.55	0.54	0.53

Corrected Spt 'N' Value 7.20

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W \; S_a$$

where
N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	50mm
1.50	1.00	1.00	36.87	73.73	3.69	7.37
	1.50	1.50	29.67	59.33	2.97	5.93
	2.00	2.00	26.44	52.89	2.64	5.29
	2.50	2.50	24.63	49.25	2.46	4.93
	3.00	3.00	23.46	46.92	2.35	4.69

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-02**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square				
Depth of footing, D (m)	2.00	2.00	2.00	2.00	2.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	1.70	1.70	1.70	1.70	1.70
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 8.45

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(N - 3)\left(\frac{B + 0.3}{2B}\right)^2 R_W \; S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	50mm
2.00	1.00	1.00	39.86	79.73	3.99	7.97
	1.50	1.50	33.97	67.93	3.40	6.79
	2.00	2.00	31.20	62.39	3.12	6.24
	2.50	2.50	29.59	59.18	2.96	5.92
	3.00	3.00	28.54	57.08	2.85	5.71

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-02**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square				
Depth of footing, D (m)	3.00	3.00	3.00	3.00	3.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	1.70	1.70	1.70	1.70	1.70
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 8.45

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in ‘mm’

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng’s equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			**Safe Settlement Pressure**			
			kN/m2		(t/m^2)	
Depth	Width	Length	25mm	50mm	25mm	50mm
3.00	1.00	1.00	39.86	79.73	3.99	7.97
	1.50	1.50	33.97	67.93	3.40	6.79
	2.00	2.00	31.20	62.39	3.12	6.24
	2.50	2.50	29.59	59.18	2.96	5.92
	3.00	3.00	28.54	57.08	2.85	5.71

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK
Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-02**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-03**

Shape of footing	Square				
Depth of footing, D (m)	4.00	4.00	4.00	4.00	4.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	1.70	1.70	1.70	1.70	1.70
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 10.71

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	50mm
4.00	1.00	1.00	56.40	112.79	5.64	11.28
	1.50	1.50	48.05	96.11	4.81	9.61
	2.00	2.00	44.13	88.26	4.41	8.83
	2.50	2.50	41.86	83.72	4.19	8.37
	3.00	3.00	40.38	80.76	4.04	8.08

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-03**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square				
Depth of footing, D (m)	1.00	1.00	1.00	1.00	1.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	0.20	0.20	0.20	0.20	0.20
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 4.32

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in ‘mm’

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng’s equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	50mm
1.00	1.00	1.00	9.66	19.31	0.97	1.93
	1.50	1.50	8.23	16.45	0.82	1.65
	2.00	2.00	7.56	15.11	0.76	1.51
	2.50	2.50	7.17	14.33	0.72	1.43
	3.00	3.00	6.91	13.83	0.69	1.38

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-03**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing: Square

Depth of footing, D (m)	1.50	1.50	1.50	1.50	1.50
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	0.20	0.20	0.20	0.20	0.20
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 4.32

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N} - 3)\left(\frac{B + 0.3}{2B}\right)^2 R_W \; S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			**Safe Settlement Pressure**			
			kN/m2		(t/m^2)	
Depth	Width	Length	***25mm***	***50mm***	***25mm***	50mm
1.50	1.00	1.00	9.66	19.31	0.97	1.93
	1.50	1.50	8.23	16.45	0.82	1.65
	2.00	2.00	7.56	15.11	0.76	1.51
	2.50	2.50	7.17	14.33	0.72	1.43
	3.00	3.00	6.91	13.83	0.69	1.38

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-03**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing: Square

Depth of footing, D (m)	2.00	2.00	2.00	2.00	2.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00

Depth of Water Table, d (m)	0.20	0.20	0.20	0.20	0.20
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 4.83

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	50mm
2.00	1.00	1.00	13.39	26.77	1.34	2.68
	1.50	1.50	11.41	22.81	1.14	2.28
	2.00	2.00	10.47	20.95	1.05	2.09
	2.50	2.50	9.94	19.87	0.99	1.99
	3.00	3.00	9.58	19.17	0.96	1.92

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-03**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing: Square

Depth of footing, D (m)	3.00	3.00	3.00	3.00	3.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	0.20	0.20	0.20	0.20	0.20
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 4.83

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	25mm	50mm	25mm	50mm
3.00	1.00	1.00	13.39	26.77	1.34	2.68
	1.50	1.50	11.41	22.81	1.14	2.28
	2.00	2.00	10.47	20.95	1.05	2.09
	2.50	2.50	9.94	19.87	0.99	1.99
	3.00	3.00	9.58	19.17	0.96	1.92

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-03**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-03**

Shape of footing: Square

Depth of footing, D (m)	4.00	4.00	4.00	4.00	4.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	0.20	0.20	0.20	0.20	0.20
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 5.36

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	25mm	50mm	25mm	50mm
4.00	1.00	1.00	17.26	34.52	1.73	3.45
	1.50	1.50	14.71	29.42	1.47	2.94
	2.00	2.00	13.51	27.02	1.35	2.70
	2.50	2.50	12.81	25.63	1.28	2.56
	3.00	3.00	12.36	24.72	1.24	2.47

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-04**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square				
Depth of footing, D (m)	1.00	1.00	1.00	1.00	1.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10	2.10	2.10
Ratio Zw/B	1.10	0.73	0.55	0.44	0.37
Water Table Factor	1.00	0.87	0.78	0.72	0.68
Corrected Spt 'N' Value	8.64				

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where
N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in ‘mm’

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng’s equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
1.00	1.00	1.00	82.51	165.02	8.25	16.50
	1.50	1.50	60.93	121.86	6.09	12.19
	2.00	2.00	50.04	100.08	5.00	10.01
	2.50	2.50	44.09	88.19	4.41	8.82
	3.00	3.00	40.37	80.73	4.04	8.07

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-04**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square				
Depth of footing, D (m)	1.50	1.50	1.50	1.50	1.50
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10	2.10	2.10
Ratio Zw/B	0.60	0.40	0.30	0.24	0.20
Water Table Factor	0.80	0.70	0.65	0.62	0.60

Corrected Spt 'N' Value 8.64

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
1.50	1.00	1.00	66.01	132.01	6.60	13.20
	1.50	1.50	49.21	98.42	4.92	9.84
	2.00	2.00	41.97	83.94	4.20	8.39
	2.50	2.50	37.97	75.94	3.80	7.59
	3.00	3.00	35.44	70.89	3.54	7.09

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-04**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square				
Depth of footing, D (m)	2.00	2.00	2.00	2.00	2.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10	2.10	2.10
Ratio Zw/B	0.10	0.07	0.05	0.04	0.03
Water Table Factor	0.55	0.53	0.53	0.52	0.52

Corrected Spt 'N' Value 8.45

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N} - 3)\left(\frac{B + 0.3}{2B}\right)^2 R_W \ S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in ‘mm’

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng’s equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	***25mm***	***50mm***	***25mm***	***50mm***
2.00	1.00	1.00	43.85	87.70	4.39	8.77
	1.50	1.50	36.23	72.46	3.62	7.25
	2.00	2.00	32.76	65.51	3.28	6.55
	2.50	2.50	30.77	61.55	3.08	6.15
	3.00	3.00	29.49	58.99	2.95	5.90

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-04**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing: Square

Depth of footing, D (m)	3.00	3.00	3.00	3.00	3.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00

Depth of Water Table, d (m)	2.10	2.10	2.10	2.10	2.10
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 8.45

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			**Safe Settlement Pressure**			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
3.00	1.00	1.00	39.86	79.73	3.99	7.97
	1.50	1.50	33.97	67.93	3.40	6.79
	2.00	2.00	31.20	62.39	3.12	6.24
	2.50	2.50	29.59	59.18	2.96	5.92
	3.00	3.00	28.54	57.08	2.85	5.71

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-04**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-03**

Shape of footing	Square				
Depth of footing, D (m)	4.00	4.00	4.00	4.00	4.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10	2.10	2.10
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 18.21

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in ‘mm’

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng’s equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			**Safe Settlement Pressure**			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
4.00	1.00	1.00	111.25	222.51	11.13	22.25
	1.50	1.50	94.80	189.59	9.48	18.96
	2.00	2.00	87.06	174.12	8.71	17.41
	2.50	2.50	82.58	165.16	8.26	16.52
	3.00	3.00	79.66	159.31	7.97	15.93

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-05**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square				
Depth of footing, D (m)	1.00	1.00	1.00	1.00	1.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	0.50	0.50	0.50	0.50	0.50
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 4.32

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
1.00	1.00	1.00	9.66	19.31	0.97	1.93
	1.50	1.50	8.23	16.45	0.82	1.65
	2.00	2.00	7.56	15.11	0.76	1.51
	2.50	2.50	7.17	14.33	0.72	1.43
	3.00	3.00	6.91	13.83	0.69	1.38

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-05**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square				
Depth of footing, D (m)	1.50	1.50	1.50	1.50	1.50
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	0.50	0.50	0.50	0.50	0.50
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50
Corrected Spt 'N' Value	4.32				

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W \; S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
1.50	1.00	1.00	9.66	19.31	0.97	1.93
	1.50	1.50	8.23	16.45	0.82	1.65
	2.00	2.00	7.56	15.11	0.76	1.51
	2.50	2.50	7.17	14.33	0.72	1.43
	3.00	3.00	6.91	13.83	0.69	1.38

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-05**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing: Square

Depth of footing, D (m)	2.00	2.00	2.00	2.00	2.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	0.50	0.50	0.50	0.50	0.50
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 6.04

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(N-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in ‘mm’

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng’s equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
2.00	1.00	1.00	22.24	44.47	2.22	4.45
	1.50	1.50	18.95	37.89	1.89	3.79
	2.00	2.00	17.40	34.80	1.74	3.48
	2.50	2.50	16.50	33.01	1.65	3.30
	3.00	3.00	15.92	31.84	1.59	3.18

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-05**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square				
Depth of footing, D (m)	3.00	3.00	3.00	3.00	3.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	0.50	0.50	0.50	0.50	0.50
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 6.04

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W \; S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	25mm	50mm	25mm	50mm
3.00	1.00	1.00	22.24	44.47	2.22	4.45
	1.50	1.50	18.95	37.89	1.89	3.79
	2.00	2.00	17.40	34.80	1.74	3.48
	2.50	2.50	16.50	33.01	1.65	3.30
	3.00	3.00	15.92	31.84	1.59	3.18

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-05**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-03**

Shape of footing	Square				
Depth of footing, D (m)	4.00	4.00	4.00	4.00	4.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	0.50	0.50	0.50	0.50	0.50
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 6.43

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in ‘mm’

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng’s equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
4.00	1.00	1.00	25.09	50.18	2.51	5.02
	1.50	1.50	21.38	42.75	2.14	4.28
	2.00	2.00	19.63	39.27	1.96	3.93
	2.50	2.50	18.62	37.24	1.86	3.72
	3.00	3.00	17.96	35.93	1.80	3.59

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-06**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing: Square

Depth of footing, D (m)	1.00	1.00	1.00	1.00	1.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00

Depth of Water Table, d (m)	2.10	2.10	2.10	2.10	2.10
Ratio Zw/B	1.10	0.73	0.55	0.44	0.37
Water Table Factor	1.00	0.87	0.78	0.72	0.68

Corrected Spt 'N' Value 7.37

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m²)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
1.00	1.00	1.00	63.93	127.86	6.39	12.79
	1.50	1.50	47.21	94.42	4.72	9.44
	2.00	2.00	38.77	77.54	3.88	7.75
	2.50	2.50	34.16	68.33	3.42	6.83
	3.00	3.00	31.28	62.55	3.13	6.26

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-06**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-01**

Shape of footing	Square				
Depth of footing, D (m)	1.50	1.50	1.50	1.50	1.50
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10	2.10	2.10
Ratio Zw/B	0.60	0.40	0.30	0.24	0.20
Water Table Factor	0.80	0.70	0.65	0.62	0.60

Corrected Spt 'N' Value 7.37

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
1.50	1.00	1.00	51.14	102.29	5.11	10.23
	1.50	1.50	38.13	76.26	3.81	7.63
	2.00	2.00	32.52	65.04	3.25	6.50
	2.50	2.50	29.42	58.84	2.94	5.88
	3.00	3.00	27.46	54.93	2.75	5.49

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-06**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square				
Depth of footing, D (m)	2.00	2.00	2.00	2.00	2.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10	2.10	2.10
Ratio Zw/B	0.10	0.07	0.05	0.04	0.03
Water Table Factor	0.55	0.53	0.53	0.52	0.52

Corrected Spt 'N' Value 4.83

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(N-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where
N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			Safe Settlement Pressure			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
2.00	1.00	1.00	14.72	29.45	1.47	2.94
	1.50	1.50	12.17	24.33	1.22	2.43
	2.00	2.00	11.00	22.00	1.10	2.20
	2.50	2.50	10.33	20.67	1.03	2.07
	3.00	3.00	9.90	19.81	0.99	1.98

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-06**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-02**

Shape of footing	Square				
Depth of footing, D (m)	3.00	3.00	3.00	3.00	3.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10	2.10	2.10
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 4.83

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W\ S_a$$

where N = Corrected Standard Penetration Resistance

B = Width of footing

RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)

Sa = Permissible settlement of foundation in ‘mm’

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng’s equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			**Safe Settlement Pressure**			
			kN/m2		(t/m^2)	
Depth	Width	Length	***25mm***	***50mm***	***25mm***	***50mm***
3.00	1.00	1.00	13.39	26.77	1.34	2.68
	1.50	1.50	11.41	22.81	1.14	2.28
	2.00	2.00	10.47	20.95	1.05	2.09
	2.50	2.50	9.94	19.87	0.99	1.99
	3.00	3.00	9.58	19.17	0.96	1.92

NET SAFE SETTLEMENT PRESSURE OF SOIL/ROCK

Based on IS: 8009 (Part –I) – 1986

Project Name	:-	**Golaghat to BCPL Lakwa Gas Pipeline Project**
Bore Hole No	:-	**BH-06**
Station ID	:-	**Rupkhelia Terminal**
Sample ID	:-	**SPT-03**

Shape of footing	Square				
Depth of footing, D (m)	4.00	4.00	4.00	4.00	4.00
Width of footing, B (m)	1.00	1.50	2.00	2.50	3.00
Length of footing, L (m)	1.00	1.50	2.00	2.50	3.00
Depth of Water Table, d (m)	2.10	2.10	2.10	2.10	2.10
Ratio Zw/B	0.00	0.00	0.00	0.00	0.00
Water Table Factor	0.50	0.50	0.50	0.50	0.50

Corrected Spt 'N' Value 10.71

Net Safe Settlement Pressure, qnssp in kN/m2 is determined as

$$Q_{nssp} = 1.385(\mathrm{N}-3)\left(\frac{B+0.3}{2B}\right)^2 R_W \; S_a$$

where N = Corrected Standard Penetration Resistance
B = Width of footing
RW = Water Table correction factor (taken as 0.5 to account for saturation of soil)
Sa = Permissible settlement of foundation in 'mm'

The above equation is recommended by IS: 8009 (Part –I) – 1986 for calculation of net safe settlement pressure Q_nssp. The equation is derived from Teng's equation of Q_nssp by excluding the depth factor.

Result:-

Dimensions of Footing			**Safe Settlement Pressure**			
			kN/m2		(t/m^2)	
Depth	Width	Length	*25mm*	*50mm*	*25mm*	*50mm*
4.00	1.00	1.00	56.40	112.79	5.64	11.28
	1.50	1.50	48.05	96.11	4.81	9.61
	2.00	2.00	44.13	88.26	4.41	8.83
	2.50	2.50	41.86	83.72	4.19	8.37
	3.00	3.00	40.38	80.76	4.04	8.08

Annexure - VII(B)

(SAFE SETTLEMENT PRESSURE CALCULATIONS)

(Based on Lab Results)

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

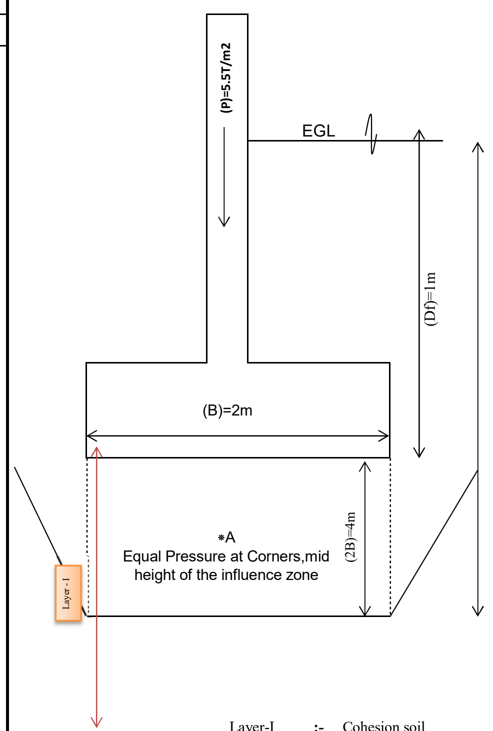
Name of the Project	AGCL
Bore Hole	BH-1
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.0	m	100 cm
Field Dry Density of soil	(γ_{dry})	=	1.680	gm/cm^3	16.464 kN/m^3
Field Moisture Content of soil	(w)	=	41.35	%	
Wet Density of soil	(γb)	=	2.37	gm/cm^3	23.272 kN/m^3
Specific Gravity of soil	(G)	=	2.72		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.00	m	500 cm
Depth of the Water Table	GWT	=	2.50	m	250 cm
Effect of water table	(W')	=	0.88	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	15.2700	MPa	15270 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	(P *B*(1-μ^2)*I)/E		
	Si	=	0.61	cm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.41	cm	
	(Sic)	=	4.11	mm	

Stress Deformation Diagram (Typical section Diagram)



W₁= 41 % E1= 15.3 MPa γ1= 2.375 gm/cc (W_L)= 33.8 %

Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.375	gm/cm^3	23.272 kN/m^3
Liquid Limit of the Soil	(W_L)	=	33.77	%	
Compression index	(Cc)	=	0.214	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	0.983	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	50.22	kN/m2	
Vertical Stress increment due to foundation load	(ΣP$_o$)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	4.54	cm	
Total Consolidation Settlement	(Sc)	=	45.35	mm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	24.98	mm	
Total Settlement (Sic+Scc)	S	=	29.10	mm	

29.10	mm	5.500	T/m2	Permissible Settlement (As per IS 1904 - Table1)	
50	mm	9.45	T/m2		
25	mm	4.73	T/m2	50	mm

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

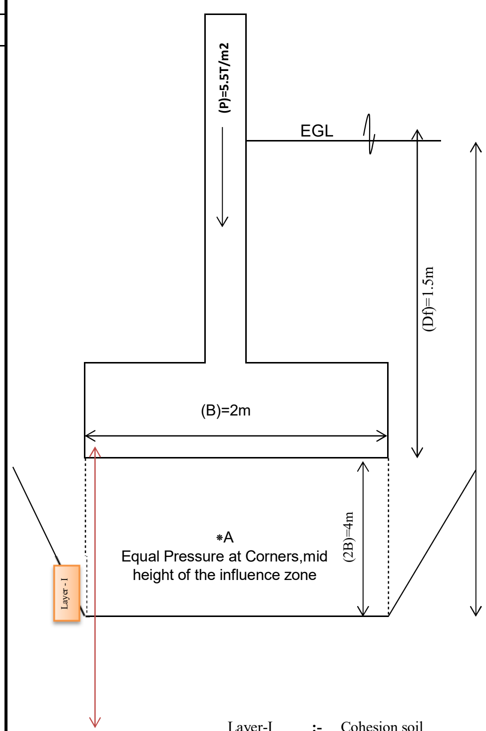
Name of the Project	AGCL
Bore Hole	BH-1
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.5	m	150 cm
Field Dry Density of soil	(γ_{dry})	=	1.671	gm/cm^3	16.376 kN/m^3
Field Moisture Content of soil	(w)	=	41.35	%	
Wet Density of soil	(γb)	=	2.36	gm/cm^3	23.147 kN/m^3
Specific Gravity of soil	(G)	=	2.72		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.50	m	550 cm
Depth of the Water Table	GWT	=	2.50	m	250 cm
Effect of water table	(W')	=	0.75	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	15.2700	MPa	15270 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	(P *B*(1-μ^2)*I)/E		
	Si	=	0.61	cm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.38	cm	
	(Sic)	=	3.82	mm	

Stress Deformation Diagram (Typical section Diagram)



W1= 41 % E1= 15.3 MPa γ1= 2.362 gm/cc (WL)= 33.8 %

Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.362	gm/cm^3	23.147 kN/m^3
Liquid Limit of the Soil	(W_L)	=	33.77	%	
Compression index	(Cc)	=	0.214	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	0.983	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	61.42	kN/m2	
Vertical Stress increment due to foundation load	(ΣP$_o$)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	3.79	cm	
Total Consolidation Settlement	(Sc)	=	37.86	mm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	19.38	mm	
Total Settlement (Sic+Scc)	S	=	23.21	mm	

23.21	mm	5.500	T/m2	Permissible Settlement (As per IS 1904 - Table1)	
50	mm	11.85	T/m2		
25	mm	5.93	T/m2	50	mm

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

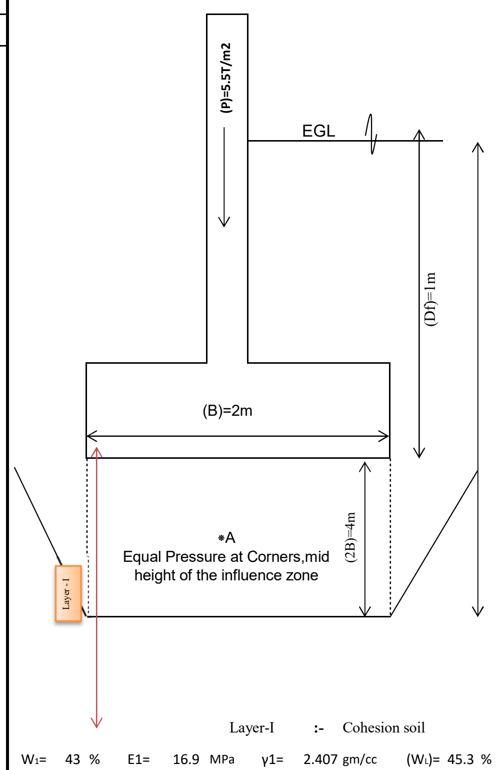
Name of the Project	AGCL
Bore Hole	BH-2
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.0	m	100 cm
Field Dry Density of soil	(γ_{dry})	=	1.680	gm/cm^3	16.464 kN/m^3
Field Moisture Content of soil	(w)	=	43.28	%	
Wet Density of soil	(γb)	=	2.41	gm/cm^3	23.590 kN/m^3
Specific Gravity of soil	(G)	=	2.76		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.00	m	500 cm
Depth of the Water Table	GWT	=	1.70	m	170 cm
Effect of water table	(W')	=	0.68	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	16.8640	MPa	16864 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	$(P * B * (1-\mu^2) * I)/E$		
	Si	=	0.55	cm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.37	cm	
	(Sic)	=	3.73	mm	

Stress Deformation Diagram (Typical section Diagram)



Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.407	gm/cm^3	23.590 kN/m^3
Liquid Limit of the Soil	(W_L)	=	45.26	%	
Compression index	(Cc)	=	0.317	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	1.328	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	51.17	kN/m2	
Vertical Stress increment due to foundation load	(ΣP$_o$)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	5.64	cm	
Total Consolidation Settlement	(Sc)	=	56.37	mm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	31.05	mm	
Total Settlement (Sic+Scc)	S	=	34.77	mm	

34.77 mm	5.500 T/m2	Permissible Settlement (As per IS 1904 - Table1)		
50 mm	7.91 T/m2			
25 mm	3.95 T/m2	50	mm	

SKP

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

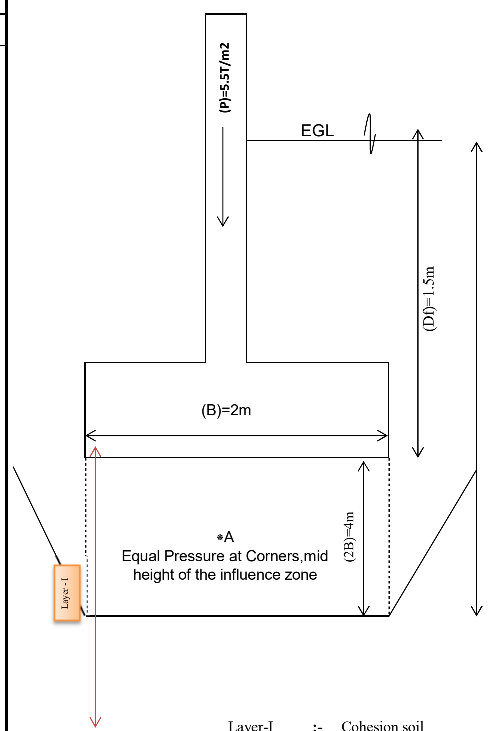
Name of the Project	AGCL
Bore Hole	BH-2
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.5	m	150 cm
Field Dry Density of soil	(γ_{dry})	=	1.680	gm/cm^3	16.464 kN/m^3
Field Moisture Content of soil	(w)	=	43.28	%	
Wet Density of soil	(γb)	=	2.41	gm/cm^3	23.590 kN/m^3
Specific Gravity of soil	(G)	=	2.76		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.50	m	550 cm
Depth of the Water Table	GWT	=	1.70	m	170 cm
Effect of water table	(W')	=	0.55	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	16.8640	MPa	16864 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	(P *B*(1-μ^2)*I)/E		
	Si	=	0.55	cm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.35	cm	
	(Sic)	=	3.46	mm	

Stress Deformation Diagram (Typical section Diagram)



W1= 43 % E1= 16.9 MPa γ1= 2.407 gm/cc (WL)= 45.3 %

Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.407	gm/cm^3	23.590 kN/m^3
Liquid Limit of the Soil	(W_L)	=	45.26	%	
Compression index	(Cc)	=	0.317	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	1.328	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	62.96	kN/m2	
Vertical Stress increment due to foundation load	(ΣP_o)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	4.68	cm	
Total Consolidation Settlement	(Sc)	=	46.78	mm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	23.95	mm	
Total Settlement (Sic+Scc)	S	=	27.41	mm	

27.41 mm	5.500 T/m2	Permissible Settlement (As per IS 1904 - Table1)		
50 mm	10.03 T/m2			
25 mm	5.02 T/m2	50	mm	

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

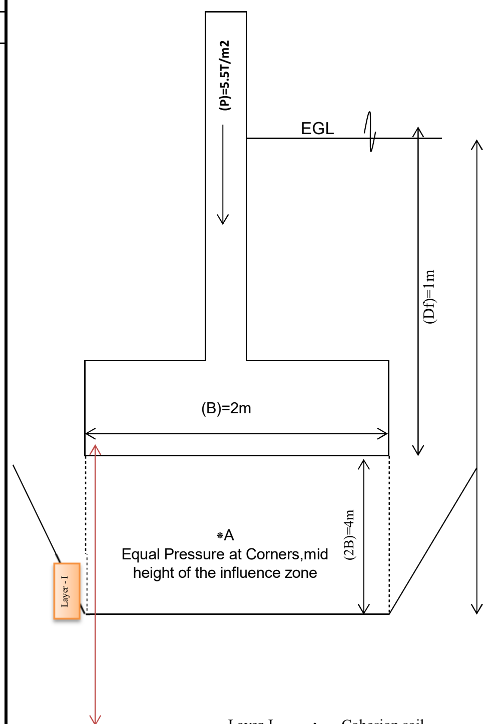
Name of the Project	AGCL
Bore Hole	BH-3
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.0	m	100 cm
Field Dry Density of soil	(γ_{dry})	=	1.684	gm/cm³	16.503 kN/m³
Field Moisture Content of soil	(w)	=	34.67	%	
Wet Density of soil	(γb)	=	2.27	gm/cm³	22.225 kN/m³
Specific Gravity of soil	(G)	=	2.62		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.00	m	500 cm
Depth of the Water Table	GWT	=	0.20	m	20 cm
Effect of water table	(W')	=	0.50	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	15.0800	MPa	15080 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m³
Immediate Settlement of Soil	(Si)	=	(P *B*(1-μ²)*I)/E		
	Si	=	0.61	cm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.42	cm	
	(Sic)	=	4.17	mm	

Stress Deformation Diagram (Typical section Diagram)



Layer-I :- Cohesion soil

W₁= 35 % E1= 15.1 MPa γ1= 2.268 gm/cc (W_L)= 40.3 %

Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.268	gm/cm³	22.225 kN/m³
Liquid Limit of the Soil	(W_L)	=	40.29	%	
Compression index	(Cc)	=	0.273	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	1.179	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	47.07	kN/m2	
Vertical Stress increment due to foundation load	(ΣP_o)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	5.57	cm	
Total Consolidation Settlement	(Sc)	=	55.70	mm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	30.68	mm	
Total Settlement (Sic+Scc)	S	=	34.85	mm	

34.85	mm	5.500	T/m2	Permissible Settlement (As per IS 1904 - Table1)	
50	mm	7.89	T/m2		
25	mm	3.95	T/m2	50	mm

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

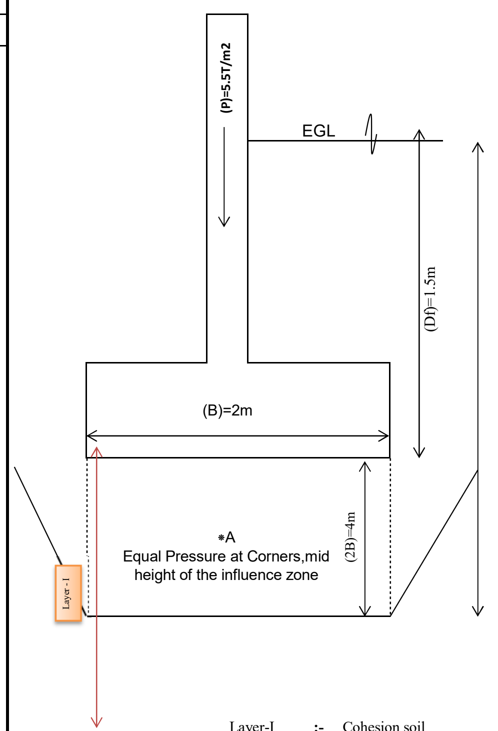
Name of the Project	AGCL
Bore Hole	BH-3
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.5	m	150 cm
Field Dry Density of soil	(γ_{dry})	=	1.684	gm/cm^3	16.503 kN/m^3
Field Moisture Content of soil	(w)	=	34.67	%	
Wet Density of soil	(γb)	=	2.27	gm/cm^3	22.225 kN/m^3
Specific Gravity of soil	(G)	=	2.62		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.50	m	550 cm
Depth of the Water Table	GWT	=	0.20	m	20 cm
Effect of water table	(W')	=	0.50	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	15.0800	MPa	15080 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	$(P*B*(1-\mu^2)*I)/E$		
	Si	=	0.61	cm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.39	cm	
	(Sic)	=	3.87	mm	

Stress Deformation Diagram (Typical section Diagram)



W_1= 35 % E1= 15.1 MPa γ1= 2.268 gm/cc (W_L)= 40.3 %

Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.268	gm/cm^3	22.225 kN/m^3
Liquid Limit of the Soil	(W_L)	=	40.29	%	
Compression index	(Cc)	=	0.273	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	1.179	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	58.19	kN/m2	
Vertical Stress increment due to foundation load	(ΣP_o)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	4.61	cm	
Total Consolidation Settlement	(Sc)	=	46.11	mm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	23.60	mm	
Total Settlement (Sic+Scc)	S	=	27.48	mm	

27.48 mm	5.500 T/m2	Permissible Settlement (As per IS 1904 - Table1)		
50 mm	10.01 T/m2			
25 mm	5.00 T/m2	50	mm	

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

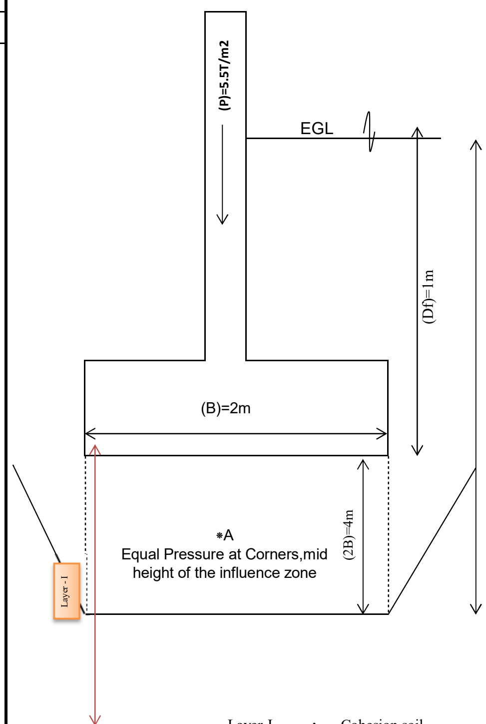
Name of the Project	AGCL
Bore Hole	BH-4
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.0	m	100 cm
Field Dry Density of soil	(γ_{dry})	=	1.694	gm/cm^3	16.601 kN/m^3
Field Moisture Content of soil	(w)	=	42.69	%	
Wet Density of soil	(γb)	=	2.42	gm/cm^3	23.688 kN/m^3
Specific Gravity of soil	(G)	=	2.74		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.00	m	500 cm
Depth of the Water Table	GWT	=	2.10	m	210 cm
Effect of water table	(W')	=	0.78	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	17.9510	MPa	17951 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	(P *B*(1-μ^2)*I)/E		
	Si	=	0.51	cm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.35	cm	
	(Sic)	=	3.50	mm	

Stress Deformation Diagram
(Typical section Diagram)



Layer-I :- Cohesion soil

W_1= 43 % E1= 18 MPa γ1= 2.417 gm/cc (W_L)= 48.6 %

Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.417	gm/cm^3	23.688 kN/m^3
Liquid Limit of the Soil	(W_L)	=	48.62	%	
Compression index	(Cc)	=	0.348	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	1.429	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	51.46	kN/m2	
Vertical Stress increment due to foundation load	(ΣP_o)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	5.89	cm	
Total Consolidation Settlement	(Sc)	=	58.87	mm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	32.43	mm	
Total Settlement (Sic+Scc)	S	=	35.93	mm	

35.93	mm	5.500	T/m2	Permissible Settlement (As per IS 1904 - Table1)	
50	mm	7.65	T/m2		
25	mm	3.83	T/m2	50	mm

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

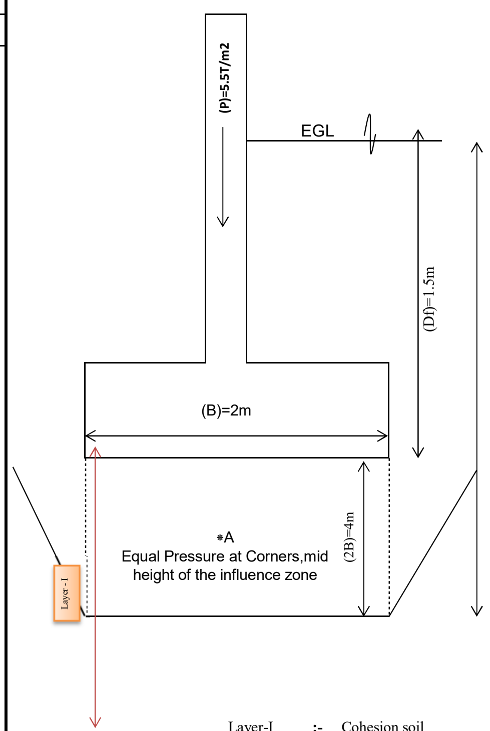
Name of the Project	AGCL
Bore Hole	BH-4
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.5	m	150 cm
Field Dry Density of soil	(γ_{dry})	=	1.694	gm/cm^3	16.601 kN/m^3
Field Moisture Content of soil	(w)	=	42.69	%	
Wet Density of soil	(γb)	=	2.42	gm/cm^3	23.688 kN/m^3
Specific Gravity of soil	(G)	=	2.74		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.50	m	550 cm
Depth of the Water Table	GWT	=	2.10	m	210 cm
Effect of water table	(W')	=	0.65	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	17.9510	MPa	17951 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	$(P*B*(1-\mu^2)*I)/E$		
	Si	=	0.51	cm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.33	cm	
	(Sic)	=	3.25	mm	

Stress Deformation Diagram (Typical section Diagram)



W1= 43 % E1= 18 MPa γ1= 2.417 gm/cc (W_L)= 48.6 %

Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.417	gm/cm^3	23.688 kN/m^3
Liquid Limit of the Soil	(W_L)	=	48.62	%	
Compression index	(Cc)	=	0.348	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	1.429	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	63.31	kN/m2	
Vertical Stress increment due to foundation load	(ΣP$_o$)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	4.89	cm	
Total Consolidation Settlement	(Sc)	=	48.87	mm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	25.02	mm	
Total Settlement (Sic+Scc)	S	=	28.27	mm	

28.27	mm	5.500	T/m2	Permissible Settlement (As per IS 1904 - Table1)	
50	mm	9.73	T/m2		
25	mm	4.86	T/m2	50	mm

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

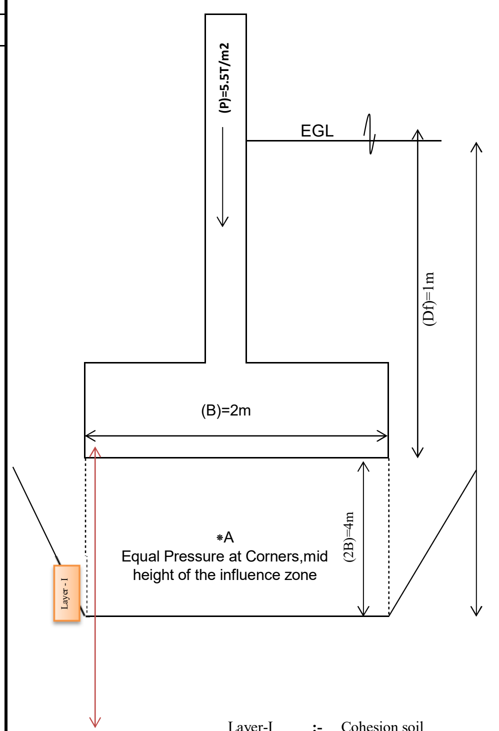
Name of the Project	AGCL
Bore Hole	BH-5
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.0	m	100 cm
Field Dry Density of soil	(γ_{dry})	=	1.674	gm/cm^3	16.405 kN/m^3
Field Moisture Content of soil	(w)	=	32.36	%	
Wet Density of soil	(γb)	=	2.22	gm/cm^3	21.714 kN/m^3
Specific Gravity of soil	(G)	=	2.71		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.00	m	500 cm
Depth of the Water Table	GWT	=	0.50	m	50 cm
Effect of water table	(W')	=	0.50	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	17.9400	MPa	17940 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	(P *B*(1-μ^2)*I)/E		
	Si	=	0.52	cm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.35	cm	
	(Sic)	=	3.50	mm	

Stress Deformation Diagram
(Typical section Diagram)



W₁= 32 % E1= 17.9 MPa γ1= 2.216 gm/cc (W_L)= 45.2 %

Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.216	gm/cm^3	21.714 kN/m^3
Liquid Limit of the Soil	(W_L)	=	45.24	%	
Compression index	(Cc)	=	0.317	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	1.327	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	45.54	kN/m2	
Vertical Stress increment due to foundation load	(ΣP$_o$)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ē0) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	6.25	cm	
Total Consolidation Settlement	(Sc)	=	62.46	mm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	34.41	mm	
Total Settlement (Sic+Scc)	S	=	37.91	mm	

37.91	mm	5.500	T/m2	Permissible Settlement (As per IS 1904 - Table1)	
50	mm	7.25	T/m2		
25	mm	3.63	T/m2	50	mm

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

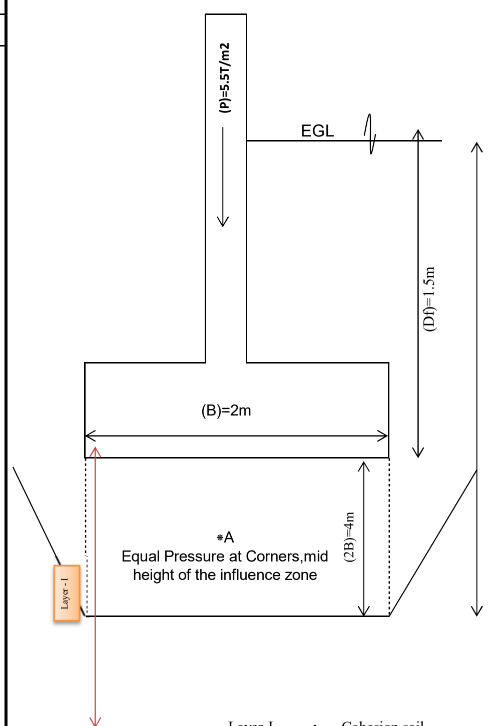
Name of the Project	AGCL
Bore Hole	BH-5
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.5	m	150 cm
Field Dry Density of soil	(γ_{dry})	=	1.674	gm/cm^3	16.405 kN/m^3
Field Moisture Content of soil	(w)	=	32.36	%	
Wet Density of soil	(γb)	=	2.22	gm/cm^3	21.714 kN/m^3
Specific Gravity of soil	(G)	=	2.71		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.50	m	550 cm
Depth of the Water Table	GWT	=	0.50	m	50 cm
Effect of water table	(W')	=	0.50	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	17.9400	MPa	17940 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	$(P*B*(1-\mu^2)*I)/E$		
	Si	=	0.52	cm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.33	cm	
	(Sic)	=	3.26	mm	

Stress Deformation Diagram
(Typical section Diagram)



Layer-I :- Cohesion soil

W_1= 32 % E1= 17.9 MPa γ1= 2.216 gm/cc (W_L)= 45.2 %

Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.216	gm/cm^3	21.714 kN/m^3
Liquid Limit of the Soil	(W_L)	=	45.24	%	
Compression index	(Cc)	=	0.317	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	1.327	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	56.40	kN/m2	
Vertical Stress increment due to foundation load	(ΣP_o)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	5.17	cm	
Total Consolidation Settlement	(Sc)	=	51.65	mm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	26.44	mm	
Total Settlement (Sic+Scc)	S	=	29.70	mm	

29.70	mm	5.500	T/m2	Permissible Settlement (As per IS 1904 - Table1)	
50	mm	9.26	T/m2		
25	mm	4.63	T/m2	50	mm

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

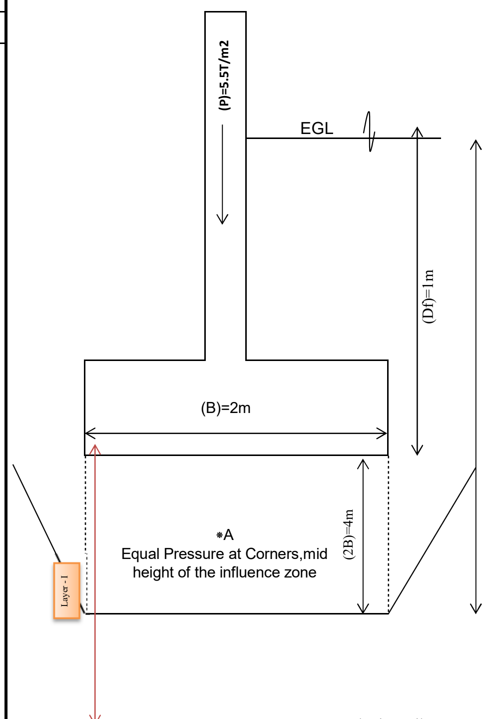
Name of the Project	AGCL
Bore Hole	BH-6
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.0	m	100 cm
Field Dry Density of soil	(γ_{dry})	=	1.699	gm/cm^3	16.650 kN/m^3
Field Moisture Content of soil	(w)	=	46.90	%	
Wet Density of soil	(γb)	=	2.50	gm/cm^3	24.459 kN/m^3
Specific Gravity of soil	(G)	=	2.73		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.00	m	500 cm
Depth of the Water Table	GWT	=	2.10	m	210 cm
Effect of water table	(W')	=	0.78	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	18.2700	MPa	18270 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	(P *B*(1-μ^2)*I)/E		
	Si	=	0.51	cm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.34	cm	
	(Sic)	=	3.44	mm	

Stress Deformation Diagram (Typical section Diagram)



Layer-I :- Cohesion soil

W1= 47 % E1= 18.3 MPa γ1= 2.496 gm/cc (W_L)= 42.7 %

Consoildation Setttlement of Soil(Sc)

Layer-I

Bulk Density	γ	=	2.496	gm/cm^3	24.459 kN/m^3
Liquid Limit of the Soil	(W_L)	=	42.73	%	
Compression index	(Cc)	=	0.295	Cc=0.009(W_L-10)	Relation
Initial Void Ratio	(e_o)	=	1.252	Cc=0.30*(e_o-0.27)	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	53.78	kN/m2	
Vertical Stress increment due to foundation load	(ΣP$_o$)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	5.17	cm	
Total Consolidation Settlement	(Sc)	=	51.74	mm	
a)Depth Correction	(Sdf)	=	0.85	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	28.50	mm	
Total Settlement (Sic+Scc)	S	=	31.94	mm	

31.94	mm	5.500	T/m2	Permissible Settlement (As per IS 1904 - Table1)	
50	mm	8.61	T/m2		
25	mm	4.31	T/m2	50	mm

CALCULATION OF SETTLEMENT OF RIGID FOUNDATION FOR COHESION SOIL AS PER IS:8009 (Part -I)-1976

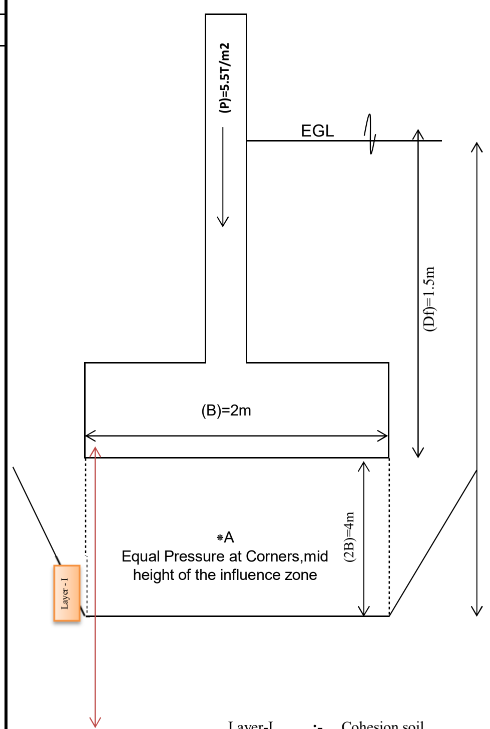
Name of the Project	AGCL
Bore Hole	BH-6
Sample ID	SPT-01
Location	Rupkhelia Terminal

Immediate Settlement of Soil(Si)

Settlement due to cohesion soil beneath foundation level

Shape of Foundation		=	ISOLATED SQUARE FOOTING		
Width of Foundation	(B)	=	2.0	m	200 cm
Length of Foundation	(L)	=	2.0	m	200 cm
Length/Width	(L/B)	=	1.0	m	100 cm
Depth of Foundation	(D_f)	=	1.5	m	150 cm
Field Dry Density of soil	(γ_{dry})	=	1.699	gm/cm^3	16.650 kN/m^3
Field Moisture Content of soil	(w)	=	46.90	%	
Wet Density of soil	(γb)	=	2.50	gm/cm^3	24.459 kN/m^3
Specific Gravity of soil	(G)	=	2.73		
Vertical Load(Net Foundation Pressure)	(P)	=	5.50	T/m2	55.000 kN/m2
Depth of influence zone(depth below foundation level)	(2B)	=	4.00	m	400 cm
Depth of end of influence zone from G.L	(Di)	=	5.50	m	550 cm
Depth of the Water Table	GWT	=	2.10	m	210 cm
Effect of water table	(W')	=	0.65	Fig-9; IS:8009,Part-1	
Poissons Ratio	(μ)	=	0.50		
Influence Factor	(I)	=	1.12	Tab-2; IS:8009,Part-1	
Modulus of Elasticity of Soil	(E)	=	18.2700	MPa	18270 kN/m2
Raw Density of Water	(γ_w)	=	1	g/cc	9.800 kN/m^3
Immediate Settlement of Soil	(Si)	=	$(P*B*(1-\mu^2)*I)/E$		
	Si	=	0.51	cm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
Corrected Immediate Settlement	(Sic)	=	0.32	cm	
	(Sic)	=	3.20	mm	

Stress Deformation Diagram (Typical section Diagram)



W1= 47 % E1= 18.3 MPa γ1= 2.496 gm/cc (WL)= 42.7 %

Consoildation Setttlement of Soil(Sc)

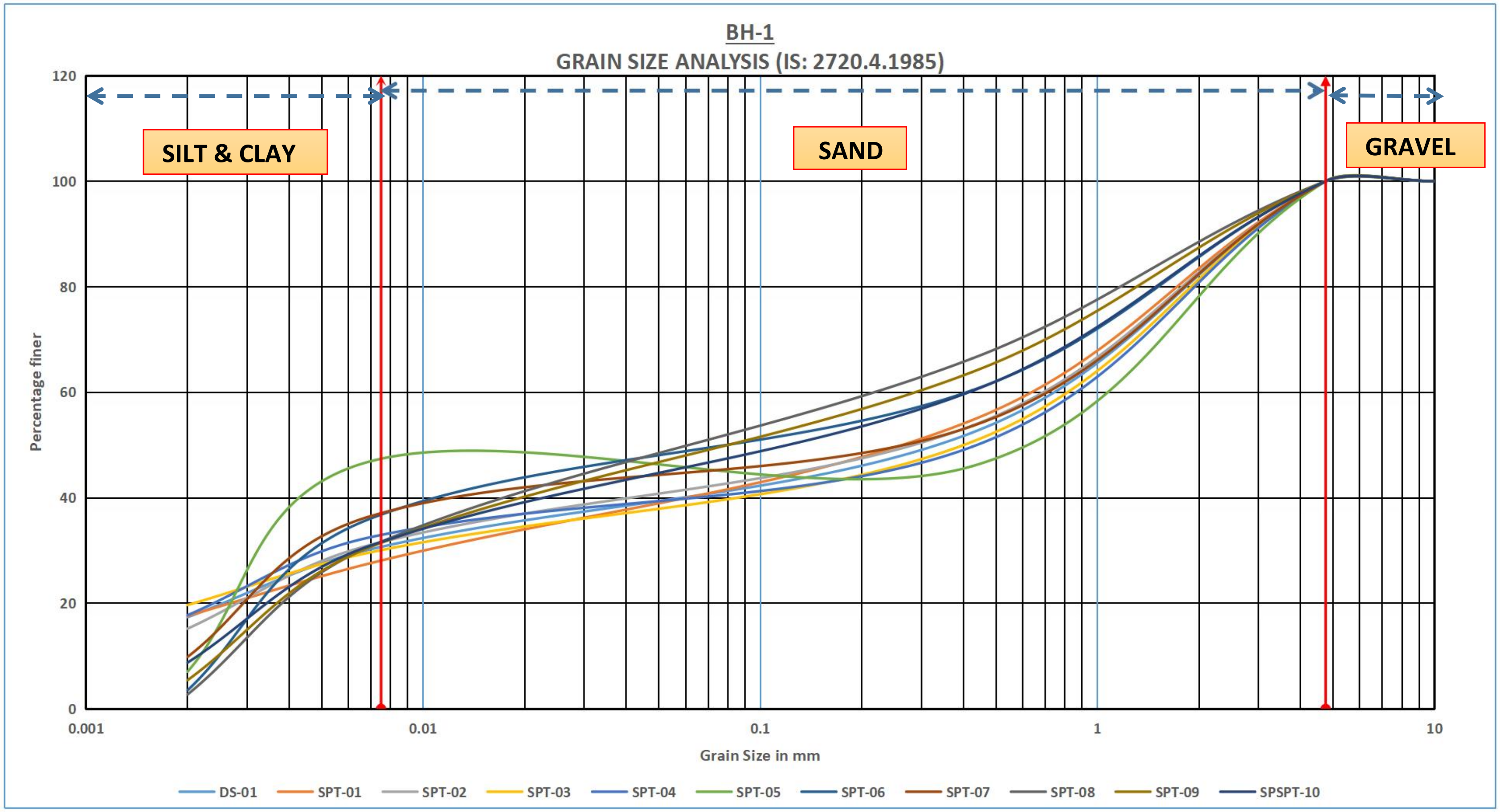
Layer-I

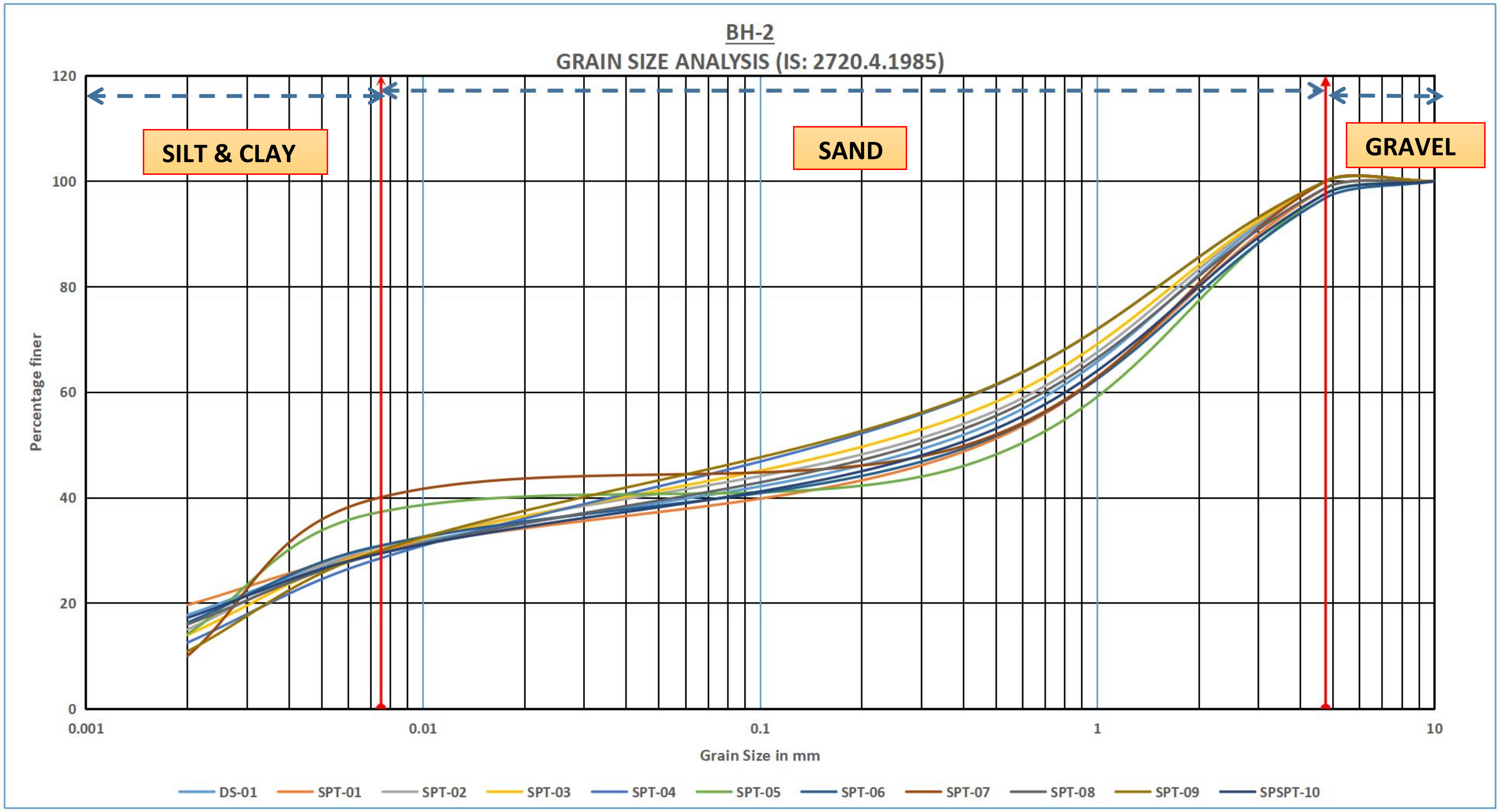
Bulk Density	γ	=	2.496	gm/cm^3	24.459 kN/m^3
Liquid Limit of the Soil	(W_L)	=	42.73	%	
Compression index	(Cc)	=	0.295	$Cc=0.009(W_L-10)$	Relation
Initial Void Ratio	(e_o)	=	1.252	$Cc=0.30*(e_o-0.27)$	Relation
Height at centre of the layer(A - point)	(Z)	=	2.000	m	200 cm
Initial Effective Overburden pressure	(P_o)	=	66.01	kN/m2	
Vertical Stress increment due to foundation load	(ΣP_o)	=	13.75	kN/m2	2:1 dispersion of Load
Height of Compressible Layer	(H)	=	4.0	m	400 cm
Consolidation Settlement of Soil	(Sc)	=	(H/1 + ēo) X CcX log((Po + ΣP)/Po)		
	(Sc)	=	4.30	cm	
Total Consolidation Settlement	(Sc)	=	43.00	mm	
a)Depth Correction	(Sdf)	=	0.79	Fig-12; IS:8009,Part-1	
b)Rigidity Correction	(Srigid)	=	0.80	Cl : 9.5.2; IS:8009,Part-1	
b)3-D Consolidation Correction	(S_{3-D})	=	0.81	Cl : 9.2.3; IS:8009,Part-1	
Corrected Consolidated Settlement	(Scc)	=	22.01	mm	
Total Settlement (Sic+Scc)	S	=	25.21	mm	

25.21	mm	5.500	T/m2	Permissible Settlement (As per IS 1904 - Table1)	
50	mm	10.91	T/m2		
25	mm	5.45	T/m2	50	mm

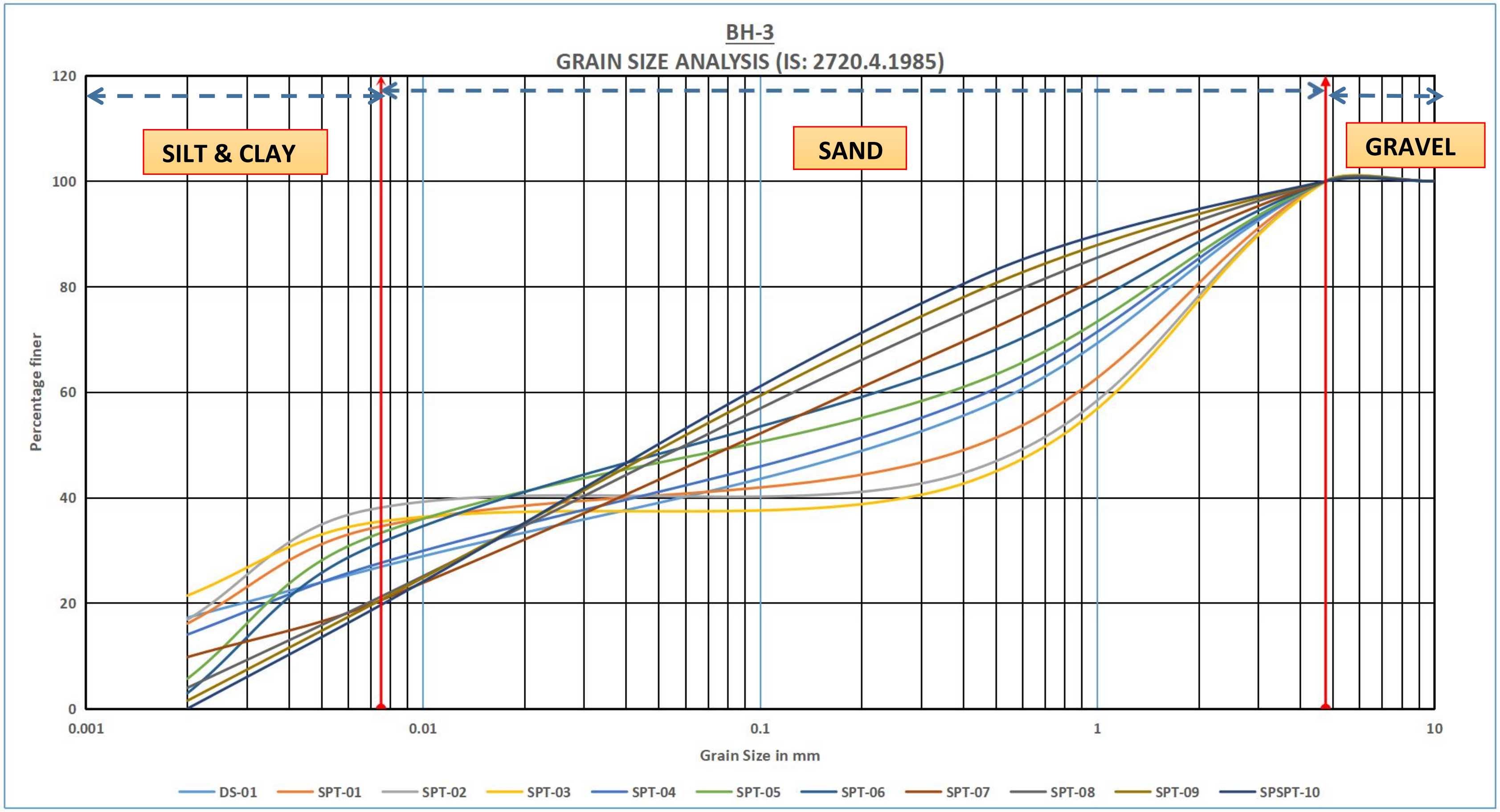
Annexure - VIII

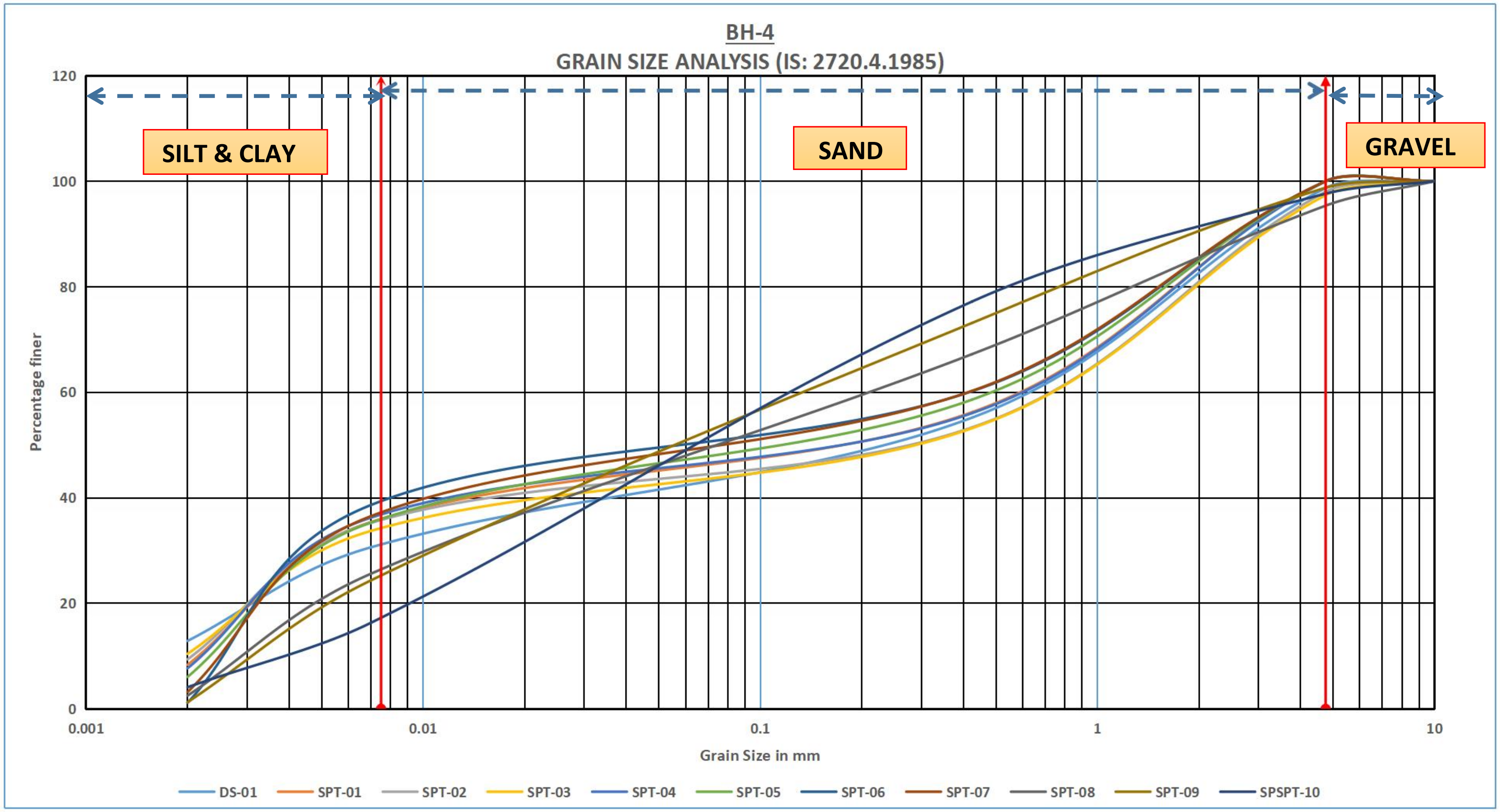
(GRAIN SIZE ANALYSIS GRAPHS)

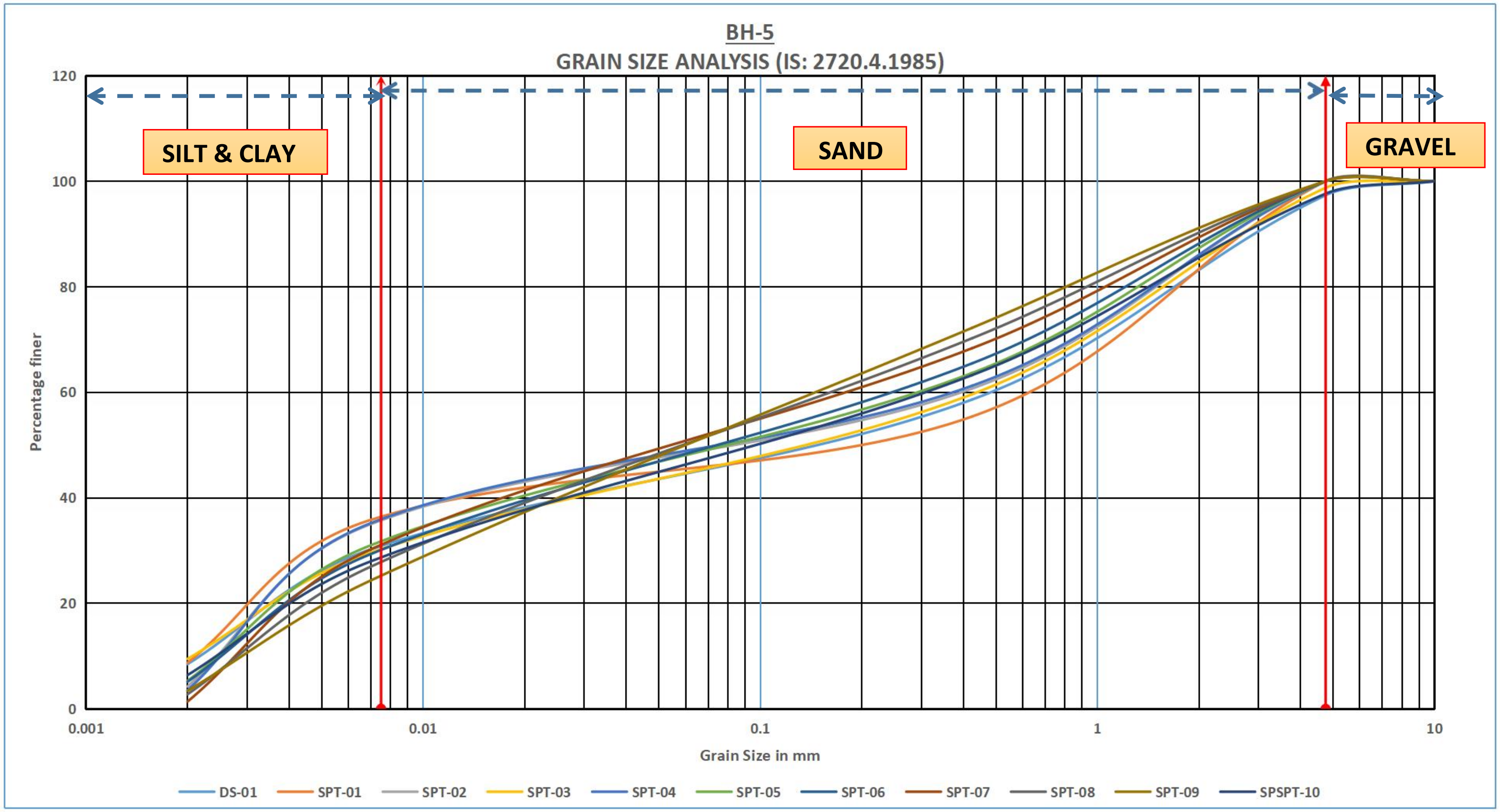

BH-1
GRAIN SIZE ANALYSIS (IS: 2720.4.1985)
SILT & CLAY
SAND
GRAVEL
Percentage finer
120
100
80
60
40
20
0
0.001
0.01
0.1
1
10
Grain Size in mm
DS-01
SPT-01
SPT-02
SPT-03
SPT-04
SPT-05
SPT-06
SPT-07
SPT-08
SPT-09
SPSPT-10



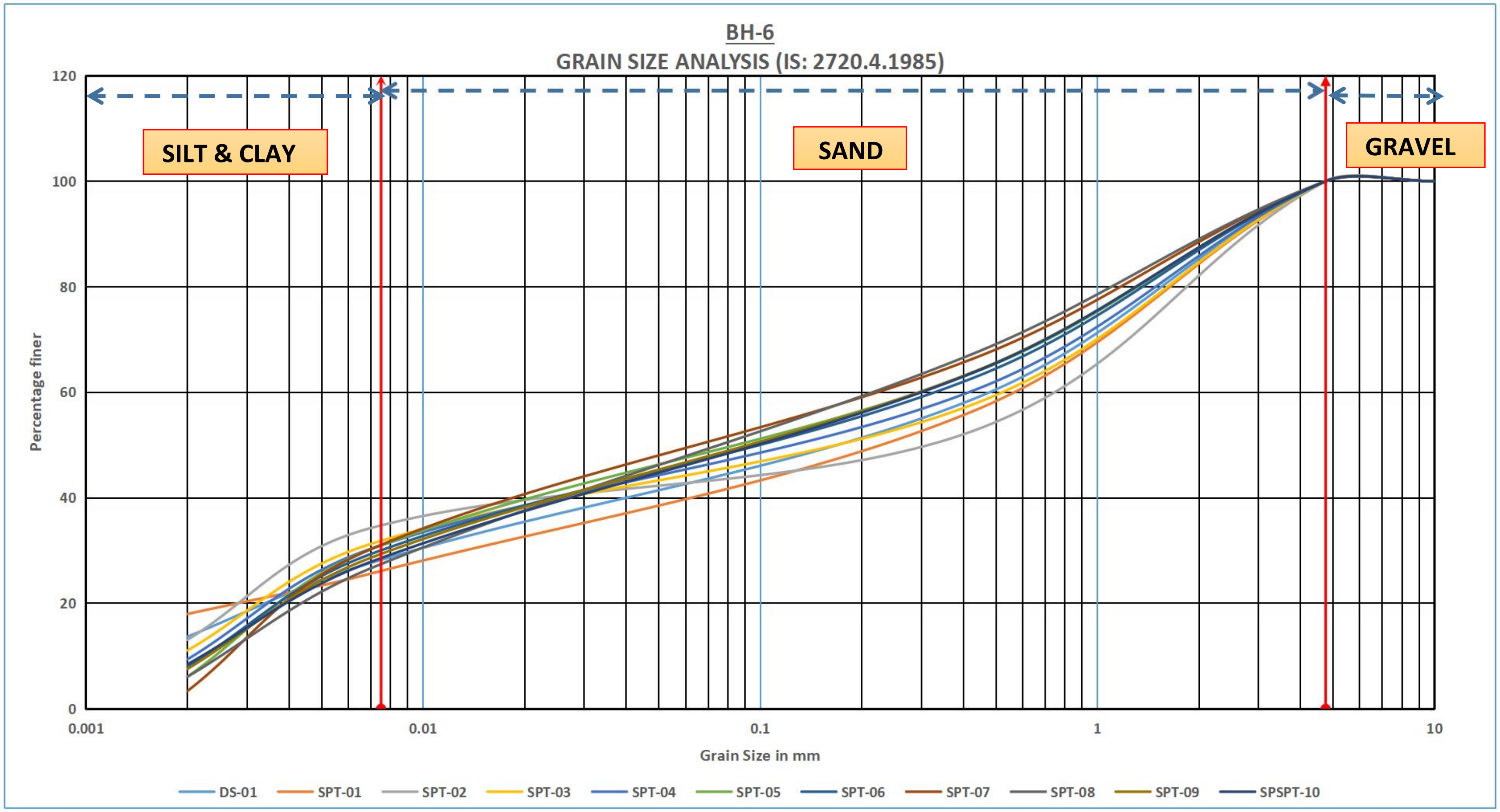
BH-2
GRAIN SIZE ANALYSIS (IS: 2720.4.1985)
SILT & CLAY
SAND
GRAVEL
Percentage finer
0
20
40
60
80
100
120
0.001
0.01
0.1
1
10
Grain Size in mm
DS-01
SPT-01
SPT-02
SPT-03
SPT-04
SPT-05
SPT-06
SPT-07
SPT-08
SPT-09
SPSPT-10


BH-3
GRAIN SIZE ANALYSIS (IS: 2720.4.1985)
SILT & CLAY
SAND
GRAVEL
Percentage finer
0
20
40
60
80
100
120
0.001
0.01
0.1
1
10
Grain Size in mm
DS-01
SPT-01
SPT-02
SPT-03
SPT-04
SPT-05
SPT-06
SPT-07
SPT-08
SPT-09
SPSPT-10


BH-4
GRAIN SIZE ANALYSIS (IS: 2720.4.1985)
SILT & CLAY
SAND
GRAVEL
Percentage finer
120
100
80
60
40
20
0
0.001
0.01
0.1
1
10
Grain Size in mm
DS-01
SPT-01
SPT-02
SPT-03
SPT-04
SPT-05
SPT-06
SPT-07
SPT-08
SPT-09
SPSPT-10



BH-5
GRAIN SIZE ANALYSIS (IS: 2720.4.1985)
SILT & CLAY
SAND
GRAVEL
Percentage finer
120
100
80
60
40
20
0
0.001
0.01
0.1
1
10
Grain Size in mm
DS-01
SPT-01
SPT-02
SPT-03
SPT-04
SPT-05
SPT-06
SPT-07
SPT-08
SPT-09
SPSPT-10

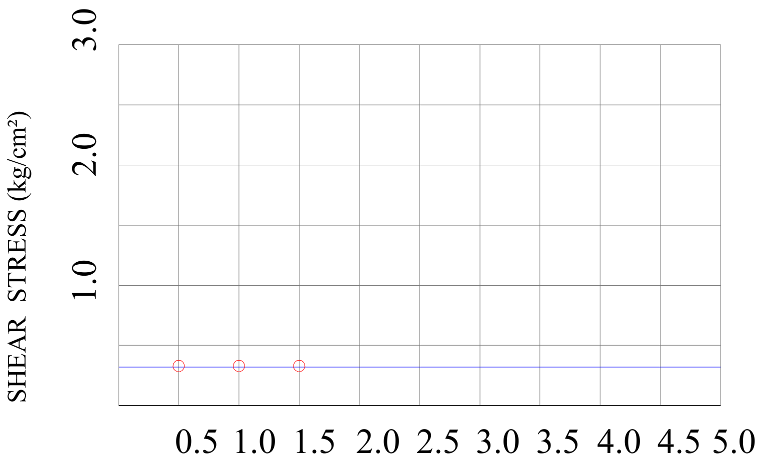

BH-6
GRAIN SIZE ANALYSIS (IS: 2720.4.1985)
SILT & CLAY
SAND
GRAVEL
Percentage finer
120
100
80
60
40
20
0
0.001
0.01
0.1
1
10
Grain Size in mm
DS-01
SPT-01
SPT-02
SPT-03
SPT-04
SPT-05
SPT-06
SPT-07
SPT-08
SPT-09
SPSPT-10

Annexure - IX
(DIRECT SHEAR GRAPHS)

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-1
SAMPLE LOCATION(m) :- 110.93/109.43
SAMPLE ID :- DS-01

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.32
2	1.0	0.33
3	1.5	0.34



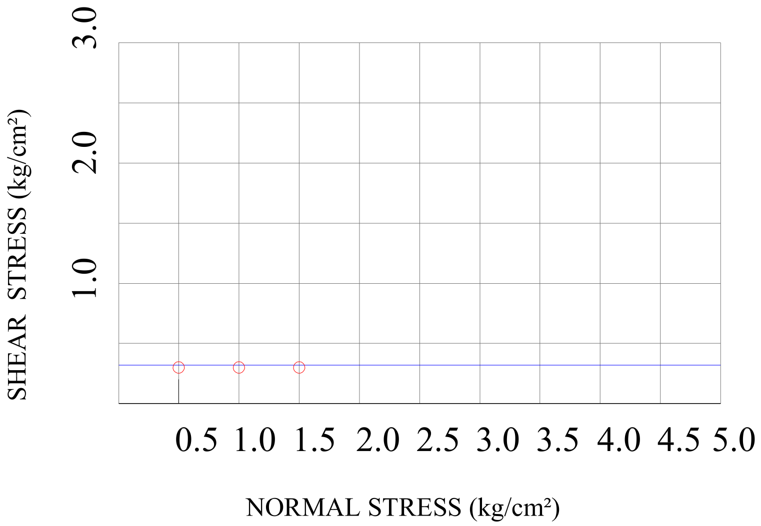
COHESION INTERCEPT 'C' (kg/cm^2) = 0.32
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-1
SAMPLE LOCATION(m) :- 109.43/108.98
SAMPLE ID :- SPT-01

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.29
2	1.0	0.30
3	1.5	0.30



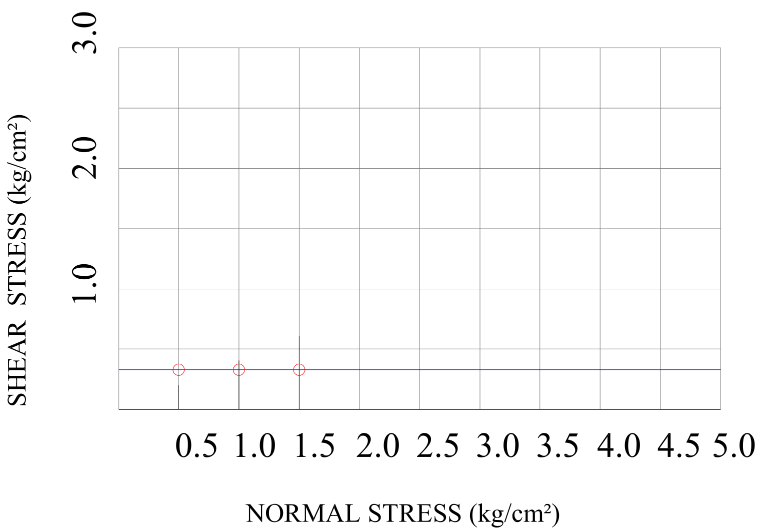
COHESION INTERCEPT 'C' (kg/cm²) = 0.32
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-1
SAMPLE LOCATION(m) :- 107.93/107.48
SAMPLE ID :- SPT-02

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.33
2	1.0	0.31
3	1.5	0.35



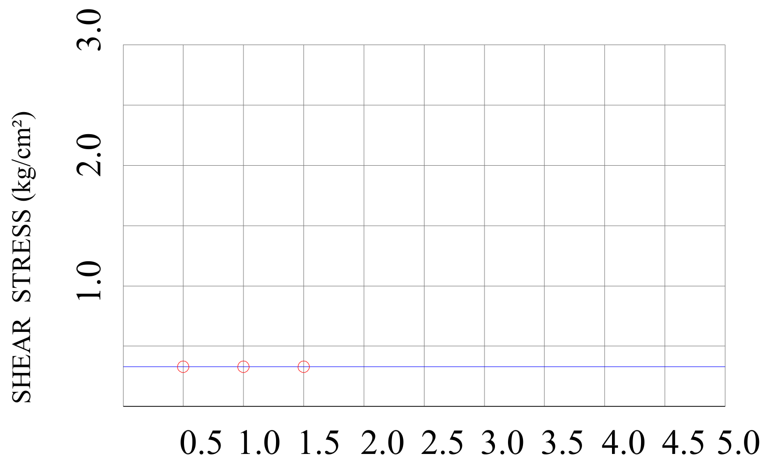
COHESION INTERCEPT 'C' (kg/cm²) = 0.33
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-1
SAMPLE LOCATION(m) :- 106.43/105.98
SAMPLE ID :- SPT-03

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.33
2	1.0	0.33
3	1.5	0.33



NORMAL STRESS (kg/cm²)

COHESION INTERCEPT 'C' (kg/cm²) = 0.33

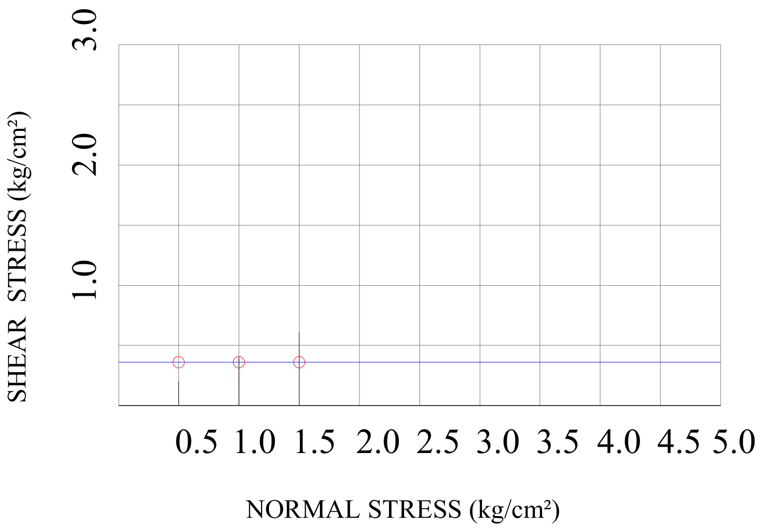
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-1
SAMPLE LOCATION(m) :- 104.93/104.48
SAMPLE ID :- SPT-04

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.34
2	1.0	0.36
3	1.5	0.38



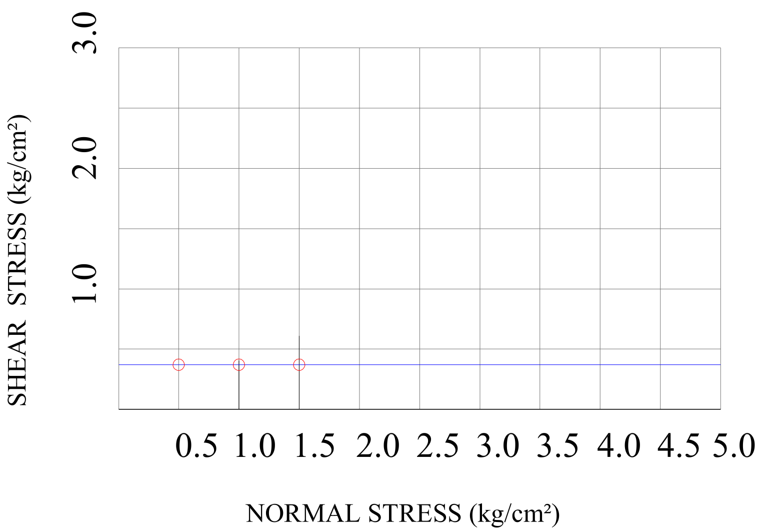
COHESION INTERCEPT 'C' (kg/cm^2) = 0.36
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-1
SAMPLE LOCATION(m) :- 103.43/102.98
SAMPLE ID :- SPT-05

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.36
2	1.0	0.37
3	1.5	0.38



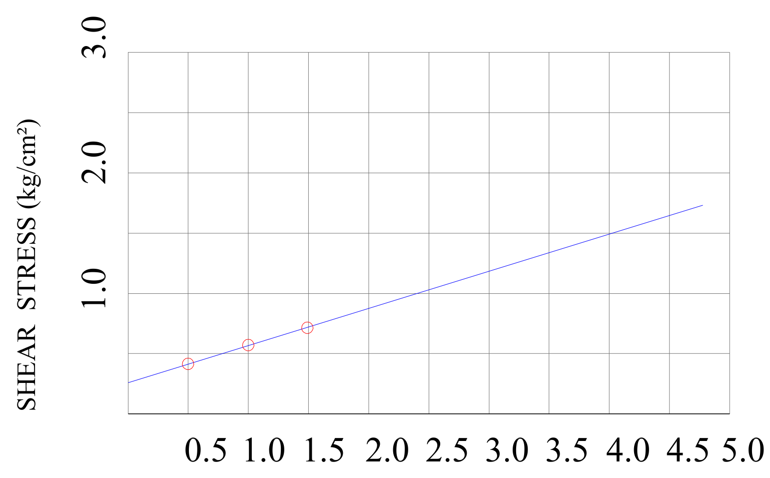
COHESION INTERCEPT 'C' (kg/cm²) = 0.37
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION	:- Ruphelia Terminal
BORE NO	:- BH-1
SAMPLE LOCATION(m)	:- 101.93/101.48
SAMPLE ID	:- SPT-06

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.41
2	1.0	0.57
3	1.5	0.72



COHESION INTERCEPT 'C' (kg/cm²) = 0.26

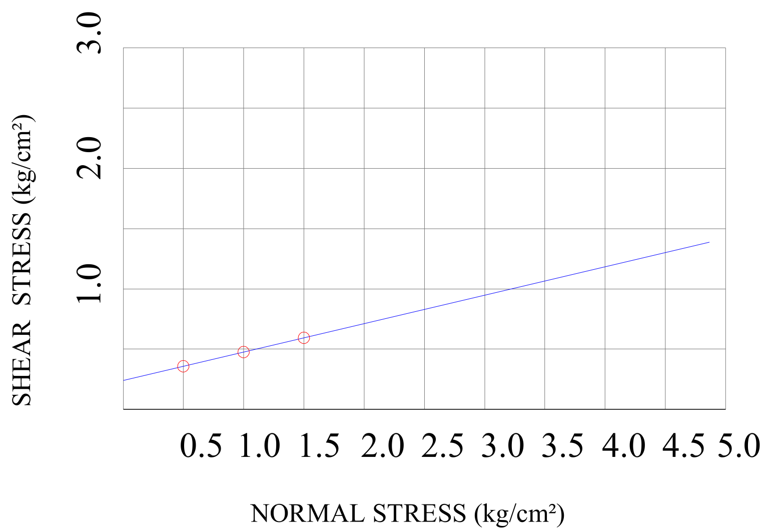
ANGLE OF SHEARING RESISTANCE = 17.12°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-1
SAMPLE LOCATION(m) :- 100.43/99.98
SAMPLE ID :- SPT-07

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.36
2	1.0	0.48
3	1.5	0.59



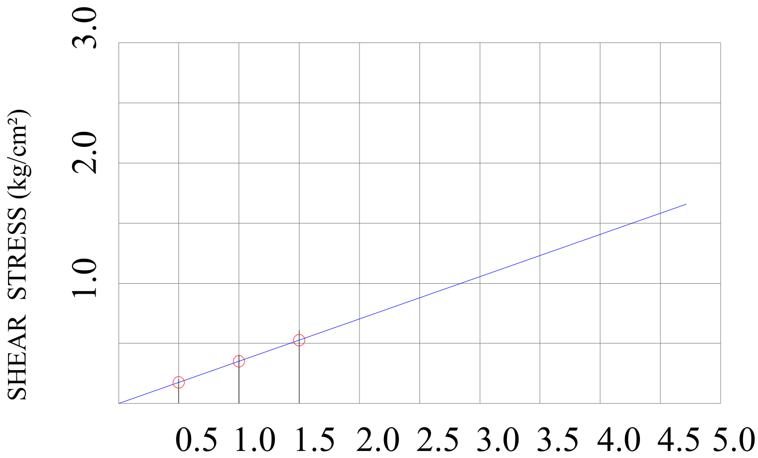
COHESION INTERCEPT 'C' (kg/cm²) = 0.24
ANGLE OF SHEARING RESISTANCE = 13.26°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-1
SAMPLE LOCATION(m) :- 98.93/98.48
SAMPLE ID :- SPT-08

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.18
2	1.0	0.35
3	1.5	0.53



NORMAL STRESS (kg/cm²)

COHESION INTERCEPT 'C' (kg/cm²) = 0

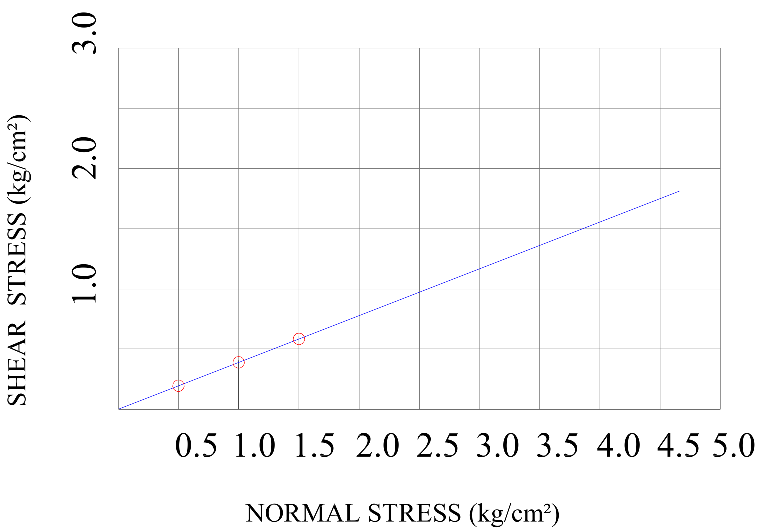
ANGLE OF SHEARING RESISTANCE = 19.38°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-1
SAMPLE LOCATION(m) :- 97.43/96.98
SAMPLE ID :- SPT-09

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.19
2	1.0	0.39
3	1.5	0.58



COHESION INTERCEPT 'C' (kg/cm²) = 0

ANGLE OF SHEARING RESISTANCE = 21.26°

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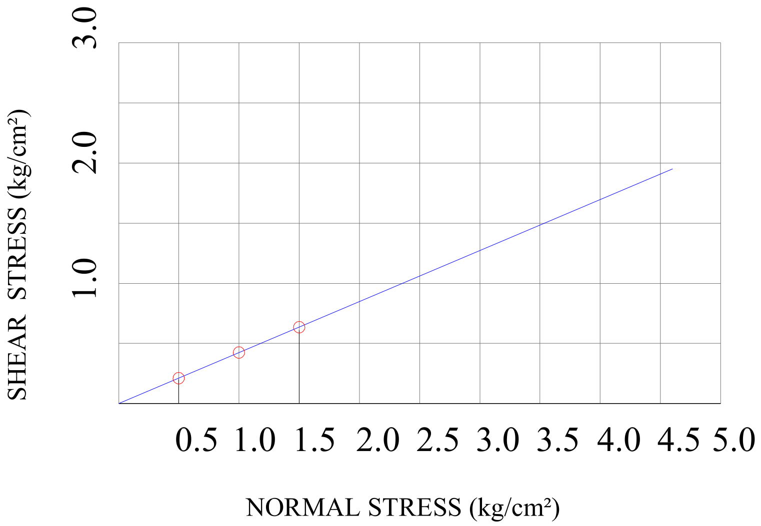
DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-1
SAMPLE LOCATION(m) :- 95.93/95.48
SAMPLE ID :- SPT-10

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.21
2	1.0	0.42
3	1.5	0.64



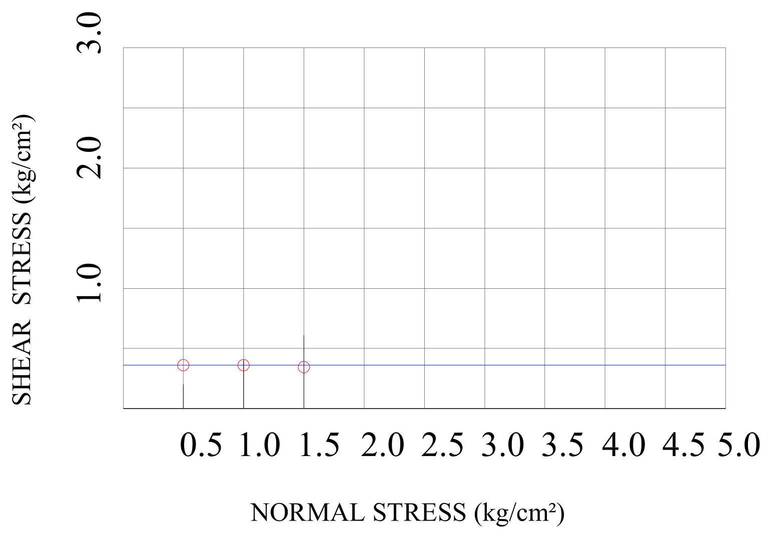
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 23°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 107.71/106.21
SAMPLE ID :- DS-01

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.35
2	1.0	0.36
3	1.5	0.36



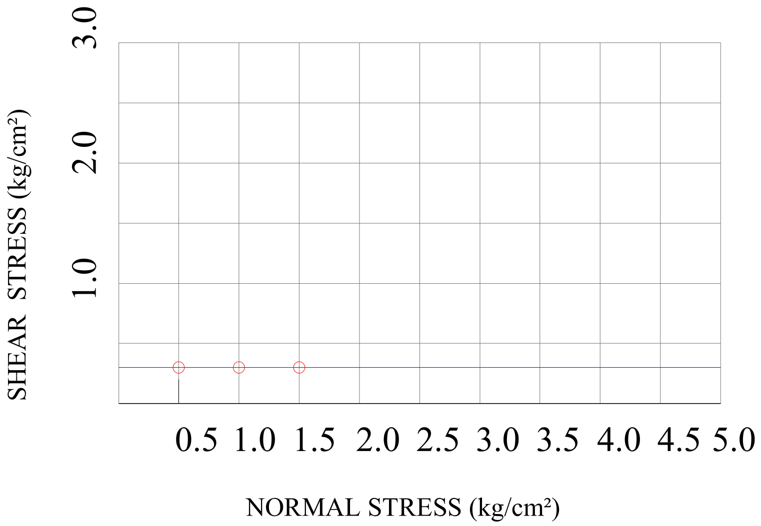
COHESION INTERCEPT 'C' (kg/cm²) = 0.36
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 106.21/105.76
SAMPLE ID :- SPT-01

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.30
2	1.0	0.30
3	1.5	0.29

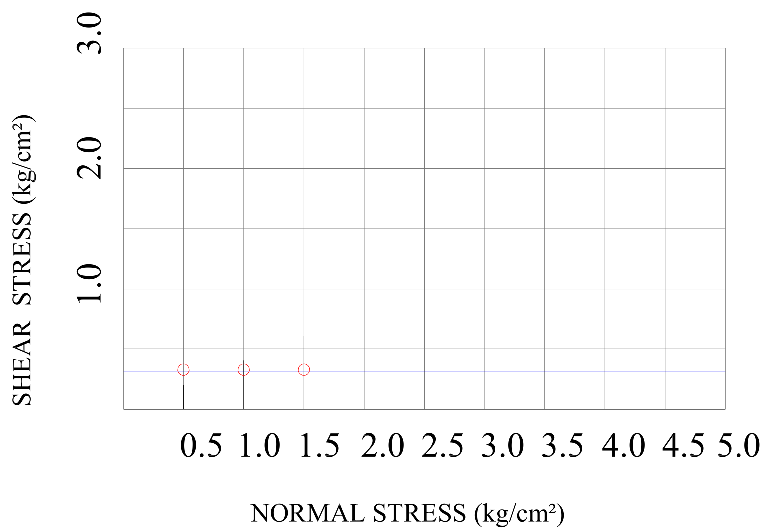


COHESION INTERCEPT 'C' (kg/cm²) = 0.30
ANGLE OF SHEARING RESISTANCE = 0°

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 104.71/104.26
SAMPLE ID :- SPT-02

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.32
2	1.0	0.33
3	1.5	0.34



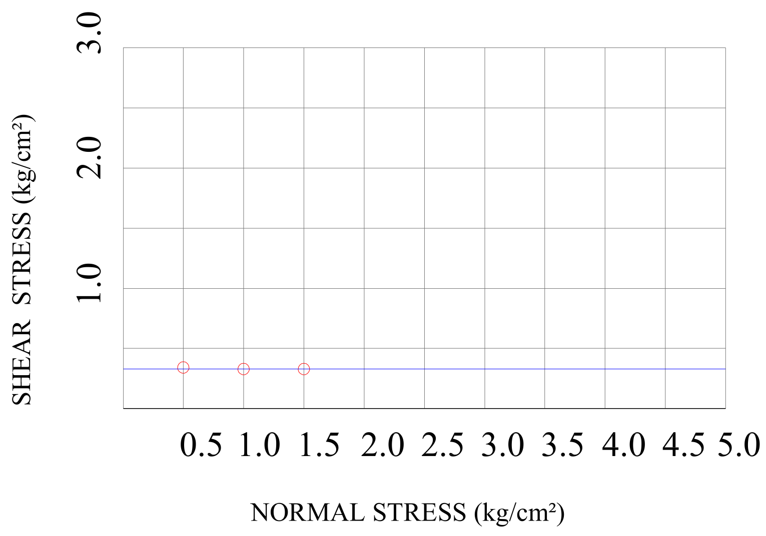
COHESION INTERCEPT 'C' (kg/cm²) = 0.31
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 103.21/102.76
SAMPLE ID :- SPT-03

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.32
2	1.0	0.33
3	1.5	0.33



COHESION INTERCEPT 'C' $(kg/cm^2) = 0.33$

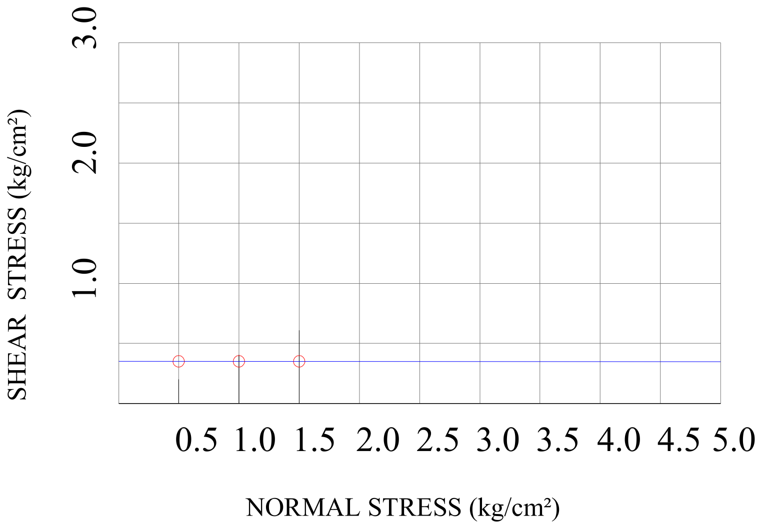
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 101.71/101.26
SAMPLE ID :- SPT-04

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.34
2	1.0	0.35
3	1.5	0.35



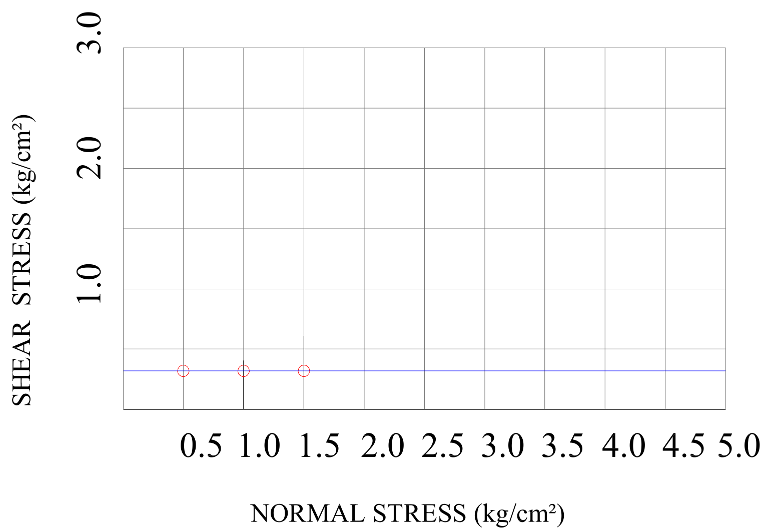
COHESION INTERCEPT 'C' (kg/cm²) = 0.35
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 100.21/99.76
SAMPLE ID :- SPT-05

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.32
2	1.0	0.32
3	1.5	0.32



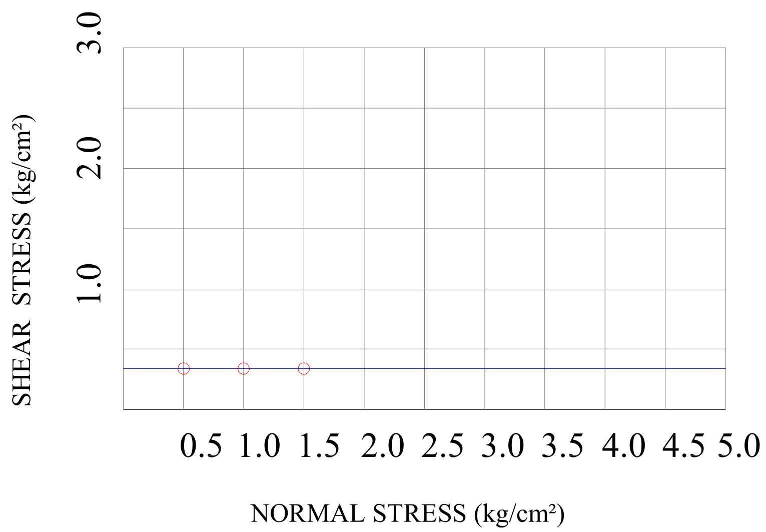
COHESION INTERCEPT 'C' (kg/cm²) = 0.32
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 98.71/98.26
SAMPLE ID :- SPT-06

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.33
2	1.0	0.34
3	1.5	0.34



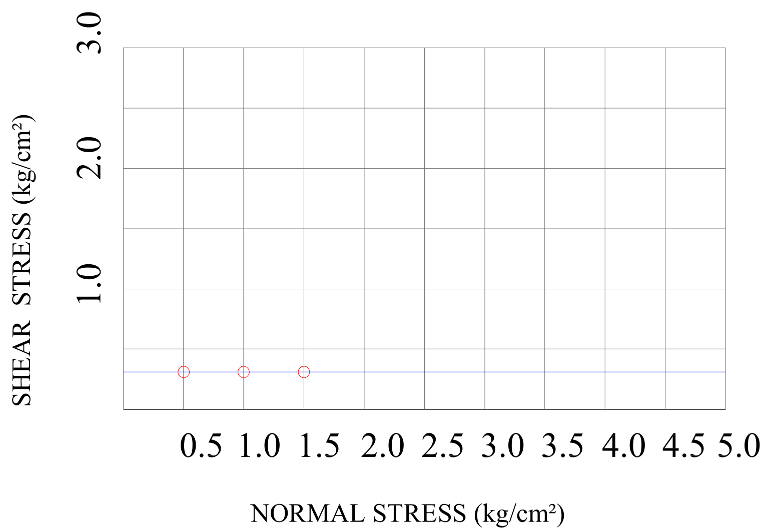
COHESION INTERCEPT 'C' (kg/cm²) = 0.34
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 97.21/96.76
SAMPLE ID :- SPT-07

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.30
2	1.0	0.31
3	1.5	0.31



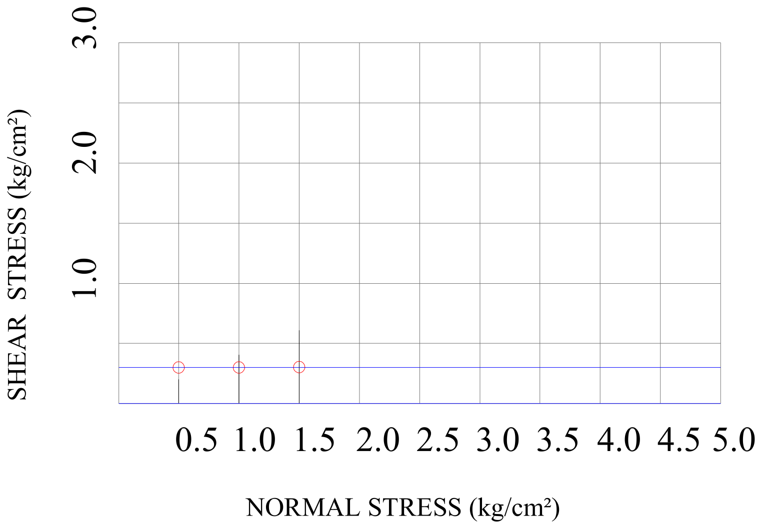
COHESION INTERCEPT 'C' (kg/cm²) = 0.31
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 95.71/95.26
SAMPLE ID :- SPT-08

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.30
2	1.0	0.30
3	1.5	0.31



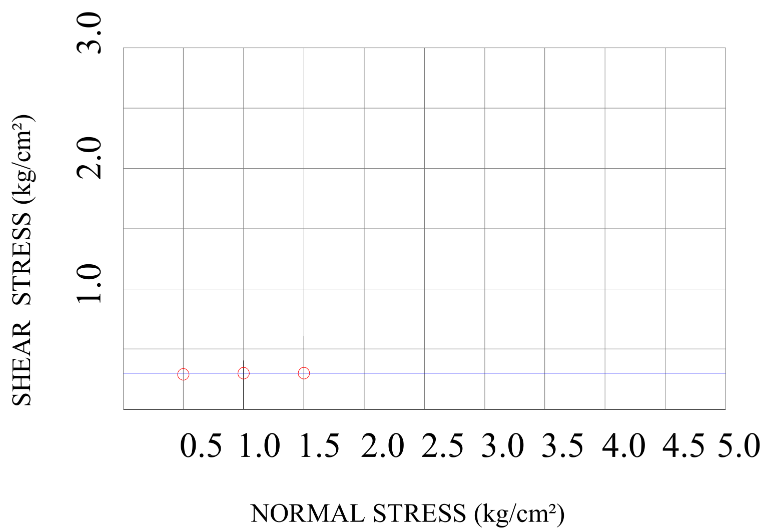
COHESION INTERCEPT 'C' (kg/cm²) = 0.30
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 94.21/93.76
SAMPLE ID :- SPT-09

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.29
2	1.0	0.30
3	1.5	0.30



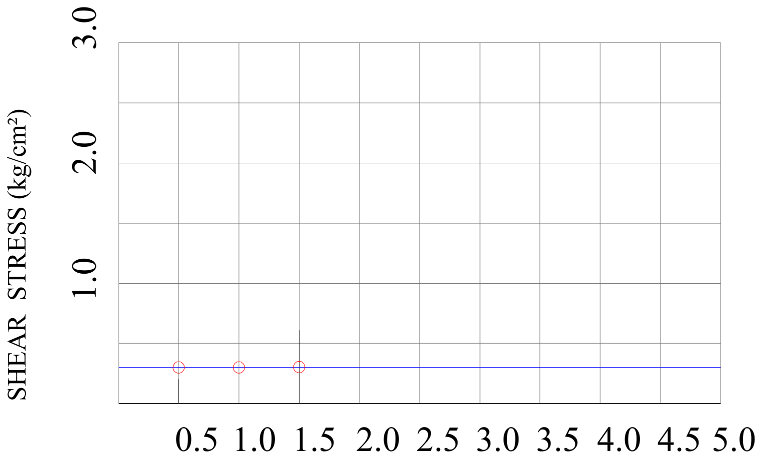
COHESION INTERCEPT 'C' (kg/cm²) = 0.30
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-2
SAMPLE LOCATION(m) :- 92.71/92.26
SAMPLE ID :- SPT-10

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.30
2	1.0	0.30
3	1.5	0.31



COHESION INTERCEPT 'C' (kg/cm²) = 0.30

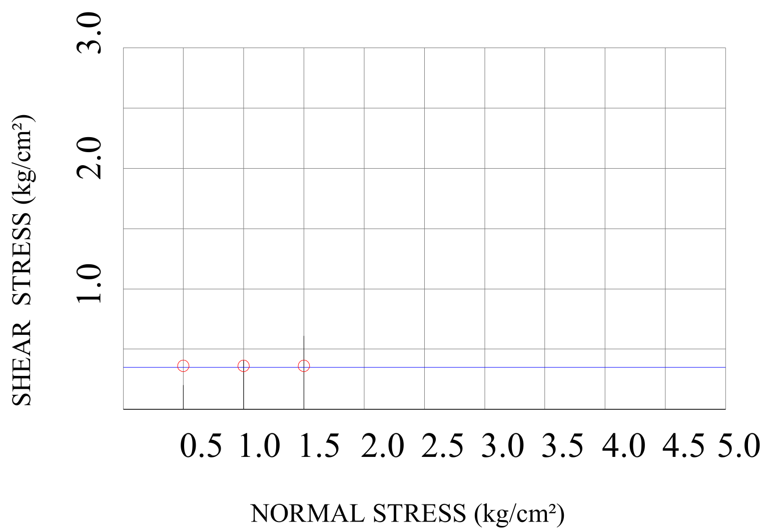
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-3
SAMPLE LOCATION(m) :- 109.31/107.81
SAMPLE ID :- DS-01

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.35
2	1.0	0.36
3	1.5	0.34



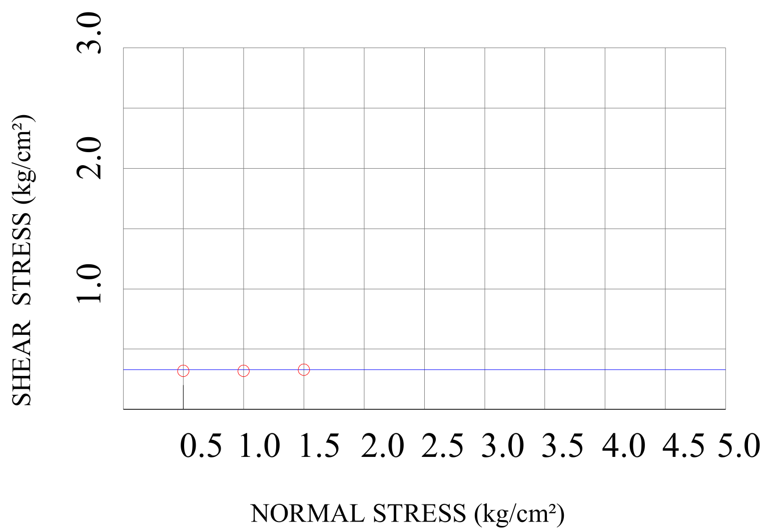
COHESION INTERCEPT 'C' (kg/cm²) = 0.35
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION	:- Ruphelia Terminal
BORE NO	:- BH-3
SAMPLE LOCATION(m)	:- 107.81/107.36
SAMPLE ID	:- SPT-01

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.33
2	1.0	0.33
3	1.5	0.33



COHESION INTERCEPT 'C' (kg/cm²) = 0.33

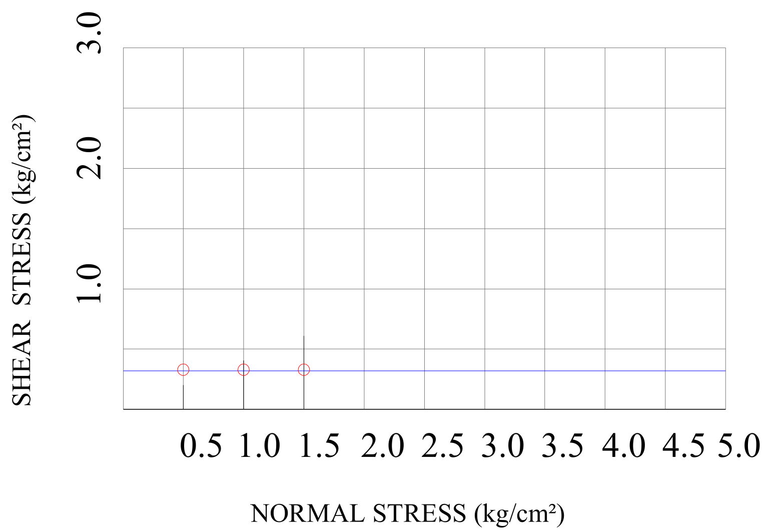
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-3
SAMPLE LOCATION(m) :- 106.31/105.86
SAMPLE ID :- SPT-02

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.31
2	1.0	0.33
3	1.5	0.31



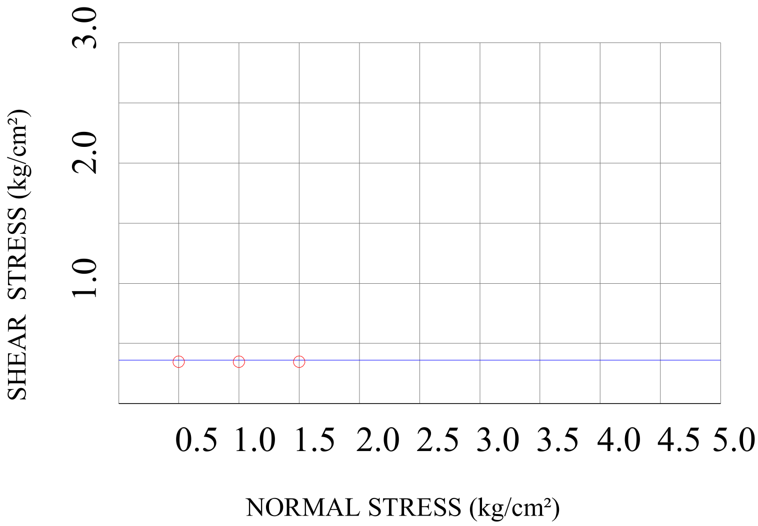
COHESION INTERCEPT 'C' (kg/cm^2) = 0.32
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-3
SAMPLE LOCATION(m) :- 104.81/104.36
SAMPLE ID :- SPT-03

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.35
2	1.0	0.36
3	1.5	0.36



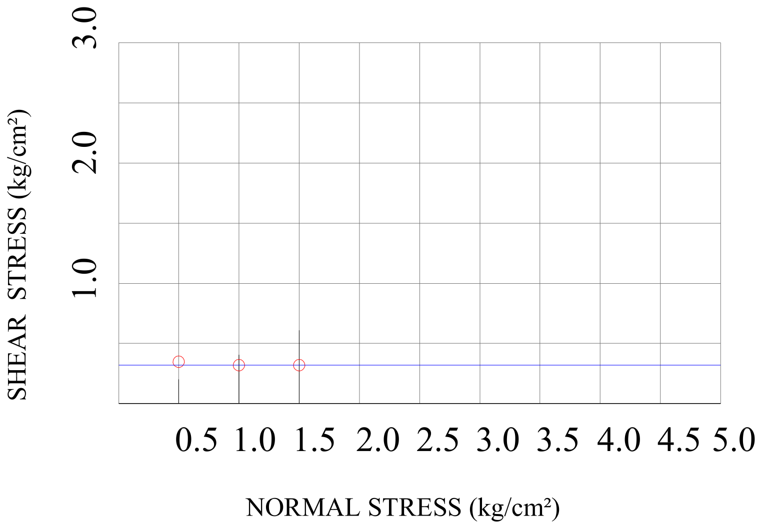
COHESION INTERCEPT 'C' (kg/cm^2) = 0.36
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-3
SAMPLE LOCATION(m) :- 103.31/102.86
SAMPLE ID :- SPT-04

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.30
2	1.0	0.32
3	1.5	0.32



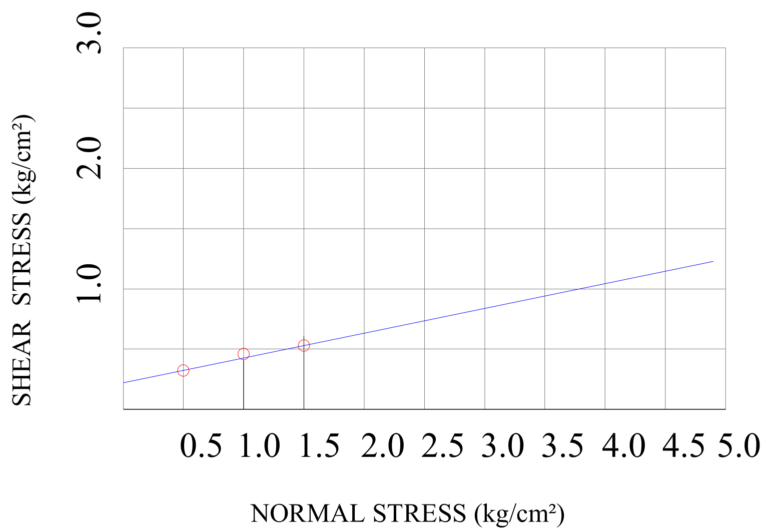
COHESION INTERCEPT 'C' (kg/cm²) = 0.32
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-3
SAMPLE LOCATION(m) :- 101.81/101.36
SAMPLE ID :- SPT-05

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.32
2	1.0	0.46
3	1.5	0.53



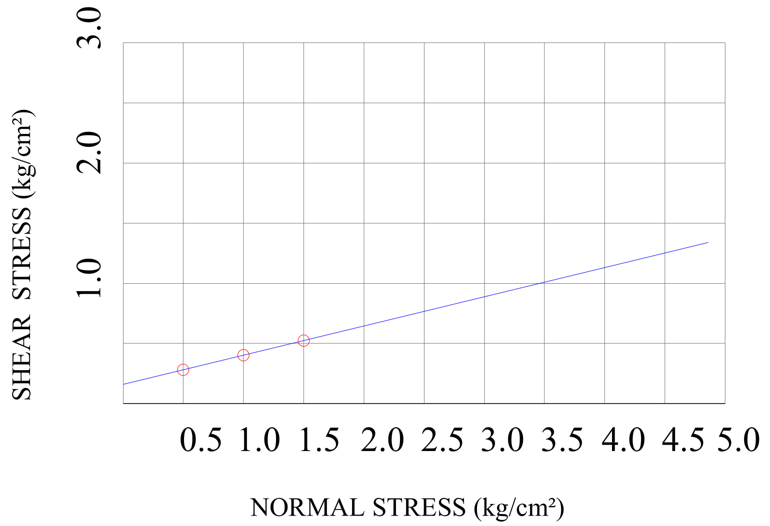
COHESION INTERCEPT 'C' (kg/cm²) = 0.22

ANGLE OF SHEARING RESISTANCE = 11.65°

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-3
SAMPLE LOCATION(m) :- 100.31/99.86
SAMPLE ID :- SPT-06

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.28
2	1.0	0.40
3	1.5	0.52



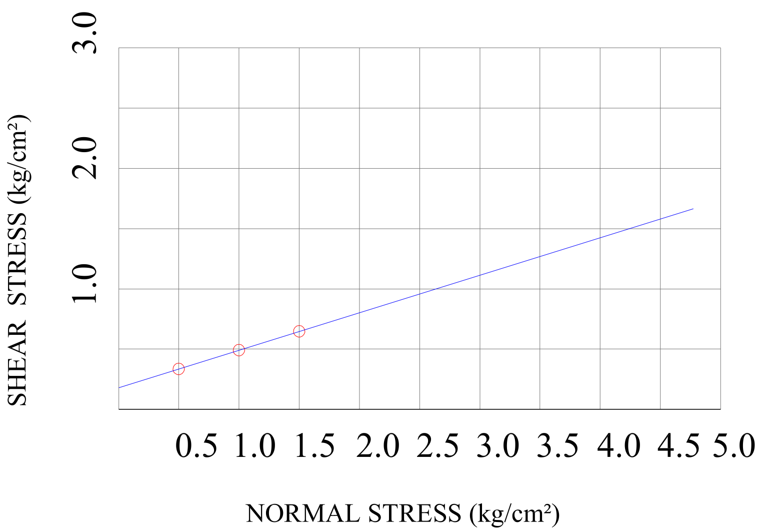
COHESION INTERCEPT 'C' (kg/cm²) = 0.16
ANGLE OF SHEARING RESISTANCE = 13.64°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-3
SAMPLE LOCATION(m) :- 98.81/98.36
SAMPLE ID :- SPT-07

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.34
2	1.0	0.49
3	1.5	0.65



COHESION INTERCEPT 'C' (kg/cm²) = 0.18

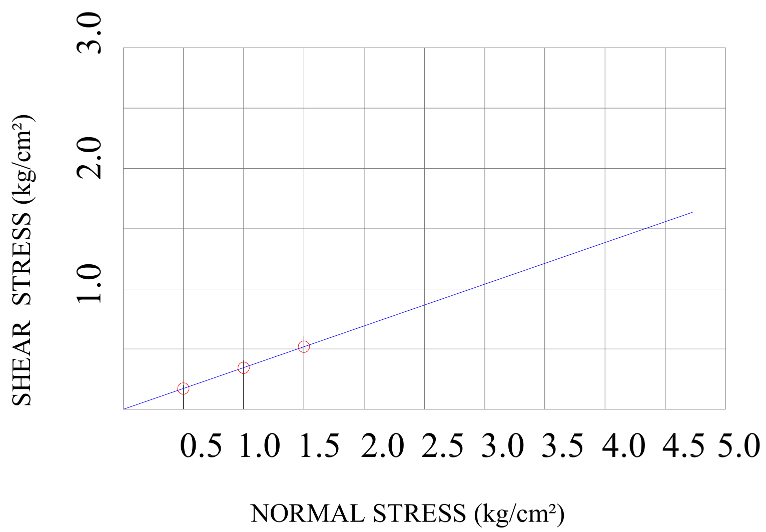
ANGLE OF SHEARING RESISTANCE = 17.28°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-3
SAMPLE LOCATION(m) :- 97.31/96.86
SAMPLE ID :- SPT-08

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.17
2	1.0	0.35
3	1.5	0.52



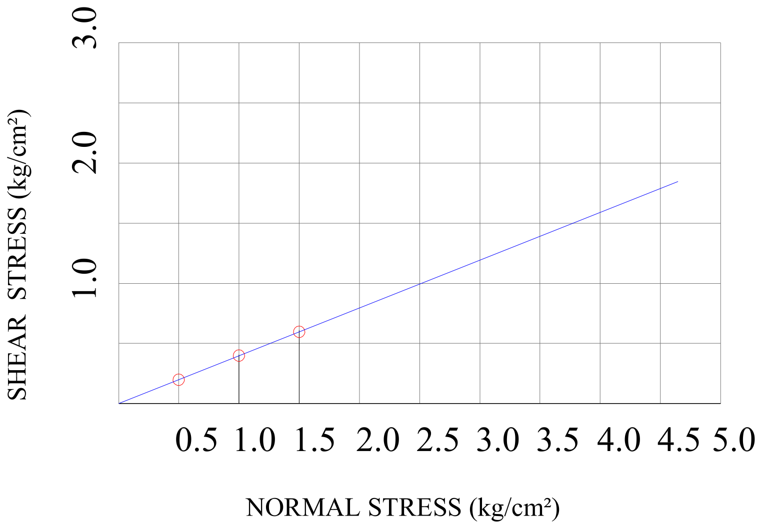
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 19.11°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-3
SAMPLE LOCATION(m) :- 95.81/95.36
SAMPLE ID :- SPT-09

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.20
2	1.0	0.40
3	1.5	0.60



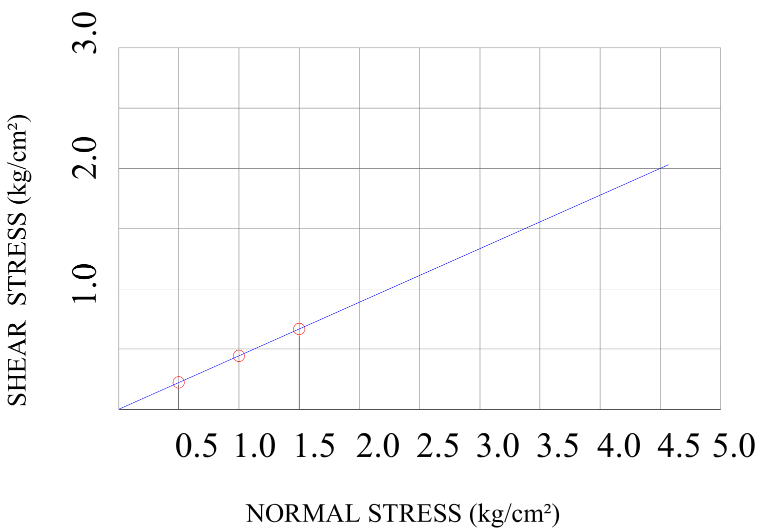
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 21.68°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-3
SAMPLE LOCATION(m) :- 94.31/93.86
SAMPLE ID :- SPT-10

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.22
2	1.0	0.44
3	1.5	0.67



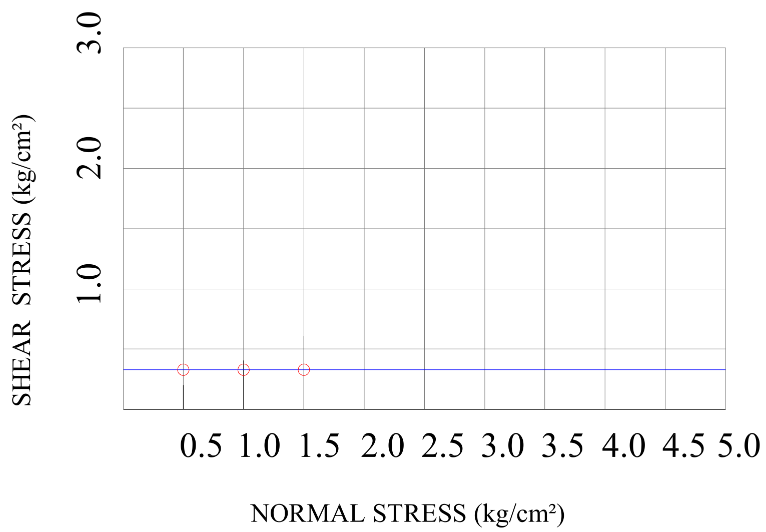
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 23.96°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 111.90/110.40
SAMPLE ID :- DS-01

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.30
2	1.0	0.33
3	1.5	0.33



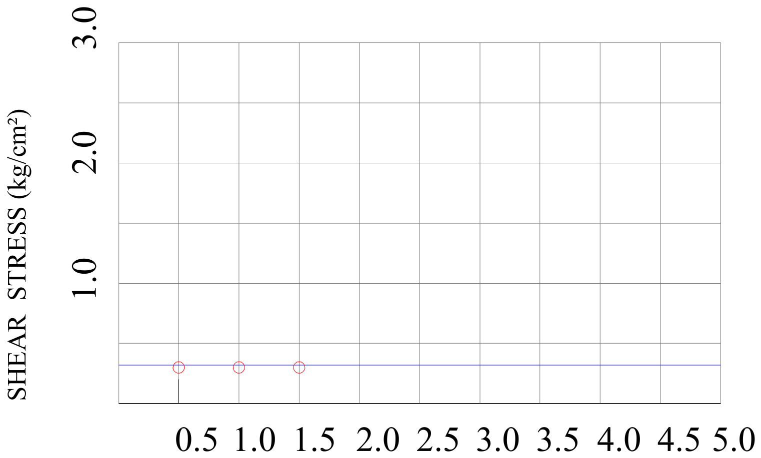
COHESION INTERCEPT 'C' (kg/cm²) = 0.33
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 110.40/109.95
SAMPLE ID :- SPT-01

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.30
2	1.0	0.30
3	1.5	0.30



NORMAL STRESS (kg/cm²)

COHESION INTERCEPT 'C' (kg/cm²) = 0.32

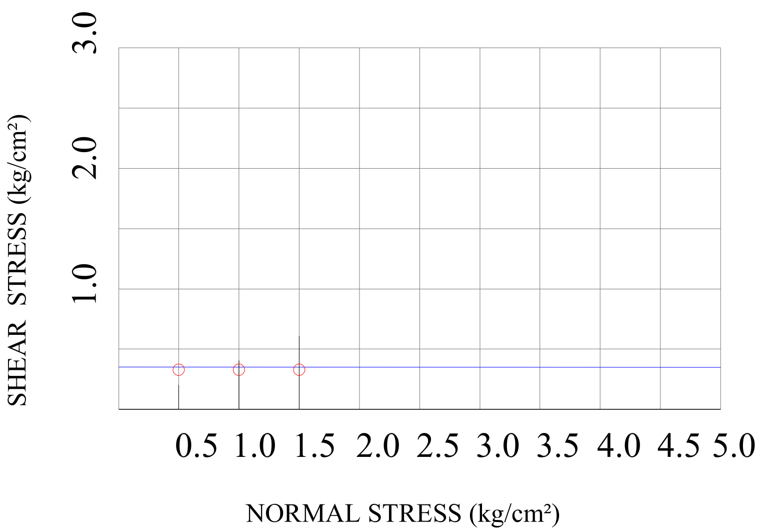
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 108.90/108.45
SAMPLE ID :- SPT-02

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.33
2	1.0	0.32
3	1.5	0.32



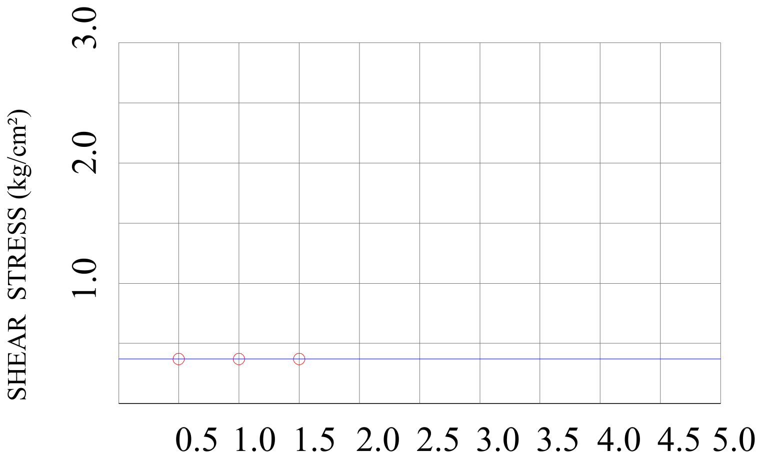
COHESION INTERCEPT 'C' (kg/cm²) = 0.35
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 107.40/106.95
SAMPLE ID :- SPT-03

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.36
2	1.0	0.37
3	1.5	0.37



NORMAL STRESS (kg/cm²)

COHESION INTERCEPT 'C' (kg/cm²) = 0.37

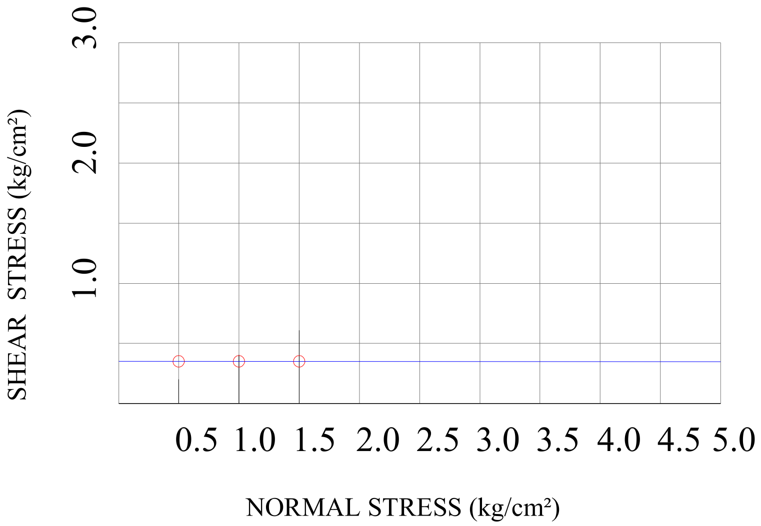
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 105.90/105.45
SAMPLE ID :- SPT-04

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.35
2	1.0	0.35
3	1.5	0.35



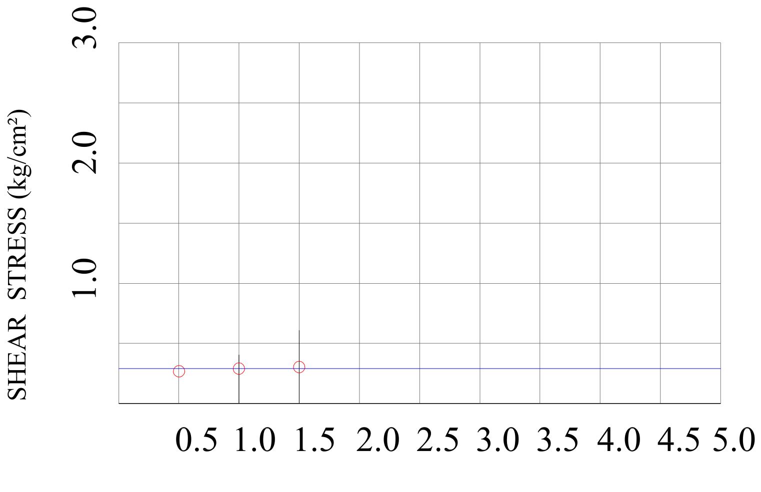
COHESION INTERCEPT 'C' (kg/cm²) = 0.35
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 104.40/103.95
SAMPLE ID :- SPT-05

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.27
2	1.0	0.29
3	1.5	0.29



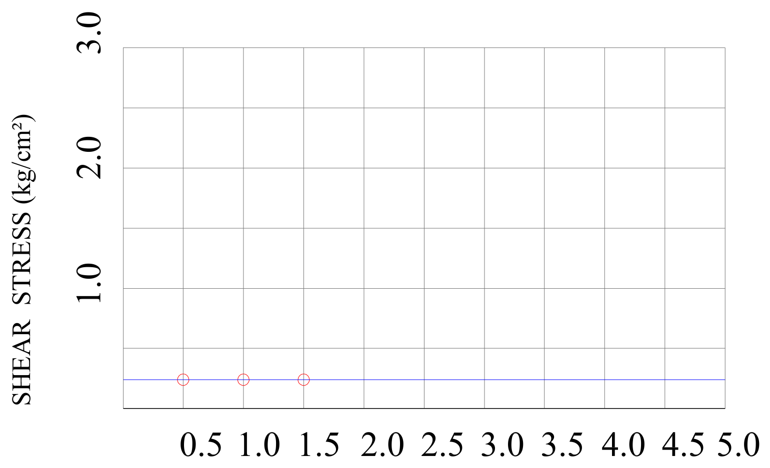
COHESION INTERCEPT 'C' (kg/cm²) = 0.29
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 102.90/102.45
SAMPLE ID :- SPT-06

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.23
2	1.0	0.24
3	1.5	0.24



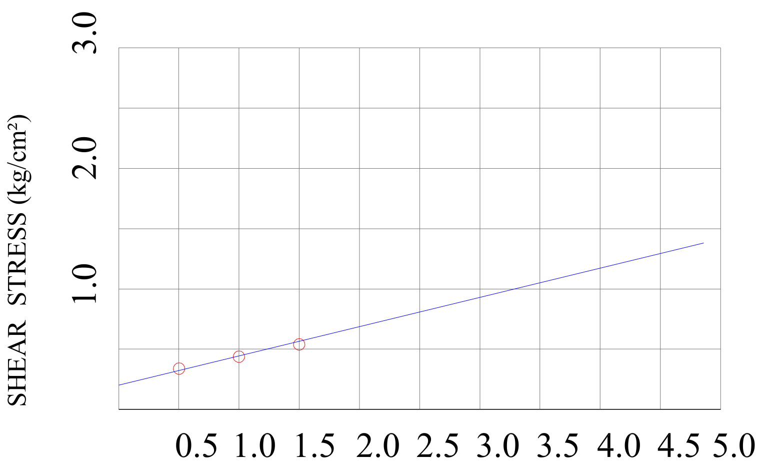
COHESION INTERCEPT 'C' (kg/cm^2) = 0.24
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 101.40/100.95
SAMPLE ID :- SPT-07

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.34
2	1.0	0.44
3	1.5	0.54



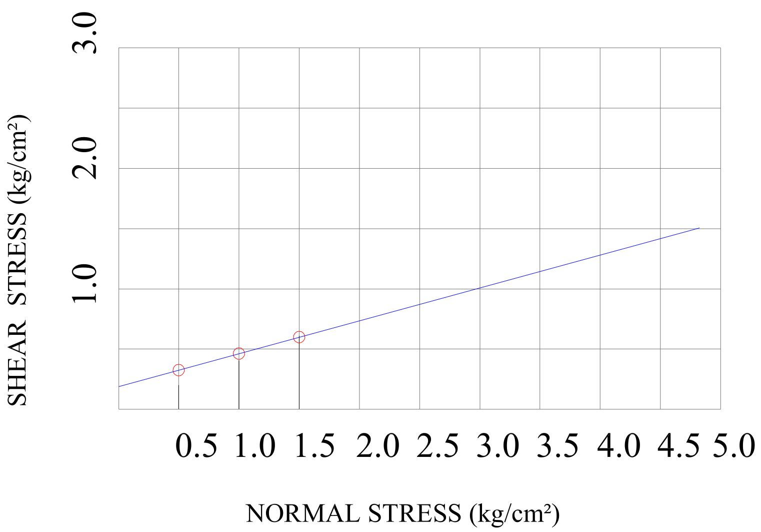
COHESION INTERCEPT 'C' (kg/cm²) = 0.20
ANGLE OF SHEARING RESISTANCE = 13.65°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 99.90/99.45
SAMPLE ID :- SPT-08

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.33
2	1.0	0.46
3	1.5	0.60



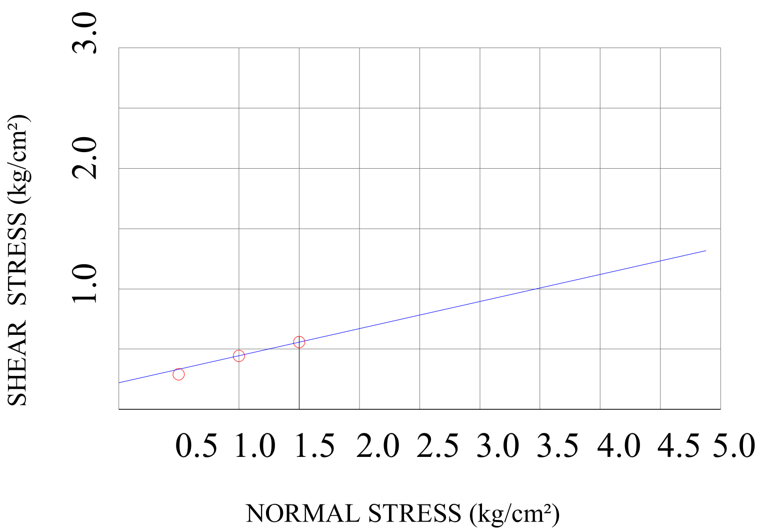
COHESION INTERCEPT 'C' (kg/cm²) = 0.19
ANGLE OF SHEARING RESISTANCE = 15.26°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 98.40/97.95
SAMPLE ID :- SPT-09

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.30
2	1.0	0.44
3	1.5	0.56



COHESION INTERCEPT 'C' (kg/cm^2) = 0.22

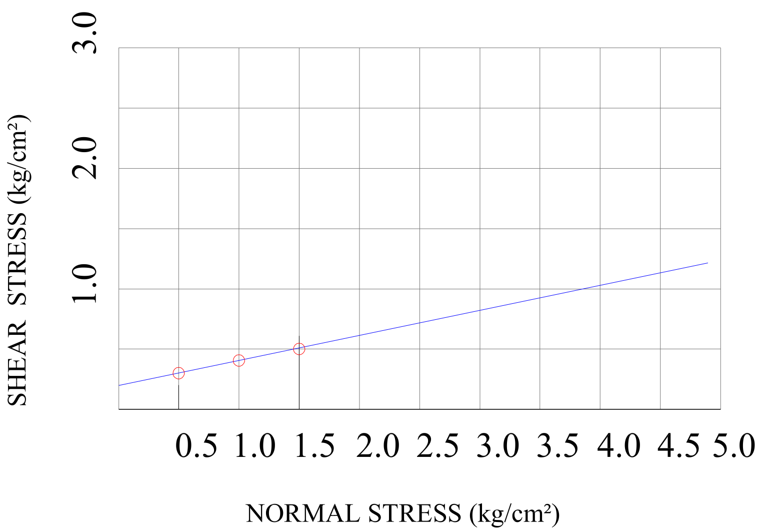
ANGLE OF SHEARING RESISTANCE = 12.68°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-4
SAMPLE LOCATION(m) :- 96.90/96.45
SAMPLE ID :- SPT-10

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.29
2	1.0	0.41
3	1.5	0.50



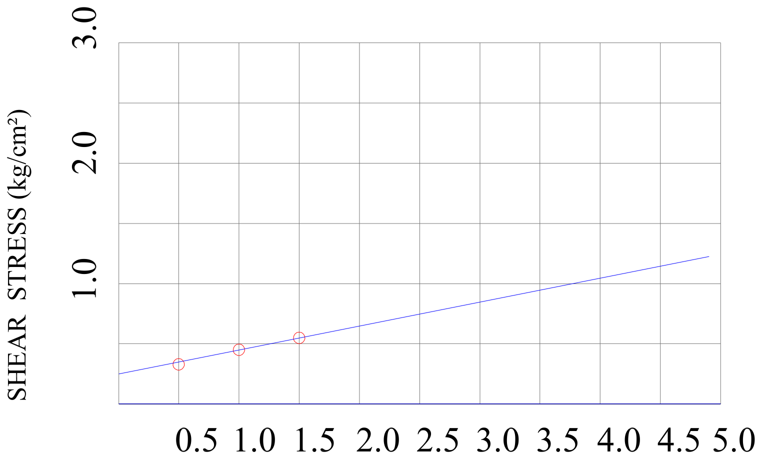
COHESION INTERCEPT 'C' (kg/cm²) = 0.20
ANGLE OF SHEARING RESISTANCE = 11.71°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 108.70/107.20
SAMPLE ID :- DS-01

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.32
2	1.0	0.45
3	1.5	0.55



COHESION INTERCEPT 'C' (kg/cm²) = 0.25

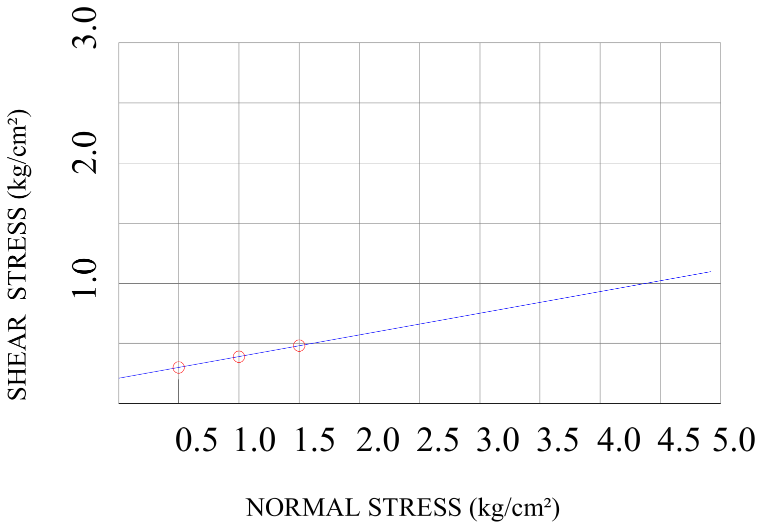
ANGLE OF SHEARING RESISTANCE = 11.25°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 107.20/106.75
SAMPLE ID :- SPT-01

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.29
2	1.0	0.39
3	1.5	0.48



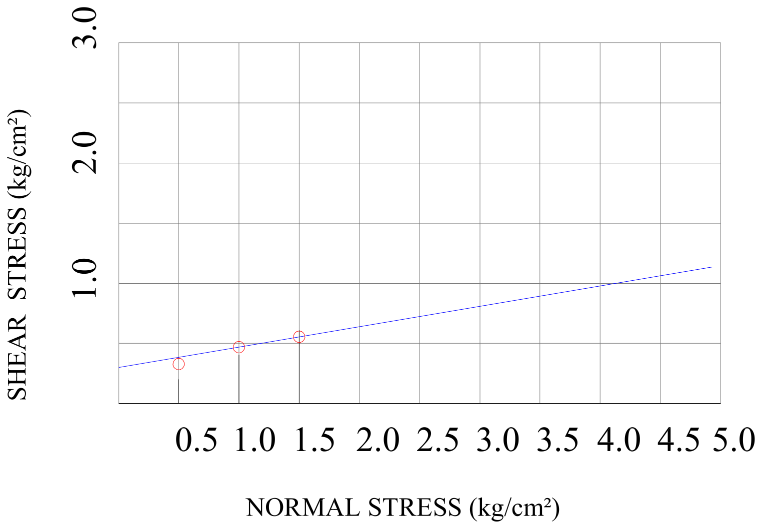
COHESION INTERCEPT 'C' (kg/cm²) = 0.21
ANGLE OF SHEARING RESISTANCE = 10.24°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 105.70/105.25
SAMPLE ID :- SPT-02

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.33
2	1.0	0.47
3	1.5	0.55



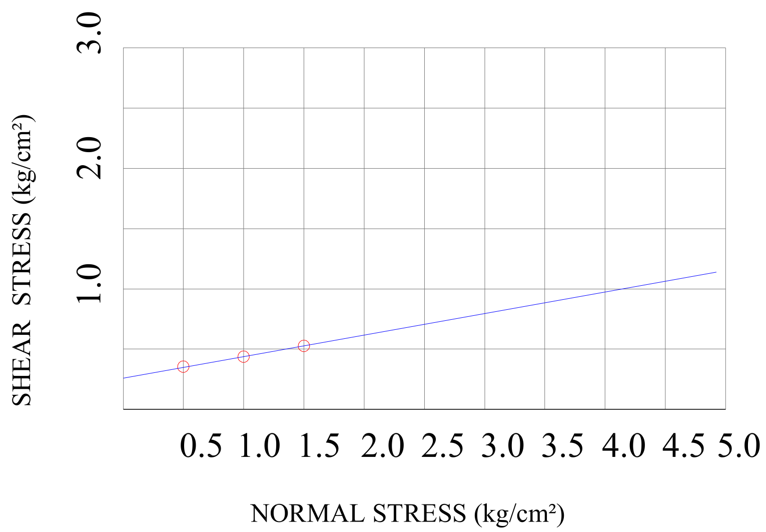
COHESION INTERCEPT 'C' (kg/cm²) = 0.30
ANGLE OF SHEARING RESISTANCE = 9.64°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 104.20/103.75
SAMPLE ID :- SPT-03

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.36
2	1.0	0.44
3	1.5	0.53



COHESION INTERCEPT 'C' (kg/cm²) = 0.26

ANGLE OF SHEARING RESISTANCE = 10.12°

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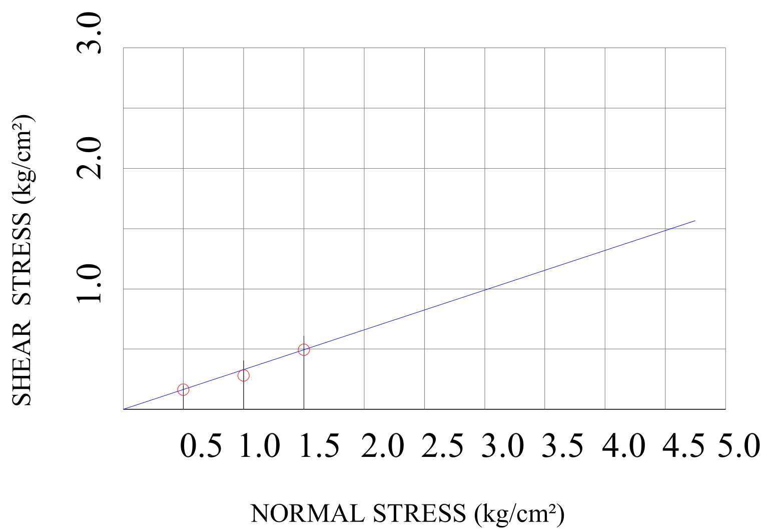
DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 102.70/102.25
SAMPLE ID :- SPT-04

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.16
2	1.0	0.30
3	1.5	0.49



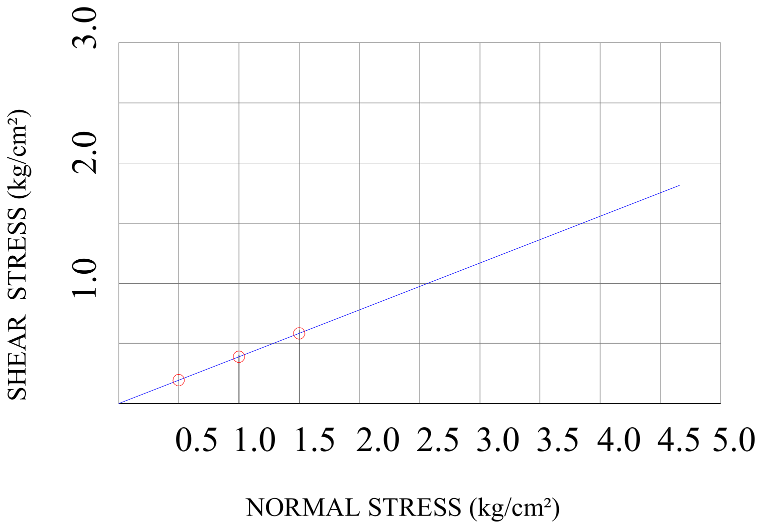
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 18.25°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 101.20/100.75
SAMPLE ID :- SPT-05

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.19
2	1.0	0.39
3	1.5	0.58



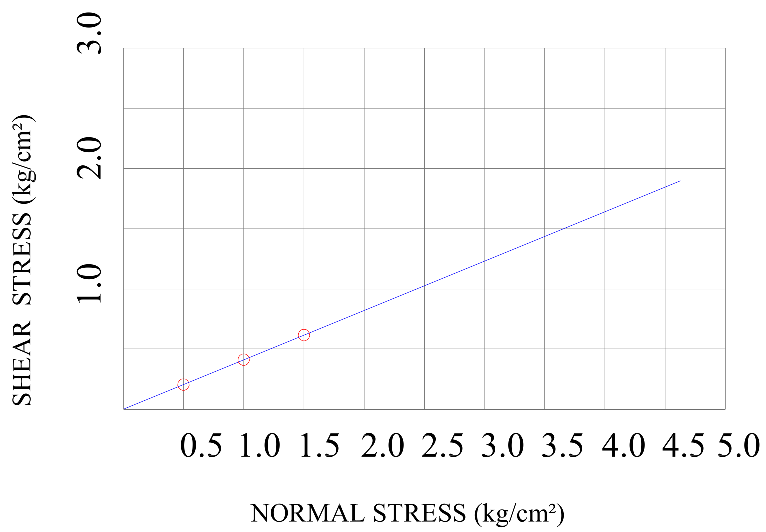
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 21.27°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 99.70/99.25
SAMPLE ID :- SPT-06

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.21
2	1.0	0.41
3	1.5	0.62



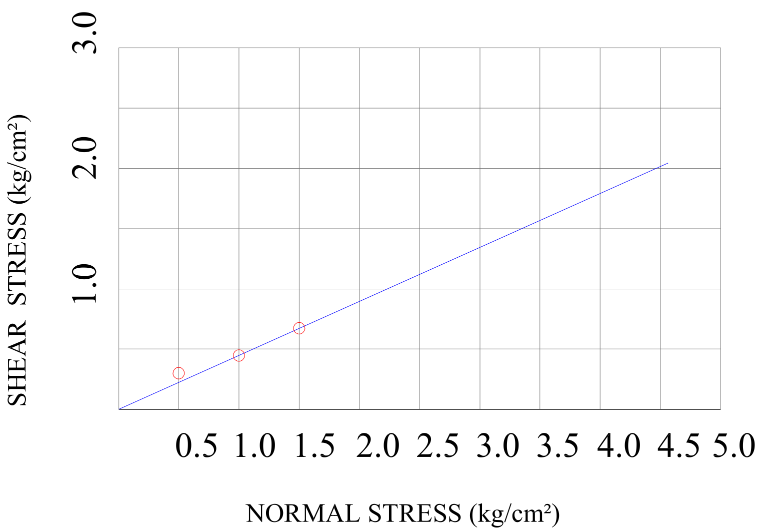
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 22.31°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 98.20/97.75
SAMPLE ID :- SPT-07

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.30
2	1.0	0.45
3	1.5	0.67



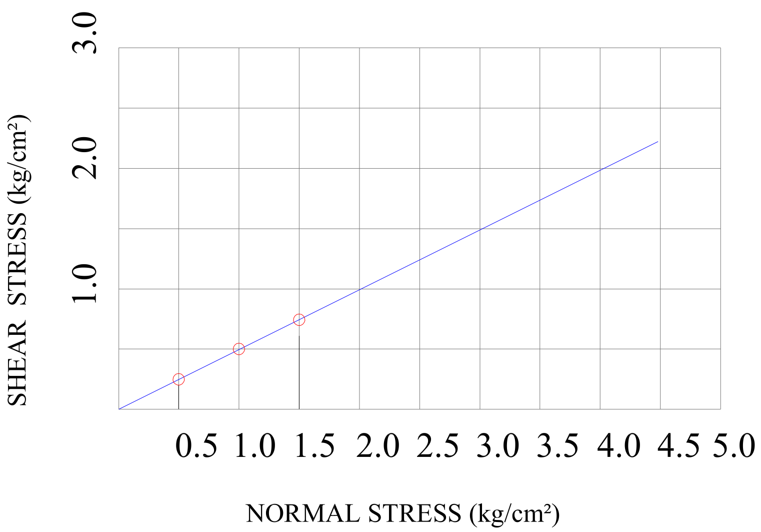
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 24.15°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 96.70/96.25
SAMPLE ID :- SPT-08

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.27
2	1.0	0.50
3	1.5	0.74



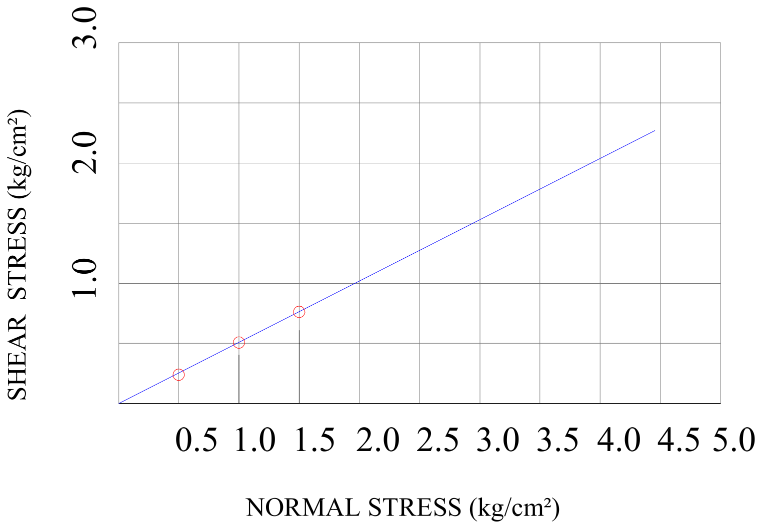
COHESION INTERCEPT 'C' (kg/cm^2) = 0
ANGLE OF SHEARING RESISTANCE = 26.38°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 95.20/94.75
SAMPLE ID :- SPT-09

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.24
2	1.0	0.50
3	1.5	0.76



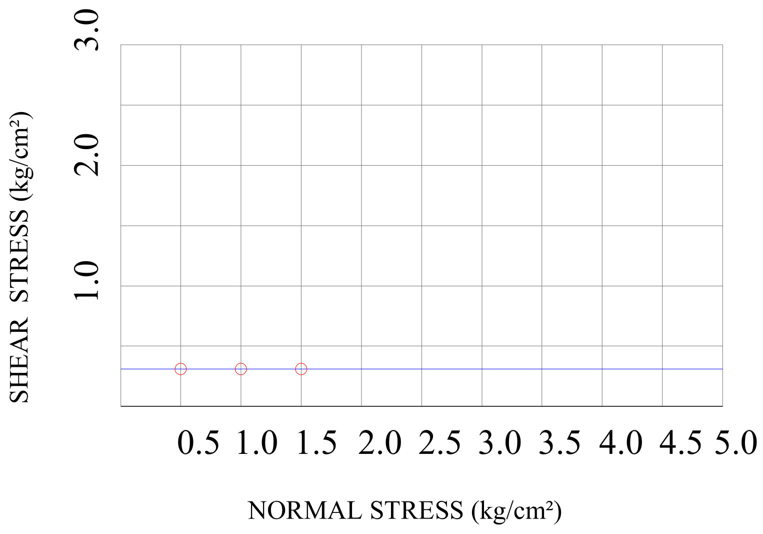
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 27°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-5
SAMPLE LOCATION(m) :- 93.70/93.25
SAMPLE ID :- SPT-10

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.30
2	1.0	0.31
3	1.5	0.31



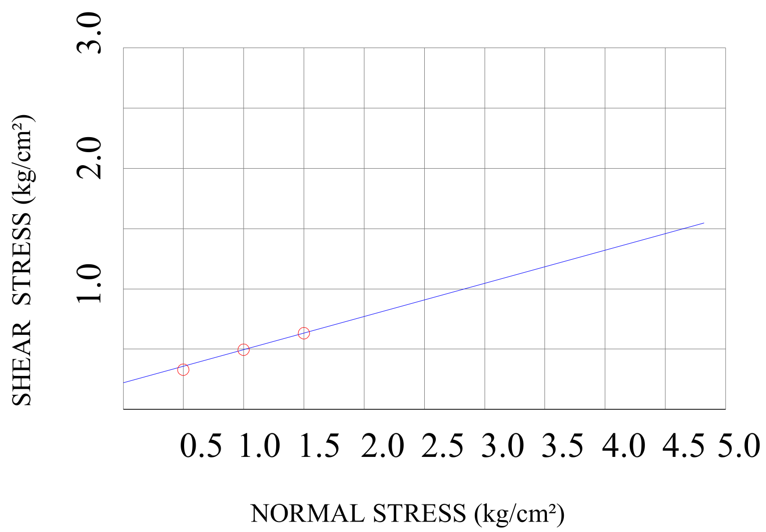
COHESION INTERCEPT 'C' (kg/cm²) = 0.31
ANGLE OF SHEARING RESISTANCE = 0°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-6
SAMPLE LOCATION(m) :- 111.30/109.80
SAMPLE ID :- DS-01

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.32
2	1.0	0.50
3	1.5	0.63



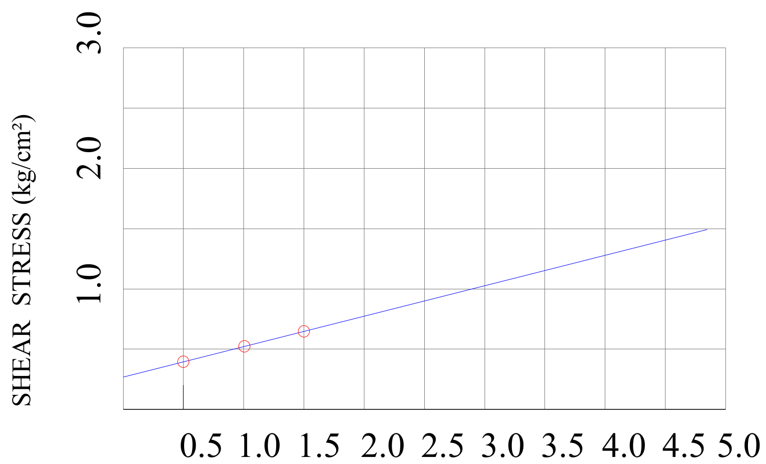
COHESION INTERCEPT 'C' (kg/cm²) = 0.22
ANGLE OF SHEARING RESISTANCE = 15.39°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-6
SAMPLE LOCATION(m) :- 109.80/109.35
SAMPLE ID :- SPT-01

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.40
2	1.0	0.52
3	1.5	0.65



NORMAL STRESS (kg/cm²)

COHESION INTERCEPT 'C' (kg/cm²) = 0.27

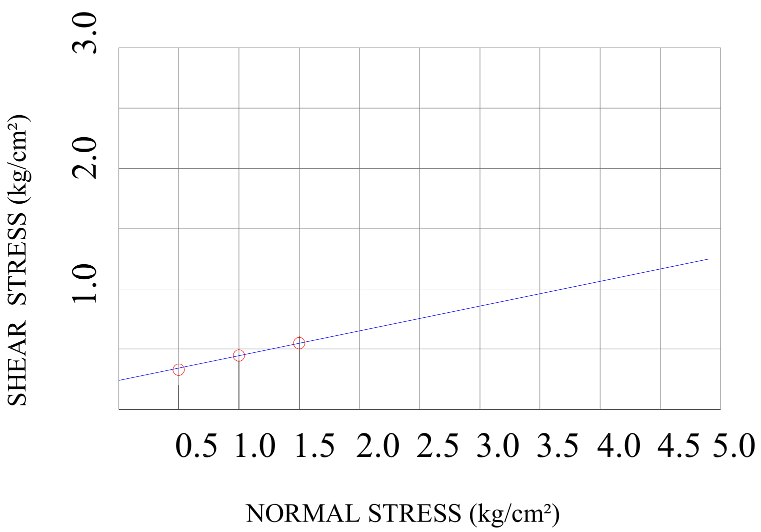
ANGLE OF SHEARING RESISTANCE = 14.15°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-6
SAMPLE LOCATION(m) :- 108.30/107.85
SAMPLE ID :- SPT-02

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.33
2	1.0	0.45
3	1.5	0.55



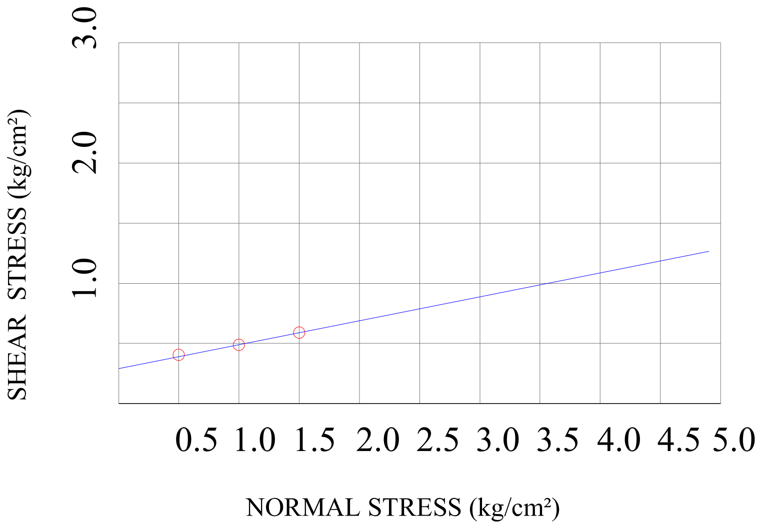
COHESION INTERCEPT 'C' (kg/cm²) = 0.24
ANGLE OF SHEARING RESISTANCE = 18.64°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION	:- Ruphelia Terminal
BORE NO	:- BH-6
SAMPLE LOCATION(m)	:- 106.80/106.35
SAMPLE ID	:- SPT-03

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.41
2	1.0	0.48
3	1.5	0.59



COHESION INTERCEPT 'C' (kg/cm²) = 0.29

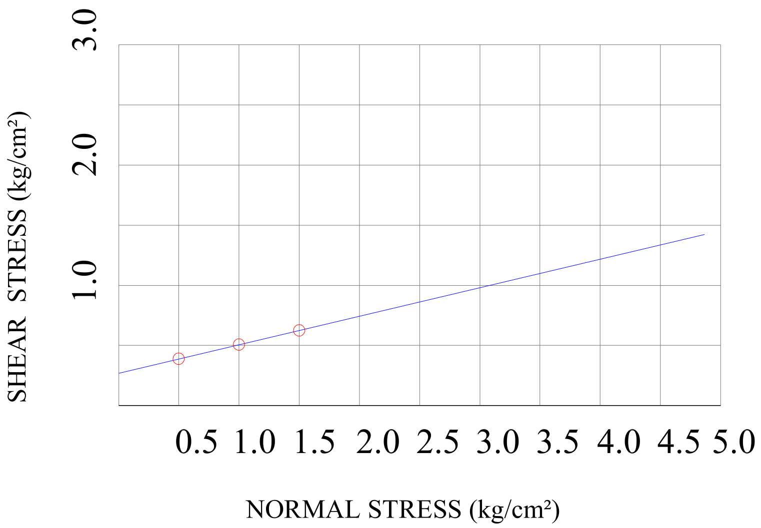
ANGLE OF SHEARING RESISTANCE = 11.27°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-6
SAMPLE LOCATION(m) :- 105.30/104.85
SAMPLE ID :- SPT-04

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.39
2	1.0	0.51
3	1.5	0.63



COHESION INTERCEPT 'C' (kg/cm²) = 0.27

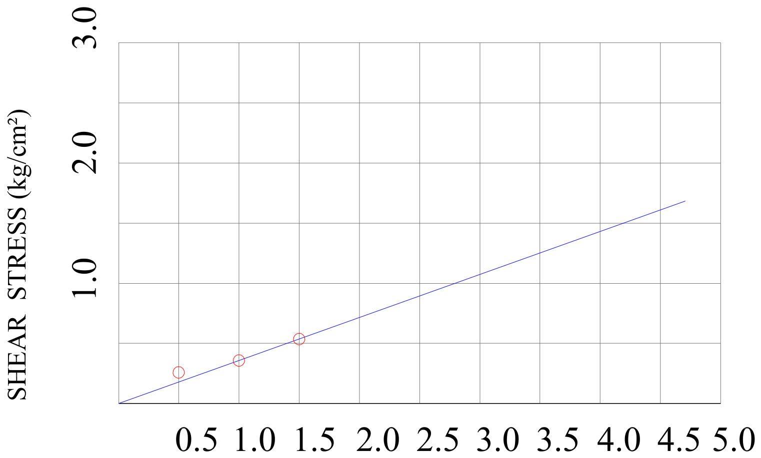
ANGLE OF SHEARING RESISTANCE = 13.33°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-6
SAMPLE LOCATION(m) :- 103.80/103.35
SAMPLE ID :- SPT-05

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.26
2	1.0	0.36
3	1.5	0.54



NORMAL STRESS (kg/cm²)

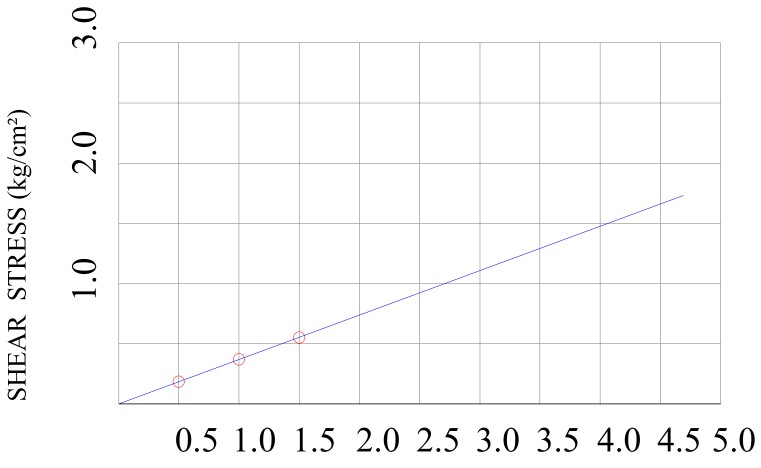
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 19.67°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-6
SAMPLE LOCATION(m) :- 102.30/101.85
SAMPLE ID :- SPT-06

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.19
2	1.0	0.37
3	1.5	0.55



COHESION INTERCEPT 'C' (kg/cm²) = 0

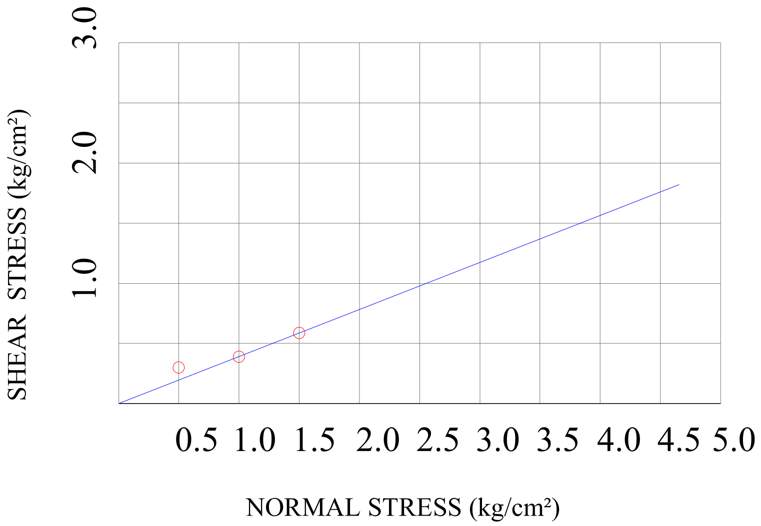
ANGLE OF SHEARING RESISTANCE = 20.26°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-6
SAMPLE LOCATION(m) :- 100.80/100.35
SAMPLE ID :- SPT-07

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.30
2	1.0	0.39
3	1.5	0.59



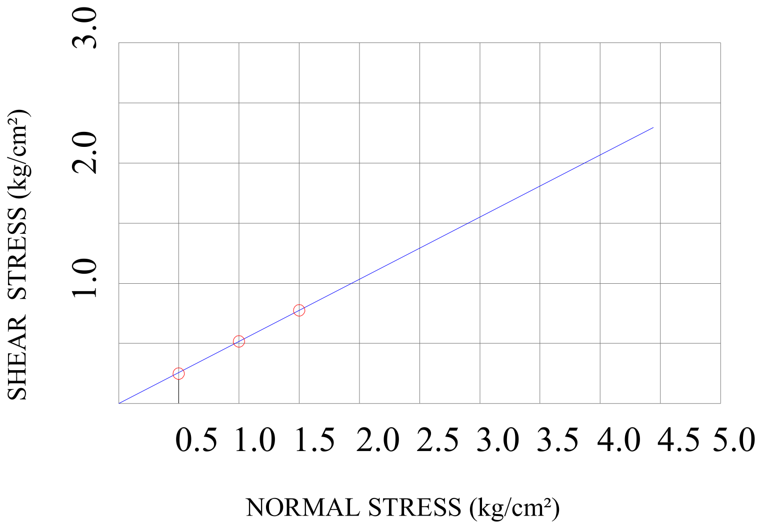
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 21.38°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-6
SAMPLE LOCATION(m) :- 99.30/98.85
SAMPLE ID :- SPT-08

Sr. No.	Normal Stress KG/CM^2	Shear Stress KG/CM^2
1	0.5	0.27
2	1.0	0.52
3	1.5	0.78



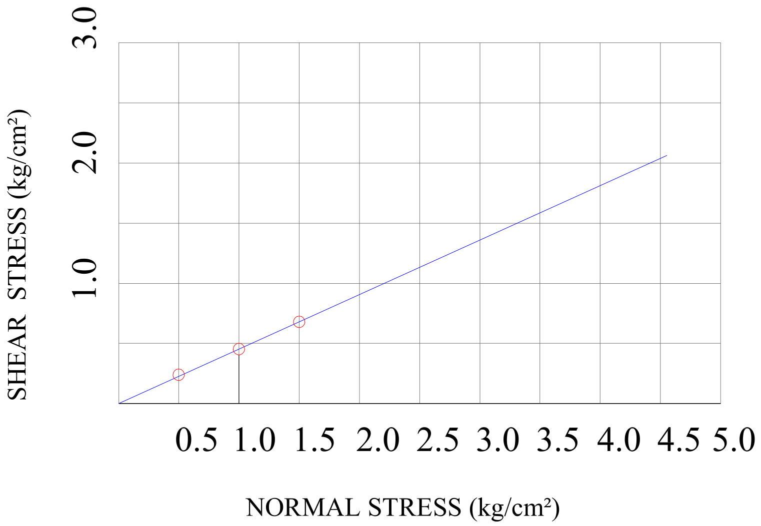
COHESION INTERCEPT 'C' (kg/cm^2) = 0
ANGLE OF SHEARING RESISTANCE = 27.36°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-6
SAMPLE LOCATION(m) :- 97.80/97.35
SAMPLE ID :- SPT-09

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.24
2	1.0	0.45
3	1.5	0.68



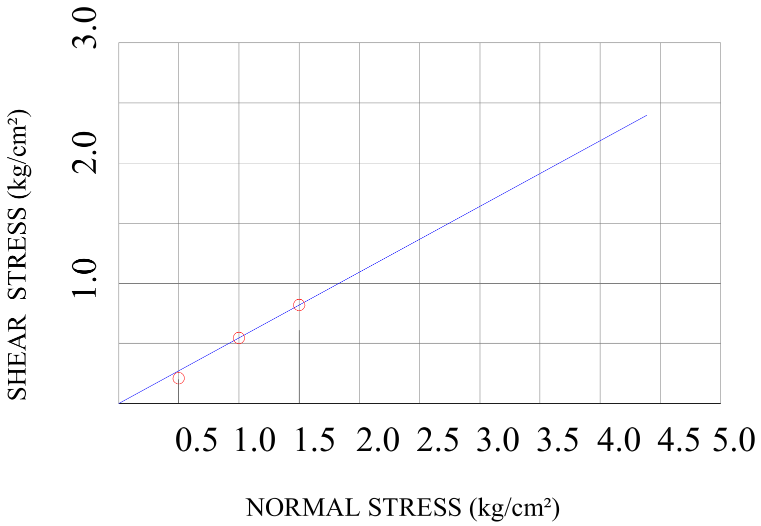
COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 24.37°

SKP PROJECTS PVT. LTD.

DIRECT SHEAR GRAPH

STATION :- Ruphelia Terminal
BORE NO :- BH-6
SAMPLE LOCATION(m) :- 96.30/95.85
SAMPLE ID :- SPT-10

Sr. No.	Normal Stress KG/CM²	Shear Stress KG/CM²
1	0.5	0.21
2	1.0	0.55
3	1.5	0.82



COHESION INTERCEPT 'C' (kg/cm²) = 0
ANGLE OF SHEARING RESISTANCE = 28.65°

SKP PROJECTS PVT. LTD.

Annexure - X
(SITE PHOTOS)

BH-1


PROJECT - Geotech investigation work
CLIENT - AGCL
LOCATION - RUPKHELIA TERMINAL
BHNO - 01
DATE - 28-9-2022
Latitude: 26.47066
Longitude: 93.971682
Elevation: 141.28±14 m
Accuracy: 3.9 m
Time: 28-09-2022 16:08
Note: Project=Geotech investigation work
BHN .1 Client=AGCL
Location=Rupkhelia terminal Date=28-09-2022
Powered by NoteCam

BH-2


Latitude: 26.470743
Longitude: 93.971172
Elevation: 142.17±10 m
Accuracy: 3.9 m
Time: 26-09-2022 08:10
Note: Project=Geotech investigation work
BHN 2 Client=AGCL
Location=Rupkhelia terminal Date=26-09-2022
Powered by NoteCam

BH-3


UTM: 46R
596786mE 2928103mN
Elevation: 99.47±100 m
Accuracy: 3.0 m
Time: 21-09-2022 13:21
Note: PROCT-Geotech investigation
CLIENT-AGCL
BHNO-03 RUPKHELIA TRMINAL
CLIENT- AGCL
BHNO - 03
Date - 21-09-2022
Powered by NoteCam

BH-4


Latitude: 26.469906
Longitude: 93.971419
Elevation: 120.67±19 m
Accuracy: 3.9 m
Time: 27-09-2022 15:55
Note: Project=Geotech investigation work
BHN 4 Client=AGCL
Location=Rupkhelia terminal
CLIENT- AGCL
Powered by NoteCam

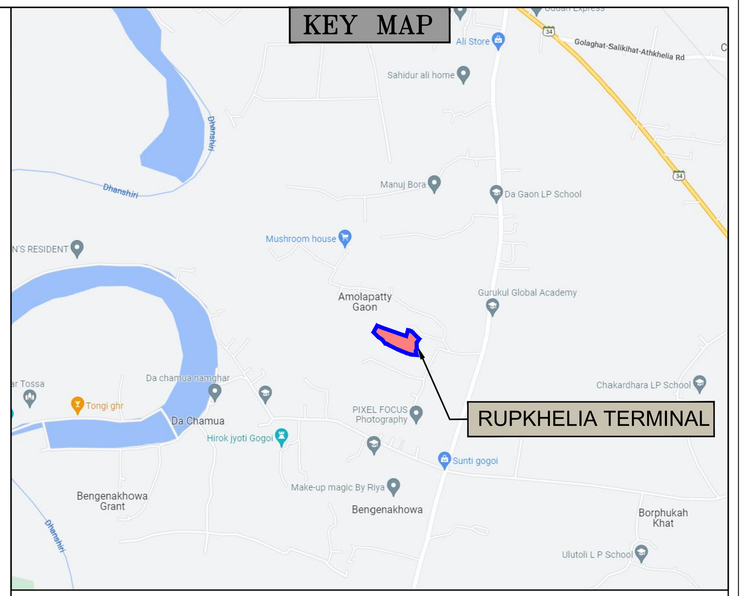
BH-5


PROJECT- G.T Investigation
CLIENT- AGCL
AT.. Rupkhelia Terminal
B.H NO - 05
Date - 23-09-2022
Depth - 15.00m
SKP
AGCL PROJECTS
Rupkhelia
23.09.2022 15:01
46R 596700 2928147
Unnamed Road, Amolapatty Gaon, Assam 785702

BH-6


PROJECT-Geotech investigation WORK
CLIENT= AGCL
LOCATION-RUPKHELIA Terminal
BHNO - 06
DATE=24-9-2022
Latitude: 26.470835
Longitude: 93.970249
Elevation: 109.65±12 m
Accuracy: 8.9 m
Time: 24-09-2022 13:27
Note: AGCL project geoteeh investigation work
Client= AGCL
Location=Rupkhelia Terminal BHNO=06 Date=24-09-2022
Powered by NoteCam

------------ END OF THE REPORT ------------



● HFL AS PER LOCAL INQUIRY : 111.02M

STATEMENT OF REFERENCE BENCH MARK & DGPS

PILLER NO	EASTING	NORTHING	MEAN SEA LEVEL
TBM-105	596860.19	2928285.13	109.83
TBM-106	596920.72	2928262.81	109.83
TBM-197	596795.21	2928200.02	110.79

STATEMENT OF REFERENCE BORE HOLE

BH NO	EASTING	NORTHING	MEAN SEA LEVEL
BH-1	596848.00	2928171.00	110.93
BH-2	596816.00	2928179.00	107.71
BH-3	596787.00	2928101.00	109.31
BH-4	596827.00	2928089.00	111.90
BH-5	596697.00	2928149.00	108.70
BH-6	596714.00	2928195.00	111.30

STATEMENT OF REFERENCE PILLAR

PILLER NO	EASTING	NORTHING	MEAN SEA LEVEL
P1	596814.25	2928204.73	110.07
P2	596838.58	2928193.88	110.21
P3	596871.31	2928161.81	109.74
P4	596855.20	2928078.43	111.36
P5	596804.01	2928089.23	109.98
P6	596783.30	2928097.61	109.89
P7	596705.23	2928135.27	109.72
P8	596688.94	2928150.54	108.60
P9	596683.21	2928158.64	108.52
P10	596664.16	2928172.36	108.50
P11	596680.23	2928210.93	110.51
P12	596713.04	2928198.67	111.00
P13	596799.28	2928177.41	110.50
P14	596805.49	2928176.26	110.54
P15	596653.91	2928152.10	111.50
P16	596617.44	2928159.96	109.67
P17	596653.75	2928231.64	110.97
P18	596659.11	2928244.07	111.00
P19	596687.62	2928238.19	111.00

STATEMENT OF REFERENCE FENCING POINTS BETWEEN PILLAR POINTS

PILLER NO	EASTING	NORTHING	MEAN SEA LEVEL
F1	596836.62	2928195.46	110.05
F2	596853.69	2928177.91	110.62
F3	596858.77	2928172.55	110.83
F4	596825.74	2928081.74	111.52
F5	596814.58	2928084.89	109.88
F6	596751.82	2928111.12	110.44
F7	596750.47	2928111.64	110.49
F8	596749.51	2928112.28	110.40
F9	596740.73	2928117.12	109.66
F10	596705.94	2928134.90	109.71
F11	596693.32	2928143.96	108.94
F12	596681.66	2928161.07	108.51
F13	596677.98	2928164.39	108.50
F14	596679.56	2928211.06	110.50
F15	596746.76	2928186.23	111.00
F16	596748.47	2928186.77	110.99
F17	596750.13	2928191.78	110.67

LEGEND

Proposed PipeLine (IP21/1, TP21)			
Road		Building	
Cart Track		Settlements	
Culvert		Temple	
River		Well	W
Nala		Tube Well	
Canal		Other Tree	
Bench Mark	TBM	Lamp Pole	
Mango Tree		Power Line	FP
DGPS		Pillar	P1
Major Contour	100.00	Sport Levels	100.50
Minor Contour	100.50	Fancing	F1

REV	DATE	REVISION	BY	CHKD	APRD	PROJ ENGR
1	23/02/2023	ISSUED FOR CLIENT REVIEW	Arti	Ramesh		
0	03/10/2022	ISSUED FOR CLIENT REVIEW	Arti	Ramesh		

Note:-

1. ALL DIMENESION & LEVEL ARE IN METER
2. REF. BENCH MARK MSL VALUE TBM-105 "110.58" MARK ON ROAD EDGE,CONTOUR INTERVAL 0.50 M
3. 48°9'12" ANGLE BETWEEN TRUE NORTH & MAGNETIC NORTH.
4. WGS-84/UTM ZONE 46 CO-ORDINATES SYSTEM.

PROJECT :- SURVEY OF PIPELINE ROUTE AND STATIONS FOR GOLAGHAT TO BCPL LAKWA GAS PIPELINE PROJECT

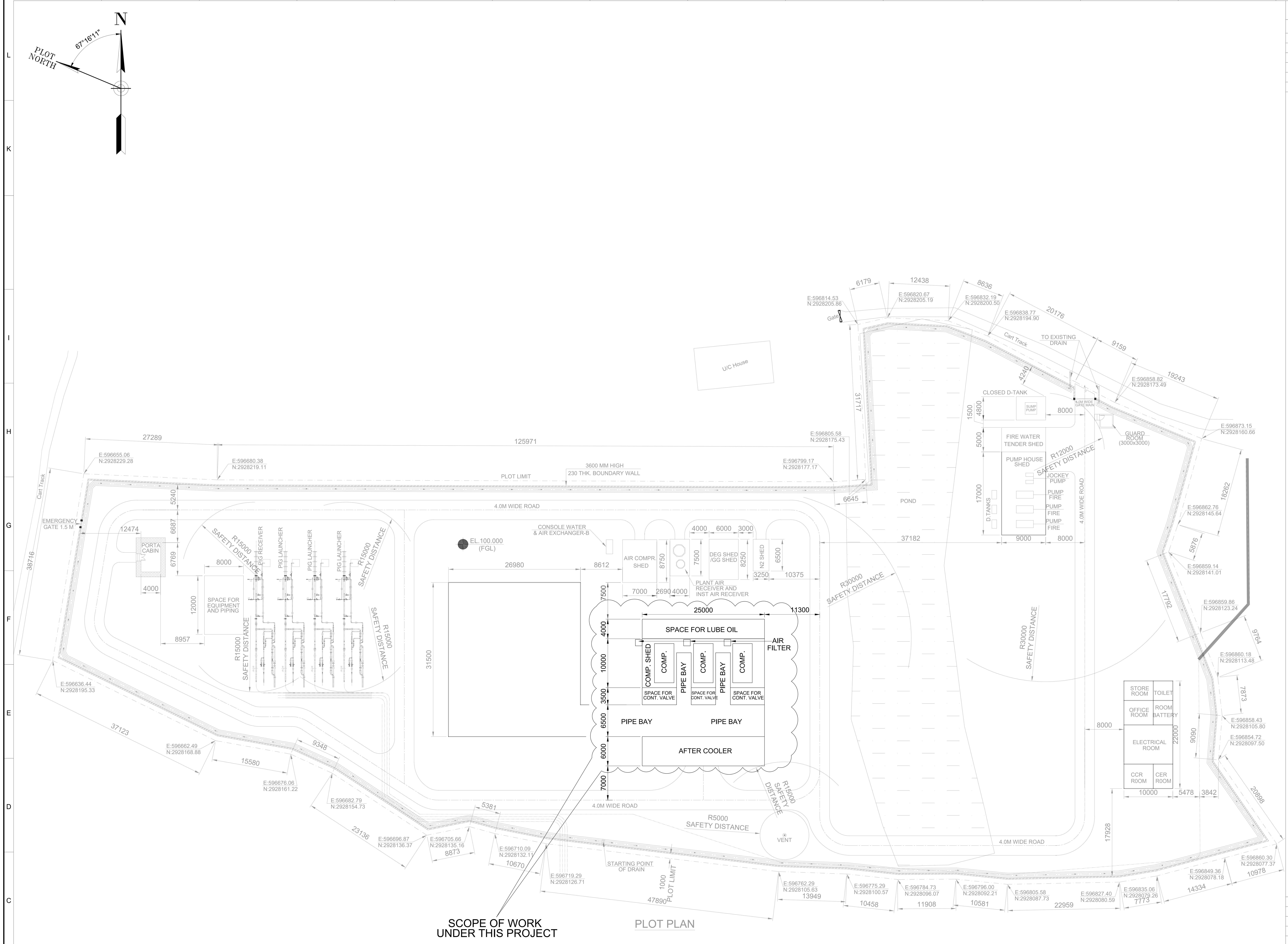
CLIENT: - ASSAM GAS COMPANY LTD (A GOVT. OF ASSAM UNDERTAKING)

SURVEY AGENCY: - SKP
201-205, Sai Samarth Complex, Near Maneja Crossing Makarpura Road, Vadodara - 390 010.
Phone= 7228940501/7228940502
(ANISO 9001:2015 CERTIFIED COMPANY)

TITLE:- TOPOGRAPHICAL SURVEY DRAWING OF RUPKHELIA TERMINAL SURVEY AREA:19094.786SQM(4.718ACRES)

SCALE:- 1M 0 1 2 3 4 5 6 7M
SCALE: 1:500 OR 1CM = 05M
CONTOUR INTERVAL = 0.5

DATE:- OCT 2022 | RIV :- | CAD FILENAME:- SKP/RUPKHELIA TERMINAL



REFERENCE DRAWINGS	
DRAWING TITLE	DRAWING NUMBER

NOTES :-

1. ALL DIMENSIONS ARE IN MM & LEVELS ARE IN METERS.

LEGENDS:-

● FGL — FINISHED GROUND LEVEL

REV	DATE	DESCRIPTION	BY	CHKD	APPD
TA	25.10.23	ISSUED WITH TENDER	SP	SS	RBS
CA	20.10.23	ISSUED FOR CLIENT REVIEW	SP	AK	RBS
IA	09.10.23	ISSUED FOR INTERNAL REVIEW	SP	AK	RBS

OWNER: ASSAM GAS COMPANY LTD.

ENGINEERING CONSULTANT : PIPELINE ENGINEERING CONSULTANTS PVT. LTD. (PLECO)

PROJECT: **DEVELOPMENT OF RUPKHELIA COMPRESSOR STATION**

DWG. TITLE : **INDICATIVE PLOT PLAN**

SCALE.	JOB NO.	DRAWING NUMBER	REV.
1:400	P167	P167-00-DWG-C001	TA
SHEET 1 OF 1			

CAD FILE NAME : \\ P167-00-DWG-C001

SHEET SIZE : A1 (841 mm x 594 mm)

DEVELOPMENT OF RUPKHELIA COMPRESSOR STATION

DOCUMENTS/ DRAWINGS REQUIRED FOR OWNER/ CONSULTANT REVIEW (CIVIL STRUCTURAL & ARCHITECTURAL)

DOCUMENT NO. P167-LST-C001-RTA

TA	25.10.23	ISSUED WITH TENDER	AK/ SS	RBS	RKB
CA	20.10.23	ISSUED FOR CLIENT REVIEW	AK/ SS	RBS	RKB
IA	06.10.23	ISSUED FOR INTERNAL REVIEW	AK/ SS	RBS	RKB
Rev.	**Date**	**Purpose**	**Prepared by**	**Reviewed by**	**Approved by**

Contents

1.0 INTRODUCTION

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e., Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCMD of gas per day.

AGCL is planning to expand its Pipeline Network in Assam for increasing gas transportation capacity so they want to develop new Compressor Station at Rupkhelia (Assam).

Pipeline Engineering Consultants Pvt. Ltd. (PLECO) has been appointed as PMC by AGCL for Project Management for the Project.

2.0 PURPOSE

The purpose of this document is to specify the documents/ drawings required for owner/ consultant review (civil, structural and architectural) for the development of BOO natural gas compressor station with maintenance area and worker shed at Rupkhelia.

3.0 DEFINITION

Where used in this document, the following terms shall have the meanings indicated below, unless clearly indicated by the context to this order.

PROJECT	Development of Rupkhelia Compressor Station
CLIENT /OWNER	Assam Gas Company Ltd. (AGCL)
PMC	Pipeline Engineering Consultants Pvt. Ltd. (PLECO)
CONTRACTOR	Agency appointed by CLIENT/ OWNER for executions of assigned tasks

4.0 LIST OF DOCUMENTS REQUIRED

Sr. No.	Description	Review	Information/ Record	Remarks
1.0	Drawing Control Index for entire work.	✓		
2.0	Architecture drawings of compressor Shed. Architecture drawings shall contain the followings. (These drawings shall be prepared incorporating comments etc. on the preliminary Dwgs.)			
2.1	Plan of all levels, Key plan.	✓		
2.2	Sections as required for complete understanding of the Design & Construction.	✓		
2.3	Elevations of all sides.	✓		
2.4	Door/ Window details.	✓		
2.5	Flooring details & layouts.	✓		
2.6	Any other Drawing as required for complete understanding of the Design & Construction.	✓		
3.1	Architecture Drawings for Maintenance area shed.		# ✓	
3.2	Architecture Drawings for worker shed.		# ✓	
4.0	Design calculations & Structural Drawings of BOO Compressor Shed.	✓		
5.0	Design calculations & Foundation Drawing for BOO Compressor.	✓		
6.0	Design Calculations & Foundation Drawing for Air Compressor.		✓	
7.0	Design calculations & Structural Drawings of operating platforms.		# ✓	

8.0	Design calculations & Structural Drawings of Pipe Supports.	✓	# ✓	One of each type.
9.0	Design calculations & Structural Drawings of Equipments.	✓	# ✓	One of each type.
10.0	Design calculations & Structural Drawings of Maintenance Shed.		# ✓	
11.0	Design calculations & Structural Drawings of worker Shed.		# ✓	
12.0	Vendor drawing/ documents submission schedule.	✓		

Drawing and documents other than those identified for review shall be submitted for records.

Notes: -

1. The categorization (Review / Records) is given as guidance only. The exact categorization shall be decided during review of drawing / document schedule of the contractor / vendor.
2. The list given above is indicative only. Contractor shall generate all other drawings & documents required for completion of the job as required by Owner / Consultant.
3. Schedule of submission of drawings & documents shall be decided during detailed engineering stage.
4. All vendor documents shall be reviewed & signed by the Contractor before forwarding the same to Owner / Consultant for review / Records.
5. General philosophy of designs of all the structures and equipment foundations along with explanatory sketches and basis of design/ analysis shall be submitted and got reviewed by Owner/ Consultant before the contractor proceeds with the final design and construction drawings.
6. Structural design and drawings for any structure/ equipment foundation shall be submitted only after the GA drawings, reference equipment data sheets have been reviewed in at least code-2 by Owner/ Consultant.
7. Submission of typical review category documents shall be taken up prior to corresponding information category documents. Owner/ Consultant comments furnished on typical review category documents shall also be duly taken care in information category documents before issuing them for construction.

8. The contractor shall make the review category drawings, duly signed by Owner/ Consultant specialist, available at site and ensure that the construction is done as per these drawings duly taking care of the comments marked on such drawings.

9. In case of drawings issued for Records simultaneously to Owner/ Consultant and site, the contractor may proceed with construction based on these drawings. However, the contractor shall make the duly signed (by Owner/ Consultant) prints available at site and take care of Owner/ Consultant comments, if any, on such drawings.

10. The contractor shall submit in one lot all the design and drawings for each independent structure so as to facilitate on overall systematic review. Incomplete lot shall be returned without review.

11. All calculations shall be done in Excel/ word format and soft copy (native files) of the calculations shall be submitted along with hard copies.

12. Usage of INHOUSE developed software package shall not be permitted. STAAD Pro shall be used for analysis and design of structures.

ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF RUPKHELIA COMPRESSOR STATION

SECTION - C

CIVIL, STRUCTURAL & ARCHITECTURAL

ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF RUPKHELIA COMPRESSOR STATION

CIVIL DESIGN BASIS

DOC NO: P167-DEB-C001-RTA

TA	25.10.23	ISSUED WITH TENDER	AK	RBS	RKB
CA	20.10.23	ISSUED FOR CLIENT REVIEW	AK	RBS	RKB
IA	06.10.23	ISSUED FOR INTERNAL REVIEW	AK	RBS	RKB
Rev.	**Date**	**Purpose**	**Prepared by**	**Reviewed by**	**Approved by**

ABBREVIATIONS

BIS	Bureau of Indian Standards
IRC	Indian Road Congress
OISD	Oil Industry Safety Directorate
PNGRB	Petroleum and Natural Gas Regulatory Board
WBM	Water Bound Macadam
WMM	Water Mix Macadam
TMT	Thermo Mechanically Treated
CBR	California Bearing Ratio

CONTENTS

1.0 INTRODUCTION

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Where used in this document, the following terms shall have the meanings indicated below, unless clearly indicated by the context to this order.

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CLIENT /OWNER	Assam Gas Company Ltd. (AGCL)
PMC	Pipeline Engineering Consultants Pvt. Ltd. (PLECO)
CONTRACTOR	Agency appointed by CLIENT/ OWNER for execution of assigned tasks

3.0 SCOPE

This document specifies the design criteria and loads that shall be taken in to account for the design of all industrial plant and non-plant structures and buildings pertaining to the project.

All codes referred in this document pertain to BIS (Bureau of Indian Standards) publications and bearing prefix IS.

Whenever any reference to BIS code is made, the same shall be taken as the latest revision (with all amendments issued there to) on the notified date of submission of tender.

Apart from the BIS codes mentioned in particular in the various clauses of this document, all other relevant codes related to the specific job under consideration and/or referred to in the above-mentioned codes, shall be followed wherever applicable. Reference to some of the codes in the various clauses of this document does not limit or restrict the scope of applicability of other relevant codes.

In case of any variation/contradiction between the provisions of BIS codes and the requirements given hereunder, the provisions given in this document shall have precedence over all others. In absence of relevant BIS codes, reference to corresponding British/American codes may be made (in that order of preference).

All designs, detailing and construction shall strictly conform to the enclosed standards, specifications. Only if relevant information is not available in this document, reference to relevant BIS code shall be made.

4.0 REFERENCE CODES & STANDARDS / PUBLICATIONS (LATEST VERSION)

The following Indian codes and standards shall be generally used for design of Civil and Structural works. In all cases, latest revisions with amendments, if any, shall be followed. Apart from the specific codes mentioned herein, all other relevant and related codes concerning the specific job under consideration and/or referred to in these codes and technical specifications shall be followed wherever applicable. (All codes shall be latest as on the date of issuing of tender / bid document).

a. IS: 875 - (part I to V) Code of practice for Design loads (other than earthquake) for Buildings & Structures.

b. IS: 1893 - Criteria for Earthquake resistant design of structure.

c. IS: 15498- Guidelines for improving the cyclonic resistance of low-rise houses and other buildings/structures.

4.1 FOUNDATION

a. IS: 1080- Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell).

b. IS: 1904- Code of practice for design and construction of foundations in soils - General requirements.

c. IS: 2911(part1 to 4) - Code of practice for design and construction of Pile Foundations.

d. IS: 2974(Part 1 to 2) - Code of practice for design and construction of machine foundations.

e. IS: 6403- Code of practice for determination of bearing capacity of shallow foundations.

f. IS: 8009 (Part-I) - Code of practice for calculation of settlement of foundations.

g. IS: 2950(part1) - Code of practice for design and construction of Raft Foundations.

4.2 CONCRETE STRUCTURES

a. IS: 432 - 1982 (Part1, 2) - Specification for mild steel and medium Tensile steel bars and hard drawn steel wire for concrete reinforcement.

b. IS: 456-2000 - Code of practice of plain and reinforce concrete.

c. IS: 1786 - High strength deformed steel bars and wires for concrete reinforcement.

d. IS: 1566 - Hard drawn steel wire fabric for concrete reinforcement.

e. IS: 13920 – Ductile detailing of RCC structures subjected to seismic forces.

f. IS: 13620 – Fusion bonded epoxy coated reinforcing bars - specification.

g. IS: 3370 (Part 1) - Code of practice Concrete structures for the storage of liquids

4.3 STEEL STRUCTURES

a. IS: 277 - Galvanized steel sheets (Plain and corrugated).

b. IS: 800 - Code of practice for general construction in steel.

c. IS: 806 - Code of practice for use of steel tubes in general building construction.

d. IS: 808 - Dimensions for Hot Rolled Steel Beams, Columns, Channel and Angle Sections.

e. IS: 813 - Scheme of symbols for welding

f. IS: 814 - Covered electrodes for manual metal arc welding of carbon and carbon manganese steel-Specifications

g. IS: 816 - Code of practice for use of metal arc welding for general construction in mild steel.

h. IS: 7215 - Tolerances for Fabrication of Steel Structures

i. IS: 1161 - Steel tubes for general structural purposes.

j. IS: 12778 - Hot rolled parallel flange steel sections for beams, columns and bearing piles- dimensions & sectional properties.

k. IS: 1367 - Technical supply conditions for threaded steel fasteners

l. IS: 2062 - Steel for general structural purposes

m. IS: 3502 -Code of Practice for steel chequered plates

n. IS: 5624 - Code for foundation bolts

o. IS: 12893 – tolerances for erection of steel structures.

4.4 OTHER CODES

a. Indian Road Congress (IRC) Codes.

b. OISD 163

c. PNGRB

4.5 LIST OF SOFTWARES

Following software shall be used for structural design of building and its foundations: -

a) STAAD Pro

b) MS Excel/Word

5.0 SYSTEM OF UNITS

SI units shall be used throughout calculations, documents, reports and drawings and are as follows:

Length	m, mm
Force	KN
Uniform load	KN/m
Area	m^2
Pressure	KN/m^2
Density	Kg/m^3
Deflections	mm
Bending moment	KN – m
Stress	N/mm^2

6.0 DESIGN CRITERIA/ PHILOSOPHY

Material of construction shall be as specified in the scope of work.

All structures shall be checked and designed to satisfy the worst load combination (refer IS: 875 & IS:456) that produces maximum forces and effects and consequently maximum stresses. Wind and earthquake (or blast) loads shall not be considered to act simultaneously.

The design and detailing of all structures, whether concrete or steel, shall suffice a minimum fire rating of greater than 2 (two) hours or as specified by licensor. Norms as defined in OISD-STD-164, IS: 800 and IS: 456 shall be strictly adhered to for structural steel and concrete works, respectively.

7.0 DESIGN LOADS

The various parameters to be used in analysis and design have been extracted from the project documents. These include the various loads and force to be considered. The same are as listed below.

7.1 DEAD LOAD (DL)

The weight of all permanent construction, including foundation, walls, floors, roofs, partitions, fire-proofing, stairways and fixed service and other equipments including all fixtures, platforms, ladders and attached piping but excluding their content. If piping weight is not indicated separately or included in the weight of the equipment, the same shall be taken as 10% of the operating weight of equipment. Component of soil backfill weight over foundation slab shall be considered as foundation dead load.

The dead load of false ceiling & false flooring shall be considered as 0.75 KN/Sq.m, wherever applicable.

The unit weight of materials in general, shall be in accordance with IS: 875 Part- 1.

7.2 LIVE LOAD (LL)

The weight superimposed by the use and occupancy of the building or structure, not including the wind, earthquake or dead load. Live load shall generally be as per IS 875 (Part-2)

The major live loads for different units shall be as per Table – 1.

Table 1. Minimum live loads on floors

SL. No.	Occupancy or use (types of floors)	Live Kg/m^2	Remarks
1a	Cross over	250	
1b	Access walkway	300	
2	Staircases	500	
3	Control room	500	
4	Electrical room	500	
5	Store room	750	
6	UPS / Battery room	750	
7	Office room	400	
8	Valve operating Platform	300	
9a	Non-accessible - Flat roofs	75	Plus hung loads if any
9b	Accessible - Flat roofs	150	Plus hung loads if any
10	Maintenance area	750	
11	Toilet & Bathroom	200	

7.3 WIND LOAD (WL)

Wind loads shall generally be as per IS 875-1987 (Part 3).

Design wind speed is the one for which a structure is to be designed and is calculated from basic wind speed as

Vz = k1*k2*k3*Vb

Where,

Vb = basic wind speed = 50 m/s

k1 = risk coefficient = 1 (Permanent Structure)

k1 = risk coefficient = 0.70 (Temporary Structure / boundary wall)

Terrain category=2

K2= terrain height structure size factor, as per table-2 of IS: 875 (III).

k3 = topography factor = 1

The design life span of all permanent structures shall be taken as 50 years.

Temporary structures & boundary wall shall be designed for a design life span of 5 years.

7.4 SEISMIC LOADS (SL)

Seismic forces shall generally be as per IS: 1893 with seismic zone-V & zone factor of 0.36.

7.5 MONORAIL LOAD

Monorail loads shall be considered in design, with impact factors and longitudinal surge as per IS: 875 (Part-2).

7.6 SOIL AND HYDROSTATIC PRESSURE

UPLIFT ON FOUNDATIONS

In the design of foundations, the upward pressure of water, if any, shall be taken as the full hydrostatic pressure applied over the entire area. The hydrostatic head shall be measured from the underside of the construction. Factor of safety against uplift shall be 1.2. For purpose of calculating downward load due to over burden, the weight for the same shall be calculated for volume over projected plan area only. In other words, volume of overburden beyond projected plan area shall not be considered. Overburden load shall be considered as dead load of soil under dry condition.

7.7 PIPING LOAD (PL)

7.7.1 PIPING LOAD FOR ERECTION P (E)

It is the weight of pipe including insulation, if any.

7.7.2 PIPING LOAD FOR TEST P (T)

It is the weight of pipe including insulation and weight of water.

7.7.3 PIPING LOAD FOR OPERATION P (O)

It is the weight of pipe including insulation and weight of contents.

Note: In calculating the actual weight of pipe, the class of pipe, material contents and insulation, if any shall be taken into consideration. Insulation density shall be taken as 260 kg/m3, if not furnished.

7.8 THERMAL LOAD (TL)

Thermal force is defined as the force occurring due to thermal expansion or contraction of the structural materials, the force occurring at piping and equipment anchor points and the sliding friction forces due to thermal expansion or contraction.

The sliding friction force shall be calculated in accordance with the actual conditions. The friction co-efficient to be used in determining lateral loads due to sliding shall be as follows:

a. Teflon pads 0.1

b. Steel plates 0.3

c. Steel to concrete 0.45

d. Concrete to soil 0.40

7.9 EQUIPMENT LOAD (EL)

7.9.1 EQUIPMENT LOAD FOR ERECTION E (E)

It is the weight of equipment excluding fire proofing, piping all loose internals, platforms supported from the equipment.

7.9.2 EQUIPMENT LOAD FOR TEST E (T)

It is the weight of equipment including fire proofing, piping, all loose internals, insulation, platforms supported from the equipment and weight of water.

7.9.3 EQUIPMENT LOAD FOR OPERATION E (O)

It is the weight of equipment including fire proofing, piping, all loose internals, insulation, platforms supported from the equipment and liquid/gas contents.

7.9.4 EQUIPMENT LOAD FOR MAINTENANCE (M)

It is the weight of equipment to be considered for maintenance purpose. In case dead weight and live load on platforms are given on equipment data sheets, it shall be taken accordingly.

8.0 FOUNDATION DESIGN

8.1 MINIMUM REQUIREMENTS

Foundation design shall be as per approved Geo-technical report. Piling if required shall be provided as per relevant specification & IS codes.

a. Minimum depth of foundation for all structures shall be from FGL or NGL, whichever is lower. Factors of safety against overturning and sliding shall be as per values given in Table - 2. Component of soil backfill weight over foundation slab shall be appropriately covered as foundation dead load. For stability checks the weight of soil as overburden shall be as per Table - 2.

Table – 2. Factors of safety

S. No.	Type of Structure	FOS OT – W/S (EL) (i)	FOS OT – N - W/S (EL) (ii)	FOS OT – W/S (OL) (iii)	FOS OT – N - W/S (iv)	FOS SL – W/S (v)	FOS SL – N - W/S (vi)

1	All Structures, Equipments in Units & Offsite	1.5	1.5	1.5	2.0	1.5	1.5
2	Flood light Mast	1.5	-	1.5	-	1.5	-
3	Retaining wall	-	-	1.5	2.0	1.5	1.5

Legend:

i. OT-W/S (EL) - FOS against Overturning with Wind/ Seismic in Erection condition.

ii. OT-N-W/S (EL) - FOS against Overturning without Wind/ Seismic in Erection condition.

iii. OT-W/S (OL) - FOS against Overturning with Wind/ Seismic in operating condition.

iv. OT-N-W/S (OL) - FOS against Overturning without Wind/ Seismic in operating condition.

v. SL-W/S - FOS against Sliding with Wind/ Seismic.

vi. SL-N-W/S - FOS against Sliding without Wind/ Seismic.

Notes:

i. * With blast pressure.

ii. Minimum factor of safety against uplift shall be 1.2 for all structures (in case of sumps, lining weight shall not be included).

iii. Percentage weight of overburden shall be taken as 100% and shall be considered on projected plan area of footing.

b. The design ground water level shall be as per the approved Geo-technical report/data and shall be adequately accounted for design due to hydrostatic pressure.

c. Allowable net safe bearing capacity of soil shall be based on the following settlement criteria for dead and imposed load conditions:

Foundations in unit areas, utility areas and foundations for Plant buildings	25mm settlement
Non-Plant buildings	50mm settlement.

For transient loadings, e.g., wind/seismic, SBC (safe bearing capacity) shall be considered based on the shear criteria instead of settlement criteria.

d. Permissible increase in SBC/ pile capacity shall be as per relevant BIS codes if not otherwise mentioned in the Geo-technical report.

e. Under blast (due to hydrocarbon explosion) load combinations the design bearing pressure of soil shall not exceed twice the allowable static bearing pressure of soil. Pile capacity shall be similarly increased in blast condition to 1.5 times the permissible capacity under compression, tension and shear modes.

f. Grade of concrete to be used in foundation shall in general be as per the philosophy adopted for the entire Project. However, minimum cement content, type of cement and any remedial actions required for foundations due to aggressiveness of sub soil water shall be as per the Geo-technical report.

8.2 ANTI – TERMITE TREATMENT

No anti termite treatment shall be provided inside the unit area except buildings. All offsite and utility plant/ non plant Buildings shall be provided with anti-termite treatment as per IS: 8944 and IS: 6313.

8.3 MINIMUM COVER TO FOUNDATION BOLTS/ POCKET

Minimum distance from the center line of foundation bolt/ anchor bolt to edge of pedestal shall be the maximum of the following:

a. Clear distance from the edge of the base plate or base frame to the outer edge of the pedestal shall be minimum 50mm.

b. Clear distance from the face of pocket to the outer edge of the pedestal shall be 100mm.

c. Clear distance from the edge of the sleeve or anchor plate to the edge of pedestal shall be 100mm.

8.4 HEIGHT OF PEDESTAL

S. No.	Project Philosophy
1	The minimum projection of pedestals supporting any steel structure/ column bases shall be 300 mm/ 150 mm above the high point of pavement/ finished grade/ finished floor level whichever is higher, for outdoor and indoor located pedestals respectively.
2	Offsite pipe rack/ pipe bridge/ pipe support pedestals shall be of minimum 500 mm height above FGL.
3	The maximum projection of pedestals for staircase/ ladder shall be 200 mm.

8.5 GROUTING & MINIMUM GROUT THICKNESS

The minimum thickness of grout shall be 30 mm. Unless/ otherwise required in equipment/ vendor data sheet.

All anchor bolt sleeves/pockets and spaces under column bases, shoe plates etc. shall be grouted with free flow, non-shrink (premix type) grout with 28-day minimum cube crushing strength of 40N/mm2.

Note: Grouting requirement for machines and equipment's are not covered here. The same shall be governed by vendor requirement.

9.0 SPECIAL CONSIDERATIONS FOR REINFORCED CEMENT CONCRETE (RCC) STRUCTURES & FOUNDATIONS

9.1 GENERAL/ DESIGN METHODS

a. All buildings, structures, foundations, machine/equipment foundations, liquid retaining/storage structures, trenches, pits etc. shall be of RCC and designed based on IS Codes (latest revision with all amendments issued there to).

b. Only limit state method as per IS: 456 shall be followed in the design unless otherwise specified elsewhere in this document for special structures.

c. All structures shall be of frame-type construction. With ductile detailing as per provisions of IS 13920 for structure falling in seismic zone III, IV & V.

d. All underground pits, basements, cable trenches etc. shall be of leak-proof RCC construction using waterproofing compounds.

e. All liquid retaining/ storage RCC structures shall be leak-proof and designed as un-cracked section as per IS: 3370. However, the parts of such structures not coming in contact with the liquid shall be designed according to IS:456 except ribs of beams of suspended floor slabs & counter-forts of walls (located on the side remote from the liquid) and roof which shall be designed as un-cracked section. No increase in permissible stresses in concrete and reinforcement shall be made under wind or seismic conditions for such structures.

f. The walls and base slabs of liquid retaining/ storage structures shall be provided with reinforcement on both faces for thicknesses greater than or equal to 150mm. In all liquid retaining structures, PVC water bars (230mm wide, 5mm thick) shall be provided at each construction joint (Horizontal and vertical).

9.2 REINFORCEMENT BARS

High strength deformed (TMT) bars of grade Fe 500D (minimum), conforming to IS: 1786 shall be used as reinforcement for all structures. 18-gauge black soft annealed SWG wire shall be used for binding reinforcement of bars.

Reinforcement bars used for underground works shall be factory manufactured corrosion resistant bars, if required as per sub-soil conditions.

9.3 CONCRETE

The minimum grade of reinforced cement concrete to be used for different structures and foundations shall be M30. From Durability considerations the minimum cement content and maximum water-cement ratio shall be as per the table -3 below. However, the maximum cement content shall not exceed 450 kg/m3.

TABLE-3

Exposure condition	Plain concrete			Reinforced concrete			Remarks
Severe	Grade of concrete	Min. cement content (kg/m³)	Max. free water – cement ratio	Grade of concrete	Min. cement content (kg/m³)	Max. free water – cement ratio	
	M20	250	0.5	M30	320	0.45	

The requirement of grade of concrete, type of cement, minimum cement content and maximum water-cement ratio for concrete to be used in piles shall be as per the requirements given in Geotechnical report.

75mm thick lean concrete of grade 1:5:10 (Nominal Mix) shall be provided under all RCC foundations except under base slab of liquid retaining structures. The lean concrete shall extend 50mm beyond the foundation edges on all sides.

100mm thick lean concrete of grade M20 or 1:1.5:3 (Nominal mix) shall be provided under base slab of liquid retaining structure. The lean concrete shall extend 75mm beyond the foundation edges on all sides.

Plain Cement Concrete (PCC) of grade M20 of minimum 150mm thickness shall be provided under all masonry wall foundations.

Plain cement concrete of grade M20 or 1:1.5:3 of minimum 40mm thickness shall be provided as damp-proof course at plinth level of all masonry walls.

9.4 MINIMUM COVER TO MAIN REINFORCEMENT

The minimum clear cover to main reinforcement shall be as given below: -

S. No.	Structure	Normal Cover	Cover for the faces in contact with soil
1	Cast-in-situ concrete slabs (roof & floor) including chajja, staircases.	45 mm or dia of bar whichever is greater	-
2	Beam (roof, floor, tie), lintel	45 mm or dia of bar whichever is greater	-

3	Column, pedestal	50 mm	50 mm
4	Foundation slab & base slab	50 mm	50 mm
5	Plinth beam	50 mm	50 mm
6	Grade slab	45 mm	50 mm
7	D.G set foundation	50 mm	50 mm
8	Cable trenches	45 mm	50 mm
9	RCC Wall	45 mm	50 mm
10	Liquid retaining str. (ALL FACES)	50 mm	50 mm

9.5 DESIGN OF MACHINE FOUNDATION

a. Machine foundation shall satisfy the requirements of IS 2974 and any other parameter as specified by the machine manufacturer.

b. The soil stress below foundation under dead loads shall not exceed 80% of the allowable soil bearing capacity of static loading.

c. All units of the foundation system, except raft shall be provided with symmetric reinforcement on opposite faces, even if not required by design.

d. The combined center of gravity of the machine and foundation system shall, as far as possible, pass through the center of area of the foundation raft or centroid of the pile group. Where unavoidable, eccentricity shall be less than 5% for block foundations and 3% for frame foundations. However, in highly compressible soils, no eccentricity shall be permitted.

e. Foundation shall be so designed that natural frequency of the foundation system shall not resonate with the following:

- Operating speed of the motor
- Operating speed of the machine
- 2 x operating speed of the machine
- Critical speed of the machine (for centrifugal machines)

f. Natural frequency of the foundation shall preferably be +20% away from the above-mentioned frequencies. However, amplitude of vibration of the foundation block shall always be checked to be within permissible limits.

g. The foundation and its superstructure shall be separated from adjacent foundations.

h. Amplitudes of vibration shall be less than values specified by the machine manufacturer. If not specified, provision of IS: 2974 shall be followed.

i. Block foundations shall be cast in a single concreting operation.

9.6 BOUNDARY WALL

a. Foundation for boundary walls shall be as per soil recommendation. If required, piles shall be provided.

b. The boundary wall will be of RCC columns/ footings/ plinth beams structure with filler walls consisting of 230mm thick brick masonry. The height of brick masonry wall will be 2.4 m/ 3.0 m (as per PNGRB guidelines) above plant level F.G.L. or N.G.L. whichever is higher. Barbed fencing arrangement will be provided above the brick masonry work for a height of 600 mm.

c. Columns will be spaced approximately at 3m centre to centre. The columns will be tied with beams at the top end of the wall.

d. It will be ensured that no part of construction is protruding out of the battery limits of plot.

e. Expansion joints will be provided in the boundary wall as per relevant IS code. The expansion joint will be filled with capitex polysulphide gap filler or equivalent.

f. If the soil investigation report indicates the presence of harmful chemicals in the subsoil/subsoil water, protective coatings will be provided for all underground structures if required, necessary treatment will be given to the soil coming directly in contact with the RCC structures.

9.7 CABLE & PIPE TRENCHES

a. The cable trenches will be provided with removable cover with suitable lifting arrangement. The cable trench covers will be of chequered plate inside the Control Room building and outside the building, it will be of precast RCC covers constructed using concrete mix M30.

b. The trench bed will have a slope of 1 in 600 along the run and 1 in 250 perpendicular to the run sumps will be constructed at the end for pump out accumulated water.

c. No interference will be permitted with surrounding foundation system. Suitable clear gap will be maintained.

d. The cable trench walls will be designed for the following load cases.

e. Dead load of 150 kg/m length of cable support per tier + 75 Kg on one tier at the end.

f. Triangular earth pressure + uniform surcharge pressure of 1T /m2.

g. Cable trench covers will be designed for self-weight of top slab + UDL of 2.0 t/m for 300 width.

h. All the construction joints of cable trenches i.e., between base slab to base slab and the junction of vertical wall to base slab will be ensured for water tightness.

i. All trenches shall be interconnected through PVC pipes and the discharge of all trenches shall go into a recharge well. The recharge well shall have boring in the centre.

10.0 SPECIAL CONSIDERATIONS FOR STEEL STRUCTURES

10.1 GENERAL/DESIGN METHODS

Design, fabrication and erection of the above work shall be carried out in accordance with IS Codes as applicable to the specific structures. Basic consideration of structural frame work shall primarily be stability, ease of fabrication/erection and overall economy satisfying relevant Indian Standard Codes of Practice.

Crane gantry girders shall generally be of welded construction and of single span length. Chequered plate shall be used for gantry girder walkway flooring.

For crossover & platforms steel staircases shall have channels provided as stringers with minimum clear width of 750mm and slope of 41 degree. The vertical height between successive landings shall not be less than 2.6 m nor exceed 4.0 metres. Treads shall be minimum 230mm wide made of grating (with suitable nosing) spaced equally so as to restrict the rise to maximum 200mm.

Cage for monkey ladder to be provided for height above 2.5m.

Hand rails, 1000mm high (from top of grating/ top of chequered plate/ FFL), shall be provided to all walkways, platforms, staircases. Toe plate (100mmx5mm) shall be provided for all hand railing (except for hand railing in inclined portion of staircases and platform around circular vessels). Spacing of uprights shall be 1500mm (maximum). Two types of hand railing shall be provided.

a. For walkways, platforms (except platform around circular vessels), and staircases: Top rail, mid-rail and upright shall be 32mm dia (NB) medium grade MS tubes.

b. For platforms around, circular vessels: Top rail shall be 32mm dia (NB) medium grade MS tubes but mid-rail and upright shall be of structural steel.

Electro-forged painted / hot dipped galvanized welded MS Gratings shall be minimum 25mm deep. The maximum size of voids in the grating shall be limited to 30mm x 55mm.The minimum thickness of galvanizing shall be 120 microns.

Welded connections shall be adopted as far as practicable except for cases where bolted connections are required viz. galvanized structures. Structural connections shall have minimum two bolts of 16mm dia. unless otherwise limited by the size of members.

Minimum two nuts shall be used for all anchor bolts.

10.2 STEEL GRADE

Structural steel shall be of grade E 250 quality BR/B0 conforming to IS: 2062. Tubular/ Hollow steel shall be of grade Yst 310 confirming to IS: 1161.

Connection bolts shall be high strength hot dipped galvanised structural steel bolts of property class 8.8 (minimum) conforming to IS 3757 and IS 4000. Hexagonal nuts shall conform to IS 6649. Washer shall conform to IS 6649.

Anchor bolts shall be of grade E250 Quality BR/B0 conforming to IS: 2062.

10.3 LIMITING PERMISSIBLE STRESSES

Permissible stresses for structural members, bolts, welds shall be as per relevant codes.

10.4 LIMITING DEFLECTION

The following limiting deflection criteria shall be considered in sizing of the structures as Per Table-6 of IS: 800.

10.4.1 LIMITING VERTICAL DEFLECTION

The limiting permissible vertical deflection for structural steel members shall be as specified below,

S. No.	Description	Limiting Permissible Deflection
1	Gantry girder E.O.T (cap. Up to 50T)	span / 750
2	Beams and Girders	span /300
3	Girder / Beam supporting dynamic equipment / hoist	span/500 for manually operated cranes. For other refer IS-800
4	Grating / Chequered plate	span/200 or 6mm whichever is smaller.

10.4.2 LIMITING HORIZONTAL DEFLECTION

The limiting permissible horizontal deflection for structural steel members shall be as specified below, where 'H' represents the height:

S. No.	Description	Limiting Permissible Deflection
1	Columns (Normal Loads)	Height/400
2	Columns (Under wind / seismic load combination)	Height/250

10.5 MINIMUM THICKNESS

Minimum thickness of any part of a structural steel shape (Hot rolled sections) shall be as follows:

S.no.	Description	Minimum Thickness
1	Columns, beams	7 mm

2	Stiffeners	8 mm
3	Base plates	10 mm
4	Chequered plate	6 mm (on plain)
5	Grating	3 mm
6	Truss, Purlin, Side girts, Bracing	6 mm
7	Gussets in trusses and girders	8 mm (up to and including 12 m span) 10mm (above 12 m span)

The minimum thickness for rolled beams and channels shall be mean flange thickness regardless of the web thickness.

However, the minimum thickness of structural component (except gratings & chequered plates) which are directly exposed to weather & inaccessible for painting shall be 8mm.

Minimum thickness of tubes shall be as specified in IS: 806. The ends of all tubes shall be sealed by using 6 mm thick. Plates welded all round.

10.6 PAINTING

Painting on Structural Steel shall be as per table 29 of IS: 800 or painting specification.

11.0 SPECIAL CONSIDERATION FOR MASONARY WORKS

11.1 GENERAL

All masonry works shall be designed in accordance with IS: 1905, IS: 1597, IS: 2185, IS: 4326 and other relevant IS Codes as applicable. All external brick, stone and hollow concrete block masonry walls shall be of minimum 230, 350 and 250mm thickness respectively. Bricks for masonry work shall be of class 5.0 conforming to IS: 1077. Hollow concrete blocks shall conform to IS: 2185.

11.2 CEMENT MORTAR

All masonry work shall be constructed in 1:6 cement sand mortar except half brick partition walls which shall be constructed in 1:4 cement sand mortar with two numbers of 8mm diameter MS bars provided at every fourth course properly anchored with cross walls or pillars.

12.0 SITE PREPARATION, ROADS, PAVEMENT, DRAINAGE, U/G PIPING, CULVERTS

12.1 SITE PRPARATION

a. The layout of the plot will be prepared and the level will be set.

b. The site preparation will conform to the requirements of the relevant sections of this design basis and specification.

c. Minimum Finished Ground Level (FGL) must be 300 mm higher than the maximum level of centerline of nearby road at entry point or highest flood water level that may be anticipated in the locality, whichever is higher.

12.2 ROADS

Road width shall be as per approved plot plan drawing. The radius of curvature of the turnings shall be 6.0m (minimum) unless otherwise mentioned in the relevant drawings. The roads shall be constructed as per the specified drawings. All the roads inside the station building shall be of RCC with TREMIX.

12.3 PAVEMENT/ FOOTHPATH

The pavement/footpath shall be as per standard drawings.

12.4 DRAINAGES

a. Surface storm water drains shall be provided. The minimum width of the drains shall be 300mm and starting depth should be 300mm. Open storm water brick masonry drains/ RCC drain shall be provided as per the layout.

b. The drains will have slope of: -

1 in 500 (min) for rectangular drain.

1 in 1000 (min) for trapezoidal drain.

c. Drains around the building shall be covered with concrete grating. For all buildings, suitable arrangement in the form of drain pits connected by buried RCC / Steel pipes for draining out water from the equipment, leakage, floor washings, fire-fighting, etc shall be provided for each floor, complete up to plant sewers / drains.

d. Roof gutters shall conduct water to storm water drains. Any drainage outside the building will be conducted away from the building to the nearest existing storm water drains / drainage ditch. The plinth protection drains shall be of brick masonry with RCC base.

e. Surface drainage system shall be designed considering run off co-efficient for paved areas 1.0, unpaved/ compacted area 0.7 and for green belt area 0.4 respectively.

f. Drain wall shall be designed to resist earth pressure.

12.5 U/G PIPING

a. Underground piping shall be constructed by excavating a trench in undisturbed soil. The pipe shall be placed on the bottom of the trench and covered with earth backfill to the original ground surface.

b. Vehicles wheel loads shall be added to the backfill load to determine the total load on the pipe in vehicle movement area.

c. Pipe shall be designed to resist the total load as per IS: 4350.

d. All underground CS/ MS pipes shall be provided with corrosion resistance protection as per project specification.

12.6 CULVERTS

ERC/IRC shall be provided for all kinds of pipelines road crossing inside the plot. Outside the plot & at the entry of plot, Culverts under roads shall be of box-shaped/ RCC Pipe culvert for passage of sewerage systems.

12.7 STONE PITCHING

Stone pitching with turfing shall be provided outside the boundary wall.

12.8 FENCING

2.0m high Barbed wire fencing with angle iron 50x50x6 mm post placed every 3.0 m c/c, with suitable foundations at least 750mm below from FGL/NGL whichever is lower.

13.0 WATER SUPPLY

a. Potable water shall be supplied to basins, water closets, urinals, sinks, water coolers, showers and other fixtures.

b. Roof water tank of adequate capacity depending on the number of users for 8-hrs storage will be provided for each building. The platform for PVC water tank shall be of masonry instead of RCC.

c. Internal piping works for potable water supply in building shall be with either UPVC or any other composite material. Waterline shall be extended up to minimum of two points at the end of the plot for purposes of gardening.

d. Capacity of overhead water shall be 500 litres.

14.0 SEWERAGE

a. Extra heavy cast iron pipes with lead joints shall be used for sanitary works below the ground of the buildings or below roads / paving. Stoneware pipes shall be used in the other areas. Soil and waste piping with traps shall lead to the site sanitary sewer system, manholes, septic tanks, soak pits, etc.

b. Heavy cast iron pipes, lead joints PVC pipes will be used for sanitary works above the ground level.

c. Sanitary sewage shall consist of septic tanks for individual buildings / areas or group of buildings. Connected to the soak pits.

d. Treated effluent from septic tank shall pass to the soak pit. Alternative arrangement shall also be provided for discharging treated effluent to the nearest drain.

e. Culvert at the entrance of terminals shall be done as per local authority guidance and requirements.

15.0 STATUTORY RULES

a. All the applicable statutory rules pertaining to factories act (as applicable for the state); Fire Safety Rules of Tariff Advisory Committee, Water Act for Pollution Control etc. Will be complied with.

b. Statutory clearance of respective NHAI, PWD, CCOE and norms of State Pollution Control Board will be followed.

16.0 ARCHITECTURAL DESIGN REQUIREMENT

Architectural design shall be in accordance with the following clauses.

16.1 REFERENCED PUBLICATIONS

a. National Building Code of India.

b. Factory Law.

c. Local Municipality or any other Authority's Bye-laws as applicable.

d. Bye-laws of Town & Country Planning Organization.

e. BIS Codes.

f. Indian Electricity Rules.

g. OISD – 174 and IE Rules for substation design.

h. TAC (traffic advisory Committee) recommendations.

i. Any other applicable Law, Rules, Standard as referred in respective clause.

16.2 STANDARD SPECIFICATIONS CODES & PRACTICES

PLECO Engineering design incorporates Codes and Standards as referred in the design philosophy of respective engineering disciplines as well as applicable PLECO standards and specifications.

16.3 DESIGN PHILOSOPHY/ CRITERIA

16.3.1 ARCHITECTURAL DESIGN

Architectural design of the buildings shall be in accordance with this design basis and references as stated above to meet the functional requirements.

16.3.2 BUILDING REQUIREMENTS

16.3.2.1 LIST OF BUILDINGS

Following buildings are envisaged in this project.

a. Upgradation of existing Control Room

b. Porta Cabin

The above list of Building is subjected to finalization during detail engineering.

Spatial requirements of these Buildings shall mainly be decided based on the equipment/ panel layout, activities to be performed in the building and consequent occupancy pattern.

Sizes of various type of spaces shall be decided based on occupancy/ equipment/ Panel layout, clearances, maintenance & safety requirements. The objective of spatial arrangement shall be to satisfy functional requirements, physical comfort, and safety regulations as well as aesthetics. Design shall be in accordance with Factory Act, NBC etc.

16.3.3 BUILDING ELEMENTS

16.3.3.1 PLINTH PROTECTION

The building shall be provided with minimum 900 mm wide (100mm high from top of Approach Road Level) plinth protection around the building.

16.3.3.2 FINISHED FLOOR LEVEL (FFL)

In general, FFL of the Building shall be determined with respect to top of approach road or pavement. Following schedule shall be adhered to for FFL of the building & sheds

a) Control Room/ Electrical room/ office room/ Store room etc. -Top of approach Road level + 300mm

Notes:

i. In case of approaches with different top levels, the highest top level of approach road/ pavement shall be considered.

ii. FFL shall be same throughout in a building.

iii. FFL of external loading/unloading bays/ platforms, toilet, pantry, and kitchen shall be 10-15 mm lower than that of the building FFL to check ingress/spillage of water.

16.3.3.3 STEPS/ RAMPS/ STAIRS

Steps/ ramps shall be provided for access to the building for pedestrian/ vehicular, equipment entry as per relevant code. Minimum 1000 mm wide platform shall be provided in between entrance door and steps/ramps. Following dimensions of the steps/ ramps shall be adhered to.

Stairs width	: 1500mm minimum
Tread	: 300 mm minimum
Riser	: 150 mm maximum
Slope of Ramp	: Not steeper than 1:6 or as per requirement
Ratio of Tread & Riser	: 2 Riser + Tread= 600 to 650 mm
No. of risers per flight	: 15 Nos. (MIN/ MAXIM)
Landing width	: 1500 minimum

16.3.3.4 WALLS

Following schedule shall be adhered to for wall material and thickness:

a. External, walls: 230 mm thk. Brick wall

b. Internal partition wall: 230/115 mm thk. Brick wall depending on the overall length and height of the wall (refer note below)

c. Transformer Walls: 200 thk. RCC or 355 thick (including plastering) fire walls as per Electrical requirements. (IER)

Notes:

115 mm thk. brick partition walls (with nominal steel requirement as per structure design) shall be provided with 230 mm thk. brick pillars for stability.

Wherever conduits or pipes are required to be concealed within partition wall, the wall thickness shall be increased suitably.

16.3.3.5 DOORS

Doors shall be provided for access, security and safety at all entry & exits of rooms, functional areas & the buildings. Air tight door shall be provided in pressurized area and in gaseous protection area. Fire check doors shall be with minimum two hours rating as per statuary requirement. Sizes of the doors shall be determined on the basis of the following schedule:

a. Equipment, Panel area: Size of max. equipment including packing.

b. Other areas: Volume of movement through door.

c. W.C., Bath Cubicle Door: 800 mm x 2100mm (wall opening size)

d. Minimum size of other doors: 1000mm x 2100mm (wall opening)

e. Minimum Entrance door size- 1500 mm x 2100 mm (wall opening size)

Notes:

i. Rolling shutters shall be provided for equipment entry for Switchgear Room/ Electrical Room, A.C. Plant Room etc.

ii. Motor operated Rolling Shutters shall be provided in the main equipment entry door.

16.3.3.6 WINDOWS/ VENTILATORS

Windows/ventilators shall be provided in all areas for natural lighting, ventilation and visibility at working level.

For the purposes of ventilation, total open able area of the windows/ventilators shall be as per Factory Act subjected to a minimum of 15% of the floor area to be ventilated. However, for non-process Control Room, security block of Gate Houses and in office areas etc. where visibility from inside is of prime importance, increased window area shall be provided. Areas accommodating panels/equipment's shall be normally provided with ventilators at high level for unobstructed distributed lighting.

Notes:

a. Requirement of window/ventilation area as stipulated above is for maximum room/area height of 4000 mm. For height more than 4000 mm additional window/ventilator shall be provided in the same manner at every work area such as walkway/gangway etc. at all such working levels. In such cases additional windows/ventilators shall also be provided to ensure min. Illumination & ventilation at every level of the building/shed.

b. Wherever due to limitation of external wall area or any other reasons, stipulated area of window/ventilation cannot be provided, suitable mechanical/electrical devices shall be provided.

16.3.3.7 CANOPY/ OVERHANG

Canopy/overhangs shall be provided at all entries & exits for rain & sun protection. Size of the canopy/ porch shall be decided w.r.to utility of the building and other aesthetic.

16.3.3.8 SHADING DEVICES

Shading devices shall be provided over all windows, open able ventilators for rain & sun protection. These devices shall be in form of horizontal projections, vertical projected fins or combination of both as per building facade treatment. Minimum projection shall be 600 mm. The top surface of the shading devices shall be finished with cement plaster mixed with waterproofing (laid to slope) compound and shall be provided with GI spouts for drainage.

16.3.3.9 PARAPET

Parapets shall be of RCC for all buildings with minimum 500 mm high for non-approachable roof and 900 mm high for approachable roof. In case of future expansion, GI/MS removable railing shall be provided.

16.3.3.10 PASSAGES/CORRIDORS

Passages/corridors shall be provided to integrate various spaces. Width of the passages/ corridors shall be as per following schedule.

I.	Singly loaded passage/corridor	=	Minimum 1200 mm.
II.	Doubly loaded passage/corridor	=	Minimum 1800 mm

But whenever passages/ corridors are to be used for equipment/ machinery/ panels etc. the width shall be determined on the basis of equipment/ machinery/ panel sizes.

16.3.3.11 ROOF GUTTER

Gutter with rain water pipes or R.C.C. shafts shall be provided for all the building for roof water drainage. Sizing of the gutter shall be based on area to be drained and number of outlets. Gutters shall be of RCC. For Workshop/ Warehouse shed with precoated roof sheeting, precoated sheets gutters may be provided and for big size of workshops/ warehouse RCC shaft may be provided at the end of gutter.

16.3.3.12 RAIN WATER PIPES, SPOUTS

Rain water pipes shall be provided for roof water drainage. Number of rain water pipes shall be decided on the basis of roof area, slope and rainfall intensity. Rain water pipes shall be embedded in concrete. RCC or GI spouts may be used for drainage of chajja/ small canopies of ground floor.

16.3.3.13 ROOF DRAINAGE

Water from the roof surface shall be drained by a system of roof drain heads, rainwater down corners and necessary fixtures. The roof will be provided with a slope of 1: 100 (min.) for efficient drainage. Cast iron rainwater down corners conforming to IS: 1230 with water tight lead joints or medium class galvanised mild steel pipes conforming to IS: 1239 / IS: 3589 shall be provided to drain off rainwater from the roof.

16.3.3.14 AIR LOCK LOBBY

This shall be provided for all entries with centrally air-conditioned spaces.

16.3.3.15 EMERGENCY EXITS

Emergency exits shall be provided for the building as per State Factory Rules, NBC-Part IV and for individual functional spaces such as Console area, Electrical room etc. Emergency exits shall be located in such a manner that escape route is direct, unobstructed & without passing through any other functional areas to safe area.

16.3.3.16 STAIRCASES

Staircases shall be provided for vertical circulation & emergency exits. Number of staircases shall be based on building/ shed sizes. Emergency exit requirements shall be as per safety distance requirement. At least one no. staircase/ladder shall be provided for access to the flat roof top for maintenance.

16.3.3.17 RAILINGS

Railings shall be provided in stairs, and in all unprotected openings in slabs as a safety device. Steel railings in loading/ unloading bay of shall be of removable type.

16.3.3.18 FALSE CEILING

False ceilings shall be provided for following purposes wherever required.

a. To reduce room volume and hide ducting etc. for air-conditioned space.

b. To maintain acoustic level inside any space.

c. To reduce habitable room, corridor, lobby, and toilet heights located in high ceiling building/shed to min. 3000 mm.

16.3.3.19 FALSE/ CAVITY FLOORING

False/ cavity flooring shall be provided to accommodate under floor cabling in Instrumentation areas like Console Room, Rack Room, Computer Room, Engineering Room etc. Extent of false/ cavity flooring shall be as per Instrumentation requirements.

16.3.3.20 TRANSFORMER GATE

Steel gate of suitable size in front of transformer bays in substations building may be provided as per electrical requirement.

16.3.3.21 ARCHITECTURAL FINISHES

All the building elements i.e., floor, wall, ceiling, roof, doors & windows etc. Shall be provided with architectural finishes as shown in the building drawings.

16.3.3.22 ROOF TREATMENT

Contractor to propose roof treatment based on following options:

a. Polyurethane waterproof coating, single component.

b. Nano technology-based system is also to be explored for roof water proofing.

16.3.3.23 TOILET

Toilet shall be provided for all buildings/sheds in every station. Toilet shall consist of Gents Toilet, Ladies Toilet (as per requirement) and separate drinking water enclosure and janitor space. Requirement of fittings & fixtures shall be as per National Building Code of India & Factory Act.

17.0 GREEN BELT DEVELOPMENT AND SIGN BOARDS

Green Belt will be developed near and around building and also in station area to comply local authority/ forest department requirement. Signboards will be provided at all stations and other points. All works will be carried out as per discretion of Owner/ Owner's representative.

18.0 CONSTRUCTION REQUIREMENTS

Construction requirement shall be as per construction specification enclosed in bid document

ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF BOO COMPRESSOR STATION AT RUPKHELIA

SCOPE OF WORK FOR COMPRESSOR PIPING & OTHER ASSOCIATED UTILITY

(SECTION-D)

Doc No.: P167-SOW-P001

REV.	DATE	DESCRIPTION	ORG	REVIEW	APPROVED
TA	25.10.2023	Issued With Tender	SS	MC	AD
CA	18.10.2023	Issued for Client review	SS	MC	AD
IA	10.10.2023	Issued for Internal Review	SS	MC	AD

CONTENTS

1.0 INTRODUCTION

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e., Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCM of gas per day.

Assam Gas Company Ltd. intends to Development of Compressor Station at Rupkhelia, Golaghat, Assam.

Pipeline Engineering Consultants Pvt. Ltd. has been appointed as Engineering Consultant by M/s. Assam Gas Company Ltd. For Development of Compressor Station at Rupkhelia, Golaghat, Assam.

2.0 DEFINITION

Where used in this document, the following terms shall have the meanings indicated below, unless clearly indicated by the context to this order.

PROJECT	Development of New Compressor Station at Rupkhelia Assam
CLIENT/ OWNER	Assam Gas Company Limited.
EPMC	Pipeline Engineering Consultants Pvt. Ltd. (PLECO) the party to act for and on behalf of Owner for for the Development of Compressor Station at Rupkhelia.
CONTRACTOR	Agency appointed by CLIENT/ OWNER for execution of assigned tasks
PURCHASER	Either of CLIENT, OWNER or EPMC
VENDOR/ MANUFACTURER	Party, which manufactures and supplies equipment and services to the OWNER or to CONTRACTOR

3.0 PROJECT BRIEF

In order to maintain the requirement of gas pressure at terminal, a gas compressor package needs to be installed.

4.0 GENERAL

The specification given herein describes the minimum requirements and guidelines to successful Bidder / contractor for the complete scope of work, supply and procurement of piping materials and consumables, fabrication, erection, testing, insulation, painting of the total piping system and commissioning of the new Gas Compression Plant at Rupkhelia.

In general, the Bidder shall visit site to acquaint and familiarize with the site for better understanding of scope of work and site conditions. After award of the job, Bidder shall do the pre-engineering survey at project site to finalize the equipment layouts, pipe rack, pipe support, tie-ins etc., and to understand the scope of work before detail engineering.

5.0 SCOPE DEMARCATION

Contractor to carry out all Compressor piping and other associated piping which are required to successful operation of specified Compressor.

Contractor to carryout piping till battery limit as shown in equipment layout attached with this tender.

This document shall be read in conjunction with List of Attachments, Schedule of Rates, specifications, standards, drawings and other documents forming a part of the Tender Document.

6.0 WORK TENDERED

Work tendered in this bid package consists of engineering and procurement supply, installation, testing, pre-commissioning and commissioning assistance of terminal Mechanical facilities and all associated works as detailed below.

- Design & Installation of Compressor Piping for suction & discharge.
- Design & Installation of utilities piping till battery limit.
- Design & Installation Instrument air Piping till battery limit.
- Design & Installation of Fire Water spray System till battery limit etc. Contractor to take hook up of fire water from tap off point.
- Design & Installation of other associated Piping till battery limit which are required to successful operational of Compressor.
- Hook up with existing/ Proposed Piping
- Supply of all materials
- Contractor shall develop and finalize all planning and design of new piping for new Gas Compression Plant.
- Contractor shall prepare all documents like PMS, thickness calculation, Piping item Data sheet, IFC GADs, Equipment layout, Isometric, Support Drawing, Support schedule, Load data, Piping stress analysis, Inspection test Plan, as built drawings & documents etc. in compliance with Company Specification submitted in Bid. Above are minimum documents are required to prepared by Contractor and approved by Company /Company Representative.
- All works related to cleaning, flushing, hydro-testing and dewatering of piping facilities and all other pre-commissioning checks as applicable to the scope of work.
- Carrying out pre-commissioning of terminal piping and associated facilities and providing commissioning assistance to the Company during overall commissioning of the Piping and Pipeline system. Company shall carry out final commissioning of facilities.
- Mobilizing and providing all equipment’s, manpower (skilled and unskilled), consumable and other resources etc. as required for the execution of the complete job defined herein.
- It shall be prime responsibility of Contractor to co-ordinate with other agency for smooth functioning of work.

7.0 SCOPE OF WORK

The Contractor's Scope of Work for the work tendered shall consist of, but not be limited to, supply (as indicated in Scope of Supply), installation, testing, pre- commissioning checks and commissioning assistance for complete station piping with all associated mechanical, civil, structural, electrical, instrumentation works as applicable including all such works which though specifically not indicated here but will otherwise be required to complete the WORK in all respects.

The scope indicated below shall be read in conjunction with Engineering Design Basis Schedule of Rates, Documents, drawings, specifications and other requirements forming part of the tender document.

8.0 BASIS OF WORK

Piping work shall be carried out as per following:

a) Approved for construction Piping General Arrangement Drawings (Piping GAD's)

b) Approved Piping and Instrumentation Diagrams (P&ID's)

c) Approved Piping Material Specification (PMS)

d) Standard Specifications

e) Piping support standards/drawings and support index

f) Any other drawings/sketches prepared by Company and/or by the Contractor and approved by the Company

g) Following codes standards and regulations:

- ASME B31.3
- ASME Sec. VIII: Rules for Construction of pressure vessels
- PNGRB Guideline and notification, applicable OISD

All the codes referred above shall be latest edition, at the time of award of contract.

9.0 DESIGN

Piping systems shall be designed in accordance with Contract requirements. Piping systems, plant layouts, and equipment spacing requirements will use consistent Design methods and practices in accordance with OISD and all applicable codes and reference documentation.

Design, materials, fabrication and testing of piping shall be in accordance with the requirements of ASME B31.3 (Latest Edition). In addition, the requirements covered by the Project Specifications shall apply.

Contractor to prepare all Piping GA's shall be prepared for all planned pipe-work. All such drawings shall clearly indicate that adequate provision has been made for access to equipment and all areas of the FACILITY, for the safe operation and maintenance of the FACILITY. All bid drawings shall be verified and updated to reflect actual site conditions and the pipes/pipelines and equipment being installed under parallel projects.

Contractor shall perform all calculations necessary to support the integrity of the detailed design.

Piping Isometrics and support drawings shall be generated for material procurement and construction purpose. Detailed piping MTO shall be generated to cover all the piping materials.

Contractor shall provide all vents and drain points required for hydrostatic testing and dewatering purposes. All vent and drain points shall be blinded after successful hydro test. All dead legs shall be provided with a drain and valve.

The drawings shall clearly indicate all valves, piping, specialty items, instrumentation and equipment (with tag numbers). Piping design shall take into account the requirements to provide adequate access, drainage, venting and isolation facilities for normal operation, and maintenance, as well as for hydrostatic testing of the pipe-work.

Contractor shall verify pipe wall thicknesses defined in project specification for piping materials. Pipe wall thickness for piping subject to vacuum service shall be checked by Contractor to verify its suitability for external pressure.

Painting of Piping shall be in line with COMPANY Specifications/Procedures.

Pipe work isometrics shall be prepared based on approved piping GA's and shall take into account ease of fabrication and installation. All isometric drawings shall have a Material Take-Off listing, including material description quantities and grade of material (ASTM grades or equivalent), clearly marked on the drawing. Piping isometrics shall also include test requirements, stating methods and pressure, NDT and stress relieving requirements, operating pressure, temperature. Prior to production of isometrics Contractor shall submit a typical isometric layout detailing the information to be provided, for Company review and approval. Contractor shall also provide isometrics for the interconnecting piping between the equipment of the vendor packages and also provide support details. Contractor shall provide a procedure which shall include weld map/joint numbering prior to starting piping work.

All plant and station pipe-work shall be verified in accordance with the requirements of ASME B31.3 (Latest Edition). Piping stress analysis shall be carried for per Company approval. The piping shall be adequately designed to allow for thermal expansions, movements imparted from the connected pipeline and loading during testing, and loads induced during normal operation. Contractor shall conduct a formal computer analysis of all critical piping systems associated with the piping configuration.

Contractor shall be responsible for review and categorization of all piping systems. Contractor shall identify the critical lines and submit stress critical line list.

The stress analysis report prepared by the Contractor shall include the isometric sketch with clear identification of each element. Contractor shall also submit the soft copy of the model for Company review and verification. Calculations shall be performed using established computation techniques. Contractor shall supply details of the software to be used for approval by Company, prior to the analysis commencing. CAESAR-II is preferred for pipe stress analysis. A functional specification of the pipe supports shall be produced as a result of the stress analysis. This shall define the type of support and the design loads, as a minimum requirement. Any modification as a result of the stress analysis shall be deemed to be included in the Contract scope of work.

Pipe supports shall be designed and drawings prepared showing pipe support locations. The design of pipe supports shall meet the requirements of specifications. The type of support shall be based on the stress analysis of the pipe-work. Contractor shall prepare a matrix of pipe supports / support schedule including sleepers, if any. All pipe supports installed during the tie-in works shall be considered to be temporary, and shall be replaced by permanent pipe supports by Contractor.

Wherever piping material is supplied under a piping material class, materials shall be in accordance with "Piping Material Specification". For any deviations this document shall be amended and the same shall be approved by Company. All the piping items including pipes, fittings, flanges, etc. necessary for completion of the work shall be supplied by the Contractor.

All the valves, Safety Valves, and specialty items like couplings, etc. shall be in accordance with Company Specifications. All the valves and specialty items necessary for the completion of the work shall be supplied by the Contractor.

Coordination with other disciplines such as civil, electrical and instrument to avoid interference with above and underground piping.

Procedures for fabrication, welding, inspection, installation and testing.

Piping material identification system during storage, fabrication, transportation and construction, including positive material identification.

Procurement & procurement engineering Furnish Final vendor drawings & documents for piping items for Company's Approval.

Arrange Company / Company's Representative / 3rd party (approved inspecting agencies) for inspection of materials as per requirements, transport and receive materials at contractor's yard or site (as applicable) and store with proper identification tags.

Execute all mechanical jobs, including additional supports, identified during Company's checklist, technical audits, pre-commissioning and commissioning.

CONTRACTOR shall ensure that all piping materials satisfy the requirements of the applicable ASTM standard and the additional requirements defined in the materials selection diagrams and project specifications for piping material. Contractor shall ensure that positive Piping Material Identification and Material Traceability are achieved throughout the Project.

CONTRACTOR shall obtain ITP and Quality control plan and submit the same for review/approval to company during evaluation stage and prior to manufacturing.

CONTRACTOR shall obtain the following certificates in accordance with EN 10204 type 3.2 for all piping items unless otherwise specified:

- Test certificates relevant to the chemical analysis and mechanical properties including hardness of the materials used for the manufacture as per relevant and this specification.
- Test reports on non-destructive testing.
- Test reports of heat treatment carried out.
- Test reports on hydro testing.

The Certificates shall be valid only when signed by the Inspector. The item certified by the Inspector shall be dispatched from the Manufacturer's works.

CONTRACTOR shall be responsible to arrange Company / Company's Representative / 3rd party (approved inspecting agencies) for inspection of materials as per requirements.

10.0 PIPING WORKS

The Composite works related to fabrication, erection, testing and commissioning of piping is as elaborated below:

Preliminary equipment layouts for the stations are included in the Composite Tender. These drawings are indicative only and are furnished to enable the Bidder to understand the nature of work involved. Issued for Construction (IFC) piping general arrangement drawings (GAD’s) shall be prepared by Contractor and review and approved by COMPANY/PMC at an appropriate time during project execution stage.

Contractor shall carry out all works strictly in accordance with the Issued for Construction (IFC) drawings Approved by COMPANY/PMC and reference specifications/standards, documents, data sheets etc. enclosed with this tender document and instructions of Company/Engineer-in-Charge and other provisions of Contract document.

a. Providing all equipment, manpower, machinery, consumables for fabrication, installation, inspection, testing, pre-commissioning and assistance during commissioning; all types of safety tools, tackles, devices and apparatus, equipment etc. including ladders and scaffolding etc. complete as required including providing all types of consumables, tools, tackles and facilities for inspection and interpretation of testing results by Company/Company's Representative personnel.

b. Furnishing and mobilizing at site(s) of all construction equipment, tools and tackles, fully equipped and fully manned with other required support facilities etc. needed for successful execution of the works.

c. “Receiving and taking over” of all Company supplied free issue materials (if any) from the Company’s designated place(s) of issue, transportation including loading, unloading, handling from Company’s designated place(s) of issue to Contractor’s own stock yard(s)/ work site(s)/work shop(s) including arranging all necessary intermediate storage area(s) thereof as required till the permanent installation of materials.

d. Procurement and supply of all materials, equipment that are included in the scope of supply of Contractor, transportation of all materials from manufacturer’s works including loading, unloading, handling, storing and transportation to work site(s)/work shop(s) including arranging all necessary intermediate storage area(s) thereof, as required.

e. Fabrication, erection, installation, testing of all above-ground/buried process and utility piping/pipeline systems at all elevations and carrying out all associated works.

f. Carrying out welding including cutting, edge preparation (inclusive of grinding the edges of pipe, fittings, flanges, etc. to match with the matching edges of different thickness wherever required), fit-up, bending, pre heating wherever required, NDT including 100% radiography and other non-destructive tests as specified.

g. Hydro-testing, dewatering, flushing, pre-commissioning and commissioning assistance activities of piping system of all sizes as per specifications enclosed including supply of all materials and manpower that are required during pre-commissioning & commissioning and all associated works.

h. Installation of all types of valves (manual/actuated), all types of inline/online instruments (other than those covered separately), , safety valves, tapping for thermo wells, sample connections, pressure gauges, etc. for all sizes and ratings including installation and fixing of gaskets, bolts, studs & nuts of all sizes, ratings and materials.

i. All associated civil, structural, mechanical and electrical works including supply of all material required, unless covered separately elsewhere in the tender, including construction of foundations for equipment and pipe supports; pipe supports and sleepers, fabrication and erection of supporting structural elements for piping such as shoes, clamps, anchors, guides, insert plates, brackets, structural column etc.

j. Hook-up of piping with equipment, existing facilities is in contractor's scope and at the battery limit of the facilities installed by others by welding or by flanged connection (as shown in IFC drawings) including cutting of temporary spool or test header, fit-up, welding, NDT, radiography, interface/co-ordination as required with other Contractor(s)/Agencies. All works related to hook-up with existing & associated piping works at terminal. For butt weld connection complete cutting, beveling, nitrogen purging during hook up shall be in the scope of contractor. The existing lines to which hook-ups are to be made will have to be cleaned, flushed again with nitrogen. No extra payment shall be made for these jobs. Contractor shall take care of this in the rates quoted by them.

k. Contractor may have to make changes in the pipe routing at site as per site conditions to clear obstructions/ fouling with existing and new facilities.

l. Painting of all equipment, pipe supports, piping and all miscellaneous items as required with paints suitable for normal corrosive environment in accordance with Standard Specification for Painting (suitable for highly corrosive/ Coastal & Marine Environment as applicable. Wherever touch up/repair of primer is required, high build epoxy zinc phosphate primer shall be used.

m. Coating of all underground piping if any shall be coated with solid epoxy 1000 microns/ Powercrete R95 or as mentioned in the data sheets/ drawings.

n. Obtaining all statutory clearances, liaising for any approvals and permissions for the works within existing facilities, as required. Obtaining hot work permits from Company/ concerned authorities having jurisdiction thereof to work within existing and operating terminals including strictly complying with all stipulations/conditions/recommendations of the concerned authorities and providing all safety appliances, gas detectors, fire screens required during execution of the work as per the direction of Company/Engineer-in-charge. Co-coordinating all activities with Company for movement of men and material from and to existing and operating terminals shall be the responsibility of the Contractor.

o. Final clean up and restoration of site, facilities etc. as per the requirement of Company/Engineer-in-Charge.

p. Preparation of isometrics and/or fabrication drawings required for the purpose of fabrication during execution of work.

q. Return of all surplus Company supplied free issue material to Company's designated store after completion of works or as directed by Engineer-in-Charge including transportation and stacking at Company's storage yard.

r. Preparation of as-built drawings, documents and project records as per instructions of Engineer-in-Charge.

s. Co-ordination as required with other Agencies/Contractor(s) till the time the commissioning operations are complete.

- **t.** Preparation of detailed procedures for fabrication, installation, testing and pre-commissioning. Such procedures shall be submitted to Company/Engineer-in-Charge for review and approval before execution of work.
- **u.** Providing support for new piping, modified piping, change of existing support/ additional support in existing piping, if any as indicated in the drawings or as required by Engineer-in charge.
- **v.** Providing brackets from existing structure/ other structures for pipe support; modifications/ extension of platforms/extension of walkways, providing additional platforms/ ladders/ walkways for improving/ providing accessibility.
- **w.** Any other works not specifically listed herein but required for completion of the works in all respects.
- **x.** All piping materials required for testing, pre-commissioning and commissioning e.g. piping spools, bolting and gaskets, flanges, blinds or any other piping materials for carrying out this activity is included in Contractor's scope of supply.
- **y.** The Contractor shall prepare MTO in different stages, Preliminary, Intermediate & Final stage. Final MTO shall be prepared from construction isometrics, in order to ensure covering of all piping components; this shall further include fabrication allowance, precommissioning and commissioning spares.

The above list (all stated above of this paragraph) of activities is not exhaustive and therefore not limited to the above. The scope includes all such activities, design engineering, supply of all materials and components as required, for successful commissioning of the plant as per the requirements of the approved final P&IDs, line lists, Piping Design Basis and Engineering specifications etc. so as to result in a total trouble free operable and maintainable plant.

11.0 FABRICATION AND TESTING

Contractor shall develop piping isometric drawings and associated bills of materials for both shop and field pipe fabrication and such shall be made available to Company, when requested. Contractor shall develop fabrication and erection procedures in accordance with the applicable codes and related Project Specifications.

Piping inspection and testing shall be in accordance with ASME B31.3 and Project Specifications. Contractor shall ensure the complete dry-out of the piping after hydrostatic testing.

Non-destructive examination requirements shall be as specified in the individual piping material and service classification. All non-destructive examination shall be in accordance with ASME B31.3 and the Project Specifications.

All tie-in spools shall be hydro tested at fabrication shop, the last weld joints

COMPANY may consider as Golden Joints depending on the weld type. However, for all such joints, CONTRACTOR shall take prior approval from COMPANY Inspection Dep.

12.0 LIST OF DRAWING AND DOCUMENTS

Following minimum drawings and documents shall be prepared by the Contractor and submitted to COMPANY / COMPANY'S REPRESENTATIVE for Review & Approval for execution of piping works as per the scope indicated in the Bid package.

Piping Key Plan and Area Division. Area division for underground piping and above ground piping shall be same however the underground and above ground piping shall be made in separate drawings.

- Piping General Arrangement Drawings (IFC) and necessary sectional details.
- Equipment layout
- Nozzle Orientation for all Vessels and tanks showing all nozzles.
- Piping Isometrics for All Lines including small bore lines with Support Marking and Bill of Material.
- Piping Hydro test Pack drawings.
- Flexibility Analysis reports/Flange leakage calculation reports, Engineering Data for Spring Supports and Pipe Rack loading data.
- Engineering Data/sketches for other miscellaneous items.
- Special support drawings and pipe supports cleats on Equipment.
- Pipe support standards/drawings to cover entire piping.
- Updated Piping Material Specifications and
- Valve data sheets.
- Site changes shall be marked with RED color on the applicable drawings, copy of which shall be submitted for Company's approval. The approved changes shall be taken up by the Contractor to "AS BUILT", Piping General Arrangement Drawings, Isometrics, Nozzle Orientations, Plot Plans, Key plan, etc.
- Welding Specification and Welding charts for all Piping Classes.
- Piping Bill of Materials / Material Summary and Material Status Reports.
- Any other deliverable as stated in the list of deliverables which are required for smooth completion of project.

13.0 PIPING SCOPE OF EXECUTION

The Bidder's scope of work shall include fabrication, laying / erection, supporting, painting, insulation, chemical cleaning, passivation of all grades of SS, testing, flushing and precommissioning including steam flushing, complete in all respects, of all piping in accordance with the final Process Package, required for successful erection, commissioning, operation and maintenance of the plant.

Execute piping fabrication including pre-fabrication, preheating, welding, NDT including radiography, site fabrication, Post weld heat treatment, laying and erection including bolt tensioning, bolt torqueing, supporting, water / steam flushing, air drying, nitrogen purging, testing, cleaning, painting, insulation, chemical cleaning etc. as per specifications.

Passivation of all grades of stainless steel including stabilized grades shall be done by Bidder. Necessary procedure and criteria shall be submitted by Bidder for COMPANY / COMPANY's Representative approval.

Fabrication and installation of supports either at ground level or in Rack as required as per site condition. These shall include construction of pipe support, RCC pedestals, etc.

Execute all mechanical works or modifications, including additional supports, identified during COMPANY / COMPANY's Representative checklist, technical audits, pre-commissioning and commissioning to comply the process requirement, system completeness, and compliance to specification / standards and for ease of operation / maintenance.

Resolve problems arising during pre-fabrication, shop fabrication, field fabrication or erection at site & based on sub vendor data. Necessary field design change drawings shall be prepared by Bidder and submitted for review / information and shall be reflected in the ASBUILT Drawings / Documents.

Bidder to obtain applicable statutory clearances/approval from all concerned authorities.

Bidder shall fully familiarize himself with the site conditions, approach roads, location of fabrication yards, transportations from the fabrication yard to the unit.

The scope of construction is not limited to the above but includes all such activities as required for successful commissioning of the plant as per the requirements of the P & ID's, line lists, Piping Design Basis and Engineering specifications/standards and all applicable codes/standards etc. enclosed in the bid document or needs to be referred so as to result in a total trouble free operable and maintainable plant.

The Bidder shall note that the Overall Plot plan given is TENTATIVE only. The Bidder shall make site visit and study the actual conditions of site, existing facilities and machineries, prior to quote.

After award of contract, the successful Bidder shall develop equipment layout / overall plot plan incorporating all the existing and new equipment, facilities, roads etc. showing all dimensions, inter distances, referral coordinates between each equipment / facilities / roads including the new land identified for expansion. This equipment layout / overall plot plan shall be developed taking account of all applicable OISD codes / statutory requirements.

Tie-in Points/Battery Limit drawings developed by Bidder shall indicate exact location and scope of piping installation for all incoming and outgoing lines. It may be either a separate drawing or it may be included in the installation piping GAD.

All lines at B/L shall be terminated at Pipe Rack/track level with an isolation valve/spectacle blind/matching flange etc. as per P&ID/requirements of process package. B/L valves and on- line instruments shall be operable and accessible from platform for regular maintenance and operation.

14.0 OTHER CONDITIONS OF WORK

a) Site Visits

For verification of the existing facilities as indicated in document/ drawings, Bidders are advised to make site visits to stations and make their own assessment with regard to nature of work involved.

b) Hydrostatic Testing

All piping in Stations up to the hook-up point/battery limit shall be hydrostatically tested. The test shall be in accordance with "Standard Specification for Inspection, Flushing and Testing of Piping System" enclosed with the tender document. All valves in the piping network being hydro-tested shall be kept in the crack-open position. Holding time shall be six hours. Hydro-test pressure shall be 1.5 times of design pressure.

c) Work Permits

Contractor shall obtain the necessary approvals, hot/ cold work permits & statutory permits for all works, from the Company for working inside existing terminal and other authorities (wherever applicable) before the actual works are taken up.

All stipulations/ conditions/ recommendations of the said authorities shall be strictly complied with at no extra cost to Company. Company may, however assist the Contractors for obtaining such permission to the extent of issuing recommendation letters only.

d) Priorities

Company may, at its sole option, assign priority of construction to any part or segment of the work area. Contractor shall comply with such priority of execution without any cost and time implication to the Company.

e) Working in Areas of Existing Facilities

- All works are to be carried out in existing stations with facilities under operation. Contractor shall obtain all necessary permissions for working in/around the facility and shall be fully responsible for the safety of the existing facilities/areas during all phases of work and shall fully abide by and comply with the restrictions and conditions imposed on Contractor from time to time. The Contractor shall provide all safety appliances, gas detectors, fire screens required during execution of the work.
- Contractor shall be permitted to work only during normal working hours, applicable for the station, in such places. Working on Sundays/Holidays may not be permitted except under extraordinary circumstances for which permission shall be obtained prior to commencement of work. During any emergency, work shall be suspended till Contractor obtains further permission. Idle period in case of interruption shall not be compensated to Contractor.
- The structure/electric poles etc. existing in the vicinity of proposed area shall be properly taken care so that the stability of structure is not affected during construction.
- All engineers and workers shall have Proper safety and other necessary training for execution of work.
- Use all health & safety appliance for manpower during working.
- Approved dress/ Dungaree/ safety dress/ safety boots/ helmet shall be worn during working inside terminal.
- Contractor shall install Fire extinguisher at different location as per OISD.

f) Tie-in and hook up at stations

Piping:

Subsequent to separate hydro-testing station piping, tie-in/ hook-up of station piping shall be carried out by the Contractor. Pipes/pre-fabricated assembly used for such tie-in shall be pre-tested to a test pressure specified for the piping, as applicable.

g) HOOK-UP with Existing Piping (if applicable)

Dismantling of existing piping at the hook-up locations for hook-up with existing piping at station with Spools/ flanged joint as per site conditions/ piping system and AFC drawings.

Contractor shall prepare a method statement with drawing for carrying out the hook-up works and submit the same to Company for review and approval. The hook-up work shall be carried out based on the approved methodology, drawings and/or as per site conditions and as per instruction of Engineer-in-Charge. Contractor shall check and ensure the safe working at the existing hook-up locations by using fire screens or any other suitable method duly approved by Company.

Hook-up shall be carried out while mainline is under operation, incase no shutdown is planned.

h) Non-Destructive Testing (NDT)

NDT requirements for process and other piping shall be in accordance with Piping Material Specification. Repeat Radiography due to defective radiograph on repaired joints due to Contractor's fault and/ or additional radiography necessitated due to poor performance of Contractor's welders shall be done at Contractor's cost.

i) Isometrics

The Contractor shall prepare all isometrics required for fabrication of piping before execution based on the followings:

- The spools which are to be welded at contractor fabrication ward (i.e., Not inside the existing plant)
- The field weld which are to be welded inside the terminal.

Contractor shall plan his welding in such a way that minimum welding are taken up inside the plant.

j) Pre-Commissioning of Terminal Piping and Commissioning Assistance

- Contractor shall be responsible for pre-commissioning of the piping and other facilities at station being installed by him. This shall include P&ID checks (with respect to requirement of design/ operation/ safety and interlocks of latest revision of P&ID), flushing/swabbing (as required), tightness test, de-watering, and supply of consumables required during pre-commissioning.
- Contractor shall make arrangement of functional testing of actuated valves during pre-commissioning without any extra cost to the company
- Contactor shall be responsible for pre-commissioning activities and providing commissioning assistance to the company including supply of manpower, materials, equipment along with necessary piping and instrumentation connections for monitoring flow rate, pressure, temperature etc., temporary venting/blow down along with necessary piping, valves and instrumentation as well as consumables.

k) Commissioning

Overall commissioning of the entire piping system shall be carried out by Company. However, all assistance including supply of manpower, temporary equipment, tools and tackles etc. during commissioning shall be provided by Contractor. Contractor shall retain minimum manpower required to rectify the workmanship defects, if any, noted during commissioning. Nitrogen for Purging shall be supplied by the contractor incase instructed by the Company.

15.0 SCOPE OF SUPPLY

a. Company scope of supply

Nil, all item shall be in Contractor scope.

b. Contractor's Scope of Supply

The Bidder's scope of supply includes supply & procurement of all piping materials and consumables complete in all respects, of all piping in accordance with the final Process Package, required for successful erection, commissioning, operation and maintenance of the plant. The Bidder's scope also includes supply & procurement of all materials and consumables complete in all respects for electrical tracing of piping as per the P&ID's.

Supply, Procurement & Storage of all piping materials including spring supports and bellows type expansion joints required within (corresponding installations) Bidder's B/L along with all material test certificates is in Bidder's scope.

Insulation materials with all accessories and execute all insulation jobs as per specifications for all sizes of piping as per line list / line schedule and insulation specification/standard requirement.

Paint for all equipment, piping (including small bore piping), structures like platform, pipe rack, technological structures, crossover, handrails etc. and other miscellaneous items as per specifications and standard enclosed herewith.

Support materials

All piping materials, tools and tackles required for testing, pre-commissioning and commissioning e.g. piping spools, bolting and gaskets, flanges, blinds or any other piping materials for carrying out this activity is included in Bidder's scope of supply.

The scope of supply is not limited to the above but includes all such activities like supply of all materials and components as required, for successful commissioning of the plant as per the requirements of the P&ID's, line lists, Piping Design Basis and Engineering specifications etc. enclosed in the bid documents so as to result in a total trouble free operable and maintainable plant.

The procurement and supply, in sequence and at the appropriate time & place, including inspection and expediting of all materials, (including any additional materials required for permanent installation) and consumables required for completion of the Work as defined in this tender document except the materials specifically listed under Para 10.A above as Company supplied free-issue material, shall be entirely the Contractor's responsibility. The item rates quoted for execution of work shall be inclusive of all these materials. All materials supplied by the Contractor shall be strictly in accordance with the requirements of relevant applicable Company Material Specifications and Technical Notes for various items enclosed with the tender document. All equipment, materials, components etc. shall be new and specifically purchased for this job from Company approved vendors, duly inspected by Company approved third party inspection agency (Only manufacturer's certificates shall not be adequate). Contractor shall submit all detail/drawings etc. to company for review and approval before placement of order. As a minimum, such materials to be supplied by the Contractor shall include, but not limited to the following:

a. Supply of all piping materials for station of all sizes including, assorted pipes, fittings, flanges, o-lets, spectacle blinds, spacer & blind with material conforming to PMS enclosed with the bid document for Process Piping.

b. Supply of all piping materials for Firewater network of all sizes including, assorted pipes, valves, fittings, flanges, o-lets, spectacle blinds, spacer & blind, hydrant posts, water monitors, landing valves, spray nozzles & hose boxes with material conforming to documents enclosed with the bid document for Firewater Network.

c. Supply of all types,all size, all rating of valves for , Process Piping , Fire water , Instrument Air service & other associated work with material conforming to documents /specification enclosed with the bid document. Each valve item shall be inclusive of commissioning and two-year normal operation spares. List of such spares shall be made part of the offer and the quoted unit/total price shall be inclusive of the spares.

d. All Fire water items all Hydrant & monitor as shown in the drawings, spray nozzles and GI pipes required for Spray systems of all sizes of all thicknesses & materials as per PMS/Documents /Specification

e. All stud bolts, nuts, jack screws, all type of gaskets (metallic spiral wound / ring type / non-metallic gaskets) in required quantities to be used for permanent installation into the system for all sizes & ratings of flanges and flanged valves, equipment etc.

f. All equipment and consumables for welding such as welding electrodes, oxygen, acetylene, inert gases, all types of electrodes, filler wires, brazing rods, flux etc. for welding/cutting and soldering purposes.

g. All equipment and materials including consumables required for hook-up wherever required.

h. All materials and consumables i.e. fittings, flanges, valves, blind flanges etc. required for isolation and nitrogen purging for piping section(s), including supply of nitrogen for purging, to carry out hook up with existing pipeline/piping.

i. All temporary materials required for filling, pressurizing and dewatering in connection with hydrostatic testing including pipes, flanges, blind flanges, fittings, temporary gaskets, nuts, bolts, clamps, strainers etc required for fabrication of test headers and all consumables.

j. All equipment and consumables required for hydrostatic testing like pumps, pressure and temperature gauges, test water and corrosion inhibitors for test water for hydrostatic testing.

k. All equipment and consumables required for all types of test and NDT (such as radiography, magnetic particle examination, Liquid penetration testing, etc.) including radiographic film, X-ray/gamma ray machines, developing equipment and consumables etc.

l. All steel materials such as structural steel, reinforcement steel, shims, wedges, packing plates, pipes, nuts & bolts, washers, U-bolts, anchor bolts, clamps, clips, pipe saddles/shoes etc. as required for the fabrication of structural supports and support basements/foundations, platforms etc. Pipes supplied by Company shall not be used for fabrication of supports and support saddles etc.

m. All materials required for associated civil and structural works including cement, sand, reinforcement, structural steel etc. for piping supports.

n. All types of coating and painting material including primers, paints, solvents, sand blasting material and cleaning agents, compressed air etc.

o. All material required for concreting and grouting works etc.

p. All type of safety tools, tackles, devices and apparatus, equipment etc. including ladders and scaffolding etc. as required.

q. All materials, equipment and manpower required for providing commissioning assistance.

r. Any other material not specifically listed above but required for successful completion of all works related to the station piping whether temporary or permanent in nature.

The item rates quoted for the execution of WORK shall be inclusive of supply of all materials mentioned above unless specifically covered otherwise under Schedule of Rates.

Contractor shall carry out MTO of all materials required, based on AFC General Arrangement drawings and firm up the actual requirement of materials. All escalations/ extra materials (left after completion of all works) procured by Contractor for contingencies shall be Contractor's property and no payments shall be made for such materials.

Payment shall be made for actual materials installed by the Contractor as a part of permanent installation.

16.0 STORAGE OF MATERIAL

i. All materials shall be preserved against deterioration and corrosion due to poor or improper storage while under the custody of the Contractor.

ii. All materials shall be duly protected by the Contractor at his own cost with the appropriate preservatives like primer, lacquer, coating, grease etc. and shall be covered with suitable material to prevent them from direct exposure to sun, rain, wind and dust.

iii. Pipes shall be stacked according to the identification marks and stacks shall be arranged on sleepers / sand bags at least 300 mm above ground.

iv. The Contractor shall check that valves, fittings, specials etc are not subjected to corrosion from hydrostatic test water remaining in the piping. Any such condition when detected should be brought to the notice of Engineer-in-Charge and remedial measures taken as directed.

v. All machined surface shall be properly greased and should be maintained and protected from damages.

vi. Openings of equipment, machinery, valves etc. shall be kept blocked / covered with blinds to prevent entry of foreign matter.

vii. As far as possible materials shall be transported to the site of erection only just prior to the actual erection and shall not be left around indefinitely on ground but kept on packing/sleepers etc. to maintain the minimum distance from the ground as specified and/or as per directions of Engineer-in-Charge.

17.0 SAFETY

- Contractor shall take all safety precaution as directed by engineer. When works are to be carried out in existing stations with facilities under operation. Contractor shall obtain all necessary permissions for working in/ around the facility and shall be fully responsible for the safety of the existing facilities/ areas during all phases of work and shall fully abide by and comply with the restrictions and conditions imposed on Contractor from time to time.

- The Contractor shall provide all safety appliances, gas detectors, fire screens required during execution of the work.
- Contractor shall take all safety precaution as directed by engineer in charge shall be taken for safety of the pipeline while working.
- Contractor shall be permitted to work only during normal working hours, applicable for the station, in such places. Working on Sundays/ Holidays may not be permitted except under extraordinary circumstances for which permission shall be obtained prior to commencement of work. During any emergency, work shall be suspended till Contractor obtains further permission. Idle period in case of interruption shall not be compensated to Contractor.
- The structure/ electric poles etc. existing in the vicinity of proposed area shall be properly taken care so that the stability of structure is not affected during construction.
- All engineers and workers shall have safety training.
- Contractor shall use all health & safety appliances for manpower during working.
- Contractor shall ensure approved dress, dungree, safety dress, safety boots & helmet shall be worn during the work period.
- Provision of adequate firefighting equipment viz. fire extinguishers, Fire shield oxygen mask and blankets etc. and strict compliance of safety & PPE. Exception to safety adherence shall not be allowed at any point of time and work shall be suspended till required safety arrangements are made and penalized accordingly.
- Contractor shall take care of all types of safety tools, tackles, devices and apparatus, equipment etc. including ladders and scaffolding etc. complete as required. Strict work permit system shall be followed & safety rules are must for manpower deployed.
- The Contractor is cautioned to exercise extreme care and take necessary precautions to prevent damage to the existing pipeline(s), facilities, electrical and other cables during execution of the entire works. Restoration/ reconstruction of all structures/ facilities affected during pipeline construction shall be carried out by Contractor.

18.0 FIRE WATER NETWORK

- Procurement and supply of all (except free issue material) Firewater Network materials.
- Design & Installation of fire water spray system.
- Installation of pipes for fire water network including external painting for above ground pipes/ wrapping/ coating for underground pipes with all associated fittings, welding etc.
- Hook up of the new above ground/ underground network with the existing facilities (if required).
- The requirement of fire protection systems is specified in this document. The Firewater equipment and piping layout are finalized as per OISD/ PNGRB/ NFPA & Design Basis.
- Immediately after award of work, Contractor shall make a visit to the stations and familiarize with the working conditions so as to plan for deployment of man and machinery.
- Providing all manpower, machinery, consumables for completion of works, inspection, testing; all types of safety tools, tackles, devices and apparatus, equipment etc. including ladders and scaffolding etc. complete as required including providing all types of consumables, tools, tackles

and facilities for inspection and interpretation of testing results by Company/Company's Representative personnel. Strict work permit system shall be followed & safety rules are must for manpower deployed.

- Contractor shall hire agency to carry out detailed engineering. Bidder shall submit details of special agency along with the bid documents for approval.
- All supply items shall be procure from approved vendor list.
- Supply, fabrication and erection of pipe/ equipment supports (for all sizes/ thickness) including shoes, pipes, cradles, turn buckles, T-posts for all types of guides, anchors, all necessary equipment, consumables, labor etc. for completing all works including supply of bolts, nuts, washers, U-clamps, wooden blocks etc. as required for supporting.
- The nozzle configuration shall direct water spray onto all exposed surfaces without leaving any dry spot. Spray system rings shall be so arranged to ensure uniform cooling above and below the rings without leaving any dry spots.
- The nozzles shall be provided with blow off caps to prevent dirt accumulation in the nozzle.
- Plugs should be installed at all nozzle points to provide a closed network while hydro testing.
- Water spray nozzle shall be tapped in such a way that complete drain of residual water from all water spray rings is ensured.
- All water spray nozzles, quartz bulb detectors shall be made of Aluminium Bronze.
- All fire water spray ring will be flanged end type so that hot work can be avoided during repairing/ maintenance.
- Water spray rings, pipes, branches etc. shall be of Galvanized Iron (GI pipe). However, as per requirement of color coding water spray rings, pipes etc. shall be painted with fire red color as per IS-5.
- The hydro test of the Fire water spray piping shall be performed at pressure 1.5 times the design pressure.
- Handing over of all left over Free issue material to client store.
- Any other work not listed specifically listed herein but required for completion of the works in all aspects. Mobilizing and providing all equipment manpower (skilled and unskilled), consumable and other resources etc. as required for the completion of the complete job defined herein.

19.0 LIST OF ATTACHMENTS

Contractor shall carry all works as per specification, drawing and documents enclosed with this document.

20.0 DOCUMENTS TO BE SUBMITTED AT THE TIME OF BIDDING

No technical documents are required to be submitted at the time of bidding. Bidder is advised to comply with all the requirements of bid document without any deviations. Company reserves the right to reject any bid with deviations without making any reference to bidder.

21.0 GENERAL

In case of conflict between the requirements given in this document and the requirements of other specifications enclosed with the tender document, the requirements specified in Scope of Work document shall govern.

If there is conflict, discrepancy, inconsistency or dispute between the various documents, they shall be referred in the order of priority as given below:

a. Scope of Work (This Documents)

b. P&ID's

c. Piping Material Specification

d. Job Specifications

e. Job Standards

f. Specifications

g. Standards

h. Sketch

i. Other documents not covered above.

22.0 CONTRACTOR'S RESPONSIBILITY

Contractor's responsibilities, besides the scope of work to be performed by him defined earlier, shall also include the following:

a) Appraisal and taking cognizance of site-conditions, Central Government, State Government rules and regulations/ bye-laws, applicable Indian Standards and Codes, authorities having jurisdiction over the work site(s), environmental and pollution concerns including conditions/ stipulations laid down by the concerned authorities etc. The Contractor is deemed to have recognized any restrictive features and constraints of the site(s), pipeline route and /or specific requirements of the work and made due allowance for it in the work to be performed by him.

b) Company has provided the available information and data. Company gives no guarantee or warranty as to the accuracy or completeness of the information provided. It is the Contractor's sole responsibility to obtain sufficient information / data.

c) Interpretation and verification of data/information furnished by Company. Any additional information/data/surveys etc. required by Contractor for detailed engineering and execution of the works, shall be obtained by him. Company may assist him in obtaining such information/ data by issuing recommendatory letters.

d) Entire engineering for procurement & fabrication, engineering for installation including drawings, QA/QC procedures, etc performed by the Contractor for the station piping system shall be reviewed and approved by Company. Contractor shall submit six sets of design/detailed engineering documents, drawings, procedures Company's review and approval. All works shall be executed based on approved documents only.

e) Review and approval of Contractor's entire work(s) by Company shall in no way relieve the Contractor of his sole responsibility for safe and efficient design, engineering, installation and subsequent operation of system.

f) Furnishing and mobilizing at site(s) of all construction equipment, manpower, tools and tackles, construction spreads, fully equipped and fully manned with other required support facilities etc. commensurate for spreads needed for successful execution of the works.

g) Contractor shall depute independent third party inspector for carrying out radiographic inspection/ UT and interpretation of radiograph/ UT of welds. Third party inspector shall be approved by Company.

h) Pre-commissioning/ commissioning of entire pipeline /piping system.

i) Preparing and furnishing material/ purchase requisitions, final purchase orders including specifications, Vendor's data books (including Guarantees), fabrication and construction drawings, all survey reports, inspection and testing reports, as-built records for all phases of work as applicable for fire water and station piping work.

j) The Contractor is cautioned to exercise extreme care and take necessary precautions to prevent damage to the existing facilities, electrical and other cables during execution of the entire works. Restoration/reconstruction of all structures/ facilities affected during construction shall be carried out by Contractor.

k) Contractor shall carry out all testing and inspection of materials, equipment etc. in independent testing institutions, laboratories, if so desired by Company.

l) Disposal and treatment of treated hydro-testing water, excavated materials, and surplus materials etc. as per local authority's requirements.

m) Any other work not specifically listed but required for successful completion of entire system.

23.0 AS BUILT DOCUMENT

On successful completion of hydrostatic testing, the Contractor shall prepare As Built drawings/ reports piping system as specified in scope of work. All "As Built" drawings/ reports shall be submitted as below.

a. Station

- All piping GA drawings and supports at stations
- Installation and testing reports.
- All purchase specification and procurement documents.
- All Inspection, Testing and NDT records. Radiographs/ UT of all weld joints.
- All inspection & testing documents.
- All purchase specification & procurement documents.

b. Others

Three sets of hard copies of following documents shall be submitted by Contractor:

- As-built drawings inclusive of Equipment Layout and Piping GAD's.

- Project Records

In addition, the above documents shall also be submitted in electronic media i.e. CD ROM diskettes. Software used for the presentation of these documents shall be as follows:

Type of Document	**Software**
a)Reports	MS Word/ Excel (MS Office 2000)
b)Drawings	AutoCAD

For the purpose of preparation of as-built drawings, Contractor shall update the "Issued for Construction" (IFC) drawings approved by the Company. Contractor shall be provided with electronic file of all 'IFC' drawings/ alignment sheets. Contractor shall update all the drawings issued by the Company. As-built drawings shall be prepared on AutoCAD.

24.0 LIST OF ATTACHMENTS

a) PIPING DESIGN BASIS
b) OVERALL EQUIPMENT LAYOUT
c) PIPING MATERIAL SPECIFICATION
d) TECHNICAL NOTES FOR PIPES
e) TECHNICAL NOTES FOR VALVES
f) STANDARD SPECIFICATION FOR FABRICATION AND ERECTION OF PIPING
g) STANDARD SPECIFICATION FOR INSPECTION, FLUSHING AND TESTING OF PIPING SYSTEMS
h) STANDARD SPECIFICATION FOR NON-DESTRUCTIVE EXAMINATION REQUIREMENTS OF PIPING
i) TECHNICAL NOTES FOR FLANGES, SPECTACLE BLINDS AND DRIP RINGS
j) TECHNICAL NOTES FOR BUTT WELDED, SOCKET WELDED AND SCREWED FITTINGS
k) TECHNICAL NOTES FOR GASKETS
l) TECHNICAL NOTES FOR BOLTS AND NUTS
m) STANDARD SPECIFICATIONS FOR PAINTING
n) INSPECTION AND TEST PLAN FOR BALL VALVE
o) INSPECTION AND TEST PLAN – FLANGES SPECTACLE BLINDS & DRIP RINGS
p) INSPECTION AND TEST PLAN FOR SMALL SIZE & ASSORTED LENGTH PIPES
q) INSPECTION AND TEST PLAN FOR CHECK, GATE & GLOBE VALVES
r) LIST OF RECOMMENDED THIRD-PARTY INSPECTION AGENCY (TPIA)
s) LIST OF APPROVED PARTIES FOR BOUGHT OUT ITEMS

ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF BOO COMPRESSOR STATION AT RUPKHELIA

Piping Design Basis

(SECTION-D)

Doc No.: P167-DB-P001

TA	25.10.2022	Issued With Tender	SS	MC	AD
CA	18.10.2022	Issued for Client review	SS	MC	AD
IA	10.10.2022	Issued for Internal Review	SS	MC	AD
REV.	**DATE**	**DESCRIPTION**	**ORG**	**REVIEW**	**APPROVED**

ABBREVIATION

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
OISD	Oil Industry Safety Directorate
API	American Petroleum Institute
ASTM	American Society of Testing and Material
NFPA	National Fire protection Association
CS	Carbon steel
LSAW	Longitudinal Submerged Arc Welding
3LPE	3 Layer Polyethylene
HDD	Horizontal Directional Drilling
SMYS	Specified Minimum Yield Strength
OFC	Optical Fiber Cable
HDPE	High-Density Polyethylene
OD	Outer Diameter

CONTENTS

1.0 INTRODUCTION

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e., Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCM of gas per day.

Assam Gas Company Ltd. intends to Development of Compressor Station at Rupkhelia, Golaghat, Assam.

Pipeline Engineering Consultants Pvt. Ltd. has been appointed as Engineering Consultant by M/s. Assam Gas Company Ltd. For Development of Compressor Station at Rupkhelia, Golaghat, Assam.

2.0 DEFINITION

Where used in this document, the following terms shall have the meanings indicated below, unless clearly indicated by the context to this order.

PROJECT	Development of New Compressor Station at Rupkhelia Assam
CLIENT/ OWNER	Assam Gas Company Limited.
EPMC	Pipeline Engineering Consultants Pvt. Ltd. (PLECO) the party to act for and on behalf of Owner for for the Development of Compressor Station at Rupkhelia.
CONTRACTOR	Agency appointed by CLIENT/ OWNER for execution of assigned tasks
PURCHASER	Either of CLIENT, OWNER or EPMC
VENDOR/ MANUFACTURER	Party, which manufactures and supplies equipment and services to the OWNER or to CONTRACTOR

3.0 DESIGN CODES AND STANDARDS & SPECIFICATION

Terminal facilities envisaged shall be designed and engineered primarily in accordance with the provisions of the OISD and ASME B 31.4. In addition, requirements, as applicable to LPG service of following codes/standards shall be complied with.

ASME Section - II, Div-1	:	Boilers and Pressure Vessels Code – Materials
ASME V	:	Boilers and Pressure Vessel Code – Non Destructive Testing
ASME VIII	:	Boilers and Pressure Vessel Code – Div. 1 Pressure Vessels

ASME IX	:	Boilers and Pressure Vessel Code – Welding & Brazing qualifications
ASME B 31.3	:	Process Piping
ASME B 16.5	:	Steel Pipe Flanges & Flanged Fittings
ASME B 16.9	:	Factory-made Wrought Steel Butt Welded Fittings
ASME B 16.11	:	Forged Steel Fittings, Socket Welding Threaded
ASME B 16.25	:	Butt Welded Ends
ASME B 16.47	:	Large Diameter Steel Flanges : NPS 26 through NPS 60
ASTM A 105	:	Forging, Carbon Steel for Piping Components
ASTM A 181	:	Carbon Steel Forgings for General – Purpose Piping
ASTM A 234	:	Piping Fitting of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A 370	:	Mechanical testing of Steel Products
ASTM A 216	:	Carbon Steel Castings suitable for Fusion Welding for High Temperature service
ASTM A 20	:	General Requirement for Steel Plate for Pressure Vessels
ASTM A 516	:	Carbon Steel Pressure Vessel plates for moderate and low temperature service
ASTM A 106	:	Carbon Steel Seamless Pipe for High Temperature Service
ASTM A 193	:	Alloy Steel and Stainless Steel Bolting materials for High Temperature
ASTM A 194	:	Carbon and Alloy Steel nuts for Bolts for High Pressure or Temperature
MSS-SP-6	:	Standard Finishes for Contact Faces of Pipe Flanges
MSS-SP-44	:	Steel Pipeline Flanges
MSS-SP-75	:	High Test Wrought Butt-Welded Fittings
ISO 9712	:	Non-Destructive Testing qualification and certification of personnel
ISO 10474	:	Steel and Steel Structures Inspection documents

ISO 9000	:	Quality Management and Quality Assurance Standards
ISO 9001	:	Quality Systems – Model for quality assurance in Design, Development, Production, Installation and Servicing
PNGRB	:	Petroleum and Natural gas Regulatory Board

4.0 PIPING DESIGN BASIS

I. GENERAL

The design basis gives the minimum basic requirement for piping design to be carried out. This shall be read in conjunction with the specifications attached elsewhere in the bid.

A) All design calculation for pressure requirements, vibrations, thermal expansions / flexibility considering seismic factors etc. Shall be made in accordance with code requirements and submitted to the owner for approval.

B) All piping shall be designed for combined effects of pressure, weight and temperature during operating conditions without over stressing the piping, valves or equipment.

C) All piping shall be adequately supported, guided or anchored so as to prevent undue vibration, deflection or loads on connected equipment such as filters, meters etc.

D) All station piping systems shall be designed as per the requirements of relevant OISD & ASME B 31.3 and utility piping (if required) to be provided at these locations shall be designed in accordance with the provisions of ASME B 31.3.

E) All piping material shall be tested as prescribed in the piping specifications and standard codes and practices and certificates of conformance shall be furnished for review and approval by owner.

F) All piping material and components i.e., Pipes, fittings, valves, flanges, gaskets and bolting etc. shall be as per the piping specifications.

G) Piping general arrangement drawing / isometric / support drawings etc. shall be prepared using good engineering practice as per the guidelines furnished in the piping specifications.

H) Thermal insulation and insulation for personnel protection shall be provided wherever required as per the P&ID and general specifications attached with the bid.

I) Threaded piping connections are not permitted.

J) Pipe wall thickness shall be calculated against each size of each piping class as per relevant codes.

K) Transition piece shall be provided between different grades of pipes welding if shown in P&ID and as per standard engineering practice.

L) All pipe, valves and fittings shall be new and unused and shall have legible mill code as to type and grade of material.

M) In the event of conflict, the following order of priority shall be generally governed, however the contractor shall inform the owner in writing and receive written clarification from the owner.

a) Piping design criteria/basis

b) P&ID diagrams

c) Data sheets

d) Piping material specification (PMS)

e) IFC drawings

f) Specialty item specification

g) General specification

h) Codes and standards

II. PIPING SPECIFICATIONS

The piping material specification shall be governed by the design conditions of pressure, temperature, corrosion allowance and compatibility with contained media.

When two lines that operates at different pressure – temperature conditions are connected; the valve segregating the two lines shall be rated for more severe service condition.

Pipe wall thickness shall be calculated in accordance with ASME 31.3. Corrosion allowance shall be as indicated in piping material specification.

III. PIPES

- Piping shall be designed to meet the design code of ASME B 31.3.
- Suitable allowance for occasional loads like seismic effect on the piping to be considered while calculating the wall thickness as per the relevant code applicable.
- No negative tolerance on thickness should be considered.
- Corrosion allowance should be considered based on the gas specification.
- Branch line shall be low temperature seamless pipes of equivalent grade to match with pressure and temperature rating.
- Transition piece has to be maintained between two different grade and thickness of line pipes.
- The minimum diameter used shall be ½”. The pipes having nominal diameters ¼”, 3/8”, 1 ¼”, 2 ½”, 5”, 7” shall not be used. If vessel has connections at these diameters the piping from the vessels shall be increased to the next largest diameter. Pipe size of 18” and above shall be welded type.
- All pipes 2” and below shall also be as per PMS.

IV. FITTINGS

Fittings up to 1 ½” diameter

- Generally, the fittings up to 1 ½” diameter shall be socketing welding type (or as per PMS) made of forged steel.
- Malleable cast iron fittings are not allowed.

Fittings of 2" or more in diameter

- Generally, the fittings used for piping 2" or larger in diameter shall be made of the Butt-Welding ends.
- Elbow shall have radius R = 1.5D.
- Fittings up to 24" size shall be seamless and beyond 24" shall be welded.

Branch connections (General)

- Branch connections shall be as per PMS (Piping Material Specification).
- All fittings 2" and below size shall be as per PMS.

V. FLANGES

- Welding neck flanges shall be generally used for sizes 2" and more.
- Socket welding shall be used for sizes less than or equal to 1 ½" as per piping class.
- The dimensions of flanges shall comply with ANSI B 16.5 for diameter up to 24".

VI. GASKET AND BOLTS

- The types to be used shall be as per piping material specification.

VII. VALVES

Application of various types of valves shall be as follows:

Valve Type	Typical Application
Globe	Throttling
Ball	On/off, Isolation (on main line)
Plug	On/off, Isolation (in the terminals)
Check	Uni-directional flow

All valves shall comply with the requirements of API 6D/ relevant PMS. In order to minimize potential leak sources, valves used in mainline shall be with butt-weld ends. Valve installed within the terminal to isolate the mainline/ pipeline shall also be provided with butt welding ends. However terminal valves shall be flanged ends. Flanges may be used where frequent access or removal of equipment is required.

- All main line valves shall be double block and bleed type, double piston effect for low temperature application.
- For underground services, fully welded valves shall be used and for above ground services flanged type valves shall be used.
- Stem extensions where specified in the requisition shall be to the proven vendor standard. The stem extensions height to be decided by the engineering consultant which shall be normal operating height up to chest level from the finished ground level.
- The first isolation valves from the mainline shall be welded types of ball valve.

- All isolation valves shall be equipped with spectacle blind at downstream of the valve.
- Valves shall be Top entry or Side entry.
- All valves on main line shall be operated by remote SCADA system.
- The face-to-face dimensions of valves shall be based on ANSI 16.10.
- Hand wheel made of aluminum alloy are not allowed.
- All soft-seated valves shall be fire safe as per API 607(latest edition) or API 6FA (latest edition).
- Ball valves shall be floating ball type / trunnion mounted type as per following:

RATING	SIZE	TYPE
150#, 900#	1.5" and below	Floating Ball
	2" and above	Trunnion mounted

- Generally valves up to 1-½" diameter shall have socket welding ends.
- Valves 2" or more in diameter shall be flanged, unless otherwise specified.
- Branch connection details: Branch connections shall be in accordance with piping material specification attached elsewhere in the bid.
- Installation and mounting of instruments shall be as per fabrication and installation specification.
- Underground valves/ pipes shall be coated with solid epoxy 1000 microns/ Powercrete R95.

VIII. VENTS AND DRAINS

- The venting arrangements in station should be ball and globe combination.
- Hydrostatic test vent connections shall be in accordance with piping material specification. Vents are not required on lines, which are pneumatically tested and may be omitted on alloy piping and on lines handling corrosive commodities. Vent size shall be not less than ¾".
- Piping and equipment shall be sufficiently drained at all low points to remove all liquid from the system. Drain shall be valve fitted and shall not be less than ¾".

IX. SITE AND ENVIRONMENTAL DATA

The site and environmental data attached elsewhere in the bid shall be referred for this purpose.

X. BATTERY LIMITS

Battery limits for the stations shall be as per the drawings attached in the bid.

XI. PIPING LAYOUT DESIGN GUIDES

A. LAYOUT

- All piping shall be routed in an orderly manner and grouped in banks wherever possible to provide an economical layout and have the minimum number of fittings consistent with ease of support and with the proper provision for expansion and flexibility and ease of maintenance.
- Where possible piping shall be grouped and run on sleepers for ease of supporting.
- Piping to be arranged for ease of inspection and servicing. Maintenance areas are to be kept clear of piping as far as possible. Piping shall be designed so that vessel connections and other pertinent components can be isolated for safe maintenance.
- Piping or equipment requiring occasional cleaning or maintenance shall be provided with break flanges for dismantling.
- All components requiring operation or maintenance, where practical shall be located where they can be operated or serviced conveniently. Access shall be provided to such components if they are located out of reach from platform.
- The piping arrangement shall provide for isolation by operation of valves or other components to accomplish safe isolation.
- Small instrument tubing and piping shall be adequately supported and protected from damage by impact.
- Bypass spools in piping shall be designed to permit the removal of the components bypassed without removing isolating block valves. A drain valve shall be provided to drain liquids between isolating valves.
- Connections from the header for air, nitrogen, fuel gas will be from the top and liquids to be either from the side or bottom.
- Control valves, relief valves shall be accessible from equipment or ground levels and grouped at main operating levels if possible. Valve stems should not be positioned below a horizontal centerline.
- Bracing and supports for pressure relief valve risers shall be designed to prevent vibrations during operation and to permit independent removal of pressure relief valve from piping systems.
- Pockets in lines including dead legs shall be avoided at all times.
- In the event this is not possible, all gas traps shall have accessible plugged vents and liquid traps shall have accessible plugged valve drains.
- Circumferential butt welds shall be separated by the maximum possible distance. For piping of sizes 4” and above shall be no less that 100mm apart or 5x W.T. whichever is greater. For piping 3” and below, minimum spacing shall be one pipe diameter.

- Bolt holes on fabricated piping items shall straddle the vertical and North / South center lines unless otherwise specified on the piping drawing.
- Changes in pressure rating in piping system shall be made at valves, a valve separating two different pressure rated systems shall carry the rating of higher-pressure system.
- Branching for instrument gas or air systems shall have block valves at the primary header.
- Control Valves shall be installed with the actuator in a vertical upward position. Manifold arrangements shall consider access, clearance, maintenance and removal of control valve without removing of stop valves. Control valve manifold shall preferably be located within view of associated instruments.
- The clearance between two pipes shall be the minimum of flanges to pipe distance plus 25 mm, or insulated flange to pipe insulation plus 25mm, in case where the two pipes are insulated, with the flanges staggered. Consideration shall be given to the expansion / contraction in spacing of pipes.
- The minimum clearance between hand wheels on valve manifolds shall be 75mm.
- Minimum clearance for personnel access ways shall be as follows:
- Overhead clearance : 2.2 m
- Horizontal clearance : 0.750 m
- All allocated areas for safety access, service, maintenance and operation shall be kept clear of piping or any other obstructions.
- Block valves in pipe work connected to equipment shall be installed as close to the equipment as practical.
- Locked open (or closed) valves should have a stainless steel tag shall be attached to the stem.

B. SPECTACLE BLINDS

- Spectacle blinds shall be provided as per the requirements shown in P&IDs.
- Spectacle blinds assembly shall be provided with jackscrews. All heavy flanges 12” NPS and above shall be provided with jackscrew holes for easy removal of flanges.

C. VENTS AND DRAINS

- Valve vents and drains (bleeds) shall be in accordance with process requirements as shown on the piping and instrument diagrams. They shall generally be provided at control valve sets, level controller and gauge glass hook-ups and where liquid / gas can be trapped between isolating valves.
- For pressure testing, all piping low points shall be drained by a valves connection and in general, all high points shall be vented by plugged, capped or flanged connection in accordance with the piping specification.

D. PIPING FLEXIBILITY/STRESS ANALYSIS

- All piping shall be designed for thermal expansion under start up, operating and shut down conditions without over stressing the piping, valves or equipment. Provisions for expansion shall normally be made with bends and offsets.

- All piping shall be adequately supported, guided or anchored so as to prevent undue vibration, deflection or loads on connected equipment's. Equipment's/ valves requiring periodical maintenance shall be supported in such a way that the valves and equipment can be removed with minimum temporary pipe supports.

E. PIPING MATERIAL SPECIFICATION

All procurement of materials shall be as per (PMS) and specifications indicated in PMS.

F. UTILITY REQUIREMENTS

Utilities like Power, Water etc. shall be provided up to a certain point by the purchaser, the further distribution has to be taken care by the contractor.

G. CLEARANCE AND ACCESSIBILITY

All equipment, structure, platform, piping and its support shall be arranged to provide the following minimum clearance:

Overhead Clearance (Vertical)

- Maintenance passageways and walkways : 2200mm
- Clearance between bottom of pipe and top : 300mm

of grade level

- Horizontal Clearance : 750 mm

H. EXITS

The piping arrangement shall be such that, so as to facilitate easy exit in case of emergency.

I. PLATFORMS. LADDERS AND STAIRWAYS

- Platforms, ladders and stairways shall be minimized consistent with access and safety requirements.
- Elevated stations requiring attention for operation and / or maintenance shall be supplied with a permanently fixed ladder and / or platform. Maintenance platforms shall be provided for all pressure vessels and other relief valves over 2000 mm above ground level. Access is not required to equipment nozzles where flanges are provided only for initial assembly of the piping.
- Gauges, instrumentation, cable trays and small-bore piping shall not interfere with access to area.
- Access and permanent maintenance facilities shall be provided for all plant and equipment subject to regular maintenance.

- On racks and pipe ways, consideration shall be given to space allocation for future piping.

J. EQUIPMENT

- Fixing/ Repairing of Equipment, if required.
- Permanently fixed equipment shall be supported on the ground / civil structure as applicable.
- Platforms and Access
- Elevation of platform to be established for access to instruments, valves and manway as per good engineering practices if required.
- Run piping at a common BOP elevation for ease of supporting.
- Minimum dimension from grade level to be 500 mm BOP or insulation.

K. INSTRUMENTS

i. Pressure Instruments

Local pressure indicators shall be visible from platform or permanent ladder. Gauge glasses shall be accessible from a platform, or a ladder.

ii. Temperature Instruments

Temperature elements or thermo wells shall be accessible from grade level, platforms or permanent ladder.

iii. Control Valves

- Control valves shall generally be installed in a horizontal line and the actuator in a vertical position. Variations shall be approved by the design Engineer.
- Control valves shall be easily accessible from the grade or permanent platform and be conveniently located for ease of operation, maintenance and removal.

iv. Safety valves

Safety relief valves shall be installed vertically and as close as possible to the equipment or piping to be protected. If for installation reasons (e.g. accessibility) the inlet connection length of safety valves has to be larger than usual, the pressure drop in the related section of pipe must be checked. Inlet and outlet lines to relief valves shall have full bore lock open ball valves.

5.0 GUIDELINES- PREPARATION OF PIPING DRAWINGS

A. TITLE BLOCKS

- At least following information shall be reflected in the TITLE BLOCK.
- The title of document, including the contract name.
- The document serial number included the contract number.
- The date and revision number of document.

- The purpose of issue of document with the signature / initials of the persons, who drafted, checked and approved the document.

B. REVISIONS

Revisions shall be clearly identified on all documents / drawings and modified portions shall be clouded in case of drawings and outlined (Δ shown with Revision) in case of documents.

C. LIST OF DRAWINGS

All documents shall be listed. From the list it should be possible to keep track of various issues and revisions of the documents. The list shall be regularly updated to reflect the latest revisions based on project requirements.

D. SCALES

- Equipment Layouts - 1:50, 1:75
- Piping plans / Support plans - 1:50
- The metric system shall be used for all drawings.
- True north and plant north to be shown. Nozzle with size, rating, orientation, to be marked on equipment layout for installation of equipment,
- The piping plan shall provide all information required for installation of piping. Sectional views and details to be drafted. Line marking shall be as per P&ID.
- Pipe support shall be marked on piping plans and support drawings shall be furnished separately for OWNER's review / information. The support arrangement shall be as per the Pipe Support Standards attached elsewhere in the bid.
- Piping arrangement inside Vendor's skid not required to be shown on piping GAD's.
- Piping up to 12" NB diameter shall be shown by single lines. Piping 14" NB or more shall be shown by double lines. All piping lines shall be identified as shown in P&ID. The direction of flow and any insulation and tracing shall be indicated.

6.0 FIRE WATER SYSTEM

Fire water system shall be provided for fire control, fire extinguishment and exposure protection of equipment and personnel from heat radiation. The fire water system shall meet the applicable Oil India Safety Directorate (OISD 214) standards and National Fire Protection Association (NFPA) standards.

The fire water system shall provide instantaneous supply of pressurized fire water through fire water network to fire water monitors, fire hydrants and fixed spray nozzles system for the purpose of automatically or manually suppressing fire.

The Fire water system shall consist of:

- Fire hydrant / Monitor distribution piping network
- Water spray / Deluge system

7.0 FIRE WATER NETWORK

General Requirements for Fire Water Network

- The fire water main ring shall be provided all around the perimeter of the installation and shall not pass through buildings.
- The firewater mains shall be laid by the side of road.
- Thermal Expansion loop shall be installed in main header.
- Number of isolation valves on main header must be decided in such a way that at a time not more than one segment (portion of line between two junctions) of fire water line is isolated.
- Isolation valve shall be gate valve having open/close indication which can be opened easily and quickly.
- Gate Valves twelve inches and above in diameter should be equipped with a gear mechanism to facilitate opening.
- Ball Valves six inches and above in diameter should be equipped with a gear mechanism to facilitate opening.
- All size globe valves shall be hand wheel operated.
- Three isolation valves shall be installed at all branch/ tapping/ T-points of fire water header /network, near to junction points.
- The isolation valves shall be easily identifiable and located where they are accessible during fire and should be close to the loop junctions.
- Additional isolation valves shall be provided in the segments where the length of segment exceeds 300 m.
- For pipeline size less than 150 mm diameter, support interval shall not be more than 3 m.
- Maximum allowable velocity in the ring main & deluge downstream piping shall be 5 m/s. The ring main shall not run under buildings, structures or equipment.

  a) Wrapping/ coating of height at least 300mm shall be provided for hydrants & monitor outlets. Coating shall be applied to pipes/ tapings of hydrants/ monitors, if pipe is needed to be buried or passed through PCC/RCC supports platform.
- Pipe supports and hangers should be designed for potential damage from impact and over pressure.
- The pipe support shall have only point contact. Pad shall be welded to the bottom of pipe & one MS bar shall be inserted between MS flat fixed over the slipper/pedestal & pipe pad (Pad welded to carrier pipe should rest on the support system).
- Guide supports using MS channels having length up to mid of main pipe/ carrier pipe shall be provided at both sides of the pipe and shall welded on MS flat insert plate on every alternate slipper/ pedestal.
- The piping system shall be hydrostatically tested for 4 hours at 1.5 times the design pressure.
- There shall be no branch line provision from the fire water network for any alternate use.
- Piping shall be grouped as far as possible for the ease of supports.
- Platforms should be designed in such a way so that all the nozzles/ valves should be approachable from platforms.
- All valves shall be located at operable height.

- Relief valve discharge piping shall be taken to safe location as per OISD requirements.
- Low point drain and High point Vents shall be provided as required for the system.
- Various full bore flushing point at suitable locations of main header/ ring main shall also be provided. All flush points shall be fixed with gate valve and fixed with end blind. Suitable drain points shall also be fixed at lowest suitable locations to drain residual water to facilitate hot work/ welding work in pipe.

8.0 WATER SPRAY SYSTEM AND SPRAY NOZZLE

General Requirements for Spray System & Spray Nozzles

- The medium velocity spray system/ high velocity spray system provided at all critical areas shall have spray nozzles directed radially to the facilities intended for cooling at a distance of 0.6 mtr. from the surface of the equipment / facility. Only one type of spray nozzles shall be provided in a particular facility. All spray nozzles shall be inspected for proper positioning, corrosion and cleaned, if necessary, at an interval of not more than 12 months or earlier based on the experience.
- The nozzle configuration shall direct water spray onto all exposed surfaces without leaving any dry spot. Where stiffener rings are welded on the tank shells, spray system rings shall be so arranged to ensure uniform cooling above and below the rings without leaving any dry spots.
- The nozzles shall be provided with blow off caps to prevent dirt accumulation in the nozzle.
- Plugs should be installed at all nozzle points to provide a closed network while hydro testing.
- Material of construction shall be Brass as per IS 319/Bronze as per IS 318 Gr LTB2, Chrome plated.
- The requirement of fire protection systems is specified in this document. The ring size & layout are finalized as per OISD/ NFPA. However, re-validation of spray system including sizing of Deluge valve shall be done by special agency under residual engineering by contractor.
- Water spray nozzle shall be tapped in such a way that complete drain of residual water from all water spray rings is ensured.
- All water spray nozzles, quartz bulb detectors shall be made of SS-316.
- Water spray rings, pipes, branches etc. shall be of Galvanized Iron (GI pipe). However, as per requirement of color-coding water spray rings, pipes etc. shall be painted with fire red color as per IS-5.

REFERENCE DRAWINGS

DRAWING TITLE	DRAWING NUMBER
TOPOGRAPHICAL SURVEY DRAWING OF RUPKHELIA TERMINAL SURVEY AREA:18248.27SQM(4.509ACRES)	SKP/RUPKHELIA TERMINAL

NOTES :-

1. ALL DIMENSION ARE IN MM AND CO-ORDINATES AND LEVELS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. ALL * MARKED DIMENSIONS ARE TENTATIVE, SHALL BE FINALIZED DURING DETAILED ENGINEERING.

REV	DATE	DESCRIPTION	BY	CHKD	APPD
TA	25.10.23	ISSUED WITH TENDER	RA	SH	AD
CA	18.10.23	ISSUED FOR CLIENT REVIEW	RA	SH	AD
IA	28.12.22	ISSUED FOR IDC	RA	SH	AD

OWNER: ASSAM GAS COMPANY LTD (A GOVT. OF ASSAM UNDERTAKING)

ENGINEERING CONSULTANT : PLECO PIPELINE ENGINEERING CONSULTANTS PVT. LTD.

PROJECT: DEVELOPMENT OF RUPKHELIA (GOLAGHAT) STATION

DWG. TITLE : TENTATIVE EQUIPMENT LAYOUT FOR RUPKHELIA (GOLAGHAT) COMPRESSOR STATION

SCALE.	JOB NO.	DRAWING NUMBER	REV.
1:400	P167	P167-00-EQP-P401	TA
SHEET 1 OF 1			

CAD FILE NAME : \\ P134-00-EQP-P401

SHEET SIZE : A1 (841 mm x 594 mm)

ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF COMPRESSOR STATION AT RUPKHELIA

PIPING MATERIAL SPECIFICATION

DOCUMENT NO.: P167-PMS-P401

TA	25.10.2023	Issued With Tender	SS	MC	AD
CA	18.10.2023	Issued for Client Review	SS	MC	AD
IA	08.10.2023	Issued for Internal Review	SS	MC	AD
REV.	**DATE**	**DESCRIPTION**	**ORG**	**REVIEW**	**APPROVED**

ABBREVIATION

PMS	Piping Material Specification
IBR	Indian Boiler Regulations
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
AARH	Arithmetic Average Roughness Height
NDT	Non-Destructive Testing
BS	British Standards
CS	Carbon Steel
MS	Mild Steel
IS	Indian Standard Code
NFPA	National Fire Protection Association
OISD	Oil Industry Safety Directorate
PNRGB	Petroleum & Natural Gas Board
ERW	Electric Resistance Welding
BE	Bevel End
BW	Butt Welded
SW	Socket Weld
FF	Flat Face
PEB	Plain Bevel End
PE	Plain End
RF	Raised Face
SCRF	Screwed End Female
SCRM	Screwed End Male
M	Matching – Schedule / Thickness
BHN	Brinell Hardness Number
MP Test	Magnetic Particle Test

1.0 SCOPE

This specification covers minimum requirements for the material specification for pipe, fittings, flanges, line blinds, bolts, gaskets, and valves that shall be used for natural gas pipeline and associated facilities in accordance with ASME B31.8, OISD-226 and PNGRB guideline

This specification also defines, by piping class for each listed service, and defines the pressure/temperature limitations within which they may be used.

This specification shall be read in conjunction with various codes and standards as applicable.

2.0 CODES AND STANDARDS

2.1 Pipeline and pipeline terminal facilities envisaged as part of this project shall be designed and engineered primarily in accordance with the provisions of the latest edition of the following codes:

i. ASME B 31.8 - Gas transmissions and Distribution Piping System

ii. ASME B 31.3 - Chemical Plant and Petroleum Refinery Piping

iii.

iv. OISD Standard 226 - Natural Gas Transmission Pipelines.

v.

vi. PNGRB - Petroleum & Natural Gas Regulatory Board

2.2 All codes, standards and specifications referred herein shall be the latest edition of such documents.

2.3 For sake of brevity the initials of the society to which the codes are referred may be omitted in the specifications, for example, B16.5 is a code referring to ASME A106 is a code referring to ASTM.

2.4 In addition to this PMS, various piping and pipeline materials shall also be applicable.

3.0 MATERIAL SPECIFICATIONS

Individual piping class has been generally designed to cover a set of service operating within pressure-temperature consideration as per ASME B16.5/ B16.34 or part of it. Deviations of material from class specifications may occur due to specific design conditions and/or availability. These deviations are permissible if they equal or better the individual class requirements and shall be subjected to approval on case-to-case basis.

4.0 CLASS DESIGNATION CODE

The piping class designation shall generally consist of three digits made up of a letter, number & letter e.g., P1C, P1L, P3C, P3L, P6C & P6L as follows:

First alphabet shall represent Pleco as well as Pipe, second place numeral is for class, 1 is for 150#, 3 is for 300# & 6 is for 600# respectively and last alphabet shall represent the material; CS, LTCS, Fire Water, Portable water.

5.0 PIPELINE

Line pipe material grade and wall thickness details are indicated in PMS.

6.0 PIPES

6.1 Carbon steel pipe shall be made by open hearth, electric furnace or basic oxygen process only. The steel used shall be fully killed and made with fine grain structure. The grade and wall thickness of various sizes of pipes shall be as per piping material specification for the applicable class.

6.2 Pipe dimensions shall be in accordance with ASME B 36.10 for carbon steel ASTM standard pipes & API 5L for carbon steel API 5L grade pipes.

6.3 All pipe threads shall conform to American Standard taper as per ASME B 1.20.1 NPT, unless otherwise specified.

6.4 For butt weld end, bevel shall be in accordance with API specification 5L or ASME B16.25 as applicable.

7.0 FITTINGS

7.1 Fully killed carbon steel shall be used in the manufacture of fittings. The fitting shall have carbon equivalent not exceeding 0.45, based on check analysis.

7.2 Threaded joints, if used, shall conform to American Standard taper as per ASME B1.20.1 NPT.

7.3 Dimensions of socket welded/screwed fittings shall conform to ASME B 16.11. Swage shall be as per BS 3799.

7.4 Dimensions of steel butt welded fittings shall be as per ASME B 16.9.

7.5 Bore of socket welded fittings shall suit outside diameter (OD) of pipe and its thickness.

7.6 Butt welding ends shall conform to API specification 5L or ASME B 16.25 as applicable. In case of difference in thickness of matching ends, requirements of ASME B 31.4 shall apply.

7.7 Integrally reinforced forged branch fittings such as Sockolet, Weldolet etc. shall be as per MSS-SP-97. Fittings not covered in ASME B16.9 and MSS-SP-97 shall conform to manufacturer’s standard.

7.8 Fittings thickness tolerances shall match pipe thickness tolerance.

8.0 BENDS

8.1 Unless otherwise specified for process piping, elbow of radius R = 1.5 D shall only be used.

8.2 In order to accommodate changes in vertical and horizontal alignment in pig gable section of pipeline, Elastic bends/ Cold field bends/ Hot formed long radius bends shall be used.

8.3 D = Specified Outside Diameter

8.4 Long Radius Bend shall be used only when indicated in AFC drawing.

8.5 Miters shall not be used.

9.0 FLANGES

9.1 Pressure Temperature rating of flanges shall conform to B16.5/ MSS-SP44/ B16.47 Series A, as applicable.

9.2 Dimensions of flanges shall be in accordance with B16.5/ MSS-SP44/ B16.47 Series A, as applicable.

9.3 Neck of weld neck (WN) flanges shall suit pipe bore and thickness.

9.4 Bore of socket welded (SW) flanges shall suit pipe O.D. and its thickness.

9.5 Threads for screwed flanges, if used, shall conform to American Standard taper as per ASME B 1.20.1 NPT.

9.6 Sizes for blind flanges shall be indicated by nominal pipe size.

9.7 Unless specified otherwise in Piping Material Specification the flange face finish shall be as per ASME B16.5.

9.8 Butt welding ends of WN flanges shall conform to ASME B 16.25.

9.9 Spectacle blind/spacer & blinds shall be in accordance with ASME B 16.48/ manufacturer's standard.

10.0 GASKETS

10.1 Spiral wound metallic gasket with Graphite filled winding with SS304 inner ring and CS outer ring and shall conform to ASME B 16.20/ API 601.

10.2 Spiral wound gasket shall be self-aligning type.

11.0 BOLTING & THREADS

11.1 Nuts for stud bolts shall be American Standard Hexagon Heavy Series and double chamfered.

11.2 Dimension and tolerances for stud bolts and nuts shall be as per ASME B 18.2.1 and 18.2.2 with full threading to ASME B 1.1 Class 2A thread for bolts and Class 2B for nuts. Diameter and length of stud bolts shall be as per ASME B 16.5/ASME B16.47 with full threading.

11.3 Threads for nuts shall be as per ASME B 1.1 as follows,

Nuts for stud bolts dia ¼" to 1"	:	UNC-2B
Nuts for stud bolts dia 1⅛" to 3¼"	:	8UN-2B

11.4 Threads for stud bolts shall be as per ASME B 1.1, as follows:

Stud bolts dia ¼" to 1"	:	UNC-2A
Stud bolts dia 1⅛" to 3¼"	:	8UN-2A

11.5 Threads for threaded pipe, fitting, flanges and valve shall be in accordance with B1.20.1 taper threads, unless specified otherwise.

11.6 Heads of jack screws shall be heavy hexagonal type. Jack screw end shall be rounded. Stud bolts shall be fully threaded with two hexagonal nuts.

12.0 THREAD SEALANT

12.1 Threaded joints shall be made with 1" wide PTFE jointing tape.

13.0 VALVES

13.1 Valve ends shall be as per valve data sheets for various piping class.

13.2 Sectionalizing valves, Block valves and other isolation valves installed on the main pipeline shall be ball valves with butt welding ends. All inline isolation valves on the mainline (pipeline) shall be full bore valves to allow smooth passage of cleaning as well as intelligent pigs.

13.3 All buried valves shall be provided with stem extension, sealant, vent/drain and shall have butt welded ends as per relevant specification/ data sheet.

13.4 Flange dimensions and face finish of flanged end valves shall conform to clause 9.0 of this specification.

13.5 Butt welding ends of Butt-Welded valves shall conform to ASME B 16.25.

13.6 Face to face and end to end dimensions shall conform to applicable standards.

13.7 Valves shall conform to following standards unless specified otherwise in piping material specification for various piping class.

Flanged/Socket Welded end valves (1½" and below)

Design STD. for Process lines

Gate Valves	:	API 602
Globe Valves	:	BS EN ISO 15761
Check Valves	:	BS EN ISO 15761
Ball Valves	:	BS EN ISO 17292
Plug Valves	:	BS 5353

Flanged/Butt Welded end valves (2" and above)

Design STD. for Process Lines

Gate Valves	:	API 6D
Globe Valves	:	BS 1873
Check Valves	:	API 6D
Ball Valves	:	API 6D
Plug Valves	:	API 6D

13.8 All manual operated valves shall be provided with wrench / hand wheel or gear operator as specified here in below.

13.8.1 Gate Valves

For ANSI class 150 and 300	-	Hand wheel operated for size ≤ 12"NB
		Gear operated for size ≥ 14" NB.
For ANSI class 600	-	Hand wheel operated for size ≤ 10"NB
		Gear operated for size ≥ 12" NB.

13.8.2 Globe Valves

For ANSI class 150, 300, 600 - Hand Wheel operated for all size

13.8.3 Ball valves & Plug Valves

For all ANSI class - Wrench operated for size ≤ 4"NB
Gear operated for size ≥ 6" NB.

13.8.4 Actuated Valves

Actuated valves shall be as per P & IDs. The actuator shall have provision for remote operation as per P & IDs. All Actuated valves shall have additional provision of hand wheel operation.

14.0 QUICK OPENING END CLOSURE

Quick opening end closure to be installed on scraper traps shall be designed in accordance with Section VIII of ASME Boiler and Pressure Vessel Code and equipped with safety locking devices in compliance with Section VIII, division 1, UG-35.2 of ASME Boiler and Pressure Vessel Code.

15.0 HYDROTESTING VENTS AND DRAINS

In terminal piping, high point vents and low point drains required for the purpose of hydro testing shall be of size 0.75". These vents & drains shall consist of gate valves with blind flange assembly.

16.0 PIPELINE SPECIATLITY ITEMS

Pipeline specialty items viz. scraper traps, flow tees, insulating joints, LR bends etc. shall be as per data sheets and specification.

For Mainline Items, corrosion allowance shall be as per data sheet.

17.0 INSULATING GASKET, SLEEVE AND WASHER

The insulating gasket shall consist of a PTFE (Teflon) spring-energized face seal, or an elastomeric O-ring, seated in an isolating laminate, which shall be permanently bonded to a high strength metal gasket core. Due to this unique pressure activated sealing mechanism, the gasket requires far less bolt stress to seal than any other gasket. The gasket inner diameter shall be exactly matched to the flange bore to eliminate turbulent flow and flange face erosion/ corrosion. The seal elements shall be replaceable in the reusable gasket retainer. The core of gasket shall be made of annealed 316 stainless steel or other metals including duplex and Inconel etc.

Insulating gasket shall include the following applications,

- Flange isolation in conjunction with cathodic protection.
- Isolation between dissimilar metals to prevent galvanic corrosion.
- Mating mismatched ring-joint to raised –face flanges.
- Eliminate fluid trap corrosion between ring-joint (RTJ) flanges where high concentrations of Co_2, H_2S and other aggressive hydrocarbon media are present.
- Eliminate turbulence and flow induced erosion between ring-joint (RTJ) flanges.
- Protect against coating impingement on coated flange faces.

- To seal between flanges subjected to vibration/ cavitation.

17.1 Insulating Gasket, sleeves and washers' material properties:

Compressive strength	:	65000 PSI
Average Dielectric strength	:	15 KV
Electrical resistance	:	> 1 Mega Ohm (When tested with 500- 1000 V DC megger)
Max. Operating temp.	:	302°F (150°C)
Min. Operating temp.	:	(minus) -200°F
Water absorption	:	5%
Flexural strength	:	70000 PSI
Tensile strength	:	50000 PSI
Bond strength	:	2600 lb
Shear strength	:	22000 lb.

17.2 Seal Material

The sealing elements shall intend to provide an impervious barrier through which no contained media or other substance can penetrate. The composite retainer backing material behind the seal remains uncontaminated and thus permanently holds the seal in place in a static, fully encapsulated manner.

Viton as a seal material shall consist following properties,

- General purpose oilfield elastomer.
- Excellent resistance to aliphatic hydrocarbons, glycols and H2S.
- Good resistance to aromatic hydrocarbons.

Isolating Sleeve

Mylar as a seal material shall consist following properties,

- Spiral wound Mylar is a general-purpose material recommended for bolting application with flange temperatures below 250°F.
- Material shall be fair resistance to crushing, cracking, breaking and thread pinch.

Isolating washer: 1/8" (0.125) Thick washer

Steel Washer: ZPS standard – Zinc plated steel washers.

Butt weld (BW) ends of the insulating assembly shall be protected by metallic or high impact plastic bevel protectors.

The dimensions of insulating components (gaskets, sleeves and washers) shall be as indicated in Data Sheet. The insulating gasket and washers shall have adequate compressive strength to permit proper tightening of flange bolts for leak proof joint.

The insulating material shall be suitable for pressure and temperature indicated in Data Sheet under connecting pipeline details and shall be resistant to the fluid to be handled through the pipeline.

I.D. and O.D. of insulating washers shall be designed to fit over insulating sleeves and within spot faces on flanges.

After the hydrostatic test, insulating flange assembly shall be tested with air at 5 kg/cm2 for 10 minutes. The tightness shall be checked by immersion or with a frothing agent. No leakage shall be accepted.

Insulating gasket, sleeve and washer after the field hydrostatic test shall be tested for dielectric integrity at 5000 V A.C., 50 Hz for one minute and the leakage current before and after shall be equal. Testing time, voltage and leakage shall be recorded and certified. The test shall be carried out in dry conditions.

18.0 CHARPY V-NOTCH TEST

All piping material like valves, fittings, flanges bolting etc. shall be Charpy impact tested. Charpy V-notch impact tests are required for the base metal weld metal and heat-affected zone (HAZ)

Sr. No.	Piping Class	Rating	C. A.	Spl. Reqt.	Basic Material	Service	Remarks
1	P1C	150	1.5	NON-IBR	CARBON STEEL	NON-CORROSIVE PROCESS-FLAMMABLE/ /NONFLAMMABLE, NON-LETHAL - HYDROCARBONS	
2	P1L	150	1.5	LOW TEMPER ATURE SERVICE	CARBON STEEL	NON-CORROSIVE PROCESS-FLAMMABLE/ NON-FLAMMABLE, NON-LETHAL - HYDROCARBONS	
3	P3C	300	1.5	NON-IBR	CARBON STEEL	NON-CORROSIVE PROCESS-FLAMMABLE / NON-FLAMMABLE, NON-LETHAL-HYDROCARBONS	
4	P3L	300	1.5	LOW TEMPER ATURE SERVICE	CARBON STEEL	NON-CORROSIVE PROCESS-FLAMMABLE / NON-FLAMMABLE, NON-LETHAL-HYDROCARBONS	
5	P6C	600	1.5	NON-IBR	CARBON STEEL	NON-CORROSIVE PROCESS-FLAMMABLE / NON-FLAMMABLE, NON-LETHAL-HYDROCARBONS	

Sr. No.	Piping Class	Rating	C. A.	Spl. Reqt.	Basic Material	Service	Remarks
6	P6L	600	1.5	LOW TEMPERATURE SERVICE	CARBON STEEL	NON-CORROSIVE PROCESS-FLAMMABLE / NON-FLAMMABLE, NON-LETHAL-HYDROCARBONS	

PIPE CLASS : P1C

RATING	:	150
BASE MATERIAL	:	Carbon Steel
CORROSION ALLOWANCE	:	1.5 MM
SPECIAL REQUIREMENT	:	Non-IBR

TEMPERATURE (Deg. C) AND PRESSURE (Kg/Sq. cm g) RATINGS

TEMP	-29	38	93	149	204	260	316	343	371
PRESS	20.03	20.03	18.28	16.17	14.06	11.95	9.84	8.78	7.73

SERVICE

Natural Gas, Utilities (water, inst. air, plant air, nitrogen, carbon dioxide)

NOTES

1. All vents and drains shall be provided with gate valve with blind flange assembly unless otherwise indicated in P&ID.
2. NDT of welds shall be as follows:

   Radiography : All butt welds 100%

   MPI : Socket welds 100%

3. Piping design as per ASME B 31.8, OISD 226 & PNGRB Guidelines
4. Charpy V notch test and hardness test shall be conducted for pipes, fittings and flanges at (-) 29°C.
5. All branch connections including vent, drain, pressure and temperature connection shall be as per branch connection table.
6. For valves, refer valve data sheets.

ITEM	SIZE	DESCRIPTION
Maintenance joints	ALL	Flanged, to be kept minimum
Pipe joints	1.5" & BELOW	SW coupling
	2.0" & ABOVE	Butt welded
Drains	ON LINES <= 1.5"	Refer std. P-STD-419
	ON LINES >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Vents	ON LINES <= 1.5"	Refer std. P-STD-419
	ON LINES >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Temp. Connection	1.5"	Flanged, installation as per std. P-STD-414 & 415, except skin temperature measurement.
Press. Connection	0.75"	SW nipple with Plug/ Ball Valve to spec. as per Refer std. P-STD-411, 412 & 413

BRANCH TABLE

																BRANCH PIPE
															T	24
														T	T	20
													T	T	T	18
												T	T	T	T	16
											T	T	T	T	T	14
										T	T	T	T	T	T	12
									T	T	T	T	T	T	T	10
								T	T	T	T	T	T	T	W	8
							T	T	T	T	T	T	W	W	W	6
						T	T	T	W	W	W	W	W	W	W	4
					T	T	T	W	W	W	W	W	W	W	W	3
				T	T	T	W	W	W	W	W	W	W	W	W	2
			T	T	T	T	S	S	S	S	S	S	S	S	S	1.5
		T	T	T	S	S	S	S	S	S	S	S	S	S	S	1
	T	T	T	T	S	S	S	S	S	S	S	S	S	S	S	0.75
T	T	T	T	S	S	S	S	S	S	S	S	S	S	S	S	0.50
0.05	0.75	1	1.5	2	3	4	6	8	10	12	14	16	18	20	24	

R U N P I P E

CODE DESCRIPTION

T	TEES
W	WELDOLETS
S	SOCKOLETS

Item	Lower Size (Inch)	UpperSize (Inch)	Sch./Thk.	Dmn. STD	Material (Charpy)	Description
Pipe Group						
PIPE	00.500	00.750	TPV*	B-36.10	ASTM A 106 GR. B	PE, SEAMLESS
PIPE	01.000	01.500	TPV*	B-36.10	ASTM A 106 GR. B	PE, SEAMLESS
PIPE	02.000	02.000	TPV*	B-36.10	ASTM A 106 GR. B (Charpy)	BE, SEAMLESS
PIPE	03.000	14.000	TPV*	B-36.10	ASTM A 106 GR. B (Charpy)	BE, SEAMLESS
PIPE	16.000	24.000	TPV*	B-36.10	ASTM A672 GR. B60 CL.12	BE, EFSW
NIPPLE	00.500	01.500	TPV*	B-36.10	ASTM A 106 GR. B	PBE, SEAMLESS
Flange Group						
FLNG.SW	00.500	01.500	M	B-16.5	ASTM A 105	150, RF/ 125AARH
FLNG.WN	2.000	24.000	M	B-16.5	ASTM A 105 (Charpy)	150, RF/ 125AARH
FLNG.BLIND	00.500	01.500		B-16.5	ASTM A 105	150, RF/ 125AARH
FLNG.BLIND	2.000	24.000		B-16.5	ASTM A 105 (Charpy)	150, RF/ 125AARH
FLNG.FIG.8	00.500	08.000		ASME B16.48	ASTM A 105 (Charpy)	150, FF/ 125AARH
SPCR&BLND	10.000	24.000		ASME B16.48	ASTM A 105 (Charpy)	150, FF/ 125AARH
Fitting Group						
ELBOW.90	00.500	01.500		B-16.11	ASTM A 105	SW, 6000
ELBOW.90	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (Charpy)	BW, 1.5D
ELBOW.45	00.500	01.500		B-16.11	ASTM A 105	SW, 6000
ELBOW.45	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (Charpy)	BW, 1.5D
T. EQUAL	00.500	01.500		B-16.11	ASTM A 105	SW, 6000
T. EQUAL	02.000	20.000	M, M	B-16.9	ASTM A 234 GR.WPB (Charpy)	BW
T.RED	00.500	01.500	M, M	B-16.11	ASTM A 105	SW, 6000

Item	Lower Size (Inch)	UpperSize (Inch)	Sch./Thk.	Dmn. STD	Material (Charpy)	Description
T.RED	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (Charpy)	BW
REDUC. CONC	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (Charpy)	BW
REDUC. ECC	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (Charpy)	BW
SWAGE. CONC	00.500	03.000	M, M	BS-3799	ASTM A 105 (Charpy)	PBE
SWAGE. ECC	00.500	03.000	M, M	BS-3799	ASTM A 105 (Charpy)	PBE
CAP	00.500	00.750		B-16.11	ASTM A 105	SCRF, 6000
CAP	01.000	01.500		B-16.11	ASTM A 105	SCRF, 3000
CAP	02.000	24.000	M	B-16.9	ASTM A 234 GR.WPB (Charpy)	BW
PLUG	00.500	00.750		B-16.11	ASTM A 105	SCRM, 6000
O' let						
WELDOLET	02.000	06.000	M, S160	MSS-SP97	ASTM A 105 (Charpy)	BW
SOCKOLET	00.500	00.750		MSS-SP97	ASTM A 105	SCRF, 6000
SOCKOLET	01.000	01.500		MSS-SP97	ASTM A 105	SW, 3000
Valves						
VLV.GLOBE	00.250	01.500		BS EN ISO 15761	BODY-ASTM A 105, TRIM-STELLITED, STEM-13%CR STEEL	SW, 800, 3000,B-16.11
VLV.GLOBE	02.000	24.000		BS-1873	BODY-ASTM A 216 GR.WCB, TRIM-13%CR. STEEL	FLGD, 150, B-16.5, RF/125AARH
VLV.GLOBE	02.000	24.000		BS-1873	BODY-ASTM A 216 GR.WCB, TRIM- 13% CR. STEEL	BW, 150, B-16.25
VLV.CHECK	00.250	01.500		BS EN ISO 15761	BODY-ASTM A 105, TRIM-STELLITED	SW, 800, 3000,B-16.11

Item	Lower Size (Inch)	UpperSize (Inch)	Sch./Thk.	Dmn. STD	Material (Charpy)	Description
VLV.CHECK	02.000	24.000		API-6D	BODY-ASTM A 216 GR.WCB, TRIM-13%CR. STEEL	FLGD, 150, B-16.5, RF/125AARH
VLV.BALL	00.500	01.500		BS EN ISO 17292	BODY-ASTM A 105, TRIM-13% CR. STEEL, SEAT-RPTFE	SW, 150,B-16.5, RF/125AARH
VLV.BALL	02.000	24.000		API-6D	BODY-ASTM A216 GR.WCB, TRIM/BALLSEAT-(AISI 4140 + 0.003"ENP)/AISI 410	FLGD, 150, B-16.5, RF/125AARH
VLV.BALL	02.000	24.000		API-6D	BODY-ASTM A 216 GR.WCB, TRIM- BALL, SEAT-(AISI 4140 + 0.003"ENP) / AISI 410	BW, 150,B-16.25
VLV.PLUG	00.500	01.500		BS-5353	BODY-ASTM A 105, PLUG - A105 +0.003" ENP	SW, 800, 3000, B-16.11,
Bolt Group						
BOLT.STUD	00.500	48.000		B-18.2	BOLT: A193 GR. B7, NUT: A194 GR.2H	
Gasket Group						
GASKET	00.500	24.000		B-16.20-ANSI B16.5	SP.WND METTALIC WITH GRAPHITE FILLER	SPIRAL, 150

TPV*: To be provided by the Vendor.

M: Match to Pipe thickness/ Schedule.

PIPE CLASS	**:**	**P1L**
RATING	:	150
BASE MATERIAL	:	Carbon Steel
CORROSION ALLOWANCE	:	1.5 MM
SPECIAL REQUIREMENT	:	Low Temperature Service

TEMPERATURE (Deg. C) AND PRESSURE (Kg/Sq. cm g) RATINGS

TEMP	-45	38	93
PRESS	18.63	18.63	17.57

SERVICE

Natural Gas, Utilities (water, inst. air, plant air, nitrogen, carbon dioxide)

NOTES

1. All vents and drains shall be provided with gate valve with blind flange assembly unless otherwise indicated in P&ID.
2. NDT of welds shall be as follows:

   Radiography : All butt welds 100%

   MPI : Socket welds 100%
3. Piping design as per ASME B 31.8 OISD 226 & PNGRB Guidelines
4. Charpy V notch test and hardness test shall be conducted for pipes, fittings and flanges at (-) 45°C.
5. All branch connections including vent, drain, pressure and temperature connection shall be as per branch connection table.
6. For valves, refer valve data sheets.

ITEM	SIZE	DESCRIPTION
Maintenance joints	ALL	Flanged, to be kept minimum
Pipe joints	1.5" & BELOW	SW coupling
	2.0" & ABOVE	Butt welded
Drains	ON LINES <= 1.5"	Refer std. P-STD-419
	ON LINES >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Vents	ON LINES <= 1.5"	Refer std. P-STD-419
	ON LINES >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Temp. Connection	1.5"	Flanged, installation as per std. P-STD-414 & 415, except skin temperature measurement.
Press. Connection	0.75"	SW nipple with Plug/ Ball Valve to spec. as per Refer std. P-STD-411, 412 & 413

BRANCH TABLE

BRANCH PIPE								
6								T
4							T	T
3						T	T	T
2					T	T	T	W
1.5				T	T	T	T	S
1			T	T	T	S	S	S
0.75		T	T	T	T	S	S	S
0.50	T	T	T	T	S	S	S	S
RUN PIPE	**0.05**	**0.75**	**1**	**1.5**	**2**	**3**	**4**	**6**

CODE DESCRIPTION

T	TEES
W	WELDOLETS
S	SOCKOLETS

Item	Lower Size (Inch)	UpperSize (Inch)	Sch./Thk.	Dmn. STD	Material (Charpy)	Description
Pipe Group						
PIPE	00.500	00.750	TPV*	B-36.10	ASTM A 333 GR.6	PE, SEAMLESS
PIPE	01.000	01.500	TPV*	B-36.10	ASTM A 333 GR.6	PE, SEAMLESS
PIPE	02.000	02.000	TPV*	B-36.10	ASTM A 333 GR.6	BE, SEAMLESS
PIPE	03.000	06.000	TPV*	B-36.10	ASTM A 333 GR.6	BE, SEAMLESS
NIPPLE	00.500	01.500	TPV*	B-36.10	ASTM A 333 GR.6	PBE, SEAMLESS
Flange Group						
FLNG.WN	00.500	06.00	M	B-16.5	ASTM A 350 GR.LF2	150, RF/125AARH
FLNG.BLIND	00.500	06.00		B-16.5	ASTM A 350 GR.LF2	150, RF/125AARH
FLNG.FIG.8	00.500	06.00		ASME B16.48	ASTM A 350 GR.LF2	150, FF/ 125AARH
Fitting Group						
ELBOW.90	00.500	00.750		B-16.11	ASTM A 350 GR.LF2	SW, 6000
ELBOW.90	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
ELBOW.90	02.000	6.000	M	B-16.9	ASTM A 420 GR.WPL6	BW, 1.5D
ELBOW.45	00.500	00.750		B-16.11	ASTM A 350 GR.LF2	SW, 6000
ELBOW.45	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
ELBOW.45	02.000	6.000	M	B-16.9	ASTM A 420 GR.WPL6	BW, 1.5D
T. EQUAL	00.500	00.750		B-16.11	ASTM A 350 GR.LF2	SW, 6000
T. EQUAL	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
T. EQUAL	02.000	6.000	M	B-16.9	ASTM A 420 GR.WPL6	BW
T.RED	00.500	00.750		B-16.11	ASTM A 350 GR.LF2	SW, 6000
T.RED	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
T.RED	02.000	6.000	M, M	B-16.9	ASTM A 420 GR.WPL6	BW
REDUC. CONC	02.000	6.000	M, M	B-16.9	ASTM A 420 GR.WPL6	BW
REDUC. ECC	02.000	6.000	M, M	B-16.9	ASTM A 420 GR.WPL6	BW
SWAGE. CONC	00.500	03.000	M, M	BS-3799	ASTM A 350 GR.LF2	PBE
SWAGE.ECC	00.500	03.000	M, M	BS-3799	ASTM A 350 GR.LF2	PBE
CAP	00.500	01.500		B-16.11	ASTM A 350 GR.LF2	SCRF, 3000
CAP	02.000	6.000	M	B-16.9	ASTM A 420 GR.WPL6	BW
PLUG	00.500	01.500		B-16.11	ASTM A 350 GR.LF2	SCRM, 3000
COUPLING FULL	00.500	00.75		B-16.11	ASTM A 350 GR.LF2	SW, 6000
COUPLING FULL	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
COUPLING HALF	00.500	00.75		B-16.11	ASTM A 350 GR.LF2	SW, 6000
COUPLING HALF	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
O' let						
WELDOLET	02.000	06.000	M, XXS	MSS-SP97	ASTM A 350 GR.LF2	BW
SOCKOLET	00.500	00.750		MSS-SP97	ASTM A 350 GR.LF2	SW, 6000

SOCKOLET	01.000	01.500		MSS-SP97	ASTM A 350 GR.LF2	SW, 3000
Valves						
VLV.GLOBE	00.500	01.500		BS EN ISO 15761	BODY-ASTM A 350 GR.LF2, TRIM STELLITED, STEM SS304	SW, 800, 3000, B-16.11
VLV.GLOBE	02.000	6.000		BS-1873	BODY-ASTM A 350 GR.LF2, TRIM STELLITED, STEM SS304	FLGD, 150, B-16.5, RF/125AARH
VLV.CHECK	00.500	01.500		BS EN ISO 15761	BODY-ASTM A 350 GR.LF2, TRIM STELLITED	SW, 800, 3000, B-16.11
VLV.CHECK	02.000	6.000		API-6D	BODY-ASTM A352 GR.LCB, TRIM STELLITED	FLGD, 150, B-16.5, RF/125AARH
VLV.BALL	00.500	01.500		BS EN 1SO 17292	BODY-ASTM A352 GR.LCB / ASTM A350 GR.LF2 CL.1, TRIM-BODY SEAT-RPTFE	SW, 800, 3000, B-16.11
VLV.BALL	02.000	6.000		API-6D	BODY-ASTM A352 GR.LCB / ASTM A350 GR.LF2 CL.1, TRIM-BODY SEAT-RPTFE	FLGD, 150, B-16.5, RF/125AARH
VLV.BALL	02.000	6.000		API-6D	BODY-ASTM A352 GR.LCB / ASTM A350 GR.LF2 CL.1, TRIM-BODY SEAT-RPTFE	BW, 150, B-16.25
Bolt Group						
BOLT.STUD	00.500	6.000		B-18.2	BOLT: A320 GR. L7, NUT: A194 GR.4	

Gasket Group						
GASKET	00.500	6.000		B-16.20-ANSI B16.5	SP.WND SS316+GRAFOIL	SPIRAL, 150

TPV*: To be provided by the Vendor

M: Match to Pipe thickness/ Schedule.

PIPE CLASS : P3C

RATING : 300

BASE MATERIAL : Carbon Steel

CORROSION ALLOWANCE : 1.5 MM

SPECIAL REQUIREMENT : Non-IBR

TEMPERATURE (Deg. C) AND PRESSURE (Kg/Sq. cm g) RATINGS

TEMP	-29	38	93	149	204	260	316	343
PRESS	52.02	52.02	47.45	46.05	44.64	42.18	38.66	37.61

SERVICE

Natural Gas, Utilities (water, inst. air, plant air, nitrogen, carbon dioxide)

NOTES

1. All vents and drains shall be provided with gate valve with blind flange assembly unless otherwise indicated in P&ID
2. NDT of welds shall be as follows:

   Radiography : All butt welds 100%

   MPI : Socket welds 100%
3. Piping design as per ASME B 31.8, OISD 226 & PNGRB Guidelines
4. Charpy V notch test and hardness test shall be conducted for pipes, fittings and flanges at (-) 29°C.
5. Corrosion allowance of 1.5 mm has been considered for terminal piping.
6. All branch connections including vent, drain, pressure and temperature connection shall be as per branch connection table.
7. For valves, refer valve data sheets as enclosed.
8. Design factor 0.5.
9. Ball Valve to be used in main pipeline shall have butt welded ends.

ITEM	SIZE	DESCRIPTION
Maintenance Joints	All	Flanged, to be kept minimum
Pipe joints	1.5" & below	SW coupling
	2.0" & above	Butt welded
Drains	on lines <= 1.5"	Refer std. P-STD-419
	on lines >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Vents	on lines <= 1.5"	Refer std. P-STD-419
	on lines >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Temp. Connection	1.5"	Flanged, installation as per std. P-STD-414 & 415, except skin temperature measurement.
Press. Connection	0.75"	SW nipple with Plug/ Ball Valve to spec. as per Refer std. P-STD-411, 412 & 413

BRANCH TABLE

BRANCH PIPE	0.05	0.75	1	1.5	2	3	4	6	8	10	12	14	16	18	20	24	30	32	36	42
42																				T
36																			T	T
32																		T	T	T
30																	T	T	T	T
24																T	T	T	T	T
20															T	T	T	T	T	T
18														T	T	T	T	T	T	T
16													T	T	T	T	T	T	T	T
14												T	T	T	T	T	T	T	T	T
12											T	T	T	T	T	T	T	T	T	T
10										T	T	T	T	T	T	T	T	T	T	T
8									T	T	T	T	T	T	T	W	W	W	W	W
6								T	T	T	T	T	T	W	W	W	W	W	W	W
4							T	T	T	T	W	W	W	W	W	W	W	W	W	W
3						T	T	T	W	W	W	W	W	W	W	W	W	W	W	W
2					T	T	T	W	W	W	W	W	W	W	W	W	W	W	W	W
1.5				T	T	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S
1			T	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
0.75		T	T	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
0.50	T	T	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

RUN PIPE

CODE DESCRIPTION

T TEES

W WELDOLETS

S SOCKOLETS

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
PIPE GROUP						
PIPE	00.500	00.750	TPV*	B-36.10	ASTM A 106 GR. B	PE, SEAMLESS
PIPE	01.000	01.500	TPV*	B-36.10	ASTM A 106 GR. B	PE, SEAMLESS
PIPE	02.000	02.000	TPV*	B-36.10	ASTM A 106 GR. B (CHARPY)	BE, SEAMLESS
PIPE	03.000	03.000	TPV*	B-36.10	ASTM A 106 GR. B (CHARPY)	BE, SEAMLESS
PIPE	04.000	06.000	TPV*	B-36.10	ASTM A 106 GR. B (CHARPY)	BE, SEAMLESS
PIPE	08.000	14.000	TPV*	B-36.10	ASTM A 106 GR. B (CHARPY)	BE, SEAMLESS
PIPE	16.000	24.000	TPV*	B-36.10	ASTM A672 GR. B60 CL.12	BE, EFSW
NIPPLE	00.500	01.500	TPV*	B-36.10	ASTM A 106 GR. B	PBE, SEAMLESS
FLANGE GROUP						
FLNG.SW	00.500	01.500	M	B-16.5	ASTM A 105	300, RF/125AARH
FLNG.WN	02.000	24.000	M	B-16.5	ASTM A 105 (CHARPY)	300, RF/125AARH
FLNG.BLIND	00.500	01.500		B-16.5	ASTM A 105	300, RF/125AARH
FLNG.BLIND	02.000	24.000		B-16.5	ASTM A 105 (CHARPY)	300, RF/125AARH
FLNG.FIG.8	00.500	01.500		ASME- B 16.48	ASTM A 105	300, FF/125AARH
FLNG.FIG.8	02.000	08.000		ASME- B 16.48	ASTM A 105 (CHARPY)	300, FF/125AARH
SPCR & BLND	10.000	24.000		ASME- B 16.48	ASTM A 105 (CHARPY)	300, FF/125AARH
FITTING GROUP						
ELBOW.90	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
ELBOW.90	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
ELBOW.90	02.000	24.000	M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW, 1.5D
ELBOW.45	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
ELBOW.45	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
ELBOW.45	02.000	24.000	M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW, 1.5D

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
T. EQUAL	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
T. EQUAL	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
T. EQUAL	02.000	24.000	M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW
T.RED	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
T.RED	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
T.RED	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW
REDUC. CONC	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW
REDUC. ECC	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW
SWAGE. CONC	00.500	03.000	M, M	BS-3799	ASTM A 105 (CHARPY)	PBE
SWAGE .ECC	00.500	03.000	M, M	BS-3799	ASTM A 105 (CHARPY)	PBE
CAP	00.500	00.750		B-16.11	ASTM A 105	SCRF, 6000
CAP	01.000	01.500		B-16.11	ASTM A 105	SCRF, 3000
CAP	02.000	24.000	M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW
PLUG	00.500	00.750		B-16.11	ASTM A 105	SCRM, 6000
PLUG	01.000	01.500		B-16.11	ASTM A 105	SCRM, 3000
CPLNG. FULL	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
CPLNG. FULL	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
CPLNG.HALF	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
CPLNG.HALF	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
CPLNG.LH	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
CPLNG.LH	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
CPLNG.RED	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
CPLNG.RED	01.000	01.500		B-16.11	ASTM A 105	SW, 3000

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
			O'let			
SOCKOLET	00.500	00.750		MSS-SP97	ASTM A 105	SW, 6000
SOCKOLET	01.000	01.500		MSS-SP97	ASTM A 105	SW, 3000
WELDOLET	02.000	08.000	M, XXS	MSS-SP97	ASTM A 105 (CHARPY)	BW
			VALVE GROUP			
VLV.GATE	00.500	01.500		API-602	BODY-ASTM A 105, TRIM-STELLITED, STEM-13% CR. STEEL	SW, 600,3000, B-16.11
VLV.GLOBE	00.500	01.500		BS EN 1SO 15761	BODY-ASTM A 105, TRIM-STELLITED, STEM-13% CR STEEL	SW, 600, 3000, B-16.11
VLV.GLOBE	02.000	24.000		BS 1873	BODY-ASTM A 216 GR.WCB, TRIM-13% CR. STEEL	FLGD, 300, B-16.5, RF/125AARH
VLV.CHECK	00.500	01.500		BS EN 1SO 15761	BODY-ASTM A 105, TRIM- STELLITED	SW, 600, 3000 ,B-16.11
VLV.BALL	00.500	01.500		BS EN 1SO 17292	BODY-ASTM A 105, TRIM-BODY SEAT - RPTFE	SW, 600, B-16.5, RF/125AARH
VLV.BALL	02.000	24.000		API-6D	BODY-ASTM A 216 GR.WCC/A234 GR.WPC, TRIM: SEAT: AISI4140+0.003 "ENP/AISI410	FLGD, 300, B-16.5, RF/125AARH
VLV.BALL	02.000	24.000	M	API-6D	BODY-ASTM A 216 GR.WCC/A234 GR. WPC, TRIM: SEAT: AISI 4140+0.003"ENP/AI SI 410	BW, 300, B-16.25
VLV.PLUG	00.500	01.500		BS-5353	BODY-ASTM A 105, PLUG-A105 +0.003" ENP	SW, 600, 3000, B-16.11
VLV.PLUG	02.000	24.000		API-6D	BODY- A 216GR. WCB, PLUG: A216 GR.WCB + 0.003" ENP	FLGD, 300, B-16.5, RF/125AARH
VLV.PLUG	02.000	02.000	M	API-6D	BODY-ASTM A 216 GR.WCB, PLUG: A216 GR.WCB + 0.003"ENP	BW, 300, B-16.25
			BOLT GROUP			
BOLT.STUD	00.500	8.000		B-18.2	BOLT: A193 GR. B7,NUT: A194	

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
					GR.2H	
GASKET						
GASKET	00.500	8.000		B-16.20-ANSI B16.5	SP.WND METTALIC WITH GRAPHITEFILLER	SPIRAL, 300

TPV*: To be provided by the Vendor

M: Match to Pipe thickness/ Schedule.

PIPE CLASS	**:**	**P3L**
RATING	:	300
BASE MATERIAL	:	Carbon Steel
CORROSION ALLOWANCE	:	1.5 MM
SPECIAL REQUIREMENT	:	Low Temperature Service

EMPERATURE (Deg. C) AND PRESSURE (Kg/Sq. cm g) RATINGS

TEMP	-45	38	93	120	149	204
PRESS	48.86	48.86	46.05	45.54	44.99	43.59

SERVICE

Natural Gas, Utilities (water, inst. air, plant air, nitrogen, carbon dioxide)

NOTES

1. All vents and drains shall be provided with gate valve with blind flange assembly unless otherwise indicated in P&ID.
2. Piping design as per ASME B 31.8, OISD 226 & PNGRB Guidelines
3. Flanged end shall be as per ASME B 16.5 for valve up to 24" (excluding 22"), for 22" as per MSS-SP-44.
4. Impact testing is required at (-45) Deg C.
5. NDT of welds within terminal shall be as follows:

Radiography	:	All Butt welds 100%
MPI	:	Socket welds 100%

ITEM	SIZE	DESCRIPTION
Maintenance Joints	all	Flanged, to be kept minimum
Pipe joints	1.5" & below	SW coupling
	2.0" & above	Butt welded
Drains	on lines <= 1.5"	Refer std. P-STD-419
	on lines >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Vents	on lines <= 1.5"	Refer std. P-STD-419
	on lines >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Temp. conn	1.5"	Flanged, installation as per std. P-STD-414 & 415, except skin temperature measurement.
Press. conn	0.75"	SW nipple with Plug/ Ball Valve to spec. as per Refer std. P-STD-411, 412 & 413

BRANCH TABLE

BRANCH PIPE													
16													T
14												T	T
12											T	T	T
10										T	T	T	T
8									T	T	T	T	T
6								T	T	T	T	T	T
4							T	T	T	T	W	W	W
3						T	T	T	W	W	W	W	W
2					T	T	T	W	W	W	W	W	W
1.5				T	T	T	T	S	S	S	S	S	S
1			T	T	T	S	S	S	S	S	S	S	S
0.75		T	T	T	T	S	S	S	S	S	S	S	S
0.50	T	T	T	T	S	S	S	S	S	S	S	S	S
RUN PIPE	0.05	0.75	1	1.5	2	3	4	6	8	10	12	14	16

CODE DESCRIPTION

T TEES

W WELDOLETS

S SOCKOLETS

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
PIPE GROUP						
PIPE	00.500	00.750	TPV*	B-36.10	ASTM A 333 GR.6	PE, SEAMLESS
PIPE	01.000	01.500	TPV*	B-36.10	ASTM A 333 GR.6	PE, SEAMLESS
PIPE	02.000	02.000	TPV*	B-36.10	ASTM A 333 GR.6	BE, SEAMLESS
PIPE	03.000	03.000	TPV*	B-36.10	ASTM A 333 GR.6	BE, SEAMLESS
PIPE	04.000	04.000	TPV*	B-36.10	ASTM A 333 GR.6	BE, SEAMLESS
PIPE	06.000	10.000	TPV*	B-36.10	ASTM A 333 GR.6	BE, SEAMLESS
NIPPLE	00.500	00.750	TPV*	B-36.10	ASTM A 333 GR.6	PBE, SEAMLESS
NIPPLE	01.000	01.500	TPV*	B-36.10	ASTM A 333 GR.6	PBE, SEAMLESS
FLANGE GROUP						
FLNG.SW	00.500	01.500	M	B-16.5	ASTM A 350 GR.LF2	300, RF/125AARH
FLNG.WN	02.000	10.000	M	B-16.5	ASTM A 350 GR.LF2	300, RF/125AARH
FLNG.BLIND	00.500	10.000		B-16.5	ASTM A 350 GR.LF2	300, RF/125AARH
FLNG.FIG.8	00.500	08.000		ASME- B 16.48	ASTM A 350 GR.LF2	300, FF/125AARH
SPCR&BLND	10.000	10.000		ASME- B16.48	ASTM A 350 GR.LF2	300, FF/125AARH
FITTINGS						
ELBOW.90	00.500	00.750		B-16.11	ASTM A 350 GR.LF2	SW, 6000
ELBOW.90	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
ELBOW.90	02.000	10.000	M	B-16.9	ASTM A 420 GR.WPL6	BW, 1.5D
ELBOW.45	00.500	00.750		B-16.11	ASTM A 350 GR.LF2	SW, 6000
ELBOW.45	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
ELBOW.45	02.000	10.000	M	B-16.9	ASTM A 420 GR.WPL6	BW, 1.5D
T. EQUAL	00.500	00.750		B-16.11	ASTM A 350 GR.LF2	SW, 6000
T. EQUAL	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
T. EQUAL	02.000	10.000	M	B-16.9	ASTM A 420 GR.WPL6	BW

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
VALVE GROUP						
VLV.GATE	00.500	01.500		API-602	BODY-ASTM A 350 GR.LF2, TRIM-STELLITED, STEM- SS 304	SW, 600, 3000, B-16.11
VLV.GLOBE	00.500	01.500		BS EN ISO 15761	BODY-ASTM A 350 GR.LF2, TRIM-STELLITED, STEM-SS304	SW, 600, 3000, B-16.11
VLV.CHECK	00.500	01.500		BS EN ISO 15761	BODY-ASTM A 350 GR.LF2, TRIM-STELLITED	SW, 600, 3000, B-16.11
VLV.PLUG	00.500	01.500		BS-5353	BODY-ASTM A 350 GR.LF2, PLUG: A350 GR.LF2 + 0.003" ENP	SW, 600, 3000, B-16.11
VLV.PLUG	02.000	10.000		API-6D	BODY-ASTM A 352 GR.LCB / A350 GR.LF2, STEM-SS 304/SS316	FLGD, 300, B-16.5, RF/125AARH
VLV.PLUG	02.000	10.000		API-6D	BODY-ASTM A 352 GR.LCB/ ASTM A350GR.LF2, TRIM-SS304/ SS316	BW, 300, B-16.25
BOLT & GASKET						
BOLT.STUD	00.500	10.000		B-18.2	BOLT: A320 GR. L7,NUT: A194 GR.4	
GASKET	00.500	10.000		B-16.20-ANSI B16.5	SP.WND METTALIC WITH GRAPHITEFILLER	SPIRAL, 300

TPV*: To be provided by the Vendor

M: Match to Pipe thickness/ Schedule.

PIPE CLASS	**:**	**P6C**
RATING	:	600
BASE MATERIAL	:	Carbon Steel
CORROSION ALLOWANCE	:	1.5 MM
SPECIAL REQUIREMENT	:	Non-IBR

TEMPERATURE (Deg. C) AND PRESSURE (Kg/Sq. cm g) RATINGS

TEMP	-29	38	93	149	204	260	316	343
PRESS	104.05	104.05	94.91	92.45	89.29	84.36	79.68	75.58

SERVICE

Natural Gas, Utilities (water, inst. air, plant air, nitrogen, carbon dioxide)

NOTES

10. All vents and drains shall be provided with gate valve with blind flange assembly unless otherwise indicated in P&ID
11. NDT of welds shall be as follows:

    Radiography : All butt welds 100%

    MPI : Socket welds 100%
12. Piping design as per ASME B 31.8, OISD 226 & PNGRB Guidelines
13. Charpy V notch test and hardness test shall be conducted for pipes, fittings and flanges at (-) 29°C.
14. Corrosion allowance of 1.5 mm has been considered for terminal piping.
15. All branch connections including vent, drain, pressure and temperature connection shall be as per branch connection table.
16. For valves, refer valve data sheets as enclosed.
17. Design factor 0.5.
18. Ball Valve to be used in main pipeline shall have butt welded ends.

ITEM	SIZE	DESCRIPTION
Maintenance Joints	All	Flanged, to be kept minimum
Pipe joints	1.5" & below	SW coupling
	2.0" & above	Butt welded
Drains	on lines <= 1.5"	Refer std. P-STD-419
	on lines >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Vents	on lines <= 1.5"	Refer std. P-STD-419
	on lines >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Temp. Connection	1.5"	Flanged, installation as per std. P-STD-414 & 415, except skin temperature measurement.
Press. Connection	0.75"	SW nipple with Plug/ Ball Valve to spec. as per Refer std. P-STD-411, 412 & 413

BRANCH TABLE

BRANCH PIPE																				
42																				T
36																			T	T
32																		T	T	T
30																	T	T	T	T
24																T	T	T	T	T
20															T	T	T	T	T	T
18														T	T	T	T	T	T	T
16													T	T	T	T	T	T	T	T
14												T	T	T	T	T	T	T	T	T
12											T	T	T	T	T	T	T	T	T	T
10										T	T	T	T	T	T	T	T	T	T	T
8									T	T	T	T	T	T	T	W	W	W	W	W
6								T	T	T	T	T	T	W	W	W	W	W	W	W
4							T	T	T	T	W	W	W	W	W	W	W	W	W	W
3						T	T	T	W	W	W	W	W	W	W	W	W	W	W	W
2					T	T	T	W	W	W	W	W	W	W	W	W	W	W	W	W
1.5				T	T	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S
1			T	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
0.75		T	T	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
0.50	T	T	T	T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
RUN PIPE	0.05	0.75	1	1.5	2	3	4	6	8	10	12	14	16	18	20	24	30	32	36	42

CODE DESCRIPTION

T TEES

W WELDOLETS

S SOCKOLETS

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
PIPE GROUP						
PIPE	00.500	00.750	TPV*	B-36.10	ASTM A 106 GR. B	PE, SEAMLESS
PIPE	01.000	01.500	TPV*	B-36.10	ASTM A 106 GR. B	PE, SEAMLESS
PIPE	02.000	02.000	TPV*	B-36.10	ASTM A 106 GR. B (CHARPY)	BE, SEAMLESS
PIPE	03.000	03.000	TPV*	B-36.10	ASTM A 106 GR. B (CHARPY)	BE, SEAMLESS
PIPE	04.000	06.000	TPV*	B-36.10	ASTM A 106 GR. B (CHARPY)	BE, SEAMLESS
PIPE	08.000	14.000	TPV*	B-36.10	ASTM A 106 GR. B (CHARPY)	BE, SEAMLESS
PIPE	16.000	24.000	TPV*	B-36.10	ASTM A672 GR. B60 CL.12	BE, EFSW
NIPPLE	00.500	01.500	TPV*	B-36.10	ASTM A 106 GR. B	PBE, SEAMLESS
FLANGE GROUP						
FLNG.SW	00.500	01.500	M	B-16.5	ASTM A 105	300, RF/125AARH
FLNG.WN	02.000	24.000	M	B-16.5	ASTM A 105 (CHARPY)	300, RF/125AARH
FLNG.BLIND	00.500	01.500		B-16.5	ASTM A 105	300, RF/125AARH
FLNG.BLIND	02.000	24.000		B-16.5	ASTM A 105 (CHARPY)	300, RF/125AARH
FLNG.FIG.8	00.500	01.500		ASME- B 16.48	ASTM A 105	300, FF/125AARH
FLNG.FIG.8	02.000	08.000		ASME- B 16.48	ASTM A 105 (CHARPY)	300, FF/125AARH
SPCR & BLND	10.000	24.000		ASME- B 16.48	ASTM A 105 (CHARPY)	300, FF/125AARH
FITTING GROUP						
ELBOW.90	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
ELBOW.90	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
ELBOW.90	02.000	24.000	M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW, 1.5D
ELBOW.45	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
ELBOW.45	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
ELBOW.45	02.000	24.000	M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW, 1.5D

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
T. EQUAL	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
T. EQUAL	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
T. EQUAL	02.000	24.000	M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW
T.RED	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
T.RED	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
T.RED	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW
REDUC. CONC	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW
REDUC. ECC	02.000	24.000	M, M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW
SWAGE. CONC	00.500	03.000	M, M	BS-3799	ASTM A 105 (CHARPY)	PBE
SWAGE .ECC	00.500	03.000	M, M	BS-3799	ASTM A 105 (CHARPY)	PBE
CAP	00.500	00.750		B-16.11	ASTM A 105	SCRF, 6000
CAP	01.000	01.500		B-16.11	ASTM A 105	SCRF, 3000
CAP	02.000	24.000	M	B-16.9	ASTM A 234 GR.WPB (CHARPY)	BW
PLUG	00.500	00.750		B-16.11	ASTM A 105	SCRM, 6000
PLUG	01.000	01.500		B-16.11	ASTM A 105	SCRM, 3000
CPLNG. FULL	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
CPLNG. FULL	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
CPLNG.HALF	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
CPLNG.HALF	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
CPLNG.LH	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
CPLNG.LH	01.000	01.500		B-16.11	ASTM A 105	SW, 3000
CPLNG.RED	00.500	00.750		B-16.11	ASTM A 105	SW, 6000
CPLNG.RED	01.000	01.500		B-16.11	ASTM A 105	SW, 3000

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
O'let						
SOCKOLET	00.500	00.750		MSS-SP97	ASTM A 105	SW, 6000
SOCKOLET	01.000	01.500		MSS-SP97	ASTM A 105	SW, 3000
WELDOLET	02.000	08.000	M, XXS	MSS-SP97	ASTM A 105 (CHARPY)	BW
VALVE GROUP						
VLV.GATE	00.500	01.500		API-602	BODY-ASTM A 105, TRIM-STELLITED, STEM-13% CR. STEEL	SW, 600,3000, B-16.11
VLV.GLOBE	00.500	01.500		BS EN 1SO 15761	BODY-ASTM A 105, TRIM-STELLITED, STEM-13% CR STEEL	SW, 600, 3000, B-16.11
VLV.GLOBE	02.000	24.000		BS 1873	BODY-ASTM A 216 GR.WCB, TRIM-13% CR. STEEL	FLGD, 300, B-16.5, RF/125AARH
VLV.CHECK	00.500	01.500		BS EN 1SO 15761	BODY-ASTM A 105, TRIM- STELLITED	SW, 600, 3000 ,B-16.11
VLV.BALL	00.500	01.500		BS EN 1SO 17292	BODY-ASTM A 105, TRIM-BODY SEAT - RPTFE	SW, 600, B-16.5, RF/125AARH
VLV.BALL	02.000	24.000		API-6D	BODY-ASTM A 216 GR.WCC/A234 GR.WPC, TRIM: SEAT: AISI4140+0.003 "ENP/AISI410	FLGD, 300, B-16.5, RF/125AARH
VLV.BALL	02.000	24.000	M	API-6D	BODY-ASTM A 216 GR.WCC/A234 GR. WPC, TRIM: SEAT: AISI 4140+0.003"ENP/AI SI 410	BW, 300, B-16.25
VLV.PLUG	00.500	01.500		BS-5353	BODY-ASTM A 105, PLUG-A105 +0.003" ENP	SW, 600, 3000, B-16.11
VLV.PLUG	02.000	24.000		API-6D	BODY- A 216GR. WCB, PLUG: A216 GR.WCB + 0.003" ENP	FLGD, 300, B-16.5, RF/125AARH
VLV.PLUG	02.000	02.000	M	API-6D	BODY-ASTM A 216 GR.WCB, PLUG: A216 GR.WCB + 0.003"ENP	BW, 300, B-16.25
BOLT GROUP						
BOLT.STUD	00.500	8.000		B-18.2	BOLT: A193 GR. B7,NUT: A194	

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
					GR.2H	
GASKET						
GASKET	00.500	8.000		B-16.20-ANSI B16.5	SP.WND METTALIC WITH GRAPHITEFILLER	SPIRAL, 300

TPV*: To be provided by the Vendor

M: Match to Pipe thickness/ Schedule.

PIPE CLASS	**:**	**P6L**
RATING	:	600
BASE MATERIAL	:	Carbon Steel
CORROSION ALLOWANCE	:	1.5 MM
SPECIAL REQUIREMENT	:	Low Temperature Service

EMPERATURE (Deg. C) AND PRESSURE (Kg/Sq. cm g) RATINGS

TEMP	-45	38	93	120
PRESS	98.07	98.07	92.79	91.27

SERVICE

Natural Gas, Utilities (water, inst. air, plant air, nitrogen, carbon dioxide)

NOTES

6. All vents and drains shall be provided with gate valve with blind flange assembly unless otherwise indicated in P&ID.
7. Piping design as per ASME B 31.8, OISD 226 & PNGRB Guidelines
8. Flanged end shall be as per ASME B 16.5 for valve up to 24" (excluding 22"), for 22" as per MSS-SP-44.
9. Impact testing is required at (-45) Deg C.
10. NDT of welds within terminal shall be as follows:

Radiography	:	All Butt welds 100%
MPI	:	Socket welds 100%

ITEM	**SIZE**	**DESCRIPTION**
Maintenance Joints	all	Flanged, to be kept minimum
Pipe joints	1.5" & below	SW coupling
	2.0" & above	Butt welded
Drains	on lines <= 1.5"	Refer std. P-STD-419
	on lines >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Vents	on lines <= 1.5"	Refer std. P-STD-419
	on lines >= 2.0"	As per P&ID or 0.75". Refer std. P-STD-418
Temp. conn	1.5"	Flanged, installation as per std. P-STD-414 & 415, except skin temperature measurement.
Press. conn	0.75"	SW nipple with Plug/ Ball Valve to spec. as per Refer std. P-STD-411, 412 & 413

BRANCH TABLE

													BRANCH PIPE
												T	16
											T	T	14
										T	T	T	12
									T	T	T	T	10
								T	T	T	T	T	8
							T	T	T	T	T	T	6
						T	T	T	T	W	W	W	4
					T	T	T	W	W	W	W	W	3
				T	T	T	W	W	W	W	W	W	2
			T	T	T	T	S	S	S	S	S	S	1.5
		T	T	T	S	S	S	S	S	S	S	S	1
	T	T	T	T	S	S	S	S	S	S	S	S	0.75
T	T	T	T	S	S	S	S	S	S	S	S	S	0.50
0.05	0.75	1	1.5	2	3	4	6	8	10	12	14	16	

RUN PIPE

CODE DESCRIPTION

T TEES

W WELDOLETS

S SOCKOLETS

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
				PIPE GROUP		
PIPE	00.500	00.750	TPV*	B-36.10	ASTM A 333 GR.6	PE, SEAMLESS
PIPE	01.000	01.500	TPV*	B-36.10	ASTM A 333 GR.6	PE, SEAMLESS
PIPE	02.000	02.000	TPV*	B-36.10	ASTM A 333 GR.6	BE, SEAMLESS
PIPE	03.000	03.000	TPV*	B-36.10	ASTM A 333 GR.6	BE, SEAMLESS
PIPE	04.000	04.000	TPV*	B-36.10	ASTM A 333 GR.6	BE, SEAMLESS
PIPE	06.000	10.000	TPV*	B-36.10	ASTM A 333 GR.6	BE, SEAMLESS
NIPPLE	00.500	00.750	TPV*	B-36.10	ASTM A 333 GR.6	PBE, SEAMLESS
NIPPLE	01.000	01.500	TPV*	B-36.10	ASTM A 333 GR.6	PBE, SEAMLESS
				FLANGE GROUP		
FLNG.SW	00.500	01.500	M	B-16.5	ASTM A 350 GR.LF2	300, RF/125AARH
FLNG.WN	02.000	10.000	M	B-16.5	ASTM A 350 GR.LF2	300, RF/125AARH
FLNG.BLIND	00.500	10.000		B-16.5	ASTM A 350 GR.LF2	300, RF/125AARH
FLNG.FIG.8	00.500	08.000		ASME- B 16.48	ASTM A 350 GR.LF2	300, FF/125AARH
SPCR&BLND	10.000	10.000		ASME- B16.48	ASTM A 350 GR.LF2	300, FF/125AARH
				FITTINGS		
ELBOW.90	00.500	00.750		B-16.11	ASTM A 350 GR.LF2	SW, 6000
ELBOW.90	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
ELBOW.90	02.000	10.000	M	B-16.9	ASTM A 420 GR.WPL6	BW, 1.5D
ELBOW.45	00.500	00.750		B-16.11	ASTM A 350 GR.LF2	SW, 6000
ELBOW.45	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
ELBOW.45	02.000	10.000	M	B-16.9	ASTM A 420 GR.WPL6	BW, 1.5D
T. EQUAL	00.500	00.750		B-16.11	ASTM A 350 GR.LF2	SW, 6000
T. EQUAL	01.000	01.500		B-16.11	ASTM A 350 GR.LF2	SW, 3000
T. EQUAL	02.000	10.000	M	B-16.9	ASTM A 420 GR.WPL6	BW

Item	Lower Size (Inch)	Upper Size (Inch)	Sch./ Thk.	Dmn. STD	Material (Charpy)	Description
VALVE GROUP						
VLV.GATE	00.500	01.500		API-602	BODY-ASTM A 350 GR.LF2, TRIM-STELLITED, STEM- SS 304	SW, 600, 3000, B-16.11
VLV.GLOBE	00.500	01.500		BS EN ISO 15761	BODY-ASTM A 350 GR.LF2, TRIM-STELLITED, STEM-SS304	SW, 600, 3000, B-16.11
VLV.CHECK	00.500	01.500		BS EN ISO 15761	BODY-ASTM A 350 GR.LF2, TRIM-STELLITED	SW, 600, 3000, B-16.11
VLV.PLUG	00.500	01.500		BS-5353	BODY-ASTM A 350 GR.LF2, PLUG: A350 GR.LF2 + 0.003" ENP	SW, 600, 3000, B-16.11
VLV.PLUG	02.000	10.000		API-6D	BODY-ASTM A 352 GR.LCB / A350 GR.LF2, STEM-SS 304/SS316	FLGD, 300, B-16.5, RF/125AARH
VLV.PLUG	02.000	10.000		API-6D	BODY-ASTM A 352 GR.LCB/ ASTM A350GR.LF2, TRIM-SS304/ SS316	BW, 300, B-16.25
BOLT & GASKET						
BOLT.STUD	00.500	10.000		B-18.2	BOLT: A320 GR. L7,NUT: A194 GR.4	
GASKET	00.500	10.000		B-16.20-ANSI B16.5	SP.WND METTALIC WITH GRAPHITEFILLER	SPIRAL, 300

TPV*: To be provided by the Vendor

M: Match to Pipe thickness/ Schedule.

TECHNICAL NOTES FOR PIPES

P-SPC-401

0	19.02.2022	ISSUED AS STANDARD SPECIFICATION	PNS	SM	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BM	Base Metal
BHN	Brinell hardness number
BIS	Bureau of Indian Standards
E.FS.W	Electric Fusion Weld
HAZ	Heat Affected Zone
HIC	Hydrogen Induced Cracking
IGC	Inter Granular Corrosion
IS	Indian Standard
LT	Low Temperature
MR	Material Requisition
MSS-SP	Manufacturers Standardization Society - Standard Practice
MPQT	Manufacturing Procedure Qualification Tests
MPS	Manufacturing Procedure Specification
NDT	Non-Destructive Testing
NACE MR	National Association of Corrosion Engineers: Material Requirement
NPS	Nominal Pipe Size
NPT	Nominal Pipe Thread
OD	Outside Diameter
OD/D	Outside Diameter, Specified
PMI	Positive Material Identification
PR	Purchase Requisition
SMYS	Specified Minimum Yield Strength
SS	Stainless Steel
RJ	Ring Joint
QOEC	Quick Opening End Closure
SAW	Submerged Arc Welded
SAWL	Submerged Arc Longitudinal Welded
SMAW	Shielded Metal Arc Welding
SMYS	Specified Minimum Yield Strength
SSPC	The Society for Protective Coatings

CONTENTS

1.0 GENERAL

1.1 All pipes and their dimensions, tolerances, chemical composition, physical properties, heat treatment, hydrostatic test and other testing and marking requirements shall conform to the latest codes and standards specified in the material requisition (MR). Supplier shall strictly comply with MR / PR and no deviations shall be permitted. Post Order Concession / Deviation is not applicable.

1.2 Testing

1.2.1 Test reports shall be supplied for all mandatory tests as per the applicable material specifications. Test reports shall also be furnished for any supplementary tests as specified in the MR & Clauses 1.10 & 1.11.

1.2.2 Material test certificates (physical property, chemical composition & heat treatment report) shall also be furnished for the pipes supplied.

1.2.3 Refer to P-ITP-001 & P-ITP-002 for Inspection & Test plans for welded pipes and seamless pipes respectively.

1.3 Manufacturing Processes

1.3.1 Steel made by acid Bessemer process shall not be acceptable.

1.3.2 All longitudinally welded pipes should employ only automatic welding.

1.4 Pipe shall be supplied in single or double random length of 4 to 7 and 7 to 14 meters respectively.

1.5 a. Seamless and E.R.W. pipes shall not have any circumferential seam joint in a random length. However, in case of E.FS.W pipe, in one random length one welded circumferential seam of same quality as longitudinal weld is permitted. This weld shall be at least 2.5 m from either end. The longitudinal seams of the two portions shall be staggered by 90°. Single random length in such cases shall be 5 to 7 m.

b. Unless otherwise mentioned in the respective material code, E.FS.W pipes < 36" shall not have more than one longitudinal seam joint and E.FS.W pipes ≥ 36" shall not have more than two longitudinal seam joints.

1.6 Pipes with screwed ends shall have NPT external taper pipe threads conforming to ASME / ANSI B1.20.1.

1.7 Pipe with bevelled ends shall be in accordance with ASME B16.25. Weld contours shall be as follows:

Material	Wall Thickness	Weld Contour
Carbon Steel (Except Low Temp. Carbon Steel)	Upto 22 mm	Figure 2 Type A
	>22mm	Figure 3 Type A
Alloy Steel, Stainless Steel & Low Temp. Carbon Steel	Up to 10 mm	Figure 4
	> 10 mm & Up to 25 mm	Figure 5 Type A
	>25mm	Figure 6 Type A

1.8 Galvanized pipes shall be coated with zinc by hot dip process conforming to IS 4736 for pipes to Indian Standards and ASTM A53 for pipes to ASTM Standards**.**

1.9 All austenitic stainless steel pipes shall be supplied in solution annealed condition. All types of 321 or 347 stainless steel pipes shall be in a stabilized heat treated condition. Stabilizing heat treatment shall be carried out subsequent to the normal solution annealing. Soaking time & holding temp. for stabilizing heat treatment shall be 4 hrs & 900°C respectively.

1.10 I.G.C. Test for Stainless Steels

1.10.1 For all austenitic stainless steel pipes inter-granular corrosion test shall have to be conducted as per following:

ASTM A262 Practice "B" with acceptance criteria of "60 mils / year (max.)".

OR

ASTM A262 Practice E: The bent specimen shall be examined under 20X magnification. The acceptance criteria is that there will be no crack or fissure in the bent specimen. The bent specimen shall also be subjected to metallographic examination at 250X magnification to ensure no crack or fissure. The photograph of the bent specimen along with comments shall be submitted for review.

1.10.2 When specifically asked for in MR for high temperature application of some grades of austenitic stainless steel (eg. SS 309, 310, 316, 316H etc.) ASTM A262 Practice "C" with acceptance criteria of "15 mils/year (max.)" shall have to be conducted.

1.10.3 For the IGC test as described in 1.10.1 & 1.10.2, two sets of samples shall be drawn from each solution annealing lot; one set corresponding to highest carbon content and the other set corresponding to the highest pipe thickness.

1.11 All welded pipes indicated as `CRY0' & 'LT' in MR shall be impact tested per requirement & acceptance criteria of ASME B31.3. The impact test temperature shall be -196°C & -45°C for stainless steel and low temperature carbon steel respectively unless specifically mentioned otherwise in MR.

1.12 NACE / HIC Requirements

1.12.1 Pipes under "NACE" category and those designated as "HIC" shall meet the requirements given in NACE MR-0103 unless mentioned otherwise.

1.13 Specified heat treatment for carbon steel and alloy steel and solution annealing for stainless steel pipes shall be carried out after weld repairs. Number of weld repairs at the same spot shall be restricted to maximum two by approved repair procedure.

1.14 For black or galvanized pipes to IS 1239, the minimum percentage of elongation shall be 20%.

1.15 All 1Cr-$\frac{1}{2}$Mo and 1$\frac{1}{4}$Cr-$\frac{1}{2}$Mo seamless pipes shall be normalised and tempered.

1.16 For all welded alloy steel pipes with mandatory requirement of heat treatment and radiography, radiography shall be performed after heat treatment.

1.17 For Hydrogen service pipes following special requirements shall also be met:

1.17.1 All carbon steel pipes having wall thickness 9.53 mm (0.375") and above shall be normalised. Cold drawn pipes shall be normalised after the final cold draw pass for all thicknesses.

1.17.2 All alloy steel (Cr-Mo) pipes shall be normalised and tempered. The normalising and tempering shall be a separate heating operation and not a part of the hot forming operation. The maximum room temperature tensile strength shall be 100,000 prig.

1.17.3 For carbon steel Pipes, hardness of weld and HAZ shall be 200 BHN (max.). For alloy steel Pipes, hardness of weld and HAZ shall be 225 BHN (max.).

1.17.4 For all Carbon steel and Alloy steel pipes with wall thickness over 20mm, Charpy-V Notch impact testing shall be carried out in accordance with paragraph UG-84 of ASME Section VIII, Div-1 for weld metal and base metal from the thickest item per heat of material and per heat treating batch. Impact test specimen shall be in complete heat treated condition and accordance with ASTM A370. Charpy V-notch test shall be conducted at -29°C for CS & -45°C for LTCS.

The average absorbed impact energy values of three full-sized specimens shall be 27 joules. The minimum impact energy value of any one specimen of the three specimens analysed as above shall not be less than 22 Joules.

1.18 For dual grades of SS where specified, chemical composition and mechanical properties of both grades specified shall be ensured.

2.0 ACCEPTABLE DEVIATIONS

2.1 Pipes to IS 3589 Gr.410 are acceptable in place of IS 3589 Gr.330.

2.2 Pipes of Grades SS317 of corresponding material are acceptable in place of Grades SS316 or SS316 (2.5 Mo min.).

2.3 Pipes of Grades SS317L of corresponding material are acceptable in place of Grades SS316L or SS316L (2.5 Mo min.).

2.4 Seamless pipes are acceptable in place of welded pipes except in the case of welded SS321 / SS321H pipes with nominal thickness greater than 9.53 mm.

3.0 HYDROSTATIC TEST

3.1 All pipes shall be hydrostatically tested.

3.2 The mill test pressure shall be as follows:

3.2.1 Seamless, E.R.W. & Spiral Welded

a) Carbon Steel

Material Std.	Test Pressure Std.
ASTM A106 Gr.B	ASTM A530
API 5L Gr.B, Seamless	API 5L
API 5L, E.R.W.	API 5L
API 5L, Spiral	API 5L
ASTM A333 Gr.3 & 6, Seamless	ASTM A530
ASTM A333 Gr.3 & 6, E.R.W.	ASTMA530

b) Searnless Alloy Steel

Material Std.	Test Pressure Std.
ASTM A335 Gr.P1, P12, P11, P22, P5, P9	ASTM A530
ASTM A268 TP 405, TP410	ASTM A530

c) Seamless Stainless Steel

Material Std.	**Test Pressure Std.**
ASTM A312 Gr.TP 304, 304L, 304H, 316, 316L, 316H, 321,347	ASTM A999

d) Searnless Nickel Alloy

Material Std.	**Test Pressure Std.**
ASTM B161 UNS N02200	ASTM B161
ASTM B165 UNS N04400	ASTM B165
ASTM B167 UNS N06600	ASTMB167
ASTM B444 UNS N06625	ASTMB444
ASTM B407 UNS N08800	ASTM B407
ASTM B423 UNS N08825	ASTM B423

e) Welded Nickel Alloy

Material Std.	**Test Pressure Std.**
ASTM B725 UNS N02200, N04400	ASTMB725
ASTM B517 UNS N06600	ASTMB517
ASTM B443/B474 UNS N06625	ASTMB474
ASTM B424/B474 UNS N08825	ASTM B474
ASTM B514 UNS N08800	ASTMB514

4.2.2 Electric Fusion Welded

a) Carbon Steel & Alloy Steel E.FS.W (16" & above)

Material Std.	**Test Pressure Std.**
API 5L Gr.B ASTM A671 Gr.CC65, 70 (Cl.32) ASTM A672 Gr.C60, 65, 70 (Cl.12,22) ASTM A671 Gr.CF60, 65, 66, 70 (Cl.32) ASTM A69 1 Gr.½Cr, 1 Cr, 1¼Cr, 2¼Cr, 5Cr, 9Cr (Cl.42)	P = 2ST/D S = 90% of SMYS Except for API 5L Gr.B S = 85% of SMYS For API 5L Gr.B T = Nominal Wall Thickness D = O.D of Pipe

b) Stainless Steel E.FS.W (2" to 6")

The hydrostatic test pressure in kg/cm^2 for the following materials shall be as given below:

Material Gr.1 : ASTM A312 TP 304 / 304H / 316 / 316H / 321 / 347 welded.

Material Gr. 2 : ASTM A312 TP 304L / 316L welded.

Size	Pipe Schedule : 10 S		Pipe Schedule : 40S		Pipe Schedule : 80S	
	Material Gr. 1	Material Gr.2	Material Gr. 1	Material Gr.2	Material Gr.1	Material Gr.2
2"	100	80	155	130	230	190
3"	80	60	155	130	230	190
4"	80	50	155	130	230	190
6"	65	35	90	75	155	130

c) Stainless Steel E.FS.W (8" and above).

Material Std.	Test Pressure Std.
ASTM A358 TP 304L, 304, 304H, 316L, 316, 316H, 321, 347 (Classes I, 3 & 4)	P =2ST/D S = 85% ofSMYS T = Nominal Wall Thickness D = O.D of Pipe
ASTM A358 TP 304L, 304, 304H, 316L, 316, 316H, 321, 347 (Classes 2 & 5)	P = 2ST/D S = 72% of SMYS T = Nominal Wall Thickness D = O.D of Pipe

4.2.3 Carbon Steel Pipes to BIS Standards

Material Std.	Test Pressure Std.
IS 1239	IS 1239
IS3589	IS3589

4.3 Hydrostatic pressure testing shall be performed using iron free water, which is clean and free of silt. Maximum chloride content in water for hydrostatic testing for SS piping shall be 50 ppm.

5.0 MARKING AND DESPATCH

5.1 All pipes shall be marked in accordance with the applicable codes, standards and specifications. In addition the purchase order number, the item code & special conditions like "CRYO", "NACE", "H2" etc. shall also be marked.

5.2 Pipes under "CRYO", "NACE" & "H2" shall be painted with one circumferential stripe of colour red, light purple brown, canary yellow & white respectively for easy identification. Width of stripe shall be 12mm for pipe sizes less than 3" and 25mm for pipes 3" and above.

5.3 Paint or ink for marking shall not contain any harmful metal or metallic salts such as zinc, lead or copper which cause corrosive attack on heating.

5.4 Pipes shall be dry, clean and free from moisture, dirt and loose foreign materials of any kind.

5.5 Pipes shall be protected from rust & corrosion.

5.6 Rust preventive used on machined surfaces to be welded shall be easily removable with a petroleum solvent and the same shall not be harmful to welding.

5.7 Both ends of the pipe shall be protected with the following material:

Plain end	:	Plastic cap
Bevel end	:	Wood, Metal or plastic cover
Threaded end	:	Metal or plastic threaded cap

5.8 Pipes may be provided with plastic push-fit type end caps/ steel caps without belt wire.

5.9 Steel end protectors to be used on galvanized pipes shall be galvanized. Plastic caps can also be used as end protectors for galvanised pipe ends.

6.0 REFERENCES

6.1 P-ITP-001: Inspection & test plan for welded pipes.

6.2 P-ITP-002: Inspection & test plan for seamless pipes.

TECHNICAL NOTES FOR VALVES

P-SPC-402

0	02.02.2022	ISSUED FOR STANDARD SPECIFICATION	PNS	MD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AARH	:	Arithmetic Average Roughness Height
ANSI	:	American National Standards Institute
API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing & Materials
BGO	:	Bevel Gear Operator
BHN	:	Brinnel Hardness Number
BIS	:	Bureau of Indian Standards
BS	:	British Standard
BVIS	:	Bureau Veritas Industrial Services
BW	:	Butt Weld
CAT	:	Category
CS	:	Carbon Steel
DFT	:	Dry Film Thickness
DNV	:	Det Norske Veritas
DP	:	Dye-Penetrant
IBR	:	Indian Boiler Regulations
IGC	:	Inter Granular Corrosion
IS	:	Indian Standard
LT	:	Low Temperature
LTCS	:	Low Temperature Carbon Steel
MOV	:	Motor Operated Valve
MP	:	Magnetic Particle
MR	:	Material Requisition
NDT	:	Non-Destructive Testing
PMI	:	Positive Material Identification
PO	:	Purchase Order
PR	:	Purchase Requisition
RFQ	:	Request for Quotation
SCRD	:	Screwed
SS	:	Stainless Steel
SW	:	Socket Weld

CONTENTS

1.0 GENERAL

1.1 Vendor shall supply valves in accordance with the valve specification sheets along with auxiliaries, if any, such as gear operator, bypasses, drains, locking arrangements etc. wherever specified in the specification sheets, subject notes and other enclosures to the material requisition (MR).

1.2 Vendor shall quote in strict accordance with the valve data / specification sheets, subject technical notes and all other enclosures to the MR. For valves, no deviations whatsoever shall be accepted. Post Order Waiver/ Deviation format as mentioned in specification for Quality Management System Requirements from Bidder is not applicable for valves. Valves, if exceptions/ deviations become absolutely must, the same shall be requested as explained giving reasons for seeking such exceptions/ deviations.

1.3 **All codes and standards for manufacture, testing, inspection etc. shall be of latest editions as on issue date of RFQ.**

2.0 DOCUMENTATION.

2.1 All document submissions to PLECO.

2.2 For 'Cat-I' valves, no documents shall be submitted with the offer.

2.3 For 'Cat-IF valves, vendor shall submit the following documents with the offer:

2.3.1 Manufacturer's complete descriptive and illustrative catalogue / literature.

2.3.2 Detailed dimensioned cross section drawing with parts / material lists, weight etc.

2.3.3 Drawings for valves with accessories like gear operator, hydraulic / pneumatic operator, motor, extension bonnet, extended stems with stands, bypass etc. giving major salient dimensions.

2.3.4 One copy of the valve specification sheets signed as "Accepted" by the manufacturer. Deviations, if any shall be marked as applicable on the valve specification sheet.

2.3.5 If the valve is regretted or has no deviation, the manufacturer shall write clearly on valve specification sheets as "Regret" or "No Deviation".

2.3.6 For 'CAT-II' valves, if there is any deviation, the same shall be listed clause wise.

2.3.7 On failure to submit documents as specified in clauses above, the offer is likely to be rejected.

2.4 The following documents shall be submitted to PLECO after placement of the order:

2.4.1 For Cat-I valves to manufacturers' standard specified in MR/valve specification sheet, detailed dimensioned cross section drawing with parts, materials, weight, etc. shall be submitted for records/information.

2.4.2 For 'Cat-II' valves, Vendor shall submit for review drawings mentioned in clauses before start of manufacture. No other drawings shall be submitted for review.

2.4.3 Test report shall be supplied for all mandatory tests as per the applicable code. Test reports shall also be furnished for any supplementary tests as specified in clauses.

2.4.4 Material test certificates (physical properties, chemical composition & heat treatment report) of the pressure containing parts shall be furnished for the valves supplied. Material test certificates for the other parts shall also be furnished for verification during inspection.

2.5 In addition to submissions to PLECO, Catalogues/Drawings shall be in submitted in hard copies (6 sets) and soft copies (2 CDs/DVDs) along with delivery for Purchaser's record for all categories/types of valves.

3.0 DESIGN AND CONSTRUCTION

3.1 Valve shall be designed, manufactured, tested, inspected and marked as per the manufacturing standards, design codes and standards indicated in the respective valve specification sheets. Any conflict between the requisition, enclosures, specification sheets and referred standards/ codes shall be brought to the notice of the purchaser for clarifications and resolution, before proceeding with the manufacture. The purchaser's decision shall be final and binding to the vendor. The drawings submitted for review shall not include any deviations except as communicated in writing in Deviation permits. The Drawings shall be reviewed only for design and construction features.

3.2 All flanged valves shall have flanges integral (except forged valves) with the valve body. Flange face finish shall be normally specified in the valve specification sheet as 125 AARH etc. The interpretation for range of face finish shall be as follows:

Stock Finish	:	1000 p. in AARH max.
125 AARH	:	Serrations with 125 to 250 p in AARH
63 AARH	:	32 to 63 p. in AARH

3.3 For all weld end valves with bevel end as per ASME B 16.25, the contour of bevel shall be as follows:

Material	Wall Thickness	Weld Contour
Carbon Steel (Except Low Temp. Carbon Steel)	Upto22 mm	Figure 2 Type A
	>22mm	Figure 3 Type A
Alloy Steel, Stainless Steel & Low Temp. Carbon Steel	Up to 10 mm	Figure 4
	> 10 mm & up to 25 mm	Figure 5 Type A
	>25mm	Figure 6 Type A

Valve ends shall match thickness of the connecting pipe. Sloping of inside contour of valves shall be done wherever necessary to achieve this.

3.4 For flanged valves with ring joint flanges the hardness shall be as follows:

Flange Material	Min. Hardness of Groove (BHN)
Carbon Steel	140
1% Cr to 5% Cr, 9% Cr	150
Type 304,316,321,347	160
Type 304L, 316L	140

3.5 Following requirements for check valves shall be met over and above the valve specification sheet requirements:

3.5.1 Unless specified otherwise in the data sheet all check valves 3" & above (except in 900#, 1500# & 2500# rating) shall have a drain boss at location "G" (Refer Fig.No.1 of ASME B16.34) where pocket is formed in valve body. A tapped drain hole with plug shall be provided as per ASME B 16.34. Threads shall be as per ASME B 1.20.1 (Taper) NPT.

3.5.2 For heavy check valves, provisions shall be available for lifting by way of lugs, eye bolts and other such standard devices.

3.6 If an overlay weld-deposit is used for the body seat ring seating surface, the corrosion resistance of the seat ring base material shall be at least equal to the corrosion resistance of the material of the shell**.**

3.7 Following valve bypass requirements shall be met:

3.7.1 By-pass requirement for Gate valves shall be as follows unless otherwise mentioned.

ASME 150 Class	:	On sizes 26" and above
ASME 300 Class	:	On sizes 16" and above
ASME 600 Class	:	On sizes 6" and above
ASME 900 Class	:	On sizes 4" and above
ASME 1500 Class	:	On sizes 4" and above
ASME 2500 Class	:	On sizes 3" and above

3.7.2 The by-pass piping arrangement shall be such that clearance between main valve body and bypass assembly shall be the minimum possible for layout reasons. Vendor shall follow the sketch enclosed in Specification No. 6-44-0052-Al.

3.7.3 By-pass valve shall be a globe valve. The sizes shall be as under:

On main valve ≤ 4"	:	1/2"
On main valve 6" to 8"	:	3/4"
On main valve 10" & above	:	1"

By-pass piping shall be of same metallurgy as main valve. The by-pass piping, fittings and valve tag numbers shall be as specified in Specification. In case details of by-pass arrangement for any Valve tag number is missing, Vendor shall bring the same to notice of PLECO and provide by-pass as per details specified.

3.7.4 Vendor shall supply the by-pass valve duly tested and fitted to the main valve. Valves with by-pass shall have the direction of flow marked on the main valve. By-pass attachment to the main valve body shall not be screwed. All fillet welds for by-pass installation shall be 100% examined by DP/MP test and Butt-weld joints shall be 100% examined by radiography.

3.8 Valve body / bonnet shall be forged / cast as specified. Forgings are acceptable in place of casting but not vice-versa.

3.9 Stem shall be forged or machined from forged / rolled bar. No casting is permitted. However, integral stem of cast material is acceptable for Plug valves.

3.10 Stelliting / hardfacing by deposition, shall be minimum 1.6 mm.

3.11 Renewable seat rings shall be seal welded for valves of size 3" and above to prevent loosening in service.

3.12 For Low Temperature & Cryogenic valve requirements, refer Specification. Unless otherwise specified.

3.13 For Hydrogen service valve requirements, refer Specification. unless otherwise specified.

3.14 Valves under `NACE' category shall meet the requirements specified in MR-0103 unless otherwise specified.

3.15 For all austenitic stainless steel valves Inter Granular Corrosion (IGC) test shall be conducted as per the following:

3.15.1 ASTM A262 Practice 'B' with acceptance criteria of '60 mils/year (max.)' for all materials - forged, rolled, wrought and casting.

Or

ASTM A262 Practice `E' with acceptance criteria of 'No cracks as observed from 20X magnification' for all materials other than castings. 'Microscopic structure to be observed from 250X magnification' in addition.

3.15.2 When specifically asked for in MR for high temperature application of some grades of austenitic stainless steel (eg. SS309, 310, 316, 316H etc.) ASTM A262 Practice 'C' with acceptance criteria of ' 15 mils/year (max.)' shall be conducted.

3.15.3 For the IGC test as described in Clauses, two sets of samples shall be drawn from each solution annealing lot. One set shall correspond to the highest Carbon content and the other to the highest pressure rating. When testing is conducted as per practice `E', photograph of the microscopic structure shall be submitted for record.

3.16 All types of 321 or 347 stainless steel valves shall be in a stabilised heat treated condition. Stabilising heat treatment shall be carried out subsequent to the normal solution annealing. Soaking temperature and holding time for stabilising heat treatment shall be 900°C and 4 hours respectively.

3.17 Spiral wound bonnet gaskets are to be provided with inner/outer ring except when encapsulated gaskets type body-bonnet joints are employed. Outer ring may be avoided in case of non-circular spiral wound gasket used in 150# valve provided the outermost layer of spiral touches the bolts ascertaining the centering.

3.18 All Stainless Steel Castings shall be solution heat treated.

3.19 **Only normalized and tempered material shall be used in the following specifications :**

Castings A217 Gr.WC1, A217 Gr.WC4, A217 Gr.WC5, A217 Gr.WC6, A217 Gr.WC9, A217 Gr.C5, A217 Gr.C12

Forgings: A182 Gr.F11 C1.2, A182 Gr.F12 C1.2

3.20 **Ball / Plug / Butterfly Valves**

3.20.1 As a prequalification, fire safe test as per API 607 / API 6FA / BS EN ISO 10497 (Supersedes BS 6755 Part II) shall be carried out on soft seated ball, plug & butterfly valves and also on lubricated plug valves. The test shall be witnessed and certified by a third-party inspection agency like Lloyds, BVIS, DNV or PLECO unless otherwise specified. The vendor has to submit test certificate for the particular design of the valve offered, if fire safe design is required as per the Valve Material Specification sheet.

3.20.2 Each valve shall be supplied with a lever / wrench except for gear operated / motor operated valves.

3.20.3 Soft-seated ball, plug & butterfly valves shall be supplied with antistatic devices.

3.20.4 BW / SW end ball valves shall have a 100 mm long seamless pipe nipple welded to each end of the valve. Nipples are to be welded prior to assembling Teflon seats / seals. Specifications of the nipples shall be as indicated in the MR.

3.20.5 The face-to-face dimensions of all ball valves shall be same as those of gate valves of the corresponding ANSI class (except 10" onwards in Class 150 where the face-to-face dimensions shall be as per API 6D long pattern).

3.20.6 The ball of ball valve shall not protrude outside the end flanges of valve.

3.20.7 Ball valves shall be of floating ball/trunnion mounted type as per following:

150#	8" & below 10" & above	Floating ball Trunnion mounted
300#	4" & below 6" & above	Floating ball Trunnion mounted
600#& above	1.5" & below 2" & above	Floating ball Trunnion mounted

3.20.8 Unless otherwise specified in the data sheets, bore of all reduced bore ball valves shall be limited to one size lower than the nominal bore.

3.21 The MOVs are to be installed in an open area and the actuators shall be suitable for all weather conditions. The testing of complete assemblies of MOVs along with the actuators shall be done by the supplier at his works.

3.22 Ends of flanged valves of 22" size shall match corresponding flanges to MSS-SP44 unless otherwise specified.

3.23 Yoke material shall be same as bonnet material where maximum temperature specified is more than 427°C.

4.0 OPERATION

4.1 Gear operation shall be provided as under:

Valve Type	Class	Size Requiring Gear-Operator
Gate Valve, Globe Valve & Diaphragm Valve	150 Class	1211 and larger
	300 Class	1211 and larger
	600 Class	10" and larger
	900 Class	6" and larger
	1500 Class	311 and larger
	2500 Class	311 and larger
Ball Valve / Plug Valve (Other than pressure balance plug valves)	150 Class	6" and larger
	300 Class	6" and larger
	600 Class	411 and larger
	900 Class	3" and larger
	1500 Class	311 and larger
Butterfly Valve	150, 300 Class	6" and larger

For sizes lower than these ranges, hand wheel / lever / wrench shall be provided. For pressure balance plug valves manufacturer's recommendation shall be acceptable provided the requirements specified in clause.

4.2 Gear operator shall be provided, with position indicators for open / close positions and with limit stops. (Limit stops are not applicable for gate and globe valves).

4.3 Where gear operator is not called for as per Clause but vendor recommends a gear operator, the same shall be highlighted.

4.4 Gear operator shall be so designed as to operate effectively with the differential pressure across the closed valve equal to the cold non-shock pressure rating.

4.5 Ball, plug and butterfly valves, shall have "Open" position indicators with limit stops.

4.6 Hand wheel diameter shall not exceed 750mm and lever length shall not exceed 500mm on either side. Effort to operate shall not exceed 35 Kg at hand wheel periphery. However, failing to meet the above requirements, vendor shall offer gear operated valve and quote as per clause

5.0 INSPECTION AND TESTING

5.1 Every valve shall be subjected to all the mandatory tests and checks called in the respective codes / data sheet by PLECO inspection or any third party as approved by the purchaser. For IBR valves refer clause.

5.2 Every valve, its components and auxiliaries must be subjected to all the mandatory tests and checks called for in the respective codes, data sheets etc. by the manufacturer.

5.3 Though the extent of inspection shall be as under, exact extent withhold points shall be decided by PLECO regional inspection office and recorded in the form of inspection plan. In case of third party inspection, the inspection plan shall be approved by the purchaser.

Forged Valves:

1. Visual and dimensional inspection.
2. Review of material test certificates.
3. Any mandatory or supplementary test.
4. Hydrostatic test on 10% valves selected on random basis.
5. Strip check is required for 1% of total ordered quantity of Gate & Globe valves (min. 1 No.) for each Valve sheet no., however, strip check is not required for CS/ Brass/ Bronze material valves with 13% Cr/ Brass/ Bronze trims.

Cast Steel Valves:

1. Visual and dimensional inspection.
2. Review of material test certificates.
3. Review of radiographs/radiographic reports or any other NDT tests wherever applicable as per data sheet.
4. Any mandatory or supplementary test.
5. Hydrostatic test 100% for body, 10% other test.
6. Strip check is required for 1% of total ordered quantity of Gate & Globe valves (min. 1 No.) for each Valve sheet no., however, strip check is not required for CS/ Brass/ Bronze material valves with 13% Cr/ Brass/ Bronze trims.

Samples for strip check shall be selected at random and shall generally be in the highest size in the lot.

5.4 In case of motor operated or actuator operated valves, functional / operational checks as per the requirements of the specifications shall be made on each valve.

6.0 RADIOGRAPHY OF CAST VALVES

6.1 Valve castings shall undergo radiographic examination as specified below.

Material	Rating	Size Range	Radiography
All	150#	24" and below	NIL**
		26" and above*	100%
	300#	16" and below	NIL**
		18" and above	100%
	600# & above	All sizes	100%

* No radiography is required for valves of size 26" and above in cooling water service.

**For sizes 24" & below in 150# and 16" & below in 300#, radiography percentage if specifically mentioned in individual valve material spec sheet shall govern.

Radiography specified as random 10% or 20% etc. in the respective valve data sheet implies 10% or 20% etc. of number of valves ordered against each item number with a minimum of one valve against each item.

6.2 Radiography procedure, areas of casting to be radiographed shall be as per ASME B 16.34 and acceptance criteria shall be as per ASME B 16.34 Annexure-B. However, for areas of casting to be radiographed for types of valves not covered in ASME B 16.34, vendor shall radiograph castings in line with ASME B 16.34.

6.3 For random radiography wherever specified in individual data sheets, the sampling shall be per size of the quantity ordered for each foundry.

6.4 Radiography wherever specified in the data sheets or as per clause shall be done by X-ray γ -ray to get the required sensitivity.

7.0 IBR CERTIFICATION

7.1 For valves described "IBR", valves shall be in accordance with the latest IBR (Indian Boiler Regulation) including the requirements specified in the specification.

7.2 For SW / BW end carbon steel valves under IBR, the chemical composition shall conform to the following:

Carbon (Max) : 0.25%

Others (S, P, Mn) : As per IBR

7.3 Valves coming under the purview of "IBR"(Indian Boiler Regulations) shall each be individually accompanied by IBR certificate original in Form III-C duly approved by IBR authority / local authority empowered by the Central Boiler Board of India. Photocopy of original certificate duly attested by the local boiler inspector where the supplier is located is the minimum requirement for acceptance.

7.4 All "IBR" valves shall be painted red in body-bonnet / body-cover joint.

8.0 MARKING

8.1 Valve markings, symbols, abbreviations etc. shall be in accordance with MSS-SP-25 or the standard referred in specification sheet as applicable. Vendor's name, valve rating, material designation, nominal size, direction of flow (if any) etc. shall be integral on the body.

8.2 Each valve shall have a corrosion resistant tag giving size, valve tag / code no., securely attached to the valve body.

8.3 Paint or ink for marking shall not contain any harmful metal or metal salts such as zinc, lead or copper which cause corrosive attack on heating.

8.4 Carbon Steel / Alloy Steel valves shall be painted with one coat of inorganic zinc silicate (minimum DFT 65 to 75 microns).

9.0 DESPATCH

9.1 Valve shall be dry, clean and free from moisture, dirt and loose foreign materials of any kind.

9.2 Valves shall be protected from rust, corrosion and any mechanical damage during transportation, shipment and storage.

9.3 Rust preventive on machined surfaces to be welded shall be easily removable with a petroleum solvent or shall not be harmful to welding.

9.4 Each end of valve shall be protected with the following materials:

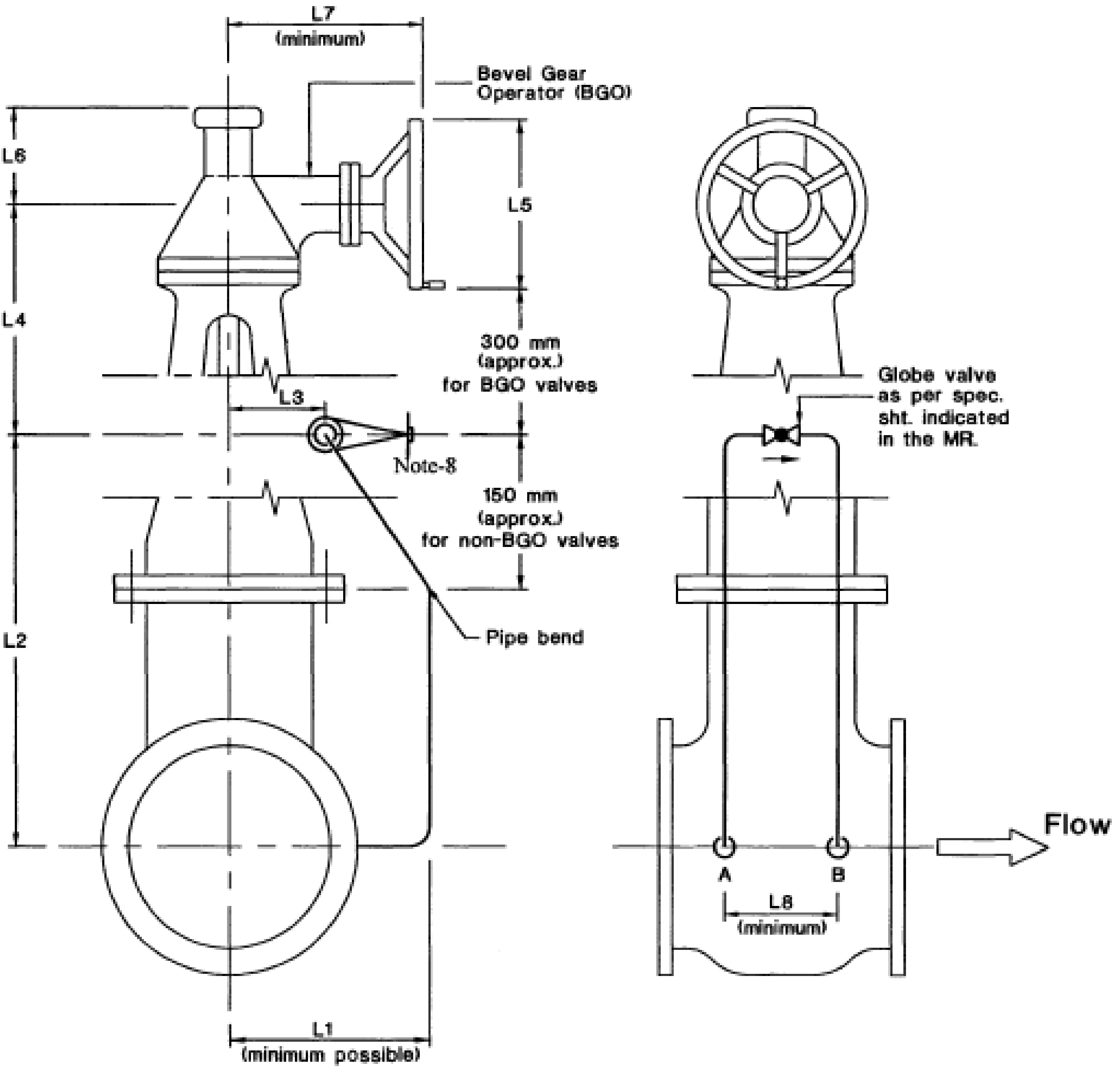
Flange Face	:	Wood or Plastic Cover
Bevelled End	:	Wood or Plastic Cover
SW & SCRD. End	:	Plastic Cap

9.5 End protectors of wood / plastic to be used on flange faces shall be attached by at least three bolts and shall not be smaller than the outside diameter of the flange. However, plastic caps for SW & SCRD end valves shall be press fit type.

9.6 End protectors to be used on bevelled end shall be securely and tightly attached.

9.7 For special service valves additional requirement for despatch shall be as prescribed in data sheet.

BYPASS PIPING ARRANGEMENT



NOTES:

1. The orientation & location of handwheel of bevel gear operator & the bypass arrangement shall be strictly as per this sketch.
2. The bypass connection ends shall be socket welded up to 600# and butt welded for 900# and above rating.
3. The bypass arrangement shall be properly clamped to & supported by the body of the main valve.
4. Basic design of bypass shall be to MSS-SP-45.
5. Material of bypass pipe & 90° elbows shall be same or equivalent to the body material as indicated in Specification.
6. This sketch is applicable for both BGO & NON-BGO Valves.
7. Vendor shall furnish dimensions L1 to L8.
8. Stem shall not be horizontal in the case of CRYO Valves

SPECIFICATIONS FOR BYPASS PIPING, FITTINGS AND VALVES

Class (Main Valve Sht.no.)	Pipe	Fittings	Bypass Valve Sht.no.
A1A(51301), A3A(51321), A9A(51301), Al0A(51301), A11A(51301), A33A(51301), B1A(51401), B9A(51401), D1A(51501), D9A (51501)	ASTM A106 Gr.B (SMLS) 0.5"-0.75": SI 60 1.0"-1.5": XS	ASTM A105 0.5"-0.75": SW 6000# 1.0"-1.5": SW 3000#	52001
A6A(51301), B6A(51401)	ASTM Al06 Gr.B (SMLS) 0.5"-0.5" : xxs 0.75"-l .5": S160	ASTMA105 0.5"-0.5" : SW 9000# 0.75"-1.5": SW 6000#	52001
A13A(51301), B13A(51401)	ASTM A106 Gr.B (SMLS) 0.5"-1.5" : xxs	ASTM Al05 0.5"-1.5" : SW 9000#	52001
A2A(51302), B2A(51402), D2A (51502)	ASTM A106 Gr.B (SMLS)- IBR 0.5"-0.75": S160 1.0"-1.5" : XS	ASTM A105 - IBR 0.5"-0.75": SW 6000# 1.0"-1.5": SW 3000#	52002
A4A (51303), B4A (51403), D4A (51503)	ASTM A333 Gr.6 (SMLS)- LT 0.5"-0.75": SI 60 1.0"-1.5" : XS	ASTM A350Gr.LF2- LT 0.5"-0.75": SW 6000# 1.0"-1.5": SW 3000#	52003
ASA (51304), BSA (51404), DSA (51504)	ASTM Al06 Gr.B (SMLS) -H2 0.5"-0.75": S160 1.0"-1.5": XS	ASTM A105 - H2 0.5"-0.75": SW 6000# 1.0"-1.5": SW 3000#	52004
A7A (51307)	ASTM A106 Gr.B (SMLS) 0.5"-0.75" : S160 1.0"-1.5": XS	ASTM A105 0.5"-0.75": SW 6000# 1.0"-1.5" : SW 3000#	52007
A16A (51311), B16A (51411), D16A (51511)	ASTM Al06 Gr.B (SMLS)- NACE 0.5"-0.5" : xxs 0.75"-1.5": S160	ASTM A105 - NACE 0.5"-0.5" : SW 9000# 0.75"-1.5": SW 6000#	52011
Al 9A (51313), Bl 9A (51413), D19A (51513)	ASTM A106 Gr.B (SMLS) 0.5"-0.75" : S160 1.0"-1.5": XS	ASTM A105 0.5"-0.75": SW 6000# 1.0"-1.5": SW 3000#	52013
ElA (51601), FIA (51701)	ASTM Al06 Gr.B (SMLS) 0.5"-1.5" : S160	ASTM A234 Gr.WPB/ ASTM A105 0.5"-1.5": BW, S160	52101
E2A (51602), F2A (51702)	ASTM A106 Gr.B (SMLS) - IBR 0.5"-1.5" : SI 60	ASTM A234 Gr.WPB/ ASTM A105 - IBR 0.5"-1.5": BW, S160 ·	52102
ESA (51604), FSA (51704)	ASTM Al06 Gr.B (SMLS) - H2 0.5"-1.5" : S160	ASTM A234 Gr.WPB/ ASTM A105 - H2 0.5"-1.5" : BW, S160	52104
E9A (51605), F9A (51705)	ASTM A106 Gr.B (SMLS) 0.5"-1.5": SCH XXS	ASTM A234 Gr.WPB/ ASTM A105 0.5"-1.5": BW, SCH xxs	52105
El9A (51613), F19A (51713)	ASTM A106 Gr.B (SMLS) 0.5"-1.5": SCH XXS	ASTM A234 Gr.WPB/ ASTMA105 0.5"-1.5" : BW, SCH xxs	52113
ASY (51384), A33Y (51384)	ASTM Al 06 Gr.B :(SMLS) 0.5"-1.5": Sl60	ASTM Al05 0.5"-1.5" : SW 6000#	52085

Class (Main Valve Sht.no.)	Pipe	Fittings	Bypass Valve Sht.no.
A1D (51330), B1D (51430), D1D (51530)	ASTM A335Gr.Pl l(SMLS) 0.5"-0.75": Sl60 1.0"-1.5": XS	ASTM Al82 Gr.F1 1C1.2 0.5"-0.75": SW 6000# 1.0"-1.5”: SW 3000#	52030
D2D (5153 I)	ASTM A335Gr.Pl I (SMLS) - IBR 0.5"-0.75": S160 1.0"-1.5": XS	ASTM Al82 Gr.F11Cl.2 - IBR 0.5"-0.75": SW 6000# 1.0"-1.5" : SW 3000#	52031
BSD (51432), DSD (51532)	ASTM 335Gr.Pl l(SMLS)- H2 0.5"-0.75" : Sl60 1.0”-1.5": XS	ASTM Al82 Gr.Fl lCl.2 - H2 0.5"-0.75": SW 6000# 1.0”-1.5" : SW 3000#	52032
BIE (51433)	ASTM A335Gr.P22(SMLS) 0.5"-0.75": Sl60 1.0”-1.5": XS	ASTM Al82 Gr.F22Cl.3 0.5"-0.75": SW 6000# 1.0”-1.5": SW 3000#	52033
DSE (51534)	ASTM A335Gr.P22(SMLS) - H2 0.5"-0.75" : S160 1.0”-1.5": XS	ASTM Al82 Gr. F22Cl.3 - H2 0.5"-0.75": SW 6000# 1.0"-1.5" : SW 3000#	52034
A4F (51336), B4F (51436)	ASTM A335 Gr.PS(SMLS) 0.5"-0.75": Sl60 1.0"-1.5": XS	ASTM Al82 Gr.PS 0.5"-0.75": SW 6000# 1.0"-1.5" : SW 3000#	52036
B3F (51436)	ASTM A335 Gr.PS(SMLS) 0.5"-1.5” : xxs	ASTM Al82 Gr.PS 0.5"-1.5” : SW 9000#	52036
A4G (51339), B4G (51439)	ASTM A335 Gr.P9(SMLS) 0.5"-0.75" : Sl60 1.0”-1.5": XS	ASTM Al82 Gr.F9 0.5"-0.75": SW 6000# 1.0”-1.5": SW 3000#	52039
F2D (51731)	ASTM A335 Gr.Pl I (SMLS) - IBR 0.5"-1.5” : S160	ASTM A234Gr.WP1 ICU/ Al 82 Gr.Fl I Cl.2 - IBR 0.5"-1.5”: BW, S160	52131
ESE (51634)	ASTM A335 Gr.P22(SMLS) - H2 0.5"-0.75" : Sl60 1.0”-1.5": XS	ASTM A234Gr.WP22Cl. I/ Al82 Gr.F22Cl.3 - H2 0.5"-0.75": BW, Sl60 1.0”-1.5" : BW, XS	52134
AIK (51345), A3K (51345), BIK (51445), DIK (51545)	ASTM A312 TP304(SMLS) 0.5"-0.75": 80S 1.0"-1.5": 40S	ASTM Al82 Gr.F304 0.5"-1.5" : SW 3000#	52045
A2K (51346), B2K (51446), D2K (51546)	ASTM A312 TP304(SMLS) - CRYO 0.5"-0.75": 80S 1.0"-1.5": 40S	ASTM Al 82 Gr.F304 -CRYO 0.5"-1.5” : SW 3000#	52046
B4K (51448), BSK (51448)	ASTM A312 TP304H (SMLS) 0.5"-1.5”: 80S	ASTM Al82 Gr.F304H 0.5"-1.5": SW 3000#	52048

Class (Main Valve Sht.no.)	Pipe	Fittings	Bypass Valve Sht.no.
A6K (51350), B6K (51450)	ASTM A312 TP304L (SMLS)0.5"-0.75" : 80S I .0"-1.5": 40S	ASTM Al82 Gr.F304L 0.5"-1.5": SW 3000#	52050
A1M (51361), BIM (51461)	ASTM A312 TP31 6(SMLS)0.5"-0.75" : 80S 1.0"-1.5": 40S	ASTM Al82 Gr.F316 0.5"-1.5": SW 3000#	52061
B5M (51462)	ASTM A312 TP316H (SMLS) -H2 0.5"-0.75" : 80S 1.0"-1.5": 40S	ASTM Al82 Gr.F316H - H2 0.5"-1.5": SW 3000#	52062
B3M (51463)	ASTM A312 TP32l(SMLS)0.5"-0.75": 80S 1.0"-1.5": 40S	ASTM Al82 Gr.F321 0.5"-1.5": SW 3000#	52063
A1N (51366), BIN (51466)	ASTM A312 TP 316L (SMLS)0.5"-0.75" : 80S 1.0"-1.5": 40S	ASTM Al82 Gr.F316L 0.5"-1.5": SW 3000#	52066

SPECIAL REQUIREMENTS FOR LOW TEMPERATURE & CRYOGENIC VALVES

1.0 SCOPE

All valves of Low Temperature Carbon Steel (LTCS) and all grades of austenitic SS (CRYO) material are categorized as cryogenic valves. All these valves shall have extended bonnet as per BS 6364 except check valves.

Following qualification criteria shall be met by the valve vendors to quote valves for cryogenic services:

2.0 QUALIFICATION CRITERIA

i) Both cryogenic test (clause) and reference list (clause) together shall be considered for vendor qualification and vendor shall furnish the same, along with his offer.

ii) Vendors who do not have cryogenic test reports and reference list covering valves of all sizes, materials and ratings required by MR, should confirm / furnish the following for consideration of their offer:

a. Evidence of having conducted successfully at least one cryogenic test as per BS 6364. Test certificate shall be furnished with the offer.

b. Vendor shall confirm to conduct cryogenic test per clauses for the remaining valves not later than 12 weeks from the date of purchase order.

c. Vendor shall also furnish reference list for valves supplied for non-cryo service if reference list referred in 2.2.1 does not cover all the sizes of MR.

Offers of vendors who do not comply with above requirements would be rejected.

2.1 Cryogenic Test

Vendors to furnish copies of cryogenic test certificate for tests conducted as per details given below:

2.1.1 Test shall be as per BS 6364.

2.1.2 Test temperature, unless specifically called for otherwise in the individual MR, shall be -45°C for LTCS and -196°C for all grades of austenitic stainless steel.

2.1.3. Tests carried out on a particular size of one type of valve, pressure rating and material shall qualify all sizes equal to and below the test valve size for the same type, pressure rating and material. In case of austenitic SS any one grade would qualify for all other grades of austenitic SS.

2.1.4. Tests should have been witnessed and certified by any one of the following third party inspection agencies; M/s Lloyd, BV, DNV, TUV or PLECO/ CPLECO.

2.1.5. Cryogenic test need not be conducted for every order. Test conducted previously and witnessed by inspection agencies listed above shall be considered acceptable and need not be repeated.

2.2 Reference List

Vendor shall furnish reference list for valves supplied for cryogenic service indicating the name of client, year of supply, size, material, pressure rating, type of valve and quantity.

2.3 Post Order Testing Procedure

2.3.1. Before conducting post order testing, vendor shall submit the following for approval:

a. Test procedure (as per BS 6364).

b. Cross-section drawing of the valve with material of construction.

c. Schematic of test rig (as per BS 6364) with complete details.

2.3.2. Test has to be conducted irrespective of the service on largest size for each type of valve and for each material and class rating. Vendor shall offer one, two or three valves for selection of test valve by inspector depending upon whether quantity of largest valve in the order is one, two or three and more than three respectively.

In the event of failure of the test valve to meet the specification requirements, the vendor shall conduct test on two more valves. These two valves which pass test successfully, are of lower size, then the qualification will be valid only to sizes upto which test has been conducted successfully.

2.3.3. In case of non-conductance of cryogenic test(s) within 12 weeks or failure in the test(s) conducted after receipt of order, the owner reserves the right to invoke any of the provisions of the purchase order including cancellation of the purchase order at the risk and cost of vendor.

3.0 Bonnet extension, wherever specified in the valve sheet to BS 6364 shall be for "non cold box application" unless otherwise specified in the MR. Even if not called for in valve sheet, valves indicated as "LT" or "CRYO" shall be supplied with bonnet extension.

4.0 Bonnet and Gland extension joints shall be of butt welded/integrally cast construction.

5.0 Repair welding procedure for austenitic stainless steel valves in "CRYO" service shall have to be qualified for impact test as per ASME B31.3. Minimum acceptable impact energy shall be 20 J or lateral expansion of 0.38 mm at temperature of -196°C.

6.0 Wherever impact test of SS studs / nuts is called for in the data sheet, the impact value shall be 27 J at the intended service temperature specified in the data sheets.

SPECIAL REQUIREMENTS FOR HYDROGEN SERVICE

1.0 GENERAL

1.1 These requirements are applicable for valves used in Hydrogen service. These are in addition to the requirements described in "Technical Notes for Valves" Spec. No. 6-44- 0052, and shall be read in conjunction with this specification.

1.2 All cast valve flanges & bodies with flange rating of Class 900 or greater shall be examined in accordance with paragraphs 7.2 through 7.5 of Appendix-VII of ASME SEC-VIII, DIV.1, regardless of casting quality factor.

1.3 Body / bonnet / cover joints & stuffing box of all valves shall have low emission. One valve per metallurgy, per rating, per size shall be helium leak tested as per ASME Sec.V, Subsection A, Article 10 (Detector Probe Technique), Appendix IV at a minimum of 25% of the allowable (rated) cold working pressure. Selection of valves for helium leak test shall be at random. Test duration shall be as follows:

Test Duration in Minutes					
Nominal Size	Pressure Class				
	Upto 300	600	800 & 900	1500	2500
Upto 2"	3	6	9	12	12
3" to 6"	6	9	12	15	18
8" to 16"	9	9	12	15	18
18" to 24"	9	12	15	18	21

The valve shall show no leakage. No leakage is defined as a total leakage rate of less than 0.0001 ml/s of helium.

2.0 Only normalized and tempered material shall be used in the following specifications:

Castings A217 Gr.WC1, A217 Gr.WC4, A217 Gr.WC5, A217 Gr.WC6, A217 Gr.WC9, A217 Gr.C5, A217 Gr.C12

Forgings A182 Gr.F11 C1.2

3.0 CS & AS VALVES

3.1 Bend test and Magnetic Particle inspection of the entire surface of body and bonnet casting shall be in accordance with ASTM A217. Supplementary requirement S3 & S4 evaluation of magnetic particle, inspection shall be in accordance with MSS-SP-53 except that no linear discontinuities shall be allowed.

3.2 The Brinell hardness of heat-treated casting shall not exceed 200 BHN for carbon steel & 225 for alloy steel.

3.3 Repair to defective casting shall be outlined in writing to the purchaser before repair starts. Repair method to be approved prior to welding.

3.4 Casting shall be preheated to a minimum of 400°F prior to welding and all Chromium-Molybdenum alloys shall be postweld heat treated after welding is complete. Stress relieving is essential for welds.

3.5 Carbon steel shall be normalised and alloy steels shall be normalised & tempered.

3.6 Dye Penetrant test of welds shall be in accordance with ASTM B165 Procedure B-2. Interpretation as per Appendix-8 of ASME-VIII Div. 1.

3.7 The tensile stress for AS shall be less than 100,000 psi.

3.8 Charpy V-notch impact testing is to be done for valve material (average 20 ft-lb for set of 3 [minimum value 15 ft-lb] at 30°F).

3.9 For radiography and acceptance criteria for valve castings, refer Cl. 4.2.

4.0 SS VALVES

4.1 Valve casting shall be in solution heat treated and pickled condition.

4.2 Critical body and bonnet casing section typically defined by ASME B 16.34 shall be radiographed and shall meet ASTM E446 (upto 2" thick) Category A, B & CA Level 2, Category CB, OC & CD Level 3, Category D, B & F Level 0. For wall thickness 2" to 4.5" comparable plates of ASTM E186 shall be used. ASTM E94 and ASTM E142 shall be used for recommended practice & controlling quality of radiography as guide. The entire surface of all castings shall be dye-penetrant inspected after pickling.

4.3 Welds shall be 100% radiographed and evaluated in accordance with paragraph 344.5 of ASME B31.3 with a minimum casting quality factor of 0.95. Dye Penetration test shall be as per ASTM E165 Procedure B-2, Interpretation as per Appendix-8 of ASME-VIII Div.l.

STANDARD SPECIFICATION FOR FABRICATION AND ERECTION OF PIPING

P-SPC-403

0	16.02.2022	ISSUED AS STANDARD SPECIFICATION	PNS	SM	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

A.S.	:	Alloy Steel
ASME	:	American Society of Mechanical Engineers
C.I.	:	Cast Iron
C.S.	:	Carbon Steel
IBR	:	Indian Boiler Regulations
LTCS	:	Low Temperature Carbon Steel
NACE	:	National Association of Corrosion Engineers
NB	:	Nominal Bore
NDT	:	Non-Destructive Testing
P&ID	:	Piping and Instrumentation Diagram
PMI	:	Positive Material Identification
S.S.	:	Stainless Steel

CONTENTS

1.0 SCOPE

This specification covers general requirements of fabrication and erection of above ground and trench piping systems at site. The specification covers the scope of work of Contractor, basis of work to be carried out by Contractor and standards, specifications and normal practice to be followed during fabrication and erection by the Contractor.

2.0 SCOPE OF WORK OF CONTRACTOR

Generally, the scope of work of Contractor shall include the following:

2.1 Transportation of required piping materials (as described in Cl. 2.1.1), pipe support (material as described in Cl. 2.3) and all other necessary piping materials from Owner's storage point or Contractor's storage point (in case of Contractor's scope of supply) to work site/shop including raising store requisitions for issue of materials in the prescribed format & maintaining an account of the materials received from Owner's stores.

2.1.1 Piping materials include the following but not limited to the same.

a. Pipes (All sizes and schedule)

b. Flanges (All sizes, types & Pressure ratings).

c. Fittings (All sizes, types and schedule)

d. Valves (All sizes, types and Ratings)

e. Gaskets (All sizes, types & Ratings)

f. Bolts, Nuts or M/C Bolts (All types)

g. Expansion Joint/ Bellows (All types)

h. Specialty items like online filters, ejectors, sample coolers, steam traps, strainers, air traps, springs, silencers, snubbers, steam and condensate manifolds, injection nozzles, MOVs, sight glass, spray nozzles, integrated steam traps, hoses, hose couplings, etc.

i. Online instruments like control valve, orifice flange, rotameter, safety valves, restriction orifice, rupture disc, de-super heaters, corrosion probes, annubar, magnetic flow meter, ultrasonic flow meter, Coriolis mass flow meters, venturi PG / PT / Flow transmitter, ejectors, static mixers, flame arrestors, thermal flow switches, prefabricated hook-ups etc.

j. Shut Down Valves with and without fire box.

2.2 Shop & field fabrication and erection of piping in accordance with documents listed under Cl. 3.0 i.e. 'BASIS OF WORK' including erection of all piping materials enumerated above.

2.3 Fabrication and erection of pipe supports like shoe, saddle, guide, stops, anchors, clips, cradles, hangers, turn-buckles, supporting fixtures, bracket cantilevers, struts, tee-posts including erection of spring supports, sway braces, dummy pipes, corrosion pads/ protection shields, low friction pads, clamps, special support, expansion bellows, steam and condensate manifolds supports etc. Corrosion Pads / Protection shields, stiffeners and stiffening rings, if not covered in the specifications / standards, shall be of the same material as of parent pipes.

2.4 Site fabrication of Piping items

Site fabrication of Piping items shall include but not be limited to the following

2.4.1 Fabrication of piping specials like special radius bends, reducers, mitres etc.

2.4.2 Fabrication of plain and threaded nipples from pipes as required during erection.

2.4.3 Fabrication of swage nipples as and when required.

2.4.4 Fabrication of odd angle elbow like 60°, 30° or any other angle from 90° / 45° elbows as and when required.

2.4.5 Fabrication of flange, reducing flange, blind flange, spectacle blinds as and when required.

2.4.6 Fabrication of stub-in connection with or without reinforcement.

2.4.7 Grinding of edges of pipes, fittings, flanges etc. to match mating edges of uneven / different thickness wherever required.

2.4.8 Fabrication of circular pipe for steam rings, fire water lines, utility lines.

2.4.9 Threading of all small bore piping as per piping material specifications.

2.4.10 Drilling on blind flange for inserting / joining small bore lines.

2.4.11 Fabrication and welding of reinforcement pads at branch pipe locations wherever required.

2.4.12 Equipment nozzle reinforcement with pads, jacket & stiffeners wherever required.

2.4.13 Fabrication of injection nozzles as per details provided wherever required.

2.4.14 Fabrication of chain operation arrangement for valves, wherever required. All material required for this modification shall be supplied by Contractor.

2.4.15 Fabrication and erection in position of funnels required for OWS / SS / Condensate blow down system as per direction of Engineer-in-charge.

2.4.16 Grinding/ finishing of uneven surfaces/ joints after welding. Internal grinding of welds of orifice flanges to render smooth surface.

2.4.17 Tapping and drilling of holes in flanges, blind flanges, piping connections for jack screw, if required.

2.4.18 Providing bird screens at the outlet of lines open to atmosphere.

2.5 Modifications like providing additional cleats, extension of stem of valve, locking arrangement of valves etc. as and when required.

2.6 Piping isometrics for main process / utility lines shall be provided to the Contractor for Units.

Preparation of miscellaneous small bore isometrics with bill of materials for process and utility lines (up to 1 1/2 " size) like instruments & pump flushing / cooling, sample connection, purging, pump casing vents & drains, pump base plate drains, control valve drains / vent to flare, instrument drains & vents, steam tracing (non-IBR) from steam supply stations up to condensate recovery station, and lines specified as field routed within the Unit battery limit as and when required are in Contractor's scope of work. Approval for these isometrics prepared by the Contractor shall be taken from Engineer-in-charge before erection.

Small bore piping isometrics given by Owner shall be rechecked by Contractor before erection and installation.

2.7 Obtaining approval for drawings prepared by Contractor from statutory authority, if required. Contractor shall also arrange all necessary permits for hot work etc.

2.8 Spun concrete lining of the inside of pipes 3" NB & above including fittings and flanges as required in accordance with specification.

2.9 Rubber lining inside pipes, fittings, flanges as and when required,' in accordance with specification.

2.10 Radiography, stress relieving, dye penetration, magnetic particle test etc. as required in specification.

2.11 Performing PMI using alloy analysers as per 'Standard Specification for Positive Material Identification at Construction Sites.

2.12 Casting of concrete pedestals and Fabrication and erection of small structures/ platforms for pipe supports and valve operation / attending some instruments, spectacle blinds etc., providing brackets, modification / extension of platforms, providing additional platforms / ladders for improving / providing accessibility.

2.13 Providing insert plates with anchor fasteners in concrete structures / paved floors and repair of platform gratings around pipe openings and providing suitable members for support under the platform grating.

2.14 Making material reconciliation statement and return of Owner's supply left over materials to Owner's storage.

2.15 Flushing and testing of all piping systems as per standard specification for inspection, flushing and testing of piping systems. The accessories required for blinding the line like flange, blind flange, gasket (all sizes, type and rating), stud-bolts, flexible hoses etc. are to be arranged by the Contractor. During flushing the discharged water / air shall be drained / routed as directed by the Engineer in Charge.

2.16 Contractor shall prepare welding specifications for all weld joints where dissimilar welding will be performed, and obtain approval from Owner.

2.17 Contractor to ensure meeting all requirements for carrying out work in shutdown / running plant.

2.18 Pickling (as and when applicable) as per Job specification(s) for chemical cleaning of CS suction piping of compressors, SS Piping, Weldments etc, as applicable.

2.19 Chemical Cleaning / Hydro jet cleaning as per marked-up P&IDs with supply of chemicals, consumables, DM water, equipments, boilers, coupons, tools & tackles and other testing equipments required for the same.

2.20 For Offsites, only Piping General Arrangement drawings shall be issued. Isometrics, if required, shall be prepared by the Contractor.

3.0 BASIS OF WORK

3.1 The complete piping work shall be carried out in accordance with the following:

3.1.1 "Approved for Construction" drawings and sketches issued by Owner to the Contractor – Plans and / or Isometrics.

3.1.2 "Approved for Construction" drawings and sketches issued by Turn-key bidders to the Contractor - Plans and / or Isometrics.

3.1.3 Approved Process Licensor's standards and specifications.

3.1.4 Drawings, sketches and documents prepared by Contractor duly approved by Engineer-in-Charge (such as isometrics of small bore piping and offsite piping etc.).

3.1.6 PLECO/ Client specifications / documents as below:

a. Process and Instrument Diagram.

b. Job Piping Materials Specification.

c. Piping support, engineering standards.

d. Line list

e. Specification of Non-destructive Requirement of Piping

f. Welding specification for fabrication of piping

g. Any other specifications

3.1.7 Following codes, standards and regulations

a. ASME B 31.3 : Process Piping

b. ASME Sec. VIII: Code for unfired pressure vessel

c. ASME Sec. IX: Qualification standard for welding and brazing procedures, welders, brazers and welding and brazing operators.

d. NACE Std. Code for Sour Services material requirements MR-0175 / MR-0103 /Job spec. (NACE), as applicable.

Note: All codes referred shall be latest edition, at the time of award of contract.

3.2 Deviations

Where a deviation from the "Basis of Work" and approved job procedure is required or where the basis of work does not cover a particular situation, the matter shall be brought to the notice of Engineer-in-Charge and the work carried out only after obtaining written approval from him in each case.

4.0 FABRICATION

4.1 Piping Material

Pipe, pipe fittings, flanges, valves, gaskets, studs bolts etc. used in a given piping system shall be strictly as per the "Piping Material Specification" for the "Pipe Class" specified for that system. To ensure the above requirement, all piping material supplied by the Owner / Contractor shall have proper identification marks as per relevant standards / PLECO specifications / Licensors specification. Contractor shall provide identification marks on left over pipe lengths wherever marked up pipe lengths have been fabricated / erected. Material - traceability is to be maintained for A.S., S.S., NACE, LTCS, material for Hydrogen service and other exotic materials by way of transferring heat number, etc. (hard punching) as per approved procedure. This shall be in addition to colour coding for all piping materials to avoid mix-up.

For the purpose of common understanding the construction job procedure, to be submitted by the Contractor, shall include proposal for

- Maximizing prefabrication, inspection and testing at fabrication shop with minimum field joints.
- Positive material identification, handling, storage & preservation.

4.2 Dimensional Tolerances

Dimensional tolerances for piping fabrication shall be as per Standard Specification. The Contractor shall be responsible for working to the dimensions shown on the drawings. However, the Contractor shall bear in mind that there may be variations between the dimensions shown in the drawing and those actually existing at site due to minor variations in the location of equipments, inserts, structures etc. To take care of these variations "Field Welds" shall be provided during piping fabrication. An extra pipe length of 100 mm over and above the dimensions indicated in the drawing may be left on one side of the pipe at each of the field welds. During erection, the pipe end with extra length at each field weld, shall be cut to obtain the actual dimension occurring at site. Isometrics, if supplied may have the field welds marked on them. However, it is the responsibility of the Contractor to provide adequate number of field welds. In any case no extra claims will be entertained from the Contractor on this account. Wherever errors / omissions occur in drawings and Bills of Materials it shall be the Contractor's responsibility to notify the Engineer-in-Charge prior to fabrication or erection.

4.4 Pipe Joints

The piping class of each line specifies the type of pipe joints to be adopted. In general, joining of lines 2" and above in process and utility piping shall be accomplished by butt-welds. Joining of lines 1-1/2" and below shall be by socket welding / butt welding / threaded joints as specified in "Piping Material Specifications". However, in piping 1-1/2" and below where socket welding / threaded joints are specified butt - welds may be used with the approval of Engineer-in-Charge for pipe to pipe joining in long runs of piping. This is only applicable for non-galvanized piping without lining.

Flange joints shall be used at connections to Vessels, Equipment's, Valves and where required for ease of erection and maintenance as indicated in drawings.

4.5 Butt Welded and Socket Welded Piping

End preparation, alignment and fit-up of pipe pieces to be welded, welding, pre-heating, post heating and heat treatment shall be as described in the Job welding specification and NDT specification.

4.6 Screwed Piping

In general, Galvanized piping shall have threads as per IS:554 or ANSI B2.1 NPT as required to match threads on fittings, valves etc. All other piping shall have threads as per ANSI B2.I, tapered unless specified otherwise.

Threads shall be clean cut, without any burrs or stripping and the ends shall be reamed. Threading of pipes shall be done preferably after bending, forging or heat-treating operations. If this is not possible, threads shall be gauge checked and chased after welding heat treatment etc.

During assembly of threaded joints, all threads of pipes and fittings shall be thoroughly cleaned of cuttings, dirt, oil or any other foreign matter. The male threads shall be coated with thread sealant and the joint tightened sufficiently for the threads to seize and give a leakproof joint. Threaded joints to be seal-welded shall be cleaned of all foreign matter, including sealant and made up to full thread engagement before seal welding.

4.7 Flange Connections

All flange facings shall be true and perpendicular to the axis of pipe to which they are attached. Flanged bolt holes shall straddle the normal centre lines unless different orientation is shown in the drawing.

Wherever jack screws are to be provided, drilling and tapping for the jack screws in the flange, shall be done as per PLECO Standard before welding it to the pipe.

4.8 Branch Connections

Branch connections shall be as indicated in the piping material specifications. For end preparation, alignment, spacing, fit-up and welding of branch connections refer welding specifications. Templates shall be used wherever required to ensure accurate cutting and proper fit-up.

For all branch connections accomplished either by pipe to pipe connections or by using forged tees the rates quoted for piping shall be inclusive of this work.

Reinforcement pads shall be provided wherever indicated in drawings / specifications etc. Reinforcement pads shall be pneumatically tested at 1.05 kg/cm^{2}g with soap solution. This test shall be carried out before hydrostatic testing.

4.9 Bending

Bending shall be as per ASME B31.3 except that corrugated or creased bends shall not be used.

Cold bends for lines 1-1/2" and below, with a bend radius of 5 times the nominal diameter shall be used as required in place of elbows wherever allowed by piping specifications. Bending of pipes 2" and above may be required in some cases like that for headers around heaters, reactors etc.

The completed bend shall have a smooth surface, free from cracks, buckles, wrinkles, bulges, flat spots and other serious defects. They shall be true to dimensions. The flattening of a bend, as measured by the difference between the maximum and minimum diameters at any cross section, shall not exceed 8% and 3% of the nominal outside diameter, for internal and external pressure respectively.

4.10 Forging and Forming

Forging and forming of small bore fittings, like reducing nipples for piping 1-1/2" and below, shall be as per ASME B 31.3.

4.11 Cutting and Trimming of Standard Fittings & Pipes

Components like pipes, elbows, couplings, half-couplings etc. shall be cut / trimmed / edge prepared wherever required to meet fabrication and erection requirements, as per drawings and instructions of Engineer-in-Charge. Nipples as required shall be prepared from straight length piping.

4.12 Galvanized Piping

Galvanized carbon steel piping shall be completely cold worked, so as not to damage galvanized surfaces. This piping involves only threaded joints and additional external threading on pipes may be required to be done as per requirement.

4.13 Jacketed Piping

The Jacketing shall be done in accordance with PLECO Specification or Licensors specification as suggested in material specification or special condition of contract.

Pre-assembly of jacketed elements to the maximum extent possible shall be accomplished at shop by Contractor. Position of jump-over and nozzles on the jacket pipes, fittings etc. shall be marked according to pipe disposition and those shall be prefabricated to avoid damaging of inner pipe and obstruction of jacket space. However, valves, flow glasses, in line instruments or even fittings shall be supplied as jacketed.

4.14 Shop Fabrication / Prefabrication

The purpose of shop fabrication or pre-fabrication is to minimize work during erection to the extent possible. Piping spool, after fabrication, shall be stacked with proper identification marks, so as to facilitate their withdrawal at any time during erection. During this period all flange (gasket contact faces) and threads shall be adequately fabricated by coating with removable rust preventive. Care shall also be taken to avoid any physical damage to flange faces and threads.

4.15 Miscellaneous

4.15.1 Contractor shall fabricate miscellaneous elements like flash pot, seal pot, sample cooler, supporting elements like turn-buckles, extension of spindles and interlocking arrangement of valves, operating platforms as required by Engineer-in-Charge.

4.15.2 Spun Concrete Lining

The work of inside spun concrete lining of pipes and specials of diameter 3" and above shall be done as per material specifications and special condition contract.

4.15.3 Fabrication of pipes from plate

Pipes shall be fabricated at site as and when required as per the specifications and the actual Piping Material Specification.

5.0 ERECTION

5.1 Cleaning of Piping before Erection

Before erection all pre-fabricated spool pieces, pipes, fittings etc. shall be cleaned inside and outside by suitable means. The cleaning process shall include removal of all foreign matter such as scale, sand, weld spatter chips etc. by wire brushes, cleaning tools etc. and blowing with compressed air / or flushing out with water. Special cleaning requirements for some services, if any, shall be as specified in the piping material specification or isometric or line list. S.S jacketed piping requiring pickling shall be pickled to remove oxidation and discolouring due to welding.

5.2 Piping Routing

No deviations from the piping route indicated in drawings shall be permitted without the consent of Engineer-in-Charge.

Pipe to pipe, pipe to structure / equipments distances / clearances as shown in the drawings shall be strictly followed as these clearances may be required for the free expansion of piping / equipment. No deviations from these clearances shall be permissible without the approval of Engineer-in-Charge.

In case of fouling of a line with other piping, structure, equipment etc. the matter shall be brought to the notice of Engineer-in-Charge and corrective action shall be taken as per his instructions.

5.3 Cold Pull

Wherever cold pull is specified, the Contractor shall maintain the necessary gap, as indicated in the drawing. Confirmation in writing shall be obtained by the Contractor from the Engineer-in-Charge, certifying that the gap between the pipes is as indicated in the drawing, before drawing the cold pull. Stress relieving shall be performed before removing the gadgets for cold pulling.

5.4 Slopes

Slopes specified for various lines in the drawings / P&ID shall be maintained by the Contractor. Corrective action shall be taken by the Contractor in consultation with Engineering in Charge wherever the Contractor is not able to maintain the specified slope.

5.5 Expansion Joints / Bellows

Installation of Expansion Joints / Bellows shall be as follows:

5.5.1 All Expansion joints / Bellows shall be installed in accordance with the specification and installation drawings, supplied to the Contractor.

5.5.2 a. Upon receipt, the Contractor shall remove the Expansion Joints / Bellows from the case(s) and check for any damage occurred during transit.

b. The Contractor shall bring to the notice of the Engineer-in-Charge any damage done to the bellows / corrugations, hinges, tie-rods, flanges/ weld ends etc.

c. Each Expansion Joint / Bellow shall be blown free of dust / foreign matter with compressed air or cleaned with a piece of cloth.

5.5.3 a. For handling and installation of Expansion Joints, great care shall be taken while aligning. An Expansion Joints shall never be slinged from bellows corrugations / external shrouds, tie / rods, angles.

b. An Expansion Joints / Bellow shall preferably be slinged from the end pipes / flanges or on the middle pipe.

5.5.4 a. All Expansion Joints shall be delivered to the Contractor at "Installation length", maintained by means of shipping rods, angles welded to the flanges or weld ends or by wooden or metallic stops.

b. Expansion Joints stop blocks shall be carefully removed after hydrostatic testing. Angles welded to the flanges or weld ends shall be trimmed by saw as per manufacturer's instructions and the flanges or weld ends shall be ground smooth.

5.5.5 a. The pipe ends in which the Expansion Joint is to be installed shall be perfectly aligned or shall have specified lateral deflection as noted on the relevant drawings.

b. The pipe ends / flanges shall be spaced at a distance specified in the drawings.

5.5.6 The Expansion Joint shall be placed between the mating pipe ends / flanges and shall be tack welded / bolted. The mating pipes shall again be checked for correct alignment.

5.5.7 Butt-welding shall be carried out at each end of the expansion joint. For flanged Expansion Joint, the mating flanges shall be bolted.

5.5.8 After the Expansion Joint is installed the Contractor shall ensure that the mating pipes and Expansion Joints are in correct alignment and that the pipes are well supported and guided.

5.5.9 The Expansion Joint shall not have any lateral deflection. The Contractor shall maintain parallelism of restraining rings or bellows convolutions.

5.5.10 Precautions

a. For carrying out welding, earthing lead shall not be attached with the Expansion Joint.

b. The Expansion bellow shall be protected from arc weld spot and welding spatter.

c. Hydrostatic Testing of the system having Expansion Joint shall be performed with shipping lugs in position. These lugs shall be removed after testing and certification is over.

5.6 Flange Connections

While fitting up mating flanges, care shall be exercised to properly align the pipes and to check the flanges for trueness, so that faces of the flanges can be pulled together, without inducing any stresses in the pipes and the equipment nozzles. Extra care shall be taken for flange connections to pumps, turbines, compressors, cold boxes, air coolers etc. The flange connections to these equipments shall be checked for misalignment, excessive gap etc. after the final alignment of the equipment is over. The joint shall be made up after obtaining approval of Engineer-in-Charge.

Hydraulic bolt tensioning & torque tensioning shall be performed on flange joints as per the requirements specified in "Standard Specification for application of Torque & Hydraulic Bolt Tension for flange joints and its addendum, if any.

Temporary protective covers shall be retained on all flange connections of pumps, turbines, compressors and other similar equipments, until the piping is finally connected, so as to avoid any foreign material from entering these equipments.

The assembly of a flange joint shall be done in such a way that the gasket between these flange faces is uniformly compressed. To achieve this, the bolts shall be tightened in a proper sequence. All bolts shall extend completely through their nuts but not more than 1/4".

Steel to C.I. flange joints, if any, shall be made up with extreme care, tightening the bolts uniformly after bringing flange flush with gaskets with accurate pattern and lateral alignment.

5.7 Vents and Drains

High point vents and low point drains shall be provided as per the instructions of Engineering in Charge, even if these are not shown in the drawings. The details of vents and drains shall be as per piping material specifications / job standards.

5.8 Valves

Valves shall be installed with spindle / actuator orientation / position as shown in the layout drawings. In case of any difficulty in doing this or if the spindle orientation / position is not shown in the drawings, the Engineer-in-Charge shall be consulted and work done as per his instructions. Care shall be exercised to ensure that globe valves, check valves, and other unidirectional valves are installed with the "Flow direction arrow "on the valve body pointing in the correct direction. If the direction of the arrow is not marked on such valves, this shall be done in the presence of Engineer-in-Charge before installation.

Fabrication of stem extensions, locking arrangements and interlocking arrangements of valves (if called for), shall be carried out as per drawings / instructions of Engineer-in-Charge.

5.9 Instruments

Installation of in-line instruments such as control valve, orifice flange, rotameter, safety valves, restriction orifice, rupture disc, de-super heaters, corrosion probes, annubar, magnetic flow meter, ultrasonic flow meter, Coriolis mass flow meters, venturi PG / PT / Flow transmitter, ejectors, etc. and Shut Down Valves with fireboxes shall form a part of piping erection work.

Fabrication and erection of piping upto first block valve / nozzle / flange for installation of offline Instruments for measurement of level, pressure, temperature, flow etc. shall also form part of piping construction work. The limits of piping and instrumentation work will be shown in drawings / standards / specifications. Orientations / locations of take-offs for temperature, pressure, flow, level connections etc. shown in drawings shall be maintained.

Flushing and testing of piping systems which include instruments mentioned above and the precautions to be taken are covered in flushing, testing and inspection of piping. Care shall be exercised and adequate precautions taken to avoid damage and entry foreign matter into instruments during transportation, installation, testing etc.

5.10 Line Mounted Equipments / Items

Installation of line mounted items like filters, strainers, steam traps, air traps, desuperheaters, ejectors, samples coolers, mixers, flame arrestors, sight glasses etc including their supporting arrangements shall form part of piping erection work.

5.11 Bolts and Nuts

The Contractor shall apply molycoat grease mixed with graphite powder (unless otherwise specified in piping classes) all bolts and nuts during storage, after erection and wherever flange connections are broken and made-up for any purpose whatsoever. The grease and graphite powder shall be supplied by the Contractor within the rates for piping work.

5.12 Pipe Supports

Pipe supports are designed and located to effectively sustain the weight and thermal effects of the piping system and to prevent its vibrations. Location and design of pipe supports will be shown in drawings for lines 2" NB & above. For lines 1 1/2" NB & below Contractor shall locate and design pipe supports in line with owner Stds. Contractor shall obtain approval of Engineer - in - Charge on drawings prepared by Contractor, before erection. However, any extra supports desired by Engineer-in-Charge shall also be installed.

No pipe shoe / cradle shall be offset unless specifically shown in the drawings.

Hanger rods shall be installed inclined in a direction opposite to the direction in which the pipe move during expansion.

Piping (including small bore) shall not be supported directly from gratings of platforms including equipment platforms.

Preset pins of all spring supports shall be removed only after hydrostatic testing and insulation is over. Springs shall be checked for the range of movement and adjusted if necessary to obtain the correct positioning in cold condition. These shall be subsequently adjusted to hot setting in operating condition. The following points shall be checked after installation, with the Engineer-in-Charge and necessary confirmation in writing obtained certifying that:

- All restraints have been installed correctly.
- Clearances have been maintained as per support drawings.
- Insulation does not restrict thermal expansion.
- All temporary tack welds provided during erection have been fully removed.
- All welded supports have been fully welded.

STANDARD SPECIFICATION

FOR INSPECTION, FLUSHING AND TESTING OF PIPING SYSTEMS

P-SPC-404

0	16.02.2022	ISSUED AS STANDARD SPECIFICATION	PNS	SM	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

ASME	:	American Society of Mechanical Engineers
IBR	:	Indian Boiler Regulations
PMI	:	Positive Material Identification
Ppm	:	Parts per million
S.S.	:	Stainless Steel

CONTENTS

1.0 SCOPE

This specification covers the general requirements for inspection, flushing and testing of piping systems.

Flushing and testing of all piping systems shall be witnessed by the Engineer-In-Charge.

2.0 RFERENCES

ASME B31.3: Process Piping

Standard Specification for Positive Material Identification (PMI) at Construction Sites

3.0 INSPECTION

During various stages and after completion of fabrication and erection, the piping system shall be inspected by the Engineer-In-Charge to ensure that:

- Proper piping material has been used.
- PMI has been performed as per Owner specification.
- Piping has been erected as per drawings and instructions of Engineer-In-Charge.
- All supports have been installed correctly.
- Test preparations mentioned in this specification have been carried out.

4.0 FLUSHING

Flushing of all lines shall be done before pressure testing.

Flushing shall be done by 'fresh potable water' or by 'dry compressed air wherever water flushing is not desirable to clean the pipe of all dirt, debris or loose foreign material.

Required pressure for water flushing shall meet the fire hydrant pressure or utility water pressure. For air flushing, the line / system shall be pressurized by compressed air at the required pressure which shall be 3.5 kg / cm^2g maximum. The pressure shall then be released by quick opening of a valve, already in line or installed temporarily for this purpose. This procedure shall be repeated as many times as required till the inside of the pipe is fully cleaned.

In line instruments like control valves, orifice plates, rotameters, safety valves and other instruments like thermowells which may interfere with flushing shall not be included in flushing circuit.

The screens / meshes shall be removed from all permanent strainers before flushing. Screens / meshes shall be reinstalled after flushing but before testing.

During flushing temporary strainers shall be retained. These shall be removed, cleaned and reinstalled after flushing, but, before testing.

In case any equipment such as column, vessel, exchanger etc. form part of a piping circuit during flushing, this shall be done with the approval of Engineer-In-Charge. However, equipments thus included in the circuit shall be completely drained and dried with compressed air after flushing is completed.

During flushing discharged water / air shall be drained to the place directed by the Engineer-In-Charge. If necessary, proper temporary drainage shall be provided by the contractor.

Care shall be taken during flushing so as not to damage / spoil work of other agencies. Precautions shall also be taken to prevent entry of water / foreign matter into equipments, electric motors, instruments, electrical installations etc. in the vicinity of lines being flushed.

The contractor shall carry out all the activities required before, during and after the flushing operation, arising because of flushing requirements, such as but not limited to the following:

Dropping of valves, specials, distance pieces, inline instruments and any other piping part before flushing. The flanges to be disengaged for this purpose shall be envisaged by the contractor and approved by the Engineer-In-Charge. These flanges shall be provided with temporary gaskets at the time of flushing.

After flushing is completed and approved, the valve distance pieces, piping specials etc. shall be reinstalled by the contractor with permanent gaskets. However, flanges at equipment nozzles and other places where isolation is required during testing, only temporary gaskets shall be provided.

Records in triplicate shall be prepared and submitted by the contractor for each piping system for the flushing done in the proforma provided / approved by the Engineer-in-Charge.

5.0 PRESSURE TESTING

Pressure testing, in general shall be as per clause A345 of ASME B31.3, unless otherwise specified, herein. Lines carrying highly hazardous / poisonous fluids must have a sensitive leak test.

5.1 Extent of Testing

With the exclusion of instrumentation, piping systems fabricated or assembled in the field shall be tested irrespective of whether or not they have been pressure tested prior to site welding or fabrication.

To facilitate the testing of piping systems, vessels and other equipments may be included in the system with the prior approval of Engineer-In-Charge if the test pressure specified is equal to or less than that for the vessels and other equipments.

Pumps, compressors and other rotary equipments shall not be subjected to field test pressure.

Lines which are directly open to atmosphere such as vents, drains, safety valves discharge need not be tested, but all joints shall be visually inspected. Wherever necessary, such lines shall be tested by continuous flow of fluid to eliminate the possibility of blockage. However, such lines if provided with block valve shall be pressure tested up to the last block valve.

Seats of all valves shall not be subjected to a pressure in excess of the maximum cold working pressure of the valve. Test pressure applied to valves shall not be greater than the manufacturer's recommendation nor less than that required by the applicable code. Where allowable seat pressure is less than test pressure, test shall be made through an open valve.

Instruments in the system to be tested shall be excluded from the test by isolation or removals, unless approved otherwise by the Engineer-In-Charge.

Restrictions which interfere with filling, venting, draining such as orifice plates etc. shall not be installed unless testing is complete.

Control valves shall not be included in the test system. Where bypasses are provided test shall be performed through the bypass and / or necessary spool shall be used in place of the control valve.

Pressure gauges which are part of the finished system, but cannot withstand test pressure shall not be installed until the system has been tested. Where piping systems to be tested are directly connected at the battery limits to piping for which the responsibility rests with other agencies, the piping to be tested shall be isolated from such piping by physical disconnection such as valve or blinds.

5.2 General Requirements / Test Preparation for Testing

Testing shall be carried out with permanent gaskets installed unless specified otherwise or instructed by the Engineer-in-Charge.

No pressure test shall be carried out against closed valve unless approved by the Engineer-in-Charge.

The Engineer-in-Charge shall be notified in advance by the Contractor, of the testing sequence and programme, to enable him to be present for witnessing the test.

Before testing, all piping shall be cleaned by flushing to make it free from dirt, loose scale, debris and other loose foreign materials.

All piping systems to be hydrostatically tested shall be vented at the high points and the systems purged of air before the test pressure is applied.

Wherever in the line any void exists due to any reasons, like absence of control valves, safety valves, check valves etc. it shall be filled with temporary spools.

All joints welded, screwed or flanged shall be left exposed for examination during the test. Before pressurizing the lines, each weld joint shall be cleaned by wire brush to free it from rust and any other foreign matter.

Where a system is to be isolated at a pair of companion flanges, a blank shall be inserted between the companion flanges. Minimum thickness of the blank shall be designed in accordance with applicable design code.

Open ends of piping system where blanks cannot be used, such as pumps, compressors, turbines or wherever equipment or pipe spools have been recovered or disconnected prior to hydrostatic testing, shall be blinded off by using standard blind flanges of same rating as the piping system being tested.

Pressure gauges used in testing shall be installed as close as possible to the lowest point in the piping system to be tested, to avoid overstressing of any of the lower portions of the system. For longer lines and vertical lines, two or more pressure gauges shall be installed at locations decided by the Engineer-in-Charge.

For lines containing check valves any of the following alternatives shall be adopted for pressure testing:

- Whenever possible pressurize up-stream side of valve.
- Replace the valve by a temporary spool and reinstall the valve after testing.
- Provide blind on valve flanges and test the upstream and downstream of the line separately and remove the blind after testing. At these flanges, temporary gaskets shall be provided during testing and shall be replaced by permanent gaskets subsequently.
- For check valves in lines 1 1/2" and below flapper or seat shall be removed during testing (if possible). After completion of testing the flapper/seat shall be refitted.

Gas lines when hydrostatically tested shall be provided with additional temporary supports during testing as directed by the Engineer-in-Charge.

Piping which is spring or counter-weight supported shall be temporarily supported, where the weight of the fluid would overload the support. Retaining pins for spring supports shall be removed only after testing is completed and test fluid is completely drained.

When testing any piping system, air or steam of approximately 2 kg / cm^2g may be used as preliminary test to detect missing gaskets etc. as this avoids the necessity of draining the line to make repairs. However, steam shall not be used for this purpose, if the steam temperature is more than the design temperature of the line.

5.3 Testing Media, Test Pressure and Test Pressure Gauges

5.3.1 Testing Media

In general all pressure tests shall be hydrostatic using iron free water, which is clean and free of silt. Maximum chloride content in water for hydrostatic testing for SS piping shall be 15-20 ppm.

Air shall be used for testing only if water would cause corrosion of the system or overloading of supports etc. in special cases as directed by Engineer-in-Charge.

If operating fluid in the line is much lighter than testing fluid, the additional weight of testing fluid may render piping supports (as designed) inadequate. This will call for additional temporary supports. The typical examples are flare and vapour lines. It is preferable that hydrostatic testing is avoided in such systems and instead pneumatic testing may be specified.

Where air / water tests are undesirable, substitute fluids such as gas oil, kerosene, methanol etc. shall be used as the testing medium, with due consideration to the hazards involved. These test fluids shall be specified in the line list given to the contractor.

5.3.2 Test Pressure

The hydrostatic/ pneumatic test pressure shall be as indicated in the line list or as per the instruction of Engineer-in-Charge.

The selection of the piping system for one individual test shall be based on the following:

- Test pressure required as per line list.
- Maximum allowable pressure for the material of construction of piping.

Depending upon the above requirements and based on construction progress, maximum length of piping shall be included in each test.

5.3.3 Test Pressure Gauge

All gauges used for field testing shall have suitable range so that the test pressure of various systems falls in 35% to 65% of gauge scale range. Pressure gage dial shall be minimum of 150 mm. Size of Bourdon shall not be less than 75% of nominal diameter of dial range. Gauge shall be of a good quality and in first class working condition.

Prior to the start of any test or periodically during the field test programme, all test gauges shall be calibrated using a standard dead weight gauge tester or other suitable approved testing apparatus. Any gauge showing an incorrect zero reading or error of more than ± 2% of full scale range shall be discarded .The Engineer-in-Charge shall check the accuracy of master pressure gauge used for calibration. Calibration certificate shall be furnished for the pressure gages.

5.4 Testing Procedure

5.4.1 Hydrostatic Test

All vents and other connections used as vents shall be left open while filling the line with test fluid for complete removal of air. In all lines for pressurizing and depressurizing the system, temporary isolation valves shall be provided if valved vents, drains do not exist in the system.

Pressure shall be applied only after the system / line is ready and approved by the Engineer-in-charge.

Pressure shall be applied by means of a suitable test pump or other pressure source which shall be isolated from the system as soon as test pressure is reached and stabilized in the system.

A pressure gauge shall be provided at the pump discharge for guidance in bringing the system to the required pressure.

The pump shall be attended constantly during the test by an authorized person. The pump shall be isolated from the system whenever the pump is to be left unattended.

Test pressure shall be maintained for a sufficient length of time not less than 10 minutes. Test pressure shall be released only after physical checking of all the joints and attachments are completed, to permit thorough inspection of all joints and connections for leakage or signs of failure. Any joint found leaking during a pressure test shall be retested to the specified pressure after repair.

The pump and the piping system to be tested are to be provided with separate pressure indicating test gauges.

Care shall be taken to avoid increase in the pressure due to temperature variation during the test.

5.4.2 Pneumatic Test

When testing with air, pressure shall be supplied by means of a compressor. The compressor shall be portable type with a receiver, after cooler and oil separator.

Piping to be tested by air shall have joints covered with a soap and water solution so that the joints can be examined for leaks.

All other details shall be same as per hydrotesting procedure (specified above).

5.5 Completion of Testing

After the hydrostatic test has been completed, pressure shall be released by opening the vents, in a manner and at a rate so as not to endanger personnel or damage equipments.

All vents shall be opened before the system is to be drained and shall remain open till all draining is complete, so as to prevent formation of vacuum in the system. After draining, lines/ systems shall be dried by air. In services like dry air, ethylene etc., small traces of water can cause problem. For such lines hot air drying is to be done after hydro-test.

After testing is completed the test blinds shall be removed and equipment / piping isolated during testing shall be connected using the specified gaskets, bolts and nuts. These connections shall be checked for tightness in subsequent pneumatic tests to be carried out by the contractor for complete loop / circuit including equipments (except rotary equipments).

Pressure test shall be considered complete only after approved by the Engineer-in-Charge. Defects, if any, noticed during testing shall be rectified immediately and retesting of the system / line shall be done by the contractor at his cost.

5.6 Test Records

Records in triplicate shall be prepared and submitted by the contractor for each piping system, for the pressure test done in the proforma provided / approved by the Engineer-in-Charge. Records shall also be submitted for the PMI undertaken as per PLECO Std. Specification.

STANDARD SPECIFICATION FOR NON-DESTRUCTIVE EXAMINATION REQUIREMENTS OF PIPING

P-SPC-405

0	25.02.2022	ISSUED FOR STANDARD SPECIFICATION	PNS	SM	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

DP / LP	:	Dye / Liquid Penetrant
MP	:	Magnetic Particle
CS	:	Carbon Steel
AS	:	Alloy Steel
SS	:	Stainless Steel
ASTM	:	American Society for Testing & Materials
ASME	:	American Society of Mechanical Engineers
IBR	:	Indian Boiler Regulations
PMS	:	Piping Material Specification

CONTENTS

1.0 GENERAL

1.1 Scope

This specification covers the general requirements for non-destructive examination of shop & field fabricated piping.

1.2 Related Codes & Engineering Standards

Referred codes / standards are as follows. Latest editions of the Codes / Standards referred to shall be followed.

a) ASME Boiler & Pressure Vessel Codes, Section V & VIII (Div.1) including addenda.

b) ASME B31.3

c) ASME B16.5

d) ASME B16.34

e) Standard Piping Material Specification,

f) Welding Specification Charts for Piping Classes,

g) Standard Specification for Fabrication & Erection of Piping

h) ASTM E10

i) Welding Specification for Fabrication of Piping,

j) Design Guide for Radiography Requirements,

2.0 VISUAL EXAMINATION

2.1 Weld shall be visually inspected wherever accessible in accordance with the following requirements:

a) Internal misalignment	:	1.5 mm or less
b) Cracks or lack of fusion	:	not permitted
c) Incomplete penetration	:	Depth shall not exceed the lesser of 0.8 mm or 0.2 times thickness of thinner component joined by butt-weld. The total length of such imperfections shall not exceed 38 mm in any 150 mm of weld length.
d) Surface porosity and exposed slag inclusions (For nom. wall thickness 4.7 mm and less)	:	Not permitted
e) Concave root surface (Suck up)	:	For single sided welded joints, concavity of the root surface shall not reduce the total thickness of joint, including reinforcement, to less than the thickness of the thinner of the components being joined.
f) Weld ripples irregularities	:	2.5 mm or less.

g) Lack of uniformity in bead width	:	2.5 mm or less.
h) Lack of uniformity of leg length	:	2.5 mm or less.
i) Unevenness of bead	:	2.0 mm or less.
j) Weld undercutting	:	0.8 mm or 1/4 thickness of thinner components joined by butt weld, whichever is less. (shall be smooth finished)
k) Overlap	:	1.5 mm or less
I) Bead deflection	:	2.5 mm or less

m) External weld reinforcement and internal weld protrusion (when backing rings are not used) shall be fused with and shall merge smoothly into the component surfaces. The height of the lesser projection of external weld reinforcement or internal weld protrusion from the adjacent base material surface shall not exceed the following limits:

Wall thickness of thinner component joined by butt weld (mm)	Weld reinforcement or internal weld protrusion (mm) max
6.4 and under	1.6
Over 6.4 -12.7	3.2
Over 12.7 -25.4	4.0
Over 25.4	4.8

n) Throat thickness of fillet welds:

Nominal thickness of the thinner component x 0.7 or more.

o) Flattening

Flattening of a bend, as measured by difference between the nominal outside diameter and minimum or maximum diameter at any cross section shall not exceed 5 % of the nominal outside diameter of pipe.

p) Reduction of wall thickness

Reduction of wall thickness of a bend, as measured by difference between the nominal thickness and minimum thickness shall not exceed 10 % of the nominal wall thickness of pipe.

2.2 Welds having any of imperfections which exceed the limitations specified in various clauses of 2.1 shall be repaired by welding, grinding or overlaying etc. Number of times of repair welding for the same weld, however shall conform to applicable notes to Table 1- Note 6(b) b.5.

3.0 NON-DESTRUCTIVE EXAMINATION

3.1 The type and extent of weld examination shall be in accordance with Table-1. All visual and supplementary methods of girth weld examination shall be in accordance with ASME B31.3 & the requirements of this standard specification.

3.2 Welds between dissimilar materials shall be examined by method & to the extent required for the material having the more stringent examination

4.0 TABLE-1 (WITH APPLICABLE NOTES)

TABLE I: CLASS, TYPE & EXTENT OF WELD EXAMINATION
INSPECTION CLASS: II

Inspection. Class	Service	Mat.	P.No	Tem. Deg. C	Press. Class B16.5/ B16.34	Appli-cable Piping Class	Type Of Examination	Type Of Weld Examined				
								Girth Butt Weld (%)	Soc-ket Weld (%)	Att-ach Weld (%)	FabBranch Weld (%)	Fab Welds Of Mitres / Red. (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
	a) ALL SERVICES COVERED UNDER INSPEC-TION CLASS-1, BUT, EXCEEDING CATEGORY 'D' PR/TEMP LIMITAT-IONS. b) ALL SERVIC-ES OTHER THAN COVER-ED UNDER	CS	1	-29 To 427	150# To 600#	P1C, P3C, P6C	a) VISUAL b) RADIOGRAPHY (NOTE 5,6) c) MP / LP (NOTE 4,6,9,10) d) HARD-NESS	a) 100 b) 5 c) -- d) Note 7	a) 100 b) --- c) 5 d) Note 7	a) 100 b) --- c) --- d) Note 7	a) 100 b) --- c) 5 d) Note 7	a) 100 b) 20 c) 20 d) Note 7

	INSPECTION CLASS-1, BUT NON TOXIC, NOT SUBJE-CTED TO SEVERE CYCLIC CONDITIONS. c) TOXIC, NON LETHAL & FLAMMABLE d) FLAMMABLE /NON FLAMMABLE & TOXIC / NON TOXIC; NOT SUBJECT TO SEVERE CYCLIC CONDIT-IONS							———		———		

REMARKS FOR ABOVE TABLE:

1 MITRES & FABRICATED REDUCERS ARE PERMITTED ONLY IF SPECIFIED IN PMS

Applicable Notes to Table-1

1. Branch welds shall consist of the welds between the pipe & reinforcing element (if any), nozzles & reinforcing element and the pipe & nozzle under the reinforcing element. Reinforcing element to be interpreted as pads, saddles, weldolets, sockolets etc.

2. Seal welds of threaded joints shall be given the same examination as socket welds.

3. Unless specifically stated, all materials shall be for "Non-IBR" service.

4. Magnetic Particle & the Liquid Penetrant method of examination shall be in accordance with Section V of the ASME Boiler and Pressure Vessel Code, Article VII and VI respectively. The entire area of the accessible finished weld surface shall be examined. Selected root runs, subject to a maximum of 10%, before finished weld, may also be examined, at the discretion of the engineer-in-charge.

   a) Wherever MP / LP testing is specified, either MP or LP test may be used. But wherever only MP test is specified, LP method of examination may be used only if MP examination is impracticable in the field as concurred by Owner site-in charge.

   b) "Random 5%" of Liquid Penetrant / Magnetic Particle test shall mean testing, by applicable test, one weld for each twenty welds or less made by the same welding procedure. "Random 10%" shall mean testing, by applicable test, one weld for each ten welds or less made by the same welding procedure. Similarly "Random 20%" shall mean testing, by applicable test, one weld for each five welds or less made by the same welding procedure. The welds to be examined in each designated lot shall include the work product of each welder or welding operator whose welds are part of the lot.

   c) When Liquid Penetrant examination is specified, the surface shall be free of peened discontinuities.

   d) Inspection shall be performed in the welds excluding those for which radiography has been done.

   e) Girth weld, branch weld, attachment weld & socket weld of 3-1/2% Ni steel shall be Liquid Penetrant tested only when welded with austenitic material where MP test has been specified.

5. Radiography:

   a) "Random 5%, 10% or 20% radiography" shall mean examining not less than one from each 20 welds or less in case of "Random 5% radiography", not less than one from each 10 welds or less in case of "Random 10% radiography", not less than one from each five welds or less in case of "Random 20% radiography" made by the same welding procedure. The welds to be examined in each designated lot shall include the work product of each welder or welding operator whose welds are part of the lot. Irrespective of percentage, no. of welds to be radiographed shall be minimum 1. However first two welds made by each welder shall also be radiographed in case of "Random radiography". Welds selected for examination shall not include flange welds and shall be radiographed for their entire length. However, where it is impossible or impracticable to examine the entire weld length of field welds for either random or 100% radiography, and if the same impossibility is agreeable to Owner site-in- charge, then a single 120 deg. exposure of the weld length may be given a Magnetic Particle test or Liquid Penetrant test. However in such cases for ferro-magnetic materials, only MP test shall be acceptable for classes higher than 600#.

   b) In-process examination shall not be substituted for any required radiographic examination.

   c) Number of radiographs per one circumferential weld shall be as per ASME Sec.V Articles 2 and 22.

6. When radiography or other non-destructive inspection is specified, acceptance criteria for repairs or defects shall be as follows:

   a) In case of 100% examination, any unacceptable weld shall be repaired and re-inspected.

b) If required random examination reveals a defect requiring repair, then:

b.1 Two additional examinations of same type shall be made of the same kind of item (if welded joint, then by the same welding procedure and same welder or welding operator).

b.2 If the group of items examined as required by b.1 above is acceptable, the items requiring repair shall be repaired or replaced and re-examined as required and all items represented by this additional examination shall be accepted.

b.3 If any of the items examined as required by b.1 above reveals a defect requiring repair, two further comparable items shall be examined for each defective item found by examination.

b.4 If all the items examined as required by b.3 are acceptable, the items requiring repair shall be repaired or replaced and re-examined as required, and all items represented by this further examination shall be accepted.

b.5 Number of times repair welding could be done for the same weld before acceptance shall be as follows:

Material	No. of times repair welding is allowed
C.S. up to 300 #	3 or less
C.S. above 300 #	2 or less
Killed steel	2 or less
Low alloy steel	2 or less
Austenitic S.S.	2 or less
3.5 Ni steel	2 or less
Al & Al base alloy	2 or less
Cu & Cu base alloy	2 or less
Others	2 or less

b.6 Welds not found acceptable for allowed number of times of repair as per b.5 above shall be replaced and re-examined.

b.7 If any of the items examined as required by b.4 above reveals a defect requiring repair, all items represented by these examinations shall be either:

- repaired or replaced and re-examined as required.
- fully examined and repaired or replaced as necessary, and re-examined as necessary.

7. Hardness Test:

a) Hardness test shall be in accordance with ASTM specification E10. hardness tests of the heat affected zone shall be made at a point as near as practicable to the edge of the weld. One test per weld shall be performed.

b) Hardness test where specifically called out in Table-1 of this specification or in PMS, shall be carried out irrespective of thickness and to the extent (%age) is mentioned therein.

c) All welds which are given heat treatment shall be hardness tested. Hardness test shall be performed after final heat treatment.

d) A minimum of 10% of welds, hot bends, and hot formed components in each furnace heat treated batch and 100% of those which are locally heat treated shall be hardness tested.

e) Hardness test requirement not covered in this specification shall be as per Engineering Specifications.

f) The hardness limit applies to the weld and heat affected zone. Following hardness values shall be maintained:

Base Metal Group	Maximum Hardness (BHN/RC)
CS	238 BHN / RC22
CS (NACE), Caustic, Amine, H2	200 BHN
Cr Up to 2%	225 BHN
Cr 2.25%40%	241 BHN
18/8 SS (NACE)	RC22

g) In case hardness values are mentioned in both Welding Specification Charts for Piping Classes & table given in Note-7(f), the lower of the two values shall be applicable.

8. For fabricated fittings LP test shall be done on the final pass of welding only, in addition to visual examination.

9. For mitres and fabricated reducers, LP / MP test shall be done on root pass in addition to radiography applicable to circumferential joint of respective piping class.

10. For branch connections, LP/ MP test shall be done on root pass and final pass.

11. 10% of the butt weld joints shall be radiographed, however, 50% of these butt weld joints shall be field weld joints.

12. For lined specs, testing (MP /LP / Radiography etc.) shall be performed before lining.

TECHNICAL NOTES
FOR
FLANGES, SPECTACLE BLINDS AND DRIP RINGS

P-SPC-406

0	16.02.2022	ISSUED AS STANDARD SPECIFICATION	PNS	SM	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AARH	:	Arithmetic Average Roughness Height
ANSI	:	American National Standards Institute
API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing & Materials
AWWA	:	American Water Works Association
BHN	:	Brinell Hardness Number
HIC	:	Hydrogen Induced Cracking
IGC	:	Inter Granular Corrosion
IS	:	Indian Standard
MR	:	Material Requisition
MSS	:	Manufacturer's Standardization Society
NACE MR	:	National Association of Corrosion Engineers: Material Requirement
PMI	:	Positive Material Identification

CONTENTS

1.0 GENERAL

1.1 All items, their dimensions, tolerances, chemical composition, physical properties, heat treatment and testing etc. shall conform to the latest codes and standards specified in the requisition. Supplier shall strictly comply with MR / PR and no deviations shall be permitted. Post Order Concession / Deviation from Bidders is not applicable.

1.2 Testing

1.2.1 Test reports shall be supplied for all mandatory tests as per the relevant material specifications. Test reports shall also be furnished for any supplementary tests as specified in the requisition & Clauses 1.11, 1.12 & 1.15.

1.2.2 Material test certificates (physical property, chemical composition & heat treatment report) shall also be furnished for the flanges supplied.

1.2.3 Refer to specification no. P-ITP-008 for Inspection and Test plans for flanges, spectacle blinds & drip rings.

1.3 Ends of weld neck flanges shall be bevelled to suit the schedule / thickness of matching pipe, as specified in the requisition.

1.4 Bevel end details for welding neck flanges shall be as per ASME B16.25. Contour of bevel end shall be as follows:

Material	Wall Thickness	Weld Contour
Carbon Steel (Except Low Temp. Carbon Steel)	Upto 22 mm	Figure 2 Type A
	>22mm	Figure 3 Type A
Alloy Steel, Stainless Steel & Low Temp. Carbon Steel	Upto 10 mm	Figure 4
	> 10 mm & Upto 25 mm	Figure 5 Type A
	>25mm	Figure 6 Type A

1.5 Bore of socket weld flanges & reducing blind flanges shall suit the outside diameter and schedule / thickness of matching pipe.

1.6 Bore of slip-on flanges shall suit the outside diameter of matching pipe.

1.7 Flange face finish shall be normally specified in the requisition as serrated finish, 125 AARH etc. The interpretation for range of face finish shall be as follows:

Stock Finish	:	1000 μ in AARH max
Serrated Finish/125 AARH	:	Serrations with 125 to 250μin AARH
63 AARH	:	32 TO 63 μ in AARH

1.8 Galvanized flanges shall be coated with zinc by hot dip process conforming to IS 4736 / ASTM A153.

1.9 Ends of screwed flanges unless otherwise specified shall have taper threads as per ASME / ANSI B1.20.1.

1.10 For ring joint flanges, blinds and spacers the hardness shall be as follows:

Flange Material	Min. Hardness of Groove (BHN)
Carbon Steel	140
1% Cr to 5%, 9% Cr	150
Type 304,316,321,347	160
Type 304L, 316L	150

1.11 For ring joint flanges, blinds and spacers, the hardness shall be recorded in the test report.

1.12 NACE / HIC Requirements

1.12.1 Flanges, blinds, drip rings under "NACE" category and those designated as "HIC" shall meet the requirements given in NACE MR-0103 unless otherwise specified.

1.13 All austenitic stainless steel flanges shall be supplied in solution annealed condition.

1.14 I.G.C. Test for Stainless Steels:

1.14.1 For all austenitic stainless steel flanges, blinds, drip rings & Fig.8 flanges intergranular corrosion test shall have to be conducted as per following:

ASTM A262 Practice `B' with acceptance criteria of "60 mils / year (max.)".

OR

ASTM A262 Practice E: The bent specimen shall be examined under 20X magnification. The acceptance criteria is that there will be no crack or fissure in the bent specimen. The bent specimen shall also be subjected to metallographic examination at 250X magnification to ensure no crack or fissure. The photograph of the bent specimen along with comments shall be submitted for review.

1.14.2 When specifically asked for in requisition for high temperature application of some grades of austenitic stainless steel (like SS309, 310, 316, 316H etc.) ASTM A262 Practice 'C' with acceptance criteria of "15 mils / year" shall have to be conducted.

1.14.3 For the IGC test as described in 1.14.1 & 1.14.2 two sets of samples shall be drawn from each solution treatment lot; one set corresponding to highest carbon content and the other corresponding to the highest rating / thickness.

1.15 All types of 321 or 347 stainless steel flanges shall be in a stabilized heat-treated condition. Stabilizing heat treatment shall be carried out subsequent to the normal solution annealing. Soaking temperature and holding time for stabilizing heat treatment shall be 900 C and 4 hours respectively.

1.16 For dual grades of SS where specified, chemical composition and mechanical properties of both grades specified shall be ensured.

1.17 AWWA C207 flanges shall be ring type.

1.18 Where ever two sizes have been specified in the MR for flanges, it shall be considered a reducing flange.

1.19 All 1Cr - $\frac{1}{2}$Mo and 1 $\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo flanges shall be normalised and tempered.

1.20 Ring Joint Fig - 8 Flanges, Spacers & Blinds shall be female type only.

1.21 The handle for spacers & blinds for classes 900# & above shall be designed by the vendor. The handle may be integral or attached to the line blank / spacer by welding. In case of attachment by welding heat treatment & welding shall be in accordance with B31.3.

1.22 For Hydrogen service following special requirements shall also be met:

a. All carbon steel flanges having wall thickness 9.53 mm and above shall be normalised. The normalising heat treatment shall be a separate heat treatment operation and not a part of the hot forming operation.

b. All alloy steel (Cr-Mo) flanges shall be normalised and tempered. The normalising and tempering shall be a separate heat treatment operation and not a part of the hot forming operation.

c. For all carbon steels and alloy steels with wall thickness over 20 mm, Charpy-V Notch impact testing shall be carried out in accordance with paragraph UG-84 of ASME Section VIII, Div-1 per heat of material and per heat treating batch. Impact test specimen shall be in accordance with ASTM A370. Impact energies at -29 C shall average greater than 27J (20 ft-lb) per set of 3 specimens, with a minimum of 20J (15ft-lb).

2.0 ACCEPTABLE DEVIATIONS

2.1 Blind Flanges and Spacers & Blinds if specified as plate materials are acceptable in forging materials also in the corresponding material grades.

2.2 Flanges/Spectacle Blinds/Drip rings of Grades SS317 of corresponding material are acceptable in place of Grades SS316 or SS316 (2.5Mo min.).

2.3 Flanges/Spectacle Blinds/Drip rings of Grades SS317L of corresponding material are acceptable in place of Grades SS316L or SS316L (2.5Mo min.).

3.0 MARKING AND DESPATCH

3.1 All items shall be legibly and conspicuously stamped in accordance with the requirements of applicable ASME, API and MSS Standards. In addition, purchase order number & special conditions like "IBR", "CRYO", "NACE" "H2" etc. shall also be stamped.

3.2 All items coming under the purview of "IBR", "CRYO", "NACE" & "H2" (hydrogen) shall be painted with one stripe of colour red, light purple brown, canary yellow & white respectively for easy identification. Width of stripe shall be 25 mm and it shall be painted longitudinally across the complete thickness of flange other than hub.

3.3 Paint or ink for marking shall not contain any harmful metal or metal salts such as zinc, lead or copper which cause corrosive attack on heating.

3.4 All items shall be dry, clean and free from moisture, dirt and loose foreign materials of any kind.

3.5 All items shall be protected from rust, corrosion and mechanical damage during transportation, shipment and storage.

3.6 Rust preventive on machined surfaces to be welded shall be easily removable with a petroleum solvent and the same shall not be harmful to welding.

3.7 Each end of flange shall be protected with the following materials:

Flange face	:	Wood, metal or plastic cover
Bevelled end	:	Wood, metal or plastic cover
Threaded end	:	Plastic plug
Socket welding end	:	Plastic cover or plug

3.8 Each size of flanges, blinds, etc. shall be supplied in separate packaging's marked with the purchase order number, item code number, material specification, size and rating.

TECHNICAL NOTES
FOR
BUTT WELDED, SOCKET WELDED AND SCREWED FITTINGS

P-SPC-407

0	16.02.2022	ISSUED AS STANDARD SPECIFICATION	PNS	SM	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AARH	:	Arithmetic Average Roughness Height
ANSI	:	American National Standards Institute
API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing & Materials
BHN	:	Brinell Hardness Number
BHN	:	Brinell Hardness Number
CS	:	Carbon Steel
DP	:	Dye Penetrant
HAZ	:	Heat Affected Zone
HIC	:	Hydrogen Induced Cracking
IGC	:	Inter Granular Corrosion
IS	:	Indian Standard
LT	:	Low Temperature
MP	:	Magnetic Particle
MR	:	Material Requisition
MSS	:	Manufacturer's Standardisation Society
NACE	:	National Association of Corrosion Engineers
MR	:	Material Requirement
NB	:	Nominal Bore
PMI	:	Positive Material Identification
PO	:	Purchase Order
PR	:	Purchase Requisition
SMYS	:	Specified Minimum Yield Strength
SS	:	Stainless Steel

CONTENTS

1.0 GENERAL

1.1 Chemical composition, physical properties, tests, dimensions and tolerances, heat treatment and marking shall conform to the applicable latest codes / standards / specifications as specified in the material requisition (MR). Supplier shall strictly comply with MR / PR and no deviations shall be permitted. Post Order Concession / Deviation is not applicable.

1.2 Testing

1.2.1 Test reports shall be supplied for all mandatory tests as per the material specifications. Test reports shall also be furnished for any supplementary tests as specified in the MR & Clauses 1.7, 1.8, 1.9, 1.10 & 1.11. Material test certificates (physical properties, chemical composition & heat treatment report) shall also be furnished for fittings supplied.

1.2.2 Refer to specification no.P-ITP-011 for Inspection and Test plan for forged, seamless and welded fittings.

1.3 All fittings shall be seamless in construction unless otherwise specified. If fittings are specified as welded, the same shall conform to clause 1.7.

1.4 Outside diameters and wall thickness (unless otherwise mentioned) of butt welded fittings shall be in accordance with ASME B36.10 and ASME B36.19 as applicable.

1.5 For reducing butt weld fittings having different wall thicknesses at each end, the greater wall thickness of the fitting shall be employed and inside bore at each end shall be matched with the specified inside diameter.

1.6 Bevelled ends for all fittings shall conform to ASME B16.25. Contour of bevel shall be as follows:

Material	Wall Thickness	Weld Contour
Carbon Steel (Except Low Temp. Carbon Steel)	Up to 22 mm	Figure 2 Type A
	>22mm	Figure 3 Type A
Alloy Steel, Stainless Steel & Low Temp. Carbon Steel	Up to 10 mm	Figure 4
	> 10 mm & up to 25 mm	Figure 5 Type A
	>25mm	Figure 6 Type A

1.7 Welded Fittings

1.7.1 All welded fittings shall be double welded. Inside weld projection shall not exceed 1.6 mm. Welds shall be ground smooth at least 25 mm from the ends.

1.7.2 For fittings made out of welded pipe, the welded pipe shall be double welded type & shall be manufactured with the addition of filler metal.

1.7.3 Welded tees / Lateral Tees shall not be of fabricated (stub-in / stub-on) type unless otherwise specified in the MR.

1.7.4 All welded fittings shall be normalized & 100% radiographed by X-ray on all welds made by fitting manufacturers & also on the parent materials.

1.7.5 Welded pipes employed for manufacture of fittings shall be made by automatic welding only.

1.7.6 Specified heat treatment for carbon steel & alloy steel fittings shall be carried out again after weld repairs.

1.7.7 Irrespective of the material code requirement, all welded fittings indicated in the MR as "Cryo"& "LT" shall meet impact test requirements of ASME B31.3. The impact test temperature shall be -196°C & -45°C for stainless steel & carbon steel respectively unless specifically mentioned otherwise in the MR.

1.8 Stainless Steel Fittings

1.8.1 All stainless steel fittings shall be supplied in solution heat treated condition.

1.8.2 Solution annealing for stainless steel fittings shall be carried out again after weld repairs.

1.8.3 For all stainless steel fittings Inter Granular Corrosion (IGC) test shall have to be conducted as per the following:

ASTM A262 Practice "B" with acceptance criteria of "60 mils / year (max.)".

Or

ASTM A262 Practice E: The bent specimen shall be examined under 20X magnification. The acceptance criteria is that there will be no crack or fissure in the bent specimen. The bent specimen shall also be subjected to metallographic examination at 250X magnification to ensure no crack or fissure.

1.8.4 When specifically asked for in MR for high temperature application of some grades of austenitic stainless steel (eg. SS309, 310, 316, 316H etc.) ASTM A 262 Practice "C" with acceptance criteria of "15 mils / year" shall have to be conducted.

1.8.5 For the IGC test as described in Clauses 1.8.3 & 1.8.4, two sets of samples shall be drawn from each solution treatment lot, one set corresponding to the highest carbon content and other set to the highest fitting thickness. When testing is conducted as per ASTM A 262 Practice "E", the photograph of the bent specimen along with comments shall be submitted for review.

1.8.6 For dual grades of SS where specified, chemical composition and mechanical properties of both grades specified shall be ensured.

1.9 NACE / HIC Requirements

1.9.1 Fittings under "NACE" category or those designated as "HIC" shall meet the requirements of NACE MR-0103 unless otherwise specified.

1.10 Thickness / schedule lower or higher than specified for the finished product shall not be accepted.

1.11 The gasket contact surfaces of stub ends shall be flat with face finish specified in the requisition. Interpretation on the specified face finish is as follows:

125 AARH : Serrations with 125 to 250 µ in AARH

1.12 Seamless stub ends shall not have any welds on the body. Stub ends shall be long pattern type.

1.13 Galvanized fittings shall be coated with zinc by hot dip process conforming to IS 4736 / ASTM A153.

1.14 Threaded ends shall have NPT taper threads in accordance with ASME / ANSI B1.20.1 up to 1.5" NB & IS 554 from 2" to 6" NB.

1.15 Unless and otherwise specified in the MR, all socket welded and screwed fittings shall be in accordance with ASME B16.11 to the extent covered in the specification except for unions which shall be in accordance with MSS-SP-83.

1.16 Special fittings like weldolet, sockolet, sweepolet etc., the dimensions of which are not covered in ASME, MSS-SP & PLECO Standards, shall be as per manufacturer's std. Contours of these fittings shall meet the requirements of ASME B31.3. Manufacturer shall submit drawings / catalogues of these items for records after acceptance of offer.

1.17 Length of all long half couplings shall be 100 mm unless otherwise specified in the MR.

1.18 For reducers to manufacturers' standard, length of reducer shall not be less than 0.7D where D is the outside diameter of the larger end.

1.19 All seamless pipes employed for manufacturing of fittings shall be required to have undergone hydrostatic test to ASTM A 530. Welded pipes employed for manufacture of fittings shall be tested as given below:

Welded Pipe Employed For Manufacture Of Welded Fittings.	Test Criteria
ASTM A671 Gr. C65,70 (Cl.32) ASTM A672 Gr. C60,65,70 (Cl.12, 22) ASTM A671 Gr. CF60,65,70,66 (Cl.32) ASTM A691 Gr. ½Cr, 1 Cr, 1¼Cr, 2¼Cr, 5Cr, 9Cr (Cl.42), 91 (Cl.42)	P = 2ST / D S = 90% of SMYS. T =Norn. Wall Thickness D = 0.D. of Pipe.
API5L ASTMA358 TP 304, 304L, 304H, 318, 318L, 318H, 321,347 (Cl.1, 3, 4)	P = 2ST / D S = 85% of SMYS. T =Norn. Wall Thickness D = 0.D. of Pipe.
ASTMB725	ASTMB725
ASTM B517	ASTMB517
ASTM B514	ASTM B514

1.20 The bevel ends of all butt weld fittings shall undergo 100% MP / DP test.

1.21 Abbreviations for ends of swages and nipples shall be as follows:

PBE	:	Plain Both Ends
TBE	:	Threaded Both Ends
TOE	:	Threaded One End
TSE	:	Threaded Small End
TLE	:	Threaded Large End

1.22 All types of SS321 or SS347 fittings shall be in stabilized heat treated condition. Stabilizing heat treatment shall be carried out subsequent to normal solution annealing. Soaking temperature and holding time for stabilizing heat treatment shall be 900°C and 4 hours respectively.

1.23 For Hydrogen service fittings following special requirements shall also be met:

a. All carbon steel fittings having wall thickness 9.53 mm (0.375") and above shall be normalised. Cold drawn fittings shall be normalised after the final cold draw pass for all thicknesses. In addition, fittings made from forgings shall have Carbon - 0.35 % max. and Silicon - 0.35 % max. The normalising heat treatment shall be a separate heating operation and not a part of the hot forming operation.

b. All alloy steel (Cr-Mo) fittings shall be normalised and tempered. The normalising and tempering shall be a separate heating operation and not a part of the hot forming operation. The maximum room temperature tensile strength shall be 100,000 psi.

c. For carbon steel fittings, hardness of weld and HAZ shall be 200 BHN (max.). For alloy steel fittings, hardness of weld and HAZ shall be 225 BHN (max.).

d. For all Carbon steel and Alloy steel fittings with wall thickness over 20 mm, Charpy-V Notch impact testing shall be carried out in accordance with paragraph UG-84 of ASME Section VIII, Div-1 for weld metal and base metal from the thickest item per heat of material and per heat treating batch. Impact test specimen shall be in complete heat treated condition and accordance with ASTM A370. Impact energies at -29°Celsius shall average greater than 27J (20 ft-lb) per set of three specimens, with a minimum of 20J (15 ft-lb).

1.24 For all welded alloy steel fittings with mandatory requirements of heat treatment and radiography, radiography shall be performed after heat treatment.

1.25 All 1Cr-0.5Mo & 1.25Cr-0.5Mo fittings shall be normalized and tempered. All 2.25Cr-1Mo, 5Cr-0.5Mo, 9Cr- 1 Mo & 9Cr-1Mo-V welded fittings shall be normalized and tempered.

1.26 Fitting material as per ASTM A234 Gr.WP5 / WP9 / WP91, wherever specified, shall be as per 'C1.1', unless otherwise specified.

1.27 Materials designated as structural steel grades like IS 2062, SA 36 etc. or similar specification are not permitted for manufacture of fittings.

2.0 ACCEPTABLE DEVIATIONS

2.1 Seamless fittings are acceptable in place of welded fittings, however, welded fittings are not acceptable in place of seamless fittings. Forged fittings are acceptable in place of wrought fittings. However, wrought seamless fittings are acceptable in place of forgings only in case of swages.

2.2 Fittings of Grades SS317 of corresponding material are acceptable in place of Grades SS316 or SS316 (2.5Mo min.).

2.3 Fittings of Grades SS317L of corresponding material are acceptable in place of Grades SS316L or SS316L (2.5Mo min.).

3.0 MARKING AND DESPATCH

3.1 Each fitting shall be legibly and conspicuously stamped in accordance with the requirements of applicable standards along with special condition like "Cryo", "NACE" and "H2" etc.

3.2 Steel die marking with round bottom punch may be permitted on body of butt weld CS & lower alloy steel fittings, but for SS & higher alloy steel fittings, the same should be marked by electro-etching only.

3.3 Paint or ink for marking shall not contain any harmful metals or metal salts such as Zinc, Lead or Copper which causes corrosive attack on heating.

3.4 Fittings shall be dry, clean and free of moisture, dirt and loose foreign materials of any kind.

3.5 Fittings shall be protected from rust, corrosion and mechanical damage during transportation, shipment and storage.

3.6 Rust preventive used on machined surfaces to be welded shall be easily removable with a petroleum solvent and the same shall not be harmful to welding.

3.7 Fittings coming under the purview of "CRYO", "NACE" & "H2"(hydrogen) shall be painted with one circumferential stripe of colour red, light purple brown, canary yellow & white respectively for easy identification. Width of stripe shall be 12mm for sizes less than 3" and 25mm for sizes 3" and above. Stripe shall be located centrally for elbows, diagonally for caps, at the larger end for reducing fittings, longitudinally for couplings and at one end near to the bevel /socket /screwed end for other fittings.

3.8 Each end of fitting shall be protected with a wood, metal or plastic cover.

3.9 Each size of fitting shall be supplied in separate packaging marked with the purchase order number, item code number, material specification, size and schedule / thickness / rating. For small quantities, fittings of different sizes may be packed in separate packing size-wise and these packing may be packed in a bigger package / container clearly identifying the contents.

4.0 REFERENCES

P-ITP-011 : Inspection & test plan for forged, seamless and welded fittings

TECHNICAL NOTES FOR GASKETS

P-SPC-408

0	21.02.2022	ISSUED AS STANDARD SPECIFICATION	PNS	SM	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AARH	:	Arithmetic Average Roughness Height
BHN	:	Brinell Hardness Number
CS	:	Carbon Steel
DP	:	Dye Penetrant
MR	:	Material Requisition
PMI	:	Positive Material Identification
RJT	:	Ring Type Joint

CONTENTS

1.0 GENERAL

1.1 All gaskets shall confirm to the codes / standards and specifications given in the requisition. Supplier shall strictly comply with MR / PR stipulations and no deviations shall be permitted.

1.2 Process of manufacture, dimensions and tolerances not specified in requisition shall be in accordance with the requirements of the manufacturer's standards.

1.3 Testing

1.3.1 Test reports shall be supplied for all mandatory tests for gaskets as per the standards specified in the requisition.

1.3.2 Chemical composition and hardness of RTJ gaskets shall also be furnished in the form of test reports on samples.

1.3.3 For Spiral wound material following shall be furnished:

a. Manufacturer's test certificate for filler material and spiral material as per the relevant material specifications.

b. Manufacturer's test certificate for raw materials and tests for compressibility / sealability & recovery as per the relevant material specifications.

1.3.4 PMI shall be performed as per the scope.

1.3.5 Refer ITP for 'Inspection & Test Plan for Gaskets'.

1.4 Full face gaskets shall have bolt holes punched out.

1.5 Filler material for spiral wound gaskets shall not have any colour or dye.

1.6 All spiral wound gaskets shall be supplied with Outer ring. Material of the outer ring shall be CS unless otherwise specified in the MR.

1.7 Inner rings shall be provided for all Spiral Wound Gaskets. For spiral wound gaskets, material of Inner Compression ring shall be same as Spiral Strip material.

1.8 Hardness of metallic RTJ gaskets shall not exceed the values specified below unless otherwise specified in MR:

Ring Gasket Material	Maximum Hardness (BHN)
Soft Iron	90
Carbon steel	120
5 Cr. 1/2 Mo	130
Type 304, 316, 321, 347	140
Type 304L, 316L	135
Inconel UNS N06625	200
Incoloy UNS N08825	190
Duplex SS UNS S32205, S31803	230

1.9 Face finish of metallic RTJ gaskets shall be 32 to 63 AARH.

1.10 Gaskets of different types and sizes shall be placed in separate shipping containers and each container clearly marked with the size, rating, material specification and item code.

1.11 All items shall be inspected and approved by PLECO Inspector or any other agency authorized by PLECO.

1.12 Any additional requirements specified in the requisition, shall be fully complied with.

1.13 Non-metallic ring gaskets as per ASME B16.21 shall match flanges to ASME B16.5 upto 24" and to ASME B16.47B above 24" unless specified otherwise.

1.14 Spiral wound gasket as per ASME B16.20 shall match flanges to ASME B16.5 upto 24" and to ASME B16.47B above 24" unless specifically mentioned otherwise.

1.15 The following abbreviations have been used in the Material Requisition for Spiral Wound Gaskets:

(I)	:	Inner Ring
(O)	:	Outer Ring
GRAFIL	:	Grafoil Filler

2.0 REFERENCES

Inspection & Test Plan for Gaskets

TECHNICAL NOTES
FOR
BOLTS AND NUTS

P-SPC-409

0	21.02.2022	ISSUED AS STANDARD SPECIFICATION	PNS	SM	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

ASME	:	The American Society of Mechanical Engineers
ASTM	:	The American Society for Testing and Materials
MR	:	Material Requisition
PMI	:	Positive Material Identification
SS	:	Stainless Steel

CONTENTS

1.0 GENERAL

1.1 The process of manufacture, heat treatment, chemical & mechanical requirements and marking for all stud bolts, m/c bolts, jack screws & nuts shall be in accordance with the codes/standards and specifications given in the requisition. The applicable identification symbol in accordance with the material specification shall be stamped on each bolt and nut. Supplier shall strictly comply with MR/PR stipulations and no deviations shall be permitted.

1.2 Testing

1.2.1 Test reports shall be supplied for all mandatory tests as per the relevant material specifications.

1.2.2 Material test certificate shall also be furnished. (Heat Analysis, Product Analysis and Mechanical Requirement)

1.2.3 PMI shall be performed as per the scope.

1.2.4 Stress Rupture Test as detailed in ASTM A453 shall be carried out for all ASTM A453 bolting material irrespective of the temperature.

1.2.5 Refer Inspection & Test Plan for Bolting Material.

1.3 All bolting shall be as per ASME B 18.2.1 for studs, M/c bolts and jackscrews and ASME B18.2.2 for nuts.

1.4 Threads shall be unified (UNC for up to 1" dia and 8UN for > 1" dia) as per ASME B1.1 with class 2A fit for studs, M/c bolts and jackscrews and class 2B fit for nuts.

1.5 Stud bolts shall be threaded full length with two heavy hexagonal nuts unless otherwise specified. Length tolerance shall be in accordance with the requirement of Table D2 of Annexure-D of ASME B 16.5.

1.6 The nuts shall be double chamfered, semi-finished, heavy hexagonal type and shall be made by the hot forged process and stamped as per respective material specification.

1.7 Heads of jackscrews and m/c bolts shall be heavy hexagonal type. Jackscrew end shall be rounded.

1.8 Each size of studs & m/c bolts with nuts and jackscrews shall be supplied in separate containers marked with size and material specifications. `CRYO' shall be marked additionally in case `CRYO' is specified in the requisition.

1.9 All items shall be inspected and approved (stage-wise) by PLECO inspector or any other agency authorized by PLECO.

1.10 The heat treatment for stud bolts & nuts shall be as per code unless mentioned otherwise.

1.11 All austenitic stainless steel bolts, nuts, screws shall be supplied in solution annealed condition unless specified otherwise in the material specification.

1.12 Any additional requirements specified in the requisition shall be fully complied with.

1.13 Stud bolts, nuts & jackscrews shall be impact tested wherever specified in the material specification and also where the material specification is indicated as "CRYO". For S.S. nuts and bolts minimum impact energy absorption shall be 27 Joules and test temperature shall be -196°C unless mentioned otherwise. For other materials impact energy and test shall be as per respective code.

1.14 Bolts/nuts of material of construction B7M / 2HM shall be 100% Hardness tested as per supplementary requirement S3 of ASTM A193.

1.15 When specified as galvanized, the studs, M/C bolts and nuts shall be 'hot dip zinc coated' in accordance with requirements of 'class C' of `ASTM A 153'. As an alternative, electro-galvanizing as per IS 1573, 'Service Grade Number 2' is also acceptable.

1.16 All Stud Bolts of Bolt diameter size 1" and above shall be provided with three nuts irrespective of whatever has been specified elsewhere in the MR.

1.17 Bolting shall be protected by non-corrosive oil or grease before dispatch to prevent rusting.

1.18 For stud bolt diameters not covered in ASTM A320, mechanical properties shall match the values specified for the matching grades and stud bolt diameters in ASTM A193.

1.19 In cases where the lengths of Stud / Machine bolts specified in the MR are not multiples of 0.25", the length supplied shall be equal to the specified length rounded up to the next higher 0.25".

1.20 All Specialties mentioned in item description like "LT", "H2", etc. other than "CRYO" & "NACE" shall be ignored.

2.0 ACCEPTABLE DEVIATIONS

2.1 'Nuts' to ASTM A194 Gr.7 are acceptable in place of ASTM A194 Gr.4.

2.2 Stud Bolts to ASTM A453 Gr.660 CLB are acceptable in lieu of ASTM A453 Gr.660 CI.A and vice versa.

3.0 REFERENCES

Inspection & 'rest Plan for Bolting Material

STANDARD SPECIFICATION FOR PAINTING

P-SPC-410

0	04.01.22	ISSUED AS STANDARD SPECIFICATION	RK	MD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

CONTENTS

1.0 GENERAL

1.1 This technical specification shall be applicable for the work covered by the contract, and without prejudice to the provisions of various codes of practice, standard specifications etc. It is understood that contractor shall carry out the work in all respects with the best quality of materials and workmanship and in accordance with the best engineering practice and instructions of Engineer-In-Charge.

Wherever it is stated in the specification that a specific material is to be supplied or a specific work is to be done, it shall be deemed that the same shall be supplied or carried out by the contractor. Any deviation from this standard without written deviation permit from appropriate authority will result in rejection of job.

1.2 SCOPE

1.2.1 Scope of work covered in the specification shall include, without being limited to the following.

1.2.2 This specification defines the requirements for surface preparation, selection and application of primers and paints on external surfaces of equipment, vessels, machinery, piping, ducts, steel structures, external & internal protection of storage tanks for all services, MS Chimney without Refractory lining and Flare lines etc. The items listed in the heading of tables of paint systems is indicative only, however, the contractor is fully responsible for carrying out all the necessary painting, coating and lining on external and internal surfaces as per the tender requirement.

1.2.3 Extent of Work

1.2.3.1 The following surfaces and materials shall require shop, pre-erection and field painting:

a. All un-insulated C.S. & A.S. equipment like columns, vessels, drums, storage tanks (both external & internal surfaces), heat exchangers, pumps, compressors, electrical panels and motors etc.

b. All un-insulated carbon and low alloy piping, fittings and valves (including painting of identification marks), furnace ducts and stacks.

c. All items contained in a package unit as necessary.

d. All structural steel work, pipe, structural steel supports, walkways, handrails, ladders, platforms etc.

e. Flare lines, external surfaces of MS chimney with or without refractory lining and internal surfaces of MS chimney without refractory lining.

f. Identification colour bands on all piping as required including insulated aluminium clad, galvanised, SS and nonferrous piping.

g. Identification lettering/numbering on all painted surfaces of equipment/piping insulated aluminium clad, galvanized, SS and non-ferrous piping.

h. Marking / identification signs on painted surfaces of equipment/piping including hazardous service.

i. Supply of all primers, paints and all other materials required for painting (other than Owner supplied materials)

j. Over insulation surface of equipments and pipes wherever required.

k. Painting under insulation for carbon steel, alloy steel and stainless steel as specified.

l. Painting of pre-erection/fabrication and Shop primer.

m. Repair work of damaged pre-erection/fabrication and shop primer and weld joints in the field/site before and after erection as required.

n. All CS Piping, equipments, storage tanks and internal surfaces of RCC tanks in ETP plant.

1.2.3.2 The following surfaces and materials shall not require painting in general. However, if there is any specific requirement by the owner, the same shall be painted as per the relevant specifications:

a. Un-insulated austenitic stainless steel.
b. Plastic and/or plastic coated materials
c. Non-ferrous materials like aluminum.

1.2.4 Documents

1.2.4.1 The contractor shall perform the work in accordance with the following documents issued to him for execution of work.

a. Bill of quantities for piping, equipment, machinery and structures etc.
b. Piping Line List.
e. Painting specifications including special civil defence requirements.

1.2.5 Unless otherwise instructed, final painting on pre-erection/ shop primed pipes and equipments shall be painted in the field, only after the mechanical completion, testing on systems are completed as well as after completion of steam purging wherever required.

1.2.6 Changes and deviations required for any specific job due to clients requirement or otherwise shall be referred to PLECO for deviation permit.

2.0 CODES & STANDARDS

Without prejudice to the specifications of the contract, the following codes and standards shall be followed for the work covered by this contract.

IS: 5 Colors for ready mixed paints and enamels.

RAL DUTCH International Standard for colour shade (Dutch Standard)

IS: 101 Methods of test for ready mixed paints and enamels,

IS: 161 Heat resistant paints.

IS: 2074	Specifications for ready mixed paint, red oxide zinc chrome priming.
IS: 2379	Color code for identification of pipelines.
IS: 2932	Specification for enamel, synthetic, exterior (a) undercoating. (b) Finishing.

3.0 CONDITIONS OF DELIVERY

Packaging

Every recipient will be fitted with a hermetically-sealed lid with an opening that is sufficiently large to allow the contents to be stirred: the outside and inside are protected against oxidation, and, the lid, are marked with a strip of color identical to the contents.

4.0 COMPOSITION OF THE PAINT PRODUCTS USED

a) Quality

The composition and quality of the products may not differ from batch to batch. A batch is all of the products of a specified manufacture. If the analyses of products bring to light that the composition does not conform to the specifications of the paint manufacturer, the OWNER may refuse to use this batch of products. The paint products must comply with the following conditions

- They must have the viscosity necessary for the described use and the established condition: use of the brush - paint roller (spray gun only for special cases and in the workshop)

b) Quality control - Sampling

While the works are in progress on the construction site, the OWNER may carry out sampling on the paint being used for the purpose of checking conformity. The paint products must be made available free of charge to the laboratory or the approved supervisory body in sufficient quantities so that all the tests can be carried out on the same batch.

If analyses reveal a non-conformity in the composition of the products used (tolerance of $\pm$ 3 % of the dosage of every component), the OWNER may refuse application of the product under consideration, halt the work and have the nonconforming product already applied removed.

Before proceeding the work, a product that does conform will be required. The only Purpose of the analysis is to reveal any nonconformity of the composition of the products. Their purpose is therefore not to assess the quality of the different components. The analyses concerned are not acceptance tests of the products supplied and in no way affect the obligations of the contractor specified in the contract towards the OWNER.

5.0 IDENTIFICATION

Every recipient will bear the following information:

- Name of the manufacturer
- Date and number of manufacture
- Name of the product type
- Batch no
- Net weight of the produced or the contents of the recipient
- Date of the expiry.

At the time of delivery, this packaging must bear labels in conformity with the legal stipulations in force.

<u>Leaving the site after work</u>

After completion of a job a general clean-up shall be carried out by the Contractor to remove all debris, materials or irregularities that his work has brought to the site so that it is left tidy:

The restoration work includes among other things:

- The removal of abrasives.
- The removal of the different protective coverings.
- The Contractor will make the required repairs to any damage after refitting the supports.
- The removal of paint and cleaning of the stains on the floor.

6.0 SURFACE PREPARATION STANDARDS

Following latest edition of standards shall be followed for surface preparations:

1. Swedish Standard Institution- SIS-05 5900-1967/ISO 8501-1
2. Steel Structures Painting Council, U.S.A. (Surface Preparation Specifications (SSPC-SP)
3. British Standards Institution (Surface Finish of Blast-cleaned for Painting) BS-4232.
4. National Association of Corrosion Engineers. U.S.A. (NACE).
5. IS-1477-1971 (Part-1) - Code of Practice for Painting of Ferrous metals in Buildings. (Part 1, Pre-treatment)

   a) The contractor shall arrange, at his own cost to keep a set of latest edition of above standards and codes at site.

   b) The paint manufacturer's instruction shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

- Proper storage to avoid exposure as well as extremes of temperature.
- Surface preparation prior to painting.
- Mixing and thinning.
- Application of paints and the recommended limit on time intervals between coats.

c) Any painting work (including surface preparation) on piping or equipment shall be commenced only after the system tests have been completed and clearance for taking up painting work is given by the OWNER, who may, however, at his discretion authorize in writing, the taking up of surface preparation or painting work in any specific location, even prior to completion of system test.

7.0 PREPARATION OF THE SURFACES

7.1 General Specifications

The cases that occur in practice on building sites, with regard to painted surfaces, can be broken down as follows:

- Material of which the oxide content disappears by natural oxidation.
- Material that has already been covered with a layer of paint in the workshop.
- Material that is covered with old paint layers that show different degrees of weathering.

Good preparation of surface is the best guarantee for good anti-corrosion protection.

Paintwork may never begin until the surface to be treated is dry and is independent of the base coat and cleared of dirt, dust, rust, scale, grease, salt attack, cement powder, cement mud-scale, sand, oil, etc.

Based on the environmental conditions of coastal and saline nature, the Painting specification for station pipes defines the complete requirements like:

- Surface preparation standards like NACE etc.
- Sand blasting process
- Color Codes for piping
- Paint materials types and their DFT measurement.
- Selection and application of paints on external surfaces.

The pipeline passes through the coastal and marine environment, the **Table-4** of this specification to be followed for the painting works.

The method of preparation of the surface will be implemented in accordance with the preparation methods described below:

- Bright blast-cleaning
- Mechanical or Power tool cleaning
- Manual or hand tool cleaning

The Contractor should have the required material at his disposal to clean the surfaces to be coated thoroughly in accordance with the preparation methods regardless of the form or the condition of such surfaces. The cleaning devices that might be damaged during the surface preparation shall be screened off by the Contractor.

7.2 Air blast cleaning with abrasive

Before beginning cleaning by blasting, the person carrying out the work will take the following measures:

- Clear the steel surface of oil and/or grease;
- Ensure that each flange collar (section where the sealing is applied) is properly screened off against the blasting and the subsequent works;
- Check that no blasting grains can act into the pipes during this process. Any openings not sealed off must be screened off;
- Where there are valves, regulators and other devices, the manufacturer's identification plate will be dismantled so that all surfaces can be treated. The plate will then be put back again.
- Screen off all non-metal structures such as rubber where there is a filter;
- With valves, operators and other devices, care should be taken to ensure that no metal filings or paint get into the apparatus:
- The OWNER reserves the right to carry out part or all of these works himself.

To prevent rust forming quickly as the result of humidity on the blasted surface, cleaning by blasting may only be carried out when the temperature of the steel surface is at least 3°C higher than the dew-point of the ambient air.

Blasting may not be carried out if the relative degree of humidity exceeds 80%. The choice of the type of blasting medium used depends on local circumstances such as the possible presence of gas and the material to be blasted.

The abrasive to be used must conform to the local law i.e. it may contain no carbon and less than 1% free silicon dioxide. The Sa 3 will always be requested and must at least reach Sa 2½ during the initial stage of the paintwork. For blasting followed by metallization, the surface preparation degree to be achieved is always Sa 3. The degree of cleanliness to be obtained will be inspected in accordance with the Swedish standard SVENSK STANDARD ISO 8501-1-1988 SIS 05.5900.

- Sa 3: surface blasted down to the bare metal; when the surface is inspected with a magnifying glass, scale, rust and foreign bodies must be completely removed and it should be possible to raise a metallic -shine on the treated surface.

- Sa 2 1/2: blasted very carefully. Scale, rust and foreign bodies must be removed in such a way that anything left behind will only be visible as nuances (shading) or strips.

The blast-cleaning will be carried out by means of compressed air free of water and oil.

After the blasting and before painting, the surface should be completely cleaned of blasting material and so forth with a soft brush, a dry cloth or dry compressed air.

7.3 Mechanical or Power tool cleaning

If sandblasting is not permitted or if the metal structures are not easily accessible for blasting or blasting for one reason or other is technically unfeasible, mechanical de rusting can be used instead. With mechanical cleaning by means of chipping, rotating steel brushes and sanding discs, a degree of cleanliness St. 3 should be reached.

St 3: removal of the old paint layers of which the adhesion leaves something to be desired and/or of which the paint layer no longer fulfills the requirements.

If parts are present that are so corroded that St 3 is difficult to achieve, this should be notified to the OWNER representative prior to the start of the works.

N.B:
St. 3: means removal of every old paint layer. Retouching means local polishing with St. 3 or Sa 3 followed by application of the desired painting system.

After mechanical cleaning, the surface should be made dust-flee with a cloth or a so brush, washed with an organic solvent and thoroughly dried off with a dry cloth (e.g. with 1.1.1. Trichoroethane such as Solvethane, Chloroethene).

7.4 Manual or Hand tool cleaning

Manual derusting with the aid of scrapers. steel brushes, sandpaper etc. shall only be permitted in exceptional cases for local repairs. Any deviation there from must be requested from the OWNER/ OWNER 's Representative.

With manual derusting, a surface preparation degree St 3 must be obtained. The length of the handles of the equipment used may not exceed 50 cm.

7.5 Preparation of a surface covered with a layer of paint in the workshop.

This layer is in general applied by the manufacturer, for example, on valves, regulators etc. Layers of this kind will be checked for their proper adhesion in accordance with ASTM D 3359, method A (Standard Test Method for measuring adhesion by tape test). The adhesion should be at least.

If the paint layer shows less adhesion or is incompatible with the rest of the system it should be completely removed. If the paint layer is not removed, the Contractor accepts it in the state in which the coating is found and the guarantee remains in force. The adhesion does not have to be examined if system 63 has already been applied in the workshop on behalf of the OWNER.

The Contractor, who must provide for the protection on the construction site, must therefore obtain the information regarding the treatment of the surface and the quality of the paint that was used and must, moreover, examine the adhesion of the layer on the construction site, the percentage of damage and weathering as well as the value of the preparation of the surface in the workshop together with the thickness thereof that must be supplemented if necessary.

a) Galvanized surface

Galvanized surfaces, both old and new will be carefully roughened up. Every foreign body (concrete splatters, chalk marks, grease and oil stains, etc.) will be removed. Thereafter, rub the surfaces with abundant water and, if necessary, with cleaning products.

To this end, nylon brushes will be used for every kind of dirt as well as for removing zinc salt residue. Thereafter, the surfaces will be treated in accordance with system 21. Where the zinc layer is lacking, it will be derusted manually to a degree of cleanliness St 3, after which a primer coat will be applied in accordance with system 22.

b) Metallized surfaces treated with an impregnation layer

- Degrease with the desired degreasing product:
- Clean under high pressure or with a product prescribed by the paint supplier.

If the paint layer adheres well and is applied on a clean base, the painting system described may be continued. If the percentage of damage and weathering does not exceed 5 % m. retouching may be considered. These partial repairs will be carried out.

If on the other hand, the percentage of damage does exceed 5 %/m or if the layer applied in the workshop comes loose the Contractor must draw the attention of the OWNER to this and carry out the complete application system.

7.6 Preparation of surfaces covered with earlier paint layers that show different degrees of weathering.

If the surfaces do not show deep weathering limited to the spread of rust by small pitted areas or non-penetrative rust in spots, it will very often be sufficient to clean the surfaces with abrasives or with an abrasive disc, then to rub them down with steel wool, remove the dust and wash off. If thick rust appears, in spots, scale rust and active rust canker, this should be removed with needle hammers or stripped away directly by blasting, removing the dust and washing off.

7.7 Preparation of concrete or cement plaster surfaces

Remove unsound paint layers and loose components with scrapers, blades or rotating steel brushes. Thoroughly clean the entire surface with water containing ammonia. Thoroughly remove moss, algae and fungal growths. Where these growths have been removed, treat the area with a fungicide in accordance with the instructions for use.

Once the entire area is completely dry, brush off the dead residue of moss, algae and fungus with a hard brush. In the case of reinforcement steel that has been laid bare, remove as rust, dust and grease as possible and treat with a printer coat. When painting concrete surfaces, they must first be checked for cracks. Cracks larger than 0.3 mm must be repaired with an appropriate system in accordance with the type and extent of the repairs (e.g. injection with epoxy mortar). Repair damage such as cracks and bursts to concrete parts with a two-component mortar or preferably with micro-mortars. Finally check the alkalinity of the surface with the aid of litmus paper and neutralize it if necessary.

7.8 Use of solvents

It is sometimes necessary to use solvents when the surfaces to be painted are streaked with grease or oil. In this case a suitable organic solvent should be applied. The operation should be carried out with the aid of clean brushes or rags and clean solvent.

All the legal specifications in connection with solvents etc. must be adhered to. The OWNER/OWNER's Representative will be informed in advance of any toxicity or flammability. All measures must be taken to prevent any risk of fire and to nick out any possibility of poisoning (ventilation). The Contractor will provide drip collectors to keep the environment free of pollution.

7.9 Condition of the metal after stripping

The Contractor must call in a representative of the OWNER/OWNER's representative or of the Approved supervisory Body responsible for checking the condition of the metal during stripping and informing the OWNER/OWNER's representative immediately of any damage that he might have noticed.

- Deep corrosion of the plates - rivets - bolts
- Faulty welding
- Fittings that appear to be dangerous because of their age.

7.10 Removing coating from surface pipelines

The Contractor must have the equipment necessary for the removal of asphalt from the pipe without damaging the latter (scratching, impact, etc,). The Contractor undertakes to carry out the work in accordance with an approved procedure.

TABLE-1 (FOR CLAUSE 7.0)
SURFACE PREPARATION STANDARDS

<table>
<tr><th rowspan="2">SL. NO.</th><th rowspan="2">DESCRIPTION</th><th colspan="3">VARIOUS INTERNATIONAL STANDARDS (EQUIVALENT)</th><th rowspan="2">REMARKS</th></tr>
<tr><th>ISO 8501-1/ SIS-05 59 00</th><th>SSPC-SP, USA</th><th>NACE, USA</th></tr>
<tr><td>1</td><td>Manual or hand tool cleaning

Removal of loose rust, loose mill scale and loose paint, chipping, scrapping, standing and wire brushing. Surface should have a faint metallic sheen</td><td>ST.2</td><td>SSPC-SP-2</td><td>-</td><td rowspan="2">This method is applied when the surface is exposed to normal atmospheric conditions when other methods cannot be adopted and also for spot cleaning during maintenance painting.</td></tr>
<tr><td>2</td><td>Mechanical or power tool cleaning

Removal of loose rust loose mill scale and loose paint to degree specified by power tool chipping, de-scaling, sanding, wire brushing and grinding, after removal of dust, surface should have a pronounced metallic sheen.</td><td>ST.3</td><td>SSPC-SP-3</td><td>-</td></tr>
<tr><td>3</td><td>Dry abrasive Blast cleaning

There are four common grades of blast cleaning</td><td colspan="3"></td><td></td></tr>
</table>

3.1	White metal Blast cleaning to white metal cleanliness. Removal of all visible rust. Mill scale, paint & foreign matter 100% cleanliness with desired surface profile.	SA 3	SSPC-SP-5	NACE#1	Where extremely clean surface can be expected for prolong life of paint system.
3.2	Near white metal Blast cleaning to near white metal cleanliness, until at least 95% of each element of surface area is free of all visible residues with desired surface profile.	SA 2½	SSPC-SP-10	NACE#2	The minimum requirement for chemically resistant paint systems such as epoxy, vinyl, polyurethane based and inorganic zinc silicate paints, also for conventional paint systems used under fairly corrosive conditions to obtain desired life of paint system.
3.3	Commercial Blast Blast cleaning until at least two-third of each element of surface area is free of all visible residues with desired surface profile.	SA 2	SSPC-SP-6	NO.3	For steel required to be painted with conventional paints for exposure to mildly corrosive atmosphere for longer life of the paint systems.
3.4	Brush-off Blast Blast cleaning to white metal cleanliness, removal of all visible rust, mill scale, paint & foreign matter. Surface profile is not so important.	SA 1	SSPC-SP-7	NO.4	

8.0 METALLISATION

8.1 Applying the metallization

Metallization must be carried out in accordance with ISO 2063,

Metallization is carried out as rapidly as possible after blasting in order to limit corrosion of the pipes (max. 3 hours later). With metallization, a surface preparation degree Sa 3 is compulsory. The roughness of the blasted surfaces should be from 25 to 50µ R_{Max}.

- The metallizing is always carried out on dry parts in good weather conditions (maximum relative humidity 80 %);

- For metallization, a wire composed of 85 % zinc and 15 % aluminum with a minimum guaranteed degree of purity of 99.5 % is used (subject to other specifications). The application thereof is always carried out in accordance with the conditions of the manufacturer and may at all times be submitted to the OWNER's representative.

- The sealant should be applied maximum 3 hours alter metallization.

- The sealant must be thinned and applied as per the present specifications. A visual inspection whereby the sealant completely covers the metallization will suffice here.

- When evaluating the metallization, a negative deviation from the minimum coating thickness, to 80 µ for 20% of the measurements will be permitted.

9.0 COATING PROCEDURE AND APPLICATION

9.1 Conditions for carrying out paintwork

Painting may not be carried out in unsuitable conditions.

All preparatory work and painting may only he carried out in dry weather and at a minimum temperature of 108C, except for special eases requested by the OWNER's Representative.

Unless otherwise stipulated in the specifications of the paint supplier, application of the paint is forbidden if it is forecast that the temperature will fall to below 08C before the paint is dry. The temperature of-the surface to be painted must be at least 3°C higher than the dew point of the ambient air. Application of the paint is also not permitted if there is a danger that the coat of paint will not be dry before dew or condensation sets in.

The work must be stopped:

- If the temperature of the surface to be painted is higher than that described by the supplier.

- In rain, snow, mist or fog or when the relative humidity is higher than 80 %.

Coats that have not yet dried and have been exposed to frost, mist, snow or rain and might thereby be damaged must be removed after drying and the surfaces must be repainted at the expense of the Contractor.

Working in direct sunlight or in hot weather must be avoided,

The first coat of paint must be applied maximum 3 hours after the preparation of the surface of the relative humidity of the air is between 50% and 80%. This time span may be increased to 6 hours if the relative humidity is less than 50%. In all cases, the preparation of the surface must exhibit degree Sa 3 and at the very least the appearance of degree Sa 2 ½ at the time of painting.

The coats of paint may only be applied on carefully cleaned surfaces that must be dry and free of grease and dust.

9.2 Special conditions

Painting may be carried out when the Contractor can be sure that the instructions of the paint supplier have been scrupulously followed with regard to the parameters in the following (non-exhaustive) list:

- Ambient temperature.
- Surface temperature.
- Relative humidity.
- Dew point.
- Drying times.

The Contractor must in this respect be able to produce the instructions for the paint on the site. The OWNER/CONSULTANT will guarantee 100% supervision in this regard during the execution of the work.

In addition, the paintwork may only be carried out to a minimum ambient temperature of 5°C and/or to a maximum relative degree of humidity of 85 %. Application of the paint is also not permitted if there is a danger that the coat of paint will not be dry before dew or condensation sets in.

10.0 PAINT MATERIAL

Manufacturers shall furnish the characteristics of all paints indicating the suitability for the required service conditions. Primer and finish coats shall be of class-I quality and shall conform to the following:

a) Primer (P-1)

Red oxide Zinc Chromate Primer

Type and Composition	Single pack, Modified phenolic alkyd medium pigmented with red oxide and zinc chromate.
Volume solids	30 - 35% (min)
DFT	25 microns/coat (min)
Covering capacity	12 - 13 M^2/Lit/coat

b) Primer (P-2)

High build chlorinated rubber zinc phosphate primer

Type and Composition	Single pack, Air Drying Chlorinated rubber medium Plasticized with unsaponifiable plasticiser pigmented with zinc phosphate

Volume solids	35 - 40% (min)
DFT	30 - 40 microns/coat (min)
Covering capacity	7 - 8 M^2/Lit/Coat

c) Primer (P-3)

High build zinc phosphate primer

Type and Composition	Single Pack, Synthetic medium, pigmented with zinc phosphate.
Volume solids	40 - 45% (min)
DFT	35 - 50 microns/coat (min)
Covering capacity	10 - 12 M^2/Lit/coat

Heat resistance Upto 80 ºC (dry)

d) Primer (P-4)

Etch Primer / Wash Primer

Type and Composition	Two pack Poly vinyl butyral resin medium cured with phosphoric acid solution pigmented with zinc tetroxy chromate.
Volume solids	7 - 8% (min)
DFT	8 - 10 microns/coat (min)
Covering capacity	7 - 8 M^2/lit/coat

e) Primer (P-5)

Epoxy Zinc Chromate Primer

Type and Composition	Two packs, Polyamide cured epoxy resin medium pigmented with zinc chromate.
Volume solids	40 % (min)
DFT	35 microns/coat (min)
Covering capacity	11 - 12 M^2/lit/Coat

f) Primer (P-6)

Epoxy Zinc Phosphate Primer

Type and Composition	Two packs, Polyamide cured Epoxy resin medium pigmented with zinc phosphate.
Volume solids	40% (min)

DFT	35 - 50 microns/coat (min)
Covering capacity	11 - 12 M^2/lit/coat

g) Primer (P-7)

Epoxy high build M10 Paint (Intermediate Coat)

Type and composition	two pack Poly Polyamide cured epoxy resin medium pigmented with micaceous iron oxide. Volume solids 7- 8%
Volume Solids	50% (min)
DFT	100 microns/coat (min)
Covering capacity	5.0 M^2/lit/coat

h) Primer (P-8)

Epoxy Red Oxide zinc phosphate primer

Type and Composition	two pack. Polyamine cured epoxy resin pigmented with Red oxide and Zinc phosphate.
Volume solids	42% (min)
DFT	30 microns/coat (min)
Covering capacity	13 - 14 M^2/lit/coat

i) Primer (P-9)

Epoxy based tie coat (suitable for conventional alkyd based coating prior to application of acrylic polyurethane epoxy finishing coat)

Type and Composition	Two packs, Polyamide cured epoxy resin medium suitably pigmented.
Volume solids	50 - 60% (min)
DFT	50 microns/coat (min)
Covering capacity	10 - 12 M^2/Lit/Coat

j) Finish Coats (F-1)

Synthetic Enamel

Type and Composition	Single pack, Alkyd medium pigmented with superior quality water and weather resistant pigments
Volume solids	30 - 40% (min)
DFT	20 - 25 microns/coat
Covering capacity	16 - 18 M^2/lit/Coat

k) Finish coat (F-2)

Acrylic Polyurethane paint

Type and Composition	Two pack, Acrylic resin and iso-cyanate hardener suitably pigmented.
Volume Solids	40% (min)
DFT	30 - 40 microns / coat
Covering Capacity	10 - 12 M^2/lit/ coat

l) Finish Coat (F-3)

Chlorinated Rubber Paint

Type and Composition	Single pack, Plasticised chlorinated rubber medium with chemical & weather resistant pigments.
Volume solids	40% (min)
DFT	30 - 40 microns/coat (min)
Covering capacity	8 - 10 M^2/lit /coat

m) Finish Coat (F-4)

High build chlorinated rubber M10 paint.

Type and Composition	Single pack Chlorinated rubber based high build pigmented with micaceous iron oxide.
Volume solids	40 - 50% (min)
DFT	65 - 75 microns/coat
Covering capacity	6.0 - 7.0 M^2/lit/coat

n) Finish coat (F-5)

Chemical Resistant Phenolic based Enamel

Type and Composition	Single pack phenolic medium suitably pigmented.
Volume solids	35 - 40% (min)
DFT	25 microns/ coat
Covering capacity	15.0 M^2/lit/coat

o) Finish Coat (F-6)

Epoxy High Building Coating

Type and Composition	Two pack. Polyamide-amine cured epoxy resin medium suitably pigmented.
Volume solids	60 - 65% (min)

DFT	100 microns/coat (min)
Covering capacity	6.0 - 6.5 M^2/lit/coat

p) Finish Coat (F-7)

High build Coal Tar Epoxy

Type and Composition	Two pack, Polyamine cured epoxy resin blended with Coal Tar.
Volume solids	65% (min)
DFT	100 - 125 microns/coat
Covering capacity	6.0 - 6.5 M^2/lit/coat

q) Finish Coat (F-8)

Self-priming epoxy high build coating (complete rust control coating)

Type and Composition	Two packs. Polyamide-amine cured epoxy resin suitably pigmented. Capable of adhering to manually prepared surface and old coatings.
Volume solids	65 - 80% (min)
DFT	125 - 150 microns/coat
Covering capacity	4 - 5 M^2/lit/coat

r) Finish Coat (F-9)

Inorganic Zinc Silicate coating

Type and Composition	Two packs, self-cured solvent based inorganic zinc silicate coating.
Volume solids	60% (min)
DFT	65 - 75 microns/coat
Covering capacity	8 - 9 M^2/lit/coat

s) Finish coat (F-10)

High build Black

Type and Composition	Single pack. Reinforced bituminous composition phenol based resin.
Volume solids	55 - 60% (min)
DFT	100 microns/coat (min)
Covering capacity	5.5 - 6.0 M^2/lit/coat

t) Finish Coat (F-11)

Heat Resistant Aluminium Paint Suitable up to 250°C.

Type and Composition	Duel container (paste & medium). Heat resistant spec varnish medium combined with aluminium flakes.
Volume solids	20 - 25% (min)
DFT	20 microns/coat (min)
Covering capacity	10 - 12 M^2/lit/coat

u) Finish Coat (F-12)

Heat Resistant Silicon Paint suitable up to 400º C.

Type and Composition	Single pack Silicone resin based with aluminium flakes.
Volume solids	20 - 25% (min)
DFT	20 microns/coat (min)
Covering capacity	10 - 12 M^2/lit/coat

v) Finish Coat (F-13)

Synthetic Rubber Based Aluminium Paint Suitable up to 1508C.

Type and Composition	Single Pack, Synthetic medium rubber medium combined with leafing Aluminium,
DFT	25 microns/coat (min)
Covering capacity	9.5 M^2/lit/coat

Notes:

1 Covering capacity and DFT depends on method of application Covering capacity specified above is theoretical. Allowing the losses during application, min specified DFT should be maintained.

2. All paints shall be applied in accordance with manufacturer's instructions for surface preparation, intervals, curing and application. The surface preparation quality and workmanship should be ensured.

3. Selected chlorinated rubber paint should have resistance to corrosive atmosphere and suitable for marine environment,

4 All primers and finish coats should be cold cured and air-drying unless otherwise specified.

5. Technical data sheets for all paints shall be supplied at the time of submission of quotations.

6. In case of use of epoxy tie coat, manufacturer should demonstrate satisfactory test for inter coat adhesion. In case of limited availability of epoxy tie coat (P-9) alternate system may be used taking into the service requirement of the system.

7. In case of F-6, F-9, F-1 1 & F-1 2 Finish Coats, No Primer are required.

11.0 MANUFACTURERS

The paints shall conform to the specifications given above and Class-I quality in their products range of any of the-following manufacturer or other approved vendors:

i) Asian Paints (India) Ltd.
ii) Bombay Paints
iii) Berger Paints India Ltd.
iv) Akzo Nobel
v) Jenson & Nicholson
vi) Shalimar Paints

STORAGE

All paints and painting material shall be stored only in rooms to be provided by contractor and approved by OWNER/ OWNER 's Representative for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent, building.

A signboard bearing the words given below shall be clearly displayed outside:
PAINT STORAGE No NAKED LIGHT highly -inflammable

12.0 COLOR CODE FOR PIPING:

i) For identification of pipelines, the color code as per Table -1 shall be used.

ii) The color code scheme is intended for identification of the individual group of the pipeline. The system of color coding consists of a ground color and color bands superimposed on it.

iii) Colors (Ground) as given in Table-2 shall be applied throughout the entire length of un insulated pipes, on the metal cladding & on surfaces. Ground color coating of minimum 2m length or of adequate length not to be mistaken as color band shall be applied at places requiring color bands. Color bands shall be applied as per approved procedure.

iv) Line coating shall meet DIN 30670 standard for external coating and API 5L RP – 2 for internal coating.

v) The thickness for the epoxy should be 180 microns, adhesive 200 microns and balance should be PE .

vi) The minimum coating thickness on weld seam shall be 3.2 mm and minimum coating thickness on body should be 3.2.

vii) Minimum thickness for liquid epoxy for internal coating should be 100 ± 20 microns.
Max design temperature for coating should be considered +80 ºC.

COLOR CODE:

A) Ball Valve (Above Ground) : Off White
B) Globe Valve (Above Ground) : Oxford Blue-RAL 5005, IS-519941005

C) Check Valve(Above Ground) : Oxford Blue-RAL 5005, IS-519941005
D) Launcher / Receiver : Yellow Golden
E) Jib Crane / Trolley : Yellow Golden
F) All underground valves shall have epoxy base coating after surface finish of SA 2:5
G) Valves and above ground pipes need to be properly blasted to achieve surface finish of Sa 2:5 before the application of paints.

Table 12.1 Colour Coding Scheme for Pipes and Equipment

Sl. No.	Description	Ground Color	First Color Band	Second Color Band
1	**COMPRESSED AIR**			
a)	Plant Air	Sky Blue	Silver Grey	-
b)	Instrument Air	Sea Green	Black	-
2	GASES			
a)	Charge Gas	Canary Yellow	Signal Red	Smoke Grey
b)	Regeneration Gas	Canary Yellow	White	Dark Violet
c)	Residue Gas	Canary Yellow	White	French Blue
d)	LPG	Canary Yellow	Brilliant Green	White
e)	Acetylene	Canary Yellow	Dark violet	-
	Flare Lines	Heat resistant aluminium		
f)	Fire water and Foam & Extinguisher	Post office red		
3	ALL EQUIPMENT			
a)	Vessels. Columns, exchangers, etc. containing non- hazardous fluids.	Light Grey		
b)	Base Frame/Structure	Black		
b)	All equipment containing hazardous fluids	Canary Yellow		

c)	Pipe carrying hazardous fluids	Bar is to be replaced by Hazardous Marking as per IS:2379 Clause 7.1C		

IDENTIFICATION SIGN

i) Colors of arrows shall be black or white and in contrast to the color on which they are superimposed.

ii) Product names shall be marked at pump inlet, outlet and battery limit in a suitable size as approved by OWNER.

iii) Size of arrow shall be either of the following:

a) Color Bands

Minimum width of color band shall be as per approved procedure.

b) Whenever it is required by the OWNER to indicate that a pipeline carries a hazardous material, a hazard marking of diagonal stripes of black and golden, yellow as per IS:2379 shall be painted on the ground color.

IDENTIFICATION OF EQUIPMENT

All equipment shall be stenciled in black or white on each vessels, column, equipment, and painting as per approved procedure.

INSPECTION AND TESTING

1. All painting materials including primers and thinners brought to site by contractor for application shall be procured directly from manufactures as per specifications and shall be accompanied by manufacturer's test certificates Paint formulations without certificates are not acceptable.

2. The painting work shall be subject to inspection by OWNER/ OWNER's Representative at all times. In particular, following stage wise inspection will be performed and contractor shall offer the work for inspection and approval at every stage before proceeding with the next stage.

In addition to above. record should include type of shop primer already applied on equipment e.g. Red oxide zinc chromate or zinc chromate or Red lead primer etc.

Any defect noticed during the various stages of inspection shall be rectified by the contractor to the entire satisfaction of OWNER/ OWNER's Representative before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work. Contractor shall be responsible for making good any defects found during final inspection/guarantee period/defect liability period as defined in general condition of contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra coat of paint should be applied to make-up the DFT specified without any extra cost to OWNER.

PRIMER APPLICATION

i. The contractor shall provide standard thickness measurement instrument with appropriate range(s) for measuring.

   Dry film thickness of each coat, surface profile gauge for checking of surface profile in case of sand blasting. Holiday detectors and pinhole detector and protector whenever required for checking in case of immerse conditions.

ii. At the discretion of OWNER/ OWNER's Representative, contractor has to provide the paint manufacturers expert technical service at site as and when required. For this service, there should not be any extra cost to the OWNER.

iii. Final Inspection shall include measurement of paint dry film thickness, check of finish and workmanship. The thickness should be measured at as many points/ locations as decided by OWNER/ OWNER's Representative and shall be within +10% of the dry film thickness.

iv. The contractor shall produce test reports from manufacturer regarding the quality of the particular batch of paint supplied. The OWNER shall have the right to test wet samples of paint at random for quality of same. Batch test reports of the manufacturer's for each batch of paints supplied shall be made available by the contractor.

18.0 PAINT SYSTEMS

The paint system should vary, with type of environment envisaged in and around the plants. The types of environment as given below are considered for selection of paint system. The paint system is also given for specific requirements.

a) Normal Industrial Environment, Table 18.2.
b) Corrosive industrial Environment, Table 18.3
c) Coastal & Marine Environment, Table 18.4

Notes 1. Primers and finish coats for any particular paint systems shall be from same manufacturer in order to ensure compatibility.

TABLE 18.1: LIST OF PRIMERS & FINISH PAINTS

PRIMERS	
P-1	Red oxide Zinc chromate Primer
P-2	Chlorinated rubber zinc Phosphate Primer
P-3	High build Zinc phosphate Primer
P-4	Etch Primer/Wash Primer
P-5	Epoxy Zinc Chromate Primer

P-6	Two component Epoxy Zinc Phosphate Primer cured with polyamine hardener
P-8	Epoxy red oxide zinc phosphate primer
<u>FINISH COATS / PAINTS</u>	
F-1	Synthetic Enamel
F-2	Two component Acrylic – Polyurethane finish paint
F-3	Chlorinated Rubber finish paint
F-5	Chemical resistant phenolic based enamel
F-6	High Build Epoxy finish coating cured with **polyamide** hardener
F-7	High build Coal Tar Epoxy coating cured with **polyamine** hardener
F-8	Self priming surface Tolerant High Build epoxy coating. cured with **polyamine** hardener
F-9	Two component Inorganic Zinc Silicate coating
F-10	High build Reinforced bituminous composition phenol based resin.
F-11	Heat resistant synthetic medium based Aluminium paint suitable for 250 deg C
F-12	Two component Heat resistant Silicone Aluminium paint. suitable for 400 deg C
F-13	Synthetic based aluminium Paint suitable for 150 deg C

Table – 18.2: Painting System for Normal Industrial Environment for Piping and Equipment (Above Ground)

Sl. No.	Temp. Range	Surface Preparation	Primer	Finish Coat	Total DFT	Remarks
1	-10 to 20	SSPC-SP-3	One coat P-2 50 microns / coat (min)	One coat F-4 65 microns/ coat (min) Two coats F-3, 30 Microns/coat (min)	175	Primer and Finish coat can be applied at ambient temp.
2	21 to 60	SSPC-SP-6	Two coats P-1, 25 microns/ coat (min.)	Two coats of F-1, 20 microns/coat (min)	90	-
3	61 to 80	SSPC-SP-6	Two coats P-3, 50 microns/ coat (min)	Two coats of F-13, 25 microns/coat (min)	150	-
4	81 to 250	SSPC-SP-6	-	Three coats of F-11, 20 microns/ coat (min)	60	Paint application at ambient temp. curing at elevated temp. during start-up.
5	251 to 400	SSPC-SP-10	-	Three coats of F-12, 20 microns/ coat (min)	60	-do-

Table – 18.3: Painting System for Corrosive Industrial Environment for Piping and Equipment (Above Ground)

Sl. No.	Temp. Range	Surface preparation	Primer	Finish Coat	Total DFT	Remarks
1	-14 to 80	SSPC-SP-10	Two coats P-6, 35 microns / coat (min.)	One coats F- 6, 100 microns coat (min.) and one coats F- 2 40 microns coat (min.)	210	Paint application at ambient temp.

2	81 to 250	SSPC-SP-10	-	Three coats F-11, 20 Microns / coat (min.)	60	Paint application at ambient temp. and curing at 250ºC for 4 hours
3	81 to 400	SSPC-SP-10	-	Three coats F-12, 20 Microns / coat (min.)	60	Paint application at ambient temp. and curing at 250ºC for 4 hours

Table – 18.4 : Painting System for Coastal and Marine Environment for Piping and Equipment (Above Ground)

Sl. No.	Temp. Range	Surface Preparation	Primer	Finish Coat	Total DFT	Remarks
1	-14 to 80	SSPC-SP-10	Two coats P-6. 35 Microns. coat (Min.)	Two coats F-6, 100 microns /coat (min.) and one coats F-2 40 Microns /coat (min.)	310	Primer and Finish coat application at Ambient temp.
2	81 to 400	SSPC-SP-I0	-	- Three coats F- 12, 20 Microns / coat (min.)	60	Paint application. at ambient temp, and curing at 250ºC for 4 hours
3	401 to 550	SSPC-SP- 10	-	Three coats F-12, 20 Microns / coat (min.	60	Paint application. at ambient temp, and curing at 250ºC for 4 hours

Table – 18.5 : Painting System for External Side of Underground Tanks in all areas.

Sl. No.	Temp. Range	Surface Preparation	Primer	Finish Coat	Total DFT	Remarks
External side of un-insulated underground storage tanks:						

1	-40 to 80	SSPC-SP-10	1 coat of F-9 @ 65-75µ DFT/ coat	3 coats of F-7 @ 100µ DFT/coat (3x100=300)	365-375	

18.2 Precautions to be taken

Neither the environment of the site nor the marking labels of devices may be covered with paint nor must they be kept free of paint splashes. To this end, it is advisable to use removable masking tape.

Paint splashes, leaks, etc. on any adjacent installations such as measuring apparatus, valves, pipes. Sources of light, insulation, heat insulators, walls, concrete, etc, must immediately be wiped up and the damage repaired before the paint is dry.

Otherwise, the OWNER will be obliged to have the cleaning carried out at the expense of the Contractor. The paint recipient will only be opened at the time of use (unless otherwise specified by the manufacturer).

The product will be mixed in the recipient with the aid of suitable tools and thus homogenized.

18.3 Method of application

Normally, three methods of application will be used on the construction site for the paint products. i.e. with a brush, with a roller or with a spray gun.

- The brush method makes it possible to obtain good penetration of the paint over irregularities in the metal.
- Only this method will be used for application of the base coats, for retouching and for protrusions, welded areas, riveted joints or bolted joints:
- The roller method may be used on large flat surfaces for the intermediate and topcoats.
- The spray gun method must be used in accordance with the instructions of the manufacturer and carried out by qualified personnel.

The Contractor must guarantee that all safety measures have been taken for such work. The spray gun method may only he used on site for places that are difficult to reach with the brush. In this case, a request must be made to the OWNER/ OWNER's Representative for a deviation.

All paintwork will be carried out with good brushes or rollers that are suitable for the type of paint being used and for the form of the material to be painted and fitted with short handles. The maximum length of the brush and roller handles will be 50 cm; longer handles may only be used for places that are absolutely inaccessible. The maximum width of a brush will be 13 cm.

18.4 Application of the coating

Application of the paint will be carried out in accordance with best practice in order to obtain a homogeneous and continuous layer. The OWNER or the Approved Supervisory body demands that painting of a layer will only be started after acceptance by them of the surface preparation or of the previous layer of paint.

The layers of paint must have a uniform thickness. They must he spread in such a way that all concave parts are dried out and that the surface is completely covered and has a glossy appearance without leaving brush marks and without exhibiting bubbles, foam, wrinkles, drips, craters, skins or gums that arise from weathered paint,

Each layer must have the color stipulated in the tables of the present specifications, which clearly differs from the previous layer, taking account of the Color of the top layer, all of which for the purpose of being able to identify the number of coats and their order of sequence. If the color of the coats is not mentioned in the tables the color difference in consecutive coats must, if possible, he at least 100 RAL. The color of the top layer is given in the table.

The coating power should be such that the underlying layer is not visible. Only 1 layer per day may be applied, unless otherwise specified by the OWNER or the Approved Supervisory Body.

The drying times prescribed by the paint manufacturer must be strictly observed in relation to the environmental conditions before proceeding with the application of the next layer.

The dry coating thickness indicated in the description of the paint systems are minimum thickness. In this connection, the Contractor is obliged to contact the paint manufacturer and conform to his guidelines. The Contractor must respect the thickness specified by the supplier.

18.5 Transporting treated items

In the case of works being carried out in a workshop, the metal structures will be surrounded by ventilated contraction film that prevents damage during transportation. This film may only be applied after complete polymerization of the paint.

19.0 GROUND-LEVEL TRANSITION POINT

19.1 Polyester protection system

The Contractor will provide system 02 over the entire length of the pipes above ground and below ground and up to a height of 20 cm and a depth of 40 cm. perpendicular to the ground level mark. In each case, he must ensure that the jointing below the asphalt is in good condition and assures' faultless adhesion. He will apply the following products over the entire surface area, prepared in accordance with is Sa 3:

1) The primer of system 01.

2) Reinforced polyester ± 20 cm above the ground level marker and ± 5 cm on the asphalt cleaned beforehand (application of reinforced polyester is carried out in accordance with the work method prescribed by the manufacturer). Moreover, in the case of PE, in contrast to asphalt, he will apply a polygon primer to PE immediately before applying the reinforced polyester.

3) He will then apply the other coats of system 01a to the surface section and thus cover the reinforced polyester with about 5 cm.

4) For new constructions, the polygon primer will be applied to PE and then subsequently processed as described under point 2.

20.0 USE OF SCAFFOLDING

Mounting, maintenance and dismantling of scaffolding for carrying out adaptation and/or paintwork to surface gas pipes or gas transport installations in use;

- The Contractor will specify the cost of scaffolding in the price list.
- The supplementary rental price for delays attributable to the Contractor will be charged to him:
- In his price quotation the Contractor should present the OWNER with diagrams of the scaffolding that he intends to install for carrying out the works of the OWNER.

21.0 QUALITY CONTROLS AND GUARANTEE

21.1 The Contractor is responsible for checking the weather conditions to ascertain whether the paintwork can be carried out within the technical specifications.

The Contractor should have the required calibrated monitoring apparatus for this purpose on site (with calibration certificates). The personnel who will have to use this apparatus should have the training for this purpose.

The OWNER or his representative and possibly the approved supervisory body indicated by the OWNER will maintain supervision during the works and inspect the works with random checks. A daily report will be drawn up in relation to the department that maintains supervision of these works.

The supplementary inspection and the supervision by the OWNER or the approved supervisory body do not diminish in any way the liability of the Contractor. The proper execution of the work and the materials used may be checked at any time.

21.2 Reference Surfaces

At the start of the works. The OWNER or the approved supervisory body will indicate a few surfaces that the Contractor will prepare and cover in accordance with the recognized method of operation under the inspection and to the satisfaction of all parties; the OWNER or his representative, the approved supervisory body, the contractor and possibly the paint manufacturer. These reference surfaces will serve as a point of comparison for the good adhesion of the paint on the installations as a whole. The parties will together work out a system for the identification of these surfaces in order to be able to monitor the conditions of the coatings over time. If the paintwork on a section of the installations is in a worse condition than the reference surfaces, the Contractor may be obliged to treat these parts again.

21.3 Measures to be taken in the event of a dispute

If on delivery of the works no agreement can be reached between the Contractor and the OWNER regarding the conformity of the works to the requirements of these specifications, an Approved Supervisory Body will he Called in. The Approved Supervisory Body will then carry out inspections' on site whereby the following assessment criteria will be used:

- The Swedish standards ISO 8501-1 1988 SS 05.5900 concerning the degree of cleanliness of the areas derusted by blasting, by machine or by hand.
- The wet film thickness of the paint will be measured in accordance with ISO 2808 or ASTM DI 212;
- The dry layer thickness of the film will be measured electronically, will complete statistical information. in accordance will, ISO 2808 or ASTM D 1186.
- The thickness of each layer will be measured in accordance with ISO 2808. ASTM 4138 or DIN 50986.
-
- Adhesion tests will be carried out in accordance with ISO 2409. ASTM 3359 or DIN 53151.
- Traction tests will he carried out in conformity with ISO 4624 or ASTM D 4541.
- The rugosity will be measured electronically in accordance with DIN 4768;
- The non-porosity will be measured with a test tension depending on the type of coating, the layer thickness and after consultation with the Paint manufacturer.
- Any defects in the paint film may be inspected visually by means of a magnifying glass or microscope. If necessary a photographic report may be drawn up in accordance with ASTM Standard D 4121-82.

The final judgment of the Approved Supervisory Body is irrevocable and binding for the Contractor and the OWNER. In the event of non-conformity of the works with the criteria of these specifications, all costs arising from the inspection by the Approved Supervisory Body shall be borne by the Contractor.

21.4 Guarantee

a) General Principles

The Contractor declares that he is aware of:

- The maximum operating temperature of the surfaces to be covered.
- The maximum permitted degree of humidity of the bearing surface.

- The properties of the environment to which the surfaces to be covered are: subject.

b) Summary of the Guarantee.

The contractor fully guarantees the following without reservation:

- The observance of all stipulations of the specifications for paintwork regarding, among other things:

  - The preparation of the surfaces.
  - The thickness of each layer.
  - The total thickness of the covering.

- The uniformity of the materials used.

- The repair of all defects before delivery of the works.

The Contractor will carry out the requested repair work as promptly as possible.

INSPECTION AND TEST PLAN

FOR

BALL VALVE

0	04.01.22	ISSUED AS INSPECTION AND TEST PLAN	PNS	MD	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by

ABBREVIATIONS:

CE	Carbon Equivalent	NPSH	Net Positive Suction Head
DFT	Dry Film Thickness	PO	Purchase Order
DPT	Dye Penetrant Testing	PESO	Petroleum Explosive Safety Organization
DHT	De-hydrogen Heat Treatment	PQR	Procedure Qualification Record
ERTL	Electronics Regional Test Laboratory	PR	Purchase Requisition
FCRI	Fluid Control Research Institute	PMI	Positive Material Identification
HT	Heat Treatment	RT	Radiography Testing
HIC	Hydrogen Induced Cracking	SSCC	Sulphide Stress Corrosion Cracking
ITP	Inspection and Test Plan	TC	Test Certificate
IP	Ingress Protection	TPI or TPIA	Third Party Inspection Agency
IHT	Intermediate Heat Treatment	UT	Ultrasonic Testing
IC	Inspection Certificate	VDR	Vendor Data Requirement
IGC	Inter Granular Corrosion	WPS	Welding Procedure Specification
MRT	Mechanical Run Test	WPQ	Welders Performance Qualification
NDT	Non-Destructive Testing	MPT / MT	Magnetic Particle Testing

1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Ball Valves.

2.0 REFERENCES

PO/ PR/ Standards referred there in/ Job specifications/ Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS:

SL. NO.	COMPONENT & OPERATION	CHARACTERISTICS / METHOD OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT & ACCEPTENCE CRITERIA	FORMAT OF RECORD	SCOPE OF INSPECTION		
						SUB SUPPLIER	SUPPLIER	TPIA
1.0	**PROCEDURES**							
1.1	Hydrostatic Test, Heat Treatment, NDT and Other Procedures	Documented Procedures	100%	-	Procedure Documents	-	H	R
1.2	WPS,PQR & WPQ	Welding Parameters & Qualification Record	100%	-	WPS ,PQR & WPQ	-	H	W- New R- Existing
1.3	Pre-Qualification Tests	Fire safe, Cryogenic & Other Test as applicable	As per PR/Purchase Specification	-	Acceptanc e Report	-	H	H (If new)
2.0	**RAW MATERIAL**							
2.1	Casting & Forging: Body & Bonnet / Connector	Visual & Dimension	100%	Material & Technical Specification	Inspection Report	H	H	-
		Chemical: Chemical Analysis	All Heats	Material & Technical Specification	Vendor Test Certificate	H	R	R

		Mechanical: Mechanical Test	All Heats	Material & Technical Specification	Vendor Test Certificate	H	R	R
		Impact Test (@ -29°C): for CS Impact Test (@ -45°C): for LTCS	All Heats	Material & Technical Specification/ ASME B 16.34	Test Report	H	R	R
		Non-Destructive Examination (NDT): Radiography (100% Critical Area & BW Ends)	100%	Material & Technical Specification/ ASME B 16.34	RT Report	H	R	R
		Non-Destructive Examination (NDT): Magnetic Particle Examination (100% exterior & accessible interior)	100%	ASME B 16.34	MPI Report	H	R	R
2.2	Forging & Casting: Ball, Seat Ring, Spindle/Stem (Trim Material)	Visual & Dimension	100%	Material & Technical Specification	Inspection Report	H	H	-
		Chemical: Chemical Analysis	All Heats	Material & Technical Specification	Vendor Test Certificate	H	R	R
		Mechanical: Mechanical Test	All Heats	Material & Technical Specification	Vendor Test Certificate	H	R	R
		Impact Test (@ -29°C): for CS	All Heats	Material & Technical Specification / ASME B 16.34	Test Report	H	R	R

		Impact Test (@ -45°C): for LTCS						
		Non-Destructive Examination (NDT): Radiography (100% Critical Area & BW Ends)	100%	Material & Technical Specification /ASME B 16.34	RT Report	H	R	R
		Non-Destructive Examination (NDT): Magnetic Particle Examination (100% exterior & accessible interior)	100%	Material & Technical Specification /ASME B 16.34	MPI Report	H	R	R
		ENP (For Ball): Visual, Thickness & Hardness	100%	25 microns (min) & 50 HRC (min)	Vendor Test Certificate	H	R	R
3.0	**INCOMING / BOF ITEMS**							
3.1	Stem	Chemical: Chemical Analysis	All Heats	Material & Technical Specification	Vendor Test Certificate	H	R	R
		Mechanical: Mechanical Test	All Heats	Material & Technical Specification	Vendor Test Certificate	H	R	R
3.2	Fasteners	Chemical: Chemical Analysis	All Heats	Material & Technical Specification	Vendor Test Certificate	H	R	R
		Mechanical: Mechanical Test	All Heats	Material & Technical Specification	Vendor Test Certificate	H	R	R

		Impact Test (@ -29°C): for CS Impact Test (@ -45°C): for LTCS	All Heats	Material & Technical Specification /ASME B 16.34	Test Report	H	R	R
3.3	Gaskets, Gear units, Gland, Packings, etc.	Physical / Chemical Properties	100%	Material & Technical Specification	Test Certificates & Lab Report	H	R	R
4.0	**MACHINED COMPONENTS**							
4.1	Body, Connector, Ball & Seat Ring	Surface examination & Dimension Inspection: Visual & Measurement	100%	Manufacturer's Drawing	Inspection Reports	100%	R	R
5.0	**IN-PROCESS**							
5.1	Body & Connector joint welding	Non-Destructive Examination (NDT): Magnetic Particle Examination (MPI)	100%	ASME Sec VIII - Appendix V & VI	MPI Report	100%	R	R
5.2	Valve & Pup Piece Bevel Ends joint welding	Non-Destructive Examination (NDT): Radiography (100% on weld joint)	100%	ASME B16.34	RT Report	100%	R	R
6.0	**FINAL INSPECTION**							
6.1	Finished Valve Assembly: Pressure Test & Final Inspection	Shell Test: Hydrostatic	100%	Testing Procedure as per Code	Test Record	-	H	RW
6.2		Seat Test: Hydrostatic				-	H	RW

6.3		Seat Test: Pneumatic				-	H	RW
6.4		Functional Test - Actuated Valve @ Atm. Pressure & Max. Diff. Pressure: Operation- Open / Close				-	H	RW
6.5		Double Block & Bleed: Hydrostatic				-	H	RW
6.6		Final Inspection: Visual, Dimension, TC Verification, Special Requirements & Marking as per sale order	100%	Approved GA Drawing (if applicable)	Test Report	-	H	RW
6.7		Anti-Static Test	100%	API 6D & Technical Specification	Test Record	-	H	RW
6.8		Fire Safe Test	100%	API-6FA / ISO-10497	Fire safe type test report	-	H	RW
6.9	PMI Check	Chemical	Technical Specification	Technical Specification	Inspection Report	-	H	RW
6.10	Final Stamping	Stamping Of Accepted Valves	Stamping of Valves which are witnessed by PLECO/ TPIA	As per Tender Specification	Inspection Report	-	H	H
7.0	**PAINTING & PACKING**	Surface examination & DFT Inspection: Visual & Measurement	100%	As per Tender Specification	Painting Record	-	H	RW

8.0	**DOCUMENTATION & INSPECTION CERTIFICATE(IC)**	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	As per Tender Specification	Supplier TC & IC	-	H	H

Legend

- H - Hold (Do not proceed without approval),
- P - Perform,
- RW - Random Witness [As specified or 10% (min.1 no. of each size and type of Bulk items)],
- R - Review,
- W - Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

1. Supplier Test Certificates to be reviewed by CLIENT / TPIA.
2. This document describes the generic test requirements. Any additional test or Inspection scope if specified/required in contract documents shall also be Applicable (unless otherwise agreed upon).
3. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in/ Job Specification /Approved Documents.
4. For orders placed on stockist, items shall be accepted based on manufacturer's TC with EN310204 type 3.2 certification from approved suppliers.

INSPECTION AND TEST PLAN – FLANGES SPECTACLE BLINDS & DRIP RINGS

0	04.01.22	ISSUED AS INSPECTION AND TEST PLAN	PNS	MD	AD
Rev.	**Date**	**Purpose**	**Prepared by**	**Reviewed by**	**Approved by**

ABBREVIATIONS:

CE	Carbon Equivalent	NDT	Non Destructive Testing
CIMFR	Central Institute of Mining & Fuel Research	NPSH	Net Positive Suction Head
DFT	Dry Film Thickness	PO	Purchase Order
DPT	Dye Penetrant Testing	PESO	Petroleum Explosive Safety Organization
DHT	De-hydrogen Heat Treatment	PQR	Procedure Qualification Record
ERTL	Electronics Regional Test Laboratory	MR	Material Requisition
FCRI	Fluid Control Research Institute	PMI	Positive Material Identification
HT	Heat Treatment	RT	Radiography Testing
HIC	Hydrogen Induced Cracking	SSCC	Sulphide Stress Corrosion Cracking
ITP	Inspection and Test Plan	TC	Test Certificate
IP	Ingress Protection	TPI or TPIA	Third Party Inspection Agency
IHT	Intermediate Heat Treatment	UT	Ultrasonic Testing
IC	Inspection Certificate	VDR	Vendor Data Requirement
IGC	Inter Granular Corrosion	WPS	Welding Procedure Specification
MPT/MT	Magnetic Particle Testing	WPQ	Welders Performance Qualification
MTC	Material Test Certificate		
MRT	Mechanical Run Test		

1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Flanges, Spectacle blinds& Drip Rings.

2.0 REFERENCES

PO / PR / Standards referred there in / Job specifications / Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS:

SL. NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	TPIA
1.0	**Procedure**						
1.1	Heat Treatment, NDT and Other Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS,PQR & WPQ	Welding Parameters & Qualification Record	100%	WPS,PQR &WPQ	-	H	W- New R- Existing
2.0	**Material Inspection**						
2.1	Raw Material Inspection	Chemical & Mechanical Properties	100%	Test Certificates	-	H	R

3.0	**In Process Inspection**						
3.1	Welding / Forging	Forging /Welding Parameters	100%	Inspection Reports	-	H	-
3.2	Heat Treatment	Stress Relieving, Normalising, Tempering, Solution Annealing, Stabilization Heat Treatment etc. as applicable	100%	HT chart	-	H	R
3.3	Identification of Test Samples	Product Chemical, Mechanical, Impact, IGC and Other test as applicable	100%	Test Reports	-	H	H(Note-1)
3.4	Product Analysis (As applicable)	Chemical Composition	As per PR/Purchase Specification	Test Reports	-	H	R
3.5	Destructive Testing	Mechanical, Impact, IGC and Other test as applicable	100%	Test Reports	-	H	H(Note-1)
3.6	NDT as applicable	Surface & Internal Imperfections	As per PR/Purchase Specification	NDT Reports	-	H	R
3.7	Galvanizing (If Applicable)	Integrity Of Galvanised Coating	100%	Inspection Report	-	H	-

4.0	**Final Inspection**							
4.1	Final Inspection	1.Visual 2. Dimensions 3.Hardness 4. Marking etc	100%	Inspection report	-	H	H(Note-1)
4.2	PMI Check	Chemical Check	As Per PLECO Spec.	Inspection report	-	H	RW
4.3	Final Stamping	Stamping of accepted Items	Stamping of Items which are witnessed by TPIA.	Inspection report	-	H	H(Note-1)
5.0	**Painting**						
5.1	Rust Preventive Coating & Colour Coding	Visual Inspection & Colour Coding as applicable	100%	Inspection report	-	H	-
6.0	**Documentation & IC**						

6.1	Documentation & Inspection Certificate(IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

Legend:

H - Hold (Do not proceed without approval), P - Perform,

RW - Random Witness (As specified or 10% [min.1 no. of each size and type of Bulk item]) R - Review,

W - Witness (Give due notice, work may proceed after scheduled date).PR- PURCHASE REQUISITION

NOTES (As applicable):

1. For Non NACE & Non Hydrogen service Carbon Steel Flanges, Spectacle Blinds & Drip Rings up to size 24"-300ANSI Class Will be accepted on review of Supplier Test Certificates. Supplier Test Certificate to be reviewed by TPIA.
2. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be Applicable (unless otherwise agreed upon).
3. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in / Job Specification /Approved Documents.
4. For orders placed on stockist, items shall be accepted based on manufacturer's TC with EN 10204 type 3.2 certification from PLECO/ OWNER approved suppliers.

INSPECTION AND TEST PLAN

FOR

SMALL SIZE & ASSORTED LENGTH PIPES

Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by
00	18.10.22	ISSUED AS INSPECTION AND TEST PLAN	PNS	SM	AD

Format : PLECO-F-006

REVISION RECORD

Rev.	Revision Date	Prepared by	Checked by	Approved by	Authorized by	Revision Description
00	19.10.2022					
		PNS	SM	AD	SK	

ABBREVIATIONS:

CE	Carbon Equivalent	NDT	Non – Destructive Testing
DFT	Dry Film Thickness	NPSH	Net Positive suction Head
DPT	Dye Penetrant Testing	PO	Purchase Order
DHT	De-hydrogen Heat Treatment	PESO	Petroleum Explosive Safety Organization
ERTL	Electronics Regional Test Laboratory	PQR	Procedure Qualification Record
FCRI	Fluid Control Research Institute	MR	Material Requisition
HT	Heat Treatment	PMI	Positive Material Identification
HIC	Hydrogen and Test Plan	RT	Radiography Testing
ITP	Inspection and Test Plan	SSCC	Sulphide Stress Corrosion Cracking
IP	Ingress Protection	TC	Test Certificate
IHT	Intermediate Heat Treatment	TPI or TPIA	Third Party Inspection Agency
IC	Inspection Certificate	UT	Ultrasonic Testing
IGC	Inter Granular Corrosion	VDR	Vendor Data Requirement
MPT/ MT	Magnetic Particle Testing	WPS	Welding Procedure Specification
MTC	Material Test Certificate	WPQ	Welders Performance Qualification
MRT	Mechanical Run Test		

1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of small sizes and Assorted length pipes.

2.0 REFERENCES

PO / MR / Standards referred there in / Job specifications / Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS:

SL.NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	PLECO/TPIA
1.0	**Procedure**						
1.1	Hydro Test, NDT, Heat treatment and Other Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS, PQR & WPQ	Welding Parameters & Qualification Record	100%	WPS, PQR & WPQ	-	H	W-New R-Existing
2.0	**Material Inspection**						

SL.NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	PLECO/TPIA
2.1.	Raw Material Inspection	Chemical & Mechanical Properties	100%	Procedure Documents	-	H	R
3.0	**In Process Inspection**						
3.1	Welding	Welding Parameters as per WPS/ PQR	100%	Inspection Reports	-	H	-
3.2	Heat Treatment as applicable	Stress Relieving, Normalising, Tempering, Solution Annealing, Stabilization Heat Treatment etc. as applicable	100%	HT chart/ Record	-	H	R

SL.NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	PLECO/TPIA
3.3	Ferrite Check of SS Pipes (If Applicable)	% Ferrite Check	Random on Weld	Inspection Report	-	H	R
3.4	NDT As Applicable	Surface & Internal Imperfections	MR/ Material Specification	RT Films/ Test Reports	-	H	R
3.5	Identifications of Test Samples	Product Chemical, Mechanical, Impact, IGC and other test as applicable	100%	Test Reports	-	H	H (Note-1)
3.6	Product Analysis	Chemical Composition	MR/ Material Specification	Test Reports	-	H	R

SL.NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	PLECO/TPIA
3.7	Destructive Testing	Mechanical, Impact, IGC and other test as applicable.	MR/ Material Specificatio n	Test Reports	-	H	H (Note-1)
3.8	Galvanizing (If Applicable)	Integrity of Galvanised Coating	100%	Inspection Reports	-	H	R
4.0	**Final Inspection**						
4.1	Hydrostatic Test	Leak check	100%	Test Report	-	H	RW (Note-1)
4.2	Visual and Dimensional Inspection (VDI)	Surface Condition, Straightness, End Finish, Bevel Angle, Root Face, Outer Dia., Thickness, Length, End Finish, Marking etc.	100%	Inspection Report	-	H	-
4.3	Weight checking as applicable	Weight	100%	Inspection Report	-	H	-

SL.NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	PLECO/TPIA
4.4	PMI Check	Chemical Check	As per spec.	Inspection Report	-	H	H (Note-1)
4.5	Final Stamping	Stamping of accepted Pipes	Stamping of Pipes which are witnessed by Owner/ TPIA	Inspection Report	-	H	H (Note-1)
5.0	**Painting**						
5.1	Rust Preventive Coating & Colour Coding	Visual & Colour Coding as applicable	100%	Inspection Report	-	H	-
6.0	**Documentation & IC**						
6.1	Documentation & Inspection Certificate (IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Manufacturer TC & IC	-	H	H

Legend: H - Hold (Do not proceed without approval), P - Perform, RW - Random Witness (As specified or 10% [min.1 no. of each size and type of Bulk item]), R - Review, W - Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

1. For Non -NACE & Non -Hydrogen service Carbon Steel Pipes up to size 12" will be accepted on review of Supplier Test Certificates. Supplier Test Certificate to be reviewed by Owner/TPIA.

2. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable. (Unless otherwise agreed upon)

3. Acceptance Norms for all the activities shall be as per PO/MR/STANDARDS referred there in /Job Specification /Approved Documents.

4. For orders placed on stockiest, items shall be accepted based on manufacturer's TC with EN310204 type 3.2 certification from PLECO / OWNER approved suppliers.

INSPECTION AND TEST PLAN

FOR

CHECK, GATE & GLOBE VALVES

0	10.03.22	ISSUED AS INSPECTION AND TEST PLAN	PNS	MD	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by

INSPECTION AND TEST PLAN FOR CHECK, GATE & GLOBE VALVES

REVISION RECORD						
Rev.	**Revision Date**	**Prepared by**	**Checked by**	**Approved by**	**Authorized by**	**Revision Description**
0	09.03.2022	PNS	MD	AD	SK	

ABBREVIATIONS:

FCRI	Fluid Control Research Institute	MPT/MT	Magnetic Particle Testing
HT	Heat Treatment	MTC	Material Test Certificate
CE	Carbon Equivalent	MRT	Mechanical Run Test
DFT	Dry Film Thickness	NDT	Non Destructive Testing
DPT	Dye Penetrant Testing	NPSH	Net Positive Suction Head
DHT	De-hydrogen Heat Treatment	PO	Purchase Order
ERTL	Electronics Regional Test Laboratory	PESO	Petroleum Explosive Safety Organization
IGC	Inter Granular Corrosion	PQR	Procedure Qualification Record
VDR	Vendor Data Requirement	PR	Purchase Requisition
WPQ	Welders Performance Qualification	PMI	Positive Material Identification
ITP	Inspection and Test Plan	RT	Radiography Testing
IP	Ingress Protection	WPS	Welding Procedure Specification

IHT	Intermediate Heat Treatment	TC	Test Certificate
IC	Inspection Certificate	TPI or TPIA	Third Party Inspection Agency
UT	Ultrasonic Testing		

1.0 SCOPE:

This Inspection and Test Plan covers the minimum testing requirements of Valves

2.0 REFERENCE DOCUMENTS:

PO / PR / Standards referred there in / Job specifications / Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS:

SL.NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	PLECO/TPIA
1.0	**Procedure**						
1.1	Hydrostatic Test, Heat Treatment, NDT and Other Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS,PQR & WPQ	Welding Parameters & Qualification Record	100%	WPS ,PQR & WPQ	-	H	W- New R- Existing
1.3	Pre-Qualification Tests	Fire safe, Cryogenic & Other Test as applicable	As per PR/Purchase Specification	Acceptance Report	-	H	H (If new)

SL.NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	PLECO/TPIA
2.0	**Material Inspection**						
2.1.	Castings & Forgings (Body, Bonnet, Disc, Stem, Body ring)	Chemical ,Mechanical , Heat Treatment, NDT,IGC & Other Properties as applicable	100%	Test Certificates	H	R	R
2.2	Castings & Forgings (Body, Bonnet, Disc, Stem, Body ring)	Visual & Dimension	100%	Inspection Report	H	H	-
2.3	Body and Bonnet Castings	Radiography Examination	As per PR / Purchase Specification	Films and report	H	R	R
2.4	Bars for Trim material	Chemical Analysis	Each Heat	Test Certificates& Lab Report	H	R	-
2.5	Gaskets, Gear units, Fasteners, Gland, Packings, etc.	Physical / Chemical Properties	100%	Test Certificates& Lab Report	H	R	-

SL.NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	PLECO/TPIA
2.6	Actuators as applicable	Performance , Statutory Certificates as applicable	100%	Test Certificates& Lab Report	H	H	R
3.0	**In Process Inspection**						
3.1	Welding	Welding Parameters as per WPS / PQR	100%	Inspection Reports	-	H	-
3.2	Machining of components	Visual / Dimension	100%	Inspection Reports	-	H	-
4.0	**Final Inspection**						
4.1	Hydrostatic / Pneumatic Test and Helium Leak test as applicable	Leak Check	As per PR / Purchase Specification	Test Report	-	H	RW (Note 1)

SL.NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	PLECO/TPIA
4.2	Visual / Dimension	Surface & Dimension Check	100%	Test Report	-	H	RW (Note 1)
4.3	Functional Test for Actuator Operated Valves	Satisfactory Performance	100%	Test Report	-	H	RW
4.4	PMI Check	Chemical	As per Spec.	Inspection Report	-	H	RW
4.5	Strip Check(As applicable)	Verify Components & Differential hardness if applicable	As per PR / Purchase Specification	Inspection Report	-	H	RW (Note 1)
4.6	Final Stamping	Stamping Of Accepted Valves	Stamping of Valves which are witnessed by PLECO/TPIA.	Inspection Report	-	H	H (Note -1)

SL.NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	PLECO/TPIA
5.0	**Painting**						
5.1	Painting and Colour coding as applicable	Visual / DFT Check	100%	Inspection Report	-	H	-
6.0	**Documentation & IC**						
6.1	Documentation & Inspection Certificate(IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

Legends:

H - Hold (Do not proceed without approval),

P - Perform,

RW - Random Witness [As specified or 10% (min.1 no. of each size and type of Bulk items)],

R - Review,

W - Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

1. For Non NACE & Non Hydrogen Service Carbon Steel Valves up to size 12" will be accepted on review of Supplier Test Certificates. Supplier Test Certificate to be reviewed by PLECO /TPIA.

2. This document describes the generic test requirements. Any additional test or Inspection scope if specified/required in contract documents shall also be Applicable (unless otherwise agreed upon).

3. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.

4. Final Certification Shall be EN 10204 Type 3.2

PLECO	LIST OF RECOMMENDED THIRD PARTY INSPECTION AGENCY (TPIA)			
	CONSULTANT:	**Pipeline Engineering Consultants Private Limited (PLECO)**		
SL. NO	**NAME OF TPI**	**ADDRESS**	**PHONE NO**	**FAX NO**
1	Tata Projects Ltd.	22,Sarvodaya Society,Nizampura,Baroda-390002	0265-2392863	0265-2785952
2	Bax counsel Inspection Bureau Pvt. Ltd.	303, Madhava,Bandra Kurla Complex, Bandra(E),Mumbai-400051	022-26591526,022-26590236	022-26591526
3	Germanischer Lloyd	4th Floor, Dakshna Building, Sec-11, Plot NO.2, CBD Belapur, Navi Mumbai 400 614	022-4078 1000	022-4024 2935
4	ABS Industrial Verification Ltd., Mumbai	404,Mayuresh Chambers,Sector-11,CBD Belapur(E),Navi Mumbai-400614	022-27578780 /1 /2	022-27578784 / 5
5	Certification Engineers International Ltd.	EIL Bhavan,5th floor,1,Bhikaji Camma Place, New Delhi-110066	011-26167539,26102121	011-26101419
6	Dalal Mott MacDonald	501, Sakar -II, Ellisbridge,Ahemedabad-380006	079-26575550	079-6575558
7	International Certification Systems	E-7,Chand Society, Juhu Road, Juhu, Mumbai-4000049	022-26245747	022-226248167
8	SGS	SGS India Pvt. Ltd.,SGS House,4B,A.S.Marg,Vikhroli(W),Mumbai-400083	022-25798421 to 28	022-25798431 to 33
9	Intertek Moody	9th Floor, Kanchenjunga Building, 18-Barakhamba Road, New Delhi-110001	011-4713 3900	011-4713 3999
10	TUV SUD South Asia	C-153/1, Okhla Industrial Ara, Phase-1, New Delhi-110020	011-3088 9611/9797	011-3088 9598
11	TUV Rheinland (India) Pvt. Ltd.	F-51, Kailash Complex GF, Veer Savarkar Marg, Vikhroli Park Site, Vikhroli(W), Mumbai-400079	022-4215 5435	022-4215 5434
12	Vincott International India Assessment Service Pvt. Ltd.	C-301, Mangalya Premises Cooperative Soc. Ltd, Off. Marol Maroshi Road, Andheri(E), Mumbai-400959	022-4247 4100	022-4247 4101
13	Meenar Global Consultants	Mr. Nitin Taneja (Project Manager)	M: +91-9711212783 T: +91-129-4072836	Web : www.meenaar.in Email : nitin.taneja@meenaar.in
14	VCS Quality Services Pvt. Ltd.	505, 5th floor, 360 Degree Business Park, Next to R-Mall, L.B.S. Marg, Mulund West, Mumbai 400080	Tel: 91 22 21649720	091 22 21646392
15	Edlipse Engg. Global Pvt. Ltd.	Office No. - 24 , Upper ground floor, Parsvnath Bibhab Plaza, Alpha-1, Commercial Belt, Greater Noida UP . Mobile - +91 9910502293 Landline - +91 120 4922792	Mobile - +91 9910502293 Landline - +91 120 4922792	www.edlipse.com

LIST OF APPROVED PARTIES FOR BOUGHT OUT ITEMS

Z-STD-001

0	26.08.22	ISSUED FOR STANDARD	PNS	MD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

CONTENTS

LIST OF SUPPLIERS OF MAJOR BOUGHT - OUT ITEMS

1. (MECHANICAL & FIRE FIGHTING EQUIPMENT)

i) Pipe Carbon Steel to Indian Standards

1. A.S.T. Pipes Pvt. Ltd. (AST Group)
2. Advance Steel Tube Ltd.
3. Apl Apollo Tubes Ltd. (Er. Bihar Tubes Ltd.
4. Asian Mills Pvt. Ltd.
5. Asrani Tubes Limited
6. Dadu Pipes (P) Ltd.
7. Essar Steel Limited (Er Hazira Pipes Mill)
8. Gaurang Products Pvt Ltd. (Ast Group)
9. Goodluck Steel Tubes Ltd.
10. Hi-Tech Pipes Limited
11. Indus Tube Limited
12. Jindal Industries Ltd
13. Jindal Pipes Ltd.
14. Jindal Saw Ltd (Kosi Works)
15. Jotindra Steel & Tube Ltd
16. Lalit Pipes and Pipes Ltd.
17. Maharashtra Seamless Ltd.
18. Man Industries (India) Ltd. – Pithampur
19. Man Industries (India) Ltd. Anjar
20. Mukat Tanks & Vessels Ltd.
21. Nezone Tubes Limited
22. North Eastern Tubes Limited
23. Pratibha Industries Limited
24. Pratibha Pipes & Structural Ltd.

25. Psl Ltd (Chennai)
26. Psl Ltd (V1, V2 & Nc)
27. Rama Steel Tubes Ltd.
28. Ratnamani Metals and Tubes Ltd.
29. Ravindra Tubes Limited
30. Samshi Pipe Industries Limited
31. Surya Roshni Ltd.
32. Swastik Pipes Ltd.
33. Utkarsh Tubes & Pipes Ltd. (Formly Bmw)
34. Welspun Corp. Limited (Dahej)
35. Zenith Birla (India) Limited

ii) <u>Pipe & Tubulars To A.P.I. Standards</u>

1. Arcelormittal Tubular Products Roman Sa, Romania
2. Bhel (Trichy), India
3. Dalmine Spa (Enquiry To Tenaris),Uae
4. Eewkorea Co. Ltd (Germany), Korea
5. Eew Korea Co. Ltd. (Korea), Korea
6. Eisenbau Kramer Gmbh, Germany
7. Hyundai Rb Co. Ltd. South Korea
8. Ilva Lamiere E Tubi Srl (Enq to Ilva Spa, Italy
9. Inox Tech. Spa, Italy
10. Ismt Ltd. Ahmedngr, India
11. Ismt Ltd. Baramati, India
12. Jindal Pipes Ltd., India
13. Jindal Saw Ltd. (Kosi Works), India
14. Jindal Saw Ltd. (Nashik Works), India
15. Lalit Pipes and Pipes Ltd. India

16. Maharashtra Seamless Ltd., India
17. Man Industries (I) Ltd. (Pithampur), India
18. Mukat Tanks & Vessels Ltd., India
19. Pratibha Industries Limited, India
20. Ratnamani Metals and Tubes Ltd., India
21. Siderca S.A.I.C (Enquiry Totenaris), Uae
22. Sumitomo Metal Ind. Ltd., India
23. Surya Roshni Ltd., India
24. Swastik Pipes Ltd, India
25. Tata Steel Uk Limited (Formerly C702)
26. Tubos De Acero De Mexico Sa (Enq. Tenaris), Uae
27. Tubos Reunidos Sa Spain
28. Umran Steel Pipe Inc (Turkey), Turkey
29. Valcovny Trub Chomutov, Czech Republic
30. Vallourec and Mannesmann Tubes, France
31. Welspun Corp Limited (Dahej), India

iii) <u>Pipe/Tube CS (Seamless) To ASTM Stds</u>

1. Arcelormittal Tubular Products Roman Sa, Romania
2. Bhel (Trichy), India
3. Changshu Seamless Steel Tube Co. Ltd., China
4. Dalmine Spa (Enquiry to Tenaris, Uae
5. Heavy Metals & Tubes Limited (Mehsana), India
6. Ismt Ltd. Ahmedngr, India
7. Ismt Ltd. Baramati India
8. Jfe Steel Corporation, Uae
9. Jindal Sdaw Ltd (Nashik Works) India
10. Klt Automotive and Tubular Products Ltd., India

11. Mahalaxmi Seamless Limited, India
12. Maharashtra Seamless Ltd, India
13. Products Tubulares S.A.U, Spain
14. Ratnadeep Metal Tubes Ltd., India
15. Staineest Tubes Pvt Ltd., India
16. Sumitomo Metal Ind. Ltd., India
17. Tubos Reunidos Sa Spain
18. Valcovny Trub Chomutov, Czech Republic
19. Vallourec Andmannesmann Tubes France
20. Yangzhou Chengde Steel Pipe Co. Ltd Dubai (UAE)

iv) <u>Pipe Carbon Steel (Welded) To ASTM Stds</u>

1. Eew Korea Co. Ltd. (Germany), Korea
2. Eew Korea Co. Ltd. (Korea), Korea
3. Eisenbau Kramer Gmbh, Germany
4. Hyundai Rb Co. Ltd., South Korea
5. Inox Tech. Spa, Italy
6. Jindal Saw Ltd (Kosi Works), India
7. Lalit Pipes And Pipes Ltd., India
8. Man Industeries (I) Ltd.(Pithampur), India
9. Man Industries (India) Ltd. Anjar, India
10. Mukat Tanks & Vessels Ltd., India
11. Ratnamani Metals And Tubes Ltd., India
12. Sumitomo Metal India Ltd., India
13. Tata Steel Uk Limited

v) <u>Valve</u>

a) Globe Valves

1) M/s BDK (New Delhi)

2) M/s Datre Corpn (Calcutta)

3) M/s KSB Pumps (New Delhi)

4) M/s L&T (New Delhi)

5) M/s Neco Schuber & Salzer Ltd. (New Delhi)

6) M/s Niton Valve (Mumbai)

7) M/s Ornate Valves (Mumbai)

8) M/s Panchavati Valves (Mumbai)

9) AV Valves Ltd.

10) BHEL (Trichy), India

11) Econo Valves Pvt Ltd, India

12) Fouress Engg (I) Ltd (Aurangabad)

13) Guru Industrial Valves Pvt Ltd

14) Leader Valves Ltd, India

15) NSSL Ltd. (Neco Schubert & Salzerltd)

16) Oswal Industries Ltd, India

17) Petrochemical Engineering Enterprises, India

18) Sakhi Engineers Pvt Ltd

19) Shalimar Valves Pvt Ltd

20) Steel Strong Valves India Pvt Ltd, India

21) Petro Valves Pvt. Limited, Ahmedabad

b) Check Valves

1. M/s Advance Valves Pvt. Ltd., Noida
2. M/s Aksons & Mechanical Enterprises, Mumbai
3. M/s Larsen & Toubro Limited (M/s Audco India Limited, Chennai)
4. M/s AV valves Ltd., Agra
5. M/s BDK engineering India Ltd., Hubli
6. M/s BHEL,OFE&OE Group, New Delhi

7. M/s Datre Coroportion Limited, Calcutta
8. M/s Leader Valves Ltd., Jalandhar
9. M/s Neco schubert &Salzer Ltd., New Delhi
10. M/s Niton Valves Industries (P) Ltd., Mumbai
11. M/s Precision Engg.Co., Mumbai
12. Econo Valves Pvt Ltd, India
13. Fouress Engg (I) Ltd (Aurangabad)
14. KSB Pumps Ltd (Coimbattore), India
15. NSSL Ltd. (Neco Schubert & SalzerLtd)
16. Oswal Industries Ltd, India
17. Panchvati Valves & Flanges Pvt Ltd, India
18. Petrochemical Engineering Enterprises, India
19. Sakhi Engineers Pvt Ltd
20. Shalimar Valves Pvt Ltd
21. Steel Strong Valves India Pvt Ltd, India

c) Plug Valves

1. M/s Breda Energia Sesto Industria Spa, Italy
2. M/s Fisher Sanmar Ltd., Chennai
3. M/s Larsen & Toubro Ltd., New Delhi
4. M/s Nordstrom Valves, USA
5. M/s Serck Audco Valves, UK
6. M/s Sumitomo Corporation India Pvt. Ltd., New Delhi
7. M/s Z Corporation, Korea
8. M/s Hawa Valves (India) Pvt. Ltd., Mumbai
9. M/s Steel Strong Valves India Pvt. Ltd., Navi Mumbai
10. M/s Econo Valves
11. M/s Flow-Serve PTE (Mfr. SERCK), India

d) Ball Valves

1. M/s Hawa Valves (India) Pvt. Ltd, Navi Mumbai
2. M/s Larsen & Toubro, Delhi
3. M/s Microfinish Valves Pvt. Ltd., Noida
4. M/s Oswal Industries Ltd., Gandhi nagar
5. M/s Virgo Engineers Ltd., Delhi
6. M/s Boteli Valve Group Co. Ltd., China
7. M/s Cameron (Malaysia) SDN BHD, Malaysia
8. M/s Dafram S.P.A., Italy
9. M/s Fangyuan Valve Group Co. Ltd., China
10. M/s Franz Schuck GmbH, Germany
11. O.M.S. Saleri (Italy)
12. Pibi Viesse S.P.A (Italy)
13. Nuovo Pignone (Italy)
14. Perar S.P.A (Italy)
15. Pietro Fiorentini (Italy)
16. Cooper Cameron Valv Italy SRL-FRM, Itly
17. Petrol Valves SRL
18. Tormene Gas Technology S.P.A (VALVITALIA)

vi) Flow Tee

1. M/s Coprosider SPA, Italy
2. M/s GEA Energy System India Limited, Chennai
3. M/s Multitex Filteration
4. M/s Pipeline Engineering, UK
5. M/s Scomark Engg. Limited (U.K.)
6. M/s Skeltonhall Limited, Engaland(U.K.)
7. M/s Technospecial SPA, Italy

8. M/s Tectubi SPA, Italy
9. M/s RMA Germany
10. M/s Pipefit Engineers Pvt. Ltd.
11. M/s PSN Energy Systems (up to 24"NB, 600#)

vii) Split Tee

1. M/s T D Williamson India Private Limited, India
2. M/s Furmanite International Ltd., USA
3. M/s Huwelco Inc., South Houston
4. M/s Plant-Tech Power Technical Services Pvt. Ltd., India
5. M/s VKVC, India
6. Teemans, UK

viii) Flanges

1. M/s Aditya Forge Ltd., Vadodara
2. M/s Amforge Industries Ltd., Mumbai
3. M/s CD Engineering Co., Ghaziabad
4. M/s Echjay Forgings Pvt. Ltd. (Bombay), Mumbai
5. M/s Echjay Industries Ltd., Rajkot
6. M/s Forge & Forge Pvt. Ltd., Rajkot
7. M/s Golden Iron & Steel Works, New Delhi
8. M/s JK Forgings, New Delhi
9. M/s Metal Forgings Pvt. Ltd., Mumbai
10. M/s Perfect Marketings Pvt. Ltd., New Delhi
11. M/s Sky Forge, Faridabad
12. M/s S&G, Faridabad
13. Chaudhry Hammer Works Ltd, India
14. JAV Forgings (P) Ltd, India
15. Kunj Forgings Pvt Ltd, India

16. MS Fittings
17. R.N. Gupta & Co. Ltd, India
18. R.P. Engineering Pvt Ltd, India
19. Sanghvi Forgings & Engineering Ltd
20. Shri Ganesh Forgings Ltd., India
21. Uma Shankar Khandelwal & Co., India
22. Sawan Engineers, Baroda
23. Stewarts & Lloyds of India Ltd., Kolkata
24. Engineering Services Enterprises
25. Pipefit Engineers Pvt. Ltd.

ix) Fittings

1. M/s Commercial Supplying Agency, Mumbai
2. M/s Dee Development Engineers Ltd.
3. M/s Eby Industries, Mumbai
4. M/s Flash Forge Pvt. Ltd., Vishakhapatnam
5. M/s Gujarat Infra Pipes Pvt. Ltd., Vadodara
6. M/s M.S. Fittings Mfg. Co. Pvt. Ltd., Kolkata
7. M/s Stewarts & Lloyds of India Ltd., Kolkata
8. M/s Teekay Tubes Pvt. Ltd., Mumbai
9. M/s Pipe Fit,Baroda
10. M/s Sky Forge, Faridabad
11. M/s S&G, Faridabad
12. M/s Sawan Engineers, Baroda
13. Eby Fasteners, India
14. Leader Valves Ltd, India
15. R.N. Gupta & Co. Ltd, India
16. Exten Engg Pvt Ltd

17. Sivananda Pipe & Fittings Ltd
18. Sawan Engg - Vadodara
19. P.K. Tubes –rajastan
20. CSA fittings
21. Dee Development Engineers Limited (Palwal)
22. Fittech Industries Pvt Ltd (Thane)
23. Gujrat Infrapipes Pvt Ltd ,Vadodara
24. K.S Pipe Fittings (P) Ltd, Palwal
25. Teekay Tubes Pvt Ltd (New Mumbai)
26. Petro Chem Industries,Vadodara
27. Topaz Piping Industires ,Vadodara
28. Tube Bend ,Calcutta
29. Tube Turn India Pvt Ltd , Navi Mumbai
30. Sidharth & Gautam Engineers

x) <u>Gaskets</u>

1. IGP Engineers (P) Ltd., Madras
2. Madras Industrial Products, Madras
3. Dikson & Company, Bombay
4. Banco Products (P) Ltd., Vadodara
5. Goodrich Gaskets Pvt Ltd
6. Starflex Sealing India Pvt Ltd, India
7. Teekay Meta Flex Pvt Ltd
8. UNIKLINGER Ltd
9. HEM Engg. Corp.
10. Unique Industrial Packing Pvt. Ltd.

xi) <u>Fasteners</u>

1. Nireka Engg. Co. (P) Ltd., Calcutta

2. Precision Taps & Dies, Bombay
3. AEP Company, Vithal Udyoug Nagar
4. Fix Fit Fasteners, Calcutta
5. Precision Engg. Industries, Baroda
6. Echjay Forgings Pvt. Ltd., Bombay
7. Capital Industries, Bombay
8. Boltmaster India Pvt Ltd, India
9. Deepak Fasteners Limited, India
10. Fasteners & Allied Products Pvt Ltd, India
11. Hardwin Fasteners Pvt Ltd, India
12. J.J. Industries, India
13. Multi Fasteners Pvt Ltd, India
14. Nexo Industries, India
15. Pacific Forging & Fasteners Pvt Ltd, India
16. Pioneer Nuts & Bolts Pvt Ltd, India
17. Precision Auto Engineers, India
18. President Engineering Works, India
19. Sandeep Engineering Works, India
20. Syndicate Engineering Industries, India

xii) <u>Welding Electrodes</u>

1. For Mainline – Lincon make
2. For Terminal – For root pass - Lincon Make
3. For other passes – Lincon, D&H or equivalent make

xiii) <u>Fire Fighting Equipment's</u>

a) Fire Extinguishers

1. Avon Services (Production & Agencies) Pvt. Ltd., Bombay
2. Kooverji Devshi & Co., Bombay

3. Zenith Fire Services, Bombay
4. Safex Fire Services, Bombay
5. Reliable (Fire Protection) India Ltd., Bombay
6. Brijbasi Hi-Tech Udyog ltd.
7. Bharat Engg Works, India
8. Gunnebo India Ltd
9. Nitin Fire Protection Industries Ltd, India
10. Supremex Equipments, India
11. Vimal Fire Controls Pvt Ltd., India

b) Fire Hydrants, Monitors, Deluge Valve, Nozzles

1. Zenith
2. Minimax
3. Newage
4. HD Fire
5. Vijay Fire
6. Asco Strumech Pvt Ltd, India
7. Brij Basi Hi
8. tech Udyog
9. Gunnebo India Ltd
10. Nitin Fire Protection Pvt Ltd
11. Shah Bhogilal Jethamal & Brothers
12. Venus Pumps & Engineering Works

c) RRL Hose

1. Jayshree
2. Newage

d) Hoses

1. Ashit Sales Corporation, Bombay

2. Royal India Corporation, Bombay
3. Gayatri Industrial Corporation
4. Simplex Rubber Products Ltd., Ahmedabad
5. Zaverchand Marketing Pvt. Ltd., Baroda
6. Presidency Rubber Mill, Calcutta
7. The Cosmopolite, Calcutta
8. Simplex Rubber Products, Thane

e) Hose Delivery

1. Chhatarya Rubber & Chemical Industries,
2. Nitin Fire Protection Industries Ltd, India

f) Fire Hose Accessories

1. Asco Strumech Pvt Ltd
2. Brij Basi Hi-tech Udyog
3. Gunnebo India Ltd
4. Shah Bhogilal Jethamal & Brothers
5. Vimal Fire Controls Pvt Ltd., India

g) Heat Shrinkable Sleeves

1. Seal for Life - Covalence
2. Canusa

h) Cold Applied Tapes

1. Denso GmBH
2. Polyken (Berry Plastics Corporation)

i) PUR Coating

1. Powercrete (Berry Plastics Corporation)

j) Casing End Closure

1. Raci, Italy
2. Raychem RPG Limited

k) Casing Insulators

1. Raci, Italy
2. Raychem RPG Limited

l) Rockshield

1. Raychem RPG Limited

m) Warning Tape /Mesh

1. Sparco Multiplast Pvt. Ltd., Ahmedabad
2. M/s Raychem RPG Limited
3. Singhal Industries Private Limited

n) High Build Epoxy Coating

1. Berry Plastics – Powercrete
2. Specialty Polymer Canada
3. Denso Protal, Canada

o) Casing Insulators

1. Raci, Italy
2. Raychem RPG Limited
3. Veekay Vikram

xiv) DRY GAS FILTER & FILTER SEPERATOR

1. Grand Prix Fab (Pvt.) Ltd.(New Delhi)
2. Perry Equipment, USA
3. Faudi Filter, Germany
4. Forain S.r.l., Italy
5. ABB, Faridabad
6. Burgess Manning, USA
7. Multitex Filtration Engineers India
8. Triveni Plenty Engg. Ltd. (New Delhi)
9. Siirtec International Contractor S.P.A (Italy)

10. Flashpoint, Pune india
11. Filteration Engineers (I) Pvt Ltd, India
12. Gujarat Otofilt, India
13. Tormene Gas Technology
14. Ultrafilter (India) Pvt Ltd, India
15. Ravi Techno Systems Pvt Ltd, India
16. Siirtec Nigi S.P.A
17. Filtan Filter Anlagenbau Gmbh
18. Fairley Arlon BV
19. PECO Facet
20. EPE Epenstenner GMBH
21. Filtrex srl
22. Petromar Engineered Soln
23. Plenty Filter
24. Eurofiltec
25. PTI Technologies Inc

xv) QUICK OPENING END CLOSURE (QOEC)

1. Forain S.R.L.
2. GD Engineering
3. Pipeline Engineering, UK
4. Siirtec Nigi S.P.A
5. TD Williamson
6. Peerless
7. Grinelli
8. Huber Yale
9. Tube Turn (U.S.A.)
10. Pipeline Technologies, France

11. M/s Grand Prix Engineering Pvt. Ltd.
12. M/s VKVC LLP
13. M/s Multitex Filtration Engineers Ltd

xvi) FILTER ELEMENT

1. Peco – Facet
2. Velcon
3. Pall – Filterite
4. Burgress Manning

xvii) NDT Agency

1. NDT Services, Ahmedabad
2. GEECY Industrial Services Pvt. Ltd., Mumbai
3. Corrosion Control Services, Mumbai
4. Perfect Metal Testing & Inspection Agency, Calcutta
5. Inter Ocean Shipping Co., New Delhi
6. RTD, Mumbai
7. Sievert, Mumbai
8. X-Tech, Vizag

xviii) Long Radius Bends

1. M/s BHEL, Trichy, Tamilnadu
2. M/s Jindal SAW Limited, (Koshi Works), U.P.
3. M/s PSL Limited, Gandhidham, Gujarat
4. M/s Welspun, Gujarat
5. M/s Fabricon, Belgium
6. M/s Sawan
7. M/s Gujarat Infra
8. M/s P K Tubes
9. M/s DEE Development

10. Pipefit Engineers Pvt. Ltd.

xix) PIG LAUNCHERS/ RECEIVERS/ PIG SIGNALERS

1. Bassi Luigi Fittings B.V., Holland
2. BRAUN STAHL PIPE TEC, GERMANY
3. FORAIN, ITALY
4. Fluidel SRL, ITALY
5. RMA Maschinen- und, GERMANY
6. Siiritec Nigi, Itlay
7. SCHUCK ARMATUREN, GERMANY
8. T.D. Williamson Inc., USA
9. Tectubi SPA, Italy
10. Taylor Forge Engineering System INC, USA
11. Tormene Americana S.A. (Argentina)
12. Tormene Gas Technology S.p.A., Italy
13. PIPELINE ENGINEERING, UNITED KINGDOM
14. Krohne, Oil & Gas BV, Drive Houston,
15. Multitex Filtration Engrs. Ltd, New Delhi
16. BGR ENERGY SYSTEMS LIMITED New Delhi
17. Glapwell Contracting Services Ltd. UK
18. FULGOSI GIOVANNI S.n.c di Corrado & C, ITALY
19. VEEKAY VIKRAM & CO, GUJRAT
20. GBM S.R.L, ITALY
21. Multitex F iltration Engineers Ltd., India
22. Cardew Ltd., Alexeander
23. Forain S.R.L.
24. GD Engineering, India

25. Pipeline Engineering, UK

26. Siirtec Nigi SPA

LIST OF MATERIALS OF APPROVED BRAND AND/ OR MANUFACTURE

2. (CIVIL & STRUCTURE)

Unless otherwise specifically mentioned in the Schedule of Items, Contractor has to use materials as listed below of only these brand names/ Company's names, which are mentioned in the approved list for civil, water supply and sanitary items thereon.

a. CIVIL

S. NO.	ITEMS/ NAME OF PRODUCTS	MAKE/ BRANDS/ MANUFACTURES
1.	Reinforcement Steel	TATA,SAIL,RINL,IISCO,RATHI
2.	Cement	Ambuja, ACC, JK, Grasim, Ultratech, Birla, L&T, Cement Corporation of India, Maihar
3.	Structural Steel	TATA, SAIL, RINL, IISCO, ESSAR, ISPAT
4.	Pre- engineered building (PEB) firms	Kirby Building system India ltd, Interach Building Product limited, Tata blue scope steel, Lloyd Insulation India ltd, Everest Industries. Ltd. Modern Prefab System Pvt Ltd, Aster Building Solution Pvt.Ltd, Octamec Engineering Ltd, Jindal Mectec Pvt Ltd, Fedders Lioyd Corporation Ltd.
5.	Structural Steel Tubes	TATA, JINDAL , SURYA , SWASTIK
6.	(a) Zincalume colour coated steel sheet (COIL) (b) Profile of Sheet (as per tender specification)	(a) Tata Blue scope, Dongbu Steel, Union Steel, JSW STEEL Ltd., Kirby Building system India ltd, Interach Building Product limited, Tata blue scope steel, Lloyd Insulation India ltd, Everest Industries. Ltd., Modern Prefab System Pvt Ltd, Aster Building Solution Pvt. Ltd, Octamec Engineering Ltd, Jindal Mectec Pvt Ltd, Fedders Lioyd Corporation Ltd.
7.	Polycarbonate Sheet	Sabic Innovative Plastic , Everest
8.	Mineral wool for thermal insulation of ceilings (Under deck insulation)	Rock wool (india) Ltd. Minwool Rock Fibres Ltd., Lloyd Insulation,

9.	Rolling shutters (ISI marked)	Swastic, Hercules, Shubdwar, M/s Bharat Rolling Shutters Industries Agra, Bengal Rolling Shutter Rama Rolling Shutter Works, Gandhi Entrance Automations Private Limited
10.	Wind driven air Ventilators	Apurva Enterprises (Mumbai), SVS Wind Driven Turbo Ventilator(Ahmadnagar), Real Green Engineers Pvt. Ltd., Bangalore, Sun Green Ventilation system Pvt. Ltd., Mylapore-Chennai, Citadel, Mumbai, Multi colour, Anchit Ispat Pvt Ltd. (Faridabad),
11.	Synthetic Enamel Paint (1st quality only)	ICI Paint (Dulux), Asian Paint (Apcolite), Berger Paints (Luxol). Goodlass Nerolac Paints (Nerolac), Jenson & Nicholson Paints Ltd (Borolac), Shalimar, Garware & Goodlass.
12.	G.I SHEET	ESSAR, JSW, SAIL
13.	Sheeting Screw	Corroshield, Buildex.
14.	Chemical for Antitermite treatment	DE-NOCIL Bombay, Pest Control of India, Trishul.
15.	Factory made Panelled Door shutter	M/s Goel Brothers Raipur New Industrial Area, Raipur (CG) M/s Hindustan Housing Factory Ltd, New Delhi M/s Delhi Construction Eqpt Sadar Bazar, Delhi M/s Joinery Manufacturing Co., Calcutta M/s Goyal Industries, Faridabad M/s Surbhi Metal (India) Ltd., Jodhpur M/s Jain wood Industries Sonipat/ Rohini, Delhi (HO) M/s Poineer Timber Products, Chandigarh

16.	Flush doors IS-2191, 2202	M/s Mysore Wood Products M/s Laxmi Doors, Faizabad Road, Chinhat, Lucknow M/s Merino flush doors M/s Poineer Timber Products, Chandigarh, M/s Goyal Industries Faridabad M/s National M/s Century Plyboards (i) Limited.
17.	Fly proof doors (Made out of solid block marine grade)	M/s Laxmi Doors, Faizabad Road, Chinhat, Lucknow, Northern doors Kanpur
18.	Natural Fibre Thermo Composite door/ window shutter & frames, roofing sheets etc.	Durosam
19.	PVC Panel Door (Solid Core)	Rajshri Plastiwood Limited, Sintex, Hindopan, Marino.
20.	Pressed steel door frames/ cupboard and window frames (manufacturers)	M/s SAIL, M/s TATA
21.	Pressed steel door frames/ cupboard and window frames (fabricators)	M/s Loyal safe works Mayapuri, New Delhi M/s Multiwyn Industrial Corpn., Calcutta M/s Metal Window Corpn., New Delhi M/s Chhabra Steel Udyog, 260 Sadar Bazar, Meerut Cantt. M/s Delite safe works, Rani Jhansi Road, New Delhi M/s Ishwar Industries, 175/A Bombay Bazar, Meerut Cantt. M/s Chandni Industries, J-142, Patel Nagar 1st, Ghaziabad.

22.	Steel Windows, Ventilators (as per IS-1038 of 1983) & frames pressed steel door/ window	M/s Multiwyn Industrial Corpn., Calcutta M/s Metal Window Corp N/ Delhi Govind Enterprises, Delhi M/s Chhabra Steel Udyog 260, Sadar Bazar, Meerut Cantt., Agent steel MFG Pvt Ltd, Ahmedabad, Godrej, M/s Chandni Industries, J-142, Patel Nagar 1st, Ghaziabad.
23.	Al Section for Al Door/ Window/ Partitions	Hindalco, Indal, Ajit India, Jindal
24.	Aluminuml Door/ Window/ Glazing Fabricated and Anodized	M/s Ahlcon M/s Alumilite Pvt Ltd, M/s Ajit India Pvt Ltd, M/s Ramniklal S Raste Agra, Argent Industries, M/s Aluminium Tech Industries, I-2249 DSIDC Narela, Delhi,
25.	Aluminium door and windows Fittings	M/s Elite Enterprises C/6 Shalimar Hardware 133, Jarg Mahal, Dhobitalao Mumbai 400002. M/s Mohan Metal Industries 178/2-A, Bhola Nath Nagar, Shahadara, Delhi 110032. M/s Mepro, Argent New Delhi, Classic, New Delhi. M/s Jindal, Argent New Delhi, M/s Golden Industries Pvt. Ltd. M/s ECIE (P) ltd.
26.	Automatic Glass Door	Ditec (Gandhi)
27.	Aluminium Grill	Alu Grill, Arihant Aluminium Corporation, Decogrille
28.	Door Closer	Everite, Golden, Gandhi
29.	Floor Spring	Prabhat, Everite
30.	Builders Hardware	M/s Golden Industries Pvt. Ltd., Everite, Solo, Hardwyn.

31.	Plywood for general purpose (IS-303)	National Plywood Inds Pvt Ltd, S Fancy lane, 8th floor, Calcutta-700001, Merino Plywood, Archid Ply, Kitply, Swastik, Universal
32.	Pre laminated Particle board	Kitply, Bhutan board, Ecoboard, Novapan, Archid ply, Merinova, Merino
33.	Laminated Sheets	Formica, Merino Lam, Greenlam, National
34.	Modular Partitions	Godrej, Blowplast
35.	False Ceiling (Mineral Fibre Board)	Armstrong, Daiken, Luxalon, Llyods, Gypboard, Trac, Aerolite
36.	False Ceiling (POP/ Gypsum Board)	Gypboard, Anchor ceiling tiles, LA
37.	Aluminium False	Lloyds, Armstrong, Luxlon, Trac
38.	Flooring Tiles (Mosaic/ Terrazzo/ PCC) (1st quality only)	M/s Mehtab Tiles, NITCO, Royal Tiles, Gem Tiles, Hindustan Tiles, M/s National Tiles & Industries, Ultra Tiles
39.	Glazed Ceramic Tiles, Non-Skid (Floor/ Wall), (1st quality only)	Kajaria, Somany, NITCO. Murudeshwar Ceramic Ltd (Navin Diamond tile), Johnson (Marbonite), Marbito, Somany, Orient, Asian
40.	Vitrified/ Designer Vitrified Tiles (1st quality only)	Asian, Marbonite (Johnson), Kerrogres (Kajaria), NITCO, Orient
41.	PVC Tiles/ Flooring (IS 3461) (1st quality only)	Marblex Tiles, Krishna Tiles, Polyfin, Armstrong, Wonder floor.
42.	False Flooring	Godrej or equivalent
43.	Glass Mosaic Tiles	Paladio, Coral, Accura, Bisazza, Italia, Mridul.
44.	Designer Paver Tiles/ Interlocking tiles ISI marked/ Grass-jointed Tiles (1st quality only)	Pavit, Ultra, Hindustan, Eurocon, Vyara, National Tiles, Gem, Unistone, Konkrete, Unitile
45.	Glass reinforced Paver block	Unistone or equivalent

46.	Wall care Putty for Base preparation (1st quality only)	Birla Wall care putty, Berger, Jenson & Nicholson, JK White
47.	White Cement	Birla, JK
48.	Cement based Paints (1st quality only)	Super Snowcem, Duracem, Super Acrocem.
49.	Dry Distemper/ Oil bound Distemper (1st quality only)	Goodlass Nerolac Paint, Shalimar Paint, Jenson & Nicholson, Asian Paint, Berger. ICI Dulux
50.	Acrylic Washable Distemper (1st quality only)	Asian, Berger, ICI Dulux, Jenson & Nicholson, Nerolac, Shalimar, Garware & Goodlass.
51.	Plastic Emulsion Paint (1st quality only)	Asian, Berger, ICI, Nerolac, Jenson & Nicholson, Shalimar, Garware & Goodlass.
52.	Exterior Acrylic Emulsion (1st quality only)	ICI (Weathercoat), Excel (Nerolac), Apex (Asian), Berger, Jenson & Nicholson, Shalimar, Garware & Goodlass
53.	Polymer based Paint	STP, CICO
54.	Textured Paint / Wall Tile (1st quality only)	Unitile, Heritage, Spectrum, Iokos, Acropaints, Asian
55.	Flexible board for Expansion joint	STP or equivalent
56.	Grout	Shrinkomp, Fosroc, Fairmate
57.	Integral water proofing compound	STP, Pidilite, Fosroc, CICO, Sika.
58.	Concrete Admixture	Pidilite, Fosroc, CICO, Sika.
59.	Water proofing for cementations surface IS-2645	Acrocrete & Acrocote, CICO, Fosroc, STP
60.	Bituminous Product	M/s Faridabad Spinning & Woolen Mills Pvt Ltd, 837, SP Mukherjee Marg Delhi, M/s STP Ltd (Formerly Shalimar Tar Products) M/s Bitufelt Pvt Ltd 123/377 Fazalm Ganj Kanpur-208012, Texas, Texas India Ltd, Multiplas, IWL Chennai

61.	Hardeners	Ironite, Ferrok, Hardonate
62.	Construction	Choksey, CICO, Forsroc, Sika
63.	Non Metalic Surface	CICO, Fosroc, STP, Sika
64.	Corrugated, Semi Corrugated & AC Sheets (IS-459-1970,IS-2098)	M/s Everest Bldg Products Ltd., Jata Sankar Bosa Marg, Muland (west), Bombay 400080 M/s Ramco AC Sheets “SWASTIK”, M/s Eternit Everest Ltd, UP Asbestos Ltd
65.	GI Sheet - ISI Marked	Multicolor, TATA, Bluescope, JSW, Colour Plus, Interarch, Lloyds, Jindal, Everest
66.	Sheet Glass/ Structural Glazing	Hindustan Pilkington Glass Works, Saint Gobain, Modi Float, Triveni Float Glass, ASI, Fresca, Emirates.
67.	Multiell/ Multiwall Polycorbonate Panel	M/s Coxwell Domes Engineering, Delhi M/s Lexan, M/s Gallina India Pvt. Ltd. M/s Vijaynath Interiors & exteriors products
68.	Stainless Steel	Jindal
69.	Punch Tape	Global Technocrat, S.G.Engineers, Delhi
70.	Punch Tape in Plastic Spool	Global Technocrat, S.G.Engineers, Delhi
71.	Stainless Steel Railing	Jindal
72.	FRP/ HDPE Garbage	Sintex, Swift, Nutech, Sheetal
73.	Thermoplastic Road	Shalimark (STP)
74.	Bollard	STP
75.	Cateye	TATA, STP
76.	Readymade Speed	STP
77.	Fountain	Ripples, Green Evolutions, Agritech Services, Premier
78.	Multi-Vent	Multicolor

79.	Sanitary ware	Neycer Kermag (standard), Hindustan Sanitary Ware (Ist quality), Parryware (superfine), Cera (Ist quality), Classica (Ist/ standard)
80.	WC seat cover - ISI Marked	Parryware, Neycer Kermag (standard), Hindustan Sanitary Ware (Ist quality), Cera (Ist quality), Classica (Ist / standard)
81.	PVC Flushing Cistern IS: 774-1984 (ISI Certified)	Parryware, Hindustan Sanitary Wares, Cera.
82.	Faucets & Taps, Stop Valves & Pillar Taps, Surgical basin mixer, Shower rose etc.	Gem, Parko, Parryware, HSW, Jaquar,Orient
83.	Kitchen Stainless Steel	Diamond, Nirali, Neel Kanth, Jayna
84.	Looking Mirror	Saint Gobain, Modi Float, Triveni Float Glass, Crown, Atul, Ashai
85.	Readymade Bathroom Cabinets	Commander Gratings (I) Pvt Ltd, Gratolite Cabinet, A-4 Sector Viii, Noida-202701, Alpina, Cera.
86.	Float Valve	Leader, Bombay Metal & Alloy Co, Bombay superflow.
87.	SGSW Pipes (IS-651) ISI Marked	Perfect Agra, Devraj Ind Gaziabad, Buran, RK, Prince, Supreme pipe and Fittings.
88.	CI (Centrifugally Cast) Pipes for sewage disposal ISI marked.	NICCO, SRIF, A-1 Singhal Casting Co Agra, Jindal Saw, Kesoram, NECO.
89.	PVC rain water/ sewage pipes (IS-4985)	Reliance, Finolex, Supreme, Kisan, Prince, Hindustan Plastic & machine corporation, Polypack industries (P) Ltd.
90.	HDPE Water storage tanks (Rotational Moulded)	Sintex, Swift, Nutech, Sheetal
91.	Cast Iron Pipes and Fittings	Hindustan Engineering Products Company Calcutta, S.L.C., Standard approved manufacturers of any other brand of fittings having ISI marking, RIF, BIS.

92.	RCC Pipes	Indian Hume Pipe Company, Delhi/ Prayagraj/ Chandigarh/ Lucknow; Hindustan Pressure Pipes, Kolhapur Dhere Concrete Products, Pune or any other approved manufacturer conforming B.I.S. Standard
93.	Brass Fittings	Leader Engineering Works, Jalandhar; L & K Mathura; Luster Sanitary, Jalandhar; Annapurna Metal Works, Calcutta; Neta Metal Works, Jalandhar; Honey Industrial Corporation, Bombay.
94.	C.P. Fittings	Ego Metal Works, Ballabhgarh; Jaquar Industries, Delhi; Soma Plumbing Fixtures Limited, Calcutta; Gem Sanitary Appliances Pvt. Ltd.,Delhi; Essco Sanitations, Delhi; Bilmet, Bombay.
95.	Stone Ware (Salt-Glazed) Pipes	Hind Ceramics Limited, Orissa; Ceramic Industries Limited, Sambalpur; Shrikamakshi Agencies, Madras; Binary Udyog Pvt. Limited, Howrah; Tirumati Moulds Limited, Nagpur; Kiran Potteries, Hyderabad; Perfect Sanitary Pipes, Bharatpur.
96.	Asbestos Cement Pipes and Fittings	Ganga Asbestos Limited, U.P.; Hyderabad Asbestos Cement Products Limited; J.K. Super Pipe Industries, Nanded; Konark Cement and Asbestos Limited, Orissa; Maharashtra Asbestos Limited, Bombay; Poddar Industrial Corporation, Patna; Sarbamangala Mfg. Company, Calcutta.
97.	HDPE pipes and fittings	ORI-PLAST, HASTI

b. STRUCTURE

S. NO.	ITEMS/ NAME OF PRODUCT	MAKES/BRANDS/MANUFACTURES
1	Structural Steel	SAIL / TATA / RINL / IISCO / ESSAR / ISPAT
2	Structural Steel	TATA / JINDAL / SURYA / SWASTIK

3	Synthetic Enamel Paint (Ist Quality only)	ICI Paint (Deluxe), Asian Paint (Apcolite), Shalimar Paint (Superlac), Goodlass, Nerolac Paint(Nerolac), Berger Paints.

Any materials not fully specified in these specification and which may be offered for use in the works shall be subject to approval of Engineer, without which it shall not be used anywhere in the construction works.

LIST OF SUPPLIERS OF MAJOR BOUGHT-OUT ITEMS

3. (ELECTRICAL)

i) Air Conditioner

1. O General
2. Daikin
3. Hitachi

ii) Batteries (Lead Acid)

1. Amco Batteries Ltd.
2. Exide Industries Ltd.
3. HBLNIFE Power System Ltd.
4. Amara Raja Batteries Ltd.

iii) Batteries (Nickel Cadmium)

1. Amco Batteries Ltd.
2. HBLNIFE Power Systems Ltd.

iv) Batteries Charger/DC-DC Converter

1. Amara Raja Power System(P)Ltd.
2. BCH.
3. Chhabi Electricals Pvt. Ltd.
4. Caldyne Automatics Limited
5. Dubas
6. HBL Nife Power Systems Ltd.
7. Universal Industries Products
8. Universal Instrument Mfg Co Pvt Ltd

v) Cable – Fire Alarm & Communication Cables

1. Cords Cable Industries Ltd.
2. CMI
3. Delton cables Ltd.

4. ELKAY Telelinks
5. KEI Industries Ltd.
6. Reliance Engineers Ltd.

vi) <u>Cable – HT (XLPE)</u>

1. Universal Cable Ltd.
2. KEI Industries Ltd.
3. Industrial Cables
4. NICCO Corporation Ltd.
5. Uniflex
6. Polycab.
7. Torrent cables Ltd.

vii) <u>Cable – LT Power and Control</u>

1. Cords Cable Industries Ltd.
2. Universal Cable Ltd.
3. KEI Industries Ltd.
4. Havells.
5. Delton
6. Elkay Telelinks
7. Evershine Electricals
8. Ecko
9. Ravin
10. Rallison.
11. Suyog
12. Netco
13. Uniflex
14. Paramount
15. Gloster

16. Associated cables Pvt Ltd.
17. CMI
18. Gemscab
19. Industrial cables
20. NICCO
21. Polycab
22. Torrent

viii) Cable – Gland

1. Baliga
2. Comet
3. Flexpro
4. Flameproof
5. FCG
6. Electro Werke
7. Dowels
8. CCI

ix) Cable – Lugs

1. Dowels
2. Jainson
3. Ismal

x) Cable – Tray

1. Ercon Composites
2. Yamuna Power & Infrastructure Ltd.

xi) Cable Termination and Jointing Kit

1. CCI
2. Raychem
3. M-Seal

xii) <u>Ceiling/Exhaust/Pedestal Fans & Circulators</u>

1. Bajaj Electricals Ltd.
2. Crompton Greaves Ltd.
3. Khaitan Electricals Ltd.
4. Havell's

xiii) <u>Contractors – AC Power</u>

1. Andrew Yule
2. ABB
3. BHEL
4. C&S
5. Havell's
6. L&T
7. Schneider
8. Siemens Ltd.
9. Telemechanique

xiv) <u>Control Transformer</u>

1. AE
2. Indushree
3. Intra Vidyut
4. Kalpa Electrikals
5. Transpower Industries Ltd.
6. Siemens

xv) <u>DG Set</u>

1. Sterling and Wilson.
2. GD ankalesaria.
3. Deev Genset.

4. Jackson Limited.
5. Sudhir Gensets.
6. Power Engineering (India) Pvt Ltd.
7. Prasha Technologies Limited.
8. Kumar Generator house.
9. Ashok Leyland Ltd.
10. Powerica Limited.
11. Supernova Engineers Limited.
12. Bhaskar Power Products (P) Ltd.
13. Caterpillar India (P) Ltd.
14. Cummins India Ltd.
15. Escorts Ltd.
16. Greaves Cotton Ltd.
17. Kirloskar ltd.
18. Mahindra & Mahindra Ltd.
19. Honda.
20. Perkins.
21. Eicher.
22. Tata Motors.
23. Ashok Leyland.

xvi) Earthing Materials

1. Rukmani Electrical & Components Pvt Ltd.
2. Indiana Grating Pvt Ltd.
3. Jef Techno Solutions Pvt Ltd

xvii) Flame proof LDB's/ JB's/ Control Station/ switches

1. FCG
2. Sudhir

3. Prompt Engineering Works
4. Flame Proof equipments pvt. Ltd.
5. Baliga Lighting Equipments Pvt. Ltd.
6. Flexpro Electricals Pvt. Ltd.

xviii) High Mast

1. Bajaj Electricals Limited
2. Crompton Greaves Limited.
3. Philips India Limited
4. Surya Roshani

xix) High Voltage PCC/ MCC panels

1. BHEL
2. Control and Switchgear
3. Siemens
4. Tricolite Electrical Industries
5. Schneider
6. CGL
7. L&T

xx) Indicating Lamps

1. Alstom Ltd.
2. BCH
3. L&T Ltd.
4. Siemens Ltd.
5. Vaishno Electricals

xxi) Indicating Meters

1. ABB
2. AMCO
3. AE

4. Alstom Ltd. (EE)
5. Conzerv/Schneider
6. Elecon Measurement Pvt. Ltd.
7. HPL Electric & Power Pvt. Ltd.
8. MECO Instruments Ltd.
9. Minilec
10. Rishabh Instruments Pvt. Ltd.
11. Trinity energy system
12. kaycee
13. Salzer

xxii) Lighting Fixtures

1. GE Lighting Pvt. Ltd.
2. Bajaj Electricals Ltd.
3. Crompton Greaves Ltd.
4. Philips India Ltd.

xxiii) Lighting Fixtures – Flameproof

1. Bajaj Electricals Ltd.
2. Baliga Lighting Equipment Pvt. Ltd.
3. Crompton Greaves Ltd.
4. CEAG Flameproof Controlgear Pvt. Ltd.
5. Flexpro Electricals Pvt. Ltd.
6. Philips India Ltd.
7. Sudhir Switchgears Pvt. Ltd.
8. FCG.

xxiv) Miniature Circuit Breakers (MCBs) and Lighting DB

1. ABB
2. Hagger

3. Havell's India Ltd.
4. Indo Asian Fusegear Ltd.
5. Legrand
6. MDS Switchgear Ltd.
7. Schneider
8. Siemens Ltd.
9. HPL

xxv) <u>Moulded Case Circuit Breaker (MCCBs)</u>

1. ABB
2. Andrew yule
3. Larsen & Toubro
4. Schneider
5. Siemens
6. Control and Switchgear

xxvi) <u>Protection Relays – Thermal</u>

1. BCH
2. L&T Ltd.
3. Siemens Ltd.
4. Telemenchanique & Controls (India) Ltd.

xxvii) <u>Low Voltage Power Control Center (PCC)/ MCC/ PDB/ MLDB/ LDB</u>

1. ABB
2. BCH
3. C & S
4. Elecmech Switchgear & Instrumentation
5. KMG ATOZ
6. L&T
7. Pyrotech Electronics Pvt. Ltd.

8. Risha control Engineers Pvt. Ltd.
9. Siemens
10. Tricolite Electrical Industries
11. Unilec Engineers ltd.
12. Vidyut Control India Pvt. Ltd.
13. Control and Schematic
14. Zenith Engineering

xxviii) <u>Push Buttons</u>

1. BCH
2. Alstom Ltd.
3. L&T
4. Siemens Ltd.
5. Telemenchanique & Controls (India) Ltd.
6. Vaishno Electricals

xxix) <u>Switches-Control</u>

1. BCH
2. Easum Reyrolle Relays & Devices Ltd.
3. Alstom
4. Kaycee Industries Ltd.
5. L&T
6. Siemens Ltd.

xxx) <u>Switches – 5/15A Piano/ Plate, Switch Socket</u>

1. Anchor Electronics & Electricals Pvt. Ltd.
2. Kingal Electricals Pvt. Ltd.
3. North-West Switchgear Ltd.

xxxi) <u>Switch Socket Outlets (Industrial)</u>

1. Alstom Ltd.

2. Best & Cromption Engineering Ltd.
3. BCH
4. Crompton Greaves Ltd.
5. Essen Engineering Company Pvt. Ltd.

xxxii) Solar Modules

1. Tata BP Solar (I) Ltd.
2. REIL, Jaipur.
3. CEIL, Sahibabad.
4. HBL Power

xxxiii) Solar Street Lighting

1. Tata BP Solar (I) Ltd.
2. REIL, Jaipur.
3. CEIL, Sahibabad.
4. HBL.

xxxiv) Terminals Blocks

1. Connectwell
2. Controls & Switchgear Co. Ltd.
3. Elmex Controls Pvt. Ltd.
4. Essen Engineering Co. Pvt. Ltd.

xxxv) Transformers

1. ABB
2. Andrew Yule
3. Areva
4. BHEL
5. Bharat Bijlee
6. Crompton Greaves
7. EMCO Ltd.

8. Intra Vidyut
9. Indushree
10. Indcoil
11. Kirloskar
12. Skippers Electricals
13. Transformers & Rectifiers (I) Ltd.
14. Voltamp

xxxvi) UPS System and Inverter

1. DB Power
2. Aplab
3. Keltron
4. Hi-Rel
5. Dubas
6. Toshiba Corporation
7. Fuzi Electric Co Ltd

xxxvii) GI-Octogonal Pole

1. Bajaj
2. Transrail
3. Wipro

xxxviii) List of Recommended Manufacturers for Heater

1. Escorts Limited, Faridabad, Haryana
2. Spherehot/ Kanti Lal Chuni Lal & Sons Appliances Pvt Ltd. Surat
3. Kerone, Bhayander (E), Thane - 401105
4. Excel Heaters, Andheri (West), Mumbai - 400 053, India
5. Nirmal Industrial Controls Pvt. Ltd., Mulund(W), Mumbai - 400 080

NOTES: Item/ Vendor, which are not listed above, shall be subject to prior approval from Client/ Consultant.

LIST OF MATERIALS OF APPROVED BRAND AND/ OR MANUFACTURE

4. (INSTRUMENTATION)

i) OFC

Manufacture/ Procurement, Testing and supply of suitable OFC Joint closures including all necessary accessories of any of the following make:

1. Raychem
2. 3M
3. Siemens
4. Any other make from the approved vendor list of client with supporting paper.

ii) METERING SKID

1. M/s Chemtrols Industries Ltd., Mumbai
2. M/s Daniel Measurement Solutions Pvt Ltd, Vadodara.
3. M/s Elster-Instromet India Pvt Ltd, Vadodara
4. M/s INEL Gas Controls Pvt Ltd, Vadodara.
5. M/s Nirmal Industrial Controls Pvt. Ltd., Mumbai
6. M/s Oswal Industries Limited, Ahmedabad
7. M/s Autometer energytech ltd, NOIDA
8. M/s Rockwin Flowmeter india Pvt Ltd, Ghaziabad.
9. M/s Intromet international Ny Rajkmakeriaan 9, B-2910, Essen, Belgium
10. M/s Pietro Fiorentini Spa, 20124, Milino, Itally
11. M/s FMC Measurement Solutions, 6 Braidway, thetford, Norfolk, IP24 1 JA, England.
12. M/s Petrogas Gas system BV, Doesburgweg, 7, 203 PL Gouda, PO Box 20, 2800, AA Gouda, Netherland.
13. Tormene Gas Technology SpA, via campolongo, 97, 35020 – Due carrare (Padova), Itally
14. M/s ODS BV, Donk 6, 2291 Berendrecht, Netherland.
15. M/s RMG Regel + Messtechnik Gmbh Osterholzstr, 45, D-34123 Kassel, Germany.

iii) PRESSURE GAUGES

1. AN Instruments Pvt Ltd

2. Badotherm Process Instruments B.V.
3. Baumer Bourdon Haenni S.A.S
4. British Rototherm Co Ltd
5. Budenberg Gauge Co Ltd
6. Dresser Inc
7. Forbes Marshall (Hyd) Pvt Ltd
8. General Instrument Consortium
9. H. Guru Instruments (South India) Pvt Ltd
10. Manometer (India) Pvt Ltd
11. Nagano Keiki Seisakusho Ltd
12. Hirlekar Precision, India
13. Waaree Instruments Ltd
14. Walchandnagar Industries Ltd (Tiwac Divn)
15. Wika Alexander Wiegand & Co GmbH
16. Wika Instruments India Pvt Ltd
17. Ashcroft India Pvt Ltd.

iv) <u>TEMPERATURE GAUGES</u>

1. AN Instruments Pvt Ltd.
2. Badotherm Process Instruments B.V.
3. Bourdon Haenni S.A.
4. Dresser Inc.
5. General Instruments Consortium
6. H. Guru Instruments (South India) Pvt Ltd
7. Nagano Keiki Seisakusho Ltd
8. Solartron ISA
9. Walchandnagar Industries Ltd (Tiwac Divn)
10. Wika Alexander Wiegand & Co GmbH

11. Wika Instruments India Pvt Ltd
12. Pyro Electric, Goa
13. Ashcroft India Pvt Ltd.

v) TEMPERATURE ELEMENTS, THERMO-WELLS

1. ABB Automation Ltd
2. Altop Industries Ltd
3. Bourdon Haenni S.A.
4. Detriv Instrumentation & Electronics Ltd
5. General Instruments Consortium
6. Japan Thermowell Co Ltd
7. Tecnomatic S.P.A
8. Tempsen Instrument India Ltd
9. Thermo Electric Co. Inc.
10. Thermo-Couple Products Co
11. Thermo-Electra B.V.
12. Wika Alexander Wiegand & Co GmbH
13. Altop Industries Ltd., Baroda
14. Nagman Sensors (Pvt.) Ltd.
15. Pyro Electric, Goa

vi) TURBINE METERS

1. Daniel (USA)
2. RMG (Germany)
3. Instromet International (Belgium)
4. Sensus Metering System Inc
5. Rockwin Flowmeter (India)
6. Vemmtec Messtechnik Gmbh, (Germany)
7. ITRON GmbH (Germany)

vii) POSITIVE DISPLACEMENT FLOW METERS

1. Actaris
2. RMG (Germany)
3. Instromet International (Belgium)
4. Romet
5. Dresser
6. Itron GmbH (Germany)

viii) ORIFICES (METER RUN, FLOW CONDITIONER, ORIFICE PLATE AND ASSEMBLY)

1. Emerson
2. FMC, USA
3. Pietro Fiorentini S.P.A (Italy)
4. Canalta Controls, Canada

ix) ULTRASONIC FLOW METERS

1. Daniel (USA)
2. RMG (Germany)
3. Instromet International (Belgium)
4. Sick Maihak, Germany
5. FMC, Germany

x) MASS FLOW METERS

1. Daniel Measurement & Control Asia Pacific
2. Endress + Hauser Instruments International
3. FMC Measurements Solutions
4. Heinrichs Messtechnik GMBH
5. Rheonik MessGerate GMBH

xi) LEVEL GAUGES/ LEVEL INSTRUMENTS

1. Bliss Anand
2. Chemtrols

3. V-Automat
4. Levcon
5. Nivo Controls
6. Sbeletro Mechanicals
7. TRAC

xii) FIELD INSTRUMENTS (P, DP, F, L, T)

1. ABB Ltd
2. Honeywell
3. Fuji Electric Instruments Co Ltd
4. Yokogawa
5. Invensys India Pvt.Ltd

xiii) FLOW COMPUTERS

1. Emerson
2. Instromet International (Belgium)
3. FMC Measurement Solutions (UK)
4. RMG (Germany)
5. OMNI Flow Computers Inc.
6. Thermo Fisher, USA

xiv) PRESSURE REGULATOR AND SLAM SHUT VALVE

1. Pietro Fiorentini S.P.A. (Italy)
2. Emerson
3. RMG-Regel Messtechnik (Germany
4. Mokveld Valves BV (Netherlands)
5. Schlumberger (USA)
6. Gorter Controls B V (Netherlands)
7. Instromet International NV
8. Nirmal Industrial Controls Pvt Ltd. (up to 6” size only)

9. ESME Valves Ltd
10. Kaye & Macdonald Inc.
11. Nuovo Pignone S.P.A (Italy) (GE Oil Co.)
12. Richards Industries (Formerly Treloar)
13. Samson AG Mess-und Regeltechnik
14. Tormene Gas Technology
15. Dresser Inc, USA (upto 8” size, 300# class only)

xv) PRESSURE SAFETY VALVES

1. Keystone Valves (India) Pvt. Ltd.
2. Larson & Toubro Ltd.
3. Lesser GmbH & Co KG
4. Mekaster Engg Ltd.
5. Tyco Sanmar Ltd. (New Delhi)
6. Anderson Greenwood Crosby
7. BHEL (Trichy)
8. Curtiss Wright Flow Control Corporation
9. Dresser Inc.
10. Fukui Seisakusho Co. Ltd
11. Nakakita Seisakusho Co Ltd
12. Nuovo Pignone S.P.A (Italy) (GE Oil co)
13. Parcol S.P.A
14. Safety Systems UK Ltd
15. Tai Milano S.P.A
16. Weir Valves & Controls France
17. Bliss Anand Pvt Ltd.

xvi) FLOW CONTROL VALVES

1. Fouress Engg. (New Delhi)

2. Fisher Xomox (New Delhi)
3. MIL Control Ltd. (Noida)
4. KOSO India Pvt ltd
5. Samson Control (Thane)
6. Dresser Valves India Pvt Ltd.
7. Fisher Controls
8. Valvitalia Italy
9. CCI Valve technology
10. Flowserve Pvt Ltd.
11. Metso Singapore Pvt Ltd.
12. Instrumentation Ltd Palghat
13. Dresser Inc. USA

xvii) MOV actuator:

1. Rotork- UK, USA & INDIA
2. Limitorque
3. Auma- India
4. Biffi- Italy

xviii) Pneumatic actuator (Solenoid Operated ON-OFF type)

1. Metso Automation
2. Tyco
3. Samson Controls
4. L&T
5. Emerson
6. Fisher
7. Masoneilan Process Control
8. Instrumentation Limited (IL)-Palghat
9. Micro Finish

10. Rotex

xix) Solenoid Valves

1. Avcon
2. Festo

xx) Electro – Hydraulic Actuator

1. Avcon Rotork controls (Deutchland Gmbh)
2. Biffi Italia Srl
3. Ledeen (Italy)
4. Virgo Valves and Controls ltd.-India
5. Limittorque
6. Reineke
7. Voith
8. Bettis
9. Rotork- UK, USA & INDIA
10. Rotex
11. Schuck Group

xxi) CONTROL PANEL & ACCESSORIES

1. Keltron Controls Ltd., Kerala
2. Elechmec Corporation Ltd., Mumbai
3. Industrial Controls & Appliances Pvt. Ltd.,
4. Alstom System Ltd., Noida
5. Emerson Process Management (I) Pvt. Ltd.
6. ABB Instruments Ltd., New Delhi
7. Larsen & Toubro Ltd.
8. Control & Automation, New Delhi
9. GE Fanuc Systems Pvt. Ltd., New Delhi
10. Rockwell Automation (I) Ltd., Ghaziabad

11. Honeywell Automation Ltd.
12. Rittal
13. Pyrotech Elcronics Pvt Ltd.
14. Positronics Pvt Ltd.
15. Electronics Corporation of India Ltd.

xxii) <u>JUNCTION BOXES AND CABLES GLANDS</u>

1. Ex-Protecta
2. Flameproof Control Gears
3. Baliga
4. Flexpro Electricals

xxiii) <u>CONTROL AND SIGNAL CABLES</u>

1. Associated Cables
2. Brook
3. Associated Flexibles & Wires (Pvt) Ltd
4. Universal Cables Ltd,India
5. Delton Cables Ltd, India
6. KEI Industries Ltd INDIA
7. CMI Limited
8. Cords Cable Industries Ltd, India
9. Elkay Telelinks (P) Ltd., India
10. Udey Pyrocables Pvt Ltd, India
11. Goyolene Fibres (I) Pvt Ltd, India
12. Netco Cable Industries Pvt Ltd, India
13. Nicco Corporation Ltd, India
14. Paramount Communications Ltd, India
15. Polycab Wires Pvt Ltd, India
16. Radiant Cables Pvt Ltd, India

17. Reliance Engineers Ltd., India
18. Suyog Electricals Ltd, India
19. Thermo Cables Ltd

xxiv) INDICATORS & CONTROLLERS

1. Yokogawa
2. Eurotherm Chessel
3. Honeywell
4. Emerson

xxv) BARRIERS

1. MTL
2. STHAL
3. P&F
4. Phoenix

xxvi) GAS CHROMATOGRAPH

1. ABB
2. Emerson
3. Instromet International, NV
4. RMG Regal+Messtechnik GmbH
5. Yokogawa

xxvii) I/P CONVERTERS

1. ABB
2. Emerson
3. IMI Watson Smith Ltd.
4. Moore Controls Ltd
5. Shreyas Instruments Pvt Ltd, India
6. Thermo Brandt Instruments

xxviii) SS FITTINGS, INSTRUMENT VALVES & MANIFOLDS

1. Aura Inc.
2. Hoke
3. Excelsior Engg Works, India
4. Parker
5. Swagelok Co.
6. Swastic Engineering Works, India
7. Comfit & Valves Pvt.Ltd
8. Arya Crafts & Engg.Pvt. Ltd

xxix) SS TUBES

1. Sandvik
2. Hoke
3. Parker
4. Swagelok Co.
5. Heavy metal & tubes LTD
6. Nuclear Fuel Complex. India
7. Ratnamani Metal & Tube Ltd
8. Jindal Saw

xxx) GAS DETECTION SYSTEM

1. Crowcon Detection Instruments Ltd
2. Detection Instruments (I) Pvt Ltd
3. Detector Electronics Corporation
4. Drager Safety AG & Co. KGAA
5. General Monitors Ireland Ltd
6. Mine Safety Appliances Company
7. MSA – Mines Safety Appliances(India) Ltd
8. Industrial Scientific Oldham France S.A.
9. Riken Keiki Co Ltd

10. Simrad Optronics Icare
11. Honeywell Analytics
12. Net Safety Monitoring Inc.
13. Simtronics SAS

LIST OF RECOMMENDED MANUFACTURERS

5. (SHOP & FIELD PAINTING)

i) Indian Vendors

1. Asian Paints(I) Ltd.
2. Berger Paints Ltd.
3. Goodlass Nerlolac Paints Ltd.
4. Jenson And Nicholson Paint Ltd & chokuGu Jenson & Nicholson Ltd.
5. Shalimar Paints Ltd.
6. Sigma Coating, Mumabai
7. CDC Carboline Ltd.
8. Premier Products Ltd.
9. Coromandel Paints & Chemicals Ltd.
10. Anupam Enterprises
11. Grand Polycoats
12. Bombay Paints Ltd.
13. Vanaprabha Esters & Glycer, Mumbai
14. Sunil Paints and Varnishes Pvt. Ltd.
15. Courtaulds Coating & Sealants India (Pvt.) Ltd.
16. Mark-chem Incorporated, Mumbai (for phosphating chemicals only)
17. VCM Polyurethane Paint (for polyurethane Paint only)

ii) Foreign Vendors for Overseas Products

1. Sigma Coating, Singapore
2. Ameron, USA
3. Kansai Paint, Japan
4. Hempel Paint, USA
5. Valspar Corporation, USA
6. Courtaulds Coating, UK.

Notes:

1. Bidder can select equipment of two different makes, selected from this VENDOR LIST and mention the same in the checklist for technical evaluation attached with the tender. The offered bid must include filled datasheet indicating make, model, size, rating of offered instrument/ equipment duly supported by sizing calculation of offered equipment (wherever applicable).

2. Vendors who have already supplied above equipment in other terminals of same Client/ Owner, shall also be considered qualified for this tender provided the supplied equipment are commissioned and running successfully and they have not been put on holiday in list of Client/PLECO/ Other PSU

3. Equipment / Instruments of any make which is offered by one bidder and acceptable to Client/ Owner shall be accepted for other bidder also. After placement of order, on request of the successful bidder list of other qualified makes for a particular item (for which successful bidder wants to change the vendor) shall be provided.

4. Bidder shall take prior approval of the make / model no of the offered item and it shall be from the list given above. However additional vendors will be considered in exceptional cases, provided they have supplied for similar application to reputed gas transmission/distribution companies, in quantities at least half the numbers being supplied for this tender, and working satisfactorily for minimum 6 months. Documentary evidence substantiating above shall be submitted for taking approval.

5. For procuring bought out items from vendors other than those listed above, the same may be acceptable subject to the following: -

   a) The vendor/ supplier of bought out item(s) is a manufacturer/ supplier of said item(s) for intended services and the sizes being offered is in their regular manufacturing supply range.

   b) Should have supplied at least one single random length (i.e. 5.5 meters to 6.5 meters) for item assorted pipes / tubes and for other items, which are to be supplied in quantity on number-basis (other than assorted pipes / tubes) minimum 01 (One) number of same or higher in terms of size and rating as required for intended services. The bidder should enclose documentary evidences i.e. PO copies, Inspection Certificate etc. for the above, along with their bids.

6. For any other item(s) for which the vendor list is not provided, bidders can supply those item(s) from vendors/ suppliers who have earlier supplied same item(s) for the intended services in earlier projects and the item(s) offered is in their regular manufacturing/ supply range. The bidder is not required to enclose documentary evidences (PO copies, Inspection Certificate etc.) along with their

offer, however in case of successful bidder, these documents shall require to be submitted by them within 30 days from date of Placement of Order for approval to CLIENT / PLECO.

7. The details of vendors indicated in this list are based on the information available with PLECO, Contractor shall verify capabilities of each vendor for producing the required quantity with. PMC does not guarantee any responsibility on the performance of the vendor. It is the contractor's responsibility to verify the correct status of vendor and quality control of each parties and also to expedite the material in time.

ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF BOO COMPRESSOR STATION AT RUPKHELIA

Instrumentation Scope of Work

(SECTION-E)

Doc No.: P167-SOW-I001

TA	25.10.2023	Issued for Tender	VK	NC	AD
CA	18.10.2022	Issued for Client Review	VK	NC	AD
IA	06.10.2022	Issued for Internal review	VK	NC	AD
REV.	**DATE**	**DESCRIPTION**	**ORG**	**REVIEW**	**APPROVED**

CONTENTS

1.0 INTRODUCTION

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e. Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCM of gas per day.

AGCL is planning to expand its Pipeline Network in Assam for increasing gas transportation capacity so they want to develop new Compressor Station at Rupkhelia (Assam).

Pipeline Engineering Consultants Pvt. Ltd. has been appointed as Engineering Consultant by AGCL for Consultancy Services Engineering, Procurement, RFP preparation and Project Management for the Project.

2.0 DEFINITION

Where used in this document, the following terms shall have the meanings indicated below, unless clearly indicated by the context to this order.

PROJECT	Development of New Compressor Station at Rupkhelia Assam
CLIENT/ OWNER	Assam Gas Company Limited.
EPMC	Pipeline Engineering Consultants Pvt. Ltd. (PLECO) the party to act for and on behalf of OWNER for the Detailed Engineering Services and Project Management.
CONTRACTOR	Agency appointed by CLIENT/ OWNER for execution of assigned tasks
PURCHASER	Either of CLIENT, OWNER or EPMC
VENDOR/ MANUFACTURER	Party, which manufactures and supplies equipment and services to the OWNER or to CONTRACTOR

3.0 PROJECT BRIEF

The brief project details for Development of Compressor Station at Rupkhelia (Assam) are as follows: Development of Compressor Station at Rupkhelia. The preliminary proposed facilities for the Compressor Station are:

- Field Instrumentation along with PLC System for Air/Gas Compressor (1W + 1S) Package and other utilities
- Fire and Gas Detection System
- CCTV System.
- USM Meter along with Flow Computers.

- Vibration Monitoring System
- Cable and Cabling from Field Instruments, Cameras and Detectors to Compressor DCS, NVR Server, F&G PLC, ESD PLC.

3.1 Document precedence:

It shall be the responsibility of the Manufacturer / Vendor to inform the Purchaser of any errors, ambiguities, inconsistencies, discrepancies or conflict of information that may be found to exist in any document, specification or drawing submitted by the Purchaser.

In case of conflict, the order of precedence shall be as follows:

- Approved Datasheets, Specification and Drawings
- Scope of Work.
- Design Basis;
- International & National Codes & Standards.

As a general rule in the event of any discrepancy between technical matter and local laws / regulations (and documents above listed) the most stringent shall be applied.

Manufacturer / Vendor shall notify Purchaser of any apparent conflicts between MR, specifications, related datasheets, any code and standards and any other specifications noted herein. (Resolution and/ or interpretation precedence shall be obtained from Purchaser in writing before proceeding with the design/ manufacturer or completion of services.)

3.2 Scope of Design and Engineering

As a general rule in the event of any discrepancy between technical matter and local laws / regulations (and documents above listed) the most stringent shall be applied.

Manufacturer / Vendor shall notify Purchaser of any apparent conflicts between MR, specifications, related datasheets, any code and standards and any other specifications noted herein. (Resolution and/ or interpretation precedence shall be obtained from Purchaser in writing before proceeding with the design/ manufacturer or completion of services.)

4.0 BRIEF SCOPE OF WORK

Vendor shall be completely responsible to supply and installation of below mentioned materials to be within the Air Compressor Package Equipment along with required accessories and services for satisfying the functional / operational requirements stated in this Scope of Work and its Attachments: (Herein after referred as Requisition).

Vendor shall have complete responsibility for all the items supplied by him including his sub-Vendors if any. The Vendor's scope of work includes, but not limited to:

- Supply and Installation of Field Instruments (ie. PT, TT, LT, TG, PG, DPT, SDV Actuator, etc. as mentioned in the PFD) in the Compressor Package;

- Supply and Installation of Fuel Meter and USM Meter on the Skid along with Flow Computer to be mounted in the Control Room;
- Supply and Installation of the Compressor Package, Flow Computer to be mounted in the Control Room;
- Supply and Installation of the Fire and Gas Detectors (ie. Point Type and Open Path Type Gas Detectors, Flame Detectors, Heat Detectors, Smoke Detectors etc.) along with the PLC based F&G System for the compressor area to be mounted in the control room;
- Supply and Installation of the CCTV System inclusive of Weather Proof & Explosion Proof PTZ and Fixed Type IP Cameras, NVR Recorder with 30 Days Backup;
- Supply and Installation of the Server Rack along with Supply and Installation of Managed Ethernet Switches, KVM Switches and CCTV Workstation.
- Supply and Installation of the New PA Communication System consisting of IP Telephones and Telephone Cables with RJ45 Connectors including integration with the existing IP EPABX System
- Supply and Installation of Vibration Monitoring System for the Compressor Package including Vibration probes and vibration monitors for motor at field. Vibration probes shall be terminated suitably by Tenderer in Vibration Monitoring Panels near the motor. Vibration Monitors shall provide local display of parameters. 4-20mAmps output signal from these monitors shall be taken to Compressor PLC/DCS and shall communicate the same to Plant DCS over communication bus.
- Supply and Installation of Skid Edge Weather Proof & Explosion Proof Junction Boxes along with Cable Glands, Termination Blocks and Accessories;
- Supply, laying, Termination and Testing of Instrumentation Cables from Package installed Instruments to Skid Edge Junction Boxes and from Skid Edge Junction Boxes to Respective PLC Panels;
- Supply, Laying, Termination and Testing of Armored CAT-6/UTP Cables from CCTV Cameras to Ethernet Switches
- Integration of the New PLC Panels with the New SCADA System (In Others Scope) through Optical Fiber Cable
- Supply, Installation, Testing and Commissioning of Operator Workstation and Engineering Workstation in the Local Control Room along with the supply of necessary software licenses.

It is Vendor's responsibility to verify the selection of type of cable, material of construction of each component as per the data mentioned in individual specifications / data sheets. Vendor shall stand guarantee for all items supplied by them, including his brought-out items.

5.0 DETAILED SCOPE OF WORK

Bidder's scope of work includes following activities related to the Brief Scope of Work mentioned in Clause 4.0:

- Bidder shall be responsible for the Complete Detailed Engineering including the Engineering Documents which shall be submitted for review and approval of AGCL/Consultant, Procurement and Construction of Field Instruments (ie. PT, TT, LT, TG, PG, DPT, SDV Actuator etc. as mentioned in the PFD) in the Compressor Package.

- Bidder shall be responsible for the Complete Detailed Engineering including the Engineering Documents which shall be submitted for review and approval of AGCL/Consultant, Procurement and Construction of the Compressor Package PLC along with Flow Computer to be mounted in the Control Room;
- Bidder shall be responsible for the Complete Detailed Engineering including the Engineering Documents which shall be submitted for review and approval of AGCL/Consultant, Procurement and Construction of the Fire and Gas Detectors (ie. Point Type and Open Path Type Gas Detectors, Flame Detectors, Heat Detectors, Smoke Detectors etc.) along with the PLC based F&G System for the compressor area to be mounted in the control room;
- Bidder shall be responsible for the Complete Detailed Engineering including the Engineering Documents which shall be submitted for review and approval of AGCL/Consultant, Procurement and Construction of the CCTV System inclusive of Weather Proof PTZ and Fixed Type IP Cameras, NVR Recorder with 30 Days Backup;
- Bidder shall be responsible for the Complete Detailed Engineering including the Engineering Documents which shall be submitted for review and approval of AGCL/Consultant, Procurement and Construction of the Server Rack along with Supply and Installation of Managed Ethernet Switches, KVM Switches and CCTV Workstation.
- Bidder shall be responsible for the Complete Detailed Engineering including the Engineering Documents which shall be submitted for review and approval of AGCL/Consultant, Procurement and Construction of Vibration Monitoring System for the Compressor Package including Vibration probes and vibration monitors for motor at field. Vibration probes shall be terminated suitably by Tenderer in Vibration Monitoring Panels near the motor. Vibration Monitors shall provide local display of parameters. 4-20mAmps output signal from these monitors shall be taken to upstream VFD for monitoring and control. VFD shall communicate the same to Plant DCS over communication bus.
- Bidder shall be responsible for the Complete Detailed Engineering including the Engineering Documents which shall be submitted for review and approval of AGCL/Consultant, Procurement and Construction of Skid Edge Explosion Proof Junction Boxes along with Cable Glands, Termination Blocks and Accessories;
- Bidder shall be responsible for the Complete Detailed Engineering including the Engineering Documents which shall be submitted for review and approval of AGCL/Consultant, Procurement and Construction of Instrumentation Cables from Package installed Instruments to Skid Edge Junction Boxes and from Skid Edge Junction Boxes to Respective PLC Panels;
- Bidder shall be responsible for the Complete Detailed Engineering including the Engineering Documents which shall be submitted for review and approval of AGCL/Consultant, Procurement and Construction of Supply, Laying, Termination and Testing of Armored CAT-6/UTP Cables from CCTV Cameras to Ethernet Switches
- Bidder shall be responsible for the Complete Detailed Engineering including the Engineering Documents which shall be submitted for review and approval of AGCL/Consultant, Procurement and Construction of Operator Workstation and Engineering Workstation in the Local Control Room along with the supply of necessary software licenses.
- Bidder shall submit the Engineering Documents for Review and Approval as Mentioned in Clause 6.0.

- Bidder shall develop all the Layouts, As Built Drawings Related to Instrumentation and shall be submitted for AGCL/Consultant Review and Approval.
- Bidder shall develop all the Panel GADs, Hook-Up Drawings for Instruments, Loop Drawings, System Configuration Drawing and shall be submitted for AGCL/Consultant's Approval.
- Bidder shall develop the IO List and Cable Schedule for the Respective PLCs and shall be submitted for AGCL/Consultant's Approval.
- Bidder shall develop the ITP and Instrument Index for the complete project and shall be submitted for AGCL/Consultant's Approval.

6.0 DOCUMENTS REQUIRED FOR REVIEW AND APPROVAL

Vendor shall submit the following documents for Client's Review and Approval:

- BOQ for Instrumentation and Control Items for the Complete Compressor System as per the Instrumentation Scope of Work, PFD, Datasheet, Specification and System Architecture Drawing.
- Datasheets of Instrumentation and Control Items for the Complete Compressor System (PT, TT, PG, TG, USM Flow Meter, LT, LG, PLC for F&G, ESD, Fuel Meter, Flow Computer and Compressor etc.) and Cables as per the Instrumentation Scope of Work
- Technical Specification of Instrumentation and Control Items and Cables as per the Instrumentation Scope of Work.
- Instrument Index for the Complete Compressor System;
- IO List for the Complete Compressor System;
- Cable Schedule for the Complete Compressor System;
- Inspection and Test Plan Developed by the Vendor for the Instrumentation Items including FAT and SAT Procedures.
- System Architecture Drawing
- Cause and Effect Drawing for the Compressor Station Area.
- PLC Wiring and Termination Details
- Actuator Wiring Diagram with Termination Details
- Hook-Up Drawings
- Loop Drawings
- Fire and Gas Detector Layout
- Instrument JB Location Layout
- Control Room Equipment Layout
- Cable Routing/Trench Layout

- CCTV Location Layout
- GADs for System Panels
- PDB Details for System Panels
- As Built Drawing
- Proposed List of Spares for Operation and Maintenance.
- Piping and Instrumentation Diagram for the Complete Compressor System;
- Operation and Control Philosophy

6.1 Documents Required with the Bid

Vendor documentation shall include the following as a minimum; however, it shall be the complete responsibility of the Automation Vendor to provide any drawings and documents as asked by Company during engineering.

- Technical Catalogue for Instrumentation Items
- PLC/SCADA Configuration Manual;
- Trouble Shooting Manual;
- Detailed Bill of Material with Make and Model Number;
- AMC for the supplied system
- Sub-Vendor List.

6.2 Language and units

All drawings, documents, information, correspondence, test reports, operating and maintenance instructions and like items shall be in the English language and SI Units. In the case of pamphlets and trade brochures, English translations neatly marked on the documents shall be deemed to have complied with this clause.

6.3 Drawings and information

Vendor shall supply and maintain a schedule of the drawings and information which he expects to prepare or provide for use during the Contract. The list shall be kept up to date during the contract period and shall not be amended or deviated from without prior approval of the Company.

6.4 Vendor Document/Drawing Review

Document/Drawings returned to Vendor for correction after markup by Company and / or Company designated representative shall be resubmitted by Vendor until "Proceed with Fabrication Issue Final Document/Drawings". All revisions to documents must be clouded and identified with the revision number contained within a triangle placed beside the cloud.

Vendor shall not proceed with changes having a commercial impact unless authorized by Change Order.

If, for any reason, Vendor believes that he is not able to comply with Purchaser and / or Purchaser's designated representative marked-up comments on documents returned after review, Vendor shall notify, in writing, Purchaser within five (5) working days of receipt, giving his reasons and requesting a resolution. It is not acceptable to ignore marked-up comments.

Vendor must submit updated documents and drawings one (1) weeks after return of approved documents.

Drawings and data approval do not relieve Vendor of his responsibility to meet Purchase Order or contract conditions relating to specifications, material design or construction, and delivery requirements, nor relieve Vendor of responsibility for compliance with laws, codes and regulations.

6.5 Statutory approvals

It shall be the responsibility of the Compressor Vendor to obtain all the necessary certificates on the job carried out by him from the any other statutory authority.

ASSAM
GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF BOO COMPRESSOR STATION AT RUPKHELIA

Instrumentation & Control Design Basis

Doc No.: P167-DEB-I001

TA	27.10.2023	Issued for Tender	VK	PK	AD
CA	18.10.2023	Issued with Client Review	VK	PK	AD
IA	07.10.2023	Issued for IDC	VK	PK	AD
REV.	**DATE**	**DESCRIPTION**	**ORG**	**REVIEW**	**APPROVED**

ABBREVIATION

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CCTV	Closed Circuit Television System
F&G	Fire & Gas
GDS	Gas Detection System
HART	Highway Addressable Remote Transducer
IR	Infrared
IP	Ingress Protection
JB	Junction Box
LER	Local Equipment Room
NFPA	National Fire Protection Association
NMS	Network Management System
OFC	Optical Fiber Cable
OISD	Oil Industry Safety Directorate
PLC	Programmable Logical Controller
RF	Radio Frequency
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition System
SV	Sectionalizing Valve Station

CONTENTS

1.0 INTRODUCTION

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e. Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCM of gas per day.

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CLIENT/ OWNER	Assam Gas Company Limited.
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PURCHASER	Either of CLIENT, OWNER or EPMC
VENDOR/ MANUFACTURER	Party, which manufactures and supplies equipment and services to the OWNER or to CONTRACTOR

3.0 BASIS OF DESIGN

The brief project details for Development of Compressor Station at Rupkhelia (Assam) are as follows: AGCL wants to Develop a Compressor Station at Rupkhelia. The preliminary proposed facilities for the Compressor Station are:

- Field Instrumentation along with PLC System for Air/Gas Compressor (1W + 1S) Package
- Fire and Gas Detection System
- CCTV System.
- USM Meter and Fuel Meters along with Flow Computers.
- Vibration Monitoring System (Make- Proglost, Woodward, Bently Nevada)
- Cable and Cabling from Field Instruments, Cameras and Detectors to Compressor PLC, NVR Server, F&G PLC, ESD PLC.

4.0 CODES & STANDARDS

The equipment shall be designed, constructed and tested in accordance with the latest edition and amendments of the following codes and standards

Code/Std. Ref. No.	**Code/Std. Title**
ANSI MC 96.1	Temperature Measurement Thermocouples
ANSI/ISA S71.04	Environmental Conditions for Process Measurement and Control Systems
API MPMS	Flow Metering and Calculation
API RP 551	Process Measurement Instrumentation
API RP 554	Process Instrument and Control
ASME PTC 19.3	Temperature measurement Instruments and apparatus
ASTM A213	Seamless Ferritic and Austenitic Alloy Steel Tubes
ASME B 2.1	NPT Pipe Threads
ASTM A269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
BS 6739	Code of Practice for Instrumentation in Process Control Systems: Installation Design and Practice
BS EN 50419	Marking of Electrical and Electronic Equipment in Accordance with Article 11(2) of Directive 2002/96/EC (WEEE)
EEMUA 191	Engineering Equipment and Material Users Association (Alarm system, A guide to design, management and procurement)

Code/Std. Ref. No.	Code/Std. Title
EN 837	Pressure Gauge, Gauge Dimensions and Testing
EU Directive 94/9/EC	Directive on equipment and protective systems intended for use in potentially explosive atmospheres (ATEX)
EIA TIA 526	Standard Test Procedures For Fiber Optic Systems
EIA TIA 455	Standard Test Procedure For Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
IEC 60079	Electrical Apparatus for Explosive Gas Atmosphere
IEC 60529	Classification of Degrees of Protection Provided by Enclosures (IP code)
IEC 60654	Industrial-Process Measurement and Control Equipment-Operating Conditions, Climatic Conditions.
IEC 60751	Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors
IEC 61000	Electromagnetic Compatibility (EMC)
IEC 61158	Digital Data Communications for Measurement and Control, Field Bus for use in Industrial Control System
IEC 61131	Programmable Logic Controllers – Part 2 and 3
IEC 61508	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems
IEC 61511	Functional safety - Safety instrumented systems for the process industry sector
IEC-60793-1	Optic Fibers, Part 1 Generic Specification
IEC-61804-3 -2010	Function Blocks (FB) For Process Control: Electronic Device Description Language
IEC 62453	Field Device Tool (FDT) Interface Specification
ISA RP 42.1	Nomenclature for Instrument Tube Fittings
ISA S5.1	Instrument Symbols and Identification
ISA S5.4	Instrument Loop Diagrams
ISA 18.02	Management of Alarm Systems for the Process Industries
ISA RP42.00.01-2001	Nomenclature for Instrument Tube Fittings

Code/Std. Ref. No.	Code/Std. Title
ISO 5168	Measurement of fluid flow - Procedures for the evaluation of uncertainties
NAMUR NE 107	Self-Monitoring & Diagnosis of Field Devices
NAMUR NE 043	Standardization of the signal level for the failure information of digital transmitters
NEMA VE1	Metal Cable Tray Systems
NFPA 72	National Fire Alarm and Signaling Code
OISD 116	Fire Protection Facilities for Petroleum Refineries and Oil / Gas Processing Plants

5.0 INSTRUMENTATION & CONTROLS SCOPE

The project shall broadly comprise of following instruments and systems:

- Field Instruments for Compressor Package;
- SDV/Pneumatic Operated On/Off Valve;
- Fire, Smoke & Gas Detectors and Equipment;
- Fire Alarm System;
- Vibration Monitoring System;
- Compressor DCS/PLC along with Alarm Annunciator;
- USM Flow Meter and Fuel Meter along with Flow Computer
- F&G PLC;
- Fiber Optic Cable;
- CCTV;
- Instrumentation Cables and Cabling from Field Instruments to Skid Edge Junction Boxes.
- CAT-6/UTP Cabling from CCTV System to Managed Ethernet Switch;
- Junction Boxes;

6.0 DESIGN CRITERIA

6.1 General

All Instrumentation and Control Systems shall be designed for continuous operation in the given site conditions with the following design criteria:

- Ease of operation and maintenance;

- Suitability for applicable environmental condition;
- Suitability for operation in the designated classification of hazardous areas;
- State of art proven technology and instrumentation;
- Safety to operating and maintenance personnel;
- Safety to connected equipment;
- Safe starting and shutdown of the plant under all conditions;
- High Redundancy with high reliability (high MTBF and low MTTR) and no single point of failure;
- Minimum cost of ownership.

6.2 Environmental Conditions

The equipment considered and the complete installation shall be suitable for continuous operation under the ambient conditions prevailing at site. All field instruments shall be provided with FRP (UV protected) canopy.

6.3 Operations and Design Life

The instrumentation and control equipment shall be designed to operate in the site environmental conditions continuously. The life time of the plant is envisaged to be 25 years. However, optimum design life expectancy of an instrument shall be 10 years and spare parts availability shall be for 10 years after cease of production. The life time expectancy of control equipment such as controllers, modules is expected to be 20 years with the availability of spares for 10 years after discontinuation of product.

The maintenance/replacement schedule shall be planned accordingly in order to maintain the instruments/control equipment for the duration of the plant life time.

6.4 Equipment Protection

6.4.1 Ingress Protection

All field instruments and outdoor equipment shall have ingress protection to IP 67 or better in accordance with IEC 60529.

For indoor installed equipments the minimum acceptable ingress protection shall be IP 42.

Sunshades shall be provided for all field mounted electronic instrumentation.

Instruments shall be tropicalized for humidity and fungus and shall be termite resistant. Electronic boards shall be varnished / potted and electro-statically protected.

6.4.2 Tropicalization

All electronic/ electrical components shall be tropicalized to protect against humidity, moisture and fungal growth by means of hermetically sealed units, protective coating on circuit boards, gold plated edge connectors etc.

6.4.3 Hermetic Sealing

All relays and switches shall be hermetically sealed, and those utilized in 24 V DC control logic circuits shall have gold plated contacts rated 1.0 Amp at 24 V DC. Those interfacing with field equipment shall be rated 2 Amp 24 V DC. All switch contacts shall be DPDT as a minimum. All relay shall have LED indication.

6.4.4 Explosive Hazard Protection Methods

In order to prevent electrical apparatus, including electronic process instrumentation, from becoming a source of ignition in potentially explosive atmospheres, protective measures shall be taken, based on the hazardous area classification of the particular area in which the electrical apparatus is being installed.

The selection of type of protection shall be in accordance with IEC 60079-14.

The following is the order of preference for the selection of type of protection:

a) For Zone 0 areas : Ex'ia' only

b) For Zone 1 areas : Ex'ia' or Ex'ib' or Ex'd'

c) For Zone 2 areas: Ex'n', Ex'e', Ex'd', Ex'ia' or Ex'ib' shall be considered.

Selection of type of protection shall take into consideration local legislation, site practices, OWNER standard etc.

Junction boxes including accessories shall be suitable for the applications of the zone.

Certificates from recognized agency shall be available for the selected type of protection for the installed electrical apparatus.

Component of systems protected by control room mounted IS isolators shall be certified individually and shall be checked by contractor as a system including the field instrument, cable and the isolator.

Field instruments protected by an IS isolator do not require a certificate provided that a document statement from the approved manufacturer is included to confirm that the instrument may be used as a “Simple Apparatus” in an IS circuit in accordance with IEC 60079-11.

All Electronic field instruments shall have ATEX certification.

6.4.5 RF Protection and EMC Compliance

All instruments and equipment shall be immune to Radio Frequency (RF) and Electro Magnetic (EM) Interface.

The design and installation of all electrical / electronic equipment shall meet the Radio Frequency Interference (RFI) or Electro Magnetic Interference (EMI) IEC 61000, emission (IEC61000-6-4) and immunity (IEC-61000-6-2) requirements for an industrial environment.

6.5 Instrument Utilities

The following utilities shall be provided for Instrument & Control Systems:

6.5.1 Power Supply

Instrumentation, control and associated systems power requirements shall be provided by dual redundant Uninterruptible Power Supply (UPS). Dual redundant power supply units are to be fed from different power distribution boards with an auto transfer switch. Refer to Electrical Design Basis for detail information regarding electrical supply distribution.

Field devices shall be loop powered by the corresponding control system as applicable. Field instruments with external power supply requirements shall be fed from dedicated redundant power supply unit in the respective panel.

Battery backup time and details are to be finalized based on the UPS capacity, electrical essential load considered and facility’s operation / emergency philosophy. Power distribution to each consumer shall be through proper, independent switch and fuse units. Power supply shall be highly reliable with no single point failures.

In general, the following power supply shall be used:

- 240 VAC +/- 5%, 50 Hz +/- 2%, Single Phase UPS power supply for all control systems such as, CCTV system, Compressor PLC, F&G System PLC, FACP, telecom equipment and certain field instruments if necessary;
- 24 VDC +/- 5% for all field instruments, derived from the Control Systems;
- 230 VAC +/- 5%, 50Hz +/- 2%, Single Phase Non UPS Utility Power for maintenance activities, miscellaneous requirements, utility sockets etc.

6.5.2 Instrument Gas Supply

Instrument gas (process fluid) shall be used for required applications instead of instrument air. Instrument Gas shall be provided by means of taking tap- off from main line.

6.6 Earthing System

Instrument and systems shall be connected to the proper earthing system for the protection of personnel and instrument / equipment from fault currents (protective earth) and to minimize electrical interference in signal transmission circuits (instrument earth). The following separate earthing systems are to be provided:

- Protective Earth (PE) – Bonded to the site structure and utilized for electrical safety of metal enclosures and chassis on all instruments and electrical components. This earthing system is used for protection of personnel and equipment from fault currents;
- Instrument Clean Earth (IE) – Insulated from the site structure and other metal work utilized for instrument cable screens and bonded to the main electrical earthing system at a single point. Electronics in the instrument shall be insulated from the metal work.

Cable screens of signal cables shall be segregated from metallic structural earth in the field and earthed at one point only at the cable marshaling point. Cable shields must have a single, continuous path to earth. Earth loops and floating shields shall be avoided. Shield drain wires shall not be daisy-chained to the ground connection.

The purpose of instrument DC & shield earth bus bar is to reduce the effect of electrical interference upon the signal being transmitted. A DC & shield earth bus bar shall be provided within each cabinet for consolidating instrument signal commons and cable shield drain wires. This earth bus shall be isolated from the safety earth system and from the body of the cabinet except at the plant earthing reference point.

Each instrument signal common shall be connected to the isolated instrument DC & shield earth bus with copper wire sized to carry the expected fault current or 1.5 mm², whichever is larger. Two insulated copper conductors shall be connected from the instrument DC & shield earth bus within each cabinet to a single tie point on the master instrument earth bar within the control building in a closed loop configuration. The resistance from the isolated instrument DC & shield earth bus to the plant ground grid shall be less than 1 ohm.

Isolated instrument DC & shield earth bars from all cabinets shall be consolidated into a master instrument earth bus located within that building. The master instrument earth bar shall be connected to the master reference earth. The master reference earth should then be connected in a loop configuration to a single point on the plant earthing. Bonding cabinet AC or DC & shield earth bus bars in a daisy-chain connection is not acceptable.

The Vendor shall be responsible for all earthing requirements within his scope of supply.

6.7 Material of Construction

The material of construction of the wetted parts and the body of all the individual instruments / equipment shall be suitable to the process fluid / conditions and the site ambient conditions.

All materials and equipment furnished shall be new and unused, of current manufacture and the highest grade and quality available for the required service, and free of defects.

Process wetted parts shall be suitable for process fluid and conditions. Body / trim materials shall be selected based on the applicable pipe class as per Piping Material Specification. Wetted parts material shall be SS316 as a minimum.

Tubing and tube / pipe fittings used to hook up instruments to piping / vessel shall be SS316. Material of construction of enclosures and junction boxes shall be cast aluminum (LM6/LM25).

Galvanic compatibility between dissimilar materials is to be ensured to prevent corrosion due to galvanic action.

6.8 Painting & Coating

Field instruments shall be epoxy coated as per Manufacturer's standard. The finish of junction boxes (Non IS) shall be light gray shade equivalent to RAL7035 and junction boxes (IS) shall be blue shade.

Field mounted panel's surface and inside coating and finish shall be as per manufacturer's recommendation. Field stanchions shall be coated with corrosive resistant coating and finish shall be light gray shade.

6.9 Tagging and Identification

Each instrument shall be provided with a permanently fastened SS 316 nameplate with details such as tag no., manufacturer name, serial and model no, operating range, hazardous area rating / certification etc. The screws used to fix the nameplate shall be SS 316.

Each instrument shall have a tag plate fixed using 316 SS screws on the instrument support. Tag plate shall be tied to the instrument with SS wire for direct mount instruments on line or vessel. Tag plates shall be made of SS 316 or phenolic plastic (traffolyte) with engraved letters. Adhesive tag plates shall not be used.

Instruments connected to safety systems shall have white background with RED letters.

Instrument and all the ancillary equipment tag numbers shall be provided as per existing AGCL tag numbering philosophy.

7.0 INSTRUMENTATION

7.1 General

All electronic transmitters shall be, “Smart” type with “HART” protocol. Transmitter output shall be 4~20mA, two wire loop powered at 24VDC from the system it is connected to. Smart sensors connected to safety systems shall be write-protected to prevent unintentional modification from a remote location.

All transmitters shall be supplied with integral LCD digital indicators scaled in engineering units; however, scale for level transmitters shall be 0 to 100% of instrument span.

Separate dedicated instruments shall be used for shutdown and process control & monitoring. Shutdown initiating devices shall only be used for shutdown functions.

Safety functions shall be derived from transmitters instead of switches. Use of switches shall be avoided for safety applications.

Low power signals (i.e. RTD / thermocouple) shall be converted in field to 4-20 mA by means of remote mounted transmitters.

Field instrument design and selection shall suit process and environmental conditions as well as hazardous area classification requirements.

All electronic / electric instruments shall have 2 Nos. ½” NPT cable entries. Suitable nickel plated brass adapters shall be provided if the cable entry on the instrument is other than NPT threads. Spare cable entries shall be plugged with certified nickel plated brass plugs.

Sunshades shall be provided for all outdoor electronic/electric instruments exposed to sunlight. The material of construction shall be FRP (non-metal) to have better heat insulation.

Gauges (pressure, temperature) shall have black letters and graduation with white background. All transmitters housing shall be aluminum or stainless steel, complete with SS316 mounting accessories as a minimum.

All field instruments shall be weatherproof to IP67 standard as a minimum. The transmitter body shall have an external earth stud connection for safety grounding.

7.2 Pressure Instruments

Pressure gauges shall be bourdon tube type as per EN837. Dial size shall be 150 mm and cases shall be stainless steel screw on or bayonet bezel type. Blow out disc and solid front protection shall be provided and gauges shall be orientated such that they vent safely. Bourdon tube material shall be SS316. Accuracy shall be +/- 1% of full range.

Differential pressure gauges shall generally be bellows type. All differential pressure gauges shall be installed so as to minimize the length of impulse lines. Necessary isolation valve / manifold shall be provided for all differential pressure gauges. Gauge enclosure shall be weather proof to IP 67.

Gauge saver/ snubbers shall be provided for lower range gauges and in vibration or pulsation services. Snubbers shall be of same material specification as the element.

Gauge windows shall be constructed from safety pattern/toughened glass.

Over-range protection for pressure instruments shall be 1.3 times the maximum scale range. Where a gauge is subject to greater pressure, a gauge protector shall be used.

Pressure transmitter shall be electronic SMART type, two wire loop powered at 24 VDC with 4-20 mA output and integral digital output meter. Transmitters shall have HART protocol for digital communication. Pressure and differential pressure (DP) transmitter sensors shall be capacitance, inductance or piezo-resistance type.

Transmitter shall be provided with external span and zero adjustment. Span shall be continuously adjustable over the transmitter range. Pressure transmitter shall have easily approachable zero and span adjustment facility.

Pressure transmitters shall be provided instead of pressure switches as pressure switches are not preferred especially in safety applications.

Range shall be selected such that the normal operating pressure lies approximately in the middle third of full scale (30% - 70% of range) and provide maximum working pressure is within the instrument range.

Manifolds shall be of SS316 material. Gauges and pressure transmitter shall be supplied with a 2-way valve manifold and DP instruments shall be provided with 5-way manifold. Manifolds shall be forged type and capable of withstanding 1.5 times design pressure. The manifold shall be factory fitted and all tests shall be conducted along with manifold. Spare ‘O’ ring set shall be supplied.

7.3 Temperature Instruments

Temperature gauges shall be used for local indication. These local temperature indicators shall in general be heavy duty, weatherproof, dial type bi-metal thermometers with 150 mm dial size, external zero adjustment, every angle rotatable and rigid stems.

The bi-metal gauges shall be adjustable union stem type with SS 316 material for the stem. The Union size shall be ½” NPT and the diameter shall suit the well diameters. However, Vendor shall verify the compatibility of the material of construction with the site/process requirements and suggest suitable material. Case material for all temperature gauges shall be SS316. Capillary and armor shall be of stainless steel.

The temperature element shall be RTD PT-100, 3-wire system. Elements shall be spring loaded, mineral insulated and shall have SS 316 sheath as minimum. The element head shall be screwed-in type and weatherproof to IP-67 as a minimum.

Sensor elements of temperature transmitters and temperature gauges shall be installed in a suitable thermo well. Thermo wells shall be SS316 as a minimum and shall conform to the process service and shall be one class higher than piping class.

Thermowell shall be flanged machined from solid bar stock and with tapered end. Thermowell construction details and insertion length criteria shall be defined during detailed design.

Thermowell shall be designed to withstand vibration stresses caused by stream velocity. Wake frequency at maximum flow velocity shall be less than 80% of the natural frequency of the thermowell. The Contractor shall provide calculations to ASME performance Test Code 19.3, Part 3: Instruments and Apparatus for Temperature Measurement.

Temperature transmitters shall not be part of the sensing element assembly. The sensing element shall be RTD 3 wire type. The temperature element length shall be selected to suit the thermowell insertion length.

The transmitter shall be head mounted "SMART" type, two wire loop powered at 24V DC with 4-20 mA output with integral digital output meter. Transmitters shall have HART protocol for digital communication.

The range shall be selected so that the normal operating temperature shall fall in the middle third of the span.

Temperature transmitters shall have a built-in linearization function to produce an output linear to temperature range.

Local temperature indication shall use bi-metallic type, weatherproof hermetically sealed, every angle adjustable, with 150 mm (6") diameter dial thermometers.

7.4 Level Instruments

Level instruments shall be mounted on stand pipes to avoid excessive numbers of individual vessel nozzles provided that:

- Construction requirements of the piping / vessel nozzles fabrication code can be met without compromising the required ranges;
- Access for operational readings and maintenance is not impaired;
- Walkway clear space is not impeded.

Shutdown instruments shall not share connections or standpipes with control instruments, whereas monitoring instruments can share the same.

Differential pressure level measurement shall be provided on proposed fire water tanks.

Differential pressure level measurement is acceptable for remote level indication where specific gravity is fairly constant and level measurement range is more than 1219 mm (48"). These instruments shall have zero elevation / suppression adjustment wherever required. Dry low pressure leg shall be maintained.

Reflex gauges shall be used on all clean services except liquid level interface.

Transparent gauges shall be used on acid, caustics, dirty fluids, colored fluids and liquid interface where the interface is visually discernible.

For high pressure, high temperature, toxic or hazardous duties, the use of magnetic follower gauges shall be considered.

The visible length of level gauge shall not exceed the range of the transmitter by 5% on both low and high level.

For critical control duties, alternative level control sensing, with deviation alarm between the two measurements shall be provided.

7.5 ON/OFF Valves/SDV/BDV

Shut Down Valve/ Pneumatic Operated On-Off Valves shall be provided to function as on / off valves in the proposed Project.

Each actuator shall be provided with open / close limit switches, remote / local selector switch. A local actuator panel shall be provided to enable opening and closing of valve under local mode. Solenoid valves shall be 3 way with manual reset facility. Solenoid valve shall have manual over ride provision/facility.

Tubing and tube fittings shall be minimum SS316. Local panel shall be die-cast aluminum and Ex"d" certified. All signals from actuator to control system shall be potential free.

The valve opening and closing times shall be reviewed based on process requirement. All accessories shall be neatly tubed and mounted in a control box adjacent to valve actuator

Material and type of construction of valve shall be in accordance with PMS and trim parts shall be as a min. SS316 grade. Shutdown valves shall be duly assembled with limit switches which shall be proximity type NAMUR switches. Partial stroke test (PST) facility/ option shall be provided for ESD/ Shutdown valves.

7.6 Pressure Safety Valves

Conventional spring loaded relief valves shall be used for process, thermal or fire relief duties where there is no back pressure, or where back pressure is constant. Balanced bellows relief valves shall be used when back pressure exceeds 10% of the relieving pressure and is variable.

Pilot operated safety and relief valves shall not be used on congealing services and generally not recommended for Hydrocarbon services and fouling services as these valves have flexible membranes which withstand only ordinary temperatures. Pilot operated safety relief valves where used shall be provided with back flow preventers.

Flanges shall be integral part of the body. Weld-on flanges shall not be allowed. Bodies and flanges shall be of the same material. Inlet flange shall be of sufficient rating to withstand the reaction force of the PSV.

Thermal relief valve shall be provided on water service, if necessary.

Safety and relief valves sizing & selection shall be in accordance with API 520, API 521, API 526 and Section I and VIII or the ASME boiler and Pressure Vessel Code.

All wetted parts of PSV shall be SS316. Safety valves shall be provided with test gags and manual test lever. Seat leakage shall be in accordance with the requirements of API STD 527. Springs of safety valves shall be selected as per process conditions.

7.7 Ultrasonic Flow Meter & Fuel Meter along with Flow Computer

Check Metering/ custody transfer metering skid shall be provided at stations as indicated in PFD/ P&ID with one working & one standby condition.

The meter uncertainty of individual ultrasonic flow meter shall be ± 0.3 % or better, repeatability shall be <0.1% or better. The flow meter shall be sized for a maximum flow velocity. The flow meter design shall be based on AGA design standard (AGA - 8, 9 &10). Ultrasonic Multi Path (Minimum 4 path) Flow meters shall be with pressure and temperature compensation. Ultrasonic flow meters based on the measurement principle of transit time shall be used. Gas velocity through ultrasonic flow meter shall not exceed 20-25 m/s.

The flow meter outputs are connected to flow computers approved for the purpose of custody transfer. The meters shall be connected to common inlet and outlet line with isolation valves. These isolation valves shall be motor operated type irrespective of line size.

Each meter shall be sized for the design flow rate. The flow computers shall be located in the control room. Signals from the flow computers shall be supplied via serial link to the SCADA System via the PLC/RTU. Signals from the individual instrument to skid junction box shall be in the package Vendor’s scope contractor to carry out the cabling between metering skid junction box to the metering panel in the control room.

The stream flow computers shall be microprocessor based, with keypad and alphanumeric display with AGA firmware for flow measurement. The stream flow computers shall be linked to the SCADA for providing the flow measurements of the individual stream runs and related process variables. Flow computers according to AGA 8 & 9. Each of the flow streams will be provided with a common flow computer. The flow computer shall access the flow meter data and diagnostic data through RS 485. The stream flow computers shall compute and display the instantaneous and totalised flow rate for each stream corrected for pressure and temperature variations. Flow computer shall be provided with facilitate for manual entry of data like atmospheric pressure, GC valves etc. also privilege for selectable units. Flow computers shall be located in safe (nonhazardous) control room. However, the entire system shall be designed for non-air conditioned environment also. It shall be suitable for ambient condition (i.e. temperature 4 to 55°C and relative humidity 100%.

7.8 Control Valves

A. INTRODUCTION

1. The control valves and accessories equipment furnished by the tenderer shall be designed, constructed and tested in accordance with the latest applicable requirements of code for pressure piping ANSI B 31.1, the ASME Compressor & Pressure Vessel code, as well as in accordance with applicable requirements of the “Federal Occupational safety and Health Standards, USA” or acceptable equal standards.

B. CONTROLVALVE DESIGN & SIZING

1. The design of all valve bodies shall meet the specification requirements and shall conform o the requirements of ANSI for dimensions, material thickness and material specification for their respective pressure classes.

2. The valve sizing shall be suitable for obtaining maximum flow conditions with valve opening at approximately 80% of total valve stem travel and minimum flow

conditions with valve stem travel not less than 10% of total valve travel. All the valves shall be capable of handling at least 120% of the required maximum flow.

Further, the valve stem travel range from minimum flow condition to maximum flow condition shall not be less than 50% of the total valve stem travel. The sizing shall be in accordance with the latest edition of ISA Handbook on control valves,. Tenderer shall furnish the sizing calculations clearly indicating the outlet velocity achieved with the valve size selected by him as well as noise calculations, which shall be subject to consultation's / owner's approval during detailed engineering.

3. Control valves for applications shall be designed to prevent cavitations, wire drawing, flashing on the downstream side of valve and down stream piping.

4. Trim shall be multistage type having sufficient number of discrete pressure drop turns (stages) to ensure elimination of vibration, erosive – action, cavitations. Tenderer shall identity the number of pressure drop turns in proposed equipment and shall also provide calculation demonstrating compliance to the trim exit velocity.

5. To prevent flow induced vibration and to protect the valve intervals from foreign particles such as weld slag flow, direction shall be a flow to close (over the plug) configuration for liquid applications. To maximize noise attenuating benefits and to allow for constant fluid expansion, flow direction shall be under the plug for steam and gas applications.

6. Control valves as per application all control valves such as low and high range feed control valves shall have min. leakage rate as per leakage class standard code shall be finalized during detailed engineering.

7. The control valve induced noise shall be limited to 85 dBA at 1 meter from the valve surface under actual operating conditions. The noise abatement shall be achieved by valve body and trim design and not by use of silencers.

8. The characteristic of the control valves shall be determined based on the application / service.

9. On supply air/Nitrogen or electrical failure for pneumatic / electrical drive, the valve shall remain full closed, open or stay – put position as per process safety requirement.

C. VALVE CONSTRUCTION

1. Proper selection of valve type and material of construction to meet operating requirement.

2. All valves shall be of globe body design and straightaway pattern with single or double port unless otherwise recommended by the manufacturer to be of angle body type. Rotary valve may alternatively be offered when pressure or pressure drops permit.

3. Valves with high lift cage guided plugs & quick charge trims shall be supplied.

4. Cast iron valves are not acceptable.

5. Bonnet joints for all control valves shall be of the flanged and bolted type for easy dis – assembly. Bonnet joints of internal threaded or union type shall not be acceptable.

6. Plug shall be of one – piece construction either cast, forged or machined from solid bar stock. Plug shall be screwed and pinned to valve stems or shall be integral with the valve stems.

7. All valves connected to vacuum on down-stream side shall be provided with packing suitable for vacuum applications (e.g. double vee type chevron packing).

8. Valve characteristic shall match with the process characteristic.

9. Extension bonnets shall be provided when the maximum temperature of flowing fluid is greater than 280 Deg C.

10. Flanged valves shall be rated at not less than ANSI pressure class of 300 lbs.
11. Teflon shall be used for valve gland packing to suit process requirement.
12. The valve body shall be marked to show direction of flow.

D. VALVE MATERIALS

1. The control valve body material shall be:

(i) Carbon steel as per ASTM – A216 GR WCB for non – corrosive, non – flashing and non – cavitations services below 275 0C temperature and above 275 deg C ASTM-A217 GR WC 9.

(ii) Alloy steel as per ASTM – A217 GR WC 9 for severe flashing / cavitations services like low load and full load, emergency drains, vessel overflow drain etc.

(iii) Alloy steel as per ASTM A – 217 GR WC 6 for low flashing / cavitations services like Heaters normal drain control, drain cooler normal level control, gland steam cooler minimum flow etc.

(iv) 316 SS for condensate service below 300 deg. C normal and emergency make – up controls etc.

2. The control valve trim material shall be:

(i) 17 – 4 PH SS for severe services listed under item D1,(i) (II) & (III) above

(ii) SS 440-C for severe services listed under item D1 (II) above

(iii) 316 SS for services listed at D.1 (IV) above and

(iv) 316 SS with satellite faced guide parts and bushings for remaining applications.

3. However, vender may offer valves with body and trim materials better than specified materials and in such cases vender shall furnish the comparison of properties including cavitations resistance, hardness, tensile, strength, strain, energy, corrosion resistance and erosion resistance etc of the offered material vis – a – vis the specified material for Consultant’s / Owner’s consideration and approval.

E. END PREPARATION

Valve body ends shall be either butt welded / socket welded, flanged or screwed as finalized during detailed engineering and as per Consultant’s / Owner’s approval. The welded ends wherever required shall be butt welded type as per ANSI B 16.25 for control valves of sizes 65 mm and above. For valves sizes 50 mm and below welded ends shall be socket welded as per ANSI B 16.11. Flanged ends wherever required shall be of ANSI pressure – temperature class equal to or greater than of the control valve body.

7.9 Process & Instrument Connection

Field instruments and / or devices that are connected to the process / utility medium shall be provided with suitable tap points and isolation valves. Each instrument shall have its own individual tap and process isolation valve (piping root valve).

All instruments shall have first isolation valves as per the piping specifications. Instrument valves and manifolds shall be provided as required for maintenance and calibration of the instruments. Vent and drain valves shall be provided on the drain and vent tubing / piping. Impulse piping up to the first isolation valve shall be as per piping specifications.

Each tap for pressure / flow / level instrument shall be provided with isolation valves as per P&IDs. In addition, a 2-valve manifold shall be provided for instrument isolation of pressure transmitters and pressure gauges. A 5-valve manifold shall be provided for instrument isolation of flow and differential pressure instruments.

Manifolds shall be integral to the transmitter and shall be of mono-flange type when possible. All pressure instruments shall have an individual piping block valve and a 2, 3 or 5 - valve manifold as appropriate, providing block, bleed and bypass.

Process connections for instruments on vessels / piping and tanks shall be as per the process connection standard depicted in table below.

Instrument	Process Connection Size			Instrument Connection
	Vessel	Piping	Tank	
Pressure Gauge	2” RF flg	2” RF flg	2” RF flg	½” threaded
Pressure Transmitter	2” RF flg	2” RF flg	2” RF flg	½” threaded
Radar	4” RF flg	--	4” RF flg	4” RF flg
Level Transmitter (Radar Type/Displacer)	2” RF flg	2” RF flg	2” RF flg	4” RF flg
Level Gauge (Magnetic)	2” RF flg	--	2” RF flg	--
Temperature Transmitter	2” RF	2” RF	2” RF	½” threaded
Thermowell	1 1/2” RF flg	1 1/2” RF flg	1 1/2” RF flg	1 1/2” RF flg

*: As per Vendor’s recommendations.

A maximum of two pressure instruments may be connected to the same pressure tapping, so long as their function is not safety-related. Instruments for safety systems shall each have their own individual tapping. The nozzle length on vessels for temperature instruments on piping shall be 150 mm. For Thermo-well installation, minimum pipe size shall be 4".

7.10 Instrument Installation

Installation of field instruments and panels / cabinets shall be of the highest quality craftsmanship and shall conform to the best applicable engineering practices, and, relevant codes. All instruments, panels / cabinets and their components shall be installed in a neat workmanlike manner ensuring ease of operation and maintenance.

Locally mounted instruments shall be located in accessible areas but must not obstruct aisles, walkways, or equipment access routes.

All installed instruments and valves shall be free from vibration. Instruments shall be mounted / connected so as not to stress vessel nozzles or pipe tapping.

Local Instruments shall be mounted approximately 1.0 to 1.4 meters above the ground or platform level. All local process-connected instruments shall be located as close as possible to the point of measurement while still being accessible.

Instruments shall preferably be installed as a close-coupled type to avoid tubing and fittings. If accessibility cannot be ensured for close-coupled type then instruments shall be line mounted or mounted on a 2" pipe stand at a height of 1400mm from grade/platform. The 2" pipe stand shall be carbon steel, galvanized and painted. The 2" mounting accessories shall be 316 SS. Insulating material shall be used to avoid direct contact between SS and CS materials.

Instruments in air or gas service shall preferably be mounted above the process line connection.

7.10.1 Tubing, Fitting & Instrument Valves / Manifolds

Tubing and tube / pipe fittings used to hook up instruments to piping / vessel shall be suitable for process fluid.

The materials used for tubes and tube / pipe fittings shall be as follows as a minimum based on the area of application:

Sensing Lines (on firewater and instrument air):

- Tubing: SS316;
- Fitting: SS316;
- Valve / Manifold: SS316.

The tubing shall be with OD of 1/4", 3/8” and 1/2" sizes and suitable wall thickness. However, higher wall thickness shall be used if required as per service pressure requirements.

8.0 COMPRESSOR PLC CONTROL SYSTEM

Operator shall provide Operation & Control Station for the Compressor Station and Associated Utilities. The Control System should consist of Compressor PLC/DCS, ESD PLC, GDS Panel, FACP and PLCs for other Package Items.

ESD & F&G System shall be SIL-3 Rated and other PLCs shall be Dual Redundant SIL-2 Rated.

8.1 Supervisory Monitoring and Control System

New Proposed SCADA system (By Others) shall be used for new proposed Compressor Station at Rupkhelia

Following philosophy shall be used for the instrumentation and control of this pipeline:

a) Instrument and control signals at Compressor station at Rupkhelia shall be connected to respective Compressor PLC. Signals from PLC shall be further transmitted through FOC based network to the New SCADA/RTU system (By Others).

b) The fire and gas devices and ESD Devices shall be connected to the F&G system and ESD System Respectively at Compressor Station Control Room of Rupkhelia, subsequently these signals / alarms shall be made available to New SCADA/RTU system(By Others)

8.2 Compressor PLC

The package units shall have their own unit control panels with dedicated PLCs supplied by the Vendor for monitoring / control and protection. The package unit shall also have their own dedicated SIL Certified PLC if required and supplied by Vendor for initiating local shut downs on skid and initiate the plant level shutdown through plant ESD system.

Primary objective of Compressor Station operation and control system design at Rupkhelia are:

a) Compressor PLC system and personnel safety;

b) System reliability, continuous and secured operations;

c) Efficient use of energy;

d) Reducing life cycle O&M costs;

e) Environmentally friendly operations;

f) Look-ahead approach for future needs and system expansion;

g) New technology and Automation.

System shall be designed to have minimal operating personnel, in fully automated mode with remote supervision and control.

During normal operations, the Compressor Instrumentation and PLC, such as F&G System, ESD System, CCTV System, Vibration Monitoring System will be monitored and operated from Local Control Room for Compressor and Master Control Room at Rupkhelia.

Necessary support and utility systems shall be designed to enable the unmanned operation with provisions for local override.

The PLC shall be microprocessor based with programmable units with both ROM & RAM providing required cache memory and main memory with battery backup for memory. The PLC shall be modular in design and shall use a 32-bit microprocessor as a minimum; a real time clock with a min. 10 m sec resolution or better.

The PLC system shall be designed for maximum reliability, safety and integrity while maintaining availability. PLC processor shall have retentive memory with battery backup. The PLC shall be supplied with panel mounted HMI.

The PLC with dual redundant hot swappable processor card & power supply cards are to be supplied. There is no redundancy for Input / Output modules. The maximum system response time shall be as short as practicable. The PLC and its cabinet shall be suitable for Indoor application. However, all signals except output for SOV's shall be intrinsically safe with barriers.

The Compressor signals shall be interfaced to this PLC and made available at SCADA system of this Compressor Station via Fiber Optic Ethernet Switch based digital telecommunication network, using Fiber optic cable.

The PLC shall be capable of communicating with other systems and sub-systems via bi-directional Modbus or Ethernet link.

8.3 Interface to SCADA

New SCADA at Rupkhelia Terminal shall be used and extended for Rupkhelia Compressor Station shall be interfaced to Compressor PLC. The following packages or system shall be interfaced to existing SCADA through a secure, redundant, Modbus / Ethernet protocol-based interface either by a Fiber Optic Cable (FOC) or serial cable link

- Compressor PLC/DCS;
- F&G System;
- ESD System;
- CCTV System
- Vibration Monitoring System
- Other Package PLC/DCS

9.0 FIRE & GAS DETECTION

9.1 Gas Detection System

GDS shall be provided at Rupkhelia Compressor Stations;

Gas detection system shall be a stand-alone microprocessor-based system fully compatible with the type of sensors specified in the data sheet.

The gas monitors/controllers shall be microprocessor based and shall have panel or standard rack mounted modular plug-in type construction.

Each gas detector shall either have dedicated single channel module or 1:1 redundant multichannel module to maintain single loop integrity.

The system shall be designed to avoid common cause of any failure. Redundancy shall be provided for all common mode failure modules/ components/ subsystems, unless otherwise specified in the purchaser's specifications.

The system shall be designed considering normally energized with normally closed concept to make it fail-safe. Monitored inputs/outputs shall be provided whenever the purchaser's data sheets specify normally de-energized/normally open system.

Gas detection system shall be interfaced with purchaser's control system e.g. PLC/Distributed Control System/ Shut down system etc.

Following outputs shall be provided for interface:

1. A redundant serial MODBUS (RTU) output with RS485 physical interface for complete data transfer and display in purchaser's DCS/PLC/SCADA. The data shall include tag wise concentration, high & high high alarms, diagnostic, status alarms and bypass status etc.
2. Potential free contacts for shutdown system as per purchaser's specification.

3. Potential free contacts for High-High group alarms

4. Provision for connection of MCP

Following indications shall be available on each monitor/controller for each detector channel:

a) Power-on light

b) Alarm high light (default setting at 20% of LEL or 20 ppm)

c) Alarm high-high light (default setting at 60% of LEL or 50 ppm)

d) Malfunction light (this shall include short circuit, line-breaking, over-range and earth fault).

Latched type of relay contacts shall be provided for each channel for

a) Alarm high

b) Alarm high high

c) Malfunction alarm

Each channel shall also have calibration switch to allow sensor calibration without alarm outputs.

The following type of fire and gas devices are provided for the Project facilities:

a) HC Detectors (IR Point type and Open Path type);

b) Manual Call Point;

c) Hooters;

d) Beacons;

GDS system shall be provided at all respective terminals and SV stations of the pipeline shall be interfaced with the RTU/SCADA system through MODBUS/ RS-485 soft link communication. GDS shall also be interface with fire suppression system panel for auto operation of Co2/ FM-200/ Clean agent flooding system.

9.2 Fire Alarm Control Panel

Fire Alarm Control Panel (FACP) shall be provided at Rupkhelia Compressor Station;

FACP shall be a standalone control panel.

FACP shall be interfaced with all addressable IS and non-IS field devices. Each FACP shall be capable of handling approximately 4 loops. Battery rooms shall be considered as hazardous area for F&G detectors and loops selection.

The following type of fire devices are provided;

- FACP (Fire Alarm Control Panel)
- Addressable multisensory (Heat & Smoke) Detector
- Manual Call Points

- Hooter
- Beacons

FACP shall be interfaced to RTU both through hardwired link and redundant serial link for monitoring and control. Moreover, FACP shall also be connected to New SCADA system for monitoring and centralized fire hazard control. FACP shall gather all data.

10.0 TELECOMMUNICATION SYSTEM

Telecommunication panel (Fiber Optic Ethernet Switch) shall be provided at Rupkhelia Compressor Station:

All FO cables entering in a building will be terminated at Intelligent Fiber Optic Patch Panels. These Intelligent Panels will be 19" cabinet mounting units with 1U height capable of terminating 24 cores fiber optic cables. It will be equipped with 24 LC-type female connectors for patching.

10.1 Fiber Optic Cable

Single mode, 24 core armored fiber optical cables (FOC) with double HDPE sheath shall be used for communication across the pipeline. The FOC shall be laid in 40 mm OD permanently lubricated HDPE duct. The pipeline Contractor shall supply & install the optical fiber cable in the pipeline trench.

10.2 PLB HDPE DUCT

The PLB – HDPE Duct shall consist of two concentric layers, the outer layer being HDPE; co-extruded with an inner layer of solid permanent lubricant, to reduce the internal coefficient of friction (ICF). The lubricant shall be of a solid layer of uniform thickness so formulated to provide a permanent, low friction boundary layer between the inner surface of the duct & optical fibre cable. The lubricant layer shall be clearly visible in cross-section, concentric with the outer layer.

10.3 CCTV System

The CCTV System is required to selectively display real time video signals of the field area in the control room. It shall monitor video signal from the various cameras. It shall be able to select individual camera without interfering with off-line functioning of the CCTV system since recording of all cameras to be simultaneous and in real time environment. It shall incorporated facilities for superimposing text for the purpose of the identification of camera positions with a time and date stamp facility and shall have facility of both i.e. viewing and for recording as well. It shall have an extensive self-diagnostic program to detect and report any system fault.

CCTV camera video recording is carried out using Network Video Recorder. Recording shall be on a continuous basis for 30 days. Recording capacity requirement shall be detailed during detail engineering. CCTV camera shall be color camera (day / night) with high resolution. It shall have programmable facility to restrict access through password. It shall have real time clock and synchronized with telecom system clock. Camera shall be able to generate alarm on detecting loss of video. It shall receive remote control for PTZ & focus functions control commands from operator keyboards.

CCTV system shall be able to work on standard 240VAC UPS power supply. All outdoor cameras & camera assemblies shall be suitable for outdoor application. All outdoor cameras shall be ingress protected to a minimum of IP65. Indoor cameras shall be ingress protected to a minimum of IP42. There shall be Wash / Wipe assembly / unit for each camera. CCTV cameras shall be with built in Pan / Tilt controllers and suitable environmental housing with stainless steel construction 316 SS suitable for corrosive environment.

The CCTV system shall include, but not limited to, the following equipment:

a) Network Digital Video Recorder (NDVR);

b) PTZ Camera Ex 'd' - Outdoor (CCTV Camera) with housing;

c) PTZ Camera - Indoor (CCTV Camera);

d) Fixed Camera – Outdoor;

e) Fixed Camera – Indoor;

f) Camera Poles;

g) CAT-6/UTP Cables.

CCTV system will provide security and control along pipeline using CCTV cameras at all respective terminals, intermediate and SV stations.

11.0 PACKAGED EQUIPMENT

The package units shall have their own unit control panels with dedicated PLCs supplied by the Vendor for monitoring / control and protection. The package unit shall also have their own dedicated SIL Certified PLC if required and supplied by Vendor for initiating local shut downs on skid and initiate the plant level shutdown through plant ESD system.

Metering System based on Ultrasonic type flow shall be in full compliance with AGA 9 and as per the technical requirements of the Project.

11.1 Vibration Monitoring System

Vibration monitoring system including Vibration probes and vibration monitors for motor at field. Vibration probes shall be terminated suitably by Tenderer in Vibration Monitoring Panels near the motor which shall be Explosion Proof SIL-3 Rated. Vibration Monitors shall provide local display of parameters. 4-20mAmps output signal from these monitors shall be taken to upstream VFD for monitoring and control. VFD shall communicate the same to Plant DCS/PLC over communication bus.

11.2 Compressor

The new Compressor Proposed for the Development of BOO Compressor Station at Rupkhelia shall have a philosophy of (1W + 1S) Concept and shall be provided as a complete package with all the instrumentation, Internal Piping, Mechanical Equipments and other associated utilities. The Compressor shall have a independent PLC Panel with IO Modules, Barriers, Isolators, Relays, HMI and Alarm Annunciator. The Suction Pressure and Discharge Pressure of the Compressor shall be as per the Process Design Basis

12.0 CONTROL ROOM

Pre-fabricated shelters (Portacabin) shall be considered Local Equipment Room (LER) at Rupkhelia. The New control room in Rupkhelia shall be used for integration of the Package System with the New SCADA System.

Local Equipment Room (LER) which is a self-contained fully functional building including but not limited to normal and emergency lighting, HVAC duty and standby, fire detection and suppression system, communication system, power distribution boards for normal and UPS power, grounding system for electrical and instrument control system.

LERs will be generally located in safe areas as identified in hazardous area classification. Human engineering will play prominent role in the design, space consideration and operator interface facilities. The design space will allow operator the comfort of utilizing the room for full operation and control room whenever required during start-up, operation and maintenance activities.

LER can be a combination of electrical LV, instrumentation I/O and control system.

Pipeline LER shall be strategically located to optimize cable runs thereby reducing cable costs and shall be normally centralized to the pipeline process area which it serves.

Control room shall comprise of LV MCC, instrumentation marshalling panels, PLC control system, package control system, shutdown system, UPS, battery system, HVAC, fire alarm panel and local telecommunication system, Vibration Monitoring System required for efficient operation and control of Rupkhelia Compressor Station

The LER building shall be elevated to allow bottom cable entry for the panels and shall be tiled raised or computer floor to allow routing of cables and trays. Panels shall be standing on steel structure flushed with the tiled raised floor. Cable penetration to the room shall be side entry below the level of the raised floor through proper openings which shall be sealed after use.

13.0 CABLING AND INSTALLATION

13.1 Instrument Cables

All instrument and F&G cables shall be shielded low smoke, low halogen, resistant to water, oil, solar radiation and ultra-violet light.

Cables shall comply with BS-5308-1, Instrumentation Cables – Part 1: Specification for XLPE insulated cable.

Cables used in essential service applications such as ESD, F&G system signals, firefighting system signals, Compressor PLC, Vibration Monitoring System and telecommunication system cables shall be fire resistant in accordance with IEC 60331. All other instrumentation cables shall be flame retardant to IEC 60332.

Instrument cable construction shall be in accordance with IEC 60227, IEC 60228 and ANSI MC 96.1 for thermocouple cables. The electrical characteristics such as conductor resistance, capacitance, L/R ratio, insulation, etc. shall be in accordance with IEC 60502-1.

Cables shall be mechanically protected using steel wire armor. The cable construction shall consist of twisted single pair / multi-pairs, single triad / multi-triad conductors of stranded annealed copper type with individual and overall shield for analog signals (AI, AO) and only an overall shield for discrete control signals (DI, DO).

Conductor insulation shall be flame retardant cross linked polyethylene (XLPE).

Cable sheath (both inner and outer) for instrument cables shall be flame retardant PVC type. Non IS instrument cables shall have black colored outer sheath. IS instrument cables shall have blue colored outer sheath. Screens shall be aluminum backed mylar tape with drain wire. Tape shall be helically wrapped with 25% overlap and shall be in continuous contact with a solid tinned- copper drain wire.

Cables shall be of voltage grade 300/500 and of types single pair / multi-pairs, single triple / multi-triples, individually and collectively screened with drain wire and armoured for the following signals:

- Analogue signals (4 ~ 20 mA);
- Gas detector signals.

Cables shall be of voltage grade 300/500 and of types single pair / multi-pairs, only collectively screened with drain wire and armoured for the following signals:

- Digital signals;
- Solenoid valve signals;
- Control signals.

Cables shall be suitably segregated, consisted with the best practice and based on voltage level, direct or alternating current, power or signal service etc. Further details shall be developed during detail engineering.

Separation between instrument and power cable shall be as follows:

Power Cable Rating	Instrument Cable Separation Distance
125V or 10A	300 mm
230V or 50A	500 mm
230V-400V or 200A	750 mm
>=1.1 kV or 800A	2000 mm

Power and instrument cable may be run in the same cable tray only if adequate mechanical segregation such as barrier plates is provided in the middle of the tray.

Redundant cables such as redundant serial / Ethernet link shall be routed in diverse paths preferably.

Minimum distance between parallel power and signal cable trench shall be as follows:

Length of Parallel Trench	Minimum Distance between Trenches
Up to 60 meter	600 mm

60 – 100 meters	1 meter
100 – 150 meters	1.5 meters

Exterior sheath and wire color coding shall be as depicted in table below:

Function	Wire Color	Outer Sheath Color
Instrument Cables (Non-IS - Control)	Black (+) / White (-)	Grey
Instrument Cables (IS - Control)	Black (+) / White (-)	Blue
Instrument Cables (Safety Systems)	Black (+) / White (-)	Red
Fire & Gas Cables	Black (+) / White (-)	Red
Thermocouple Cables	As per ANSI MC 96.1	As per ANSI MC 96.1
AC Power	Brown (+ve) / Blue (-ve)	Black
Safety Earth	-	Green / Yellow
Instrument Earth	-	Green

Electrical connections on the instrument side, JB side and panel side shall be NPTF as minimum. End connection for cable termination shall be 1/2"NPTF for 2-wire instruments whereas for 3-wire or 4-wire instrument, 3/4"NPTF is also acceptable.

13.2 Junction Boxes

All junction boxes shall be made of cast aluminum (LM6/LM25) with UV resistant, EEx 'd' certified and IP-65 rated for outdoor and IP-42 rated for indoor installation. The finish of junction boxes (Non IS) shall be light gray (RAL7035) and junction boxes (IS) shall be blue shade.

Separate junction boxes shall be considered for SCADA, ESD system and F&G system signals. Signal segregation shall be followed for junction box and cables and is as follows:

- Analog Signals for control / monitoring (IS);
- Digital signals for control / monitoring (Non IS);
- Analog signals for safety (ESD);
- Digital signals for safety (ESD);
- Power supply for instrumentation of Compressor;
- Solenoid signals for control / monitoring (PCS or PLC);

- Solenoid signals for safety (ESD).

Cabling to redundant instruments and actuators (if any) shall be distributed in separate junction box and multi-pair cable.

Cable entries (both single and multi-pair/core cable) shall be at the bottom of the box; where side entry is used, the cable shall be installed in a manner to minimize the possibility of water ingress.

Cable entries shall be sealed for gas/water ingress. All spare entries shall be plugged with certified nickel plated brass plugs; plastic plugs shall not be used. Terminals shall be compression type mounted on a DIN type rail suitable for 2.5 sq.mm conductor, as a minimum.

Junction boxes shall be sized adequately considering the space required inside boxes for cable termination, space required between cable glands, space to operate tools to tighten the glands, etc. 20% spare terminals shall be provided.

Junction boxes shall be provided with internal and external earth studs with associated serrated rings, nuts, etc.

13.3 Cabinets

Cabinets shall be required to house flow computers, RTU, FACP, GDS and any other systems as applicable. Cabinets and panels utilized to house system components shall have a minimum ingress protection (IP) of IP-42 for installation in a controlled environment.

Cabinets shall be of the free standing type with bottom cable entry and floor mounting with anchor bolt. Cabinets shall be painted RAL7035 (Light Grey).

Cabinet doors shall be hinged opening, preferably 180 degrees, and detachable. Doors shall be fitted with seals for dust exclusion.

Doors shall be provided with locks, all keys shall be identical for all cabinets under the Vendor's scope of supply. All installed components shall be easily accessible for removal/replacement and to facilitate wiring terminations.

Cables shall enter the cabinet from the bottom through removable, fully gasketed, split gland plates. Cable clamp rails shall be provided for firmly clamping the incoming and outgoing cables. Adequate cable connection stress relief shall be provided.

Door switch activated lighting shall be provided for system and marshaling cabinets. Each cabinet section shall be provided with a LED light with on/off switch and a 230 V AC power socket.

All cabinets and consoles shall be provided with removable eyebolts for lifting. Blanking plugs shall also be provided for these.

Cabinets shall be provided with removable side panels. Facilities shall be provided for bolting adjacent cabinets together. If cabinets are permanently bolted together to form sections, the length of these sections shall not exceed 2400 mm.

Cable segregation shall be provided inside the cabinet based on the type of signal (analog/digital) and signal excitation voltage level.

13.4 Instrument Cable Glands

Cable glands shall be double compression type, brass nickel plated type with ISO threads. All cable glands shall be EEx ‘d’ certified and shall be weather proof to IP-65 as minimum.

Cable glands shall be supplied and installed with all necessary ancillaries and accessories such as washer, PVC shroud, lock nut and earth ring etc. Cable glands shall have double lock nuts inside the JB.

Cable glands shall not be used for cable entries at the cabinet / panel end and shall be through cutoffs provided in the gland plates.

13.5 Cable Trays

All cable trays shall be made of hot dip galvanized steel, painted and perforated type with self-secured covers.

The sheet steel thickness shall be minimum 1.5mm for cable tray. Cable trays shall be painted white (RAL 9010). All external cable trays shall be provided with cable tray cover with clamps. The tray cover shall be fabricated from the same material of cable trays and shall be of same color.

Cable trays shall be heavy duty, class C as per NEMA VE1 and designed, manufactured and tested in accordance with the requirements with international codes and standards such as NEMA VE1.

The cable trays assembly shall be designed to ensure personnel and operational safety during all operating conditions, inspection and maintenance. Cable tray construction shall be such as to facilitate easy handling and to ensure easy laying of cables without damage to cables. The inside surface shall be free from sharp edges, burrs or projections.

All cable trays shall have 20% spare capacity for future cables. Cable trays shall be supported on structural steel members, at a distance of not more than 3 meters.

13.6 Multi Cable Transits (MCT)

All cable entries to control room/-closed building shall be through MCT blocks. The MCT shall be used where cables are led through exterior walls, floors or partitions with a fire blocking, water blocking or sealing function. MCT shall be gas tight.

MCT’s shall comprise of frame and insert blocks and complete with all accessories. Frame material shall be mild steel suitable for environmental conditions. MCT’s shall be installed at all cable penetrations into the control room and other buildings as applicable. MCTs shall be suitably fire rated to suit the purpose.

All MCT’s shall be blast proof type capable of withstanding 0.5 Bar. Outdoor MCT’s shall be installed for cables crossing from outdoor to indoor. Sizing of MCT shall be designed based on number and size of cables passing through the respective MCT. All MCTs shall comprise 20% spare insert blocks with core for future cables.

Insert blocks shall have a good plasticity, to enable the sealing of uneven diameter cables. Insert blocks shall be suitable to accommodate different cable diameter. Any sealing strip to be used to wrap around cables to fit the diameter into the insert blocks, shall have the same characteristics as the insert blocks. Lubricant for assembling blocks of MCT shall be considered as applicable.

14.0 SPARES

For all instrument items, Vendor shall provide:

- Spare parts for commissioning and start-up (duly approved by the Company);
- 2 years O&M spare parts priced list.

Vendor shall submit spares form for two-year operational period as a part of required documentation.

Following Installed spare criteria shall be considered as a minimum in instrumentation and control system design:

- Instrument air header shall be provided with 20% spare connections;
- All pairs of multi-pair cables shall be terminated in the junction boxes as well as at panel side (including the unused spare pairs);
- Field junction boxes shall have 20% spare terminals and 20% cable entries for connecting future instrument cables;
- All multi-pair/multi-core instrument cables shall have 20% spare pairs;
- All Instrument cable trays and trenches shall have at least 20% spare capacity for future cables;
- Instrument cabinets shall have 20% spare space for I/O cards, marshaling terminals, cable entries etc. for future additions;
- I/O cards shall have 20% spares for future use (separate for each I/O card type i.e. AI/AO/DI/DO etc.);
- Control room shall have 20% space for future instrument panel / equipment.

STANDARD SPECIFICATION

FOR

RESTRICTION ORIFICE PLATES

I-SPC-002

0	05.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

NIL

CONTENTS

1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets, describes the requirements for the design, materials, nameplate marking, inspection, testing and shipping of restriction orifice plates and multistage restriction orifice assemblies.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest edition of the following codes, standard practices & publications unless specified otherwise:

ASME	American Society of Mechanical Engineers.	
	B 16.5	Pipe Flanges and Flanged Fittings
	B16.34	Valves Flanged, Threaded and Welding End
	B 36.10	Welded and Seamless Wrought Steel Pipe.s
EN	European Standards	
	10204	Inspection Documents for Metallic Products
IBR	Indian Boiler Regulation	
ISO	International Organisation for Standardisation . .	
	5167	Measurement of fluid flows by means of orifice plates, nozzles and venturi tubes inserted in circular cross-section conduits running full.

1.1.3 In the event of any conflict between this standard specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Job Specifications / Data Sheets

c) Standard specification

d) Codes and standards

1.1.4 In addition to compliance to purchaser's specifications in totality, vendor's extent of responsibility shall include the following:

a) Purchaser's data sheets specify the material for restriction orifice plates. Unless specifically indicated otherwise, alternate superior material of construction shall also be acceptable provided vendor assumes complete responsibility for the selected materials for their compatibility with the specified fluid and its operating conditions.

b) Purchaser's data sheets indicate the thickness of the restriction orifice plate. If found necessary, vendor may provide higher thickness of the restriction orifice plate considering process conditions, specified in the purchaser's datasheets.

c) Sizing of the multistage restriction orifice plate assembly and the number of stages to meet the process conditions specified in purchaser's datasheet

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instruction to the vendor attached with the Material Requisition.

1.2.2 All documentation submitted by the vendor including their quotation, drawings, installation, operation and maintenance manuals etc. shall be in English language only.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, specification sheet and manuals shall be submitted by vendor as per vendor data requirement attached with Requisition.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc., shall be submitted by the vendor after placement of purchase order as per vendor data requirement attached with Requisition.

2.0 DESIGN AND CONSTRUCTION

2.1 Unless otherwise specified, restriction orifice plates shall be concentric square edge type and shall be manufactured as per company standard drawing number with the thickness as per data sheets. However restriction orifice plates shall not be bevelled and they shall not have weep holes. Serration shall be considered on the restriction orifice plate near the gasket zone.

2.2 Whenever multi-orifice plate assembly is specified, vendor shall supply complete assembly with orifice plates, spool piece and flanges duly welded. The orifice plate design shall be either of the concentric or eccentric type. The number of stages of orifice plates shall be calculated by vendor based upon the process data indicated in the purchaser's data sheet.

In addition to the plates installed inside the spool piece, 2 nos. of additional blind plates of the same thickness and material shall be supplied so that the same in case required for additional pressure drop shall installed at the multi-orifice spool end flange for bolting with Purchasers mating flange.

2.3 Wherever, RTJ flanges have been mentioned in the data sheet for pressure rating more than 600 class as per ASME, shall be followed.

2.4 For multiple restriction orifice assembly, the number of stages / plates and thickness of the plates shall be decided by vendor to meet process conditions. However minimum two number of stages shall be provided by vendor for such tags irrespective of sizing requirements. The sizing calculation for restriction orifices and multiple restriction orifice assembly shall be furnished by vendor for review during detail engineering. Vendor to note that while sizing, pressure drop achieved in the first stage shall not be more than 50% of the total pressure drop. The complete system shall be supplied with flanged end connections in fully assembled condition.

2.5 Each restriction orifice plate shall have an integral handle, which upon assembly shall extend by minimum of 50mm beyond flange edge.

2.6 Restriction orifice plate with thickness greater than 12 mm, Vendors scope shall include long stud bolts for bolting in between Purchaser's flanges. Minimum bore dia., for the restriction orifice plate shall be 1.6 mm.

2.7 Where weld-in type restriction orifice plates have been specified, the welding and edge preparation shall be as per ASME B 36.10.

2.8 Where the restriction orifice plate is to be mounted between ring-type joint flanges, vendor shall supply the plate with a plate-carrying holder. Flange assembly including studs, nuts & gasket shall be supplied by vendor in case specified in Purchase datasheets.

2.9 The inlet face of the orifice plate shall be as per ISO-5167 or any other standard indicated in the purchaser's datasheet.

2.10 The fluid outlet surface of the plate should be flat and smooth and shall not have roughness and scores that can be ascertained by touch or sight.

2.11 Restriction orifice plates in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride and all connections shall be plugged after degreasing process in order to avoid entrance of grease or oil particles

3.0 NAMEPLATE

3.1 Each restriction orifice plate shall have the following nameplate information punched on its handle:

a) Tag number as per purchaser's data sheets.

b) Nominal flange size in inches and rating in pounds.

c) Plate and Flange material to ASTM specifications.

d) Bore diameter

3.2 Each multi-orifice plate assembly shall have a stainless steel nameplate attached firmly to it

at a visible place, furnishing the following information:

a) Tag number as per purchaser's datasheet

b) Manufacturer's name / trade mark

c) Nominal end connection size and rating

d) Orifice plate and assembly material of construction

e) Number of orifice plate stages

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing at vendor's works as per Inspection Test Plan and approved quality documents. All these tests shall be completed by the vendor and test reports shall be submitted to Purchaser for scrutiny.

PMI on all incoming material shall be carried out as per Inspection and Test Plan as applicable.

5.0 SHIPPING

5.1 Each restriction orifice plate shall be packed inside thick polythene bags with suitable protective packing outside.

5.2 Each plate shall be packed separately.

5.3 All restriction orifice plates in oxygen and chlorine service shall be separately packed along with a certificate indicating 'SUITABLE FOR OXYGEN/CHLORINE SERVICE', as applicable.

STANDARD SPECIFICATION

FOR

ULTRASONIC FLOW METER

I-SPC-003

0	05.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AARH	:	Arithmetic Average Roughness Height
EDDL	:	Electronic Device Description Language
FDT / DTM	:	Field Device Tool / Device Type Manager
FISCO	:	Fieldbus Intrinsic Safe Concept
HART	:	Highway Addressable Remote Transducer
LAS	:	Link Active Scheduler
NIST	:	National Institute of Standards and Technology
NPT	:	National Pipe Thread
PID	:	Proportional, Integral and Derivative
SS	:	Stainless Steel

CONTENTS

1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets covers the requirements for the design, materials, nameplate marking, inspection, testing and shipping of Ultrasonic Flow meters and their accessories.

1.1.2 The standards referred to herein and mentioned below shall be of the latest editions unless otherwise specified:

AGA	American Gas Association, Gas measurement committee	
	Report No. 8	Compressibility and Super-compressibility for Natural Gas and other Hydrocarbon Gas Transmission Measurement
	Report No. 9	Measurement of gas by Multipath Ultrasonic flow meters
	ReportNo.10	Speed of sound in Natural Gas & other Related Hydrocarbon Gases
API	American Petroleum Institute	
	MPMS	Manual of Petroleum Measurement Standards
	Chapter 1	Vocabulary
	Chapter 4	Proving Systems
	Chapter 5	Metering
	Chapter 5.8	Measurement of Liquid Hydrocarbons by Ultrasonic Flow Meters using Transit Time Technology
ASME	American Society of Mechanical Engineers	
	B 1.20.1	Pipe Threads
	B 16.5	Steel Pipe Flanges and Flanged Fittings
	B 16.20	Ring-joint Gaskets and Grooves for Steel Pipe Flanges
	B 16.47-B	Large Diameter Steel Flanges
EN	European Standard	
	60947-5-6	Pulse generator requirements
	10204	Inspection documents for metallic products
IS/IEC	Indian Standards/International Electro-Technical Commission	
	IS/IEC 60079	Electrical Apparatus for Explosive Gas Atmospheres.
	IS/IEC60529	Degree of Protection Provided by Enclosures (IP Code).
	IEC61000-4	Electronic compatibility for Industrial Process Measurement and Control Equipment
ISO	International Organization for Standardisation	
	2186	Fluid Flow in Closed Conduits - Connections for Pressure Signal Transmissions between Primary and Secondary Elements
	5168	Measurement of Fluid Flow: Estimation of Uncertainty of Ultrasonic Flow meters
	6551	Cabled transmission of electric and/or electronic pulse data
	6569	Natural Gas - Rapid Analysis by Gas Chromatography
	6976	Natural gas - Calculation of Calorific Value, Density and Relative Density

	10723	Natural gas — Performance evaluation for On-line Analytical Systems
	12765	Measurement of Fluid Flow in Closed Conduits — Methods using Transit Time Ultrasonic Flow meters
OIML	International Organisation of Legal Metrology	
	R 117	Measurement systems for liquids other than water

1.1.3 In the event of any conflict between this standard specifications, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Job Specifications / Data Sheets

c) Standard specification

d) Codes and standards

1.1.4 In addition to compliance to purchaser's specifications in totality, vendor's extent of responsibility shall include the following:

a) Purchaser's data sheets indicate the minimum acceptable materials of construction for body, trim and accessories of the Ultrasonic flow meter. Alternative superior material of construction shall also be acceptable provided vendor assumes complete responsibility for proper selection of offered materials for their compatibility with the process fluid and its operating and design conditions specified in the data sheets.

b) Sizing of the Ultrasonic flow meter and indicating the velocity and accuracy at the specified flow conditions.

c) Coordination and approvals from statutory authorities like weights and measures etc, wherever required.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instruction to the vendor attached with the Material Requisition.

1.2.2 Whenever a detailed technical offer for each item is specifically indicated, vendor's quotation shall include the following:

a) Compliance to the specifications

b) A detailed specification of each Ultrasonic meter having following details as a minimum. All the material specifications and units of measurement for various parts in the vendor's specification sheet shall be to the same standards as those indicated in the purchaser's data sheets.

   i) Details regarding type, material of construction etc., for various parts of the Ultrasonic flow meter, meter runs, flow conditioner and its accessories.

   ii) All the design characteristics and performance characteristics including meter accuracy, repeatability, velocity at operating flow and minimum detectable flow rate.

   iii) Specification and type of cabling required between the meter and its associated receiver instrument/flow computer including the maximum permissible cable length.

   iv) Maximum pressure loss through the meter and meter runs at maximum flow rate.

   v) Upstream and downstream straight pipe length requirement for installation.

c) Overall dimensions in millimetres of the Ultrasonic flow meter, meter runs and its accessories.

d) Type test certificate from accredited laboratory.

e) Certificate from regulatory authority for custody transfer application (whenever Custody Transfer application is specified in the data sheets).

f) A copy of approval from local statutory authority, as applicable, such as Petroleum and Explosives Safety Organisation (PESO)/Chief Controller of Explosives (CCE) or Director General of Mine Safety (DGMS) in India, for the electronic instruments installed in electrically hazardous area along with

g) Deviation on technical requirements shall not be generally entertained. In case vendor has some valid technical reason for not complying with the specific requirements due to superior alternatives and materials, tag wise deviation list must be provided along with the technical justification

h) Catalogues in English giving detailed technical specifications; model decoding details and other information for the type of ultrasonic flow meter and its accessories covered in the bid.

1.2.3 Vendor shall also quote for the following:

a) Two years' operational spares for Ultrasonic flow meter and its accessories covered in the bid.

b) Any special tools needed for maintenance work on the Ultrasonic flow meter and its accessories. Vendor must confirm in their offer if no special tools are needed for maintenance of the offered Ultrasonic flow meter.

c) Unit rate (per meter) for interconnecting cable between sensor unit & transmitter along with SS flexible metallic conduit in case of unarmoured cables

d) Any Start-up and Commissioning spares, if required, as recommended by vendor.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required shall be submitted by vendor as per vendor data requirements attached with the requisition.

1.3.2 Final documentation consisting of design data, installation manual, operational and maintenance manual etc., submitted by the vendor after placement of purchase order, shall include the following, as a minimum:

a) Specification sheet for each Ultrasonic flow meter, Meter Run including flow conditioner, if required, Meter electronics and its accessories

b) Weight in kilograms of each Ultrasonic flow meter and its accessories, meter run with flow conditioners, if required, etc.

c) Certified drawings for each Ultrasonic flow meter, meter runs with flow conditioner, if required, etc., which shall provide dimensional details, internal construction details, material of construction etc.

d) Copy of type test certificates

e) Proving procedure

f) Detailed wiring diagrams

g) Certificate of compliance to purchaser's specification as per clause 3.1 of EN 10204.

h) Graphs of correction factors such as pressure, temperature, density and viscosity.

2.0 DESIGN AND CONSTRUCTION

2.1 Flow meter Body and Trim

2.1.1 The Ultrasonic flow meter shall be based on transit time technology.

2.1.2 The design used shall provide maximum reliability, maximum on-line performance and minimum maintenance. It shall be immune to other impurities in the fluid stream.

2.1.3 The flow meter transducers shall be energized by the integral electronics to transmit and receive ultrasonic waves.

2.1.4 The meter design shall have the facility to remove /replace the transducers in situ under line operating condition. Failure or removal of one pair of transducers shall not cause the meter to lose all measurement function. Failure of any path shall generate an alarm identifying the affected path. Also transducers ports shall be designed in a way to reduce the possibility of liquid or solid accumulation.

2.1.5 It shall be possible to replace transducers without a change in meter performance. After replacement of transducers and a possible change of the associated software constants, the resulting shift in the meter's performance should not be more than the allowable repeatability of the meter.

2.1.6 The vendor shall comprehensively advise the impact of transducer failure on the performance and accuracy of the Ultrasonic flow meter. Ultrasonic flow meters and the meter runs/flow conditioners shall be rated for the maximum design pressure as indicated in the data sheets.

2.1.7 Ultrasonic flow meter spool inside diameter (ID) shall meet the specified pipe ID and internal surface roughness shall be as per API standard.

2.1.8 The meter shall be suitable for horizontal & vertical mounting. However, the flow direction shall be clearly stamped or cast on the body.

2.1.9 End connections:

2.1.9.1 Spool piece type Ultrasonic flow meters shall have flanged end connections. Weld joints, if any, shall be of radiographic quality.

2.1.9.2 Unless otherwise mentioned, end connection details shall be as below:

a) Threaded end connections shall be to NPT as per ASME B 1.20.1

b) Flanged end connections shall be as per ASMEB 16.5

c) Grooves of ring type joint flanges shall be octagonal as per ASME B 16.20 and groove finish shall be as follows:

63 AARH : 32 to 63 micro inch AARH

d) When Flanges are Raised Face (RF) type, the face finish shall be as per ASME B 16.5 and shall be as follows:

125 AARH : 125 to 250 micro inch AARH

2.1.10 The material of construction of Ultrasonic flow meter internals/wetted parts and body shall be as specified in the respective data sheets.

2.1.11 Meter Sizing:

2.1.11.1 All the calculations and units of measurement shall be in metric standard only.

2.1.11.2 Flare Ultrasonic flow meter shall be suitable for measuring flow with specified accuracy for velocity range from 0.3 m/s to 120 m/s, however, the flow measurement corresponding to 0.03 m/sec shall be detectable without ascertaining the accuracy.

2.1.11.3 For Process application, Ultrasonic flow meter shall be selected ensuring the capability of measuring minimum flow with specified accuracy at a velocity of 0.5 m/sec within the meter body.

2.1.11.4 For cases where sizing and selection of flow meter is to be performed by vendor, vendor shall furnish the sizing calculations to justify the selection of Ultrasonic flow meters considering the density and viscosity of the fluid. Selected meter size shall ensure that flow meter operates within 85% of their standard range (not extended).

2.1.11.5 Overall pressure loss across the meter assembly including meter runs shall be within the permissible pressure loss specified in data sheet. Pressure drop calculation across the meter shall be furnished.

2.1.11.6 Unless otherwise specified in the data sheets, vendor to ensure the velocity in the Ultrasonic flowmeter and meter run shall not exceed maximum permissible velocity.

2.1.11.7 Vendor shall indicate the range of viscosities over which the measurement accuracy remains within limits.

2.1.11.8 Ultrasonic flowmeters shall be suitable for measuring the flow with the specified accuracy with upstream and downstream straight length of 10D and 5D respectively for both process and flare application. Required calibration analysis to establish the specified performance shall be carried out by the vendor and included in their offer.

2.2 Meters in Custody Transfer Applications

2.2.1 The design, construction and operation of Ultrasonic flow meters in Custody transfer applications shall conform to API standard (latest version) for Measurement of liquid Hydrocarbon by Ultrasonic flow meters using transit time technology and AGA Report 9 (latest version) for hydrocarbon Gas service

2.2.2 The average velocity of the fluid shall be measured along four acoustic paths as a minimum. Numerical calculation techniques shall then be used to compute the average axial flow velocity and volume flow rate at operating conditions through the meter.

2.2.3 Temperature and Pressure sensing devices shall be installed immediately downstream of the meter run to accurately represent the actual metering conditions and any calculation required for compensation of varying density.

2.2.4 Meter Runs:

2.2.4.1 Unless otherwise specified end connections for the upstream and downstream meter runs shall conform to this specification.

2.2.4.2 Flow Conditioners:

a) Type of flow conditioner (tube or vane type or Flow profiler etc.) shall be as recommended by vendor best suitable for the application. All Ultrasonic flow meters shall be provided with meter run and flow conditioner as per purchaser's datasheet. Minimum upstream and downstream run lengths shall be 10D and 5D respectively, where D is the inside diameter of the run.

b) The straightening element shall be made out of a thin walled tube or light gauge metal vane. However, the design shall be rugged enough to resist the forward thrust due to high flows. The element shall have smooth leading and trailing edges.

c) For tube type flow straightener, the length to diameter ratio of each tube shall be at least 10:1

1.3 Meters in Process/Flare Applications

2.3.1 The ultrasonic flow meters shall be supplied in completely assembled condition with all the probes (sensor/transducer), nozzles for installation of these probes ready for installation on a pipeline or duly mounted on a spool piece.

2.3.2 Spool piece type design shall be selected for meter sizes up to 16". For higher meter sizes, Insertion type design shall be used.

2.3.3 The number of probes required for a particular application and probe configuration shall be decided by the vendor. The same shall be decided such that measurement is considered across two acoustic paths as a minimum for process applications and single or more paths for flare applications. Supply of single or multipath flow meter shall be accordingly considered by vendor

2.3.4 Whenever the sensor / receiver probes are insertion type:

a) The material of construction of all the wetted portions of probe shall be suitable for the specified process conditions.

b) The probes shall be inserted through flanged nozzles of minimum 2" size to ensure insertion and removal of probes. Threaded nozzles for insertion shall not be acceptable.

c) It shall be possible to insert or retract the probes on-line without process interruption. Suitable retraction assembly shall be supplied for insertion and removal of probes on-line. In case of Flare meters, Vendor shall mandatorily provide full bore ball valve, for isolation, with each probe. The location of probes shall be selected to avoid fouling.

2.3.5 For high temperature application, suitable arrangement shall be provided to protect the sensor from high temperature. Any additional mounting accessory, if necessary shall be supplied by vendor.

2.3.6 Ultrasonic signal frequency shall be dependent on the application. Accordingly, vendor to select suitable piezo-crystal probes meeting the specified requirements.

2.4 Meter Electronics

2.4.1 Ultrasonic flow meter's electronics system including power supplies, microcomputer, signal processing components and ultrasonic transducer excitation circuits, may be housed in one or more enclosures mounted locally or remotely to the meter and is referred to as the Signal Processing Unit (Transmitter). It shall be designed and installed to meet the specified hazardous area classification.

2.4.2 The transmitter/ signal processing unit shall be microprocessor-based electronics suitable for installation in the field under the ambient condition specified. Meter electronics shall be Weather proof to IP 65 and flameproof certified suitable to install in area classification. All field mounted items shall have enclosures suitable for the area classification indicated in purchaser's data sheets.

2.4.3 The transmitter/ signal processing shall have extensive diagnostic capability. Self-diagnostic feature should include monitoring the health of the transducers and signal quality. Meter parameters and factors set into the meter electronics shall be retained in non-volatile memory and shall be secured with password such that un-authorized changes are prohibited. Configuration software and firmware shall be provided.

2.4.4 For meter electronics, vendor shall ensure that the input/output signals and performance characteristics of individual instruments are compatible with each other.

2.4.5 The transmitters shall accept inputs from probes either directly or through pre-amplifier. The number of inputs shall be based on the number of paths selected for particular application.

2.4.6 The flow transmitter shall also accept inputs from pressure, temperature and/or density transmitters for accurate measurement at operating conditions (as applicable).

2.4.7 The cable entry sizes between the transmitter/ signal processing unit and preamplifier/ transducers shall be decided by vendor. All interconnecting cables and the weatherproof& flameproof cable glands shall be supplied by vendor accordingly. 2.4.8 Meter output signals from the meter electronics shall be without flying leads. Number of cable entries and their sizes for the output signals shall be as per purchaser's datasheets.

2.4.9 Meter electronics shall be capable of providing the following output signals (as applicable):

a) Individual 4-20 mA outputs for Mass flow rate (Kg/h), Volumetric flow rate (m3/h or Nm3/h), Pressure (Kg/cm2a), Temperature (°C), molecular weight, sound speed (m/s) as per the requirements mentioned in the purchaser's datasheets.

b) High-resolution dual pulse outputs to flow computers configurable for flow rate signals and shall be user selectable to be either same outputs or one signal dedicated to each direction of flow. The transmitters shall comply with the principles of ISO 6551 cabled transmission of electric and/or electronic pulse data. At least security level B as defined by ISO 6551 shall be provided and the checking facility shall be of type P.

c) Digital discrete outputs for direction of flow, trouble alarm and output data validation.

d) RS-485/422 communication port with MODBUS protocol for communicating with the control room mounted flow computer for measured data, meter diagnostics, test and health data. Vendor shall supply the signal interconnection cables as per purchaser's datasheets for Pulse Outputs and RS 485 serial link (armored cables) including connectors at both ends against each tag for communication between flow meter in field and flow computers mounted on control panel located at respective control room.

2.4.10 Whenever HART transmitters or field bus based transmitters are mentioned in purchaser's datasheets, the following features must be ensured:

a) It shall allow multi master (primary and secondary) for configuration, calibration, diagnosis and maintenance. The primary could be the control system or host computer, and the secondary could be the hand held communicator.

b) It should be capable of implementing universal command

2.4.11 In addition to the requirements specified above, field bus based transmitter, wherever specified in the purchaser's data sheet, shall meet the following requirements:

a) All instruments must satisfy the requirements of the field bus registration laboratory with applicable checkmark like foundation field bus, profibus NutZer organisationer(PNO), or as specified in the purchaser's data sheets.

b) All instruments shall have one analog input blocks, as a minimum. In addition, when specified the transmitter shall also have PID controller block.

c) All instruments must be interoperable and shall have valid interoperability test clearance like ITK latest version for foundation field bus or equivalent for profibus PA, as applicable.

d) The field bus instruments shall support peer-to-peer communication.

e) All instruments shall be polarity insensitive. Also transmitter shall be LAS capable.

f) The field bus instruments in hazardous area shall be certified as per entity concept or shall be FISCO approved as per the requirements specified in the purchaser's specification.

g) All instruments shall support EDDL or FDT/DTM requirements, as specified in data sheets.

h) Internal Software shall be configured by the vendor including the following information.

- Serial Number
- Device Tag (Tag No.)
- Process Description

i) All instruments shall be capable of supporting incremental Device Descriptor (DD for extra functionality and/or software revisions in Device Memory.

2.4.12 Meter electronics shall operate on 110/230 V AC ± 10%, 50 Hz ± 3HzUPS or 24V DC and shall be protected from overload and from transients. Low power consumption is desired. Supply voltage fluctuation of ± 10 percent from the specified value and supply frequency fluctuation of ± 3 Hz from the specified value shall not affect the meter performance.

2.4.13 The design of electronic instruments shall be in compliance with the electromagnetic compatibility requirements as per IEC61000-4.

2.4.14 The meter transducers shall be intrinsically safe certified suitable for the specified area classification and weather proof to IP65 /.and vendor shall supply necessary isolating barriers between the transducers and preamplifier/transmitter. However the transducer/sensor housing can be flameproof (Ex d) certified suitable for the specified area classification instead of intrinsically safe.

2.4.15 The transmitter's enclosure housing the electrical parts shall be suitable for the area classification indicated in the purchaser's data sheets. Unless otherwise specified, the enclosure shall conform to the following standards:

Weather proof housing - IP 65 as per IS/IEC 60529

Flame proof housing - EX (d) as per IS/IEC 60079

Flameproof housing shall also be made weather proof.

2.5 Performance Requirements

Vendor shall meet the accuracy requirements mentioned herein, and indicate the same in the offer with sizing calculations and back-up documentation. The minimum no. of paths, as defined for each application, shall be ensured.

2.5.1 For Custody Transfer and Pipeline Applications:

a) Liquids

a. Accuracy ±0.15% of reading

b. Repeatability ±0.02% of reading

b) Gases

a. Accuracy ±0.3% of reading

b. Repeatability ±0.1% of reading

3.0 NAMEPLATE

3.1 Each Ultrasonic flow meter and its accessory shall have a SS nameplate attached firmly to it at a visible place, furnishing the following information:

a) Tag number as per purchaser's data sheet.

b) Manufacturers serial no. and model no.

c) Manufacturer's name/trade mark.

d) Nominal end connection size and rating in ASME B16.5 class.

e) Meter Body and Probe material.

f) Calibrated range & units of measurement of flow.

g) Area classification in which the equipment can be used.

h) Hazardous area certification number and marking.

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing at vendors works in-line with the Inspection Test Plan for Ultrasonic Flowmeter and approved quality documents. All these tests shall be completed by vendor and test reports shall be submitted to purchaser for scrutiny

5.0 SHIPPING

5.1 All threaded and flanged openings shall be suitably protected to prevent entry of foreign material.

5.2 The ultrasonic flow meter and accessories shall be packed separately.

STANDARD SPECIFICATION FOR OPTICAL FIBRE CABLES (OFC) AND CONDUIT

I-STD-201

0	11.01.22	ISSUED AS STANDARD SPECIFICATION	KS	AD	AD
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by

ABBREVIATION

ASTM	American Society of Testing and Materials
CSTA	Computer Supported Telecommunication Application
FAT	Factory acceptance Test
DC	Direct Current
HDPE	High Density Poly Ethylene
ITU	International Telecommunication Union
OFC	Optical Fibre Cable
IEC	International Electro-technical Commission
IS	Indian Standards
PLB	Permanently Lubricated
SAT	Site acceptance Test
UV	Ultra violet

CONTENTS

1 SCOPE

This Standard Specification, together with the Data Sheets attached herewith, establishes the minimum technical and functional requirements for design, engineering, materials, fabrication, painting, inspection and testing, documentation, marking, packing and shipping of Optical Fiber Cables (OFC) and Conduit / Ducts along with its spares and accessories.

2 DEFINITIONS

For the purpose of this document, the words and expressions listed below shall have the meanings assigned to them as follows:

Owner/ Purchaser/ Company	Owner of the particular Project (Project Specific).
Consultant	The party which comes out all or part of the engineering, procurement, construction, pre-commissioning and assistance for commissioning, monitors and controls the overall project management.
Bidder/ Manufacturer / Supplier / Vendor	The party(s) which manufactures and / or supplies material, equipment, technical documents / drawings and services to perform the duties specified by Contractor.
Works/ Shop	The place where the Item / Unit is fabricated and tested and transported to Purchaser.
Datasheet	Technical data provided by the Purchaser / Owner / Company.
Standard Specification	Specifications Developed as Standard by the Company.
Job Specification	Specifications Developed pertaining to particular project / Job in regard.
Material Requisition	Requisition as raised to Supplier for Quotation of the item
Purchase Requisition	Requisition as raised to Supplier for Procurement of the item
Purchase Order	Legal Order supplied to Supplier for procurement of the Engineered Item
Site	The work place where the equipment is installed and commissioned.

3 REFERENCE DOCUMENTS

3.1 Codes & Standards

The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the Purchaser's enquiry.

ASTM D 1693	Standard Test Method for Environmental Stress Cracking of Ethylene Plastics
IS 12235	Methods of test for un plasticized PVC Pipes' for potable water supplies

IS 2530	Methods of test for polyethylene moulding materials and polyethylene compounds
IS 4984	Specification for high density polyethylene pipes for potable water supplies
IS 7328	High Density Polyethylene Materials for Moulding and Extrusion - Specification
IS 9938	Recommended colours for PVC insulation for LF wires and cables
ITU-T G 652	Characteristics of a single-mode optical fibre and cable

3.2 Order of Precedence

In the event of conflict between Specifications, Data sheets, related standards, codes etc., the order of precedence shall be as follows:

a. Data sheets

b. Project Specifications

c. Standard Specifications

d. Codes and Standards

Vendor shall refer the matter to the Purchaser for clarification and only after obtaining the approval in writing, the same should proceed with the manufacture of the items in question.

4 MATERIALS

Materials selected shall be in accordance with the Data Sheets and Company's Standard Specifications.

5 DESIGN & CONSTRUCTION

5.1 General

The fibre shall fulfil latest ITU-T Recommendation G-652 / G-655 for single mode optical fibres.

Total Number of Fibers	Project Specific
Type	G.652 or Composite (G.652+G.655)

5.2 Geometrical, Optical and Physical characteristics of Optical Fibres

Mode field diameter	Vendor to Specify
Cladding Diameter	125 µm ± 1%
Mode field concentricity error	Less than 1 µm
Cladding non-circularity	Less than 2%

Cut-off wavelength	Vendor to specify and the project job specification shall be referred
Protective materials / coatings	Optical fibers shall be coated with UV cured double Acrylic Resin. It should not have any reaction with cladding or core material
Nominal Overall thickness	250 µm

The coatings should provide max. Resistance to micro bending & abrasion and ensure mechanical & optical strength. The coatings shall be easily stripped with mechanical tools.

5.3 Fiber Identification

The coating shall be in various colors in order to facilitate fiber identification. Fiber colors shall correspond to IEC publications. The colors shall be durable. The colors should have color fast properties also in the presence of other materials during the lifetime of cable. The coating and the color shall not react with surrounding jelly.

Each fiber and tube shall be identifiable thought the length of the cable in accordance with following color sequence:

Tube No.	Colour of Tube	Fibre Colour	Tube No.	Colour of Tube	Fibre Colour
1	Blue	Blue	7	Red	Blue
		Orange			Orange
2	Orange	Green	8	Black	Green
		Brown			Brown
3	Green	Slate	9	Yellow	Slate
		White			White
4	Brown	Red	10	Violet	Red
		Black			Black
5	Slate	Yellow	11	Pink	Red
		Black			Black
6	Black	Pink	12	Aqua	Pink
		Aqua			Aqua

5.4 Transmission Characteristics of Fibres

Attenuation	The cabled fiber shall have attenuation coefficient 0.38 dB/km at 1310 nm wavelength region and 0.22 dB/km at 1550 nm wavelength region
Chromatic dispersion coefficient	• Less than 3.5 ps/nm.km at 1288 to 1339 nm

	• Less than 5.3 ps/nm.km for 1271 to 1360 nm
Polarization mode dispersion coefficient	Less than 0.5 ps / (km)1/2

5.5 Cable Construction

5.5.1 Design Life

Operating life of cable: Better than 35 years

a. Drum length : 4 km +/- 5%

i. Cable weight in drum (for nominal drum length), to be provided by Vendor

ii. No splicing shall be permitted on any fibre in a drum length of the cable.

b. Protection Required

The cable shall be protected against damages from termite, fire, chemicals (such as oil & natural gas and other petroleum products), moisture and water, over the lifetime of the cable.

c. Construction Details of Cable

i. Strength member: Vendor has to specify the "strength member" (in case of metallic strength member, the same shall be provided with suitable chemical coating to prevent corrosion).

ii. Filling of cores: The stranded tubes shall be filled with moisture resistant jelly, which should be compatible with the coated fibre and the surroundings.

iii. Number of fibres per tube shall be two.

iv. Moisture barrier: Polymer coated Aluminium tape placed longitudinally over the loose tubes. The tape shall form a close fit around the cable core with a sealed overlap of 6 mm minimum. Alternatively, water swellable tape or water swellable powder may be provided over the tube.

v. Inner sheath shall be of MDPE. Thickness of inner sheath shall be 1.50 mm minimum Aluminium foil.

vi. Outer sheath shall be of HDPE with a thickness of 1.50 mm minimum.

vii. Electrical continuity of the respective metallic layers shall be maintained between the ends of the cable in each drum. The different metallic layers shall not be electrically shorted to each other.

viii. If Fibre Optic cable is to be buried directly into the soil/ground, a metal jacket or armouring shall be provided outside the cable. The project job specifications shall be referred for the exact requirement of the same. Also the metal portion of the cable have to be well grounded before entering building, to protect it from lightning strike effects ..

d. Mechanical Characteristics of Cable

i. Temperature : 0°C to +60 °C

ii. Installation & Operation : 0°C to +60 °C

iii. Storage : 0°C to +60 °C

iv. Tensile strength for Cable : 9.81 W Newton (W is weight of 1 km of Cable in kg)

v. Cable weight in kg/km : Vendor to specify

vi. Minimum bending radius: 20 x Cable Diameter

e. Average splice loss

Average splice loss shall be 0.01 db / splice.

5.6 Identification Marking

The outer surface of the cable shall be permanently & legibly marked with color in contrast to the outer sheath at regular intervals not exceeding one meter, with the following details:

- Name of client;
- Name of manufacturer;
- Part Number;
- "OPTICAL FIBRE CABLE";
- Year of manufacture;
- Drum No;
- Meter markings;
- No. of Cores.

All the marking over OFC shall be such that it should not be erased during field use.

The outer surface of each completed cable shall have sequentially numbered metric length markers spaced at regular intervals of one meter.

6 PERMANENTLY LUBRICATED CONDUIT

6.1 General

The HDPE conduit shall be permanently lubricated with an inner layer of solid permanent lubricant by co-extrusion method to minimize the internal coefficient of friction. The duct/conduit should have shallow groove for air cushioning. The co-extruded inner layer of above lubricant shall be continuous throughout the length of the HDPE conduit.

The HDPE conduits shall also be free of blisters. Shrink hooks, break and other defects. The internal and external pipe surfaces shall be smooth. Pipes shall not display any stress edged grooves or sink marks. The colour of the pipes shall be orange and be uniform throughout. The HDPE conduit shall unroll off the drums without snaking or waving having zero coil set.

Following are the mechanical and dimensional specifications of HDPE conduit:

Pressure Rating	Minimum 6 Kg/cm2 and suitable for blowing at 6 Kg/cm2
Outer diameter	50 mm (50 mm + 0.4 mm)
Wall thickness	4.0 ± 0.3 mm with shallow groove
Tensile strenngth	20 N/mm2 or better
Density	940.0 - 950.0 kg/cm at 27 Deg.C
Melt Flow index	0.4 to 0.95 gm/10 minutes at 90°C under 5 kg load
Intrinsic coefficient of friction	0.06 (max) when-tested with respect to Nylon

Impact strength	As per IS: 12235 (part 9)

The pipes should confirm to following IS specifications:

a. IS – 2530;

b. IS – 4984;

c. IS – 7328;

d. IS – 9938;

e. ASTM D -1693.

6.2 Conduit / Duct Construction Specification

6.2.1 Outer Layer

The base HDPE rein used for the outer layer of the PLB HDPE duct/conduit shall conform to any designation of IS - 7328 or to any equivalent standard meeting the following requirements, when tested as per IS - 2530. However, the manufacturers shall furnish the designation for the HDPE resin as permanently IS - 7328 as applicable.

Density	: 0.940 to 0.958 g/cc at 27 Deg.C
Melt Flow Rate (MFR)	: 0.2 to 1.1 g/10 minutes at 190 Deg.C & 5 kg load

6.2.2 Inner Layer

The inner lubrication material shall be of friction reducing, polymeric material which shall be integral with HDPE layer. The lubricant materials shall have no toxic or dermatic hazards for safe handling. In the finished PLB HDPE duct/conduit, the co-extruded layer of solid permanent lubricant shall be integral part with HDPE and shall be white in colour and clearly visible in cross-section of duct/conduit.

The inner layer of solid permanent lubricant shall be continuous all through and shall not come out during storage, usage and throughout the life of the duct/conduit.

6.2.3 Homogeneous Construction

The HDPE material used for this construction shall meet the requirements of project specification and relevant data sheets.

The raw material (s) used for the duct/conduit shall meet the following requirements:

a. The anti-oxidants used shall be physiologically harmless;

b. None of the additives shall be used separately or together in quantities as to impair long term physical and chemical properties of the duct/conduit;

c. Single pass rework material of the same composition produced from the manufacturer's own production shall be used and it shall not exceed 10% in any case;

d. The raw material used for extrusion shall be dried the moisture content to less than 0.1%;

e. Suitable UV stabilizers shall be used for manufacturer of the duct/conduit to protect against ultra violet degradation, when stored in open for a minimum period of 8 months;

f. The raw material used in the manufacturer of the duct/conduit shall be such that the service life of the duct/conduit and all its accessories can be expected to be more than 50 years including the life of permanent lubricant.

6.3 PLB HDPE Conduit / Duct Accessories

The following accessories are required for jointing the duct/conduits and shall be supplied along with the duct/conduits. The manufacturers shall provide complete design details, procedure for method of installation and type/ grade of the material used for the accessories.

6.3.1 Duct/conduit Coupler (Fusion Type)

It is used to couple two duct/conduits. The design of this shall be simple, easy to install and shall provide airtight and water tight joint between the two duct/conduits by way of fusion technique. The coupler shall ensure that the two duct/conduits are fused smoothly without any step formation in the inner surface. The jointing shall meet the air pressure test of 10 kg/cm2 for a minimum period of 2 hours without any leakage.

6.3.2 End Plug

This is for sealing the ends of the empty duct/conduits, prior to installation of the Optical Fiber Cable and shall be fitted immediately after laying of the duct/conduit, to prevent the entry of any dirt, water, moisture, insects/ rodents etc.

6.3.3 Cable Sealing Plug

This is used to seal the ends of the duct/conduits perfectly, after the cable is installed in the duct/conduit, to prevent the entry of dirt, water, moisture, insects/ rodents etc. This is required at all places where cable has come out of the duct/conduit either for jointing or entry into the building as required. The sealing plug shall be capable of accommodating standard sizes of optical fibre cable taking into account the variation in diameter due to tolerance limits, etc.

6.3.4 End Cap

This cap is made of hard rubber, shall be fitted into both ends of duct/conduit coil after manufacturing the duct/conduit. This shall avoid entry of duct/conduit, mud and rainwater into the duct/conduit during the transit and storage.

6.4 Name Plate

The OFC duct / conduit shall be prominently marked with indelible ink, with the following information at intervals every meter to enable identification of the pipe. The size of ink markings shall be distinct, clearly and easily visible

a. Client name;
b. Client logo;
c. Manufacturer's name (Also can be abbreviated form);
d. Name of the duct/conduit with size;
e. Machine number / specific serial number of the duct/conduit;
f. Date of manufacturing;
g. Sequential length marking at every meter.

All the markings over HDPE conduit shall be such that it should not be erased during field use.

6.5 Jointing Closures

Jointing closure shall be suitable for armoured and unarmoured optical fibre cables of all construction designs (slotted core, stranded tube, central tube). Jointing closures shall have 4 entry ports to allow entry/exit of four optical fibre cables. The same shall have provision of blocking/sealing of the ports, if not in use.

The fibres and their storage shall be managed with proper bend radius controls and protection. The fibre organizer trays shall have provision of maximum 6 fibres per tray. The trays should be hinged in such a manner that if moved about the hinge, the fibres are not strained, kinked or stressed.

Also, it should be possible to work on the fibres on one tray without disturbing the fibres on the other trays.

The jointing closure shall enable the metal parts of the cable and the internal metal parts of the closure to be maintained at earth potential.

The sealing of the entry ports, shall provide adequate sealing and shall be capable of withstanding an axial pull applied using 50 kg freely suspended weight of the cable, without using any additional clamps, etc.

Jointing closures should be Dust tight (No dust ingress) and protected against immersion in water (suitable for continuous immersion in saline water under 4-meter water-head). It should be complete with all accessories including splice cassettes splice protection and all other accessories including accessories for electrical continuity of metallic layer of optical fibre cable, etc. along-with instruction sheets.

The complete jointing closures including trays, joint protection sleeves etc. shall be sourcing form the above sub-vendors as a composite item.

7 INSPECTION AND TESTING

Vendor shall perform all inspection and testing as per Job Specification requirements, and as per relevant codes, prior to shipment. The inspection and testing for Optical Fiber Cables and Conduit / Ducts shall be carried out as per approved Inspection and Test Plan. Vendor shall submit the Inspection and Testing for Approval. Vendor shall submit the test certificates to the Company for the tests conducted during the manufacturing process like hydro test, material test, hazardous area certification test, and any other before Factory Acceptance Testing (FAT).

7.1 Factory Acceptance Testing (FAT)

Prior to FAT, Vendor shall submit to the Company a detailed FAT procedure, for review and approval. FAT shall be carried out as per approved Inspection and Test Plan. FAT shall be carried out prior to shipment of the Optical Fiber Cable drums and OFC conduits.

FAT procedures shall be submitted at least 4 weeks prior to FAT testing taking place. FAT shall be carried out at the manufacturing facilities. The tests shall be witnessed by the Company or their approved representative. FAT procedure will be signed off by the Vendor and Company or their approved representative at the successful completion and conclusion of testing.

7.1.1 For Optical Fiber Cables

The following minimum tests shall be conducted at the factory for the acceptance of the cable:

a. Core (mode field) diameter and concentricity error test;

b. Cut-off wavelength;

c. Attenuation coefficient at 1300nm, 1550nm, Spectral attenuation;

d. Chromatic dispersion at 1300nm, 1550nm, from 1530 to 1565nm;

e. Cladding: Diameter, Non circularity.

7.1.2 Tests on Completed Cables

a. Visual Inspection

- Cable lay-up and fiber identification;
- Identification and length marking on outer jacket;
- Colour contrast of the marking with the outer sheath of the cables;
- Overall diameter of the cable.

b. Tests for moisture barrier

- Thickness of layers;
- Extent of overlapping;
- Electrical continuity of metallic layers;
- Water swellable tape or power;
- Water immersion.

c. Tests for corrugated steel tape armouring

- Thickness of layers
- Extent of overlapping
- Electrical continuity of metallic layers
- Electrical discontinuity between CSTA and moisture barrier

d. Other Tests

- Attenuation at 1310 nm & 1550 nm Polarization Mode dispersion
- Tensile performance: direct underground burial type OFC (with a tensile load of value T= 9.S1W Newton, where W = weight of 1 km 'Cable' in kg).
- Crush (with 200 kg of load to be slowly placed and held for 60 seconds. The change in attenuation should not exceed 0.1 dB/km).
- Impact (with a mass of 5 kg allowed to fall freely from 500 mm height on the cable sample 10 times repeatedly with a gap between one impacts to another approximately at 60 seconds. The change in attenuation should not exceed 0.05dB/km).
- Torsion (with a weight of 7.5 kg attached to the stationery chuck and shall be subjected to 10 cycles. The change in attenuation should not exceed 0.05dB/km).
- Bend (To be performed preferably with Procedure 1 (of IEC) with a mandrel diameter of 240 mm, where 0 is the diameter of the cable and testing shall be done with 4 turns of cable wrapped and then unwrapped for 10 complete cycles. The change in attenuation should not exceed 0.05 dB/km)
- Snatch (with a load of 100 N. No damage to the fibre, sheath or to the other cable elements).
- Kink Radius: 10 x Cable diameter. No kink shall occur.
- Temperature cycling (This test shall be performed with a cable length of 200 m.
- Temperature cycle shall be taken as (The change in attenuation should not exceed 0.1 dB/km)

At room temperature	1 hr.
At zero degrees temperature	12 hrs
At 65 degrees temperature	12 hrs
From 65 degrees to room temperature	1 hr

- Water penetration test
- Water immersion
- Sheath integrity (spark test). The sheath shall withstand a spark test voltage of at least 8 KV r.m.s. or 12 KV DC.

7.1.3 For OFC Conduits

A separate sample size for each of the tests shall be taken as stipulated at random from the samples already examined for dimensions and visual inspection. All the conduits shall be tested for compliance as per the requirements.

Following tests are needed to be done for acceptance:

a. Visual Inspection;
b. Dimension of Duct/conduits;
c. Tensile Strength & Elongation;
d. Reversion Test;
e. Environmental Stress Crack Resistance;
f. Impact Strength;
g. Crush Resistance;
h. Mandrel Test;
i. Ovality Test;
j. Coil Set Test;
k. Oxidation Induction Test;
l. Hydraulic Characteristics;
m. Internal Co-efficient of Friction;
n. Optical Fibre Cable Blowing Test;
o. Duct / Conduit coupling test by fusion technique.

7.1.4 For Jointing Closures

The following tests shall be conducted as a minimum:

a. Water Ingress Test;
b. Impact test;
c. Drop and topple test;
d. Pulling test;
e. Static load test.

7.2 Site Acceptance Testing (SAT)

A SAT shall be carried out on completion of the installation of the Optical Fiber Cables and Conduit / Ducts at site which shall be witnessed by the Company / Owner's representative. SAT shall be performed as per the approved test procedure. A comprehensive test procedure in compliance with the company specification shall be developed and issued to Company / Owner for review and approval.

The Site Acceptance Test (SAT), in general, shall demonstrate that the Optical Fiber Cables and Conduit / Ducts functions correctly and properly in accordance with the specified requirements.

8 MARKING, PACKING AND SHIPMENT

Following FAT completion, Vendor ensure that all Cables, associated materials and accessories are designed properly, marked and packed, and secured for transit to site without damage.

Vendor shall provide and submit his standard “Marking, Packing and Shipping Procedures” for review by Company / Owner.

Vendor shall specify any conditions, normal or special, to be verified in intermediate storage and during transport.

Adequate protection shall be provided to prevent mechanical damage and atmospheric corrosion in transit and at the jobsite.

Conduits/Ducts shall be suitably packed including any dismantling, transit fastening and bracing necessary to prevent distortion or damage during transit.

Preparation for shipment and packing will be subject to inspection and rejection by Company’s inspectors. All costs occasioned by such rejection shall be to account of the Vendor.

9 SPARES AND ACCESSORIES

The following spare philosophy shall be followed in case it is not covered in Job Specification.

The Vendor shall include recommended Spare Parts List for start-up, pre-commissioning and two years operation as per the following;

a. Itemized recommended spare parts list for start-up and pre-commissioning;

b. Itemized recommended spare parts list for two years operation.

Vendor shall recommend accessories and special tools required for operation and maintenance of Optical Fiber Cables and Conduit / Ducts for Company review.

All the spare parts furnished by Vendor shall be wrapped and packaged to preserve an original as-new condition under normal conditions of storage. The same parts shall be properly tagged with stainless steel tags and coded so that later identification as to their intended equipment usage shall be clear.

All items supplied shall be packaged separately and clearly marked as "Spare Parts" and shipped with the equipment.

10 DOCUMENTATION

The following documentation shall be fulfilled by the Vendor, if it is not covered in Job Specification.

10.1 Documentation Required with Technical Bid

During bidding stage Vendor shall submit in his offer the following documents as a minimum:

- Standard Specification, Data Sheets;
- Bill of Materials including Vendor list, details of third party items;
- Catalogues and Manuals;
- Quality Assurance Plan;
- Any other documents.

10.2 Documentation Required for Approval

Upon placement of Purchase Order, Vendor shall submit as a minimum the following drawings, documents and specifications for the Company’s approval:

a. Specifications, Data Sheets;

b. Bill of materials including Vendor list, details for third party items;

c. Catalogues, Manuals and relevant drawings and documents;

d. Dimensional drawings;

e. Material test certificates;

f. Procedures for FAT;

g. Quality Assurance Plan.

10.3 Guarantee & Warranty

Vendor shall guarantee that the complete scope of supply shall be safely and reliably meet all of the requirements of this Company Specification.

Vendor shall provide warranty support for a period of 12 months from the date of supply or 18 months from the date of manufacturing, whichever later Warranty shall apply to defective material workmanship and facility design. The cost of correction / replacement of any warranty items shall be borne by the Vendor, as per the purchase conditions of the Material / Purchase Requisition.

The Job specifications / Data sheets shall be referred for any specific warranty / guarantee.

INSTALLATION AND ASSOCIATED WORKS

1 INSTALLATION AND ASSOCIATED WORKS

1.1 Trench Excavation

OFC shall be laid at depth of 1 meter in the pipeline trench generally. At crossings, OFC installation depth shall be 1.5 meter typically.

The trench shall be enlarged at the splicing points as needed to carry out the splicing works. The enlargement shall be carried out on the same side of the cable for the entire route.

1.2 Laying Bed Preparation

All works concerning the preparation of the laying bed shall be carried out by the contractor.

The laying bed of 10cm depth shall be made of sand or riddled earth obtained by passing through a sieve having meshes not exceeding 15 mm2, or of a natural soft around not requiring riddling.

1.3 Cable Laying

All works concerning the cable laying shall be earned out by the Contractor.

Contractor shall plan the cable-laying operation such that the complete drum-length of cable can be laid without cutting in-between.

The cable cable shall be carefully inspected for jacket defects as it is removed from the reel. If defects are noticed, the pulling operation shall be terminated immediately and the Construction Manager (Site Incharge) notified.

The Contractor shall establish section by section the ways and means for the cable laying taking into account the characteristics of the layout.

In all jointing locations including the normal joint at the end of the drum length and also at points of cable-cuts due to laying necessities, at least one of cable from each end of the cables at the joint location shall be left in a coiled form in the pit to allow for splicing and jointing of the cable. Minimum 15 meters of extra length of optical fiber cable shall be left at jointing locations for future maintenance.

At all telecom building locations (including terminals and intermediate stations) an extra length of about 20 meters of each cable shall be kept in a coiled form.

Contractor shall provide the necessary cable leading pipes for cable(s) entry inside the telecom room. All these leading-in-pipes shall be properly scaled to prevent entry of rodents, snakes, insects and foreign materials. At locations where the telecom room shall not be available, extra length of the cable shall be kept buried in ground near the proposed telecom room location.

If the splicing or termination operation does not follow immediately after the cable laying, all cable ends must be sealed carefully with heat-shrinkable end-caps.

Bi – directional “center pull” techniques shall be acceptable in order to accommodate long continuous installation length and shall be implemented as follows:

- From the midpoint pull the optical fiber cable into the conduit from the shipping reel in accordance with the manufacturer's specifications.
- When this portion of the pull is complete, remainder of the cable shall be removed from the reel to make the inside end available for pulling in the opposite direction.
- This is accomplished by hand pulling the cable from the reel and laying into large "figure eight 8”. The purpose of the figure eight pattern is to avoid cable tangling and kinking. This loop shall be laid carefully one upon the other (to prevent subsequent tangling) and shall be placed in a protected area. The inside reel end of the cable is then available for installation.
- In some cases, it may be necessary to set up a winch at an intermediate cable vault. The required length of cable shall be pulled to that point, and brought out of the cable vault and coiled into a figure eight “8”.

- The figure eight is the then turned over to gain access to the tree cable end. This can then be reinserted into the duct system for installation into the next section.
- When power equipment is used install optical fiber cables, the pulling speed shall not exceed 30 meters per minute. The pulling tension, bending radius and twist limitation for optical fiber cable shall not be exceeded under any circumstances.
- Large diameter wheels, pulling sheaves. and cable guides shall be used to maintain the appropriate bending radius. Tension monitoring shall be accomplished using commercial dynamometers or load cell instruments.
- The pulling eye / sheath termination hardware on the optical fiber cables shall not be pulled over any sheave blocks.
- Under no conditional shall OFC be left exposed or unattended.
- Repair of cable jacket shall not be permitted. Jacket damage shall require removal and reinstallation of a new cable run at the Contractor's expense.

1.4 OFC Pressure Blowing Procedure in HDPE Duct

The cable laying consists in using a mechanical feeder to push a OFC into a HDPE duct, through which flows a powerful air-stream, generated by a compressor. This high speed airflow exerts a drag on the entire surface of the cable, assisting its progression. The cable is therefore being not pulled but pushed and carried in the air. It moves easily along inside the duct, following any undulations or change in direction, even if these are abrupt and/or frequent. As no tractive force is exerted at the front end of the cable, it is not subjected to the stress usually encountered with conventional methodize, like pulling with a shuttle or rope. After installation, the cable rests on the bottom of the duct.

This is also called Cable Jet method and provides lowest friction, lowest tension method of installing optical cables into sealed duct system as depicted in figure below.

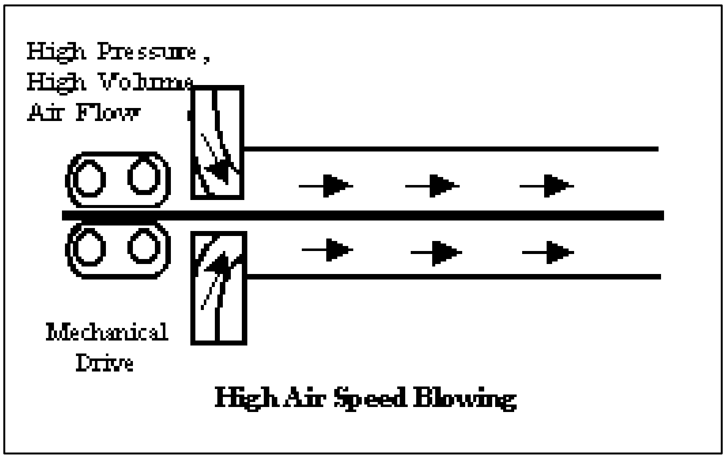

Figure 1: High Air Speed Blowing

In this process, duct shall be wide open and high air volume (300-600 cfm) is blown through it. This wind pushes on the cable and advances it forward at whatever speed pusher shall support. There is no pulling force on the front end of the cable, only a mechanical pushing force at the back and an air drag force distributed along its length.

The following are general steps required for the installation:

- The HDPE duct shall be in the range of 1075 m – 1500 m drums:

- Dielectric and seamless Accessories shall be used for jointing HDPE ducts. The jointing accessories shall withstand the pressure required to blow the cable.
- Suitable jointing tubes with indented rings, which mate with external corrugations, shall be utilized for all joints. Joints shall provide a watertight seal.
- During construction the ends of the conduit shall be closed to prevent foreign objects.
- Upon completion the ends shall be sealed to prevent ingress of water and using a plug.
- The Telecom contractor shall provide the sealing and it shall be achieved without use of glues, sealing compounds or foams.
- After its installation, the conduit shall be cleaned on the inside from any kind of material (earth, stones, etc.)
- Air blowing test shall be conducted to confirm the intact of the joints and no air leaks exist.
- The HDPE duct shall be provided in a 1075m – 1500m per drum. The Telecom Contractor shall advise for any preferable change subject to COMPANY approval.
- After duct installation, integrity testing shall be conducted to ensure proper duct installation.
- Using one blowing machine (Cable Jet), Up to 1500 or 2000m can be blown, depending on quality and characteristics of the cable, ambient temperature and profile of the trench.

1.4.1 Factor to be considered

Following important factors are to be considered in air assisted installation of OFC in order to obtain best performance in blown installations:

- **Flexibility of the cable:** A cable that is too flexible cannot be pushed properly without bunching up. While stiffer cables can be blown, some cables are designed specifically for blowing. Consult your cable manufacturer for recommendations.
- **Selection of cable:** Choosing the proper cable is important for optimal blowing. Although most fibre cables can be blown, some cables are designed specifically for blowing. Consult your cable manufacture for recommendations.
- Type of duct is another significant factor in optimized blowing. Smooth wall and longitudinal ribbed HDPE conduits are preferable.

1.4.2 Field Procedures

General field practices followed in air assisted installation of OFC are as listed below:

- Ensure that the duct system is properly installed with pressure tight splices. This shall be tested by sealing one end of the duct and pressurizing the duct using a sealed blowing machine. The duct shall not lose air pressure at any significant rate. Sand and projectiles can be blown from the duct, and poor-quality duct splices can fly apart.
- For HASB, end cap the front end of the cable so that it does not hang up in the duct. Be sure that you have air seals to fit the OD of the cable you are installing.
- Clean, dry, and prove the duct. If it was not done previously, blow through a hard mandrel to establish that the duct is not crushed. Then blow a tight-fitting foam carrier through the duct at high pressure. The foam should travel through at approximately 100 ft/sec in a clean duct. If excess water or dirt comes from the duct, repeat the process. If necessary, dry the duct with dry airflow.
- For high air speed machines (no missile), inject the recommended amount of lubricant and spread it by blowing through another foam carrier. For piston type machine, majority of the lubricant are injected in front of the missile with some placed behind it.

- Hook the blowing machine to the duct. For HASP machines, hand pushes a hundred feet or so of cable into the duct. Close and seal the cable and air chamber on the blowing machine. Follow the machine manufacturer's instructions for all operations.
- Check all pneumatic and hydraulic hook-ups. Slowly turn up the air and watch it go.
- An after-cooler shall be sued for all for all pressure blowing (Cable Jet) installation, particularly when the cable is to be installed in high ambient temperatures (such as in Oman and the Middle East). The use of an un-cooled compressed air source can cause a dramatic increase in the coefficient of friction between the duct and the cable sheath.

1.4.3 Lubrication

HDPE duct shall be sufficiently lubricated by a water based lubricant approved by cable Manufacturer, as the cable is pulled into the duct.

Lubricant shall be applied at a rate to provide a continuous 10-Mil coating, as recommended by the manufacturer.

1.5 Jointing / Installation at Pull Box

The Pulling of the cable shall be hand assisted at each pull box. The cable shall not be crushed, kinked or forced around a sharp corner. Sufficient slack shall be left at each end the cable to allow proper cable termination.

The extra length of optical fiber cable shall be coiled and secured with cable ties ion the pull box. The contractor shall ensure that the minimum bending radius of the optical fiber cable is not compromised when preparing this stored cable slack.

Imprinted plastic – coated cloth identification forwarding tags shall be securely attached to the cables in at least two locations in each pull box / manhole.

When all cables at each pull box are securely racked, unused conduits and void area around conduit containing cables shall be sealed.

The joint enclosure shall support an optical fiber organizer and allow sealing-off the outer sheaths of the cable.

Contractor shall provide detailed procedure for jointing of the cable along with the details of the jointing pits to be used for housing the joint enclosure and the excess cable after jointing.

Splicing loss shall not be more than 0.1 dB / splice.

Contractor shall provide electronic marker & electronic indicator of approved make at each jointing location.

1.6 OFC Splicing

Splicing of fibers shall be done by fusion splicing only. Splicing loss in each fiber in the joint location should be better than 0.02 dB (mechanical splice loss as shown in the splicing machine) & better than 0.1 dB at 1310 nm / 1550 nm as shown in the OTDR of each fiber.

Minimum 15 meters of extra length of optical fiber cable shall be left at jointing locations for future maintenance.

1.7 Crossing

Canal and river crossings shall be through a suitable casing pipe, provided as part of the pipeline laying. An additional pulling rope shall be kept inside to meet future requirements.

After installation, the casing pipe shall be cleaned inside of any kind of dirt and stones etc. Bituminized jute shall be used to close the ends of the conduit to prevent any dirt deposit. Similarly, bituminized jute shall be used to close the conduits ends after introduction of the cable.

Where crossing of existing underground pipelines and cables, pipes on sleepers, etc. occur, the same requirements for normal laying shall apply, the cable maintaining the normal position with respect to the pipeline.

1.8 Back Filling

Above the laid cable, a cover of 75 mm minimum depth of fine sand shall be provided by the Contractor. Above this cover a single layer of second-class brick shall be laid in a transverse manner over the cable laid in the trench. The bricks shall be fully soaked in water before being laid in the trench.

Minimum seven bricks per meter shall be laid with uniform spacing over the length of the laid cable.

A warning tape / mat made of PVC sheet of orange color with clear permanent print as "<Client Name>" minimum 150 mm wide and 0.1 mm thick shall be laid over the cable at regular interval of 1.5 meters.

Thereafter the trench shall be backfilled with the excavated earth. Normally, no mechanical protection shall be provided on the cable except at spiking points and rocky areas and as stated in particular cases.

The joints, relevant cable rings and other underground constructions shall be protected by bricks or concrete slabs to be supplied by the Contractor.

At the splicing points, the Contractor shall also take care to backfill the trench and to restore the relevant area and to repair any damaged works.

ANNEXURE

1 HOP TESTING

After backfilling of the trench, optical fiber cable shall be tested for continuity and attenuation over the laid length.

The test shall be conducted both before and after the splicing. It shall be ensured that the cable attenuation does not exceed as recommended for G 655 or G 652 cables (excluding the splice loss) and the splice loss on each fiber shall be 0.1 dB per splice (max.). Test procedures mentioned herein are minimum requirements to be followed. However, Contractor shall provide the detailed procedure for cable testing.

Fiber optic cable test-results shall clearly provide the attenuation for each fiber in following aspects:

- Different Wavelengths (1310 nm and 1550 nm);
- Each cable section;
- Individual splice.

Total Attenuation = (wavelength (λ) loss dB/km x fiber length) + (connector loss x number of connectors) + (splice loss x number of splices).

Where,

L = Length of the cable between two nodes;

N = No. of joints between two nodes.

Result shall be within permissible limits. After hop testing results with average losses shall be recorded for each fiber and hop wise report shall be submitted as per approved procedure. Testing shall be witnessed jointly by Client and PMC. Contractor shall furnish as built documents and hop loss report hop wise.

2 FIBER LENGTH MEASUREMENT

2.1 Test Description

This test will check the continuity of the fibre from station to station and record the length of fibre. Average loss per kilometre of fibre length shown in dB/km shall be recorded for information only. Testing will be done from both ends and average loss will be calculated (for 310nm/1550nm/1625nm, as applicable).

2.2 Test Equipment

Following test equipment shall be used:

- Optical time Domain Reflectometer (OTDR);
- Patch cords;
- Pigtails

2.3 Procedure

Test procedure shall be as detailed below. Test formats (1A & 1B) shall be as depicted in Section 2.4 and 2.5.

- Power ON the OTDR and make the settings as required for the hop under test;
- Connections OTDR with patch cord to the connector in OTC;
- Make the Laser ON and observe the trace till it gets settled up to the end of the trace;
- Store the results in the hard disk/floppy disk with proper identification of the fibre under test;
- Record the result in format provided;

- Repeat the procedure for the opposite direction;
- Repeat above steps for each fiber.

2.4 Format 1A

Fiber Length Measurement (G.652)

Date:-

Location A:

Location B:

Wavelength: 1310 nm & 1550 nm

Equipment Used

Tube No. / Color	Fiber No. / Color	Fiber Length (m)	Optical Loss dB/km		Average Cable Loss (dB/km)
			From A	From B	

2.5 Format 1B

Fiber Length Measurement (G.652)

Date:-

Location A:

Location B:

Wavelength: 1550 nm & 1625 nm

Equipment Used:

Tube No. / Color	Fiber No. / Color	Fiber Length (m)	Optical Loss dB/km		Average Cable Loss (dB/km)
			From A	From B	

3 INSERTION LOSS MEASURMENT

3.1 Test Description

During insertion loss measurement, light is launched (LASER) in the fibre by using a LASER source from one end at the other end by using an Optical Power meter the received power is measured. Fiber loss is calculated by subtracting the receive power from the transmit power. This test also determines the fiber termination continuity on end-to-end basis as the measurement is done on both the ends of a link.

3.2 Test Equipment

Following test equipment shall be used:

- Power meter working on 1310 nm / 1550 nm / 1625 nm;
- Laser source working on 1310 nm / 1550 nm / 1625 nm;
- Patch cords;
- Pigtails;

3.3 Procedure

- Test procedure shall be as detailed below. Test formats (2A & 2B) shall be as depicted in Section 3.4 and 3.5.
- One power meter , one laser source and one unit of optical talk set is required at each station between which the link is to be tested.
- At location A, switch ON the laser source, set it to operating wavelength of 1310nm and connect it to the power meter (set at 1310nm for G.652 fibres) by two FC/PC patch cords (these FC/PC patch cords will be connected to each other with FC / PC coupler) and record the laser power transmitted. Subtract 0.5 dB (Coupler Loss) from this reading and record it in the test sheet (Appendix-2A & 2B) as ‘Power transmitted’.
- Disconnect the power source and power meter by disconnecting FC/PC patch cords from the FC/PC connector. Do not disconnect patch cords from the power meter and power source.
- Connect the power source to the one of the fibres terminated in FTC at location A and the power meter to the same fibre under test in FTC at location B.
- Record the power received in test sheet.
- To establish communication between two stations A & B, optionally connect optical talk set to one of the fiber (e.g. No 12) at both the stations. When that particular fiber is due for testing connect the talk set to one on which testing is complete (e.g. No 1).
- Confirm on the talk set that the power received is recorded.
- Repeat the test for 1550nm.
- Connect the source to next fibre terminated in FTC at location A and power meter at location B.
- Repeat the same procedure with source at location B and power meter at location A.
- Continue the above process till all fibers are tested.
- Average loss of each fiber should be less than the average loss estimated.

Above test procedure shall be repeated for G.655 fibers for 1550 nm / 1625 nm as required. Test formats (3A & 3B) shall be as depicted in section 3.6 and 3.7.

3.4 Format 2A

Insertion Loss Measurement (G.652)

Date:-

Location A:

Location B:

Wavelength: 1310

Equipment Used:

Cable Length (km) (L):

Number of splices including Pigtails (N):

Number of Connectors (C):

Average Insertion Loss Estimated (dB/km) (037L + 0.07N + 0.5C):

<table>
<tr><td rowspan="3">Tube No. / Color</td><td rowspan="3">Fiber No. / Color</td><td colspan="2">A-B</td><td colspan="2">B-A</td><td rowspan="3">Average Insertion Loss (IL)
(dB/km)</td></tr>
<tr><td colspan="2">Power Transmitted at A</td><td colspan="2">Power Transmitted at B</td></tr>
<tr><td>Power Received at B</td><td>Insertion Loss
(A-B) (dB/km)</td><td>Power Received at A</td><td>Insertion Loss
(B-A) (dB/km)</td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
</table>

3.5 Format 2B

Insertion Loss Measurement (G.652)

Date:-

Location A:

Location B:

Wavelength: 1550

Equipment Used:

Cable Length (km) (L):

Number of splices including Pigtails (N):

Number of Connectors (C):

Average Insertion Loss Estimated (dB/km) (0.22L+0.07N+0.5C):

<table>
<tr><th rowspan="3">Tube No. / Color</th><th rowspan="3">Fiber No. / Color</th><th colspan="2">A-B</th><th colspan="2">B-A</th><th rowspan="3">Average Insertion Loss (IL) (dB/km)</th></tr>
<tr><th colspan="2">Power Transmitted at A</th><th colspan="2">Power Transmitted at B</th></tr>
<tr><th>Power Received at B</th><th>Insertion Loss (A-B) (dB/km)</th><th>Power Received at A</th><th>Insertion Loss (B-A) (dB/km)</th></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
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3.6 Format 3A

Insertion Loss Measurement (G.652)

Date:-

Location A:

Location B:

Wavelength: 1550

Equipment Used:

Cable Length (km) (L):

Number of splices including Pigtails (N):

Number of Connectors (C):

Average Insertion Loss Estimated (dB/km) (0.244L+0.07N+0.5C)

Tube No. / Color	Fiber No. / Color	A-B		B-A		Average Insertion Loss (IL) (dB/km)
		Power Transmitted at A		Power Transmitted at B		
		Power Received at B	Insertion Loss (A-B) (dB/km)	Power Received at A	Insertion Loss (B-A) (dB/km)	

3.7 Format 3B

Insertion Loss Measurement (G.652)

Date:-

Location A:

Location B:

Wavelength: 1625

Equipment Used:

Cable Length (km) (L):

Number of splices including Pigtails (N):

Number of Connectors (C):

Average Insertion Loss Estimated (dB/km) (026L+0.07N+0.5C):

<table>
<tr><th rowspan="3">Tube No. / Color</th><th rowspan="3">Fiber No. / Color</th><th colspan="2">A-B</th><th colspan="2">B-A</th><th rowspan="3">Average Insertion Loss (IL)
(dB/km)</th></tr>
<tr><th colspan="2">Power Transmitted at A</th><th colspan="2">Power Transmitted at B</th></tr>
<tr><th>Power Received at B</th><th>Insertion Loss
(A-B) (dB/km)</th><th>Power Received at A</th><th>Insertion Loss
(B-A) (dB/km)</th></tr>
<tr><td></td><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
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STANDARD SPECIFICATION

FOR

PRESSURE, DIFFERENTIAL PRESSURE AND VACCUM GAUGES

I-SPC-004

0	07.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AARH	:	Arithmetic Average Roughness Height
IBR	:	Indian Boiler Regulations
MAWP	:	Maximum Allowable Working Pressure
NPT	:	National Pipe Thread

CONTENTS

1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets describes the requirements for the design, materials, nameplate marking, and inspection, testing and shipping of pressure, differential pressure and vacuum gauges.

1.1.2 The related standards referred herein and mentioned below shall be of the latest edition of the following codes, standard practices and publications, unless otherwise specified:

ASME	American Society of Mechanical Engineers	
	B 1.20.1	Pipe Threads, General Purpose, Inch
	B 16.5	Steel Pipe Flanges and Flanged Fittings. NPS ½ through NPS 24
	B 16.20	Metallic Gaskets for Pipe Flanges
EN	European Standard	
	10204	Inspection documents for metallic products
IS/IEC	Indian Standards/International Electro-Technical Commission	
	IS/IEC60529	Degree of Protection Provided by Enclosures (IP Code).
	IS 3624	Specification for Pressure and Vacuum Gauges

1.1.3 In the event of any conflict between this standard specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Data Sheets

c) Standard specification

d) Codes and standards

1.1.4 In addition to compliance to purchaser's specifications in totality, vendor's extent of responsibility shall include the following:

a) Purchaser's data sheets specify the type of pressure element. Unless specifically indicated otherwise, alternate type of pressure elements shall also be acceptable provided all the functional and performance requirements specified in the respective data sheets are guaranteed by the vendor.

b) Purchaser's data sheets indicate the material of construction for pressure element, movement etc. Alternate superior material of construction shall also be acceptable provided vendor assumes complete responsibility for the selected materials for their compatibility with the specified fluid and its operating conditions.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instruction to the vendor attached with the Material Requisition.

1.2.2 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals etc. shall be in English language only

1.3 Drawing and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by purchaser in the vendor data requirement sheets attached with the requisition.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum:

a) Certified drawings sheets for each gauge and its accessories, which shall provide dimensional details, internal constructional details, end connection details and materials of construction.

b) Installation procedure for each gauge and its accessories.

c) Calibration and maintenance procedures including replacement of internal parts wherever applicable

2.0 DESIGN AND CONSTRUCTION

2.1 Pressure Elements, Gauge Movement and Socket

2.1.1 The pressure element shall be an elastic element like bourdon tube, bellow, diaphragm etc with material as specified in the data sheet. In general, bourdon type gauges shall be considered. Bellow, diaphragm or capsule type gauges shall be supplied for very low pressure ranges. Compound gauges shall be supplied for gauges having ranges from negative to positive pressure values.

2.1.2 In case of bourdon type of gauges, the size of the bourdon tube shall not be less than 75% of the nominal diameter of the dial size.

2.1.3 Gauge construction shall ensure no leakage of process fluid from the sensor elements to atmosphere and from between the high pressure and low-pressure side (in case of differential pressure gauges) under normal conditions.

2.1.4 The gauge socket shall be in one piece and shall also serve as element anchorage in case of bourdon tube type element, which shall be directly connected to the socket, without any capillary or tube in between. For other types of elements, the anchorage may be integral with the socket or connected with the socket using capillary tube with minimum bore of 3 millimetres.

2.1.5 Any joint in the process wetted system including joint between the element and the anchorage/socket shall be welded type only.

2.1.6 Unless specified otherwise, the pressure gauges shall have an over-range protection of 130% of maximum working pressure, as a minimum.

2.1.7 Data sheet indicates the minimum requirement of material of construction.

2.1.8 The gauge movement material shall be of stainless steel unless specified otherwise in the data sheet. It shall be adjustable for calibration without dismantling the sensor unit. The use of 'S' link for calibration of span is not permitted.

2.1.9 Vendor shall ensure that the operating pressure falls in the middle 30% of the full working range i.e. operating pressure shall fall between 35% and 65% of the range offered. For Pressure gauges in IBR Service, range shall be minimum of two times the operating pressure, if operating pressure is less than or equal to 35 Kg/cm2, and range shall be minimum of 1.5 times, if operating pressure is greater than 35kg/cm2.

2.1.10 Pressure gauges having range of 0 to 100 kg/cm2g and above shall necessarily have safety type solid front case.

2.1.11 Gauges shall be supplied with external zero adjustment.

2.2 Cases and Dials

2.2.1 The gauges shall be weather proof to IP 55 as per IS/IEC 60529.

2.2.2 In general, dial markings and dial colour shall be as per IS 3624. Dials of gauges in oxygen service shall additionally have the word 'OXYGEN' or 'CHLORINE' written in black and `USE NO OIL' written in red.

2.2.3 The gauge dial shall be made of a suitable metallic materials so that the finished dial shall be capable of withstanding a dry heat of 85°C for 10 hours and immersion in water at 85°C for 1 hour without cracking, blistering, warping or discolouration of the dial or paint on the dial.

2.2.4 The pointer stops shall be provided at both ends of the scale to restrict the pointer motion beyond 5% above the maximum of scale and less than 5% below the minimum of the scale.

2.2.5 In general dial size shall be 150mm unless otherwise specified in data sheet. The dial cover shall be made out of shatter proof glass sheet of thickness 1.5 to 3mm for gauges with dial size less than 100mm while minimum 3.0mm for gauges with dial size 100mm or greater.

2.2.6 All gauges shall be provided with a blowout device i.e. blow out disc of aperture not less than 25mm for gauges with dial size 100mm and above, while 20mm for gauges with dial size less than 100mm.

2.2.7 When safety type solid front type of gauges are specified, they shall consist of a solid partition isolating the pressure element from the dial. In such gauges the total solid partition disc area shall not be less than 75% of the cross sectional area of the inside of the case surrounding the pressure element.

2.2.8 The bezel ring shall be Screwed or Bayonet type.

2.3 Diaphragm Seals

2.3.1 Unless otherwise indicated in purchaser's data sheets, gauges specified with diaphragm seals shall have their diaphragms integral with the gauges.

2.3.2 Whenever diaphragm seal gauges are specified with capillary, the size of the capillary shall be selected to ensure response time of the gauge better than 5 seconds. Remote mounting accessories including 2" mounting bracket etc, shall be supplied in all such cases.

2.3.3 The sealing liquid for diaphragm seal gauges shall be an inert liquid, compatible with the process fluid and its temperature. For gauges in oxygen and chlorine service, the sealing liquid shall be fluro lube or equivalent compatible with the specified service.

2.3.4 For diaphragm seal pressure gauges with flanged ends, the diaphragm shall be rated for the maximum allowable pressure of the associated flange.

2.3.5 The fill fluid of diaphragm remote seal gauges shall be capable of withstanding the Design temperature & pressure as specified in the data sheet.

2.4 End Connection

Unless specified otherwise, the following shall govern;

a) Threaded end connections shall be NPT as per ASME B.1.20.1.

b) Flanged end connection shall be as per ASME B.16.5

c) Ring joint flanges shall have octagonal grooves as per ASME B16.20.

d) Flange face shall be as per clauses ASME B16.5. The face finish as specified in the data sheet shall be as follows;

125AARH : 125 to 250 micro inch AARH

63 AARH : 32 to 63 micro inch AARH

2.5 Performance Requirements

Unless otherwise specified, the accuracy which is inclusive of repeatability and hysteresis of Pressure gauges / differential pressure gauges shall meet the following performance Requirements:

a) Direct pressure gauge	:	±1% of full scale
b) Chemical seal type pressure gauge	:	±2% of full scale
c) Differential pressure gauges	:	±2% of full scale

2.6 Accessories

2.6.1 Gauges shall be supplied with all accessories as specified in the data sheets pre-installed, however accessories which have been supplied loose shall be supplied along with tag number.

2.6.2 For flanged diaphragm seal gauges, spacer ring, isolation valve and plugs of SS material, as a minimum, shall be provided whenever specified.

2.6.3 Over Range Protector (Gauge Saver)

a) Whenever the maximum pressure specified in the data sheet exceeds the over range protection pressure, over range protector shall be supplied.

b) In case of pressure gauges with diaphragm seal, the over-range protector shall be installed between the seal and the gauge.

c) The material of construction of over range protector shall be same as socket material, or superior.

2.6.4 Snubber

a) Whenever the service specified is pulsating type, snubber shall be supplied.

b) The material of construction of snubber shall be same as socket material, or superior.

2.6.5 Syphon

a) Syphon shall be supplied for steam services where temperature is above 200 °C or condensate services wherever specified in datasheet.

b) Unless otherwise specified, the size of the syphon shall be 1/2" with plain end connection of S160 thickness and SS316 material of construction.

2.6.6 Liquid filled casing shall be considered for gauges in vibrating/pulsating services e.g. gauges in pump discharge, as specified in datasheet.

2.6.7 Vacuum protectors shall be supplied for all gauges where, full vacuum condition is specified as applicable in the datasheet.

3.0 NAMEPLATE

3.1 Each gauge shall have a stainless steel nameplate attached firmly to it at a visible place either by riveting or screwed to the case, furnishing the following information:

a) Tag number as per purchaser's data sheet.

b) Vendor's name

c) Model number and manufacturer's serial number.

d) Range of the instrument.

e) MAWP and maximum vacuum rating of the element.

f) Material of the pressure element

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing at vendor's works as per Inspection Test Plan specified in project. All these tests shall be completed by the vendor and test reports shall be submitted to Purchaser for scrutiny.

5.0 SHIPPING

5.1 All threaded and flanged openings shall be suitably protected to prevent entry of foreign material.

5.2 All pressure gauges in oxygen and chlorine service shall be separately packed along with a certificate indicating 'SUITABLE FOR OXYGEN/CHLORINE SERVICE', as applicable.

5.3 Proper care shall be taken in shipping gauges with diaphragm seals to ensure safety of the diaphragm seals, extensions, capillaries, where specified, shall also be suitably protected.

S. No.	Item	Specified Material of Construction	Alternate Material of Construction
1.	Sensing Element	SS 316	SS316L, SS316Ti
2.	Socket	SS 316	SS 316L, SS316Ti
		SS 304	SS 304L, SS 316, SS316L, SS316Ti
3.	Case	Cast Aluminium	SS304,SS304L,SS316,SS 316Ti, SS 316L
4.	Capillary·	SS	SS 304, SS316, SS 304L, SS 316L, SS 316Ti
5.	Diaphragm	SS 316	SS 316L, SS 316Ti
		SS	SS 302, SS 304, SS 304L, SS 316, SS 316L, SS 316Ti

STANDARD SPECIFICATION

FOR

TEMPERATURE GAUGES AND THERMOWELLS

I-SPC-005

0	07.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AARH	:	Arithmetic Average Roughness Height
NPT	:	National Pipe Thread
PTC	:	Performance Test Code

CONTENTS

1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets, describes the requirements for the design, materials, nameplate marking, inspection, testing and shipping of temperature gauges and thermowells.

1.1.2 The related standards referred herein and mentioned below shall be of the latest edition of the following codes, standard practices and publications, unless otherwise specified:

ASME	American Society of Mechanical Engineers	
	B 1.20.1	Pipe Threads, General Purpose (Inch)
	B 16.5	Pipe Flanges and Flanged Fittings
	B 16.20	Metallic Gaskets for Pipe Flanges-Ring Joint, Spiral wound and Jacketed.
	PTC 19.3 TW	Thermowells Performance Test Code
EN	European Standard	
	10204	Inspection documents for metallic products
	13190	Dial Thermometers
IS/IEC	Indian Standards/International Electro-Technical Commission	
	IS/IEC60529	Degree of Protection Provided by Enclosures (IP Code).
IBR	Indian Boiler Regulations	

1.1.3 In the event of any conflict between this standard specifications, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Data Sheets

c) Standard specification

d) Codes and standards

1.1.4 In addition to compliance to purchaser's specifications in totality, vendor's extent of responsibility shall include the following:

a) Purchaser's data sheets indicate the material of construction for sensing element, capillary, stem, thermowell etc. Alternate superior material of construction shall also be acceptable provided vendor assumes complete responsibility for the selected materials for their compatibility with the specified fluid and its operating conditions.

b) Vendor shall carryout the vibration analysis of the thermowells as per ASME PTC 19.3 TW latest standard and shall provide suitable design for the thermowells wherever necessary and required as per data sheets.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instruction to the vendor attached with the Material Requisition.

1.2.2 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals etc. shall be in English language only.

1.2.3 Vendor shall quote for two years' operational spares for each temperature gauge and its accessories, which shall include movement, pointer, glass cover plate etc. as a minimum.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets attached with the requisition.

1.3.2 Final documentation consisting of design data, installation manual and maintenance manual submitted by the vendor after placement of purchase order, as per vendor data requirement, shall include the following as a minimum:

a) Certified drawings sheets for each gauge and its accessories, which shall provide dimensional details, internal constructional details, end connection details and material of construction.

b) Installation procedure for each gauge and its accessories.

c) Calibration and maintenance procedures including replacement of its internal parts wherever applicable.

d) Vibration analysis for thermowell wake frequency calculations.

e) Certificates from statutory body (IBR, wherever applicable) and test certificates.

f) Catalogues in English language.

2.0 DESIGN AND CONSTRUCTION

2.1 Temperature Gauges

2.1.1 Temperature gauges shall be of the separate socket type suitable for well installation. Upon assembly of components, the temperature gauge element shall firmly contact the bottom of the well. The gauge stem shall fit the well so that maximum heat transfer rate results.

2.1.2 Unless otherwise specified in the purchaser's data sheet, the temperature gauges shall be of bimetallic type.

2.1.3 Whenever filled system type temperature gauges are specified, the temperature gauge shall be gas filled only as per EN13190.

Liquid Filled Temperature Gauges shall be with Full compensation only and not case compensation.

2.1.4 The range shall be selected in such a way that the operating temperature falls in the middle 30% of the full working range i.e. 35% to 65% of the offered range.

2.1.5 Unless otherwise specified, the temperature gauges shall have an over range protection of at least 110% upto temperature 500°C.

2.1.6 Data sheets indicate the minimum requirements of material of construction. Alternate material as specified in clause 2.2.1 of this specification shall also be acceptable.

2.1.7 Whenever temperature gauges are specified with capillary extension for remote installation, the capillary shall be of 304 Stainless Steel or better and protected by stainless steel flexible armour.

2.1.8 The gauge movement material shall be of stainless steel, as a minimum.

2.1.9 Cases and dials

2.1.9.1 The case of bimetallic type of gauges shall be all angles rotatable type.

2.1.9.2 The gauges shall be weatherproof to IP 65 as per IS/IEC 60529 as a minimum.

2.1.9.3 The gauge dial shall be made of a suitable metallic material so that the finished dial shall be capable of withstanding a dry heat of 85°C for 10 hours and immersion in water at 85°C for 1 hour without cracking, blistering, warping or discolouration of the dial or paint on the dial.

2.1.9.4 The pointer stops shall be provided less than 5% below the minimum of the scale.

2.1.9.5 The dial cover shall be made out of shatter proof glass sheet of thickness of minimum 4.0mm.

2.1.9.6 Zero adjustment screw shall be external without opening the case.

2.1.9.7 Dial colour shall be white and size shall be 150 mm minimum unless otherwise specified.

2.1.10 Performance Requirements

Unless otherwise specified, the accuracy of temperature gauge shall be as per EN 13190 Class 1.

2.2 Thermowell

2.2.1 Unless otherwise specified, the thermowell material shall be 316 Stainless Steel, as a minimum. Alternate material as specified in the table below shall also be acceptable subject to meeting process conditions specified in the data sheet.

Sr. No.	**Item**	**Specified Material of Construction**	**Alternate Material of Construction**
1	Thermowell	ss 316	SS 316L, SS 316Ti
2	Case	ss 304	SS316
3	Capillary	ss 304	SS 316, SS 304L, SS316L, SS 316 Ti
4	Stem	ss 316 SS 321 for temperature above 600°C	SS 316L, SS 316Ti SS 321 for temperatureabove 600°C

2.2.2 Thermowells with immersion length up to 500mm shall be machined out of forged barstock. Built-up thermowell with welded well construction shall be considered for immersion length of greater than 500mm, unless specified otherwise in purchaser's datasheet.

2.2.3 The base of the thermowells shall be chosen to fit the instrument without air gap for minimizing measurement lag.

2.2.4 Thermowell flange material and rating shall be as specified in the purchaser's data sheet.

2.2.5 All thermowell weld joints shall be full penetration weld type only.

2.2.6 Thermowell immersion length shall be as specified in purchaser's data sheets. Where immersion length is not specified in the purchaser's data sheet, following shall govern;

Line Size	Immersion Length
From	4"to 6"280mm
From 8" to 20"	320mm
From 20" to 24" & Vessels/ Columns	400mm

Above 24" & upto 42' 500mm

Built-up thermowell shall be considered for line size above 42" and immersion length shall be as specified in the purchaser's data sheets. Immersion length is based on 200 mm length between flange face and outer wall of pipe and 200 mm length between flange face and inner wall of the vessel. Unsupported length shall be considered accordingly in the vibration analysis.

2.2.7 Unless otherwise specified, the following shall govern:

a) Threaded end connections shall be NPT as per ASME B 1.20.1

b) Flanged end connections shall be to ASME B 16.5

c) Where ring type joint flanges shall have been specified, groove shall be suitable for octagonal rings as per ASME B 16.20.

d) Flange face finish shall be as per ASME B 16.5. The face finish as specified in the datasheets, shall be as follows:

125 AARH : 125 to 250 micro inch AARH

63 AARH : 32 to 63 micro inch AARH

2.2.8 Vendor shall carry out the vibration analysis of thermowell as per ASME PTC 19.3 TW latest standard and shall provide suitable design for the thermowells wherever necessary.

Thermowells shall be suitable for stresses due to stream velocity condition. Any design change necessary as a consequence to this vibration analysis shall be included and provided by vendor.

Modifications to meet wake frequency shall be in the following order of precedence:

a) Maximum possible increase of thermowell OD for fitting into nozzle ID.

b) Decrease of thermowell length by not more than 50 mm from that specified in purchaser's data sheet.

c) Step design or any other proven design by vendor.

2.2.9 All thermowells in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride. All connections shall be plugged after degreasing process in order to avoid entrance of grease or oil particles.

2.2.10 All thermo-wells installed on pipes and vessels under IBR shall be certified by IBR or their authorized representative.

3.0 NAMEPLATE

3.1 Temperature Gauges

3.1.1 Each temperature gauge shall have a stainless steel nameplate attached firmly to it at a visible place either by riveting or screwed to the case, furnishing the following information;

a) Tag number as per purchaser's data sheet.

b) Vendor's name.

c) Model number and manufacturer's serial number.

d) Range of the instrument.

3.2 Thermowell

3.2.1 The following information shall be punched on the extension of the thermowell:

a) Tag number as per purchaser's data sheets.

b) Thermowell material as per purchaser's data sheets.

c) Thermowell immersion length 'U'.

3.2.2 The following information shall be punched on the thermowell flange at a visible place:

a) Nominal flange size in inches and rating in pounds.

b) Flange material as per purchaser's data sheets.

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing at vendor's works as per Inspection Test Plan. All these tests shall be completed by the vendor and test reports shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 Proper care shall be taken in shipping the temperature gauges, especially for the case glass and extension capillaries, where specified. All items shall be adequately packed to withstand shipping conditions, without damage.

5.2 All threaded and flanged openings shall be suitably protected to prevent entry of foreign material.

5.3 All thermowells in oxygen and chloride service shall be separately packed along with a certificate 'CERTIFIED FOR USE IN OXYGEN / CHLORINE SERVICE', as applicable.

STANDARD SPECIFICATION

FOR

THERMOCOUPLES, RTDs AND THERMOWELLS

I-SPC-006

0	08.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AARH	:	Arithmetic Average Roughness Height
NPT	:	National Pipe Thread
PTC	:	Performance Test Code
RTD	:	Resistance Temperature Detector
SS	:	Stainless Steel

CONTENTS

1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets describes the requirements for the design, materials, nameplate marking, inspection, testing and shipping of thermo-couples, RTDs and thermowells.

1.1.2 The related standards referred herein and mentioned below shall be of the latest edition of the following codes, standard practices and publications, unless otherwise specified:

ASME	American Society of Mechanical Engineers	
	B 1.20.1	Pipe Threads, General Purpose (Inch)
	B 16.5	Pipe Flanges and Flanged Fittings
	B 16.20	Metallic Gaskets for Pipe Flanges
	PTC 19.3	TW Performance Test Code-Temperature measurement
API	American Petroleum Institute	
	RP 551	Process Measurement Instrumentation.
EN	European Standard	
	10204	Inspection documents for metallic products
IS/IEC	Indian Standards/International Electro-Technical Commission	
	IS/IEC-60079	Electrical Apparatus for Explosive Gas Atmosphere
	IS/IEC 60529	Degree of Protection provided by Enclosures (IP Code)
	IEC-60751	Industrial Platinum Resistance Thermometers an Platinum temperature sensors
	IEC-60584-1	Thermocouples—Part 1: EMF specifications & Tolerances
IS	Indian Standards	
	7358	Specifications for Thermocouples

1.1.3 In the event of any conflict between this standard specifications, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Job Specifications / Data Sheets

c) Standard specification

d) Codes and standards

1.1.4 In addition to compliance to purchaser's specifications in totality, vendor's extent of responsibility shall include the following:

a) Purchaser's data sheets indicate the material of construction for sensing element, thermowell etc. Alternate superior material of construction shall also be acceptable provided vendor assumes complete responsibility for the selected materials for their compatibility with the specified fluid and its operating conditions.

b) Vendor shall supply the Thermowell meeting vibration analysis as per ASME PTC 19.3TW latest edition.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instruction to the vendor attached with the Material Requisition.

1.2.2 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals etc. shall be in English language only.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required shall be submitted by the vendor as per Vendor data requirement attached with the requisition.

1.3.2 Final documentation consisting of design data, installation &maintenance manuals, test certificates & reports etc. shall be submitted by vendor after placement of Purchase order, as per vendor data requirement:

2.0 DESIGN AND CONSTRUCTION

2.1 Thermocouples

2.1.1 The type of thermocouple shall be as specified in purchasers data sheets. However when the type of thermocouple is not specified in purchaser's data sheet, following shall apply:

Copper-Constantan (ISA-Type-T)	:	(-) 200 to 200°C
Chromel-Constantan (ISA-Type-E)	:	200 to 600°C
Chromel-Alumel (ISA-Type-K)	:	600 to 1200°C
Platinum Rhodium-Platinum (ISA Type-S)	:	600 to 1600°C
Platinum Rhodium-Platinum Rhodium (ISA Type-B)	:	600 to 1700°C

2.1.2 The thermocouple element shall be 18 AWG for Single type thermocouples and 20 AWG for Duplex type thermocouples, unless otherwise specified in purchaser's data sheet. Single or Duplex type thermocouples shall be specified in Purchaser's data sheet.

2.1.3 The thermocouple properties and limits of error shall be as per IEC-60584-1.

2.1.4 Thermocouple shall be minimum 316 Stainless Steel sheathed magnesium oxide insulated, ungrounded type, for all tags with operating temperature less than 350 deg C, unless otherwise specified. For tags where operating temperature is greater than or equal to 350 degC, sheath material shall be Inconel as a minimum. Sheath OD shall be selected to suit the thermowell ID, subject to minimum sheath OD as 1 mm less than the thermowell ID.

2.2 Resistance Temperature Detectors

2.2.1 The type of RTD shall be as specified in purchaser's data sheet. In general RTD shall be 3 wire type with platinum element having 100 ohms resistance at 0°C, selected for temperature range of (-) 200 to 650°C.

2.2.2 The element shall be of highly refined material of reference grade and shall have been stress relieved. RTD including its calibration shall be as per IEC-60751 to have standard electrical resistance & temperature coefficient of resistance.

2.2.3 The wire shall be wound on a ceramic core and immobilised against strain or damage. The winding shall be of bifilar type. The leads shall be copper up to terminal block.

2.2.4 The element shall be within a metal sheath, in a manner which provides good thermal transfer and protection against moisture. The sheath material shall be 316 Stainless Steel, unless otherwise specified. Sheath OD shall be selected to suit the thermowell ID, subject to minimum sheath OD as 1 mm less than the thermowell ID.

2.3 Common Head assembly specifications for Thermocouples & RTDs

2.3.1 Temperature element assemblies shall be with threaded heads and shall be spring loaded. The heads shall consist of a case, screwed on cover and terminal block. The Temperature element shall be screwed to the terminal block. Separate screw shall be provided on the terminal block for terminating the incoming cables. There shall be an extra terminal in the terminal block connected to the head for grounding the shield.

2.3.2 Unless otherwise specified, the assembly shall confirm to the following standards;

a) The heads shall be weatherproof to IP 65 as per IS/IEC-60529

b) In case of flameproof construction, heads shall be flame proof as per IS/IEC-60079 and weather proof to IP 65 as per IS/IEC-60529

2.3.3 The case shall be suitable for mounting terminal blocks for single or duplex type Temperature element assemblies.

2.3.4 A heat resistant and moisture proof asbestos free gasket shall be fitted between the case and cover. Head support chain (between case and cover) material shall be of stainless steel.

2.3.5 The terminals shall be permanently and legibly identified for their polarity. The terminal block shall be permanently and legibly marked with the IEC letter code to designate the type of Temperature element.

2.3.6 For Duplex type Temperature element, one entry of the element head shall be provided with SS316 plug, unless otherwise stated in the Purchaser's datasheet.

2.4 Thermowells

2.4.1 Unless otherwise specified, the thermowell material shall be minimum 316 Stainless Steel. Alternate material as SS 316L / SS 316 Ti shall also be acceptable instead of SS 316 subject to meeting process conditions specified in the data sheet.

2.4.2 Thermowells with immersion length up to 500 mm shall be machined out of forged barstock. Built-up thermowell with welded wall construction shall be acceptable for immersion length of greater than 500 mm, unless specified otherwise in purchaser's datasheet.

2.4.3 The base of the thermowells shall be chosen to fit the instrument without air gap for minimizing measurement lag.

2.4.4 Thermowell flange material, rating and facing shall be as specified in the data sheet. Suitability of thermowell rating shall be verified as per the operating and design pressure/temperature conditions for individual tags as per ASME 16.5.

2.4.5 All thermowell weld joints shall be full penetration weld type.

2.4.6 Thermowell immersion length shall be as specified in purchasers data sheet. Where immersion length is not specified in purchaser's data sheet, following shall govern:

Line Size	Immersion Length
From 4"to 6"	280mm
From 8" to 20"	320mm
From 20" to 24"	400 mm
Vessels/Columns (side mounted)	400 mm
Above 24"& upto 42"	500 mm

Built-up thermowell shall be considered for line size above 42" and immersion length shall be as specified in the purchaser's data sheets. Immersion length is based on 200 mm length between flange face and outer wall of pipe and 200 mm length between flange face and inner wall of the vessel. Unsupported length shall be considered accordingly in the vibration analysis.

2.4.7 Vendor shall carry out the vibration analysis of thermowell as per ASME PTC 19.3TW latest edition and shall provide suitable design for the thermowells wherever necessary.

Thermowells shall be suitable for stresses due to stream velocity condition. Any design change necessary as a consequence to this vibration analysis shall be included and provided by vendor.

Modifications to meet wake frequency shall be in the following order of precedence:

a) Maximum possible increase of thermowell OD for fitting into nozzle ID.

b) Decrease of thermowell length by not more than 50 mm from that specified in purchaser's data sheet.

c) Step design or any other proven design by vendor

For all such changes, vendor must obtain prior approval from purchaser before proceeding with the fabrication of thermowells.

2.4.8 All the thermowells in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride.

3.0 NAMEPLATE

3.1 Thermocouple/RTD's

3.1.1 Each thermocouple / RTD assembly shall be provided with a stainless steel nameplate attached firmly to it, furnishing the following information:

a) Tag number as per purchaser's data sheets.

b) Thermocouple type/RTD element type (along with sensor. part number).

c) Type of protection whether sheathed or beaded.

d) Grounded or Ungrounded.

3.2 Thermowell

3.2.1 The following information shall be punched on the extension of the thermowell:

a) Tag number as per purchaser's data sheets.

b) Thermowell material as per purchaser's data sheets.

c) Thermowell immersion length 'U'.

3.2.2 The following information shall be punched on the thermowell flange at a visible place:

a) Nominal flange size in inches and rating in pounds.

b) Flange material as per purchaser's data sheets.

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing at vendor's works as per Inspection Test Plan. All these tests shall be completed by the vendor and test reports shall be submitted to Purchaser for scrutiny.

5.0 SHIPPING

5.1 Proper care shall be taken in shipping. All items shall be adequately packed to withstand shipping conditions, without damage.

5.2 All thermowells in oxygen and chlorine service shall be separately packed along with a certificate indicating 'CERTIFIED FOR OXYGEN/CHLORINE SERVICE', as applicable.

5.3 All threaded and flanged openings shall be suitably protected to prevent entry of foreign material.

STANDARD SPECIFICATION

FOR

JUNCTION BOXES AND CABLE GLANDS

I-SPC-007

0	08.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

IP	:	Ingress Protection
NPT	:	National Pipe Thread
PVC	:	Poly Vinyl Chloride
SS	:	Stainless Steel
Sq.mm	:	Square millimeter (mm2)

CONTENTS

1.0 GENERAL

1.1 Scope

1.1.1 This standard specification, together with the data sheets describes the requirements for design, materials, nameplate marking, testing and shipping of junction boxes and cable glands which include the following types.

a) Electrical junction boxes

b) Cable glands

c) Plugs

d) Reducers/ Adaptors

1.1.2 The related standards referred herein and mentioned below shall be of the latest edition of the following codes, standard practices and publications, unless otherwise specified:

ASME	American Society of Mechanical Engineers	
	B 1.20.1	Pipe Threads, General Purpose (Inch)
API	American Petroleum Institute	
	RP 551	Process Measurement Instrumentation.
EN	European Standard	
	10204	Inspection documents for metallic products
IS/IEC	Indian Standards/International Electro-Technical Commission	
	IS-5	Colours for ready mixed paints and enamels.
	IS/IEC-60079	Electrical Apparatus for Explosive Gas Atmosphere.
	IS/IEC-60529	Degrees of Protection Provided by Enclosures. (IP Code)
IS	Indian Standards	
	7358	Specifications for Thermocouples

1.1.3 In the event of any conflict between this standard specifications, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Data Sheets

c) Standard specification

d) Codes and standards

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached along with the Material Requisition.

1.2.2 Deviation on technical requirements shall not be entertained.

1.2.3 All documentation submitted by the vendor including their drawings, installation manual etc shall be in English language only.

1.2.4 Statutory Approvals

Junction boxes and cable glands located in the hazardous area shall be certified by the local statutory authorities for their use in the specified hazardous area classification. In general following certification shall be given:

i) For all flameproof Junction box and cable which are manufactured abroad and certified by any statutory authority like Laboratories Central Des Industries Electriques (LCIE), British Approval Service for Electrical Equipment in Flammable Atmospheres (Baseefa), Factory Mutual (FM), Underwriters laboratories (UL) etc. for compliance to ATEX directives or other equivalent standards. All these junction boxes and cable glands shall additionally have the approval of Petroleum and Explosives Safety Organisation (PESO), Nagpur, if installed in INDIA and the same is mandatory.

ii) For all flame proof junction box and cable gland manufactured locally (indigenously), the testing shall be carried out by any of the approved test house like Central Institute of Mining & Fuel research (CIMFR)/Electronics Regional Testing Laboratory (ERTL) etc. The equipment shall in addition bear the valid approval from Petroleum and Explosives Safety Organisation (PESO), Nagpur and a valid BIS license.

iii) Approvals other than above shall neither be offered nor will these be acceptable.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals shall be submitted by the vendor as per vendor data requirement attached with the requisition.

1.3.2 Final documentation consisting of design data and installation manual submitted by the vendor after placement of purchase order. As per vendor data requirement, shall include the following, as a minimum;

a) Specification sheet for each junction box and its accessories like cable glands, plugs etc.

b) Installation procedure for junction boxes and its accessories.

2.0 DESIGN AND CONSTRUCTION

2.1 Junction Boxes

2.1.1 Junction boxes shall be either of the following type as specified in data sheets.

a) Weather proof junction boxes.

b) Weather proof and flameproof junction boxes

No other type of junction boxes shall be offered / supplied unless specifically indicated otherwise by Purchaser.

2.1.2 Unless otherwise specified, the enclosure shall conform to the following standards:

Weatherproof housing : IP 65 to IS/IEC-60529

Flameproof housing : Flameproof, Ex(d) as per IS/IEC-60079.

Flameproof housing shall also be made weatherproof

2.1.3 Number of cable entries shall be as per Purchaser's data sheet and their location shall be bottom in general for both multi pair and single pair cables. Side cable entries for branch cables shall only be considered when specifically indicated in the Purchaser's data sheets. Junction boxes with top entries shall not be offered. The size of cable entries shall be as per the cable gland sizes indicated in the data sheet.

2.1.4 Multi-pair junction boxes shall be provided with telephone sockets and plugs for connection of hand-powered telephone set.

2.1.5 Electrical Junction Boxes

a) The material of construction of junction boxes shall be followed as below:

i) Enclosures : Cast light metal alloy

ii) Internal plate : Nickel plated steel/ Aluminium rails

b) Weatherproof junction box shall have door with SS hinge and with Neoprene /Silicon rubber gasket, which shall be fixed to the box by SS countersunk screws.

c) Flameproof junction box shall have detachable cover, which shall be fixed to the box by means of cadmium plated triangular head/hexagonal head screws of SS material

d) Flameproof junction boxes for signal, alarm and control shall have the following warning engraved/integrally cast on the cover:

"Isolate power supply elsewhere before opening"

e) Power junction boxes (junction boxes for power supply cable / distribution) shall have either the warning cast or shall have warning plate with following marking:

"Isolate power supply elsewhere before opening".

t) Unless otherwise indicated in the job specification. Power junction boxes shall be suitable for incoming armoured Power cable up to 185 sq.mm conductor size; exact requirement of cable entry shall be specified in purchaser's datasheet.

g) Terminals shall be spring loaded, vibration proof, clip-on type, mounted on nickel plated steel rails complete with end cover and clamps for each row.

h) Terminals shall be non-hygroscopic type made up of unbreakable, fire-retardant, safe extinguishable, halogen free polyamide compound.

i) The metal parts of terminals shall be of high quality (pure electrolytic) copper and shall be tin or nickel plated (of thickness up to 15 micron). The spring material for all terminals shall be chrome nickel spring steel of high tensile strength and of excellent corrosion resistance.

j) All terminals used in signal alarm and control junction boxes shall be suitable for accepting minimum 4.0 sq.mm copper conductor, in general.

k) Terminal used in power junction boxes / power supply distribution box shall be suitable for accepting conductor size of 4.0 Sq. mm to up to 50 sq. mm. Exact requirement shall be specified in purchaser's datasheet. Higher size of terminals shall be provided when indicated.

Bus bar terminals shall be provided for cable size 50 sq. mm and above. Suitable size of lugs shall be provided to suit cable size specified.

l) Number of terminals/ junction Box:

Each junction shall have minimum of 30% spare terminal of those actually required to be utilised. Unless higher numbers of terminals are specified in the purchaser’s data sheet, the number of terminals for various types of junction boxes shall be as follows:

- For 6 pair junction box: 24 Nos terminals

- For 12 pair junction box: 48 Nos terminals
- For 6 triad junction box: 36 Nos terminals
- For 8 triad Junction Box: 48 Nos terminals
- For 3 way Junction Box: 12 Nos terminals

m) Terminals shall be identified as per the type of input signal indicated in data sheets e.g. all terminals for intrinsically safe inputs shall be blue while others shall be grey in colour.

n) Junction boxes shall be provided with external earthing lugs.

o) Internal design of a Junction Box:

Sizing shall be done with due consideration for accessibility and maintenance in accordance with the following guidelines:

Following gap shall be maintained strictly when designing the junction box sizes:

i) 50 to 60 mm gap between two terminal strips and sides of box parallel to terminal strip for up to 50 terminals and additional 25 mm for each additional 25 terminals.

ii) 100 to 120 mm between two terminal strips for up to 50 terminals and additional 25 mm for each additional 25 terminals.

iii) Bottom/top of terminal shall not be less than 100 mm from bottom/top of the junction box.

2.1.7 Painting

a) Surface shall be prepared for painting. It shall be smooth and devoid of rust and scale.

b) Two coats of lead-free base primer and two final coats of lead free, epoxy based paint shall be applied both for interior and exterior surfaces, powder coating shall also be acceptable. The colour shall be as specified in data sheets. However, following philosophy shall be followed, in general:

i) Light blue for all intrinsically safe junction boxes.

ii) Light grey for all others

2.2 Cable Glands, Plugs and Reducers/Adaptors

2.2.1 Cable glands shall be supplied by vendor as per the purchaser data sheets.

2.2.2 Cable glands shall be double compression type for use with armoured cables.

2.2.3 The cable glands shall be of nickel plated brass, as a minimum and shall be provided with PVC shrouds.

2.2.4 All the cable glands shall be weatherproof and flameproof (Ex'd') to gas group HA / 11B as a minimum, unless otherwise specified in data sheets.

2.2.5 Cable glands shall be supplied to suit the cable dimensions along with tolerances indicated in data sheets. Various components like rubber ring, metallic ring, metallic cone and the outer / inner nuts etc. shall be capable of adjusting to the indicated tolerances of cable dimensions.

2.2.6 Reducers / adapters shall be supplied as per details indicated in data sheets. They shall be nickel-plated brass, as a minimum. These shall also be weatherproof and / or flame proof wherever specified.

2.2.7 Plugs shall be provided wherever specified. They shall be of nickel-plated brass.

2.2.8 Plugs shall be certified flameproof, when used with flameproof junction boxes.

3.0 NAMEPLATE

Each Item covered under requisition i.e. Junction box, Cable glands, Adapters, Plugs etc shall have shall have proper identification as per details below:

3.1 For Junction boxes:

Two name plated shall be provided with an anodised aluminium sheet as below:

i) Name plate- I: It shall be permanently fixed on the JB at a visible place furnishing the following information:

a. Type of Junction box

b. Type of protection for use in hazardous area.

c. Manufacturer's serial number and model number.

d. Manufacturer's name/ trade mark.

e. Stamp of certifying agency with certificate number.

f. Provision of space for Tag number plate as per purchaser's data sheet to be permanently fixed at site with suitable provisions as per detail below.

ii) Name plate-2:

It shall be as per purchaser's data sheet to be fixed at site permanently with rivet type arrangement. It shall be supplied loose separately with a reference table identifying the Tag number of Junction box as per the requisition item number and data sheet

3.2 For cable Glands/ Adapter/ Plugs:

Each item shall be marked with Size, applicable area classification and type of thread i.e. NPT.

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing al vendor's works as per Inspection Test Plan. All these tests shall be completed by the vendor and test reports shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 All threaded openings shall be suitably protected to prevent entry of foreign material.

5.2 All threaded components shall be protected with plastic caps to prevent damage of threads during shipping and handling.

STANDARD SPECIFICATION
FOR
FLOW COMPUTER

I-SPC-008

0	08.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

GPA	:	Gas Processors Association
ASME	:	American Society of Mechanical Engineers
NFPA	:	National Fire Protection Association
FAT	:	Factory Acceptance Test
IEC	:	International Electro-technical Commission
IP	:	Ingress Protection
GC	:	Gas Chromatograph
USM	:	Ultrasonic Meter
ISO	:	International Organization for Standardization
NACE	:	National Association of Corrosion Engineers
NPT	:	Nominal Pipe Thread
SAT	:	Site Acceptance Test
SS	:	Stainless Steel

CONTENTS

1.0 SCOPE

This Standard Specification, together with the Data Sheets attached herewith, establishes the minimum technical and functional requirements for design, engineering, materials, fabrication, painting, inspection and testing, documentation, marking, packing and shipping of Flow Computer along with its accessories.

2.0 DEFINITIONS

For the purpose of this document, the words and expressions listed below shall have the meanings assigned to them as follows:

Owner/ Purchaser/ Company	Owner of the particular Project (Project Specific).
Consultant	The party which comes out all or part of the engineering, procurement, construction, pre-commissioning and assistance for commissioning, monitors and controls the overall project management.
Bidder/ Manufacturer / Supplier / Vendor	The party(s) which manufactures and / or supplies material, equipment, technical documents / drawings and services to perform the duties specified by Contractor.
Works/ Shop	The place where the ITEM / UNIT is fabricated and tested and transported to Purchaser.
Datasheet	Technical data provided by the Purchaser / Owner / Company.
Standard Specification	Specifications Developed as Standard by the Company.
Job Specification	Specifications Developed pertaining to particular project / Job in regard.
Material Requisition	Requisition as raised to Supplier for Quotation of the item
Purchase Requisition	Requisition as raised to Supplier for Procurement of the item
Purchase Order	Legal Order supplied to Supplier for procurement of the Engineered Item
Site	The work place where the equipment is installed and commissioned.

3.0 REFERENCE DOCUMENTS

3.1 Codes & Standards

The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the Purchaser's enquiry.

AGA Report no. 3	Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids
AGA Report No. 7	Measurement of Gas by Turbine Meters

AGA Report No. 9	Measurement of Gas by Multi-Path Ultrasonic Meters
AGA Report No. 10	Speed of sound in natural gas and other related hydrocarbon gases
ISO 6976	Natural gas - Calculation of calorific values, density, relative density and Wobbe index from composition
GPA 2172	Calculation of Gross Heating Value, Relative Density, Compressibility and Theoretical Hydrocarbon Liquid Content for Natural Gas Mixtures for Custody Transfer
GPA 2145	Table of Physical Properties for Hydrocarbons and Other Compounds of Interest to the Natural Gas Industry
IEC 60079-0	Explosive atmospheres - Part 0: Equipment - General requirements
IEC 60079-1	Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60801	Electromagnetic Compatibility For Industrial-process Measurement And Control Equipment - Radiated Electromagnetic Field Requirements
ASME B 1.20.1	Pipe Threads, General Purpose, Inch
ASME B 16.5	Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard
ASME B 16.20	Metallic Gaskets for Pipe Flanges: Ring-Joint, Spiral-Wound, and Jacketed
EN 10204	Metallic Products – Types of Inspection documents
NFPA 496	Purged and pressurized enclosures for electrical equipment

3.2 Order of Precedence

In the event of conflict between Specifications, Data sheets, related standards, codes etc., the order of precedence shall be as follows:

a. Data sheets

b. Job Specifications

c. Standard Specifications

d. Codes and Standards

Vendor shall refer the matter to the Purchaser for clarification and only after obtaining the approval in writing, the same should proceed with the manufacture of the items in question.

4.0 MATERIALS

Materials selected shall be in accordance with the Data Sheets and Standard Specifications. For corrosion service the material selected shall be in compliance with the requirements of NACE MR-0175 / IS0-15156 latest editions.

5.0 DESIGN

The flow Computer shall be either field mounted or installed in the control/ equipment room and should have operator interface for configuration and data display.

Flow computers shall perform all required calculations for custody transfer application using latest relevant AGA standards.

Field mounted flow computers, if located in hazardous area, shall be certified for use in classified area as per relevant sections of IEC 60079. Ingress protection for field mounted flow computers shall be IP65 in accordance with IEC 60529.

Flow computers in equipment room shall be rack (within panel)/ wall mountable as mentioned in datasheet. If wall mountable then the ingress protection shall be IP 54 in accordance with IEC 60529.

All software and firmware with licenses shall be in the name of owner. Manufacturer shall provide an undertaking to upgrade free of cost all software and firmware to the latest version and to incorporate all algorithm corrections and changes in line with latest industry standards for a period of ten years from the date of supply of the system

The offered flow computer shall be certified for custody transfer application from NMI/ PTB or equivalent.

The enclosure material of the flow Computers shall be manufacturer standard.

Flow computers shall be individual microprocessor based devices specifically designed to perform flow related calculations. Each flow computer shall be dedicated to a single meter run.

Measurement data inside the flow computer shall be protected against tampering via any serial port or networked connections.

Configuration and operating parameters shall be protected by either a hardware key lock switch or by multi-level password protection.

Field instruments from the meter run shall be directly connected to the flow computer to ensure signal integrity and to prevent tampering.

Flow computers shall remain unaffected by radio transmissions (Levels of permissible RFI shall be as per IEC 60801). Band-pass and / or band stop filers shall be fitted, as necessary.

5.1 Display Unit

LCD display shall be available in front panel of flow computers with at least 10 character display. Resolution of display shall be such that the time interval between rollovers of each total, when operating at maximum flow rate is greater than three calendar months.

The following data shall be available on front panel display as a minimum:-

a. Gross/ Standard/ Mass/ Energy Volume Flow Rate
b. Gross/ Standard/ Mass/ Energy Volume Total
c. Stream downstream Temperature/ Pressure
d. Standard Compressibility/ Compressibility (In use/ Calculated/ Keypad)

e. Standard Density/ Density (In use/ Calculated/ Keypad)
f. Calorific Values (In use/ Calculated/ Keypad)
g. Gas Compositional Data
h. AGA 8 variables, constants and results
i. Meter Status (Flow/ No Flow/ Maintenance)
j. Time/ Date
k. Maintenance Mode (entry/ exit)
l. Security Mode
m. Meter Status and Diagnostics

Reset of any totals through front panel display shall be through suitable access privilege.

5.2 Security

Provision shall be available to view/ Modify data of flow computers through access privileges from front panel display.

Typically, four access levels shall be defined namely Administrator, Engineer, Technician and Operator.

Access control shall be available for the following

a. Displays
b. Reports
c. Acknowledge Alarms
d. Modify/ Change
e. Diagnostics
f. Remote Access
g. Create/ Delete/ Modify users

Manufacturer shall define the access privileges and submit document to owner along with procedure for system administrator for review/ approval and it shall also be part of documentation.

5.3 Calculations

Flow computer will do volume/ flow calculation in standard metric units as per relevant AGA standard. Reference conditions for calculations shall be as specified in datasheet.

Super compressibility/ compressibility of gas shall be calculated as per AGA 8 (full version) using the composition available from gas chromatograph (GC).

Energy related calculations shall be in accordance with ISO 6976 and/ or GPA 2172 with tables from GPA 2145. It shall be possible for user to select either one of the standard or both for the calculations. Reference conditions shall be same as used for volume/ flow calculations.

For Ultrasonic meter, speed of sound (SOS) calculations as per AGA Report no 10 shall be available for comparing the SOS obtained from USM and SOS obtained from GC. Manufacturer shall inform the acceptable limit for the variance and incorporate necessary logics, alarms in the flow computer design.

Parameters and characteristics of flow meter required for computation shall be keyed into the flow computer. Any change in the parameters would require suitable privilege level passwords and shall be captured in audit trail. Manufacturer shall provide detailed procedure for changing of flow meter parameters in flow computer.

All calculations shall be using third party certified math blocks with programmed logics to meet the requirement. Certificates of math blocks shall be submitted to owner as part of documentation.

The following features shall be available as a minimum in all flow computers: -

a. Read flow, temperature (deg C), Pressure (bar g)
b. Read Gas chromatograph (Mole %)
c. Distinguish grade of gas
d. Log time and delivery of each grade of gas
e. Calculate “Z”
f. Indicated actual volume flow rate
g. Standard volume flow rate
h. Volume total
i. Energy flow rate
j. Energy total
k. Hourly logs
l. Daily logs
m. Audit Logs
n. Error log
o. Line up meter via RTU, Check Meters (Prove), and use corrected meter factors
p. Read USM alarm and diagnostic data.
q. Should have one spare RS 232 / 485 Modbus port.
r. Each flow computer will have dual TCP Ethernet Communication path to control system.
s. Communicate with the GC controller via serial link using Modbus RTU protocol
t. Control station flow rated based on local or remote set point from station control system.
u. Should manage meter runs through station control system based on flow to maintain the system accuracy.
v. Respond to orderly Shutdown and start-up of metering station in response to ESD.

5.4 Automatic Calibration Software

The calibration software (to be enabled using security code) in flow computer shall allow for the calibration of the following constituent components of the metering facility:-

a. Pressure Transmitters
b. Temperature Transmitters
c. Differential pressure transmitters

The software shall guide each calibration by an instructive step-by-step procedure. Calibration software with the following features shall be provided:

a. User editing of computer field and test equipment data

b. Automatic test equipment certification check

c. Viewing and printing of individual calibration test sheets

d. Printing of complete set of individual week's test sheets

On completion of the procedure an output form shall be printed giving all details of "as found" values and "as left", in cases where adjustment and changes to instrument report is done and a remark column shall be provided where there is no change. The form shall print the current date and signature boxes. The report form sheet shall be alterable.

5.5 Historical Data, Alarms, Reports and Logs

The flow computer shall be able to store for future reference events, alarms and trend data.

Historical data storage shall comprise of last 30 days alarms and events, important measurement parameters for a period of one year based on FIFO basis. It should be possible to retrieve this data and be able to manipulate it to produce displays and reports from any of the workstations on the network.

There shall be three categories of alarm that shall be raised and logged by the flow computers. The generated alarms shall also be capable of being routed to a local dot matrix printer. The alarms are as below:-

a. Computer Alarms

   This generally shall comprise of Cold Start, Warm Start, Battery Fail, RAM Fail, ROM Fail, Reset Required, Total Rollover etc.

b. System Alarms

   This generally shall comprise of Temperature Under range/ Over range, Pressure Over Range/ Over Range, Dew Point Under Range/ Over Range, Moisture Under range/ Over Range etc.

c. Process Alarms

   This generally shall comprise of Temperature Low/ High, Pressure Low/ High, Dew Point Low/ High, Moisture Low/ High etc.

5.6 Diagnostics and Error Handling

The flow computers shall have self-diagnostic feature and any failure in the computers or deviations beyond high-low limits of all inputs shall be displayed as an alarm and logged. Also an alarm contact shall be available for extension of the contact to the supervisory system. Alarms shall not reset automatically and must be acknowledged by operator before resetting.

In the case where the parameters received are deemed invalid, the flow computer shall alarm the incident and proceed with the last valid value in memory. This shall be true for all inputs such as the gas composition, specific gravity and heating value. Keypad default values shall not be used, unless specified by the Operator.

The memory content of the flow computer shall not be lost in the event of failure or interruption of the power supply. The equipment shall be provided with internal battery backup.

The flow computer shall have hardwired interfaces to the supervisory system for hardware failure and instantaneous corrected flow rate.

5.7 Power Supply

Manufacturer to note that the UPS power supply available shall be 110 V AC ± 10%, 50 Hz ± 3 %. Further rectifier / transformer if required to achieve the desired working voltage shall be provided by the manufacturer.

The system performance shall be within specifications even when the supply voltage varies by ± 10% of specified value and supply frequency varies by ± 3 HZ of specified value.

Manufacturer to ensure that there is no damage to any component of the offered system because of black outs / brown outs. Manufacturer to indicate steps to be taken for fail safe operation under power failure.

5.8 Electric Transients

The flow computer shall have provisions for protection against system errors and hardware damage resulting from electrical transients on power or signal wiring. These electrical transients include power line faults, lightning strikes, and lightning-induced surges on power or signal cables. The manufacturer shall clearly describe the method used to provide the electrical transient protection which shall comply with the guidelines of IEC 61000-2.

The flow computer shall operate satisfactorily not only independently, but also in conjunction with other equipment, which is placed nearby. The operation of flow computer shall not be adversely affected by interference voltages and fields reaching it from external sources, and also will not in itself, be a source of interference that might adversely affect the operation of other equipment.

Design of equipment, components and assemblies shall consider RFI/EMI control. The design shall ensure easy serviceability and also ensure that integrity of RFI/EMI protection features, such as screening, shall not degrade under normal maintenance conditions.

5.9 Communication Interfaces

The various types (hardwired, serial or Ethernet) and numbers of output shall be as defined in the datasheet.

Protocol for Ethernet and serial communication shall be Modbus RTU. Manufacturer shall furnish the complete Modbus database including message structures, frame structures, synchronizing / timing signals, memory locations for data addressability and interface software driver details for owner’s review and approval prior to proceeding with software/ hardware configuration.

Flow computers shall be serially interfaced to gas chromatograph for transfer of gas compositions etc. Manufacturer shall be totally responsible for this interface and the same shall be demonstrated by manufacturer during FAT.

Hardwired digital outputs shall be potential free and analogue signals in 4 to 20 mA format shall be isolated type capable of driving 600 ohms load resistance. All outputs shall be user configurable.

Data available through Ethernet and serial communication shall be user configurable and shall be finalized with owner prior to implementation. Any addition or deletion to the data highway shall not require reconfiguration and/or programming and shall be capable of being accomplished while the flow computer is "on-line".

Upon failure of any data link, an alarm shall be generated to alert the user and shall be logged in system memory.

There shall be a dedicated communication port for connecting a laptop (not in scope of supply) for configuration, diagnostics, report generation etc. Software required for the same shall be included in the scope of supply.

Dedicated port for printer shall be available.

5.10 Name Plate

Each flow computer shall have a stainless steel name plate attached firmly to it at a visible place either by riveting or screwed to case, furnishing the following information:-

a. Tag number as per owner's data sheet
b. Manufacturer's name and trademark
c. Model number and manufacturer's serial number
d. Electrical classification and Ingress protection

6.0 FABRICATION AND PAINTING

Vendor shall obtain approval in writing from the Purchaser before start of fabrication of Flow Computer. Vendor shall submit the required Specification, drawings & documents for approval. Also Vendor shall refer the relevant codes and standards for manufacturing herein.

7.0 INSPECTION AND TESTING

7.1 General Requirements

i. The Manufacturer shall ensure all equipment used for inspection and testing purposes is calibrated and certified.

ii. The Manufacturer shall record all inspection and testing activity on the appropriate inspection certificate.

iii. The inspection and testing shall be carried out as per Company approved inspection and test plan (ITP) prior to marking and shipment of materials.

7.2 Testing of Materials

Manufacturer shall carry out all chemical and mechanical testing of materials in accordance with applicable material specification and requirement specified under section 5 of this specification.

7.3 Witnessed Inspection

i. The flow computers shall be offered for pre dispatch inspection for following as minimum:-

a. Visual Inspection and Dimensional checks.

b. Performance test including simulation of all calculations and verification with third party certified software.

c. Demonstration of correct operation of all diagnostic and maintenance functions

d. Effects of variation in power supply voltage and frequency.

e. Review of all certificates and test reports.

ii. In the event when witness inspection is not carried out by owner, manufacturer shall anyway complete the tests and test documents for the same shall be submitted to owner for scrutiny and approval prior to dispatch.

7.4 Factory Acceptance Testing (FAT)

Prior to FAT, Vendor shall submit to the Company a detailed FAT procedure, for review and approval, listing all the Flow Computer complete with the project approved tags, and highlighting the inspection and testing requirements of all such devices. FAT shall be carried out as per approved Inspection and Test Plan. FAT shall be carried out prior to shipment of the Flow Computer.

FAT procedures shall be submitted at least 4 weeks prior to FAT testing taking place. FAT shall be carried out at the manufacturing facilities. The tests shall be witnessed by the Company or their approved representative. FAT procedure will be signed off by the Vendor and Company or their approved representative at the successful completion and conclusion of testing.

The FAT shall be consisting of the following as a minimum:

a. Visual inspection

b. Dimensional check

c. Calibration

d. Functional test

7.5 Site Acceptance Testing (SAT)

A SAT shall be carried out on completion of the installation of the equipment at site which shall be witnessed by the company / owner's representative. SAT shall be performed on the Flow Computer as per the approved test procedure. A comprehensive test procedure in compliance with the company specification shall be developed and issued to company / owner for review and approval.

The Site Acceptance Test (SAT), in general, shall demonstrate that the Flow computer functions correctly and properly in accordance with the specified requirements.

8.0 MARKING, PACKING AND SHIPMENT

i. Proper care shall be taken in shipping complete system to ensure safety of the electronics, display units and exposed parts.

ii. All items shall be packed in sea-worthy crates or boxes. Cable entries shall be protected with plastic caps to prevent damage/entry of foreign matter.

iii. A packing list shall be prepared for each case and attached therein in a waterproof plastic sleeve. The data to be recorded on each packing list shall contain following:

    a. Name and Address of Manufacturer;
    b. Purchase Order number;
    c. Case identification number;
    d. Overall dimensions in meter;
    e. Gross weight of the case;
    f. Itemized list of the contents

9.0 SPARES AND ACCESSORIES

The following spare philosophy shall be followed in case it is not covered in Job Specification.

The Vendor shall include recommended Spare Parts List for start-up, pre-commissioning and two years operation as per the following;

a. Itemized recommended spare parts list for start-up and pre-commissioning.

b. Itemized recommended spare parts list for two years operation.

Vendor shall recommend accessories and special tools required for operation and maintenance of Flow Computer, for Company review.

All the spare parts furnished by Vendor shall be wrapped and packaged to preserve an original as-new condition under normal conditions of storage. The same parts shall be properly tagged with stainless steel tags and coded so that later identification as to their intended equipment usage shall be clear.

All items supplied shall be packaged separately and clearly marked as "Spare Parts" and shipped with the equipment.

10.0 DOCUMENTATION

The following documentation shall be fulfilled by the Vendor, if it is not covered in Job Specification.

10.1 Documentation Required with Technical Bid

During bidding stage Vendor shall submit in his offer the following documents as a minimum:

a. Standard Specification, Data Sheets;

b. Bill of Materials including Vendor list, details of third party items;

c. Catalogues and Manuals;

d. Quality Assurance Plan;

e. A list of accessory items together with Manufacturer's name and part number;

f. Any other documents.

10.2 Documentation Required for Approval

Upon placement of Purchase Order, Vendor shall submit as a minimum the following drawings, documents and specifications for the Company's approval:

a. Specifications, Data Sheets;

b. Bill of materials including Vendor list, details for third party items;

c. Catalogues, Manuals and relevant drawings and documents;

d. Dimensional drawings;

e. Calibration certificates;

f. Material test certificates;

g. Procedures for FAT;

h. Quality Assurance Plan;

i. Any Other documents.

10.3 Guarantee & Warranty

Vendor shall guarantee that the complete scope of supply shall be safely and reliably meet all of the requirements of this Company Specification.

Vendor shall provide warranty support for a period of 12 months from the date of supply or 18 months from the date of manufacturing. Warranty shall apply to defective material workmanship and facility design .The cost of correction / replacement of any warranty items shall be borne by the Vendor, as per the purchase conditions of the Material / Purchase Requisition.

The Job specifications / Data sheets shall be referred for any specific warranty / guarantee.

STANDARD SPECIFICATION FOR PRESSURE / DIFFERENTIAL PRESSURE TRANSMITTER

I-SPC-009

0	08.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

ANSI	:	American National Standards Institute
API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society of Testing and Materials
FAT	:	Factory acceptance Test
IEC	:	International Electro technical Commission
IP	:	Ingress Protection
IS	:	Indian Standard
ISO	:	International Organization for Standardization
NACE	:	National Association of Corrosion Engineers
NPT	:	Nominal Pipe Thread
SAT	:	Site acceptance Test
SS	:	Stainless Steel

CONTENTS

1.0 SCOPE

This Standard Specification, together with the Data Sheets attached herewith, establishes the minimum technical and functional requirements for design, engineering, materials, fabrication, painting, inspection and testing, documentation, marking, packing and shipping of Pressure Transmitter /Differential Pressure Transmitter along with its accessories.

2.0 DEFINITIONS

For the purpose of this document, the words and expressions listed below shall have the meanings assigned to them as follows:

Owner/ Purchaser/ Company	Owner of the particular Project (Project Specific).
Consultant	The party which comes out all or part of the engineering, procurement, construction, pre-commissioning and assistance for commissioning, monitors and controls the overall project management.
Bidder/ Manufacturer / Supplier / Vendor	The party(s) which manufactures and / or supplies material, equipment, technical documents / drawings and services to perform the duties specified by Contractor.
Works/ Shop	The place where the ITEM / UNIT is fabricated and tested and transported to Purchaser.
Datasheet	Technical data provided by the Purchaser / Owner / Company.
Standard Specification	Specifications Developed as Standard by the Company.
Job Specification	Specifications Developed pertaining to particular project / Job in regard.
Material Requisition	Requisition as raised to Supplier for Quotation of the item
Purchase Requisition	Requisition as raised to Supplier for Procurement of the item
Purchase Order	Legal Order supplied to Supplier for procurement of the Engineered Item
Site	The work place where the equipment is installed and commissioned.

3.0 REFERENCE DOCUMENTS

3.1. Codes & Standards

The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the Purchaser's enquiry.

American Society of Mechanical Engineers

ASME B 16.5	Steel Pipe Flanges and Flanged Fitting
ASME B 16.20	Ring Joint Gaskets and Grooves for Steel Pipe Flanges
ASME B1.20.1	Pipe Threads

American Petroleum Institute (API)

API RP 551	Process Measurements Instrumentation

International Electro technical Commission

IEC-60529	Degree of Protection by providing Enclosures (IP Code)
IEC-60079-15	Electrical Apparatus with type of protection 'n'
IEC-60079-7	Electrical apparatus for explosive gas atmospheres increased safety 'e'
IEC-60605-1	Equipment Reliability Testing.
IEC-60068.2-13	Basic Environmental Testing Procedure for Electrical Components and Electronic Equipment.

Indian Standards

IS 2147	Degree of Protection provided for Enclosures

3.2. Order of Precedence

In the event of conflict between Specifications, Data sheets, related standards, codes etc., the order of precedence shall be as follows:

a. Data sheets

b. Job Specifications

c. Standard Specifications

d. Codes and Standards

Vendor shall refer the matter to the Purchaser for clarification and only after obtaining the approval in writing, the same should proceed with the manufacture of the items in question.

4.0 MATERIALS

Materials requirements for Pressure/ Differential Pressure Transmitter shall be in accordance with the Data sheets and Company's Standard Specifications. For corrosion service the material selected shall be in compliance with the requirements of NACE MR-0175/ISO-15156 latest editions

Transmitter body studs shall be high tensile stainless steel or other corrosion - resistant material for higher stress levels.

5.0 DESIGN

5.1. General

The Pressure / Differential Pressure Transmitters shall be used in all cases where a continuous transmission of a pressure measurement is required in the control room for use in a control loop, or for indication or data acquisition.

Pressure / Differential Pressure Transmitters shall have an electronic state-of-art capacitance or any other type of sensor meeting all functional requirements. Element material for Transmitters shall be SS316 as a minimum.

Diaphragm seal element with capillary shall be used for congealing, corrosive and highly viscous services.

All Transmitters shall have an integral output meter. Remote mounted meters may be provided if required in addition. All Transmitters shall have accuracy of ±0.25% of full scale deflection, unless otherwise specified.

Transmitter shall be capable of working with a minimum load of 600 ohms and at a 24V DC supply.

All electronic modules shall be designed for short circuit protection.

The change in output due to change in ambient temperature should be very minimum.

Electronic Transmitters shall have externally adjustable zero and span. Setting adjustment shall have locking adjustment.

5.2. Process Connection

Process connection for Transmitters shall be ½ NPT or 2" flanged connection as per the Job Specification.

Process connection should be from bottom side.

3 Valve manifold in SS316 shall be used for Pressure Transmitter and 5 Valve manifold in SS316 shall be used for Differential Pressure Transmitter.

5.3. Equipment Protection

Transmitter shall be furnished with all necessary weather and anti-corrosion protection to prevent damage from saline and corrosive process atmosphere.

Over range protection shall be 130 % of range or maximum pressure whichever is higher.

5.4. Enclosure Class

In addition to weatherproof, the Pressure Transmitter enclosure shall be explosion-proof to NEMA-7 and certified by third party statutory bodies like UL/FM/BASEEFA or equal for use in hazardous area.

5.5. Range

Where possible, Pressure Transmitters shall use the same range selection as Pressure Gauges. However, the range of a Transmitter shall always be within the range of the local gauge used to monitor its output.

The normal pressure shall not be read at greater than 75 % of the Transmitter calibrated range for instruments reading steady pressure. For fluctuating service, the normal pressure shall be not more than 60 % of the range:

5.6. Name Plate

All transmitters shall be marked as per Manufacturer's standard and shall have a permanently attached stainless steel plate with the following, as a minimum detail:

a. Tag number as per Data Sheet

b. Manufacturer's name and trade mark

c. Area classification

d. Adjustment range.

e. Element material.

f. Body material.

g. Service

6.0 FABRICATION

Vendor shall obtain approval in writing from the Purchaser before start of fabrication of Pressure/ Differential Pressure Transmitter. Vendor shall submit the required specification, drawings & documents for approval. Also Vendor shall refer the relevant codes and standards for manufacturing herein.

7.0 INSPECTION AND TESTING

Vendor shall perform all inspection and testing as per Job Specification requirements, and as per relevant codes, prior to shipment. The inspection and testing for Pressure Transmitter shall be carried out as per approved Inspection and Test Plan. Vendor shall submit the Inspection and Testing for Approval. Vendor shall submit the test certificates to the Company for the tests conducted during the manufacturing process like hydro test, material test, hazardous area certification test, calibration test and any other before Factory Acceptance Testing (FAT).

7.1. Factory Acceptance Testing (FAT)

Prior to FAT, Vendor shall submit to the Company a detailed FAT procedure, for review and approval, listing all the Pressure/Differential Pressure Transmitter complete with the project approved tags, and highlighting the inspection and testing requirements of all such devices. FAT shall be carried out as per approved Inspection and Test Plan. FAT shall be carried out prior to shipment of the Pressure Transmitter.

FAT procedures shall be submitted at least 4 weeks prior to FAT testing taking place. FAT shall be carried out at the manufacturing facilities. The tests shall be witnessed by the Company or their approved representative. FAT procedure will be signed off by the Vendor and Company or their approved representative at the successful completion and conclusion of testing.

The FAT shall be consisting of the following as a minimum:

a. Visual inspection

b. Dimensional check

c. Chemical and mechanical properties as per relevant material standards

d. Calibration

e. Functional test

A certificate to detail the results and records obtained during the FAT shall be made available for ratification by the Vendor on the date of test.

7.2. Site Acceptance Testing (SAT)

A SAT shall be carried out on completion of the installation of the equipment at site which shall be witnessed by the Company / Owner's representative. SAT shall be performed on the Pressure / Differential Pressure Transmitter as per the approved test procedure. A comprehensive test procedure in compliance with the Company Specification shall be developed and issued to company / owner for review and approval.

The Site Acceptance Test (SAT), in general, shall demonstrate that the Pressure Transmitters functions correctly and properly in accordance with the specified requirements.

8.0 MARKING, PACKING AND SHIPMENT

Following FAT completion, Vendor responsible for the Pressure Transmitter shall ensure that all equipment and associated materials and accessories are designed properly, marked and packed, and secured for transit to site without damage.

Vendor shall provide and submit his standard "Marking, Packing and Shipping Procedures" for review by Company / Owner.

Vendor shall specify any conditions, normal or special, to be verified in intermediate storage and during transport.

Equipment shall be suitably packed including any dismantling, transit fastening and bracing necessary to prevent distortion or damage during transit.

Adequate protection shall be provided to prevent mechanical damage and atmospheric corrosion in transit and at the jobsite.

Preparation for shipment and packing will be subject to inspection and rejection by Company's inspectors. All costs occasioned by such rejection shall be to account of the Vendor.

9.0 SPARES AND ACCESSORIES

The following spare philosophy shall be followed in case it is not covered in Job Specification.

The Vendor shall include recommended Spare Parts List for start-up, pre-commissioning and two years operation as per the following;

a. Itemized recommended spare parts list for start-up and pre-commissioning.

b. Itemized recommended spare parts list for two years operation.

Vendor shall recommend accessories and special tools required for operation and maintenance of Pressure / Differential Pressure Transmitter, for Company review.

All the spare parts furnished by Vendor shall be wrapped and packaged to preserve an original as-new condition under normal conditions of storage. The same parts shall be properly tagged with stainless steel tags and coded so that later identification as to their intended equipment usage shall be clear.

All items supplied shall be packaged separately and clearly marked as "Spare Parts" and shipped with the equipment.

10.0 DOCUMENTATION

The following documentation shall be fulfilled by the Vendor, if it is not covered in Job Specification.

10.1. Documentation Required with Technical Bid

During bidding stage Vendor shall submit in his offer the following documents as a minimum:

a. Standard Specification, Data Sheets;

b. Bill of Materials including Vendor list, details of third party items;

c. Catalogues and Manuals;

d. Quality Assurance Plan;

e. Any other documents.

10.2. Documentation Required for Approval

Upon placement of Purchase Order, Vendor shall submit as a minimum the following drawings, documents and specifications for the Company's approval:

a. Specifications, Data Sheets;

b. Bill of materials including Vendor list, details for third party items;

c. Catalogues, Manuals and relevant drawings and documents;

d. Dimensional drawings;

e. Calibration certificates;

f. Material test certificates;

g. Procedures for FAT;

h. Quality Assurance Plan;

i. Any Other documents.

10.3. Guarantee / Warranty

Vendor shall guarantee that the complete scope of supply shall be safely and reliably meet all of the requirements of this Company Specification.

Vendor shall provide warranty support for a period of 12 months from the date of supply or 18 months from the date of manufacturing. Warranty shall apply to defective material workmanship and facility design. The cost of correction / replacement of any warranty items shall be borne by the Vendor, as per the purchase conditions of the Material / Purchase Requisition.

The Job specifications / Data sheets shall be referred for any specific warranty / guarantee.

STANDARD SPECIFICATION FOR TEMPERATURE TRANSMITTER

I-SPC-010

0	08.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

ANSI	:	American National Standards Institute
ASME	:	American Society of Mechanical Engineers
IEC	:	International Electro technical Commission
NACE	:	National Association of Corrosion Engineers
HART	:	Highway Addressable Remote Transmission
PROM	:	Programmable Read only Memory
RTD	:	Resistance Temperature Detector
HHC	:	Hand Held Communicator
LCD	:	Liquid Crystal Display
IP	:	Ingress Protection

CONTENTS

1.0 SCOPE

This Standard Specification, together with the Data Sheets attached herewith, establishes the minimum technical and functional requirements for design, engineering, materials, fabrication, painting, inspection and testing, documentation, marking, packing and shipping of Temperature Transmitter.

2.0 DEFINITIONS

For the purpose of this document, the words and expressions listed below shall have the meanings assigned to them as follows:

Owner/ Purchaser/ Company	Owner of the particular Project (Project Specific).
Consultant	The party which comes out all or part of the engineering, procurement, construction, pre-commissioning and assistance for commissioning, monitors and controls the overall project management.
Bidder/ Manufacturer / Supplier / Vendor	The party(s) which manufactures and / or supplies material, equipment, technical documents / drawings and services to perform the duties specified by Contractor.
Works/ Shop	The place where the ITEM / UNIT is fabricated and tested and transported to Purchaser.
Datasheet	Technical data provided by the Purchaser / Owner / Company.
Standard Specification	Specifications Developed as Standard by the Company.
Job Specification	Specifications Developed pertaining to particular project / Job in regard.
Material Requisition	Requisition as raised to Supplier for Quotation of the item
Purchase Requisition	Requisition as raised to Supplier for Procurement of the item
Purchase Order	Legal Order supplied to Supplier for procurement of the Engineered Item
Site	The work place where the equipment is installed and commissioned.

3.0 REFERENCE DOCUMENTS

3.1. Codes & Standards

The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the Purchaser's enquiry.

ANSI/ASME	ASME B 16.5	Steel Pipe Flanges and Flanged Fitting

	ASME B 16.20	Ring Joint Gaskets and Grooves for Steel Pipe Flanges
	ASME B1.20.1	Pipe Threads

IEC-529	Degree of Protection by Provided by Enclosures
IEC-60529	Degrees of protection provided by Enclosures (IP Code)
IEC-60770	Transmitters for use in Industrial Process control systems
IEC-60751	Industrial Platinum resistance thermometer sensors
BS-5345	Electrical and Instruments in Hazardous Areas.
IS-2147	Degree of protection Provided for Enclosures for Low Voltage Switch gear and control gear
IS-2148	Flameproof Enclosures for Electrical Apparatus
NACE MR-01-75	Material Requirement- Sulfide stress cracking Resistant Material for oil Field Equipment (Latest)

3.2. Order of Precedence

In the event of conflict between Specifications, Data sheets, related standards, codes etc., the order of precedence shall be as follows:

a. Data sheets

b. Job Specifications

c. Standard Specifications

d. Codes and Standards

Vendor shall refer the matter to the Purchaser for clarification and only after obtaining the approval in writing, the same should proceed with the manufacture of the items in question.

4.0 MATERIALS

Materials selected shall be in accordance with the Data Sheets and Standard Specifications. For corrosion service the material selected shall be in compliance with the requirements of NACE MR-0175 / ISO-15156 latest editions.

5.0 DESIGN

5.1. General

The temperature element type shall be as specified in the Data Sheets unless otherwise specified. The Temperature Transmitters should be "SMART' type suitable for analog signal transmission using HART protocol and have a non-volatile memory, unless otherwise specified. A self-diagnostic facility shall be available. The Transmitters shall be certified for use in a hazardous area classified as mentioned in Data Sheet. The Vendor shall supply the extension cable between the temperature element and the Transmitter. All field Transmitters shall have an accuracy of 0.25% of span and shall be provided with output meter / output gauge at the signal output. Burn out protection must be provided with Temperature Transmitters and trip amplifiers. Upscale or down scale protection shall be decided based on its application to ensure fail safe operation.

5.2. Element

If element is RTD, then RTD shall comply with IEC 60751. The RTD shall be three-wire type unless otherwise specified and shall have a resistance value of 100 ohms at 100°C.

5.3. Output

Transmitter output shall be 4-20 mA analog signals complying with HART protocol. The Transmitter power supply shall be normally 24 VDC, arranged for two wire transmission, with minimum power supply voltage of 12.5 VDC.

5.4. Electronics

The Transmitter electronics shall be solid state with appropriate smart circuitry. Printed circuit boards should be of a replaceable modular construction and shall be hermetically sealed or protected by a corrosion resistant coating. It should be supported against vibration in the case of plug-in type circuit boards. Signal wiring terminals and electronics shall be housed in separate compartments so that the electronics remain sealed during electrical connection to the signal cable. The electronics system shall be provided with environmental protection cover.

5.5. Calibration / Configuration

It shall be possible to perform on-line and remote set point configuration / calibration of the transmitter via a hand held communicator (HHC) The HHC shall be of easy to use and shall be suitable for use in the area classification specified in this Specification. The analog output of the transmitter shall not be affected during communication with the HHC. At least one number of hand held configurator shall be supplied as a minimum

5.6. Adjustments

The zero and span of the Transmitters shall be adjusted through a hand held communicator (HHC). A facility for engineering unit selection shall be available from the hand held communicator. The zero and span adjustments shall be non-interactive and continuously adjustable.

5.7. Indication

The Transmitters shall be provided with integral digital output indicator with 4 digits, LCD readout. The output meter scale meter shall cover the range specified in the Data Sheets, with selectable indication either in the specified engineering units or in percentage value.

5.8. Performance

The Transmitter accuracy, including the combined effect of linearity, hysteresis and repeatability shall be equal to or better than as stated in the Data Sheets. With reference to IEC 60770, errors shall be expressed as percentage of calibrated span, unless stated otherwise

5.9. Temperature Compensation

The Transmitter electronics shall include for the temperature compensation. The sensor characterization curve shall be stored in PROM.

5.10. Transmitter Housing

The instrument housing shall be low copper aluminium coated with epoxy paint. The epoxy coating shall be as per the industry standard, and shall be done on dry blast clean surface. The ingress protection for the enclosure shall be IP 65 as a minimum. No aluminium in its un-anodized form shall be used. No copper or its alloys shall be used except in its plated or tinned condition. No plastic shall be used except with a UV filter. The unit shall be supplied in housing suitable for outside (field) mounting in service conditions mentioned in the data sheets. Transmitters shall be installed in a sunshade for protection against direct sunlight.

5.11. CABLE ENTRY / CONNECTION

The electrical signal cable entry shall be M20. Unused cable entries shall be plugged off in compliance with the specified electrical safety rating. Signal wiring terminals shall be of the screw type.

5.12. TAGGING

Transmitters shall be provided with an identification plate, with all data clearly stamped on a corrosion resistant plate permanently attached to each instrument by means of rivets or pins and shall indicate, as a minimum, the following:

a. Name of the Manufacturer or trademark.
b. Instrument tag number.
c. Serial number
d. Year of manufacture
e. Range & calibration (including units of measurement)
f. Type of input
g. Electrical safety (Type of Protection)
h. Output signal.
i. All information on the nameplate shall be die- stamped or deep engraved.

6.0 FABRICATION

Vendor shall obtain approval in writing from the Purchaser before start of fabrication of Temperature Transmitter. Vendor shall submit the required Specification, drawings & documents for approval. Also Vendor shall refer the relevant codes and standards for manufacturing mentioned herein. Painting of Thermocouple & RTD shall be in accordance with Company Painting Specifications.

7.0 INSPECTION AND TESTING

Vendor shall perform all inspection and testing as per Job Specification requirements, and as per relevant codes, prior to shipment. The inspection and testing for Temperature Transmitter shall be carried out as per approved Inspection and Test Plan. Vendor shall submit the Inspection and Testing for Approval. Vendor shall submit the test certificates to the Company for the tests conducted during the manufacturing process like hydro test, material test, hazardous area certification test, calibration test and any other before Factory Acceptance Testing (FAT).

7.1. Factory Acceptance Testing (FAT)

Prior to FAT, Vendor shall submit to the Company a detailed FAT procedure, for review and approval, listing all the Temperature Transmitter complete with the project approved tags, and highlighting the inspection and testing requirements of all such devices. FAT shall be carried out as per approved Inspection and Test Plan. FAT shall be carried out prior to shipment of the Temperature Transmitter.

FAT procedures shall be submitted at least 4 weeks prior to FAT testing taking place. FAT shall be carried out at the manufacturing facilities. The tests shall be witnessed by the Company or their approved representative. FAT procedure will be signed off by the Vendor and Company or their approved representative at the successful completion and conclusion of testing.

The FAT shall be consisting of the following as a minimum:

a. Visual inspection
b. Dimensional check
c. Functional test
d. Any other relevant test

A certificate to detail the results and records obtained during the FAT shall be made available for ratification by the Vendor on the date of test.

7.2. Site Acceptance Testing (SAT)

A SAT shall be carried out on completion of the installation of the equipment at site which shall be witnessed by the company / owner's representative. SAT shall be performed on the Temperature Transmitter as per the approved test procedure. A comprehensive test procedure in compliance with the company specification shall be developed and issued to company / owner for review and approval.

The Site Acceptance Test (SAT), in general, shall demonstrate that the Temperature Transmitter correctly and properly in accordance with the specified requirements.

8.0 MARKING, PACKING AND SHIPMENT

Following FAT completion, Vendor responsible for the Temperature Transmitter shall ensure that all equipment and associated materials and accessories are designed properly, marked and packed, and secured for transit to site without damage.

Vendor shall provide and submit his standard "Marking, Packing and Shipping Procedures" for review by Company / Owner.

Vendor shall specify any conditions, normal or special, to be verified in intermediate storage and during transport.

Equipment shall be suitably packed including any dismantling, transit fastening and bracing necessary to prevent distortion or damage during transit.

Adequate protection shall be provided to prevent mechanical damage and atmospheric corrosion in transit and at the jobsite.

Preparation for shipment and packing will be subject to inspection and rejection by Company's inspectors. All costs occasioned by such rejection shall be to account of the Vendor.

9.0 SPARES AND ACCESSORIES

The following spare philosophy shall be followed in case it is not covered in Job Specification.

The Vendor shall include recommended Spare Parts List for start-up, pre-commissioning and two years operation as per the following;

I. Itemized recommended spare parts list for start-up and pre-commissioning.
II. Itemized recommended spare parts list for two years operation.

Vendor shall recommend accessories and special tools required for operation and maintenance of Pressure Switch, for Company review.

All the spare parts furnished by Vendor shall be wrapped and packaged to preserve an original as-new condition under normal conditions of storage. The same parts shall be properly tagged with stainless steel tags and coded so that later identification as to their intended equipment usage shall be clear.

All items supplied shall be packaged separately and clearly marked as "Spare Parts" and shipped with the equipment.

10.0 DOCUMENTATION

The following documentation shall be fulfilled by the Vendor, if it is not covered in Job Specification.

10.1. Documentation Required with Technical Bid

During bidding stage Vendor shall submit in his offer the following documents as a minimum:

a. Standard Specification, Data Sheets;
b. Bill of Materials including Vendor list, details of third party items;
c. Catalogues and Manuals;
d. Quality Assurance Plan;

10.2. Documentation Required for Approval

Upon placement of Purchase Order, Vendor shall submit as a minimum the following drawings, documents and specifications for the Company’s approval:

a. Specifications, Data Sheets;
b. Bill of materials including Vendor list, details for third party items;
c. Catalogues, Manuals and relevant drawings and documents;
d. Dimensional drawings;
e. Calibration certificates;
f. Material test certificates;
g. Procedures for FAT;
h. Quality Assurance Plan;
i. Any Other documents.

10.3. Guarantee / Warranty

Vendor shall guarantee that the complete scope of supply shall be safely and reliably meet all of the requirements of this Company Specification.

Vendor shall provide warranty support for a period of 12 months from the date of supply or 18 months from the date of manufacturing. Warranty shall apply to defective material workmanship and facility design. The cost of correction / replacement of any warranty items shall be borne by the Vendor, as per the purchase conditions of the Material / Purchase Requisition.

The Job specifications / Data sheets shall be referred for any specific warranty / guarantee.

STANDARD SPECIFICATION
FOR
INSTRUMENTATION CABLES

I-SPC-013

0	08.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

ASTM	:	American Society of Testing and Materials
AWG	:	American Wire Gauge
BS	:	British Standards
DC	:	Direct Current
DIN	:	Deutsches Institute for numbering
EPR	:	Ethylene Propylene Rubber
F&G	:	Fire and Gas
IEC	:	International Electro-technical Commission
IS	:	Indian Standards
PVC	:	Polyvinyl Chloride

CONTENTS

1.0 SCOPE

This Standard Specification, together with the Data Sheets attached herewith, establishes the minimum technical and functional requirements for design, engineering, materials, fabrication, painting, inspection and testing, documentation, marking, packing and shipping of Cables along with its spares and accessories.

2.0 DEFINITIONS

For the purpose of this document, the words and expressions listed below shall have the meanings assigned to them as follows:

Owner/ Purchaser/ Company	Owner of the particular Project (Project Specific).
Consultant	The party which comes out all or part of the engineering, procurement, construction, pre-commissioning and assistance for commissioning, monitors and controls the overall project management.
Bidder/ Manufacturer / Supplier / Vendor	The party(s) which manufactures and / or supplies material, equipment, technical documents / drawings and services to perform the duties specified by Contractor.
Works/ Shop	The place where the ITEM / UNIT is fabricated and tested and transported to Purchaser.
Datasheet	Technical data provided by the Purchaser / Owner / Company.
Standard Specification	Specifications Developed as Standard by the Company.
Job Specification	Specifications Developed pertaining to particular project / Job in regard.
Material Requisition	Requisition as raised to Supplier for Quotation of the item
Purchase Requisition	Requisition as raised to Supplier for Procurement of the item
Purchase Order	Legal Order supplied to Supplier for procurement of the Engineered Item
Site	The work place where the equipment is installed and commissioned.

3.0 REFERENCE DOCUMENTS

3.1. Codes & Standards

The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the Purchaser's enquiry.

IEC-332-3 Part 3	Tests on bunched wires and cables
IEC 584-3 Part	Extension and compensating cables – Tolerances identification system

IEC-60332 Part 3	Tests on electric and optical fibre cables under fire conditions - Test for vertical flame spread of vertically mounted bunched wires or cables
IEC-60331	Fire-Resisting Characteristics of Electric Cables
ASTM D 2863	Test method for measuring the minimum oxygen concentration to support candle like combustion of plastics (Oxygen index)
BS-5308 Part 1	Specification for Polyethylene insulated cables
BS-5308 Part 2	Specification for PVC insulated cables
DIN-50049	Document on Material Testing
IS-1554 Part 1	PVC insulated (heavy duty) electric cables-working voltage up to and including 110 V
IS-2633	Method for testing uniformity of coating on zinc coated articles
IS-3975	Mild steel wires, formed wires and tapes for armouring cables
IS-5831	PVC insulation and sheath of electric cables
IS-8784	Thermocouple compensating cables

3.2. Order of Precedence

In the event of conflict between Specifications, Data sheets, related standards, codes etc., the order of precedence shall be as follows:

a. Data sheets

b. Job Specifications

c. Standard Specifications

d. Codes and Standards

Vendor shall refer the matter to the Purchaser for clarification and only after obtaining the approval in writing, the same should proceed with the manufacture of the items in question.

4.0 MATERIALS

Materials selected shall be in accordance with the Data Sheets and Company's Standard Specifications. Type and material of extension Cable shall be as per IS-5831 and IEC 584-3 where applicable.

Cable cores shall be of annealed electrolytic tinned copper conductor with PVC jackets conform to IS-5831. Insulation shall be Mica-glass / EPR or silicon rubber for F&G. signal/control Cables. Armouring shall be of galvanized steel wire / strip armour conforming to IS-1554. Screening / shielding shall be of black Aluminium backed Mylar / Polyester foil.

5.0 DESIGN

The following design requirement covers the general requirements of Instrument Cables and accessories etc., but for the exact requirements and applications, the relevant, specific job Specifications and design basis shall be referred and complied.

5.1. Signal and Control Cables

5.1.1. Type – I (Single Pair / Triad Shielded Cable)

Each core shall be 1.5 mm2, made of 7 stranded annealed electrolytic copper conductor. Each strand shall be 0.53 mm dia.

Primary insulation shall be 85°C polyvinyl chloride (PVC) as per IS-5831 Type-C. Thickness shall be 0.5 mm minimum.

A pair or triad shall have twisted cores and number of twists shall be not less than 10 per meter. Colour of core insulation shall be black-blue in pair and black-blue-brown in a triad.

Individual pair and triad shall be shielded. Shield shall be Aluminium backed by Mylar / polyester tape with the metallic side down helically applied with either side 25 % overlap or 100% coverage. Minimum shield thickness shall be 0.05 mm. Drain wire shall be 0.5 mm2 multistrand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with Aluminium side of the shield.

Inner and outer jacket shall be made of extruded flame retardant 90°C PVC to IS 5831 - Type ST2. Oxygen index of PVC shall be over 30 %. Temperature Index shall be over 250°C. The thickness of the jacket shall be as per IS-1554 Part-1.

Inner jacket colour shall be black. Outer jacket colour shall be black, except for cables to be used in intrinsically safe systems it shall be light blue. A rip cord shall be provided for inner jacket.

Armour over inner jacket shall be of galvanized steel wire / flat as per IS-1554 Part-1.

Tolerance in overall diameter of cable shall be within ±2 mm over offered value.

5.1.2. Type – II (Multipair / Multitriad Cable with Individual Pair Shield and Overall Shield)

a. Generally the Cable shall be same as single pair shielded Cable except conductor sizes shall be 0.5 mm2 made of 7 strands of annealed electrolytic copper conductor. Each strand shall be of 0.3 mm dia.

b. Overall shield shall be of Aluminium backed up by Mylar / polyester tape helically applied with the metallic side down with either side 25% overlap or 100% coverage. Minimum shield thickness shall be 0.075 mm. Drain wire shall be similar to individual pair drain wire and shall be of the overall shield.

c. Overall twist of all pair / triads shall be as per Vendor's standard.

d. A pair of communication wire shall be provided for multipair / multitriad cables. Each wire shall be 0.5 mm2 of plain annealed single or multistrand copper conductor with 0.4 mm thick 85°C PVC insulation. Insulation shall be green and red colour coded.

e. Pair identification shall be with numbers at interval of not more than 250 mm as per vendor's standards.

5.1.3. Type – III (Multipair / Multitraid Cable with Only Overall Shield)

a. These Cables shall be same as type-II cables except that the individual pair / triad shall not have shielding.

5.1.4. Type - IV (Multipair / Multitriad Cable with Individual Pair Shield and Overall Shield)

a. The Cable shall be same as Type II except conductor size shall be 1.5 mm2 made of 7 stranded annealed electrolytic copper conductor. Each strand shall be of 0.53 mm dia.

5.1.5. Type – V (Multipair / Multitriad Cable with Overall Shield only)

a. The Cable shall be same as type IV except that the individual pair / triad shall not have the shielding.

5.2. Fire and Gas Cables shall be fire resistant and shall meet all the Specifications mentioned above and:

a. Insulation shall be Mica-Glass / EPR or silicon rubber.
b. The inner sheath shall be applied with a low smoke fire resisting compound.
c. Suitable filler material (if necessary) shall be filled.
d. Outer sheath shall be made up of low smoke, heat and oil resistant and flame retardant material.
e. Circuit integrity of the Cable shall be maintained for a minimum period of 3 hours as per IEC-60331.
f. The outer jacket colour shall be orange.

5.3. Thermocouple Extension Cables

Type and material of extension cable shall be as per IS-5831 and IEC-584-3 where applicable.

5.3.1. Type – I (Single Pair Shielded Cable)

a. Each core shall be made of 16 AWG solid conductors.
b. Primary insulation shall be 85°C polyvinyl chloride (PVC) as per IS 5831 Type C. Thickness shall be 0.5 mm minimum. Colour coding shall be as per IS-8784 Table-5.
c. The cores of the pair shall be twisted and number of twists shall be not less than 10 per meter. The pair shall be shielded. Shield shall be Aluminium backed by Mylar / polyester tape bonded together helically applied with the metallic side down with either side 25% overlap and 100% coverage. Minimum shield thickness shall be 0.05 mm. Drain wire shall be 0.5 mm2 multistrand bare tinned annealed copper conductor. The drain wire shall be continuous contact with Aluminium side of the shield.
d. Inner and outer jacket shall be made of extruded flame retardant 90°C PVC to IS 5831- Type ST2. Oxygen index of PVC shall be over 30 %. Temperature index shall be over 250°C. The thickness of the jacket shall be as per IS-1554 part-1. Inner jacket and outer jacket colour shall be as per IS-8784. A rip cord shall be provided for inner jacket.
e. Armour over inner jacket shall be of galvanized steel wire/flat as per IS-1554 Part-I.
f. Tolerance in overall diameter of cable shall be within ±2 mm over offered value.

5.3.2. Type – II (Multipair Cable with Individual Shield and Overall Shield)

a. The Cable shall be same as single pair shielded cable except for following;
   i. Each core shall be 20 AWG solid conductor.
   ii. In addition to individual pair shield overall shield shall be provided. Overall shield shall be of Aluminium backed up by Mylar / polyester tape helically applied with metallic side down either side 25% overlap or 100% coverage. Minimum shield thickness shall be 0.075 mm. Drain wire shall be similar to individual pair drain wire and shall be in continuous contact with the aluminium side of the overall shield.
   iii. Overall twist of all pair shall be as per Vendor's standard.
   iv. A pair of communication wire shall be provided for multipair cables. Each wire shall be 0.5 mm2 of plain annealed single or multistrand copper conductor with 0.4 mm thick 85°C PVC insulation. Insulation shall be green and red colour coded.
   v. Pair identification shall be with numbers at interval of not more than 250 mm as per Vendor's standard.

5.3.3. Type – III (Multipair Cable with Individual Pair Shield and Overall Shield)

a. The Cable shall be same as type II except conductor size shall be 16 AWG.

5.4. Electrical Characterstics

5.4.1. Cable parameters L/R ratio, capacitance shall conform to intrinsic safety requirements for IS cables. Limitations for cable parameter shall be as follows:

a. Maximum DC resistance of the conductor of the completed cable shall not exceed 12.3 Ω/km at 20°C for cables with 1.5 mm2 conductors and 39.7 Ω/km at 20°C for cables with 0.5 mm2 conductors.
b. Mutual capacitance between any core and screen shall not exceed 250 pF/m at 1 KHz. Capacitance between any cores or screen shall not exceed 400 pF/m at 1 KHz.
c. L/R ratio of adjacent core shall not exceed 40 μH/Ω for cables with 1.5 mm2 conductors and 25 μH/Ω for cables with 0.5 mm2 conductors.
d. Electrostatic noise rejection ratio shall be minimum 76 dBA.
e. Drain wire resistance including screen shall not exceed 30 Ω/km.
f. Core inductance shall not exceed 4 mH/Km.
g. Values shall be derived under the fault condition in the cable which produces the worst case parameters for intrinsic safe cables.

All Cables shall have insulation voltage rating of 600 / 1100 V.

5.5. Name Plate

All Instrument Cable shall be marked as per Manufacturer's standard and shall have a permanently attached stainless steel plate with the following, as a minimum detail:

a. Tag number as per Data Sheet;
b. Manufacturer's name;
c. Details of the Cable;
d. Length of the Cable in meters contained in the drum;
e. Gross weight;
f. Direction of rotation of drum for unwinding by means of an arrow;
g. Purchase Order number.

6.0 FABRICATION AND PAINTING

Vendor shall obtain approval in writing from the Purchaser before start of fabrication of Cables. Vendor shall submit the required Specification, drawings & documents for approval. Also Vendor shall refer the relevant codes and standards for manufacturing herein.

7.0 INSPECTION AND TESTING

Vendor shall perform all inspection and testing as per Job Specification requirements, and as per relevant codes, prior to shipment. The inspection and testing for Instrument Cables shall be carried out as per approved Inspection and Test Plan. Vendor shall submit the Inspection and Testing for Approval. Vendor shall submit the test certificates to the Company for the tests conducted during the manufacturing process like hydro test, material test, hazardous area certification test, and any other before Factory Acceptance Testing (FAT).

7.1. Factory Acceptance Testing (FAT)

Prior to FAT, Vendor shall submit to the Company a detailed FAT procedure, for review and approval, listing all the Instrument Cables, complete with the project approved tags, and highlighting the inspection and testing requirements of all such devices. FAT shall be carried out as per approved Inspection and Test Plan. FAT shall be carried out prior to shipment of the Instrument Cables.

FAT procedures shall be submitted at least 4 weeks prior to FAT testing taking place. FAT shall be carried out at the manufacturing facilities. The tests shall be witnessed by the Company or their approved representative. FAT procedure will be signed off by the Vendor and Company or their approved representative at the successful completion and conclusion of testing.

The FAT shall be consisting of the following as a minimum:

7.1.1. Standard Type Test certificate shall be furnished for Cables similar to those being offered,

a. Cable shall be flame retardant to IEC-60332 part-III category A.
b. Cables required for F&G applications shall be as per IEC-60331.

7.1.2. Standard Routing Test (to be carried out by the manufacturer during various stages of manufacturing, test certificates shall be furnished)

a. Insulation resistance, voltage test and spark test as per 8S-5308 part-ll and sheath test as per IS-5831;
b. Armor test as per IS-3975;
c. Cable capacitance, L/R ratio and inductance test;
d. Conductor resistance test in Ohms/km;
e. Thermo emf tests for thermocouple extension cables.

7.1.3. Standard Acceptance Test shall be carried out in the presence of Purchaser or his authorized representatives,

a. Continuity test;
b. Voltage test as per 8S-5308 part-II;
c. L/R ratio and capacitance values test;
d. Oxygen index test as per ASTM D 2863 latest edition;
e. Conductor resistance and drain wire resistance;
f. Dimensional check for overall diameter and under armor lover armor diameter;
g. Fire resistant test / certificate review (when specified);
h. Tests for uniformity of galvanization of armor as per IS-2633;
i. Check for drum length and overall length tolerances.

7.2. Site Acceptance Testing (SAT)

A SAT shall be carried out on completion of the installation of the Cables at site which shall be witnessed by the company / owner's representative. SAT shall be performed as per the approved test procedure. A comprehensive test procedure in compliance with the company specification shall be developed and issued to company / owner for review and approval.

The Site Acceptance Test (SAT), in general, shall demonstrate that the Cables functions correctly and properly in accordance with the specified requirements. SAT mainly consists of the following inspections:

a. Continuity test

b. Conductor resistance and drain wire resistance

c. Drum length and overall length tolerances

d. Any other test, if required.

8.0 MARKING, PACKING AND SHIPMENT

Following FAT completion, Vendor ensure that all Cables, associated materials and accessories are designed properly, marked and packed, and secured for transit to site without damage.

Vendor shall provide and submit his standard "Marking, Packing and Shipping Procedures" for review by Company / Owner.

Vendor shall specify any conditions, normal or special, to be verified in intermediate storage and during transport.

Adequate protection shall be provided to prevent mechanical damage and atmospheric corrosion in transit and at the jobsite.

Cables shall be dispatched in wooden drums, securely battened with take-off end fully protected against damage

The ends of the Cable shall be sealed with suitable PVC / Rubber caps to prevent ingress of moisture.

Preparation for shipment and packing will be subject to inspection and rejection by Company's inspectors. All costs occasioned by such rejection shall be to account of the Vendor.

9.0 SPARES AND ACCESSORIES

The following spare philosophy shall be followed in case it is not covered in Job Specification.

The Vendor shall include recommended Spare Parts List for start-up, pre-commissioning and two years operation as per the following;

a. Itemized recommended spare parts list for start-up and pre-commissioning.

b. Itemized recommended spare parts list for two years operation.

Vendor shall recommend accessories and special tools required for operation and maintenance of Instrument Cables for Company review.

All the spare parts furnished by Vendor shall be wrapped and packaged to preserve an original as-new condition under normal conditions of storage. The same parts shall be properly tagged with stainless steel tags and coded so that later identification as to their intended equipment usage shall be clear.

All items supplied shall be packaged separately and clearly marked as "Spare Parts" and shipped with the equipment.

10.0 DOCUMENTATION

The following documentation shall be fulfilled by the Vendor, if it is not covered in Job Specification.

10.1. Documentation Required with Technical Bid

During bidding stage Vendor shall submit in his offer the following documents as a minimum:

a. Standard Specification, Data Sheets;

b. Bill of Materials including Vendor list, details of third party items;

c. Catalogues and Manuals;

d. Quality Assurance Plan;

e. Any other documents.

10.2. Documentation Required for Approval

Upon placement of Purchase Order, Vendor shall submit as a minimum the following drawings, documents and specifications for the Company's approval:

a. Specifications, Data Sheets;

b. Bill of materials including Vendor list, details for third party items;

c. Catalogues, Manuals and relevant drawings and documents;

d. Dimensional drawings;

e. Material test certificates;

f. Procedures for FAT;

g. Quality Assurance Plan;

h. List for spare parts for start-up and for 2 years of operation.

10.3. Guarantee & Warranty

Vendor shall guarantee that the complete scope of supply shall be safely and reliably meet all of the requirements of this Company Specification.

Vendor shall provide warranty support for a period of 12 months from the date of supply or 18 months from the date of manufacturing. Warranty shall apply to defective material workmanship and facility design .The cost of correction / replacement of any warranty items shall be borne by the Vendor, as per the purchase conditions of the Material / Purchase Requisition.

The Job specifications / Data sheets shall be referred for any specific warranty / guarantee.

STANDARD SPECIFICATION FOR INSTRUMENT TUBE FITTINGS

I-SPC-014

0	28.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

ANSI	:	American National Standards Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society of Testing and Materials
BS	:	British Standards
FAT	:	Factory Acceptance Test
IS	:	Indian Standards
ISA	:	Instrument Society of America
ISO	:	International Organization for Standardization
NACE	:	National Association of Corrosion Engineers
NPT	:	Nominal Pipe Thread
SAT	:	Site Acceptance Test
SS	:	Stainless Steel

CONTENTS

1.0 SCOPE

This Standard Specification, together with the Data Sheets attached herewith, establishes the minimum technical and functional requirements for design, engineering, materials, fabrication, painting, inspection and testing, documentation, marking, packing and shipping of instrument tube fittings which includes the following types :-

a. SS compression fittings (for SS tube)

b. Brass compression fittings (for copper tube)

2.0 DEFINITIONS

For the purpose of this document, the words and expressions listed below shall have the meanings assigned to them as follows:

Owner/ Purchaser/ Company	Owner of the particular Project (Project Specific).
Consultant	The party which comes out all or part of the engineering, procurement, construction, pre-commissioning and assistance for commissioning, monitors and controls the overall project management.
Bidder/ Manufacturer / Supplier / Vendor	The party(s) which manufactures and / or supplies material, equipment, technical documents / drawings and services to perform the duties specified by Contractor.
Works/ Shop	The place where the ITEM / UNIT is fabricated and tested and transported to Purchaser.
Datasheet	Technical data provided by the Purchaser / Owner / Company.
Standard Specification	Specifications Developed as Standard by the Company.
Job Specification	Specifications Developed pertaining to particular project / Job in regard.
Material Requisition	Requisition as raised to Supplier for Quotation of the item
Purchase Requisition	Requisition as raised to Supplier for Procurement of the item
Purchase Order	Legal Order supplied to Supplier for procurement of the Engineered Item
Site	The work place where the equipment is installed and commissioned.

3.0 REFERENCE DOCUMENTS

3.1 Codes & Standards

The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the Purchaser's enquiry.

American Society of Mechanical Engineers

ASME B1.20.1	Pipe Threads
ASME B 16.5	Steel Pipe Flanges and Flanged Fitting
ASME B 16.20	Ring Joint Gaskets and Grooves for Steel Pipe Flanges
ASMEB16.11	Forged Steel Fittings -Socket Welding and Threaded
British Standards	
BS-4368	Carbon and Stainless Steel Compression Couplings for Tubes - Part-IV
Instrument society of America	
ISA RP 42.1	Nomenclature for Instrument tubing fittings
Indian Standards	
IS-319	Specification for free cutting Brass Bars, Rods and Sections

3.2 Order of Precedence

In the event of conflict between Specifications, Data sheets, related standards, codes etc., the order of precedence shall be as follows:

a. Data sheets

b. Job Specifications

c. Standard Specifications

d. Codes and Standards

Vendor shall refer the matter to the Purchaser for clarification and only after obtaining the approval in writing, the same should proceed with the manufacture of the items in question.

4.0 MATERIALS

Materials selected shall be in accordance with the Data Sheets and Standard Specifications. For corrosion service the material selected shall be in compliance with the requirements of NACE MR-0175 / IS0-15156 latest editions.

5.0 DESIGN

5.1 SS Tube Fittings

Nomenclature of all Tube Fittings shall be as per ISA RP 42.1.

Fittings shall be of flare less compression type and four - piece (for double compression type) construction consisting of two ferrules, nut and body suitable for use on SS tubes conforming to ASTM A 269 TP 316 with hardness in the range of RB 70 to 79.

All the parts shall be of SS 316.

Hardness of the ferrules shall be in the range of RB 85-90 so as to ensure a hardness difference of the order of 5 to 10 between Tube and Fittings, for better sealing.

Nuts and ferrules of a particular size shall be interchangeable for each type.

Spanner hold shall be metric.

Threaded ends of Fittings shall be NPT as per ANSI B 1.20.1.

Vendor shall ensure that the ferrules and nuts supplied for fittings shall be suitable for the sample Tube which shall be supplied during manufacture.

Specific techniques like Silver plating shall be used over threading in order to avoid jamming and galling.

5.2 Copper Tube Fittings

Nomenclature of all Tube Fittings shall be as per ISA RP 42.1.

Fittings shall be of flare less compression type and of three- piece construction consisting of ferrule, nut and body suitable for use on copper tubes conforming to ASTM B 68/B 68M hardness not exceeding RB 50.

All parts shall be manufactured from Brass as per IS 319 bar stock and nickel plated.

For better grip, Vendor shall maintain hardness difference between tube and ferrule and indicate the same along with the offer.

Nuts and ferrules of a particular size shall be interchangeable for each type.

Threaded ends of Fittings shall be NPT as per ANSI B 1.20.1.

Spanner hold shall be metric.

Vendor shall ensure that the ferrules and nuts supplied for fittings shall be suitable for sample tube which shall be supplied during manufacture.

5.3 Name Plate

No separate nameplates are required on the Fittings. However, a Manufacturer's name / trademark should be punched on a visible place on the body of each Fittings for easy identification.

6.0 FABRICATION AND PAINTING

Vendor shall obtain approval in writing from the Purchaser before start of fabrication of Instrument Tube Fittings. Vendor shall submit the required Specification, drawings & documents for approval. Also Vendor shall refer the relevant codes and standards for manufacturing herein.

7.0 INSPECTION AND TESTING

Vendor shall perform all inspection and testing as per Job Specification requirements, and as per relevant codes, prior to shipment. The inspection and testing for Instrument Tube Fittings shall be carried out as per approved Inspection and Test Plan.

Type test for the products shall be according to 8S-4368 Part IV which shall necessarily include the following:-

a. Hydrostatic proof pressure test
b. Minimum hydrostatic burst pressure test
c. Disassembly and reassembly test

d. Minimum static gas pressure (vacuum) test
e. Maximum static gas pressure test
f. Hydrostatic impulse and vibration test.

The type test results shall be made available for scrutiny during inspection.

Vendor shall submit the test certificates to the Company for the tests conducted during the manufacturing process like hydro test, material test, hazardous area certification test, calibration test and any other before Factory Acceptance Testing (FAT).

7.1 Factory Acceptance Testing (FAT)

Prior to FAT, Vendor shall submit to the Company a detailed FAT procedure, for review and approval, listing all the Instrument Tube Fittings complete with the project approved tags, and highlighting the inspection and testing requirements of all such devices. FAT shall be carried out as per approved Inspection and Test Plan. FAT shall be carried out prior to shipment of the Instrument Tube Fittings.

FAT procedures shall be submitted at least 4 weeks prior to FAT testing taking place. FAT shall be carried out at the manufacturing facilities. The tests shall be witnessed by the Company or their approved representative. FAT procedure will be signed off by the Vendor and Company or their approved representative at the successful completion and conclusion of testing.

The FAT shall be consisting of the following as a minimum:

a. Hydrostatic Test: SS Tube Fittings shall be subjected to hydrostatic test at the following pressures.

   For 6 mm Fittings, at 80 kg/cm2.

   For 1/2" Fittings, at 153 kg/cm2 or 400 kg/cm2 at 38°C, as specified in the Data Sheets. The ratings are based on usage in piping classes with flange ratings up to 600#, 900# and 1500# respectively.

   Brass compression Fittings shall be subjected to hydrostatic test at the following pressure:

   For 1/4" Fittings, at 10 kg/cm2, 3/8 " at 80 kg/cm2, at 38° C.

   During and after the hydrostatic test, the tubes shall not show any leaks or rupture.

b. Pneumatic Pressure Test: The Fittings shall be tested at 7 kg/cm2 of dry air. During and after the test, tubes shall not show any leaks or rupture.
c. Disassembly and Reassembly Test.
d. Hardness verification. Test for hardness shall be done on parent material for the ferrules.
e. Dimensional test report

A certificate to detail the results and records obtained during the FAT shall be made available for ratification by the Vendor on the date of test.

7.2 Site Acceptance Testing (SAT)

A SAT shall be carried out on completion of the installation of the equipment at site which shall be witnessed by the company / owner’s representative. SAT shall be performed on the Instrument Tube Fittings as per the approved test procedure. A comprehensive test procedure in compliance with the company specification shall be developed and issued to company / owner for review and approval.

The Site Acceptance Test (SAT), in general, shall demonstrate that the Instrument Tube Fittings functions correctly and properly in accordance with the specified requirements.

8.0 MARKING, PACKING AND SHIPMENT

Following FAT completion, Vendor responsible for the Instrument Tube Fittings shall ensure that all equipment and associated materials and accessories are designed properly, marked and packed, and secured for transit to site without damage.

Vendor shall provide and submit his standard "Marking, Packing and Shipping Procedures" for review by Company / Owner.

Vendor shall specify any conditions, normal or special, to be verified in intermediate storage and during transport.

Equipment shall be suitably packed including any dismantling, transit fastening and bracing necessary to prevent distortion or damage during transit.

Adequate protection shall be provided to prevent mechanical damage and atmospheric corrosion in transit and at the jobsite.

Preparation for shipment and packing will be subject to inspection and rejection by Company's inspectors. All costs occasioned by such rejection shall be to account of the Vendor.

9.0 SPARES AND ACCESSORIES

The following spare philosophy shall be followed in case it is not covered in Job Specification.

The Vendor shall include recommended Spare Parts List for start-up, pre-commissioning and two years operation as per the following;

a. Itemized recommended spare parts list for start-up and pre-commissioning.
b. Itemized recommended spare parts list for two years operation.

Vendor shall recommend accessories and special tools required for operation and maintenance of Instrument Tube Fittings, for Company review.

All the spare parts furnished by Vendor shall be wrapped and packaged to preserve an original as-new condition under normal conditions of storage. The same parts shall be properly tagged with stainless steel tags and coded so that later identification as to their intended equipment usage shall be clear.

All items supplied shall be packaged separately and clearly marked as "Spare Parts" and shipped with the equipment.

10.0 DOCUMENTATION

The following documentation shall be fulfilled by the Vendor, if it is not covered in Job Specification.

10.1 Documentation Required with Technical Bid

During bidding stage Vendor shall submit in his offer the following documents as a minimum:

a. Standard Specification, Data Sheets;

b. Bill of Materials including Vendor list, details of third party items;

c. Catalogues and Manuals;

d. Quality Assurance Plan;

e. Any other documents.

10.2 Documentation Required for Approval

Upon placement of Purchase Order, Vendor shall submit as a minimum the following drawings, documents and specifications for the Company's approval:

a. Specifications, Data Sheets;

b. Bill of materials including Vendor list, details for third party items;

c. Material test certificates;

d. Procedures for FAT;

e. Quality Assurance Plan;

10.3 Guarantee & Warranty

Vendor shall guarantee that the complete scope of supply shall be safely and reliably meet all of the requirements of this Company Specification.

Vendor shall provide warranty support for a period of 12 months from the date of supply or 18 months from the date of manufacturing. Warranty shall apply to defective material workmanship and facility design .The cost of correction / replacement of any warranty items shall be borne by the Vendor.

STANDARD SPECIFICATION
FOR
PRESSURE RELIEF VALVES

I-SPC-0015

0	09.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AARH	:	Arithmetic Average Roughness Height
NPT	:	National Pipe Thread

CONTENTS

1.0 SCOPE

1.1 General

1.1.1 This specification, together with the data sheets describes the requirements for the design, materials, fabrication, documentation, nameplate marking, inspection, testing and shipment of pressure relief valves.

1.1.2 The related standards referred herein and mentioned below shall be of the latest edition of the following codes, standard practices and publications, unless otherwise specified-

ANSI - American National Standard Institute /
NACE - National Association for Corrosion Engineers

MRO175/Petroleum and natural gas industries-Materials for use in H2S-ISO-15156 containing environments in oil and gas production

API - American Petroleum Institute

520 Sizing, Selection and Installation of Pressure Relieving Devices in Refineries.

Part I: Sizing & Selection

Part II: Installation

521: Guide for Pressure Relieving and Depressurising Systems.

526: Flanged Steel Pressure Relief Valves.

527: Seat Tightness of Pressure Relief Valves.

ASME - American Society of Mechanical Engineers.

B 1.20.1: Pipe Threads General Purpose (Inch).

B 16.5: Pipe Flanges and Flanged Fittings

B 16.20: Metallic Gaskets for Pipe Flanges

B 16.34: Valves- Flanged, Threaded and Welding End

Sec-VIII: Boiler and Pressure Vessels Code Section VIII 'Pressure Vessels'

Sec-XIII: Boiler and Pressure Vessels Code Section XIII 'Overpressure Protection'

Sec-I: Boiler and Pressure Vessels Code. Section-I 'Power Boilers'

EN - European Standards

10204: Inspection Documents for Metallic Products.

IBR - Indian Boiler Regulations

1.1.3 In the event of any conflict between this specification, data sheets, related standards and codes, the following order of priority shall govern.

a) Statutory Regulations

b) Data Sheets

c) Standard Specification

d) Codes and Standards

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the Material Requisition.

1.2.2 Vendor's quotation shall include the following:

a) Detailed specification sheet for each item which shall provide information regarding type, construction materials, sizing code, inlet and outlet type, size and rating, relieving area, relieving capacity, orifice letter designation, overpressure, blow down, operating pressure etc. and any other valve accessories. The material specifications and units of measurement for various items in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets.

b) ASME certificate for discharge co-efficient or ASME certified capacity curves to be submitted along with offer.

c) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate, they must include a list of deviations tag number wise, summing up all the deviations from the purchaser's data sheets and other technical specification along with the technical reasons for each of these deviations.

d) Catalogues giving detailed technical specifications (i.e. available sizes, ratings, sizing codes, approvals & certifications, MOC, etc), model decoding details and other related information for each type of pressure relief valve covered in the bid. In case catalogues do not provide all such technical details, vendor shall submit supplementary technical literature.

e) Any special tools and tackles needed for maintenance work. In case no special tools are necessary for the offered pressure relief valve, vendor must certify in their offer.

1.2.4 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals etc. shall be in English language only.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogue and manuals required shall be submitted by the vendor as per vendor data requirements attached with the requisition.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc. shall be submitted by vendor after placement of purchase order which shall include the following as a minimum:

a) Specification sheet for each pressure relief valve and its accessories;

b) Certified drawings and technical catalogues for each pressure relief valve and accessories, which shall provide dimensional details, internal construction details, end connection details, weight, and materials of construction, sizing codes, approvals & certifications;

c) Copy of type test certificates;

d) Installation procedure for Pressure relief valve and its accessories;

e) Calibration and maintenance procedure including replacement of internals wherever applicable.

2.0 DESIGN AND CONSTRUCTION

2.1 Valve Design

2.1.1 The definitions of various terminologies used in purchaser's data sheets are as per API RP 520 part I.

2.1.2 Unless specified otherwise, all pressure relief valves shall be full nozzle full lift type and all relief valves in thermal safety application shall be modified nozzle or full nozzle type.

2.1.3 For flanged pressure relief valves, the valve inlet and outlet size, rating, the orifice designation and corresponding relieving area shall be as per API 526.

2.1.4 The design of pressure relief valves in steam service under IBR design code shall be governed by Regulation 294 and regulation 295 of IBR. However where design code is specifically indicated as ASME Section I, the valve design shall meet the pressure relief valve requirements specified in ASME Section I.

2.2 Valve Sizing

2.2.1 Sizing shall be carried out using the method mentioned in the following standards whenever the sizing code mentioned in the purchaser's data sheets refers to these;

Size Code	Standard
API	API RP 520 Part I
	API RP 521
ASME	Boiler and Pressure vessels code Section VIII 'Pressure Vessels'.
	Boiler and Pressure Vessels Code Section XIII 'Overpressure Protection'
	Boiler and Pressure vessels code Section-I - 'Power Boilers'
IBR	Indian Boiler Regulations, paragraph - 293

2.2.2 Discharge Co-efficient

Following discharge coefficient values shall be used for sizing of pressure relief valves;

a) For all valves with design code as ASME Sec VIII, discharge co-efficient (Kd) of 0.975 in gas or vapour service and 0.65 in liquid service shall be used as per API 520.

b) For all valves in steam service covered under IBR design code, discharge co- efficient shall either be selected as per Regulation 293 or as tested and certified by IBR as per Appendix 'L' of IBR. For all valves in steam service with design code as ASME Section-I certified discharge co-efficient / certified discharge capacity as per ASME section-I shall be used.

2.2.3 For the selected orifice letter designation and inlet and outlet size of the pressure relief valve, relieving area of the valve offered by vendor shall meet those in API-526.

2.2.4 For valves having ASME certified discharge coefficient / capacity curves and sizing code mentioned in purchaser's datasheet as API, vendor shall select the valve as per API-526 standard orifice area and designation by considering the following effective area:-

Effective area= ASME calculated area x (ASME Kd /API Kd)

In any case, the orifice designation of the selected valve shall not be lower than the orifice designation specified in purchaser's datasheet.

2.2.5 For pressure relief valve covered under ASME Sec-I design code, the valve design shall conform to ASME Section I requirements with selected area higher of the area calculated as per ASME Section I requirements and that calculated as per regulation 293 of IBR.

2.3 Valve Construction

2.3.1 Body

2.3.1.1 Body rating shall be as per API-526 I ASME B16.34.

2.3.1.2 Unless otherwise mentioned, end connection details shall be as below:

a) Threaded end connections shall be to NPT as per ASME B 1.20.1.

b) Flanged end connections shall be as per ASME B 16.5.

c) Flanged face finish shall be as per ASME B 16.5.The face finish as specified in the data sheets, shall be as follows;

125 AARH	:	125 to 250 microinchAARH
63 AARH	:	32 to 63 microinchAARH

2.3.1.2 For flanged valves, inlet and outlet sizes and ratings and centre to flange face dimensions shall be in accordance with API-526 / ASME B 16.34 (as applicable). Dimensional tolerance shall be as mentioned therein.

2.3.1.3 Pressure relief valves shall be self-draining type or shall have body drain plugs.

2.3.1.4 For the pilot operated pressure relief valves, where vendor's standard model provides only semi nozzle design (i.e. the body is part of the inlet flow path), body material and nozzle material shall be same and as specified in purchaser's data sheets, as a minimum.

2.3.2 Trim

2.3.2.1 The term 'trim' covers all the parts of the valves exposed to and in contact with the process fluid except for the body and bonnet assembly i.e. nozzle, disc, disc holder, stem etc. In case cast nozzle is offered, the nozzle shall be radiographically tested irrespective of the pressure relief valve rating.

2.3.2.2 Valves shall be of the full nozzle type of design with the exception as per clause 2.3.1.4 and valves in thermal relief application as per clause no 2.1.2.

2.3.2.3 Wherever stelliting of disc and nozzle has been specified, it stands for stelliting of the seat joint and the entire disc contour, unless otherwise mentioned.

2.3.2.4 For high temperature application, the materials for the internals shall be selected to avoid galling.

2.3.2.5 Pressure relief valves in steam drum/boiler application with design as per ASME Section I, shall have two adjustable rings to adjust valve over-pressure and blow down.

2.3.2.6 Resilient seat, seals or o-rings wherever used shall be suitable for pressure and temperature conditions specified.

2.3.2.7 Gaskets wherever used shall be metallic type. Gaskets with asbestos filler or with asbestos bearing material shall not be used.

2.3.2.8 Selection of material of construction for guide and rings compatible with specified nozzle & disc material and meeting process and design conditions is the vendor's responsibility.

2.3.3 Bonnet and Spring

2.3.3.1 All valves shall be provided with a cap over the adjusting bolt. Cap shall be of either bolted type or screwed type.

2.3.3.2 Lifting lever shall be provided for temperature exceeding 60°C whenever the fluid to be relieved is steam, air or water.

2.3.3.3 Valve spring shall be selected such that the set pressure falls in the adjustable range of the spring.

2.3.3.4 Carbon steel springs shall be made corrosion resistant through plating/coating as per manufacturer's standard design or as specified in the purchaser's data sheets.

2.3.3.5 The allowable tolerance in set pressures is as below:

a) ±0.14 kg/cm2 g for set pressure upto and including 5kg/cm^2 g.

b) ±3% for set pressure above 5kg/cm^2 g.

2.3.3.6 Bonnet shall be of the closed type for all process applications in general. For valves discharging to atmosphere, open type bonnet can be used only for steam, non-hazardous/ non- toxic and non-hydrocarbon fluids. Closed bonnet can be used in place of open bonnet in case the pressure relief valve is suitable for design conditions. For all steam applications under design code IBR or ASME Section I with open bonnet design, weather protection cover shall be provided.

2.3.4 Pilot Design

2.3.4.1 For pilot operated valves, the pilot design shall be of inherently fail safe.

2.3.4.2 Unless specified otherwise, pilot shall be non-flowing type.

2.3.4.3 All accessories like back flow preventer, pilot filter etc. required for proper operation of pilot operated valves as per indicated service conditions shall be included.

2.3.4.4 Material of construction of pilot shall be same as that of main valve nozzle as a minimum.

2.3.4.5 The o-ring and diaphragm material of pilot shall be suitable for the pressure and temperature conditions specified in the data sheet.

2.3.5 Minimum acceptable materials

2.3.5.1 Minimum acceptable materials of construction to be considered by vendor for valve components are already specified in datasheets.

However, alternate superior materials may be provided if they meet all process conditions (operating, design, fluid properties, corrosion, etc), testing (ASME, API, radiography, etc) and statutory requirements (ASME, API, IBR, NACE, etc) specified by purchaser.

3.0 NAMEPLATE

3.1 Each pressure relief valve shall have a stainless steel nameplate attached firmly to it at a visible place, furnishing the following information: -

a) Tag number as per purchaser's data sheet.

b) Manufacturer's serial number and/or model number.

c) Manufacturer's name/trade mark.

d) Nominal flange size in inches and rating in pounds for both inlet and outlet.

e) Orifice letter designation.

t) Valve set pressure.

g) Cold bench test set pressure.

3.2 For the above, pressures shall be marked in the same units as those followed in purchaser's data sheets.

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing at vendor's works as per Inspection Test Plan. All these tests shall be completed by the vendor and test reports shall be submitted to Purchaser for scrutiny.

5.0 SHIPPING

5.1 Valves shall be supplied as a whole, complete with all the accessories like cap, lifting lever, test gag etc.

5.2 All threaded and flanged openings shall be suitably protected to prevent entry of foreign material.

5.3 All pressure relief valves in oxygen and chlorine service shall be separately packed along with a certificate indicating 'CERTIFIED FOR OXYGEN/CHLORINE SERVICE', as applicable.

STANDARD SPECIFICATION
FOR
CONTROL VALVES

I-SPC-0016

0	11.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AARH	:	Arithmetic Average Roughness Height
CIMFR	:	Central Institute of Mining and Fuel Research
EDDL	:	Electronic Device Description Language
ERTL	:	Electronics Regional Testing Laboratory
FCRI	:	Fluid Control Research Institute
FDT/DTM	:	Field Device Tool/Device Type Manager
FF	:	Fieldbus Foundation
FISCO	:	Fieldbus Intrinsic Safety Concept
HART	:	Highway Addressable Remote Transducer
HHT	:	Hand Held Terminal
NACE	:	National Association of Corrosion Engineers
NPS	:	Nominal Pipe Size
NPT	:	National Pipe Thread
PID	:	Proportional, Integral and Derivative
PTFE	:	Poly Tetra Fluoro Ethylene
SS	:	Stainless Steel
TSO	:	Tight Shutoff

CONTENTS

1.0 SCOPE

1.1 General

1.1.1 This specification, together with the data sheets describes the requirements for the design, materials, fabrication, documentation, nameplate marking, inspection, testing and shipment of pressure relief valves.

1.1.2 The related standards referred herein and mentioned below shall be of the latest edition of the following codes, standard practices and publications, unless otherwise specified-

ASME - American Society of Mechanical Engineer

B 1.20.1	: Pipe Threads, General Purpose (Inch)
B 16.5	: Pipe Flanges and Flanged fittings
B 16.20	: Metallic Gaskets for Pipe Flanges
B 16.34	: Valves - flanged, Threaded and Welding End.
B 16.47	: Large Diameter Steel Flanges: NPS 26 through NPS 60 Metric/Inch Standard

ANSI/FCI - American National Standard Institute/Fluid Control Institute

FCI 70-2	: Control Valve Seat Leakage

API - American Petroleum Institute.

6 D	: Specification for Pipeline and Piping Valves
598	: Inspection Requirements
609	: Lug and wafer type, Butterfly valves.
624	: Type Testing of Rising Stem Valves Equipped with Graphite Packing for Fugitive Emissions

AWWA - American Water Works Association

C207 CL.D	: Steel Pipe Flanges for Water Works Services

BS – British Standards

6364	: Valves in cryogenic service

EN - European Standards

10204	: Inspection Documents for Metallic Products.

IBR - Indian Boiler Regulations

IS/IEC - Indian Standards/International Electro-Technical Commission

IS/IEC 60079	: Electrical Apparatus for Explosive Gas Atmosphere.
IS/IEC 60529	: Degree of Protection Provided by Enclosures (IP Code).
IEC 60534-3-2	: Face to Face dimension of rotary valves except butterfly valves.
IEC 60534-4	: Inspection & Routine Testing
IEC 60534-8-3	: Industrial process control valves, noise consideration, control valve aerodynamic noise prediction method

IEC 60534-8-4	:	Industrial process control valves, noise consideration, prediction of noise generated by hydrodynamic flow
IEC-61158	:	Fieldbus Standard for use in Industrial Control System
IEC-61158-2	:	Physical layer specification and Service definition for Fieldbus
FF 890	:	Function Block Application Process Part 1
FF 891	:	Function Block Application Process Part 2
FF 892	:	Function Block Application Process Part 3
FF 893	:	Function Block Application Process Part 4
FF 894	:	Function Block Application Process Part 5
IEC 61508	:	Functional Safety of Electrical/Electronic/Programmable Electronic Safety related Systems.
IEC-61511	:	Functional safety instrumented system for the process industry sector
IEC-61804	:	Function Blocks (FB) for Process Control: Electronic Device Description

ISA – International Society of Automation

75.01.01	:	Flow equation for sizing control valves.
75.02	:	Control valve capacity test procedure.
TR75.04	:	Control Valve positioner stability
75.05.01	:	Control Valve terminology
75.07	:	Laboratory measurement of aerodynamic noise generated by control valves
75.08.01	:	Face to face dimensions for integral flanged Globe-style control valve bodies (ASME Class 125,150,300 and 600)
75.08.02	:	Face to face dimensions for flangeless control valve (ASME Class 150,300 and 600)
75.08.04	:	Face to face dimensions for Buttweld-end globe style control valve (ASME Class 4500)
75.08.05	:	Face to face dimensions for Buttweld-end globe style control valve (ASME Class 150,300, 600, 900, 1500 and 2500)
75.08.06	:	Face to face dimensions for flanged Globe-style control valve bodies (ASME Class 900, 1500 and 2500)
75.11.01	:	Inherent flow characteristic and Rangeability of control valves.
75.19.01	:	Hydrostatic testing of control valves.
75.22	:	Face to centre-line dimensions for flanged Globe-style Angle control valve bodies (ASME Class 150,300 and 600)
75.25.01	:	Test Procedure for Control valve response measurement for step inputs
TR 75.25.02	:	Control valve response measurement for step inputs
75.13	:	Method of evaluating the performance of positioners with analog input signals and pneumatic output.

75.17 : Control valve aerodynamic noise prediction.

RP75.23 : Considerations for evaluating control valve cavitation.

ISO – International Organization for Standardization

15848-1 : Industrial valves - Measurement, test and qualification procedures for fugitive emissions

ITK - Interoperability Test Kit (latest version)

MSS : Manufacturer's Standardisation Society

SP25 : Standard Markings System for Valves, Fittings, Flanges and Unions

NACE - National Association of Corrosion Engineers

MR0103 : Materials Resistant to Sulphide stress cracking in Corrosive Petroleum Refinery Environments

OSHA - Occupational Safety and Health Authority

1.1.3 In the event of any conflict between this standard specification, job specifications/data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern.

a) Statutory Regulations

b) Job Specification / Data Sheets

c) Standard Specification

d) Codes and Standards

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the Material Requisition.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

i) Compliance to the specifications.

ii) Whenever specifically indicated, a detailed specification sheet for each control valve which shall provide information regarding type, material of construction, capacity sizing code, inlet and outlet type, size and rating, etc. of the control valve and its valve accessories. The material specifications and units of measurement indicated in the specification sheet shall be to the same standards as those in purchaser's data sheet.

iii) Whenever the requirement of sizing calculation is specifically indicated in the materials requisition, vendor shall furnish sizing calculation for each tag number clearly highlighting the standard used for calculation, noise level, cavitation or flashing, Cv selected, percentage opening at minimum, normal and maximum flow, inlet and outlet velocity etc.

iv) A copy of approval for items such as limit switches, solenoid valves, electro- pneumatic converters, electro-pneumatic positioners, smart positioners, Fieldbus positioners from local statutory authority, as applicable, such as Petroleum and Explosives Safety Organization (PESO) in India, along with:

2.0 DESIGN AND CONSTRUCTION

2.1 Body

2.1.1 Control valves shall have flanged end connections integral to the valve body. Split body type valve design shall not be offered unless specifically indicated in the purchaser's data sheets. Whenever flangeless control valve body design is specified in the purchaser's data sheet, following shall apply:

a) Wafer type or lug type body design for control valves body size up to 6 inches.

b) Lug type body design for butterfly type of control valve body size more than 6 inches.

2.1.2 The minimum control valve body size shall be 1 inch. Control valve body size of less than 1 inch shall be offered only when specifically indicated in the purchaser's data sheet. The control valve body size shall be adhered to the size mentioned in the data sheet, if due to process condition and other parameters the same size is not suitable than higher size can be offered with reason. Only after acceptance of offered higher size by client, vendor shall proceed. In general, Control Valve size shall neither be more than the inlet line size nor be less than half the inlet line size unless specified otherwise in datasheets.

2.1.3 The valve body rating shall be equal to or higher than the flange rating specified in the data sheets. As a minimum, control valve body shall be rated for ASME Class 300. However, end connection shall be as specified in purchaser's data sheet.

2.1.4 The control valves shall be suitable for installation in horizontal as well as in vertical lines.

2.1.5 For all applications, where full port valves are specified in on-off service, following shall apply:

a) Port size shall be equal to line size for rating up to ASME Class1500.

b) Port size shall not be smaller than one size lower than that of the line size for body rating ASME Class 2500 and above.

2.1.6 Vendor to note that there shall not be any price or time implications in case the valve port size need to be changed to accommodate minor process changes while keeping the valve size and other specifications same during detailed engineering.

2.1.7 Flow Direction

2.1.7.1 In general, flow direction shall be as below:

a) Flow tending to open for single seated unbalanced valve design.

b) Flow entering between the seats for double seated valves.

c) Flow entering at the side and leaving at the bottom for angle valves.

For valves design other than those specified above, flow direction shall be as per manufacturer standard.

2.1.7.2 Flow direction shall be clearly marked on the control valve body.

2.1.7.3 For 3-way control valves, service like mixing or diverting, shall be clearly identified with inlet and outlet end connection clearly marked on the control valve body.

2.1.8 End Connections

2.1.8.1 Unless otherwise specified, the following shall govern:

a) Threaded end connections shall be to NPT as per ASME B1.20.1.

b) Flanged end connections shall be as per ASME B 16.5/ B 16.47B/ AWWAA C207 CL.D.

c) Flange face finish shall be as per ASME B16.5. The face finish shall be as follows:

125 AARH	:	125 to 250 micro inch AARH
63 AARH	:	32 to 63 micro inch AARH

d) Grooves of ring type joint flanges shall be octagonal as per ASME B 16.20

2.1.8.2 Face-to-face dimensions of globe type control valves shall be in accordance with ISA 75.08.

2.1.8.3 Where provided, control valve bottom drains shall be blind flanged. Flange dimensions and rating shall correspond to ASME B16.5.

2.1.9 Material of Construction

2.1.9.1 The material of construction of control valves body shall be as specified in the data sheet. No material shall be substituted by vendor without specific written approval from purchaser.

2.1.9.2 Control valve body, bonnet, bottom flange, line flanges and other pressure containing assemblies shall be of the same material of construction as specified for valve body in the purchaser's data sheets.

2.1.9.3 The bonnet flange and bottom flange shall have metallic spiral wound gaskets suitable for the specified service. The gaskets with asbestos bearing fillers shall not be used.

2.1.9.4 Vendor shall be responsible for selecting proper material for the internal parts of control valve. All such materials shall have the same or better specification than specified in the purchaser's data sheets.

2.1.9.5 The material of construction of silencers, diffuser plates, diffuser plate assembly etc shall be as per the body material specified in the purchaser's data sheets, as a minimum.

2.2 Trim

2.2.1 The term 'trim' covers those parts of valve assembly (excluding the body, bonnet and bottom flange) which are exposed to and are in contact with the line medium consisting of but not limited to the seat ring, valve stem, valve plug, valve plug guide, guide bushing and cage.

In case of rotary type of control valves like butterfly, ball, segmental ball, rotary plug, eccentric disc and rotary disc, the term trim covers disc/ball, seat ring, shaft and bearing.

2.2.2 Guiding

2.2.2.1 Single seated globe and angle type control valves shall have heavy top plug guiding or cage guided design as per data sheets. The cage shall provide a continuous plug guiding

2.2.2.2 Double seated valves shall have top and bottom or cage guiding and shall be of the pressure balanced type.

2.2.2.3 Whenever cage type control valves are specified, top guided or top and bottom guided control valves can be offered provided it meets all other process and functional requirements. But whenever top or top and bottom type of guiding is specified, cage type control valves shall not be offered. However, if the service requires the anti-cavitation trim or low noise trim then in place of top or top and bottom guiding the cage type control valve can be accepted only after review in the control valve sizing.

2.2.2.4 Rotary control valves like butterfly, segmental ball, eccentric rotary plug etc shall have blowout proof shaft guiding design.

2.2.3 Trim Design

2.2.3.1 Control valve manufacturer/vendor shall be responsible for trim selection and trim design of the control valve. However it must meet the following minimum requirements:

a) Control valve trim design shall suit the type of guiding specified in the data sheet.

b) The trim design and material of construction shall be selected to minimize the risk of galling particularly in case of cage guided valves. Vendor shall select proper material pairs, surface finish, hardness and clearances wherever possibility of galling exist.

c) Under extreme temperature conditions, vendor shall consider increased clearances at room temperature and seal welding of threaded seat rings etc. Hard facing of trim shall be used in high temperatures. For very low temperature application, material used shall have adequate cold impact strength.

d) For globe/angle/3-way type of control valves, stem and plug shall be detachable and shall be attached together by suitable threaded design secured with a pin to avoid plug rotation during operation.

e) For top and bottom guided control valves with sizes above 8", post and guide bushing design shall be used to prevent rotation of plug and stem.

f) Whenever cavitation conditions are expected, vendor shall select a special anti- cavitation trim design and shall use trim material of sufficiently high hardness.

g) Whenever the possibility of aerodynamic noise in a control valve exists under any operating condition specified in purchaser's data sheet, vendor shall select a special low noise trim for that application. ·

h) For control valves with anti-cavitation or low noise trim, the no. of stages shall be decided by vendor ensuring that the selected number of stages can sufficiently withstand the dynamic fluid forces to avoid vibration of stem and plug during normal continuous operation. Vendor shall ensure trim design to account for worst case dynamic force· / power generated by the process fluid under maximum operating conditions with a 10% safety margin.

2.2.3.2 The plug inherent characteristics shall be as indicated in the purchaser's data sheet.

2.2.3.3 Trim Material

2.2.3.3.1 Whether stellited or hardened trim is specified in the data sheets following material of construction for the trim parts shall be acceptable.

a)	Plug and seat	Stellite sheathing/hard alloy coating or solid stellite
b)	Cage	Nitrided or stellite sheathing/hard alloy coating or solid stellite.
c)	Guide bushing	Stellite coating/sheathing or solid stellite
d)	Valve stem	Hardened SS /Inconel X-760

In case of steam, water, air and other non-hydrocarbon utility services 17-4 PH SS or 440C is also acceptable.

. Special material requirements, if specified in the datasheets, shall supersede the above mentioned requirements.

2.23.3.2 Minimum acceptable hardness in case of stellited or hardened trim shall be of the order of RC 38 (BHN 352) to RC 45 (BHN 429).

2.2.3.4 Leakage class

a) Leakage class as per ANSI FCI 70.2 shall be specified in the purchaser's data sheet for each control valve. Where no leakage class is specified, the same shall be considered as Class III for Top-bottom Guided valves and Class N for all other type of valves. Higher leakage class shall be provided wherever indicated in purchaser's data sheet.

b) For control valves specified with Class VI leakage class, vendor shall select the soft seat (elastomer) material suitable for the process conditions i.e., shut off pressure, maximum temperature and process fluid.

2.2.3.5 Control valve experiencing cavitation, flashing and noise are generally identified in the purchaser's data sheet. Same must be offered without exception. In case in any valve, vendor's _calculation show occurrence of cavitation, flashing or noise under any of the specified process condition, vendor shall select proper type of valve trim to suit such process conditions even if the same is not explicitly specified in the Purchaser's data sheets.

2.2.3.6 Minimum acceptable materials of construction to be considered by vendor for valve components are specified in Purchaser's datasheets.

However, alternate superior materials may be provided if they meet all process conditions (operating, design, fluid properties, corrosion, etc), testing (ASME, API, radiography, etc) and statutory requirements (ASME, API, IBR, NACE, etc) specified by purchaser. Accordingly, the following alternate materials can be accepted: Body & bonnet: ASTM A105, ASTM A 216 gr. WCB / WCC in place of carbon steel.

2.3 Sizing

2.3.1 The control valve capacities in terms of flow coefficient (Cv) shown in the purchaser's data sheets have been calculated based on the formulae given in the standard ISA 75.01 "Control valve sizing equations".

All factors used while arriving at the sizing are also as per ISA 75.01. Vendor must resize the control valves considering various factors specific to the offered valves.

2.3.2 Purchaser's data sheet indicates calculated flow co-efficient values at minimum, normal and · maximum operating conditions. Vendor shall calculate this co-efficient as per the offered control valve and select the size considering valve openings as under:

At maximum flow - less than 90% open

At normal flow - typically 75% open

At minimum flow - more than 10% open

2.3.3 Rangeability of globe type of valves shall be 30:1, as a minimum. Vendor shall ensure that the actual rangeability of offered valves shall meet these requirements. For other types of offered control valves, vendor to specify that the available rangeability of the offered valves meet the requirements specified in the purchaser's data sheets.

2.3.4 Wherever butterfly valves are specified, these shall be high performance type with maximum valve opening of 90°.

2.3.5 Vendor shall offer valves with standard Cv as per their catalogue. However in case it is unavoidable due to percentage opening or any other technical sizing criteria to offer valve Cvs which are not indicated in standard product catalogue, vendor shall ensure that capacity test certificate is made available for the valves from independent test laboratory like FCRI, etc. clearly indicating the capacity in terms of Cv values (as per ISA 75-01) and valves shall be provided accordingly.

2.3.6 Vendor to note that wherever more than one case is specified in data sheet, vendor to size the control valves for all cases and select the valve based on the governing case.

2.4 Noise

2.4.1 Vendor shall examine each control valve for noise generation possibilities. The noise level shall be calculated as per ISA 75.17 or any other equivalent standard.

2.4.2 Noise generated by control valve during operation shall be limited to OSHA specified levels i.e. the maximum allowable noise shall be less than 85 dBA, when measured at a distance governed by ISA 75.17.

2.4.3 If the predicted noise level is found to exceed 85 dBA SPL, control valve shall be treated for noise. Source treatment for noise shall be resorted to. When source treatment for noise is not sufficient to reduce the noise level below 85 dBA, vendor shall provide path treatment like diffuser plate (silencer) etc in addition to source treatment so as to reduce the level below 85dBA. Whenever additional path treatment is recommended, the maximum differential pressure across the diffuser plate shall not exceed 40% of the specified differential pressure. Where path treatment is required for noise, suitable baffle / diffuser plates shall be provided installed within expander assembly with flanged ends.

2.4.4 Vendor shall also furnish noise calculations with and without the use of these devices and the noise abatement achieved in individual components.

2.4.5 Whenever Diffuser plate is provided by the vendor as part of path treatment of noise, Diffuser plate shall be inserted between control valve body and pipe flanges.

In cases where the diffuser plate size is higher than the valve body size or there is a need of multiple diffuser plates, vendor shall supply the complete diffuser assembly with eccentric expander and flanged end connections for mating with die upstream control valve. Flange and downstream line size, unless otherwise specified in the Requisition.

2.5 Packing Box, Bonnet and Stem

2.5.1 Packing Box

2.5.1.1 The packing box shall be flanged bolted to the bonnet and shall meet the requirements specified in purchaser's data sheet.

2.5.1.2 Generally low friction type packing like braided PTFE will be used wherever operating conditions permit.

2.5.1.3 An isolating valve shall be provided with all valves having external lubrication provision. Vendor shall specify the lubricator stick material used in each case.

2.5.2 Bonnet

2.5.2.1 The bonnet shall be flanged bolted to the body. Threaded bonnets are not permitted.

2.5.2.2 Wherever the operating temperature of the fluid is above 280°C, extension or radiation finned bonnet shall be provided. Vendor standard bonnet design shall also be acceptable if these are suitable for higher temperatures.

2.5.3 Stem

2.5.3.1 The stem surface finish shall be fine. Extra fine surface finish shall be provided wherever the packing material is PTFE.

2.6 Actuator

2.6.1 Pneumatic Actuator

2.6.1.1 Actuator shall be sized for the shut-off differential pressure indicated in purchaser's data sheets. However, for 3-way type control valve, the actuator shall be sized for maximum differential pressure, unless specifically indicated otherwise.

2.6.1.2 The actuator shall be designed to move the valve to the failure position specified in the purchaser's data sheet. For failure position specified as 'fail-locked' (with Drift close or Drift open), vendor shall provide fail-lock relays to meet the requirement.

2.6.1.3 Actuator casing shall be made of pressed steel or anodised aluminium. Non-metallic actuator casings shall not be offered.

2.6.1.4 Springs shall be corrosion-resistant and shall be cadmium or nickel-plated. Alternately vendor standard coating shall also be acceptable. These shall be of the enclosed type. The compression of the springs shall be adjustable.

2.6.1.5 In general, an actuator operating range of 0.2-to 1.0 kg/cm2g is preferred. However when vendor standard actuator model is not able to meet the specified shutoff pressure, higher actuator operating range may be offered.

2.6.1.6 In-general, spring opposed diaphragms type actuators shall be used. Only when this type of actuator becomes extremely unwieldy, based on the data specified in the purchaser's datasheet, should a piston and cylinder type of actuator be considered.

2.6.1.7 Whenever piston and cylinder actuator is considered, single acting spring return type shall be used.

2.6.1.8 Whenever double acting springless type of actuator is specified in Purchaser's valve data sheet or offered by the vendor, all accessories like pilot valves, booster relays, non-return valve, pressure gauge, volume tank etc. shall be provided to ensure desired action on air failure: · Volume tank is not required when failure position in Purchaser's data sheet is · specified as 'Fail lock' only.

2.6.1.9 Volume Tanks (Volume bottles / Air reservoirs), required for double acting springless type actuator or where ever specified in Purchaser's valve data sheet shall be provided by vendor with all required accessories including PG, PSV, NRV, etc. in 316 Stainless steel construction as a minimum. The volume tank shall be sized at the minimum air supply pressure for a minimum of three full strokes. Volume tanks shall be painted with same colour as that of the corresponding actuator. The volume tanks when provided shall be free standing equipment and not mounted on valve actuator. Volume tanks shall be of SS304 construction and shall be designed as per ASME Sec VIII Div. I with a design pressure of 10.5 Kg/cm2g with a minimum thickness of 6mm. Unless otherwise specified, vendor shall supply minimum 10 m of interconnecting tubing between the Volume Bottles / Volume tanks and actuator assembly. Volume bottle shall be tagged with the associated control valve tag number by the vendor

2.6.1.10 For actuator casing design, vendor shall consider at least any one of the following:-

- Actuator casing shall be suitable for 1.5 times the maximum pneumatic operating pressure
- Actuator provided with upstream safety valve set at "Actuator Casing suitable pressure less 0.2 kg/sq.cmg"
- Actuator provided with Positioner having Overpressure Limit feature and set for the "Actuator Casing suitable pressure less 0.2 kg/sq.cmg"

2.6.1.11 Valve stem position indicator shall be provided for every control valve. The position indicator scale shall be marked from 0 to 100% in steps of 10%.

2.6.1.12 In general, side-mounted hand-wheel shall be provided whenever specified in Purchaser's data sheet. Hand-wheel shall provide manual control in both opening and closing directions independent of spring action. Hand-wheels shall be of non-rising type suitable for accurate valve positioning .The hand-wheel actuator shall be sized to provide the required thrust for valve positioning with 178N force applied to the hand-wheel.

2.6.1.13 Actuator orientation shall be as per purchaser's requirements, in general. When, no requirements are indicated by purchaser, vendor shall provide recommended actuator orientation. It shall be possible to change this orientation at site for the offered valve- actuator combination in case it is found necessary.

2.6.1.14 The failure position of valves shall be indicated in the data sheet, vendor to note that change in failure position if intimated by Purchaser during review of engineering drawings in the order execution phase shall not have any implication.

2.6.1.15 All the control valves shall be provided with rain protection for diaphragm vent ports. 1/4 inch SS tube formed to inverted U shape with necessary fitting shall be provided for this purpose.

2.6.2 Actuator Sizing

2.6.2.1 Vendor shall be fully responsible for the sizing and selection of the correct actuator for the specified control valve. Any change in actuator model number necessary to meet requisition requirements after placement of order shall be taken care of by vendor without any price or time implication. While sizing the actuator, vendor shall ensure that the actuator is able to develop sufficient thrust to properly seat the control valve plug/disc at a pressure which is at least 0.5 units less than the minimum air supply pressure specified in purchaser's datasheet and the specified shut-off conditions.

While-sizing the actuator, vendor must ensure that the sizing factors· indicated below are fully complied. Higher sizing factor may be considered if found necessary by vendor.

a) For control valves with leakage class IV and below, the actuator shall be sized considering actuator thrust at least 1.3 times the total force induced by shut-off conditions specified in the data sheet and the force required to overcome packing friction. Vendor shall utilize this factor as 1.5 in case the control valve is operating between 80% to 90% or 10% to 20% in any of the specified conditions.

b) For control valves with leakage class V and above, the actuator shall be sized considering actual thrust at least 1.5 times the total force induced by specified shut- off conditions in the purchaser's data sheet and the force required to overcome packing friction.

2.7 Accessories

2.7.1 Positioners

2.7.1.1 Positioners shall be of force-balance type or smart digital type or fieldbus type as specified in the purchaser's datasheet. They shall be direct acting, with an adjustable gain unless otherwise specified.

2.7.1.2 The pneumatic positioner shall be provided with an integral by-pass switch whenever the operating range of the actuator is the same as that of the control signal.

2.7.1.3 Every positioner shall have two pressure gauges mounted on it, one each for air supply and for positioner output to actuator. In addition, pneumatic positioner shall have a third pressure gauge for control signal.

2.7.1.4 Pneumatic connections shall be ¼" NPT (F) I ½" NPT (F) as per vendor's requirement and cable entry shall be ½" NPTF. If connection for cable entry is different than that specified, suitable adapters shall be provided.

2.7.1.5 Positioners shall be side-mounted on control valves and shall be Linkage-less / contact less type. Alternatively, positioners with SS linkages is also acceptable. Any applicable links shall be of corrosion resistant Stainless-steel linkages and with rugged brackets. All control valve positioners shall have metallic casing.

2.7.1.6 All positioners in Electrical Gas Group IIC area as specified in Purchaser's datasheet shall be dual certified. i. e certified intrinsically safe Ex 'i' and Flameproof Ex 'd'.

2.7.1.7 Valve position shall be available through HART/FF signal as a default. Additionally, Positioners shall be provided with 4-20mA hardwired output signal for position transmission if specifically indicated in Purchaser's data sheet.

2.7.1.8 The Software necessary for advance control valve diagnostics like seat ring condition, gland packing condition, actuator leakage, device checks, maintenance etc. shall be supplied by vendor. Any such diagnostic software related to Smart or fieldbus positioner shall be of "plug-in" type and the software shall be easily integrated with Asset Management System Platform of purchaser. This advance diagnostic software shall be of latest release or version with advanced features

2.7.1.9 Vendor shall also ensure that all electric & pneumatic entries to be suitably plugged before dispatch to site and metallic plug shall be provided.

2.7.2 Smart type and fieldbus type positioners

2.7.2.1 Digital smart positioners or fieldbus type of positioners with diagnostic capabilities shall be supplied whenever specified in the purchaser's data sheets. These shall meet the following minimum requirements:

a) The positioner sensor and sensing mechanism shall be rugged and shall not be affected by the line/valve vibration. The performance of the positioners shall be immune to above vibration.

b) The positioner's output and input range shall be field adjustable without any hardware modification. The output from the positioners shall be available for both single acting as well as double acting actuator.

c) Each positioner shall be operable, configurable and accessible through HART compatible hand held configurator/fieldbus configurator as applicable.

d) The positioner shall be a two-wire device, which shall operate on two-way digital communication mode. All engineering, configuration, diagnostic and maintenance related data shall be provided by the positioner.

e) The smart positioner shall provide HART protocol of latest version and shall be capable of implementing commands from Instrument Asset Management System / hand-held HART configurator.

f) Positioners with fieldbus output shall meet the following requirements:

i) All positioners must satisfy the requirements of the fieldbus registration laboratory with applicable checkmark like Field Bus Foundation, Profibus Nutzer organisation e.v (PNO) or as specified in the purchaser's data sheets.

ii) All positioners shall have analog output (AO) and controller blocks (PID).

iii) All positioners must be interoperable and shall have valid interoperability test clearance like ITK latest version for foundation fieldbus or equivalent for profibus PA, as applicable.

iv) The fieldbus positioners shall support peer-to-peer communication with two wire communicator and bus powered supply.

v) Fieldbus positioners as offered shall not be polarity sensitive.

vi) The fieldbus positioners in hazardous area shall be certified as per entity concept or shall be PISCO approved as per the requirements specified in the purchaser's specification.

vii) Internal software shall be configured by the vendor including the following information:

- Serial Number
- Device tag (Tag No.)
- Process Description/service

vii) Positioners shall be capable of supporting 'incremerrtal Device Description (DD) for extra functionality and/or software revisions in Device memory.

g) The positioners shall be suitable to operate with commercially available asset management software and shall support the following features, as a minimum:

i) It shall allow multi-master for configuration, calibration, diagnosis and maintenance. The primary could be a host computer and secondary could be a hand held communicator.

ii) It shall be capable of implementing universal commands. It shall be possible to communicate all commands of commercially available asset management system to/ from smart positioner.

h) The offered positioners shall meet the following performance characteristics: -

i) Overall control accuracy shall be better that ±0.5% of span.

ii) Repeatability shall be less than± 0.25% of span.

iii) Hysteresis shall be less than ± 0.5% of span.

iv) Vendor shall supply the valve's operating signatures in the form of hard copy and soft copy for each control valve supplied with smart positioners. The necessary software for advanced control valve diagnostics like seat ring condition, gland packing condition, actuator leakage etc. shall also be included.

i) All positioners shall have metallic casing and cover either of stainless steel or of anodized aluminium.

j) Fieldbus positioners shall support EDDL requirements as per IEC 61804 / FDT / DTM requirements, as specified in job specifications.

k) Acceptance criteria for Performance/Calibration of Valves with Smart / FF Positioners shall be 1% of span.

2.7.3 Electro-Pneumatic Converter

2.7.3.1 Electro-pneumatic converter shall be of electronic feedback type unless specified otherwise and shall be yoke mounted.

2.7.3.2 It shall have an integral terminal housing. Electro pneumatic converter with flying leads shall not be acceptable.

2.7.3.3 Unless otherwise mentioned, it shall be intrinsically safe.

2.7.3.4 Pneumatic connections shall be ¼" NPT (F) I ½" NPT (F) as per vendor requirement. The electrical connections shall be l/2" NPT (F). If they are different, suitable adapters shall be provided.

2.7.3.5 The overall accuracy of the electro-pneumatic converter shall be better than ±0.3%.

2.7.3.6 Acceptance criteria for Performance/Calibration of Valves shall be 1.5% of span.

2.7.4 Air Filter Regulator.

2.7.4.1 Vendor shall supply air filter regulator with each positioner complete with an integral output gauge.

2.7.4.2 Air filter regulator shall be sized considering the air supply pressure and flow required to meet requirements specified in the purchaser's data sheets.

2.7.4.3 Filter material shall be sintered bronze. Filter size shall be maximum 5 microns. However, lower filter mesh size shall be considered to suit the electro pneumatic converter vendor's requirement.

2.7.5 Valve Jacketing

2.7.5.1 The jacketed valves shall have steam inlet/outlet connections as flanged.

2.7.5.2 The valve end connections shall be one size higher than the normal valve connections for jacketed valve.

2.7.6 Hand held configurator for Smart Instruments

Hand Held configurator shall be universal type and shall be able to communicate with all make and models of smart instruments with HART output like transmitters, smart positioners etc., and shall be capable of carrying out all engineering functions like calibration, configuration and diagnostics. The hand held configurator shall be certified intrinsically safe when used in hazardous area. Carrying case shall be supplied with each configurator.

2.7.7 Fieldbus configuration:

The fieldbus configuration, whenever specified in datasheet, shall be provided with hardware and software for configuration and maintenance of fieldbus devices and also to perform diagnostics and troubleshooting of the fieldbus segments.

2.7.8 Battery charger

Both Fieldbus and HART configurations shall be supplied with battery-charger for battery charging. Unless otherwise specified, battery charger shall operate at 230V 50Hz supply.

2.7.9 Wherever solenoid valves have been asked for control valves in modulating service, the control valves are for modulating cum shutdown application. For all such cases, solenoid valve shall be installed between positioner output and actuator. The de-energisation of solenoid valve shall bring the control valve to failure position by venting the actuator

2.8 Control valve accessories like Air Filter Regulators (AFR), Smart Positioners, Foundation Fieldbus Positioners, Solenoid valves, Limit switches, handwheel, Pneumatic lock relay etc. (Wherever applicable) shall be supplied in fully assembled conditions with minimum of ¼" / 6.0mm or 8.0mm OD with 0.04"/ 1 mm wall thickness SS316L air tubing. Material for mounting part/bracket shall be SS as minimum. Tube fittings shall be of flareless compression type of SS316 material. The fitting/ ferrule hardness shall be in the range of RB 85-90 so as to ensure a minimum difference of RB 5 to 10 between tube and fitting. The ferrule shall also be made of stainless steel (SS 316). Tubing of higher size like ½" / 12.0mm OD or higher, min 0.049"/ 1.2mm thick (if required) for proper actuation of actuator / control valve shall be provided by vendor. Accessories like AFR shall be selected to match the air tubing requirements.

2.9 Special Service Valves

All control valves in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetra-chloride. End connections shall be blinded/ plugged after this degreasing process in order to avoid entrance of grease and oil particles.

2.10 Finish

2.10.1 The body shall be painted as below:

Carbon steel body	-	Light grey (RAL -7035)
Alloy steel body	-	Canary yellow (RAL-1003)
Stainless steel body	-	Natural
Above 150°C Operating Temp.	-	Aluminium white (RAL - 9006)

Items like silencers, diffuser plate assemblies etc., shall be painted as per respective control valve body requirements.

2.10.2 The actuator shall be painted as below:

Direct action (open on air failure including fail lock drift open) valves	- Green (RAL-6024)
Reverse acting (close on air failure including fail lock drift close) valve	- Red (RAL-3001)
Fail Lock/ Fail Last (Stay-put on air failure) valve	-Yellow (RAL-1004)

Items like air volume tanks etc., supplied as an accessory along with the actuators, shall be painted as per corresponding ·actuator. · ·

2.10.3 Valve Body, Actuator and accessory Paint colours complying to equivalent BIS Standard IS-5 in place of specified RAL Codes mentioned above are also acceptable.

3.0 NAMEPLATE

Each control valve shall have a stainless steel nameplate attached firmly to it at a visible place, furnishing the following information:

a) Tag number as per purchaser's data sheet.

b) Body and port sizes in inches.

c) Valve flow coefficient (Cv).

d) Stem travel in millimetres.

e) Action on air failure.

f) Spring range.

g) Air supply pressure.

h) Manufacturer's model number for the valve body, actuator and positioner.

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing at vendor's works as per Inspection Test Plan. All these tests shall be completed by the vendor and test reports shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 The control valve and its accessories shall be supplied pre-assembled and pre-tubed.

5.2 All threaded and flanged openings shall be suitably protected to prevent entry of foreign material.

5.3 Valves with external lubricators shall be lubricated prior to shipment.

5.4 Valves in oxygen and chlorine service shall be packed separately along with a certificate indicating 'CERTIFIED FOR OXYGEN/ CHLORINE SERVICE', as applicable.

STANDARD SPECIFICATION
FOR
CONTROL PANEL AND ACCESSORIES

I-SPC-0017

0	20.02.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

AC	:	Alternating Current
DC	:	Direct Current
DPDT	:	Double Pole Double Throw
HRC	:	High Rupturing Capacity
LED	:	Light Emitting Diode
NPT	:	National Pipe Thread
PVC	:	Poly Vinyl Chloride

CONTENTS

1.0 SCOPE

1.1 General

1.1.1 This specification, together with the data sheets covers the requirements for the design, materials, fabrication, wiring, painting, nameplate marking, inspection & testing, shipment and site activities including installation of control panels and accessories.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry-

ASME - American Society of Mechanical Engineer

B 1.20.1	:	Pipe Threads, General Purpose (Inch)
B 16.5	:	Pipe Flanges and Flanged fittings
B 16.20	:	Metallic Gaskets for Pipe Flanges

API - American Petroleum Institute.

MPMS	:	Manual of Petroleum Measurement Standards
RP 552	:	Transmission Systems

EN - European Standards

10204	:	Inspection Documents For Metallic Products.

IS/IEC - Indian Standards/International Electro-Technical Commission

IS/IEC 60079	:	Electrical Apparatus for Explosive Gas Atmosphere.
IS/IEC 60529	:	Degree of Protection Provided by Enclosures (IP Code).
IEC-61000-4	:	Electromagnetic Compatibility for Industrial : Testing and Measurement Techniques.
IS-5	:	Colours for Ready Mixed Paints.
IS-2062	:	Hot rolled Medium and High Tensile Structural Steel.

1.1.3 In the event of any conflict between this standard specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern.

a) Statutory Regulations

b) Job Specification, Data Sheets

c) Standard Specification

d) Codes and Standards

1.1.4 In addition to meeting purchaser's specifications in totality, vendors' extent of responsibility shall also include the following.

Vendor shall be responsible for panel front arrangement including proper location and spacing of instruments and accessories like switches, push buttons, lamps, terminal blocks, supporting steel members, wiring raceways etc., from the point of view of accessibility and ease of maintenance based on the indicative drawings/schemes furnished by the purchaser.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the Material Requisition.

1.2.2 Vendor's quotation, catalogues, drawings, installation, operation and maintenance manual etc. shall be in English language only.

1.3 Drawing and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets attached with the requisition.

1.3.2 Final documentation consisting of design data, installation manual, maintenance manual etc. submitted by the vendor after placement of purchase order shall include the following, as a minimum;

a) Specification sheet for control panels, instruments and accessories.

b) Certified drawings for each control panel, which shall provide following details:

i) Control panel front arrangement drawing showing all dimensions including bezel/cut out dimensions.

ii) Loop wiring drawings showing the terminal numbers of each instrument/ accessory used in the wiring.

iii) Ladder drawings and relay wiring drawings showing terminal numbers for interlock/shutdown.

iv) Power supply distribution drawings with terminal numbers, incoming/ outgoing feeder size, fuse and isolator rating etc.

c) Vendor shall provide test certificates for all the tests indicated in Clause 4.0 of this specification.

d) Maintenance procedure including replacement of instruments and accessories in vendor scope.

2.0 DESIGN AND CONSTRUCTION

2.1 Control panel and accessories shall be designed and fabricated in accordance with the drawings/data sheets enclosed with the Enquiry. Applicable standards and codes shall include relevant sections of APT-MPMS APT BP 552

2.2 The design of the electronic instruments, relays etc. shall be in compliance with electromagnetic compatibility requirements as per IEC 61000-4.

2.3 Construction

2.3.1 Control panels shall generally be 2100 mm high and I 000 mm deep and shall be mounted on 100mm high channel base. Width of the panels shall be 1200 mm or 800 mm in general (as indicated in material requisition), however it may vary as per actual requirements.

2.3.2 Panels shall be free standing type. Panels with instruments mounted on the front shall be Fabricated from 3 mm thick cold rolled steel sheet. If the same is not available, 4 mm thick Hot rolled steel sheet shall be used. All other panels shall be fabricated from 2mm thick cold Rolled steel sheet. Angle iron framework shall use a minimum section of 50 x 50 x 4 mm Angle. Panel painting procedure shall include blast cleaning, grinding, chemical cleaning, Surface finishing by suitable filler and two coats of high grade lacquer with wet blasting Wherever required. Two coats of paint in the panel colour shall be provided for non-glossy High satin finish. Final coat shall be given after assembly at site.

For local control panel, Steel sheets for panels shall be cut on a squaring shears to ensure tight flush joint when butted together. Adjacent panels are bolted together with cadmium- plated bolts and nuts. Bolts or screw shall not be exposed on the face of the panel. Welded coupling of panel section is not allowed. Adjacent panels shall be assembled with face flush. Gaps or cracks shall not be visible from the front of assembled panels.

2.3.3 Where specified vendor to provide one digital clock on the panel front. Clock display shall be seven segments LED with AM/PM or 24-hour mode, which shall be field selectable. Display shall be visible from a distance of7 metres arc covering an angle of minimum 120°.

2.3.4 All exposed surfaces in plain view shall be perfectly level, smooth and free from any protrusions and tool or clamp marks. All edges including cut outs shall be ground smooth.

2.3.5 Rear of each panel section shall have a steel framework assembled to it for supporting instruments, raceways and other accessories like power distribution boxes etc. Panel stiffeners shall be welded to the rear of the panel and shall not interfere with instrument installation. All structural shapes of steel members shall be as per IS-2062.

2.3.6 Enclosed cubicle panels shall have removable hinged doors (rear) for easy maintenance and Accessibility of the instruments. Doors shall be double leaved type with handle and shall be Provided with lock and key. Adequate illumination shall be provided inside the panel. All Light fittings shall be suitable for 240 V, 50 Hz AC. Power supply greater than 240 V shall Also not enter the control panel..

2.3.7 All cable entries to the panel shall be from panel bottom only using cable glands of adequate Size. Cable gland plate thickness shall be a minimum of 3 mm cold rolled cold annealed (CRCA) as a minimum. All unused cable entries must be plugged.

2.3.8 One telephone socket, and 110V 50 Hz/ 230V 50 Hz plug in outlets shall be provided for every three panel sections.

2.3.9 Semigraphic displays shall be screen printed as per approved drawings, on the front of fibre glass or back of transparent acrylic sheet as specified in material requisition and screwed to a steel backplate of indicated thickness. Semigraphic background colour shall be same as that of control panel.

2.3.10 Where specified LEDs shall be provided on the semigraphic section complete with all wiring brought to terminal boxes located on the framework of semigraphic section. A redundant power supply unit with 100% spare capacity for each power supply shall be provided by vendor for LEDs operation.

2.3.11 After completing fabrication of panels and semigraphics, semigraphics shall be erected and bolted to the top of the panel sections. Suitable angles and tees shall be provided between top of panel sections and bottom of semigraphic sections and at the top of semigraphics. Any defect/misalignment of the assembly shall be rectified before first coat of painting.

2.3.12 Lifting eyebolts shall be provided for each panel.

2.3.13 Normal mounting heights on panel of instruments (centre lines of instruments to floor) shall conform to the following, with minor adjustments depending upon instruments selected:

1	Instruments	Bottom Row Middle Row Top Row	1100mm 1350mm 1600mm
2	Annunciators	-	1950mm
3	Electrical push buttons, Selector switches,lamps, etc.	-	700mm

2.3.14 The design of panel shall incorporate provision for expansion by installing adequate spare Capacity. Each panel shall be designed to accommodate the following additional equipment, As a minimum:

a) 20% of panel front/inside mounted instruments including lamps, push buttons, switches, relays etc.

b) 20% additional power feeders each provided with switch fuse assembly.

c) 20% additional spare windows in alarm annunciators.

d) 20% spare cable entry points.

2.4 Local Control panel

Local Control panel and accessories shall be suitable for location in non air-conditioned building. Panel and associated accessories shall be designed to withstand environmental conditions at site. Panel in open areas shall be weatherproof to IP-55 as per IS/ IEC-60529. Gasketed glass doors shall be used for normal visibility wherever required.

2.4.1 Panels Located in Hazardous Area

2.4.1.1 Pressurised Panel

Pressurisation shall be as per NFPA-496 type X (for panels located in Zone-I) or Z (for panels located in Zone-2) in general. However, actual requirements shall be as specified in job specification. Vendor shall provide all the instrumentation and accessories being mounted on/inside the panel, including the pressurisation kit. Make/model of all instrumentation shall be subject to approval by owner. The pressurisation kit shall be complete with filter regulator, differential pressure purge rotameter and differential pressure indicator on front panel, differential pressure switch for alarm or power cut off as per area classification and for remote alarm in case of pressurisation failure. The control unit and other electrical components like pressurisation status, purge medium control solenoids etc. required for purging/ pressurisation of panel shall be flame proof. All incoming/outgoing contacts from panel shall be routed through the flameproof control unit, which will provide isolation of the contacts automatically during pressurisation failure in case of IEC-Zone-1 area, or manually through a switch for maintenance purpose. Pressurisation level adjustment should be possible externally without depressurising the panel. The atmospheric open end of differential pressure gauge/switch shall be provided with bug screen. No hazardous gas shall be piped inside the panel. All cutouts shall be properly gasketed for good pressurisation. An additional glass door opening at the front shall be provided for weather protection of instruments mounted on the front of the panel. All instruments shall be calibrated at shop before despatching the panel. Glass door, if any, shall be of shatterproof glass. Cable glands shall be double compression types. Instruments that are liable to get damaged during shipment shall be removed and despatched loose along with the panel.

2.4. I .2 Flame-proof Panel

These panels shall be duly certified by statutory authority, as mentioned in clause 1.2.2 of this specification, for safe use in specified hazardous area. Glass door if any shall be of shatterproof glass. All special tools shall be supplied for maintaining these panels. Cable glands shall be double compression types.

Weatherproof panel but with all electrical components and accessories flameproof. All electrical components and accessories shall be flame proof and duly certified by statutory authority as mentioned in clause 1.2.2 of this specification. Cable glands shall be double compression type

2.4.1.3 Pneumatic Panel

2.4.1.3.1 Air Supply

i) Each pneumatic instrument shall be fed through 1/4" isolation valve and air filter regulator.

Air reducing station shall be provided for panels housing more than ten instruments

ii) Air pressure reducing station shall have two parallel branches each consisting of block valves, filter and regulator. Pressure relief valve and a pressure indicator shall be installed at the common outlet. Each branch of air reducing station shall be designed for full capacity.

iii) Vendor shall furnish air supply piping from a point on the panel framework to the inlet side of the pressure reducing station or alternatively to the inlet side of individual pressure regulators. A flanged connection shall be provided on the framework to connect the inlet p1pmg.

iv) Fittings and 1/4" valves downstream of the filters at the air reducing station shall be of brass material. All headers shall be minimum 2" and shall be nickel-plated brass material.

v) Air supply header shall be extended from downstream side of the main pressure reducing valves across the length of the panel.

vi) The air header shall be installed with proper slope towards the dead end. A brass gate valve shall be provided at the dead end of the air header for cleaning or draining the header. Air reducing station shall not hinder access to bulk head fittings.

vii) Where miniature type instruments are used, vertical sub-air headers for each panel shall be provided with 1/4" NPT (F) brass needle valves. In all cases 10% spare take-off points with needle valves shall be provided for future use.

2.4.1.3.2 Tubing

i) Vendor shall supply and install all tubing between instruments to bulkhead fittings and from auxiliary items such as pressure switch rack mounted within panel.

ii) All bulkhead union shall be suitable for 1/4" OD copper tube on either side. 10% spare bulkhead fittings shall also be furnished.

iii) Tube fittings shall be compression, double ring ferrule type.

iv) 6 mm OD x 1 mm thick bare wall copper tube shall be used for tubing inside the panel and accessories.

v) PVC ducts shall be used for laying of tubing behind the panel, racks etc. Rubber grommets shall be provided wherever tubings are taken in and out of instruments, racks etc.

vi) Spare pens/pointers in recording/indicating instruments shall also be tubed and connected to bulk head.

2.5 Painting

2.5.1 The entire surface of panels and accessories, comprising front, rear and sides shall be treated and painted as follows:

a) All surfaces including structures shall be sand blasted and grinded until they are smooth and free of scale, rust etc.

b) Chemical treatment shall be done to remove rust, oil, entrapped impurities and other foreign materials.

c) If necessary, suitable filler shall be applied to all pits and blemishes on the surfaces.

d) The front surface of the panels shall be painted with three coats of sealing primer and surfacer. The entire surface shall be wet sanded between coats. Two coats of finish paint of high-grade lacquer enamel shall be given at shop.

e) All other surfaces including those of accessories shall be painted with two coats of sealing primer and surfacer and two coats of lacquer enamel finish paint.

f) A final coat of finish paint of high grade lacquer enamel shall be given at site after assembly and filling of front panel butt joints with suitable filler, to present a continuous panel surface.

g) The finish of the final coat shall be of semi-gloss texture to minimise light reflection.

2.5.2 Unless otherwise specified, exterior portion of all panels and closed cabinets shall have a colour of light admiralty grey shade ISC No.697 as per IS-5 (RAL-7035). Panel rear surface, frame works and bulkhead plates/gland plates shall have a finish colour of light admiralty grey shade ISC No.697 as per IS-5 (RAL-7035). Channel base shall be of black colour.

2.6 Electrical System

2. 6.1 General Requirements

2.6.1.1 All equipment and wiring in control room shall be of general-purpose type unless otherwise specified.

2.6.1.2 All wiring shall confirm to API-MPMS, RP 552 and shall be as per approved drawings.

2.6.1.3 All wiring shall be housed in covered non flammable plastic raceways which shall be arranged for easy maintenance. Raceways shall have 50% spare capacity. Rubber/plastic gromets shall be used for wire entry into individual instrument cases and for entry/exit of cables through raceways.

2.6.1.4 Wires carrying measurement signals associated with thermocouple, resistance temperature detectors (RTD), pH Instruments and other low-level signals shall be routed in separate wire ways and not along with power cables. Power wiring and control wiring should be separated by not less than 150 mm. If they have to cross, the crossing should be as close to right angle as possible. Parallel runs of AC and DC wiring closer than 300mm shall be avoided.

2.6.1.5 All intrinsically safe wiring shall be routed in separate wire ways, separate from non- intrinsically safe and power wiring. The minimum separation shall be 150mm. Intrinsic safe raceways shall be light blue in colour.

2.6.1.6 Intrinsically safe terminals shall be adequately separated from non-intrinsically safe terminals. The minimum separation shall be 50 mm. Intrinsic safe terminals shall be light blue in colour.

2.6.1.7 Panel wiring for signal and controls shall be carried out using 600 V grade, 1.0 mm2 stranded copper conductors with flame retardant PVC insulation. Power supply wiring between distribution box and individual instruments shall be done using 600 V grade, 1.5 mm2 stranded copper conductors with flame retardant PVC insulation. All internal wiring will be supplied by the panel vendor.

2.6.1.8 Alarm wiring shall be through multicore cables between alarm terminal box and annunciator directly without any intermediate terminals. Raceways on panel to have sufficient space to accommodate such wiring. Vendor to install and wire all annunciators including signal lights, bull's eye lamp, push buttons, audible devices etc.

2.6.1.9 All wiring, external to main panel/racks (except for alarm annunciators), shall terminate in terminal boxes/terminal strips and their quantity and size shall be determined by vendor. Panel shall be supplied completely wired requiring only field connection at site.

2.6. 1.10 All terminals shall be of mechanical screw clamp type with pressure plates. Self-insulating crimping wire lugs shall be used for all terminations on terminal blocks, whereas forked tongue type or lug with eyehole type shall be used for termination on screwed terminals such as on relays, push buttons, lamp etc. Terminals shall be suitable to accept 2.5mm2 size conductor, as a minimum. Terminal blocks shall be rated for 600 V. Separate set of terminals for accepting higher size of incoming power cables shall be provided. At least 20% spare terminals evenly distributed throughout the panels shall be provided.

2.6.1.11 Generally, no more than two wires shall be terminated on a single terminal. Additional terminals shall be used for looping if necessary. Use of shorting links for looping shall be avoided.

2.6.1.12 Where panel is located in hazardous area, all electrical components including junction boxes shall be flame proof and suitable for hazardous area specified in material requisition.

2.6.1.13 Terminals housings shall be sized with due consideration to accessibility and maintenance. Following guidelines shall be observed:

a) 50 mm mm1mum space shall be provided between terminal strips and sides of the box parallel to the strip for up to 50 terminals and an additional 25 mm for each additional 25 terminals.

b) 100 mm minimum space to be provided between adjacent terminal strips for up to 50 terminals and an additional 25 mm for each additional 25 terminals.

c) 75 mm minimum space shall be provided between terminal strip and top or bottom of the box for upto 50 terminals and an additional 25 mm for each additional 50 terminals.

d) The bottom of any terminal strip shall not be lower than 300 mm from the gland plate unit in any cabinet.

2.6.1.14 All terminal strips shall be mounted on suitable anodised metallic or plastic stand off. Terminal strips shall be arranged group wise for incoming and outgoing cables separately.

2.6.1.15 Wire colour code for panel and accessory shall be as follows:

Power supply hot	Red
Power supply neutral	Black
Ground	Green
Alarm System	Yellow
Signal: IS	Blue
Signal: Non-IS	Grey

2.6.2 Power Supplies

2.6.2.1 Main power distribution box shall have copper busbars suitable for required current rating. Bus bars shall be suitably insulated. Provision of reducing type of lugs is not acceptable. Main power supply box shall be provided with two pole circuit breakers of thermo-magnetic type.

2.6.2.2 Each section of main panel shall have a separate power supply distribution box with two pole toggle switches and glass cartridge fuses. Power supply to individual instruments shall be through DPDT isolation switch and HRC fuse. Vendor may provide two pole circuit breakers of suitable rating for power distribution.

2.6.3 Grounding

2.6.3.1 Each panel section and accessory equipment in control room shall be provided with an earthing lug and shall be grounded to an earth bus bar to be provided by purchaser. All panel structure, racks, cabinets etc shall be connected to this power ground bus.

2.6.3.2 In addition to above, vendor shall also provide a separate instrument circuit ground bus along the panel length. This shall be electrically isolated from panel structure, equipment, incoming cable armour etc. This ground bus shall be typically 8 mm thick and 37.5 mm wide and of copper. All circuit grounds of electronic instrument, drain wires of alarm signal cables, intrinsic safety barrier insulated bus bar etc shall be connected to this ground bus by insulated copper conductor. Both ends of this bus bar shall have suitable terminals for further connection to ground electrode by purchaser. Creation of multiple grounds in a loop should be avoided.

2.6.4 Identification and Marking

2.6.4.1 All electrical terminals and equipment on the panel and other accessories shall be identified with appropriate tag, cable marker etc.

2.6.4.2 All terminals in a terminal strip shall be identified by their individual numbers located integral with the terminal itself.

2.6.4.3 Interconnecting multicables shall be identified by metal tags as indicated in cable schedules.

2.6.4.4 Wiring at terminals shall be identified by the terminal number and termination services at the other end of the wire. Wiring at instruments and accessories like alarm relays, push buttons etc shall be identified by the item tag number and terminals number and the termination service at the other end of the wire. Ferrule shall be used for this purpose.

2.6.4.5 Identification markers as mentioned above shall be indicated in vendor drawings.

2.6.4.6 For pneumatic panel, Air supply tubes and signal tubes etc shall be provided with PVC sleeves with inscription strips fitted on it at either end. Sleeves for air supply shall be in red while other sleeves shall be yellow in colour

2.6.5 Internal lighting shall be installed within panel using two fluorescent lighting fixtures to provide adequate lighting for maintenance of equipment. The location of lighting fixtures must not interfere with doors and other equipment and shall be accessible for fluorescent tube replacement. Lighting shall be operable through door switch in a suitable surface mount enclosure.

3.0 NAMEPLATE

3.1 Nameplates shall be provided for all front panel instruments and accessories. For sub miniature instruments, nameplate shall be written on the nameplate slip supplied along with the instrument. For other instruments and accessories (push buttons, lamps etc) nameplates with 1.5 mm thick black laminated plastic with white engraved letters shall be provided.

3.2 Front panel nameplates shall be fixed by means of chrome or nickel plated counter sunk screws. These nameplates shall be 25 mm high with 5 mm letter height, and provide information like tag number, service, multiplication factor etc. Rack nameplates to be fixed by suitable adhesives and shall generally be 15 mm high with 5mm letter height to indicate item tag number.

3.3 Front panel instruments shall also be identified by their tag numbers on nameplates fixed by adhesives on panel back surface.

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing at vendor's works as per inspection test plan. All these tests shall be completed by the vendor and test report shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 Each panel and accessory shall be suitably packed and protected from damage due to transportation, loading and unloading.

5.2 Each component part requiring identification for proper assembly at site shall be place wise marked.

5.3 Shipping breaks shall be provided as applicable to avoid panel damage during transportation.

6.0 SITE ACTIVITIES

6.1 Vendor shall furnish a detailed activity schedule covering various activities like installation of panel and accessories, laying of cables, wiring, interconnection, testing etc in consultation with engineer-in-charge.

6.2 Vendor shall install all panel and accessories in the control room as per final approved layout drawings.

6.3 Control panel and semi graphic shall be checked for proper alignment and defect, if any, shall be rectified.

6.4 Vendor shall install all panel-mounted instruments, alarm annunciators and other free issue items as per approved drawings.

6.5 Painting, wiring, cabling etc shall be done as per the respective clauses of this specification.

6.6 Functional tests for panel and accessories shall be carried out after actual installation, wiring, interconnection to the satisfaction of the engineer-in-charge.

6.7 Vendor shall assist field contractor for loop checking.

6.8 Vendor shall maintain the control room and workplace neat and clean. Minor civil work, if necessary, shall be carried out by vendor arising due to damage to flooring during panel installation.

6.9 Vendor shall arrange to draw and transport free issue material and is responsible for safe custody of the same.

6.10 Vendor shall prepare and furnish as built drawing for final record.

STANDARD SPECIFICATION
FOR
GAS DETECTION SYSTEM

I-SPC-0019

0	14.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

DCS	:	Distributed Control System
GA	:	General Arrangement
GPS	:	Global Positioning System
HART	:	Highway Addressable Remote Transducer
HVAC	:	Heating Ventilation & Air Conditioning
LEL	:	Lower Explosive Limits
LOS	:	Line of Sight
MOS	:	Metal Oxide Semiconductor
MTBF	:	Mean Time Between Failures
MTTR	:	Mean Time To Repair
NPT	:	National Pipe Thread
PFD	:	Probability of Failure on Demand
PLC	:	Programmable Logic Controller
SIL	:	Safety Integrity Level

CONTENTS

1.0 SCOPE

1.1 General

1.1.1 This standard specification, together with the data sheets describes the requirements for the design, manufacture, nameplate making, inspection and testing and shipping of the complete gas detection system.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of purchaser's enquiry:

API - American Petroleum Institute

RP-55	:	Recommended Practice for Oil and Gas Producing & Gas Processing Plant Operations Involving Hydrogen Sulphide.
RP-552	:	Transmission Systems

EN - European Standards

10204	:	Inspection Documents for Metallic Products.
61779-1	:	Electrical Apparatus for the Detection and Measurement of Combustible Gases - General Requirements and Test Methods.
61779-4	:	Electrical apparatus for the detection and measurement of flammable gases. Performance requirements for group II apparatus indicating a volume fraction up to 100% lower explosive limit.

IS/IEC - Indian Standards/International Electro-Technical Commission

IS/IEC 60079	:	Electrical Apparatus for Explosive Gas Atmosphere.
IEC 60331	:	Testing of Fire Resisting Cables
IEC 60332	:	Tests on bunched wires and cables.
IEC 60617	:	Graphical Symbols for Diagrams
IS/IEC 60529	:	Degree of protection provided by Enclosures (IP code).
IEC 61000-4	:	Electromagnetic compatibility (EMC) —Part 4: Testing and measurement techniques
IEC 61131	:	Programmable Logic controllers
IEC 61508	:	Functional Safety of electrical/electronic/programmable electronic safety related systems
IEC 61511	:	Functional Safety — Safety Instrumented Systems for the Process Industry Sector.

1.1.3 In the event of any conflict between this standard specifications, job specification/datasheets, statutory regulations, related standards, codes etc the following order of priority shall govern.

a) Statutory Regulations

b) Job Specification / Data Sheets

c) Standard Specification

d) Codes and Standards

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to the vendor attached with the material requisition.

1.2.2 Vendor's quotation shall include the following:

a) Compliance to the specifications.

b) Gas Detection System shall also include detailed specification sheet for each item, which shall provide information regarding monitor, data logger, gas detection panel, monitoring console with MMI, gas detection system with PLC etc as applicable.

d) A copy of approval for gas detectors for installations in electrically hazardous area, wherever specified, from local Statutory authority as applicable such as Chief of Controller of Explosive (CCE), Nagpur or Director General of Mines Safety (DGMS) in India, along with Petroleum and Explosives Safety Organization (PESO).

1.2.3 Whenever specified, vendor must furnish tested values of failure rates, probability of failure on demand (PFD) and test intervals for the safety integrity level (SIL) analysis from third party certification agency.

1.2.4 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation manual, operation and maintenance manuals etc shall be in English language only.

1.3 Drawing and Data

1.3.1 Detailed drawings, data and catalogues required from the vendor are indicated by the purchaser in vendor data requirement sheets.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc. submitted by the vendor after placement of purchase order, shall include the following, as a minimum:

Wherever Gas Detectors are specified,

a) Specification sheets for gas detectors along with model no's as applicable.

b) Maximum and minimum supply voltage required for the detector to function within the stated performance characteristics and power consumption.

c) Power supply distribution drawing and Wiring diagram.

d) Calibration gas sample details along with correlation factors, as applicable.

e) Copy of test certificate including type test certificates.

f) Copy of test certificate for all the tests indicated in clause 4.0 of this specification.

g) Installation procedure for gas detectors and its accessories.

h) Calibration and maintenance procedure for complete gas detectors including replacement of parts, as applicable and recommended calibration frequency.

Wherever Gas Detection System is specified, In addition to the requirements specified in 1.3.2, following shall be included.

a) Specification sheets for gas detection system.

b) Certified drawings of complete gas detection system including each detector, monitor, panel etc. as applicable, which shall provide:

i) Dimensional details in mm.

ii) Material of construction.

iii) GA drawing for Panel/ Cabinet, man-machine interface.

iv) Channel base details

v) Panel/ Cabinet weight (with or without packing)

c) Wiring diagram of Panel/ Cabinet.

d) Purchaser's interface details including details of serial interface.

e) Complete application program as configured, wherever applicable.

f) Number of user's licenses as per job requirements, wherever applicable.

g) Installation procedure for gas detection system including detectors and its accessories.

h) Calibration and maintenance procedure for complete gas detection system including replacement of parts, as applicable and recommended calibration frequency.

2.0 DESIGN AND CONSTRUCTION

2.1 Gas Detectors

2.1.1 All gas detectors shall be suitable for outdoor installation certified for use in electrically hazardous area. The detectors shall be weather proof to IP65 in accordance with IS/IEC60529, as a minimum and certified flameproof (EExd) or certified intrinsically safe (EEx i) in accordance with IS/IEC 60079 for the area classification specified in purchaser's data sheet.

2.1.2 All gas detectors shall be provided with dust guard and splashguard.

2.1.3 All gas detectors shall be provided with terminal box for terminating incoming cabling. Flying leads shall not be acceptable. The cable entry in the terminal box shall be ¾" NPTF.

2.1.4 Gas detectors shall have an integral transmitter, which shall provide 4-20mA outputs with HART (latest version). Gas Detectors with HART protocol shall be capable of implementing commands from universal Hand Held HART Communicator. RS485 MODBUS (RTU) etc. shall be offered when Smart detectors or Addressable detectors are specified in the purchaser's data sheets.

2.1.5 All detectors shall be supplied with local LED/ LCD digital display, which shall provide currently detected gas concentration. In case separate local display unit is offered, the same shall be loop powered type and shall be supplied complete with proper terminal blocks housing suitable for mounting in hazardous area classification. Removal/disconnection of local indicator shall not affect performance of the meter.

2.1.6 Mounting accessories like mounting bracket (Stainless Steel / GI) required for the installation of gas detectors for 2" pipe mounting shall be supplied by the vendor.

2.1.7 For EEx'd' detectors, intrinsically safe port shall be provided for connecting the Hand Held Communicator.

2.1.8 Flammable Gas Detectors (Hydrocarbon)

2.1.8.1 Flammable Hydrocarbon gas sensors shall be Non-Selective Infra-Red (IR) type. "Dual beam" with heated optics or other suitable arrangements to overcome environmental effects of fogging/fouling shall be provided.

2.1.8.2 Flammable gas detector including terminal box shall have Stainless Steel body/ casing.

2.1.8.3 Detectors installed in pressurized lines e.g. HVAC duct etc., shall be provided with in-situ calibration facility (facility to calibrate the gas detectors externally without removing from the duct).

2.1.8.4 IR detector lamp shall be replaceable type. Detector shall be compensated for lamp intensity variation due to dust, humidity, sun-light, wear & tear etc.

2.1.8.5 Aspirator shall be supplied wherever specified in the data sheet.

2.1.8.6 Range

a) The range of the Flammable gas detectors shall be as follows:

Point detector: 0-100% LEL

Open-path detector: 0-5 LEL meters

(LEL meter is equal to ¾ LEL/100 x length of gas cloud).

The gas detectors shall have an over range protection in case of sudden exposure to large quantity of Hydrocarbon gases.

2.1.8.7 Detector failure/sensor failure alarms shall be provided. In addition, the infrared detector shall provide diagnostic alarms for dirty or misaligned optics and blocked beam.

2.1.8.8 Performance requirements:

The flammable gas detectors shall meet the following performance requirements:

Repeatability:±2% of full scale

Response time (T90): Less than 30 seconds with splash guard and dust guard.

2.1.8.9 The minimum life expectancy of flammable gas detectors shall be five (5) years.

2.1.9 Flammable gas detectors (Hydrogen)

2.1.9.1 Flammable gas sensor for hydrogen shall be poison resistant catalytic diffusion type and shall be specific for hydrogen gas only.

2.1.9.2 Catalytic type detector shall incorporate a plug-in type sensor and metallic flame arrestor.

2.1.10 Addressable gas detectors

2.1.10.1 Addressable detectors, when specified, shall be similar in mechanical construction, range and performance requirements of detectors specified in clauses 2.1.1 to 2.1.9 as applicable. These detectors, in addition, shall provide two-way communications with the gas detection system.

2.1.10.2 Addressable gas detectors shall be connected over a system communication bus with each detector having a unique address code, which shall be programmed on each device. The detector address shall be programmable from the gas detection system.

2.1.10.3 The communication protocol for data transfer between detector and host shall be deterministic. The protocol shall ensure reliable data transfer and verify the data integrity using parity data bit error checking subroutines for address code and check sum routine for the data transmission.

2.1.10.4 All addressable devices shall have capability of being disabled or enabled individually.

2.1.10.5 It shall be possible to replace failed detector on-line with a similar device without any specific tools and without data interruption.

2.1.10.6 The addressable system digital communication network shall be continuously monitored for detection and isolation of network communication failure and shall also provide an alternative path in case of a single failure of a gas detector in the network.

2.2 Portable Gas Detectors

2.2.1 The portable gas detectors shall be supplied for Hydrocarbon, Hydrogen, H2S and other toxic gas detectors complete with its controller, audio-visual alarm. The portable gas detectors shall be suitable (preferably intrinsically safe) for use in hazardous area specified. These units shall be supplied with rechargeable batteries and 240 V, 50 Hz AC battery chargers. Sufficient number of battery charger/number of points per charge shall be provided based on quantity of such portable units. These units shall be supplied complete with its accessories like carrying case, maintenance kit, calibration kit etc.

2.3 Beacon and Hooter

2.3.1 Beacon and Hooter shall be supplied by the vendor as per the requirements specified in the purchaser's data sheets

2.3.2 Unless otherwise specified, the Beacons and Hooter shall meet the following functional requirements:

a) The Beacon colour shall be 'ORANGE' for flammable gas detection.

b) Beacon light shall follow the following sequence:

Gas leakage detected	- Flashing Beacon light - Hooter continuous
Field Acknowledge	- Flashing Beacon light - Hooter off
Gas leakage stops	- Flashing Beacon light - Hooter continuous
Field reset	- Beacon off - Hooter off

Reset shall be activated only after acknowledge and leakage stop.

2.3.3 The beacon shall be of stroboscopic type and shall be of sufficient intensity to provide visibility and clear contrast during full daylight.

2.3.4 The hooter shall be electronic type and shall have sound intensity of 100dBA, as a minimum. Different tones shall be provided for Flammable gas and Toxic gas releases.

2.3.5 Both Beacon and hooter units shall operate at 110V AC / 110 V DC / 24 V DC as specified in the data sheet and shall be certified explosion proof (flame proof) when installed in hazardous area.

2.3.6 Hooter/ Beacon shall be flameproof and shall be supplied with test / Acknowledge / reset push-buttons which shall be rated for 110V AC, 0.5 A / 110V DC, 0.5 A/ 24V De, 2 A as per the requirement specified in the data sheets.

2.4 **Gas Detection System**

2.4.1 General

2.4.1.1 Purchaser's requisition shall specify the functional requirements of gas detection system. Vendor shall size their system as per the specified requirements and shall be responsible to consider all hardware and software necessary to meet these requirements based on the offered system.

2.4.1.2 Gas detection system shall be a stand-alone microprocessor based system fully compatible with the type of sensors specified in the data sheet.

2.4.1.3 The system shall be designed to avoid common cause of any failure. Redundancy shall be provided for all common mode failure modules/ components/ subsystems, unless otherwise specified in the purchaser's specifications.

2.4.1.4 The system shall be designed considering normally energized with normally closed concept to make it fail-safe. Monitored inputs/outputs shall be provided whenever the purchaser's data sheets specify normally de-energized/normally open system.

2.4.1.5 System Reliability and Availability:

The system shall be designed to avoid unrevealed failures ensuring maximum reliability, safety and integrity. The system design availability shall meet the requirement of 99.7%, as a minimum where system availability shall be defined as follows:

$$\% \text{ System Availability} = \frac{\text{MTBF}}{\text{MTBF+MTTR}} \times 100$$

Vendor shall consider the following points while calculating the system availability:

a) MTBF values for detectors and corresponding system components i.e. detector, input and output module, power supply module, display unit, alarm annunciator etc.

b) Items like data logger, serial outputs to purchaser's systems, hooters and beacons shall not be considered for availability calculation.

c) MTTR value of 4 hours shall be considered uniformly for all items.

2.4.1.6 Redundancy shall be provided such that single revealed or unrevealed failure shall not affect the performance of the system.

2.4.1.7 All contacts provided by the vendor for purchaser's use from the system shall be potential free and shall be rated for ll0V DC 0.5A / 240V AC 5.0A / 2 A, 24 V DC as specified in the data sheets.

2.4.1.8 Interface with purchaser's Control System

Gas detection system shall be interfaced with purchaser's control system e.g. Distributed Control System, Shut down system etc. Following outputs shall be provided for interface:

a) A redundant serial MODBUS (RTU) output with RS485 physical interface for complete data transfer and display in purchaser's Distributed Control System. The data shall include tag wise concentration, high & high high alarms, diagnostic, status alarms and bypass status etc.

b) Potential free contacts for shutdown system as per purchaser's specification.

c) Potential free contacts for High-High group alarms for connection to purchaser's Distributed Control System.

2.5 Power Supply

The Gas detection system shall operate at 110V, 50Hz. AC / 240 V, 50 Hz AC power supply. The system performance shall be within specified requirements for a voltage variation of ±10% and frequency variation of ±3 Hz of the specified value. In addition system shall be unaffected by a power fluctuation / power dip up to one cycle i.e. 20 millisecond. This power supply shall be made available to the vendor at one point i.e. in control panel or system cabinet, as applicable. Further distribution of this power supply for the equipments being supplied by vendor shall be in vendor's scope. The detailed power supply distribution requirements shall be as follows:

a) Distribution of power supply within the Control Panel/ Cabinet shall be by vendor.

b) For the equipments installed outside the Control Panel / Cabinet i.e. monitors, printers, gas detector etc., vendor shall provide outlet feeders of suitable size in the Panel/ Cabinet.

c) The system shall be capable of accepting two power feeders either from the same source or from two different power sources. The distribution of power supply to other system consumers shall be through dedicated switch-fuse unit. Circuit breakers can also be used in place of switch-fuse unit.

d) The system power supplies shall be dual redundant each of which shall be sized for 150% of the total load of the power supply under the worst loaded condition. Redundant power supplies shall be supplied power from the different power feeders.

e) Power supply units shall be replaceable on-line without switching-off the power. The system shall remain operational uninterruptedly under single power supply unit failure and during failed power supply unit replacement.

2.5.1 The design of electronic instruments shall be in compliance with the electromagnetic compatibility requirements as per IEC-61000-4.

2.5.2 Gas Monitors/Controllers

2.5.2.1 A standard panel from a reputable Manufacturer shall be used.

a) Vendor shall assume that the panel '"will be positioned against a wall- unless otherwise specified All access required shall be possible from the front of the cabinet. There should be easy access to terminations;

b) The panel shall be designed to house the following instrument / accessories Monitors/ controllers for Fire detectors, Alarm annunciator , relays / logic cards for shutdown / protection system, Pushbuttons /switches as required (including lamp. test pushbuttons), any other items which are not listed above but essential to make the system operational and to meet requirements specified in Job Specification;

c) Cabinet doors shall be of the window type so that alarms and status indications can be viewed without the need to open doors;

d) The cabinet shall have a minimum of IP-42 degree of Ingress protection, as per BS EN 60529, and shall be fitted with a tamperproof locking system;

e) The cable entry shall be from the bottom of the cabinet;

f) All required cooling, venting and air filtering facilities shall be included;

g) Suitable Cable clamps and rails shall be provided for all incoming cables for adequate cable connection stress relief;

h) All unused card locations shall be fitted with cover plates;

i) Galvanic isolators for intrinsically safe circuits;

j) A separate insulated IS earth bar;

k) The Vendor shall apply a universal method as per referred Codes & Standards, of allocating inputs, outputs and other components to the cabinet, to provide an easy maintainable system;

l) The cabinet shall have lifting eyes to facilitate handling during transportation and installation;

m) Cabinets shall have 30% spare space;

n) Each cabinet shall be provided with a nameplate;

o) The nameplate made from Traffolyte engraved with black letters on white background;

p) Final tagging details shall be advised at order placement.

3.0 NAMEPLATE

3.1 Wherever Gas Detectors are specified,

Local mounted instruments shall have a stainless steel nameplate attached firmly to it at a visible place, furnishing the following information:

a) Tag number as per purchaser's data sheets.

b) Manufacturer's serial number and /or model number

c) Manufacturer's name/trade mark.

d) Body material.

e) Measuring element material.

f) Range of measurement.

g) Area classification in which the equipment can be used, this shall be to the same code as per purchaser's data sheets.

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing of all the items at the vendor's works in line with the inspection test plan and approved quality documents for gas detection system. All these tests shall be completed by the vendor and test reports shall be submitted to Purchaser for scrutiny.

5.0 SHIPPING

5.1 Wherever Gas Detectors are specified,

a) All threaded and flanged openings shall be suitably protected to prevent entry of foreign material.

b) Instruments shall be supplied individually, in suitable sealed packing.

c) All electronic instruments in oxygen and chlorine service shall be separately packed along with a certificated indicating 'CERTIFIED FOR OXYGEN / CHLORINE SERVICE', as applicable.

d) Loose supplied accessories shall be packed with proper tag numbers of their respective instruments.

STANDARD SPECIFICATION
FOR
FIRE DETECTION SYSTEM (UV/IR)

I-SPC-0020

0	14.01.22	ISSUED AS STANDARD	KS	AD	AD	SK
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ABBREVIATIONS

AC	:	Alternating Current
AWG	:	American Wire Gauge
DC	:	Direct Current
SPDT	:	Single Pole Double Throw
SS	:	Stainless Steel
UV/IR	:	Ultraviolet/ Infrared
NPT	:	National Pipe Thread
HART	:	Highway Addressable Remote Transducer

CONTENTS

1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets, covers the requirement for the design, manufacture, materials, nameplate marking, inspection, testing and shipping of the complete UV/IR Fire Detection System including all detectors, monitors, control panel duly wired and any other hardware as necessary.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions

BS		**British Standards**
5839-1	:	Code of Practice for design, installation, commissioning and maintenance of systems in Non — domestic premises
EN		**European Standard**
54	:	Fire Detection and Fire Alarm Systems.
10204	:	Inspection Documents for Metallic Products
FM		**Factory Manual**
3260	:	Approval standard for Radiant Energy - Sensing Fire Detectors for Automatic Fire Alarm Signalling
IS/IEC		Indian Standards/ International Electro-Technical Commission
60079-	:	Electrical Apparatus for Explosive Gas Atmosphere.
60529 -	:	Degree of protection provided by Enclosures (IP Code)
61000-4-	:	Electromagnetic compatibility for Industrial Process Measurement and Control Equipment.
ISA		**International Society of Automation**
S 71.01	:	Environmental Conditions for Process Measurement and Control System, Temperature and Humidity.
18.1	:	Annunciator Sequences and Specifications
NFPA		**National Fire Protection Association**
NFPA-72	:	National Fire Alarm and Signalling Code
NFPA-70	:	National Electrical Code

1.1.3 In the event of any conflict between this standard specifications, job specification/ datasheets, statutory regulations, related standards, codes etc, the following order of priority shall govern:

a) Statutory Regulations

b) Job Specifications / Data Sheets

c) Standard Specifications

d) Codes and Standards

1.2 BIDS

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to the vendor attached with the Material Requisition.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

a) Compliance to the specifications.

b) Fire Detection System shall include detailed specification sheet for each item, which shall provide information regarding monitor, Test Lamp, Fire detection panel etc. as applicable.

c) A copy of approval from local statutory authority, as applicable, such as Petroleum and Explosives Safety Organisation (PESO)/ Chief Controller of Explosives (CCE) or Director General of Mine Safety (DGMS) in India, for the electronic instruments installed in electrically hazardous area.

1.2.3 Whenever specified, vendor must furnish tested values of 'failure rates', 'Probability of Failure as demand' and 'Test intervals' for the safety integrity level (SIL) analysis.

1.2.4 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation manual, operation and maintenance manuals etc., shall be in English language only.

1.3 DRAWINGS AND DATA

1.3.1 Detailed drawings, data and catalogues required from the vendor are indicated by the purchaser in vendor data requirement sheets shall be submitted by the vendor.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual submitted by the vendor after placement of purchase order as per vendor data requirement, shall include the following as a minimum:

a) Specification sheet for fire detector and system, as applicable.

b) Certified drawing for complete system.

c) Maximum and minimum supply voltage required for the instrument to function within the stated performance characteristics.

d) Clearance required for maintenance work.

e) Copy of type test certification.

f) Calibration procedures for detector.

g) Copy of test certificates for all the tests.

h) Installation procedures for detector.

2.0 DESIGN AND CONSTRUCTION

2.1 The Vendor's scope of supply shall include, but not limited to, the following types of equipments and vendor shall state in his proposal the quantity of each being provided to meet the necessary requirements: -

a) Field mounted fire detectors (UV, IR, and Combination UV/IR).

b) Monitors/Controllers for fire detectors.

c) UV/IR test lamps.

d) A panel (completely wired) housing the monitors, annunciators, switches and relays for carrying out the necessary shutdown functions.

e) Other items not listed here, but required to make the system operational.

2.2 Fire detection system shall be designed based on fail-safe philosophy.

2.3 Output contacts derived from the panel shall be potential free SPDT contact with 110V DC 0.5A / 240V AC 5.0A/ 24V DC 2A ratings unless otherwise specified in the datasheet / job specification.

2.4 For shutdown functions, one common switch for fire detection system shall be provided for bypassing such functions. Red light shall be provided on panel to indicate the system in bypass mode. Also, one SPDT potential free contact shall be provided for use by purchaser.

2.5 The design of electronic instruments shall comply with the electromagnetic compatibility requirements as per IEC-61000-4.

2.6 All field-mounted instruments of the system shall be suitable for the hazardous area as defined in the data sheets.

2.7 UV Sensors

2.7.1 Type — Ultra violet radiation, self-checking type. It shall not be sensitive to direct or reflected sunlight or normal artificial light. It shall have UV lamp for automatic optical integrity check.

2.7.2 Construction — Weather proof (IP65 as per IS/IEC-60529) and Flameproof Ex (d) or intrinsically safe Ex (i) as per IS/IEC-60079 as specified in data sheet, with swivel bracket for surface mounting. Cable entry shall be 3/4" NPTF. The range and cone of vision shall be as specified in the Datasheet.

2.8 IR Sensors

2.8.1 Type — Infrared radiation, self-checking type. It shall be designed to avoid actuation by sunlight or reflected sunlight. It shall be able to detect both hydrocarbon & non-hydrocarbon fires. It shall have IR source for automatic optical integrity check.

2.8.2 Construction — Weather proof (IP-65 as per IS/IEC-60529) and Flameproof Ex (d) or intrinsically safe Ex (i) as per IS/IEC-60079 as specified in data sheet, with swivel bracket for surface mounting. Cable entry shall be 3/4" NPTF. The range and cone of vision shall be as specified in the Datasheet.

2.9 Combination UV/IR Sensors

2.9.1 Type — Combination Ultraviolet and Infrared radiation sensor, self-checking type. It shall not be sensitive to direct or reflected sunlight or normal artificial light. It shall have UV lamp / IR source for automatic optical integrity check.

2.9.2 Construction — Weather proof (1P65 as per IS/IEC-60529) and Flameproof Ex (d) or intrinsically safe Ex (i) as per IS/WC-60079, as specified in data sheet, with swivel bracket for surface mounting. Cable entry shall be 3/4" NPTF. The range and cone of vision shall be as specified in the Datasheet.

2.10 Fire detectors shall have an integral transmitter, which shall provide 4-20mA outputs with HART (latest version).Fire Detectors with HART protocol shall be capable of implementing commands from universal Hand Held HART Communicator.

2.11 Monitors/Controllers.

2.11.1 Type — Microprocessor based electronic, panel mounted, compatible with UV, IR or UV/IR sensors as applicable, with automatic integrity check and with adjustable sensitivity.

2.11.2 Power Supply — As indicated in data sheet. Monitor/controller shall supply power to sensor.

2.11.3 Indicator lights

- Power on
- Fire detection (each channel)
- Malfunction (common) - Malfunction shall include short circuit, line breaking, over range and earth fault.

2.11.4 Other features

- SPDT latching type relay contacts shall be provided for following:
  a) Fire detection (area wise).
  b) Malfunction (common).
- Common reset push button.
- Calibration/test switches to allow manual check without alarm outputs. Display for detailed self- diagnostics.

2.12 Test Lamp

It shall be suitable for testing/calibrating fire detection system. It shall be intrinsically safe or flameproof certified, lightweight, portable torch type unit. It shall operate on rechargeable battery. Battery charger suitable for 240 V, 50 Hz shall be supplied. Battery drain indication shall also be provided.

2.13 Fire Detection Panel

2.13.1 The panel shall be designed to house the following instruments/accessories:

i) Monitors/controllers for Fire detectors.

ii) Alarm annunciator.

iii) Relays/ logic cards for shutdown/ protection system.

iv) Pushbuttons /Switches as required (including lamp test Pushbuttons).

v) Any other items, which are not listed above, but essential to make the system operational and to meet requirements specified in job specification.

The panel shall be provided with 10% installed spare (minimum one number) for items like monitors/controllers, relays/logic cards etc. Alarm annunciator shall have 10% spare points.

2.13.2 Panel Construction

2.13.2.1 Panel Enclosure

All panels shall be free standing, floor mounting type unless specified otherwise and shall be fabricated out of minimum 2 mm thick CRCA sheets and doors shall be fabricated out of minimum 1.6 mm CRCA sheets. Panel shall be naturally ventilated in IP-42 enclosure protection as a minimum.

In equipment mounting, all apparatus display screen, instruments and indicating lamps mounted on the panel front shall be flush mounting type. External cabling shall not be terminated directly on the base connector of PCBs but shall be terminated on separate terminal block. Further connection to PCBs shall be as per manufacturing standard. Routine calibration, adjustment, programming and operation shall be acceptable from the front of the panel without opening the door. External cabling shall preferably be done from the rear.

Power supply system including battery bank shall be mounted inside the panel.

Doors shall be provided with pistol grip handle with lock. Lamps shall be provided inside the panel to provide adequate light for maintenance of equipments.

Cable entry shall be from bottom unless otherwise specified. Terminal strips shall be provided for incoming / outgoing cables.

In wiring and terminals, wiring within the panel shall be laid in slotted plastic raceways enclosed with cover. Control connection shall be done with 660 V grade PVC insulated wires having stranded copper conductors. 1.5 sq.mm size of wire shall normally be used for circuits with control fuse rating of 10A or less. Control wiring for electronic circuits shall be through ribbon cable or through copper wire minimum of 0.5 mm dia. Panels shall supplied completely pre-wired, such that only field termination shall be required at site before it is energized.

PCBs for identical function shall be interchangeable. PCBs shall be plug in type having pin / edge connectors. PCBs shall be suitable for use in tropical, humid and dusty environment. These shall be protected with anti fungus treatment.

The cables shall be terminated on the terminal blocks. Clamp type terminals shall be spring loaded, stacking type, mounted on rails. Terminals shall be sized to accept as a minimum 2.5 sq.mm cross section conductors. Not more than one conductor shall be provided in each panel for termination of spare cores of cables.

In earthing, a common earth bar of minimum 25 X 3 mm. copper or equivalent aluminium shall be provided through the length of the panel. All noncurrent carrying metallic parts of the panel-mounted equipment shall be earthed. Flexible jumpers shall connect all doors and movable parts to the earth bus, two number earth lugs shall be provided outside the panel.

In name plates / warning plates, all name plates for panel shall be engraved out of 3 ply (black - white-black) lamicoid sheets or anodized aluminium. Back engraved perspex sheet nameplates will also be acceptable. Engraving shall be done with square groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable.

Label shall be provided for each component on cards, connecting wires as well as for the terminals in the terminal strip inside the panel .wiring diagram shall be pasted inside the panel door as required for termination and maintenance.

Special warning plates shall be provided on all removable covers or doors giving access to energize metallic parts above 24 volts.

The panel shall be of freestanding, self-supporting cubicle type, fully enclosed construction and shall be formed out of cold rolled carbon steel plate of minimum thickness 3mm for front sheet and 2mm for other sides and doors. Panel shall be designed to allow for 10% expansion for future changes without involving any major modification in the system. When specified, the panel shall be matched with the other panels to be supplied by other vendors.

2.14.2.5 Equipment Mounting

Fire Monitors/Controllers

The front of panel mounted Fire Monitors/Controllers shall be installed in mating cases or mounting trays as recommended and supplied by the manufacturer for panel mounting. All wiring to these controllers shall be terminated on terminal blocks and/or multi-pin connectors provided as an integral part of the case. Routine calibration adjustments shall be accessible from the front of the panel, without having to remove any wiring or causing loss of the instrument function. In addition, total removal of the instrument and replacement with a spare shall be possible from the front of the panel.

2.14.2.7 Electrical Construction

Code Compliance

The installed electrical equipment component parts and associated wiring in the panel shall be in accordance with the practices outlined in the National Electric Code, latest edition, for non-hazardous area.

Panel Wiring

The vendor shall supply all wire required for panel internal wiring. Interconnecting wires shall be standard copper conductor, with 600 volt rated flame retardant PVC insulation. Minimum size shall be 1.0 mm2 except for power wiring which shall be 1.5mm2. The size and type of wires shall be confirmed by vendor. Each wire shall be distinctly colour coded or tagged at both ends with full ring type labels, colour coding/tagging shall correspond to that used on panel schematic drawings.

The panel shall be designed for field wiring entry from the bottom. Vendor shall provide removable gland plate for this purpose.

2.14.2.8 Terminals

Terminals shall be non-hygroscopic type made up of unbreakable, fire-retardant, safe extinguishable, halogen free polyamide compound. No more than two (2) wires shall be installed on same terminal of any electrical device. Terminal blocks shall be of heavy duty nylon, 600 volt rated and break resistant type. Terminal strips shall be spring loaded, screw locked, stacking type with all terminals clearly labelled. Terminal strips shall be mounted on suitable anodised metallic stand-off. A minimum of 10% spare shall be provided.

2.13.2.9 Grounding

A separate signal ground shall be provided for circuit ground of instruments, drain wires of signal cable shields etc. All fire detector circuits shall be grounded as per manufacturer's recommendations and good engineering practice. For signal ground, a grounding bus bar 25 mm wide x 6 mm thick of copper material (insulated from panel structure) shall be provided, which shall run the entire panel length near floor level. The bus bar shall be provided with grounding terminals at either end.

All instrument cases and housing capable of carrying current shall be grounded to panel structure. The panel structure shall be provided with earthing lugs for eventual connection to electrical safety earth.

2.13.2.10 Power Supply and Distribution

The main power supply feeder to the panel shall be protected by a suitably sized circuit breaker with manual trip lever. The breaker shall be housed in a suitable surface-mount enclosure. Power supply shall be made available at one point. Further power supply distribution to instruments and accessories shall be provided by the vendor. Each consumer shall be provided with a separate switch and fuse for isolation and protection of the system. All necessary components like circuit breakers, rectifiers, filters, switches, fuses etc. shall be provided by the vendor.

2.13.2.11 Lighting

Internal lighting· shall be installed within the panel to provide adequate lighting for maintenance of equipment. The location of lighting fixtures must not interfere with doors or other equipment, shall be accessible and space shall be maintained for bulb replacement. A control switch in a suitable surface-mount enclosure shall be provided for the lighting inside the panel near the door.

The power supply shall be protected by a suitably sized fuse. The vendor shall maintain separation in his panel design between the AC circuit wiring and all other DC circuits.

2.13.3 Alarm Annunciator

2.13.3.1 Alarm annunciator shall be provided at top of panel to display group alarms, shutdown alarm etc. as indicated in Requisition. In addition, 'Malfunction in fire detection system' alarm shall be provided.

2.13.3.2 Alarm annunciator shall be solid-state electronic type or microprocessor based provided with solid-state audio alarm. It shall be provided with first-out type sequence (ISA F3A) with function test, acknowledge and reset push buttons. Each window shall be provided with two lamps. Lamps shall be removable from panel front

3.0 NAMEPLATE

3.1 Fire Detectors shall have a stainless steel nameplate attached firmly to it at visible place, furnishing the following information:

a) Tag number as per purchaser's data sheets.

b) Type of Fire Detector.

c) Type of Protection for the instrument.

d) Manufacturer's name/trade mark

e) Manufacturer's serial number or model number

4.0 INSPECTION AND TESTING

Purchaser reserves the right to inspect and witness testing all the items at the vendor's works in line with the inspection test plan for Fire Detection system (UV/IR). All these tests shall be completed by the vendor and test reports shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 After initial acceptance of the panel at the vendor's shop by the purchaser, the sensors and all panel components, which the vendor considers liable to be damaged during shipment or storage, shall be packaged for separate shipment. If instruments are removed from the panel, they and their connections shall be suitably tagged to ensure simple re-installation at the job site. Each instrument shall be sealed in plastic bags containing moisture-absorbing desiccant.

5.2 Spare parts shall be packaged separately and clearly marked as 'Spare Parts'.

5.3 All threaded entries shall be suitably protected to prevent entry of foreign material.

STANDARD SPECIFICATION
FOR
CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

I-SPC-0021

0	20.02.22	ISSUED AS STANDARD	KS	AD	AD	SK
Rev.	Date	Purpose	Prepared by	Reviewed by	Approved by	Approved by

ABBREVIATIONS

API	:	Application Programming Interface
B/W	:	Black & White
CCU	:	Central Control Unit
CIF	:	Common Intermediate Format
CMOS	:	Complementary Metal Oxide Semiconductor
DCS	:	Distributed Control System
DMZ	:	Dimilitarized Zone
FRP	:	Fibre-Reinforced Plastic
FO	:	Fibre Optic
HD	:	High Definition
HOPE	:	High-Density PolyEthylene
IP	:	Internet Protocol
LCD	:	Liquid Crystal Display
LED	:	Light Emitting Diode
MPEG	:	Moving Picture Experts Group
MJPEG	:	Motion Joint Photographic Experts Group
NAS	:	Network Attached Storage
NTSC	:	National Television System Committee
NVMS	:	Network Video Management System
NVR	:	Network Video Recorder
OSI	:	Open Systems Interconnection
PAL	:	Phase Alteration by Line
PLC	:	Programmable Logic Controller
PTZ	:	Pan, Tilt & Zoom
RAID	:	Redundant Array of Independent Discs
SS	:	Stainless Steel
TCP	:	Transmission Control Protocol
UDP	:	User Datagram Protocol

CONTENTS

1.0 SCOPE

1.1 General

1.1.1 This specification, defines the minimum functional requirements for the design, hardware, software and firmware specifications, nameplate marking, testing and shipping of Closed Circuit Television (CCTV) System designed for reliable, effective and optimum monitoring of a Plant/ Non-Plant area.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions, unless otherwise specified:

ASME American Society of Mechanical Engineers

B1.20.1	: Pipe Threads
B 16.5	: Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard

EN European Standards

10204	: Inspection Documents for Metallic Products.

IS/IEC - Indian Standards/International Electro-Technical Commission

IEC 60079	: Electrical Apparatus for Explosive Gas Atmosphere.
60529	: Classification of degree of protection provided by enclosures.
60793-2	: Optical Fibres, Part 2: Product specifications
60304	: Standard colours for insulation for low-frequency cables and wires
60332	: Tests on electric and optical fibre cables under fire conditions
60794-1-21	: Optical Fibre Cables. Generic Specification - Basic optical cable test procedures - Mechanical tests methods
62443	: Security for Industrial Automation and Control System

ITU-T – International Telecommunication Union-Telecommunication

G.652	: Characteristics of a single-mode optical fibre and cable

1.1.3 In the event of any conflict between this standard specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern.

a) Statutory Regulations

b) Job Specification / Data Sheets

c) Standard Specification

d) Codes and Standards

It shall be obligatory on the part of the Vendor to bring such discrepancies for Purchaser's review and Purchaser's decision in this regard shall be final.

1.1.4 In addition to meeting purchaser's specifications in totality, vendor's extent of responsibility shall also include the following:

a) Purchaser's data sheets indicate the minimum requirements of cameras, video management system, video recorders etc., however, this does not absolve the vendor of the responsibility for proper selection with respect to the following:

i) Selection of lens which shall have clear in focus image, brightness, contrast, focal length, camera, encoding & compression techniques, selection of hardware and appropriate software for video management, selection of video recorder and its sizing to meet the storage requirements mentioned in the datasheets, accessories etc for proper monitoring and control.

ii) Selection of equipment suitable for the environmental conditions.

b) Carryout complete application engineering so as to achieve the desired objectives with the stated performance requirements.

c) Provide all hardware and latest secured version of software, as necessary, to meet functional requirements specified in the purchaser's specification.

d) Adequacy of Bill of Material selected to meet purchaser's requirements including spares. Vendor to note that bill of material shall not be verified by the purchaser during evaluation stage. Any hardware, software and firmware required to meet the purchaser's specified requirements shall be provided by the vendor without any implication.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the requisition.

1.2.2 Vendor's technical offer shall include the following:

a) Compliance to the specifications

b) Detailed specification sheet for each item providing all the details regarding make and model, type, construction, Maximum and minimum viewable distance, Maximum tilt or pan angle possible, Pan and tilt speed, Allowable Voltage and frequency variations, Interconnecting cable and transceiver module specifications, utility requirement, Network Bandwidth requirements, Hardware, software and licensing requirements, Storage calculations for video recorders.

c) Detailed dimensional and sectional drawings including mounting details for all the units offered. All dimensions shall be in millimetres

d) Block-diagram showing all units with model numbers

e) Interconnection wiring diagram between the various components of CCTV system, including location of each item. The diagram shall show the type of cable and brief specification of the cable

f) Proven references for the offered model of CCTV system.

g) Equipment/instruments/systems located in the hazardous area shall be certified by the local statutory authorities for their use in the area of their installation. In general following certification shall be given:

a. For all explosion-proof / flame-proof equipment, instruments, systems or those with any other type of protection that are manufactured abroad shall be certified by statutory authorities like Laboratorie Central Des Industries Electriques (LCIE), British Approval Service for Electrical Equipment in Flammable Atmospheres (Baseefa), Factory Mutual (FM), Underwriters laboratories (UL) etc. for compliance to ATEX directives or other equivalent standards. All these equipment / instruments / systems shall additionally have the approval of Petroleum and Explosives Safety Organization (PESO), Nagpur, if installed in India and the same is mandatory.

b. For all flame-proof equipment manufactured locally (indigenously), the testing shall be carried out by any of the approved test house like Central Institute of Mining & Fuel research {CIMFR) / Electronics Regional Testing Laboratory (ERTL) etc. The equipment shall in addition bear the valid approval from Petroleum and Explosives Safety Organization (PESO), Nagpur.

h) Power consumption for the complete CCTV system including accessories.

i) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason, they must include a list of deviations clause wise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations

j) Catalogues giving detailed technical specifications, model decoding details and other information related to hardware and software for the items covered in the bid.

k) Regulatory Approvals/ Certifications- BIS, UL or equivalent Indian Certification for Safety, CE/FCC or equivalent Indian standard Certifications for EMC & Immunity.

The Regulatory Approvals/ Certifications are to be provided from NABL/NABCB accredited Labs or internationally reputed and accredited Labs/Agencies.

1.2.3 Vendor's quotation, catalogues, drawings, installation, operation and maintenance manuals shall be in English language.

1.2.4 Vendor shall also quote for the following:

a) All associated accessories and cables:

b) Two years operational and maintenance spares for all items including their accessories as per vendor's recommendation which shall include the following as a minimum:

i) Each type of electronic module

ii) Fuses

c) Any special tool or test equipment needed for calibration and maintenance work.

1.3 Drawing and Data

1.3.1 Detailed drawings, data, catalogues and manuals required shall be submitted by the vendor as per Vendor data requirement attached with the requisition.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc. shall be submitted by vendor after placement of purchase order which shall include the following as a minimum:

a) Certified drawings for the CCTV system which shall provide the following information:

i) Overall dimensions in millimetres

ii) Detailed interconnection diagram identifying each component with terminal number, cable type, cable size and cable entry details. The interface details shall be clearly identified in the drawing

iii) Grounding detail of each item

iv) Power supply distribution details

v) Clearance space required for maintenance work

vi) Weight of camera and other accessories

vii) System Configuration diagram

b) Installation procedure of camera and other accessories.

c) Maintenance procedure including replacement of its parts/ internals.

d) List of Software & software licenses

e) Any other drawings and documents specifically indicated m vendor data requirement enclosed with the Requisition.

2.0 DESIGN AND CONSTRUCTION

2.1 The Closed-Circuit Television (CCTV) system shall consist of the following units as a minimum:

a) Camera Unit with mounting accessories and Junction boxes (wherever required by vendor for field cables' termination and media convertor for camera).

b) Video Management Software

c) Network Video Recorder (NVR) with display unit

d) Recording Server with Storage

e) Video Analytics Server with Software (as applicable)

f) Client Workstation with display unit

g) Separate Viewing Monitor (as applicable)

h) CCTV System cabinet

i) Power supply distribution board

j) Cables (Power /Cat-6/OFC/Earthing), cable glands, Junction Boxes, connectors and other accessories

k) Managed Network switches (Ethernet Switch)

I) Media Convertors (shall be IP 65)(as applicable)

m) Power Converter (as applicable)

The CCTV system shall be IP based system based on IP cameras.

2.1.1 Camera Unit

Camera unit shall consist of Video Camera, Remote controlled Pan, Tilt and Zoom unit (for PTZ Cameras), IR illuminator, camera unit enclosure, remote controlled washer and wiper assembly (as applicable), sunshield and thermostatically controlled heaters/blower/ heat sink unit (as applicable), mounting accessories,junction boxes etc.

2.1.1.1 Video Camera

a) Video Cameras shall be color day/night IP based cameras with HD Resolution - ' l080p (progressive scan) with 1920 X 1080 pixels images' as a minimum and 1/2" to 1/3" or better CMOS Image Sensor. For the supplied IP cameras, the encoder shall be in built in the camera unit & shall meet the following specifications as a minimum:

i. Direct IP based.

ii. MPEG-4 / H.264 based hardware compression, 1080p min.@25 frame/sec

iii. Network: IEEE802.3, 10/I00Base T Ethernet (RJ45) for LAN/WAN, TCP, UDP, IGMP, HTTP

b) The camera and lens system shall have Automatic Gain Control (AGC) facility with gain adjustment of typically up to 18dBA. The video amplifier shall ensure a signal to noise ratio of 50.

c) The camera and lens system shall be able to operate satisfactorily under varied light intensity levels. The light sensitivity of the CCTV camera shall be 1 Lux or better (Color) and 0.1 Lux or better (B/W).

All the cameras shall have night vision suitable for viewing object size which may be as small as an object of dimension one foot by one foot (facing camera) and at a distance of minimum 60 m.

d) Automatic lens iris control facility shall also be provided as per the background light levels.

e) The focal length of the camera shall be based on the distance of the objects from the camera. The lens adjustment for focus control and zoom control shall be motorized and remote controllable. The lens of the field CCTV cameras shall be selected to cover a minimum object height of approximately 3.5 meter to maximum object height of approximately 35 meters at an object distance of approximately 60 meters on the full screen of the monitor.

For the CCTV cameras pertaining to Flare, the lens of the CCTV cameras shall be selected to cover a minimum object height of 15 meters to maximum object height of 150 meters at an object distance of approximately 300 meters on the full screen of the monitor.

f) The camera shall have feature ofbacklight compensation.

g) Unless otherwise specified, In-built IR illuminator of following specification shall be provided along with camera:

- LED based
- Automatic Dawn/Dusk power on/off

2.1.1.2 Pan, Tilt and Zoom Unit

The pan and tilt arrangement shall be able to adjust camera within an angle of 0° to 360°horizontally (i.e. pan range) and a minimum of 180° (±90°) vertical (i.e. Tilt range) with Zoom of minimum (l2x digital + 30x optical). The movement of the device shall be smooth. Pan speed shall be 6 degrees /sec and tilt speed shall be 3 degree/second as a minimum. Pan, tilt and Zoom action shall be operable from video management system in control room.

2.1.1.3 Wiper and Washer

Whenever specified in the Requisition, Washer & Wiper Unit shall be provided as per following requirements:

a) Camera units in field shall be provided with 1/2" water line connection and shall be provided with Ex'd' SOV (Solenoid valve) suitable for the specified hazardous area classification for water connection to washer and wiper system associated with the camera unit. The washer & wiper assembly shall be operated locally on 240 VAC non UPS power supply with local push button near the camera unit.

b) The washer unit shall comprise of washer tank, motorized pump (if required) and associated tubing for connecting from Purchaser's water tap-off and up to the camera unit. The washer tank shall be placed in an FRP enclosure near the camera and shall be easily accessible. The tank shall have a water inlet connection, a valve along with ball float actuator, a water outlet connection, necessary tubing & connectors between the water outlet connection, water pump, and nozzle at the camera. The nozzle connection for drinking/ potable water shall be½".

The rising water level in the tank shall raise the lever which will close the valve at the Tank water inlet Vendor shall consider a distance of minimum 10 meters between water tap point and camera mounting location and if minimum water pressure mentioned in requisition is suitable for filling of wash water tank of the washer wiper assembly located near the camera, in such case pump is not required, else, Ex'd' pumps suitable for the specified hazardous area classification shall be provided for filling of wash water tank which shall be operated through the same command as used for washer wiper assembly SOV.

Unless otherwise specified, the washer tank shall have a capacity of 10 litres as a minimum and the minimum flow rate of the pump shall be 0.5 litres per minute.

2.1.1.4 Camera and Pan, Tilt & Zoom unit enclosure

a) The Camera unit and Pan, Tilt & Zoom unit enclosure(s) shall be suitable for the area classification indicated in the purchaser's data sheets. Unless otherwise specified, the enclosure shall conform to the following standards :

Weatherproof housing IP-65 as per IS/IEC-60529

Flameproof housing Flameproof/ Ex (d) as per IS/IEC-60079

Flameproof housing shall also be made weatherproof.

b) For CCTV cameras required in hazardous area, shall be certified Ex'd' models of the CCTV camera manufacturers themselves and retrofitting option of the CCTV cameras in separate Ex'd' enclosure shall not be considered.

2.1.1.5 Space Heater

For outdoor applications and where there is a possibility of condensation on the glass window, the camera unit shall be provided with a thermostatically controlled anti- condensation heater. However, space heater is not mandatory if the cameras are suitable for the ambient operating conditions specified in the requisition.

2.1.1.6 Junction Box

The junction boxes for housing the accessories shall be suitable for outdoor installation with minimum IP-65 weatherproof protection as per IS/IEC-60529 and shall be certified Flameproof/ Ex (d) as per IS/IEC-60079 for the hazardous area classification as per location of junction boxes. Junction boxes for IP based CCTV system cameras shall include necessary fibre optic transceivers/ media convertors. Whenever separate junction boxes are provided by vendor along with camera for cable termination purpose," all interconnecting cables between junction boxes, Camera & CCTV system shall be by vendor. Junction boxes with all necessary terminals & media convertors and related interconnecting cable and accessories shall be an integral part of each camera unit supply by the vendor including those supplied as mandatory spares.

2.1.1. 7 Camera Mounting

Cameras shall be provided with suitable mounting accessories like Pedestals, Stanchions etc. for mounting on Technical structures, Roofs, Building tops, Poles as indicated in the datasheets.

In case mounting is to be done on Poles, the height of the support poles shall be as per the datasheets. The pole shall have ladder for camera maintenance. The structural steel shall be painted to meet the environment. Pole material shall be GI (Galvanized iron).

2.1.1 .8 CCTV Cameras for Buildings

The CCTV cameras located within the Control rooms/ Satellite Rack Rooms (SRRs) / substations (SS) or any other buildings as specified in the requisition shall be IP based Dome type fixed cameras with autofocus features and provided with mounting accessories for ceiling/ wall mounting. All other specifications regarding the cameras shall be same as that of the Process unit cameras mentioned above.

2.1.2 Video Management System/Video Recording/Video Analysis

2.1.2.1 The system shall support the virtual matrix capability (i.e., software based matrix) to allow the operator to assign any camera to any local or remote monitor on the network. Also it shall be possible to Control and monitor any camera on the network.

2.1 .2.2 The video management system shall be able to permit online selection of:

a) Camera Units

b) Monitors

c) No. of views on one monitor

d) Recording commands

e) Pan-tilt-zoom control

f) Sequential switching of images on monitors

g) Focus, wiper, wash and zoom operating for each camera unit.

h) Motion detection

i) Analytics (as applicable) - Fire & Smoke Detection, Flare Monitoring, Object detection, Line crossing, Number counting, Human movement Tracking (via PTZ Camera) etc.

2.1.2.3 The monitors shall be coloured LCD with backlit LED display unit, with necessary controls like colour brightness, contrast adjustment and monitor ON/OFF control. These functions shall be possible from the monitor front. The monitor size shall be minimum 21" or as specified in the CCTV camera datasheet.

2.1.2.4 The camera views on the monitor shall be populated based on the operator request. The operator shall be able to view 1/4/9/16/25 cameras views per monitor. The operator shall be able to enlarge the views.

2.1.2.5 The operator shall be able to view cameras through simple drag and drop commands.

2.1.2.6 The system shall be equipped with the web based client software to allow users to view the cameras on the browser from any PC on the network, provided if they are given the permission and password.

2.1.2.7 The user interface shall present the operator with a camera tree that shall show the list of all the cameras and camera sequences that are available to the operator. The Vendor shall present the hierarchy of the camera tree together with the grouping of cameras and the way in which the user/ operator shall interact with it.

2.1.2.8 The NVMS user interface shall have a map to allow viewing of graphical representation of the area. The operator shall be able to place camera icons on the map. The Vendor shall present the full features and operations of the map in the way in which the user/ operator shall interact with the map.

2.1.2.9 The operator shall be able to perform pan/ tilt/ zoom/ washer and wiper unit control for PTZ cameras.

2.1.2.10 The operator shall be able to enable/ disable Motion detection feature of the CCTV system.

2.1.2.11 The operator shall be able to write macros/scripts for the cameras to do the following as a minimum:

a) To define the sequence of cameras to be viewed on a given monitor

b) To define the period and start/ stop time for viewing a camera on a monitor

2.1.2.12 The viewing and control of cameras shall be controlled by use of passwords. Two levels of password shall be provided:

a) The operator level in which the operator shall be able to perform PTZ controls, viewing, recording and playback

The supervisor level in which the supervisor shall be able to make configuration changes in addition to the PTZ controls, viewing, recording and playback.

2.1.2.13 Network Video Recorder (NVR)

Vendor shall submit calculations/ equations for storage requirements for Purchaser's review. Use of software without supporting calculations shall not be acceptable

Whenever specified the system shall also be supplied with Network Video Recorder to record & manage video images automatically or on manual demand. The recorder shall meet the following requirements as a minimum:

a) NVR shall be a fully IP based system integrated with Network Video Management software and IP camera management software suitable for the IP cameras.

b) The NVR server shall be RAID 5/6/IO machine and shall have disk space to store on- line video storage for duration as specified in the datasheets and access to high capacity archiving mechanisms for removal of stored video to off-line storage media.

c) System shall be triplex i.e. it should provide facility of Viewing, Recording & Replay simultaneously.

d) The vendor shall size the video recorder hard disc space based on the total number of cameras, number of days for which the recording to be done (minimum 60 days), the resolution ofrecording (l080p as a minimum for HD resolution), the number of frames per second to be recorded (25 fps minimum) and future expansion capacity as indicated in the Requisition. Vendor shall submit calculations/ equations for storage requirements. Vendor shall submit calculations/ equations for determining storage requirements for Purchaser's review during detail engineering. Use of sizing software without supporting calculations shall not be acceptable. The recording resolution and frame rate for each camera shall be user programmable.

e) The system shall mark the events with time and date stamping during monitoring and recording. The system shall allow the operator to view stored information with respect to time and date of recording with scan and search of the marked events/ timing.

f) System must provide built-in facility of watermarking or Digital certificate to ensure tamperproof recording so that these can be used as evidence at a later date, if so desired.

g) System should have feature to generate alerts when the data utilization in storage system gets near to its full capacity.

h) Network Video Recorder Server(s) / Camera Servers shall be standard servers on which all the 64-bit software like Application software, Video Management software, Video Recording Software, Video Motion Detection / Video Analytics Software, etc. shall be installed and operate.

i) The operator shall be able to playback the recorded events in forward, rewind, pause along with fast/slow motion with variable speed.

j) It shall be possible for the operator to schedule recordings for each individual camera taking place in the future. The operator shall be able to configure the Start and Stop time for the scheduled recording.

k) The system must support video motion detection algorithms (residing either in CCTV Cameras or Video Management Server end). The enabling of Video Motion Detection shall be user configurable: either in a continuous basis or in scheduled manner for particular times, dates, days, months etc. System shall generate alarm on motion detection in areas where no motion is expected. System shall also generate alarm on no motion detection in areas where motion is expected.

l) The operator shall be able to export previously stored video to DVD or latest storage option as specified in the datasheets.

m) The exported video shall be able to retrieve archived video from DVD or the latest storage option as specified in the datasheets.

n) NVR shall be able to support the cameras as per the requirement and also be expandable to 100% margin for future by addition of only licenses and storage capacity.

o) Captured images or videos shall be easily distributed to any remote locations through the LAN/WAN environment, if required. The operator shall be able to export previously stored video from a recorder to any other network storage devices including a network drive. An exported file must be in MPEG-4/ MJPEG/H.264/H.265 format and, as such, should be readable using any MPEG-4/MJPEG/H.264/H.265 compliant decoding software.

p) All the Client Workstations in the System should be provided with software along-with its license, to view and control the cameras and retrieve the recorded video images from the NVR/CAMERA SERVER/NAS storage device seamlessly. Web view of cameras shall also be supported by the system.

q) The System must support integration with Access Control System, Fire-Alarm Systems and open protocol like MODBUS, MODBUS TCP/IP.

r) The System must have the capability to integrate with other IP network for remote operation / monitoring of the system. The system shall support Remote Clients with following minimum functionalities:

- Login from client software
- Remote view and search
- Remote configuration

s) The System shall support the following provisions for system integration & customization:

- Simple API for integration with 3rd party Video Management Systems
- Seamless connection with Video Analytics Enterprise server used for managing individual Video Analytics Software instances and generating combined reports.

t) The System should support automatic full system restore after unexpected events like complete power loss.

u) The Video Recording & Management Software of the CCTV Surveillance System shall have following features:

- It shall have open architecture.
- It shall be capable of providing web based access
- The VMS software should be ONVIF Profile S Conformant
- VMS shall have ability to reduce the frame rate of previously recorded video after a specified number of days, resulting in increase of retention time and storage cost savings

v) Each Video management/ NVR server shall be of 19" rack mounted type and provided inside the CCU cabinet which shall be· mounted inside the Rack room of Control room/ SRR. The CCTV system programming terminal shall be connected to the Rack mounted Video management / NVR server in CCU cabinet. All necessary KYM extender switches, connectors/convertors, as required, at both ends & interconnecting cables for connecting the programming terminal & printer to CCU cabinet shall be supplied by the vendor.

w) The CCTV system software shall include the operating system and application program. The application program shall include software for performing all functions like Camera functions, camera configuration, camera maintenance & troubleshooting, Network Recorder configuration etc. as specified above. The licensed software for operating system and Application program shall be supplied for each programming PC. The program language shall be in English.

2.1.3 Alarms & Events

a) The operator in the control room shall be able to get an indication of the faults occurring in any of the devices connected over the network. This includes faults occurring in the cameras, Client workstations, and video recorders. Faults occurring in each of these devices shall generate an alarm in the operator console.

b) The operator shall be able to view the chronology of events by device, date, time and description.

c) The system shall support logging of events for reviewing and analysis in the future.

d) Upon detecting a fault, the system shall be able to automatically send an E-mail alert.

2.1.4 Configuration

The following facilities shall be provided for configuration of the CCTV system as a minimum:

a) Automatic IP camera discovery and configuration

b) Assign an ID or name to each camera.

c) Add/delete cameras.

d) Change the camera details (e.g. Camera location, Camera ID, Camera number, etc)

e) Configure the camera encoding parameters in terms of number of frames per second.

f) Configure the camera encoding resolution in terms of setting it to CIF, 2CIF, or 4CIF or higher.

g) Creation of schedules for recordings.

h) Configure recording either on demand, continuous recording or based on motion detection.

i) Add/ delete monitors to the system.

j) Add/ delete Client workstations to the system.

k) Creation of a camera group, view a camera group, view a camera sequence, and view a multiple view screen.

l) Client workstations of video management system, video recorders, and video wall controllers as applicable.

m) Program external outputs based on certain events.

2.1.5 Interfacing with Purchaser's Systems

Wherever specified, interfacing with Purchaser's DCS / Plant LAN/ Giant Screen shall be done to allow Plant operators to view live Video on the DCS operator consoles / Giant Screens in the Control Room and any other Purchaser's system connected to Plant LAN. TCP/IP connectivity along with DMZ Firewall (double firewall) for the same shall be provided by vendor. Necessary Software required in video management system and Purchaser's DCS / Giant Screen control station / Purchaser's LAN system shall also be provided by the vendor for i.his purpose.

The CCTV System shall be compliant to security Level -1 of IEC-62443-4-1 & 4-2 /ANSUISA TR99.00.0l as a minimum.

2.1.6 CCTV Cabinets

2.1.6. 1 The CCTV cabinet(s) shall house the following components:

(i) Network Video Recorder(s)

(ii) Database Management Server (as applicable_)

(iii) Recording Server along with Storage

(iv) NVR Monitor

(v) Analytics Server (as applicable)

(vi) Network switches

(vii) Media Converter

(viii) Indoor fibre patch panel, if any

(ix) Miniature circuit breakers, Surge Protector etc. as applicable

2.1.6.2 The cabinet(s) shall be fitted with lockable doors and shall have front and rear access. All system cabinets shall be completely wired. The cabinet(s) (with handles) shall be with lockable (three point contact at top, middle and bottom) toughened glass front and provided with perforated rear doors

2.1.6.3 The cabinet shall be free standing, enclosed type and shall be designed for bottom cable entry. Cabinet structure shall be rigid and shall be provided with removable lifting lugs to permit lifting of the cabinets.

2.1.6.4 Cabinets shall be fabricated from cold rolled steel sheet of minimum l .5 mm thickness for sides and rear and 2 mm thickness for doors and suitably reinforced to prevent warping and buckling. The rack/

rail mounting plates inside the cabinets shall be of 3 mm thickness. Cabinets shall be thoroughly deburred and all sharp edges shall be grounded smooth after fabrication. Cabinet frame shall be of 9 fold profiled CRCA or of Angle iron frame using minimum section of 50 x 50 x 4 mm angle.

2.1.6.5 Each cabinet shall be maximum 2100 mm high (excluding 100 mm channel base), 800 mm wide and 800/1000 mm deep, in general. Construction shall be modular preferably to accommodate 19" standard racks. Maximum swing out for Pivot card racks, doors and drawers shall be limited to 800 mm. Doors of the cabinet shall be equipped with lockable handles and concealed hinges with pull-pins for each door removal. All cabinets shall be of same height.

2.1.6.6 In order to effectively remove dissipated heat from the cabinets, vent louvers backed by wire-ply screen shall be provided on the cabinet doors. Ventilation fans shall be provided in each cabinet along with fan failure alarm contact.

2.1.6.7 LED lamps shall be provided in each cabinet for each cabinet for internal illumination along with door operated micro switches. All lighting shall be on 240VAC, 50Hz normal power supply.

2.1.6.8 All wiring within the cabinet shall be neatly laid and shall be accessible. Clamping rails shall be provided for incoming cables to present excessive stress on the individual terminals. All metal parts of the cabinet including doors shall be electrically continuous and shall be provided with common grounding lug.

2.1.6.9 The colour of the CCTV cabinets shall RAL 7035, unless otherwise specified.

2.1.6.10 Cable glands shall be provided for cable entry into the CCTV cabinet. Spare cable entries shall be plugged.

2.1.7 Optical Fibre Cable

The Optical Fibre Cable (OFC) used for the CCTV system shall conform to the following Specification as a minimum:

a) The OFC shall have FRP strength member, loose tubes for single mode optical fibres filled with moisture resistant jelly, moisture barrier of polymer coated Aluminium tape or water swellable tape, inner sheath of HDPE, CST (Corrugated steel tape) armouring and outer sheath of HOPE for outside plant applications.

   For inside plant applications, PVC shall be used as outer & inner sheaths in OFC. PVC jackets shall be rated for Flame retardant (IEC 60332).

b) Optical fibres shall be single mode fibres compliant to ITU-T G 652 and fibres colours shall correspond to IEC 60793-2 and 60304. Optical fibres shall be coated with UV cured double acrylic resin. It should not have _any reaction with claddir_1g or core material. The coating should provide maximum resistance to micro-bending & abrasion and ensure mechanical & optical strength. The coating shall be easily stripped with mechanical tools.

c) The number of fibres in the OFC shall be decided depending upon the requirement with 6 fibres as a minimum.

d) The cabled fibre attenuation shall be :S 0.37 dB/km for 13 IO nm wavelength range and 0.22 dB/km for 1550 nm wavelength range.

e) The tensile performance shall be as per IEC-60794-1-21 and with tensile load of9.8l W Newton with attenuation change :S 0.05 dB/km at 1310 nm. W is weight of OFC/km.

f) Whenever the Fibre optic cables for the CCTV System are in Purchaser's scope of supply as per the requisition, the same shall be of 6 Fibres and Vendor's media convertor and termination assemblies/ connectors for bare fibre at both the ends shall be suitable for the same.

2.1.8 Network Switch

The network switch used for the CCTV system shall conform to the following specification as a minimum:

a) The network Switch shall be configured to provide communication paths and provide the facility for adaptive packet and message routing through any available communication link. The network Switch shall provide the facility of multiple protocol router and bridge that provides high bandwidth connections into backbone networks for remote sites.

b) The hardware design shall be based on distributed processing architecture with packets forwarding to be performed on the network interface modules.

c) The network Switch shall support both intra-area and inter-area routing for transporting messages between nodes and shall support the network routing/ bridging services for OSI, TCP/ IP, X.25, LAT and other industry standard wide area networks/ protocols. The network switch shall be adaptive 10/100/IO00 Mbps interface port, supporting pass through/ crossover adaptation of port. The network switch shall be provided with optical fibre module interface suitable for long distance transmission.

d) Network security shall have Password Protection, IP address filtering, encryption, IEEE 802.IX network access control, user access log etc as minimum.

e) Network Switch shall be minimum managed Layer-2 type.

2.1.9 Power Supply

2.1.9.1 The system shall operate on I IO VAC/ 240VAC UPS (as specified in the datasheets) with the following specifications. However, Space heater (if applicable) shall not be on UPS:

Voltage variation	± 1 0%
Frequency	50 Hz ± 3 Hz

Any other power supply required shall be derived from this power supply by the vendor

2.1.9.2 Power Supply distribution for all items related to closed circuit television system shall be carried out from the system cabinet itself. Vendor shall supply any hardware required for conversion/ distribution. Power supply for each item shall be provided with a separate switch and fuse for isolation and protection of the system.

2.1.9.3 The CCTV camera unit shall be capable of withstanding plant vibration level of 2.1G (within the frequency range of 5 Hz to 200 Hz) and sudden shocks of level 5 G (with frequency of 2 Hz). Any vibration pads required to meet this requirement shall be in vendor's scope of supply.

2.1.9.4 The CCTV system shall have the capability for future expansion to add cameras and additional storage in video recorders considering mandatory spares quantity specified in the requisition as minimum.

2.1.9.5 All cable glands, as required, for camera enclosure, pan/ tilt unit, junction boxes, CCTV cabinet etc. shall be Nickel plated brass, dual compression type, suitable for armoured cables &area classification specified in datasheets. Slipper type PVC sleeves (cable shrouds) shall be used over cable glands.

3.0 NAMEPLATE

3.1 Each camera shall have a SS label name plate attached firmly to it at a visible place furnishing the following information:

a) Manufacturer's model no. and serial no.

b) Manufacturer's name/ trademark.

c) Type and Resolution of Camera

d) Lens Focus Length

e) Pan, Tilt and Zoom Range

f) Type of explosion protection and certificate number

g) Power Requirement.

3.2 Each item of Close Circuit Television and its accessory shall have SS labels attached firmly to it at a visible place, furnishing the following information:

a) Manufacturer's model no. and serial no.

b) Manufacturer's name/ trademark.

c) Type of explosion protection and certificate number

d) Power Requirement.

4.0 INSPECTION AND TESTING .

4.1 Vendor shall submit the following test certificates and test reports for purchaser's review:

a) Dimensional verification certificate

b) Manufacturer's test reports as per Type 3.1 of EN 10204

c) Minimum light intensity testing

d) Power supply variation check

e) Certificate from Statutory authority for flame proof and weather proof enclosure, as applicable

4.2 Witness Inspection

4.2.1 All items shall be offered for pre-dispatch inspection for following, as a minimum, unless otherwise specified:

a) Physical dimensional verification and workmanship, verification of recording rack, display resolution, configurations (software),

b) Bill of material check, check for Layout such as viewing station, multiple display, windows, etc.

c) Effect of variations in power supply, voltage and frequency

d) Performance testing and verification of integrated CCTV system (recording & retrieve video quality, alarms, etc.).

e) Review of all certificates and test reports.

f) Complete system integration check with all the accessories (including printer), system diagnostic check and reports generation check.

4.2.2 Purchaser reserves the right to inspect and witness testing at vendor's works as per approved Inspection Test Plan and quality documents. In case the purchaser does not witness the tests, all the tests shall anyway be completed by the vendor and test reports shall be submitted to purchaser for scrutiny.

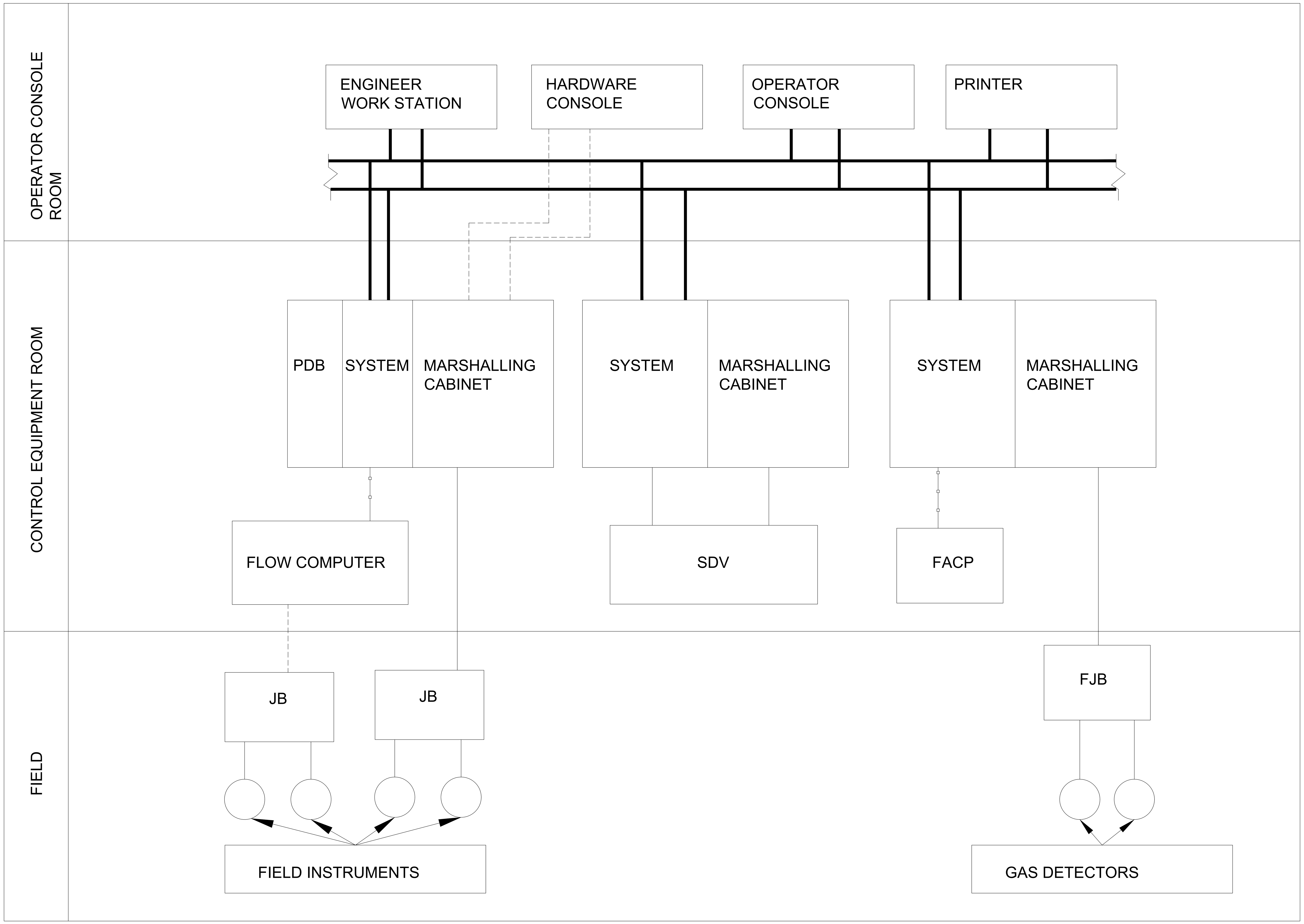
5.0 SHIPPING

5.1 All threaded openings and cable entries shall be suitably protected to prevent entry of foreign material.

5.2 Any glass item shall be protected with foam sheet to protect against damage during transportation.

5.3 Each panel/cabinet and accessory shall be suitably packed and protected from damage due to transportation, unloading and loading.

5.4 Each component part requiring identification for proper assembly at site shall be piecewise marked.



REFERENCE DRAWINGS

DRAWING TITLE	DRAWING NUMBER

NOTES :-

REV	DATE	DESCRIPTION	PRED.	CHKD.	APPRD.
TA	27-10-23	ISSUED FOR TENDER	SC/VK	NC	AD
CA	18-10-23	ISSUED FOR CLIENT REVIEW	SC/VK	NC	AD
IA	18-10-23	ISSUED FOR INTERNAL REVIEW	SC/VK	NC	AD

OWNER:
ASSAM GAS COMPANY LTD.

EPMC:
PIPELINE ENGINEERING CONSULTANTS PVT. LTD.

PROJECT:
DEVELOPMENT OF BOO COMPRESSOR STATION AT RUPKHELIA

DWG. TITLE :
SYSTEM BLOCK DIAGRAM

SCALE.	JOB NO.	DRAWING NUMBER	REV.
1:50	P167	P167-SYS-I001	CA
SHEET 1 OF 2			

SHEET SIZE : A1 (841 mm x 594 mm)

DEVELOPMENT OF BOO COMPRESSOR STATION AT RUPKHELIA

ELECTRICAL SCOPE OF WORK

Doc No: P167-SOW-E001

REV.	DATE	DESCRIPTION	ORG	REVIEW	APPROVED
TA	25-10-2023	ISSUED WITH TENDER	AK	SP	AD
CA	16-10-2023	ISSUED FOR CLIENT REVIEW	AK	SP	AD
IA	09-10-2023	ISSUED FOR INTERNAL REVIEW	AK	SP	AD

ABBREVIATION

CEA	Central Electricity Authority
SEA	State Electricity Authority
BS	British Standards
AGCL	Assam Gas Company Limited
DGMS	Director General Mines Safety
OISD	Oil Industry Safety Directorate
ONGC	Oil and Natural Gas Corporation

CONTENTS

1.0 BACKGROUND

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e., Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCM of gas per day.

AGCL is planning to expand its Pipeline Network in Assam for increasing gas transportation capacity so they want to develop new Compressor Station at Rupkhelia (Assam).

Pipeline Engineering Consultants Pvt. Ltd. has been appointed as Engineering Consultant by AGCL for Consultancy Services Engineering, Procurement, RFP preparation and Project Management for the Project.

2.0 BRIEF DESCRIPTION OF PROJECT

The brief project details for Development of Compressor Station at Rupkhelia (Assam) are as follows: Development of Compressor Station at Rupkhelia. The preliminary proposed facilities for the Compressor Station are:

- Field Instrumentation along with PLC System for Air/Gas Compressor (1W + 1S) Package and other utilities
- Fire and Gas Detection System
- CCTV System.
- USM Meter along with Flow Computers.
- Vibration Monitoring System
- Cable and Cabling from Field Instruments, Cameras and Detectors to Compressor DCS, NVR Server, F&G PLC, ESD PLC.
- Earthing and Lightning protection system.
- Lighting installations.
- Input Electrical Power Hook-up.
- Cathodic Protection (if required).
- Emergency Power requirements and availability audit etc.
- Hazardous area classification.
- Cable route and schedule.
- Feeder Modification (if required).

3.0 SCOPE

The electrical scope of work shall include but not limited to the following:

1. Contractor shall carry Electrical load calculation and shall make arrangement of reliable power supply.
2. Supply, laying & termination and testing of power & control cable(s) of required sizes & cores shall be the responsibility of the Contractor.
3. All erection and installation material like cable glands, cable lugs, connectors, cable supports, nuts, bolts and other required hardware shall be supplied by the Contractor. Cabling work shall include cable laying, end terminations, clamping, tagging etc.

The Contractor's scope of work encompasses the following:

- Providing, laying & termination of LT cable of required sizes & core from designated MCC Panel to cater various loads of Motor/Drives.
- Supply & installation of lighting equipments for compressor unit, field cabin, store rooms etc.
- Providing area lighting which includes supply & installation of pole light as per area classification.
- Installation of Earth Pits / Earth Grid as per Standard Engineering Practices and IS:3043.
- Earthing of the Motor / Distribution Panel and other Electrical Fittings / Fixtures, lighting poles including provision of equipments/foundations.
- Equipment/body/foundation earthing should be done at two sides opposite to each other.
- Providing rubber mattress of ISO standard, wherever required
- Health monitoring, periodic/predictive/breakdown maintenance along with supply of requisite spares/consumables.
- Availability of spares along with skilled/experienced manpower.
- UPS supply, if required to be arranged by the contractor.
- Installation of adequate nos. of emergency lights. This will keep the area illuminated during power failure.

4. The contractor shall ensure that all electrical equipments / apparatus / instruments/fittings provided & installed are suitable as per applicable National / International standards and statutory regulations with respect to Area Classification.
5. Supply & installation of complete earthing system for the new equipment including supply of materials. Grounding and bonding of all equipment is included in the scope of work.
6. Main earth grid of bare 50X6 mm, GI strip will be used below ground. Above ground green /yellow PVC insulated copper conductors shall be used.GI Earth rod of 50 mm diameter 3m long shall be used. LV motors, cable trays, metallic equipment, enclosures etc. shall be connected to the main earth grid with 35 mm^2, PVC insulated copper conductors. Joint is not allowed in cable for grounding/earthing purpose.
7. All the equipment shall be earthed from two points. —Double earthing system.
8. All equipment shall be grounded and bonded in accordance with the recommendations of IS: 3043 /IEEE-142 —Recommended practice for grounding of Industrial & Commercial power system.

AREA CLASSIFICATION AND EQUIPMENT REQUIREMENTS

i. Area Classification for Process Gas Compressor shall be done as per IS 5572 and Temperature Class-T3. However detailed area classification drawing shall be prepared by the contractor.
ii. The enclosure protection for various package equipment shall be minimum as follows:

- MV Motors: Ex (n)
- Local control stations: Ex (d)

- All electrical equipment installed in hazardous areas shall meet the requirements of relevant IS/IEC standards. Equipment suitable for safe/non-hazardous areas application shall not be used in Zone-1 / Zone- 2 hazardous area.

iii. Electrical equipment having flameproof enclosure protection shall conform to IS- 60079 (Part 1):2007/IEC-60079-1 (2007).

iv. Electrical equipment having enclosure protection Ex (n) i.e. non-sparking type (without prestart ventilation) shall conform to IS/IEC 60079-15 (2005).

All electrical equipment for hazardous areas shall be certified by CMRI or equivalent international testing agency and shall be CCOE/PESO approved for the service and area in which it could be used.

4.0 MEASUREMENT AND TEST EQUIPMENT

Wherever testing and measurement is required, Contractor shall propose a list of measurement and test equipment in his procedure and shall demonstrate that sufficient equipment's will be allocated for all concurrent tasks. All measurement equipment's shall be fit-for-purpose and, for each piece of equipment, the Contractor shall provide documentation of current third-party calibration by a recognized independent certified testing house.

5.0 INSPECTION AND TESTING

Inspection and testing by Third Party Inspection agency (TPIA) and Third-party test laboratory requirement for all materials as part of scope of this tender shall be in scope of Contractor, in addition to the same Owner may also consider additional agency / own personal for such inspections review.

No materials shall be supplied without TPI inspection release and Owner's dispatch clearance.

6.0 SITE ACCEPTANCE TESTING

The Contractor shall implement procedures and Inspection and Test Plans (ITPs) and, in accordance with the vendor documentation, shall complete Site Acceptance Testing (SAT). All equipment shall pass SAT and the Contractor shall submit SAT documentation in order to obtain approval of the Engineer-In-Charge (EIC) to proceed for further installations commissioning.

7.0 CO-ORDINATION WITH OTHER CONTRACTORS

Owner shall be engaging other contractors/agencies for performance of other works associated with as Pipeline works. It shall be the responsibility of contractor to communicate, co-operate, co-ordinate and provide assistance to such agencies and sort out all interface issues in consultation with Engineer-in-Charge, for carrying out scope of work of system. The Contractor shall appoint a representative to meet weekly with other contractor's representatives in the presence of the Owner. The contractor in meeting shall provide the locations to determine programming for construction and commissioning activities such that the Owner's needs for co-ordination for other contractor is not disadvantaged by one contractor's activities.

The contractor shall plan his activities requiring interfacing with other contractors / agencies well in advance and provide details to the other contractors / agencies at least one month in advance so that all interface issues can be resolved prior to actual execution of the work. All delays on account of such interface problems arising out of non-co-operation / lack of co-ordination by the Contractor shall be to Contractor's account.

8.0 COMMUNICATION

For effective communication with Owner, Related facility installation & piping laying and other contractors, landowners, local authorities, sub-contractors, etc., the Contractor shall establish a detailed project communication procedure in consultation with Engineer-in-Charge, that will include as a minimum an organization chart and details of communications structure.

9.0 SAFETY

The Contractor shall be responsible for implementation of a project specific Safety and Health Management Plan immediately after award of work, in line with statutory requirements. The Contractor shall be responsible for the safety at all sites including all travel to the sites and any remote offices. The safety plan shall be in compliance to all local and government safety requirements, approvals and standards and Owner’s safety manual. Contractor shall depute experienced and sufficiently trained safety personal at site throughout the project phase.

ASSAM GAS COMPANY LTD
(A GOVT. OF ASSAM UNDERTAKING)

DEVELOPMENT OF BOO COMPRESSOR STATION AT RUPKHELIA

ELECTRICAL DESIGN BASIS

Doc No.: P167-DEB-E001

REV.	DATE	DESCRIPTION	ORG	REVIEW	APPROVED
TA	25.10.2023	Issued for tender	AK	SP	AD
CA	18.10.2023	Issued for Client review	AK	SP	AD
IA	12.10.2023	Issued for Internal review	AK	SP	AD

CONTENTS

1.0 INTRODUCTION

Assam Gas Company Ltd. (AGCL) is a 60 years old Natural Gas transmission and distribution company, wholly owned by the Govt. of Assam with its registered office at Duliajan, Dist. Dibrugarh, Assam 786602.

The company transports Natural Gas through its integrated pipeline infrastructure to several market segments i.e. Power, Fertilizer, Petrochemicals, Industrial, Commercial and Domestic consumers primarily located in upper Assam. The present infrastructure of the company has a transportation capacity of about 6.0 MMSCM of gas per day.

AGCL is planning to expand its Pipeline Network in Assam for increasing gas transportation capacity so they want to develop new Compressor Station at Rupkhelia (Assam).

Pipeline Engineering Consultants Pvt. Ltd. has been appointed as Engineering Consultant by AGCL for Consultancy Services Engineering, Procurement, RFP preparation and Project Management for the Project.

1.1 Purpose of Document

The purpose of this document is to define the minimum technical requirements to design the new required facilities.

2.0 DEFINITION

Where used in this document, the following terms shall have the meanings indicated below, unless clearly indicated by the context to this order.

PROJECT	Development of New Compressor Station at Rupkhelia Assam
CLIENT/ OWNER	Assam Gas Company Limited.
EPMC	Pipeline Engineering Consultants Pvt. Ltd. (PLECO) the party to act for and on behalf of OWNER for the Detailed Engineering Services and Project Management.
CONTRACTOR	Agency appointed by CLIENT/ OWNER for execution of assigned tasks
PURCHASER	Either of CLIENT, OWNER or EPMC
VENDOR/ MANUFACTURER	Party, which manufactures and supplies equipment and services to the OWNER or to CONTRACTOR

3.0 PROJECT BRIEF

The brief project details for Development of Compressor Station at Rupkhelia (Assam) are as follows: Development of Compressor Station at Rupkhelia. The preliminary proposed facilities for the Compressor Station are:

- Field Instrumentation along with PLC System for Air/Gas Compressor (1W + 1S) Package and other utilities
- Fire and Gas Detection System

- CCTV System.
- USM Meter along with Flow Computers.
- Vibration Monitoring System
- Cable and Cabling from Field Instruments, Cameras and Detectors to Compressor DCS, NVR Server, F&G PLC, ESD PLC.
- Earthing and Lightning protection system.
- Lighting installations.
- Input Electrical Power Hook-up.
- Cathodic Protection (if required).
- Emergency Power requirements and availability audit etc.
- Hazardous area classification.
- Cable route and schedule.
- Feeder Modification (if required).

4.0 SITE CONDITIONS

Equipment's & materials shall be suitable for giving trouble free service under the environmental conditions given hereunder. Electrical equipment shall be specified for operation under the following site conditions:

Maximum Ambient Temperature	40°C
Equipment Design Temperature	45°C
Minimum ambient temperature	16°C
Design Relative humidity Max/Min	70% / 66%

5.0 CLASSIFICATION OF HAZARDOUS AREAS

Area classification for the plant shall be done in accordance with Petroleum Rules, DGMS Regulations and IEC60079-10 & IS 5572. Following factors shall be considered for proper selection of electrical equipment for use in hazardous area:

i) Area Classification I.e. Zone ii) Gas Group.IIA/IIB/IIC.

iii) Temperature Classification T3. iv) Atmospheric Pollution.

The hazardous areas shall be classified as Zone 1 or 2 or 0 and shall be IIC for areas where hydrogen gas may be present and IIA/IIB for remainder of classified areas. Surface temperature classification for all equipment for use in hazardous areas shall not exceed 200 deg. C (T3 Class).

All electrical equipment installed in hazardous area shall be selected as per IS 5571 and IEC60079-10 and shall meet the requirement of relevant IS, IEC.

All electrical equipment for hazardous area shall be certified by CIMFR (CENTRAL INSTITUTE OF MINING AND FUEL RESEARCH) / ERTL and as per PNGRB guidelines for use in oil & gas area as per the Oil Mines regulations. All electrical equipment for hazardous area shall have the valid PNGRB Guidelines at the time of installation and commissioning.

Isolating devices for equipment located in hazardous areas shall switch all poles of the supply including the neutral.

6.0 DESIGN CODES AND STANDARDS

- M/s AGCL Pipelines and terminal facilities envisaged shall be Designed and Engineered primarily in accordance with the provisions of the latest edition of Codes, specifications, OISD & Standards for Electrical Systems for Design and Construction Requirements for Cross Country Hydrocarbon Pipelines and PNGRB and DGMS guidelines.
- However, all facilities shall be Designed and Engineered with the provisions of the latest edition of Codes, applicable OISD and PNGRB Guidelines rule.
- The equipment offered and its installation shall comply with the latest issue of the relevant Indian Standards and shall be accordingly to PNGRB Guidelines.
- In addition, requirements, as applicable to gas service of following codes / standards shall be complied with.

IS:3043	Code of Practice for earthing.
IS:2309	Code of Practice for the Protection of Buildings and Allied Structures against lightning.
IS:9676	Reference ambient temperature for electrical equipment.
SP:30	National Electrical Code (NEC) -BIS Publication.
IS:13234	Guide for short circuit calculations in three phase AC systems.
IS:5572	Classification of hazardous areas having flammable gases and vapors for Electrical installations.
IS:4146	Application guide for C. T. Application guide for V.T.
IS:6665	Code of practice for Industrial Lighting
IS:3646	Code of practice for Interior Illumination

IS:13346	General requirements for electrical apparatus for explosive gas atmospheres.
IS:13408	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres.
IS:3716	Application guide for Insulation Coordination.
IS:10118	Code of practice for selection, installation and maintenance for switchgear and control gear.
IS:7689	Guide for Control of undesirable static electricity.
IS:2309	Code of practice for the protection of buildings and allied structures against lightning.
IS:12360	Voltage bands for electrical installations including preferred voltages and frequencies.
IS:3961	Recommended current ratings for cables.
IS:7752	Guide for improvement of power factor consumer's installations.
IS:1646	Code of practice for the fire safety of buildings – Electrical installation.
IS:325	Three phase induction motor specifications.
IS:1554 (Part-1)	Specification for PVC insulated heavy duty electrical cable for working voltage up to & including 1100 Volts.
IEEE 515	Standard for Testing, design, installation and maintenance of Electrical Resistance Heating for industrial applications.
IS :16242	Uninterruptible power systems (UPS)
IS: 1180-1	Outdoor type three phase distribution transformers up to & including 100kVA 11kV.
IS:7098(Part 2)	Cross linked polyethylene insulated thermoplastic sheathed cables specification.
IS:398(Part 2)	ACSR & Aluminum conductor for overhead transmission purposes.
IS:12762(Part 2)	Photovoltaic devices: Part 2 Requirement for reference solar cells.
IS :12834	Solar photovoltaic energy systems-Terminology
IEC:62093	Balance-of-system components for photovoltaic system design qualification natural environments.
IEC:6/683/62509	For safety and durability of solar charge controllers.
BS 6351 (Pt. 1,2, & 3)	Electrical surface heating: Devices, Systems & code of practice.

- In case of conflict between the requirements of codes/Standards referred above, requirement of NEC, OISD shall govern.
- However, In case of conflict between the requirements in AGCL existing terminal area AGCL requirements/standards shall supersede all.

7.0 REGULATIONS

The electrical equipment / installation offered shall comply with requirements of the following rule /regulations as amended up to date:

(a) Central Electricity Authority regulations 2010.

(b) The Indian Electricity Act

(c) The Indian Electricity Supply Act.

(d) The Indian Factories Act,

(e) The Petroleum Rules,

(f) PNGRB

(g) CCE

(h) Terms & Condition

(i) Any other State Regulations in force

The Contractor shall obtain the necessary clearance from the Electrical Inspector / Competent Authority for equipment supplied and installed. All necessary drawings, calculations, test certificates, etc. as required by Electrical Inspector /Competent Authority shall be furnished. Any modification/rectification as required by him shall be carried out free of cost. The fees required to be paid to the Electrical Inspector /Statutory Authority for inspection shall be borne by Owner on production of documentary evidence.

8.0 ELECTRICAL DESIGN PARAMETERS.

Pipeline and pipeline stations to be installed as a part of this project shall be designed and engineered in accordance with the standards/codes referred in above section of this document.

8.1 VOLTAGE AND FREQUENCY VARIATION FOR ELECTRICAL EQUIPMENT

Equipment shall be capable of meeting its rated output continuously at 90% to 110% of system voltage at consumer terminals coincident with -2% to +2% of system frequency.

Voltage depressions to 90% of system voltage at the switchgear during motor starting shall have no detrimental effect on equipment operation.

415 Volt, 50Hz. 25kA, 3 phase-4 wire supply will be provided by AGCL. For single phase power requirement suitable for 230V.

Individually, 1-ph load shall have 2 pole isolation provisions, 3-ph load shall have 3 pole isolation & 3-ph + N load shall have 4 pole isolation provisions

8.2 VOLTAGE DROPS

The maximum voltage drops in various sections of the electrical system under steady state conditions at full load shall be within the limits stated in the following table:

System Element	**Maximum Permissible Voltage Drop**
Cable between PCC and MCC or auxiliary switchboard	2%
Cable between MCC and Motors	5%
Circuit between lighting panels and lighting points	4%
DCDB to Control Room	2%
UPS outgoing circuit	2%

The maximum voltage drop at various buses during start-up of large motor shall be within the limits stated below:

System Elements	**Operating Conditions**	**Max. Perm. Voltage Drop**
At the bus bar of the worst affected Switchboard (PCC /MCC)	Start-up of large 415 V motor with other loads on the bus	10%
Cables between (PCC / PMCC /MCC and Motors	Motor start up	15%

8.3 SYSTEM EARTHING

The 415V system neutral is resistance grounded type, the 415V system shall be solidly connected to earth via generator neutral point to earth. The earthing system shall conform to IS 732 and IS 3043. All non-current carrying metallic parts and enclosures of electrical equipment and metallic structures used for mounting electrical equipment shall be effectively bonded to earth throughout the terminal in accordance with IS 732, IS 3043 and IS 7689. All exposed conductive parts of equipment; piping, vessels and structural items shall be effectively bonded so as to prevent the accumulation of static charge. Every multicore power cable shall contain a separate equipment-earthing conductor which is connected to the earth bar at the Switchgear / MCC, and which is connected to the utilization equipment at the load end. This shall provide a low impedance path for earth fault currents to permit rapid operation of protective devices. The resistance of the earth pit shall not be more than 1 Ohm as per Indian Standards.

a. All non – current carrying metal enclosures shall be bonded for earth continuity to the main earth Grid/earth bus.

b. The minimum of two earth studs must be provided on the skid base, diagonally Opposite to each other, for connection to the main plant earth system.

c. No. of earth pits shall be provided as per IS: 3043. All earthing materials shall be supplied as per Technical Specification.

i) 600 x 600 x 3 mm thick copper plate earth electrodes for UPS, RTU, Telecom, Instrument Control Panel, metering panel.

ii) 100 mm dia X 3000 mm (L) GI Pipe electrode for other

d. All equipment earthling· shall be carried out as per IS : 3043, Minimum size of earth conductor to be used shall be as given below:

Equipment	Conductor size
Main Grid & equipment such as main Electrical Distribution Board.	50 X 6 mm GI Flat/as per earthing calculation
Switch Socket DB, UPS, DB, Lighting DB	25 x 6 mm GI flat / 16 sq. mm GI rope
Compressor	50 X 6 mm GI Flat
Pipe/cable racks, structure, fencing UPS, Telecom, RTU	10 Sq. mm Cu cable
Field Instruments	2.5 sq mm copper PVC Wire

10 sq. mm Cu armored cable shall be used for Cu plate electrode interconnection of two earth pits.

- Earthing Electrode shall be GI pipe/ copper plate.
- Minimum 2 Nos. Copper Plate Electrodes will be provided for RTU/Control Panel equipment at new station.

- Minimum 2 Nos. Copper Plate Electrodes will be provided for Telecommunication System at new station.

- Minimum 2 Nos. Copper Plate Electrodes will be provided for UPS system at each station.

- GI pipe electrodes for new stations will be provided as per IS-3043 and as per site requirement.

- Minimum Nos. GI pipe electrodes for each station shall be provided as per IS-3043 and as per site requirement (2 Nos. For neutral earthing of Generator, 2 Nos. For neutral earthing of Transformer, 2 Nos. For equipment earthing for each equipment). All these earth electrodes shall be interconnected. However, bidder shall decide actual number of electrodes during detail engineering as per IS 3043.

A board of 250 X 250 mm, 3mm thick GI plate shall be provided adjacent to all earth pits. Board shall display earth pit number, date of testing, test values & next due date, as per guide line of SEA/CEA.

8.4 LIGHTNING PROTECTION:

Lightning protection shall be provided to protect the station and equipment against lightning thunderstorms expected during monsoon season. The system shall be modelled to ensure that a complete coverage to the Terminal is provided. Required number of lightning arresters shall be provided at the appropriate highest points and earthed individually.

Dedicated earth pits shall be provided one for each down conductor running from the lightning arrester. The down conductors shall be copper and sized to carry the lightning energy safely down to earth without damaging itself or causing any harm to the surface on which it is supported. The down conductors shall not be run in conduits, ladders or other routes that are common to other electrical cables and services. The lightning earth pits shall not be connected to the other Terminal electrical earth grid system. A disconnection point at the earth pit shall be provided for testing the earth resistance of each pit.

Design of lightning protection system for structures provided with lightning protection shall be as per IS 732 and IS 2309.

8.5 SOLAR POWER SYSTEM

Solar power supply system Outgoing along with additional Battery charger & Sealed maintenance free battery bank suitable for solar charging, as per specification and datasheet suitable for sufficient backup time at full load shall be provided. For meeting critical loads that cannot withstand even a momentary interruption in voltage. Following loads shall be connected to the solar power system.

- Critical instrumentation and control

- Critical security equipment

- Annunciation panel.
- Emergency lightings & Fans

8.6 EMERGENCY POWER SUPPLY

GG Set to be considered for Emergency power supply

8.7 UNINTERRUPTED POWER SUPPLY (UPS)

Uninterrupted power supply system (230 V, AC, 1 Ph, N, Redundancy Parallel redundant UPS) along with Sealed maintenance free VRLA battery bank (as per specification and datasheet) suitable for sufficient backup time at full load shall be provided for meeting critical loads that cannot withstand even a momentary interruption in voltage. Following loads shall be connected to the UPS system:

- Critical instrumentation and control
- Critical security equipment
- Annunciation panel

Configuration: -

2 X 100 % KVA rating with bypass arrangement three /single phase UPS in parallel redundant configuration shall be
charging
the batteries@0.2C operating only on grid power is
available.
i.UPS protection class shall be IP-52.

ii.Battery Bank: 2 Nos.x 50% Sealed maintenance free VRLA battery bank for

4 hours' backup.

8.8 EQUIPMENT ENCLOSURES

Equipment Enclosures shall be of heavy-duty construction and shall provide the following

minimum degrees of ingress protection.

Outdoor locations Local Control Stations /Motors	IP55
Outdoor locations Lighting Fittings	IP55
Outdoor locations Receptacles / Sockets / JBs	IP55
Outdoor locations Electric motor	IP55

HV/LV Switch board	IP-42
Distribution Boards	IP-42
UPS	IP-52

The list is not exhaustive; therefore, Contractor shall consider the above-mentioned requirement in selection of equipment's for the desired application.

8.9 MOTOR

In general, three phase induction motors designed for direct on line starting shall be used. Motors shall be totally enclosed, fan cooled type and suitable for continuous outdoor use.

8.10 The substation building shall be sized to maintain adequate clearances between equipment for ease of maintenance. The following minimum clearances around various equipment shall be maintained:

Sl. No	LOCATION	CLEARANCE
a)	Front clearance for HV switchboard	2500mm
b)	Front clearance for all other switch boards/panels	2000mm
c)	Rear clearance for panels having maintenance	Less than 200mm or more access from front only
e)	Side clearance between two switch boards or from nearest obstruction	1000mm after considering space for future panels.
f)	All around clearance for transformers 1000 mm	1000 mm
h)	All around clearance for capacitor bank/ series 1000 mm reactor	1000 mm

I)	Battery rack to wall clearance Single row, single/double tier Double row, single tier Double row, double tier	100mm 100mm 750mm
J)	Front clearance for wall mounted equipment	1000mm

9.0 CABLE SYSTEM

9.1 CABLES

All cables shall be 0.65 /11 kV grade PVC insulated, extruded inner sheath Tinned Copper wire, wire / flat armoured stranded annealed copper conductor FRLS PVC outer sheathed heavy-duty cables manufactured in accordance with the IS: 1554 Part-1 (0.6 /1.0 kV grade as per IEC). Where cables have to be routed underground in the plant (e.g., for final connection to motor), they shall be protected by conduits & sealed to prevent ingress of hydrocarbons.

Physical segregation shall be maintained between conductors carrying different voltage levels.

Cable ladder/tray covers shall be provided on cable ladders/trays exposed to direct sun to protect

the cable outer sheath from Ultra-Violet radiations. All the power and control cable which are going to be installed in the Hazardous area shall be DGMS approved type with valid DGMS approval certificates. Cable shall be marked permanently with legible words "MINING", DGMS approval number in every three meters. Each conductor shall be identified with separate color such as Red, Yellow, Blue & Black. Vendor shall provide the valid Test certificate and DGMS approval certificate of the cable. Vendor shall provide the valid manufacturers guarantee certificate.

a. **Power Cable**
b. Stranded Annealed Copper Conductor up to 10 mm^2
c. Stranded Aluminum Conductor from 16 mm^2 and above
d. XLPE insulation- Type A
e. Inner and outer Sheath will be extruded
f. Inner sheath will be ST2
g. Steel strip/wire armoured
h. Outer sheath of cable will be FRLS XLPE, ST2 Type
i. Voltage grade- 1100 V
j. IS 1554/7098 Part 1

a) **Control Cable**
b) Stranded Annealed Copper Conductor 2.5 sq mm
c) XLPE insulation type A.
d) Inner and outer Sheath will be extruded
e) Inner sheath and outer sheath will be ST2

f) Steel strip/wire armoured
g) Outer sheath of cable will be FRLS XLPE, ST2 type
h) Voltage grade - 1100 V
i) IS-1554/7098 Part I

j) Lighting Cable/Wire in conduit

2.5 mm2 stranded Copper XLPE/PVC insulated wire in concealed PVC conduit will be used in Lighting fixtures/ flameproof fixtures.

4 core 6 mm2 stranded Copper will be used from indoor lighting DB to junction box on the lighting poles.

3 core 2.5 sq. mm stranded copper cable (YWY} will be used from junction box on the lighting pole to lighting fixture.

9.2 CABLE SIZING

Cables shall be heat and oil resistant and suitable for service in the maximum environmental conditions described for the Platforms/Terminal and can be expected at the respective locations. All nominal power cable ratings shall be based on maximum ambient temperatures (design temperature) as specified under site conditions. De-rating factors shall be applied as necessary to take account of Installation configuration and variation in ambient temperature.

Conductor current ratings for distribution board feeders shall be established on the basis of 125 % of the rated actual load current at the ambient temperature and de-rated for grouping and method of installation. Cables for emergency duty equipment shall have fire performance characteristics to IEC 332-3 Category A. Safety critical circuit cables, such as certain Fire and Gas and communication signals required to maintain integrity during a fire, shall be fire resistant type to the requirements of IEC 331. Control & Instrument multicore cables shall have 20% spare conductors (cores).

9.3 CABLE RACKING

As far as possible the cables shall be installed in the existing cable ladders / trays. In case new cable trays are required, the same shall be of marine grade Aluminum (MGA) / or stainless steel (SS). Continuous Marine Grade Aluminum barrier strips may be used to separate power cables of different voltage grades. Cables shall be fitted with the removable, ventilated covers where there is exposure to chemical spillage, falling objects or direct sunlight.

Cable trays / ladders shall be installed in accordance with the manufacturer's recommendations and specially supported at each elbow. The overhead cable trays / ladders shall be installed at a minimum of 500 mm above ground level at on-shore facility. Single core cables shall be laid in trefoil group. All fasteners shall be made from Marine Grade Aluminum or Stainless-Steel material. All cable trays / ladders support shall be located to suit structural features and manufacturers recommendations. All cable trays / ladders shall be electrically connected to the earthing system. Cable ladder/tray covers shall be provided on cable ladders/trays exposed to direct sun to protect the cable outer sheath from Ultra-Violet radiations.

9.4 CABLE ACCESSORIES

Each cable shall be provided with a number, which shall be tagged on the cable at regular intervals for easy identification. The numbering scheme to be adopted for the cables, shall match with the existing cable numbering philosophy. Cable sockets shall be heavy duty crimped type copper. These shall conform to the relevant standards. No cable shall be terminated directly without sockets. Provision shall be made to avoid bimetallic corrosion.

9.5 CABLE GLANDS AND TRANSIT FRAMES

All cables shall be fitted with FLP double compression type cable glands. All cable glands and adopters shall be made of non-ferrous/non-corrosive material and shall be fitted with soft sealing nylon washers. Fiber washers shall not be used. Flameproof double compression cable glands and flameproof plugs shall be certified by CIMFR.

Such transit frames shall include at least 20% spare capacity for future use.

9.6 LIGHTING SYSTEM

Plant lighting system shall comprise:

a) Normal Lighting

b) Emergency lighting

c) Critical Solar Lighting

Normal and shall be fed by AC supply 240 V, 1 phase system (specifically required by DGMS). Normal lighting system shall provide enough illumination so as to enable plant operators to move safely within the accessible areas of plant to perform routine operation include reading of field instruments, operation of all valves etc. and to carry out all the necessary maintenance and adjustment to equipment.

Emergency lighting

Lighting requirements provided during the failure of power supply for normal lighting are broadly indicated here below:

a) To facilitate carrying out of specified operations, for safe shutdown of the plant.

b) To gain access and permit ready identification of firefighting facilities such as fire water pumps, fire alarm stations etc.

c) Critical/Solar Lighting: (1x18W) 12 hours battery backup with lighting pole (4.5 meters shall be provided for critical lighting).

Adequate number of self-contained portable hand lamps and battery-operated emergency lighting units shall be provided for immediate use for buildings where no DC supply Is available.

LED Lamps shall generally be used for Indoor/outdoor plant lighting, non-process buildings and control room. All ballasts shall be with copper winding and capacitor for power factor improvement (to 0.95) shall be provided with fixtures as applicable.

All outdoor lighting shall be automatically controlled by means of photo switch or timers with manual control.

The Lighting panels shall be provided with MCB as incomer and miniature Circuits

Breakers (MCBs + ELCB) for outgoing feeders control and protection of lighting circuits. MCBs shall not be loaded beyond 80% of rated capacity. A minimum of 25% of miniature circuit breakers of each board shall be left as spares.

10.0 Lighting Lux Level

Lighting system design shall be based on minimum illumination levels as specified below:

Sr. Nos.	Area/Location	Lux Level
1	Roads	10
2	Pumps House & Sheds/ compressor	100
3	Main Operation Platforms	60
4	General Area	20
5	Process Area,	60
6	Switchgear Rooms, UPS Rooms	200
7	Cable Cellars	70
8	Battery Room	150
9	Ware-House	100
10	Office	300
11	Control Room, Laboratory	400-500

Lighting design shall confirm to relevant International Codes and Standards, IES Hand Book and shall take into consideration the requirements from point of view of safety and ease in operation and maintenance. A maintenance factor of 0.8 for outdoor & 0.9 for indoor shall be assumed for lighting illumination level calculations for normal areas. However, for dusty areas maintenance factor as per relevant codes and standards shall be considered.

Wiring for lighting and convenience outlets in outdoor areas shall be carried out with PVC/XLPE armored cables run along the column / platforms and structures. The armored cable shall enter lighting fixture / JB through double compression gland for safe area, Ex(e) or Ex(d) equipment and through flameproof glands for Ex(d) equipment. Where required suitable mechanical protection shall be provided for lighting fixtures (e.g. wire guard).

Two pole MCB shall be used for controlling fixtures in hazardous areas to isolate phase as well as neutral.

11.0 LOW VOLTAGE (LV) FEEDERS

Switchgear used for LV feeders shall incorporate the following protective devices:

a) Short Circuit

b) Earth fault

Protective devices for the MCC and emergency panel feeders shall be housed within the low voltage MCC and emergency enclosure.

12.0 ELECTRICAL EQUIPMENTS FOR HAZARDOUS AREA

Electrical Equipment's

The Electrical equipment's for hazardous areas shall be selected as per IS: 5571 and petroleum rules. The minimum requirements are summarized below

Equipment's	Zone-1		Zone-2	
	Gas Gr.	Gas Gr. IIC	Gas Gr. IIA, IIB	Gas Gr.
LV Ind. Motors	Ex-d	Ex-d	Ex-d	EX-e
HV Ind. Motors	Ex-d / Ex-	Ex-d / Ex-p	Ex-d	EX-e
Push Button Stations	Ex-d	Ex-d	Ex-d	Ex-d
Motor Starter	Ex-d	Ex-d	Ex-d	Ex-d
Plug Sockets	Ex-d	Ex-d	Ex-d	Ex-d
Welding Receptacles	Ex-d	Ex-d	Ex-d	Ex-d
Lighting Fixtures ☐ Lighting Fitting	Ex-d Ex-d	Ex-d Ex-d	Ex-d / Ex-e* Ex-d	Ex-d Ex-d
Junction Boxes	Ex-d	Ex-d	Ex-e	Ex-d
Hand Lamps i) Light Fitting ii) Transformer	Ex-d Ex-d Ex-d	Ex-d Ex-d Ex-d	Ex-d Ex-d Ex-d	Ex-d Ex-d Ex-d
Lighting Panels / Power Panels	Ex-d	Ex-d	Ex-d	Ex-d
Break Glass Units (Fire Alarm System)	Ex-d	Ex-d	Ex-d	Ex-d

13.0 ELECTRICAL INSTALLATION

Electrical installation design shall be in accordance with IS 732.

14.0 CABLE LAYING:

Cable shall be laid in the cable trays / ladders as specified under clause 6. Segregation / Separation (cables): Emergency and Instrumentation systems cables shall as far as practical be routed away from normal services systems. Special consideration shall be given to the routing and segregation of cables, to minimize the effects of fire on emergency and essential supplies and production operation. Wherever practicable the cables for duplicate feeds and equipment shall run via separate routes to increase security of supply. In addition, the minimum distances between power / control wiring and electronic / signal wiring on prolonged cable routes shall be as follows

Power/Control Cables	Minimum Distance from
up to 125 V	250 mm
up to 300 V	500 mm
up to 1000 V	750 mm
above 1000 V	1250mm

14.1 LIGHTING AND SMALL POWER

Lighting:

All exterior lighting and general area lighting shall be provided according to good engineering practice. LED fixtures shall be used for outdoor lighting. Perimeter lighting shall be provided using LED lighting fixtures with suitable spaced at an interval. The lighting fixtures and other equipment shall be suitable for the area of classification in which they are located. The illumination levels shall be as covered in the specifications & IS 6665.

Small Power:

3-Phase and single-phase socket outlet systems shall be provided in the facilities for:

240V, 50 Hz, 1 phase, neutral and earth, 16A, 5 pin, domestic type outlets for the living quarters and for general purpose use in the CCR, Switchgear rooms, local equipment rooms, offices and workshops.

Socket outlets shall be provided in all switch rooms and CCRs for special test equipment.

All single-phase socket outlets shall be protected by 30 mA earth leakage circuit breakers. All other earth leakage protection requirements shall be identified on the basis of minimizing earth leakage protection where not required by statutory requirements, standards, or regulations to minimize nuisance tripping, and where reduction of such protection does not degrade safety.

Nameplates shall be installed at each receptacle clearly indicating source of supply, voltage and amperage.

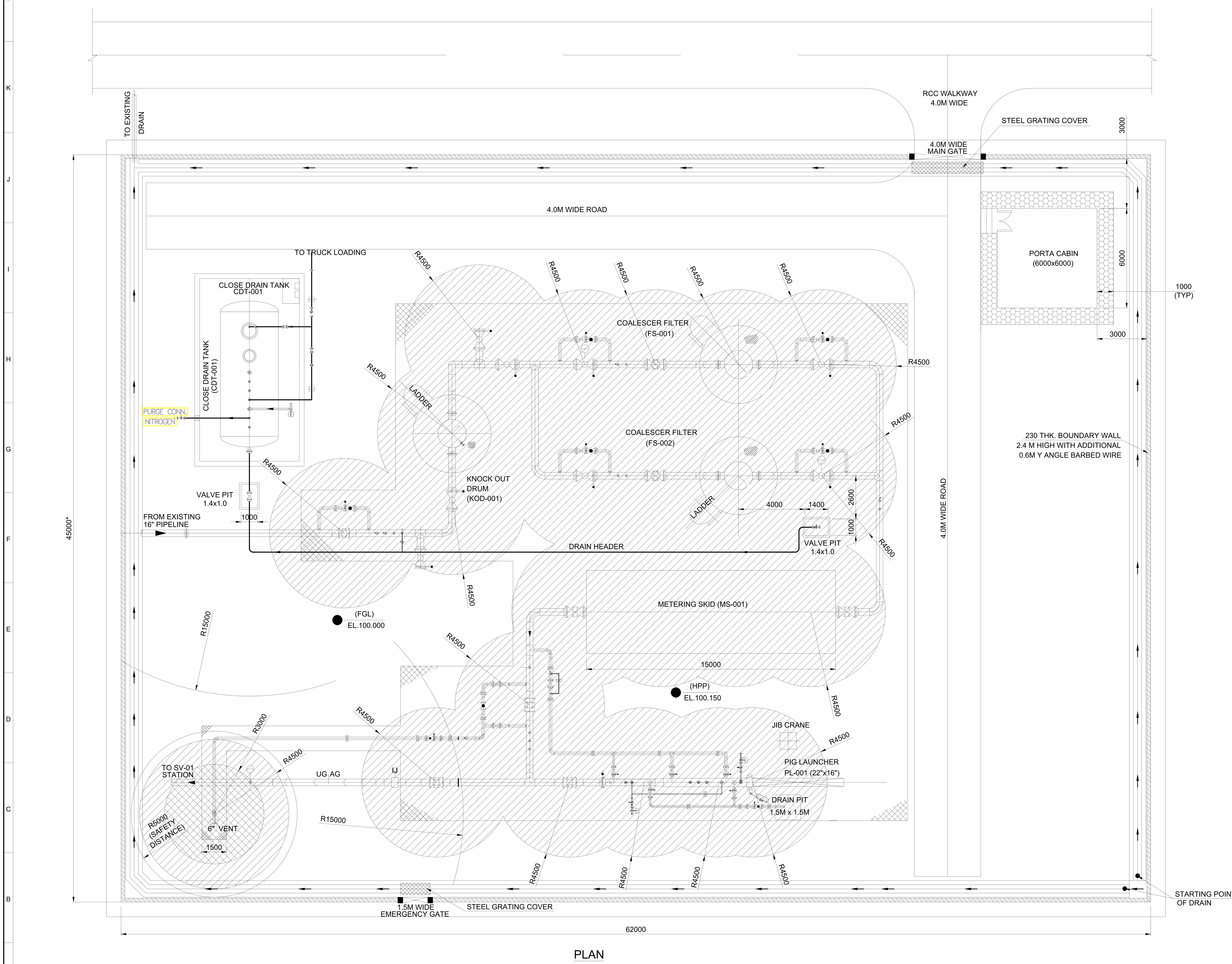
REFERENCE DRAWINGS	
DRAWING TITLE	DRAWING NUMBER

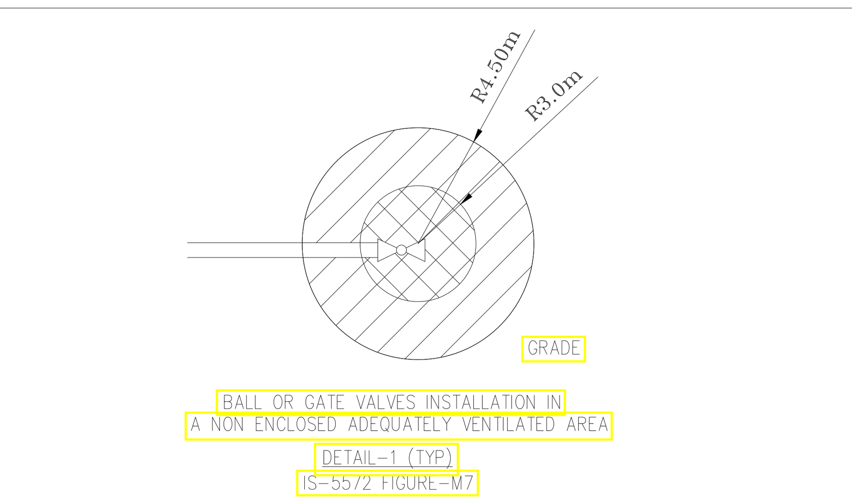
NOTES:-

1. ALL DIMENSIONS ARE IN mm, ELEVATION AND COORDINATES ARE IN M.
2. AREA NEAR VALVES DOOR SHALL HAVE A ZONE 1 CLASSIFICATION OF 1.5m RADIUS & AN ADDITIONAL ZONE 2 CLASSIFICATION OF 3m RADIUS AS PER IS 5572 & OISD-113 & 179.
3. THIS CLASSIFICATION IS IN ACCORDANCE WITH IS 5572 (2009) & OISD -113 & 179 (2013).
4. AREAS OUTSIDE THE CLASSIFIED BOUNDARIES ARE CONSIDERED AS UNCLASSIFIED AREA.
5. HAZARDOUS AREA EXTENT IS MEASURED FROM PERIMETER OF EQUIPMENT AND PACKAGE.

LEGENDS :-

- ZONE-0, GAS GROUP-IIA/IIB HAZARDOUS AREA, TEMP CLASS-T3
- ZONE-1, GAS GROUP-IIA/IIB HAZARDOUS AREA, TEMP CLASS-T3
- ZONE-2, GAS GROUP-IIA/IIB HAZARDOUS AREA, TEMP CLASS-T3
- UNCLASSIFIED AREA





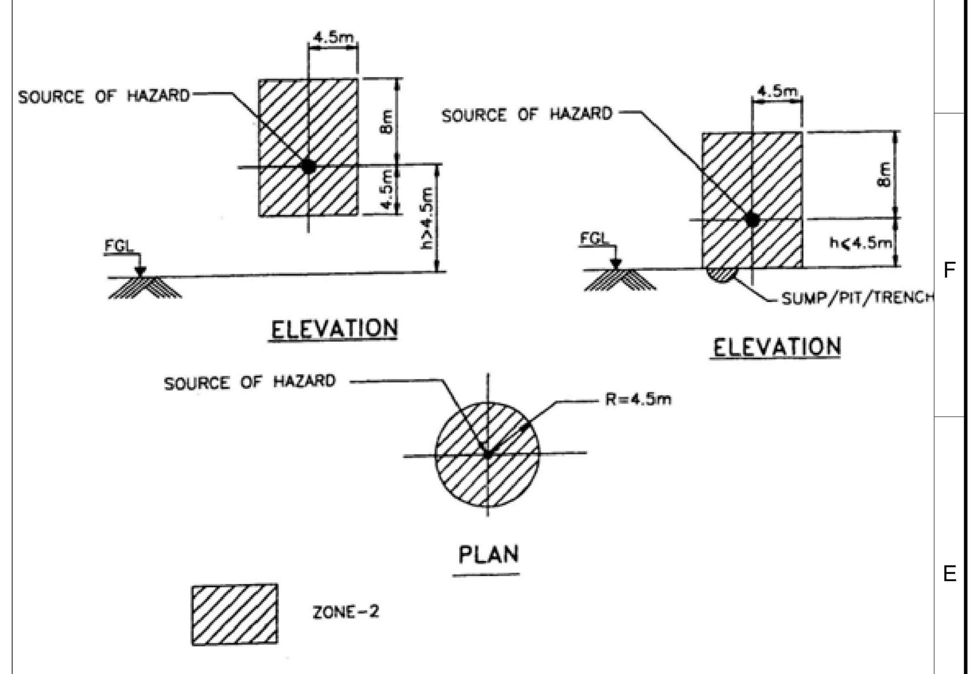


Fig. L1 Freely Ventilated Process Area (for Lighter-than-Air Gases or Vapours)

REV	DATE	DESCRIPTION	BY	CHKD	APPD

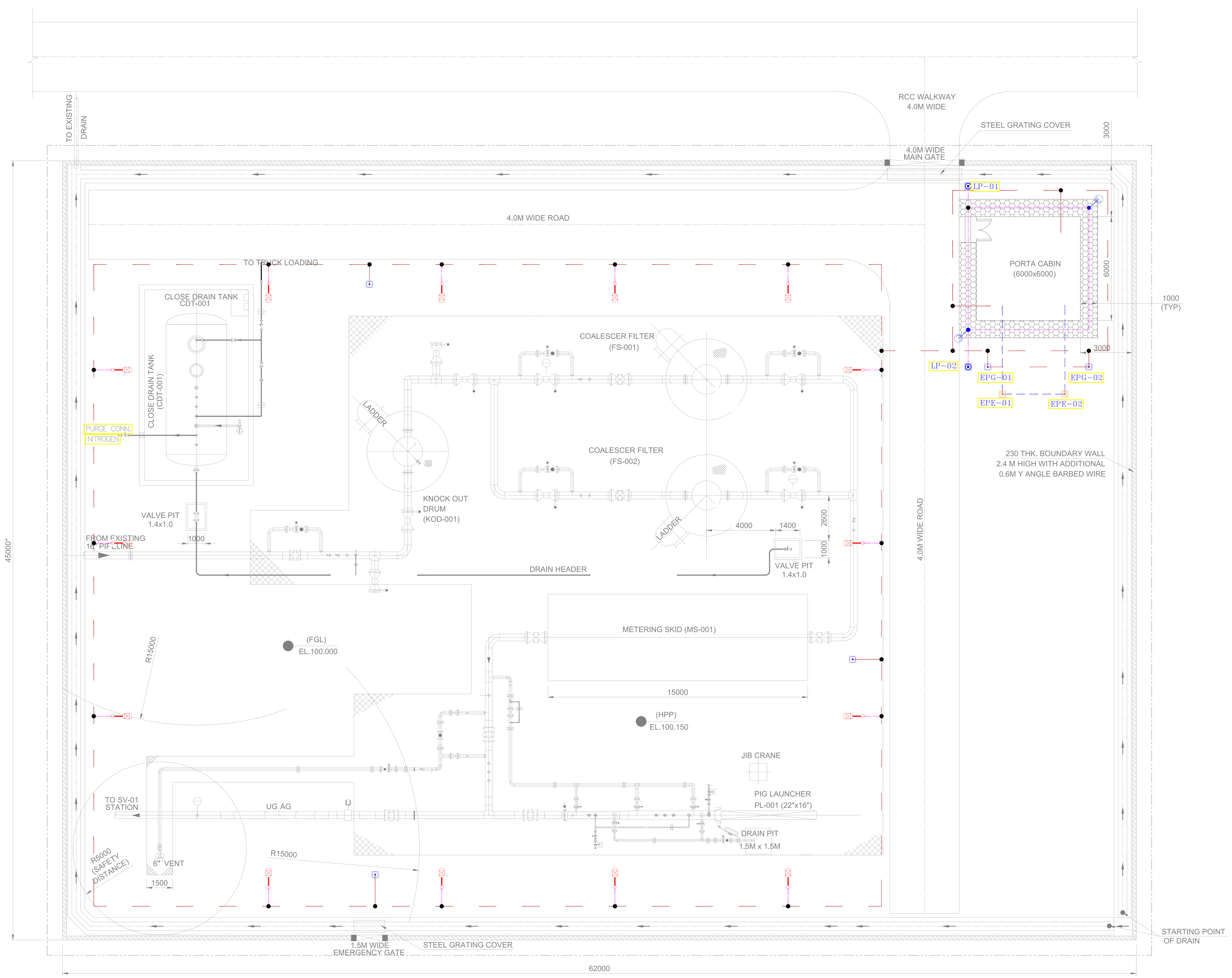
OWNER:

ENGINEERING CONSULTANT :
PIPELINE ENGINEERING CONSULTANTS PVT. LTD.

PROJECT:

DWG. TITLE :
TYPICAL ELECTRICAL HAZARDOUS AREA CLASSIFICATION

SCALE.	JOB NO.	DRAWING NUMBER	REV.



PLAN

REFERENCE DRAWINGS

DRAWING TITLE	DRAWING NUMBER

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS SPECIFIED OTHERWISE.
2. SHARP BENDS SHALL BE AVOIDED IN ALL GROUNDING CONDUCTORS. SURFACE SHALL BE THOROUGHLY SMOOTHED AND CLEANED BEFORE MAKING GROUNDING CONNECTION.
3. GROUND/EARTH STRIP SHALL BE BURIED AT THE DEPTH OF 600MM.
4. PIPE RACK AND PIPE SUPPORTS SHALL BE GROUNDED AFTER EVERY 30 METERS.
5. NON ELECTRICAL EQUIPMENTS EXPOSED TO LIGHTNING (TANKS, COLUMNS, TALL METAL STRUCTURE, LADDER, RAILING, GRATING, METALLIC GATES ETC.) SHALL BE CONNECTED TO MAIN EARTH GRID.
6. FENCING SHALL BE CONNECTED TO GROUND GRID AFTER EVERY 30 METERS DISTANCE.
7. G.I STRIP SHALL BE CROSSED ACROSS THE ROAD USING ELECTRICAL ROAD CROSSING PIPES.
8. JOINING OF G.I STRIPS SHALL BE DONE BY WELDING ONLY FOR BURIED PORTION. BOLTING MAY BE USED FOR ABOVE GROUND STRUCTURE.THE WELDED PORTION SHALL BE SUITABLY PAINTED WITH BITUMINOUS PAINT TO AVOID CORROSION.
9. RE-BAR OF CONCRETE FOUNDATION OF THE BUILDINGS/ COLUMNS SHALL BE EARTHED WITH STEEL COLUMNS/ G.I STRIPS OF 50X6 MM.
10. INSTRUMENTATION EARTH PITS SHALL BE CONNECTED TO MAIN ELECTRICAL EARTH PIT AT ELECTRODE LEVEL. INSTRUMENTATION EARTH PITS.
11. Al. LIGHTNING CONDUCTOR FROM LIGHTNING PITS TO BE CONNECTED TO DOWN CONDUCTORS FROM SHED / BUILDING COLUMNS.
12. ALL EARTHING TO BE EXTENDED AND CONNECTED TO THE EXISTING EARTH GRID.
13. ALL PROCESS EQUIPMENT SHALL BE EARTHED.
14. ALL EQUIPMENTS UPTO 250V AC SHALL BE PROVIDED WITH SINGLE EARTHING AND OTHER SHALL BE DOUBLE EARTHED.
15. ALL JOINTS IN ABOVE GROUND PIPELINES, VALVES AND OTHER ASSOCIATED FACILITIES SHALL BE MADE CONTINUOUS BY BONDING WITH EACH OTHER USING Cu. JUMPER CABLE ACROSS THE FLANGES. THESE PIPELINES SHALL BE EARTHED AT ENTRY/EXIT POINTS AT BATTERY LIMIT.
16. THE MARKED LOCATION OF PITS, EARTH STRIPS/ WIRE, EARTH BUS ETC. ARE INDICATIVE ONLY. THE EXACT LOCATION SHALL BE AS PER ACTUAL SITE CONDITIONS. THE EARTH STRIP/ WIRE SHALL BE ROUTED THROUGH CABLE TRENCHES AS MUCH AS POSSIBLE.
17. LIGHTING POLE SHALL BE EARTHED BY 25mmX6mm GI STRIP, CONNECTED TO MAIN EARTH GRID. ALL LIGHTING POLE JB SHALL BE EARTHED WITH 6mm Cu. CABLE (DOUBLE EARTHING).
18. FOR INSTALLATION DETAILS OF EARTHING SYSTEM, REFER STD DRAWING.
19. MINIMUM DISTANCE BETWEEN EARTH PITS AND CABLE TRENCHES SHALL BE 300MM.
20. JB FOR POWER CABLE TERMINATION OF E/H VALVES & MOVs SHALL BE EARTHED USING 25X6MM GI STRIP.
21. THE MIN. SIZES FOR CONNECTION OF ENCLOSURES OF ELECTRICAL/ NON ELECTRICAL EQUIPMENT SHALL BE AS BELOW:
   - SWITCHBOARD, STORAGE TANK AND COMPRESSOR - 50X6MM GI STRIP
   - LIGHTING POLES, DISTRIBUTION BOARD - 25X6MM GI STRIP
   - INSTRUMENT - 10MM² Cu. CABLE

LEGENDS :-

SYMBOL	MATERIAL DESCRIPTION
	1 X 100W LED FLP STREET LIGHTING FIXTURE, MOUNTED ON 6.0M GI OCTAGONAL POLE
	50 X 6 mm G.I EARTHING STRIP
	25 X 3 mm G.I EARTHING STRIP
	25 X 3 mm CU. EARTHING STRIP
	ELECTRICAL G.I EARTH PIT (EPG)
	INSTRUMENTATION, CU. EARTH PIT (EPE)
	PHYSICAL CONNECTION (WELDING/BOLTING)

REV	DATE	DESCRIPTION	BY	CHKD	APPD

OWNER:

ENGINEERING CONSULTANT :

PLECO

PIPELINE ENGINEERING CONSULTANTS PVT. LTD.

PROJECT:

DWG. TITLE :

TYPICAL ELECTRICAL OUTDOOR EARTHNG LAYOUT

SCALE.	JOB NO.	DRAWING NUMBER	REV.

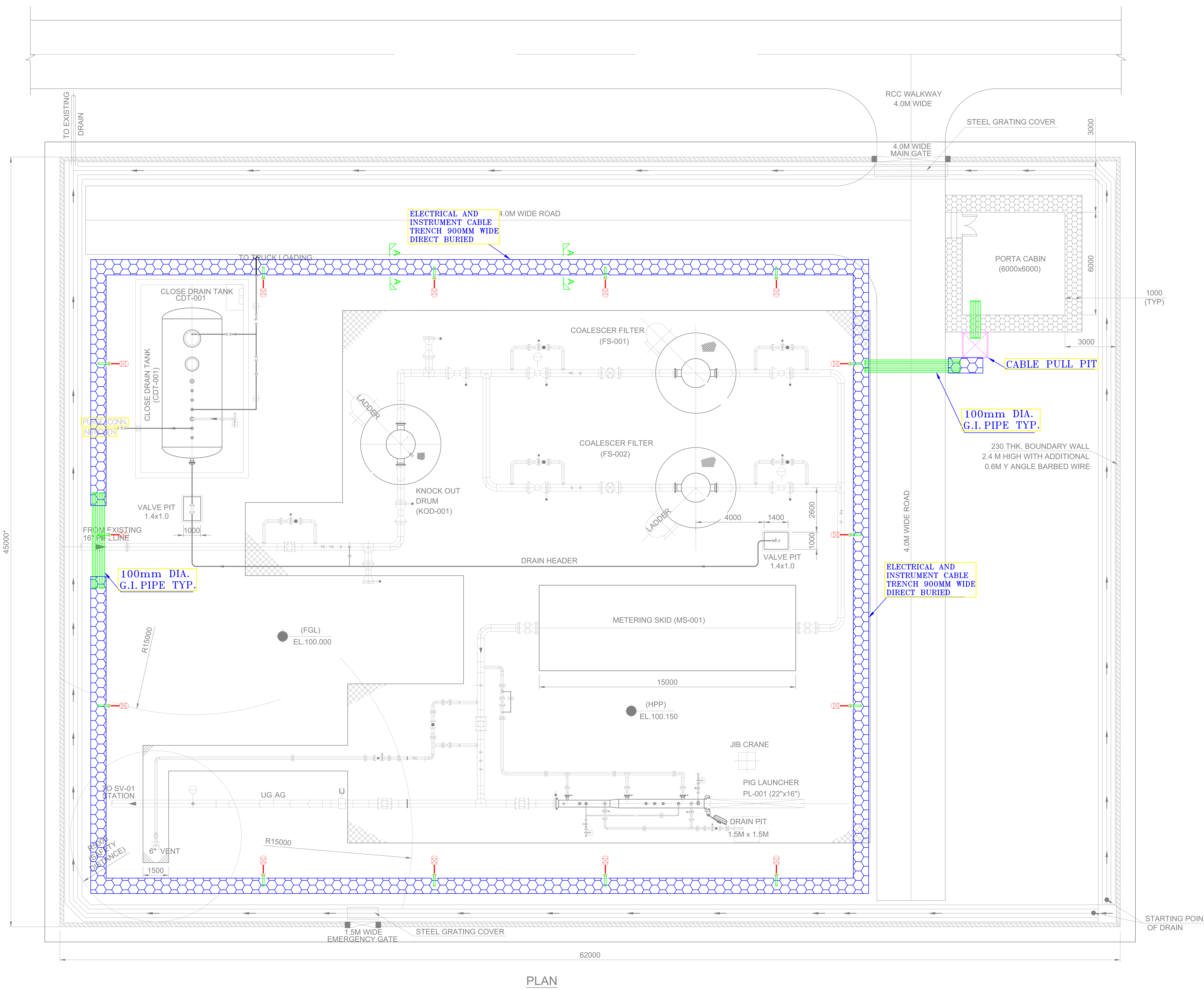
REFERENCE DRAWINGS	
DRAWING TITLE	DRAWING NUMBER

NOTES

1. ALL DIMENSIONS ARE IN MM & ELEVATION ARE IN METERS UNLESS NOTED OTHERWISE.
2. LIGHTING SYSTEM SHALL BE AS PER DB SOW & STD SPECIFICATIONS.
3. THE ILLUMINATION LEVELS SHALL BE MAINTAINED AS PER STD & DB.
4. EMERGENCY LIGHTS SHALL BE APPROXIMATELY 20% OF THE TOTAL PLANT OR AREA LIGHTING.
5. LIGHTING FIXTURES SHALL BE INSTALLED SUCH THAT THEY DO NOT OBSTRUCT OR IMPAIR THE CLEARANCE OF PASSAGEWAYS FOR PERSONNEL OR EQUIPMENT.
6. ALL OUTDOOR LIGHTING FIXTURES SHALL BE LED TYPE.
7. LOCATION / MOUNTING HEIGHT OF LIGHTING FIXTURES AND SOCKETS ARE INDICATIVE.FINAL LOCATION MAY CHANGE TO SUIT BEST AT SITE.
8. ALL UNUSED ENTRIES FOR LIGHTING FIXTURE AND JUNCTION BOXES SHALL BE PLUGGED PROPERLY WITH SUITABLE SEALING PLUGS.
9. THE LIGHTING JUNCTION BOX SHALL BE PROVIDED AT ACCESSIBLE HEIGHT.
10. OUTDOOR LIGHTING SHALL BE INSTALLED ON 6 mtrs. POLE .

LEGEND:-

SYMBOL	DESCRIPTION
	CABLE ROUTING
	100MM HUME PIPE
	1 X 100W LED FLP STREET LIGHTING FIXTURE, MOUNTED ON 6M HIGH POLE



PLAN

REV	DATE	DESCRIPTION	BY	CHKD	APPD

OWNER:

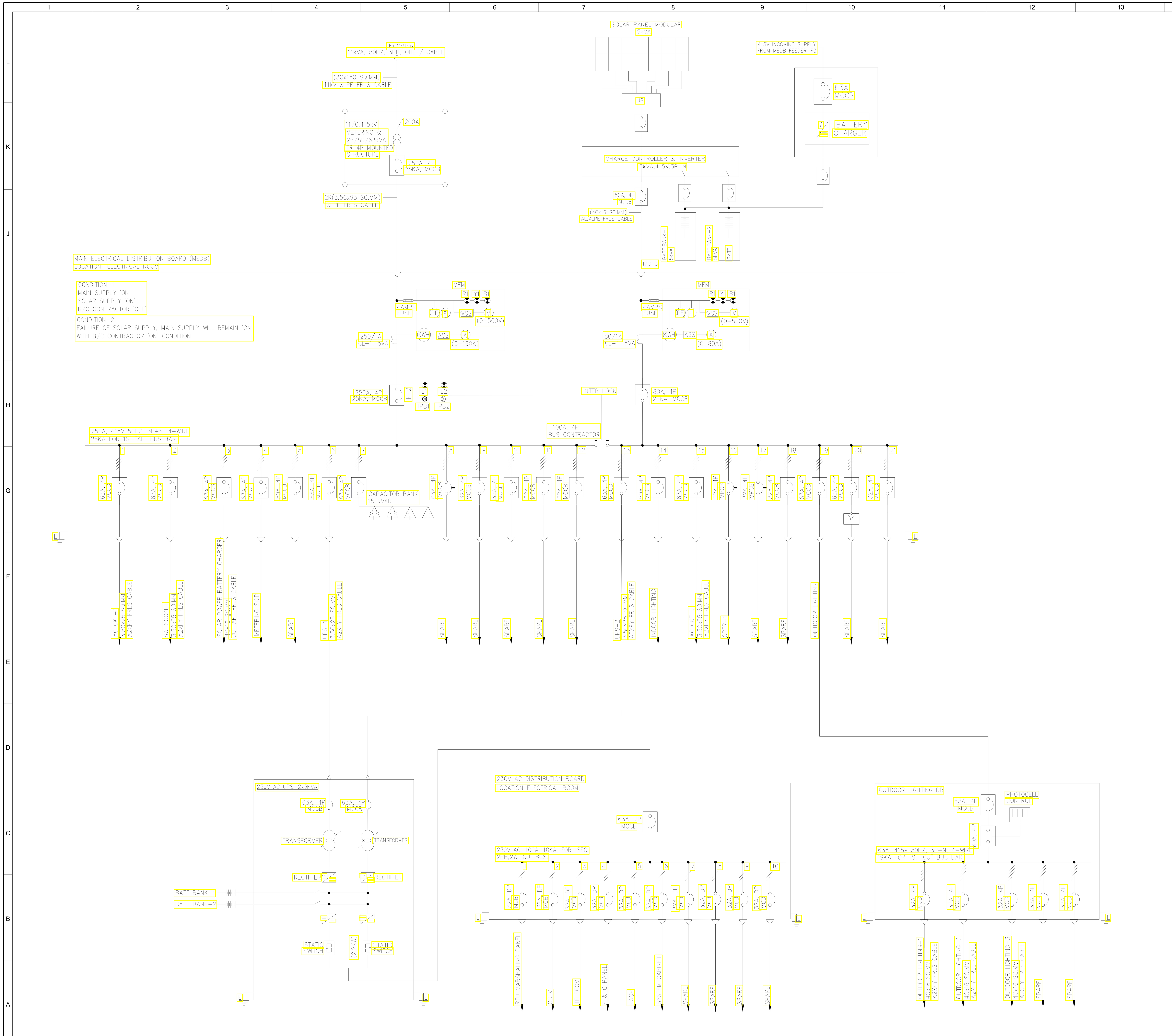
ENGINEERING CONSULTANT :

PLECO PIPELINE ENGINEERING CONSULTANTS PVT. LTD.

PROJECT:

DWG. TITLE : **TYPICAL ELECTRICAL OUTDOOR LIGHTING &CABLE ROUTING LAYOUT**

SCALE.	JOB NO.	DRAWING NUMBER	REV.



REFERENCE DRAWINGS

DRAWING TITLE	DRAWING NUMBER

NOTES :-

1. ALL ELECTRICAL EQUIPMENT BE TROPICALISED IN COMPLIANCE WITH LOCAL SITE CONDITION.
2. THE METERS INSTALLED IN SOLAR POWER SET LOCAL PANEL SHALL BE DIGITAL MULTIFUNCTIONAL METERS.
3. R.Y.B. INDICATIONS ARE FEED TO SCADA SYSTEM FROM MEDB FOR PANEL & SOLAR SUPPLY.
4. THE CAPACITOR BANK FEEDER SHALL BE USED FOR FUTURE POWER FACTOR IMPROVEMENT AS PER SEB REQUIREMENT.
5. THE SIZE OF ALL INSTRUMENTS SHALL BE 95mm x 95mm FOR FULL & HALF SIZE MODULES AND 72mm x 72mm FOR LOWER SIZE MODULES.
6. ALL AMMETER & VOLTMETERS SHALL BE DIGITAL TYPE AND OF CLASS 1.5 ACCURACY.
7. POWER & CONTROL CABLES SHALL BE 1.1W GRADE, STRANDED COPPER / ALUMINUM CONDUCTOR, PVC INNER SHEATH & PVC OUTER SHEATH WITH FRLS CHARACTERISTICS CABLES SHALL CONFIRM TO IS:7000.
8. THE CABLE SIZE ARE CALCULATED ACCORDING TO CABLE SIZING CALCULATION SHEET.
9. ALL INDOOR DB'S SHALL BE PROVIDED WITH IP53 PROTECTION AND FOR OUTDOOR IP55.
10. MCCB'S SHALL BE 3P, 25kA AND MCB'S SHALL BE DP, 10kA
11. CPTR UNIT SHALL BE CONSIDERED ACCORDING TO APPROVED PCP DESIGN.
12. THE INCOMER TO ILDB SHALL BE PROVIDED WITH EARTH LEAKAGE CIRCUIT BREAKER.
13. OUTDOOR LIGHTING DB SHALL BE PROVIDED WITH PHOTO CELL FOR AUTO CONTROL PHOTO CELL SHALL BE LOCATED AT THE TOP OF THE ROOF OF THE ELECTRICAL ROOM.

LEGENDS :-

S.NO.	LEGENDS	DESCRIPTION
1.	CP/TR	CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT
2.		RECTIFIER
3.		SWITCH
4.		BATTERY
5.		INVERTER
6.		INDICATION LAMP
7.		PUSH BUTTON
8.	F	FREQUENCY METER
9.	PF	POWER FACTOR METER
10.	V	VOLTMETER
11.	A	AMMETER
12.	KWH	ENERGY METER
13.	ASS	AMPERE SELECTOR SWITCH
14.	VSS	VOLTAGE SELECTOR SWITCH
15.	ELL	ELECTRICAL INTERLOCK
16.	SSVS	SOLID STATE VOLTAGE STABILIZER
17.		MCCB
18.		MCB
19.		MPCB
20.		CONTACTOR
21.		CURRENT TRANSFORMER
22.		ISOLATION TRANSFORMER
23.	MFM	MULTIFUNCTION METER
24.		EARTH
25.	O/L	OVER LOAD
26.	S/C	SHORT CIRCUIT
27.		NO. OF CORE IN CABLE
28.		STATING POINT
29.		ISOLATOR

REV	DATE	DESCRIPTION	BY	CHKD	APPD

OWNER:

ENGINEERING CONSULTANT :

PLECO PIPELINE ENGINEERING CONSULTANTS PVT. LTD.

PROJECT:

DWG. TITLE :

TYPICAL SINGLE LINE DIAGRAM

SCALE.	JOB NO.	DRAWING NUMBER	REV.