

**DARLIPALI SUPER THERMAL POWER PROJECT
PHASE-II (1X800 MW)
EPC PACKAGE**

**TECHNICAL SPECIFICATION
FOR
COMPRESSED AIR SYSTEM**

SPECIFICATION No. PE-TS-540-555-A001
REV. No. 00



**BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA, INDIA**



**TECHNICAL SPECIFICATION
DARLIPALI STPP PH-II (1X800 MW)
COMPRESSED AIR SYSTEM**

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Rev. No. 00

Date: AUG 2026

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PROJECT INFORMATION		
S. No.	DESCRIPTION	DETAILS
1	CUSTOMER	NTPC LTD.
2	LOCATION	Darlipali STPS is located in Sundargarh District of Odisha. Sundargarh is connected to Rourkela and Sambalpur by State Highway SH-10. The Project is located north of Raigarh – Jharsuguda National Highway, NH-200 and is approachable from Gandhi Chowk (near Brajrajnagar) through 15 Km long road. Nearest major town is Jharsuguda, located at a distance of 25 Km from the project.
3	METEOROLOGICAL DATA	
3.1	SUMMER OUTSIDE DBT	43 deg C
3.2	SUMMER OUTSIDE WBT	27.0 deg C
3.3	MONSOON OUTSIDE DBT	34 deg C
3.4	MONSOON OUTSIDE WBT	28 deg C
3.5	WINTER OUTSIDE DBT	11 deg C
3.6	WINTER OUTSIDE WBT	5 deg C
3.7	PEAK GROUND HORIZONTAL ACCELERATION (MCE), AS PER DVC SPEC	0.1*g
3.8	BASIC WIND SPEED	39 m/s
3.9	HEIGHT ABOVE MSL	230 m
4	ELECTRICAL DATA	
4.1	AMBIENT TEMPERATURE FOR DESIGN OF ELECTRICAL EQUIPMENT	50 deg C
4.2	RATED FREQUENCY	50Hz
4.3	FREQUENCY VARIATION	(+)3% to (-)5%
4.4	AC VOLTAGE	415V, 3 Phase
4.5	AC VOLTAGE VARIATION	+/-10%
4.6	SYSTEM FAULT LEVEL AT RATED VOLTAGE	50KA for 1.0 sec
4.7	SHORT TIME RATING FOR TERMINAL BOXES	50KA for 0.25 sec
5	ANALYSIS OF DMCW WATER TO BE USED FOR COMPRESSOR & DRYER COOLING	
	CHARACTERISTICS	VALUE
i)	SILICA (Max.)	0.01 ppm as SiO2
ii)	IRON as Fe	Not detectable
iii)	TOTAL HARDNESS	Not detectable
iv)	pH VALUE	6.8 to 7.3
v)	CONDUCTIVITY	Not more than 0.1 micro mho/cm at 25 DegC.
5.1	DESIGN DMCW INLET TEMP. TO VARIOUS COOLERS	38 deg C
5.2	COOLING WATER PRESSURE DROP ACROSS COMPRESSOR HOUSE	10 MWC

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SCOPE

SCOPE OF THIS PACKAGE COVERS THE FOLLOWING:		
S. No.	PARAMETERS	REQUIREMENT
1	Supply Including Design, Engineering & Manufacturing of	
a)	Main Supply	YES
b)	Commissioning Spares	YES
c)	Consumables	YES
2	Painting	YES
3	Inspection & Testing	YES
4	Packing	YES
5	Transportation & Delivery to Site	YES
6	Transportation, Handling & Storage in the Plant	YES
7	Erection & Commissioning	YES
8	Supervision of Erection & Commissioning	NO
9	Performance Guarantee (PG) Test	YES
10	Training of BHEL/Customer personnel	YES
11	Mandatory Spares	NO
12	Annual Maintenance Contract (AMC)	YES
13	Operational Spares	YES
14	Handover of CAS system	YES

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GENERAL TECHNICAL REQUIREMENT - MECHANICAL		
1.0	It is not the intent to specify herein all the details of design and manufacturing. Bidder shall ensure that the offered equipment confirms in all respects to high standards of design, engineering and workmanship.	
2.0	The equipment shall comply with all applicable safety codes and statutory regulations of India as well as of the locality where the equipment is to be installed.	
3.0	In the event of any conflict between the codes and standards referred to in the above clauses and the requirement of this specification, the requirement of Technical Specification shall govern.	
4.0	The equipment shall conform in all respects to high standards of design, engineering and workmanship and shall be capable of performing the required duties in a manner acceptable to purchaser who will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material which in his judgement is not in full accordance herewith.	
5.0	Drawing/document submission shall be through web based Document Management System. Bidder would be provided access to the DMS for drg/doc approval and training for the same. Bidder to ensure proper internet connectivity at their end.	
6.0	Transit Insurance & Insurance till receipt of MRC/ MDCC is in the scope of CAS supplier.	
7.0	Bidder shall carry out the inspection & testing as per the Quality Plan.	
8.0	Bidder shall submit stamped QP on compliance route in the event of order. In case, the bidder is supplying the item from outside India, the third party inspection shall be arranged and considered by the bidder in their offer.	
9.0	Sub vendor list is attached with the specification. Any additional sub - vendors proposed by bidder during contract stage shall be subject to BHEL & Customer approval in the event of order.	
10.0	Document approval by BHEL & Customer shall not absolve the supplier of their contractual obligations of completing the work as per specification requirement without any commercial and delivery impact.	
11.0	All hot vessels/pipelines/ valves shall be insulated to restrict the outside temperature within 60 deg.C or less with mineral wool (or equivalent), GI wire netting and aluminum cladding/cover.	
12.0	To clock equal number of running hours, sequential panel for the same is in CAS supplier scope.	
13.0	Instruments to be used for PG test shall be additionally supplied over and above the instruments shown in tender P&IDs. PG test Instruments being supplied, installed and commissioned for each unit, shall be retained by Customer after completion of PG test.	
14.0	Mandatory Spares: Wherever the quantities have been indicated for each type, size, thickness, material, radius, range etc., these shall cover all the items supplied and installed and the breakup for these shall be furnished in the bid. In case spares indicated in the list are not applicable to the particular design offered by the bidder, the bidder should offer spares applicable to offered design with quantities generally in line with the approach followed in the mandatory spare list (Refer Price Format attached elsewhere in the NIT).	
15.0	CAS supplier shall supply with the equipment one complete set of all special tools and tackles and other instruments required and other instruments for the erection, assembly, disassembly and proper maintenance of the plant and equipment and systems (including software).	
16.0	No material brought to the Site shall be removed from the Site by the CAS supplier and/or his Sub-supplier without the prior written approval of the BHEL & Customer.	
17.0	The Contractor shall establish an Office at the Site and keep posted an authorised representative for the purpose of the Contract.	
18.0	The CAS Supplier shall have total responsibility for protecting his works till it is finally taken over by BHEL. No claim will be entertained by BHEL for any damage or loss to the CAS supplier works and the CAS supplier shall be responsible for complete restoration of the damaged works to original conditions to comply with the specification and drawings.	
19.0	In addition to all local laws and regulations pertaining to the employment of labour to be complied with by the CAS supplier, also will be expected to employ on the work only his regular skilled employees with experience of the particular work. No female labour shall be employed after darkness. No person below the age of eighteen years shall be employed.	
20.0	All travelling expenses including provisions of all necessary transport to and from Site, lodging allowances and other payments to the CAS supplier's employees shall be the sole responsibility of the CAS supplier.	
21.0	The CAS supplier shall provide all the construction equipments, tools, tackles and scaffoldings required for pre-assembly, installation, testing, commissioning and conducting Guarantee tests of the equipments covered under the Contract.	
22.0	The CAS supplier shall have total responsibility for all equipment and materials in his custody stores, loose, semi-assembled and/or erected by him at Site.	
23.0	The work procedures that are to be used during the erection shall be those which minimise fire hazards to the extent practicable. Combustible materials, combustible waste and rubbish shall be collected and removed from the Site at least once each day.	
24.0	Void.	
25.0	All the Plant and equipments / Systems supplied under the contract shall be designed following "Fail Safe" concept. In case of failure of Power supply like Electric power, Hydraulic pressure, Pneumatic pressure, Vacuum etc. the system should be designed in such a way that the equipment/Valves/dampers etc. shall always move/remains (as applicable) to safest position as per system requirement to ensure safety of Man and Machinery.	
26.0	After Rev-0 comments, the drawing will be locked in the system. CAS supplier will review the Rev-0 comments within 7 days & furnish the Comment Reply Sheet (CRS) to Customer as an agenda point for TCM.	
27.0	It is responsibility of the CAS supplier to get all the drawings approved in the Category I & IV (as the case may be) and complete engineering activities within the agreed schedule. Any delay arising out of submission and modification of drawings shall not alter the contract completion schedule.	
28.0	All the first fill and the for the period as specified elsewhere in spec., topping requirement of consumables such as greases, oils, lubricants, servo fluids / control fluids etc. which will be required to put the equipment covered under the scope of specification into successful commissioning/initial operation and to establish completion of facilities shall be supplied by the CAS supplier. Suitable standard lubricants as available in India are desired. Efforts should be made to limit the variety of lubricants to minimum.	
29.0	All equipment name plates, instruction plates, etc. shall be bilingual with Hindi inscription first, followed by English. Alternatively, two separate plates one with Hindi and another with English inscriptions may be provided.	

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30.0	All primers/paints/coatings shall take into account the hot humid, corrosive & alkaline, subsoil or over ground environment as the case may be.		
31.0	Field Quality Plans will detail out for all the equipment, the quality practices and procedures etc. to be followed by the Contractor's "Site Quality Control Organisation", during various stages of site activities starting from receipt of materials/equipment at site.		
32.0	CAS supplier shall submit Field Welding Schedule for field welding activities. The field welding schedule shall be submitted to the Employer along with all supporting documents, like welding procedures, heat treatment procedures, NDT procedures etc. at least ninety days before scheduled start of erection work at site.		
33.0	Certification from OEM's authorized signatory that software offered, declaring that the all the offered software(s) had gone through the established software quality test and offered software is not of β -version and offered software is also free from all known bugs as on date of approval of systems documents by Customer as a part of quality documentation review and approval process during detail engineering.		
34.0	The manual shall be a two rim PVC bound stiff sided binder able to withstand constant usage or where a thicker type is required it shall have locking steel pins, the size of the manual shall not be larger than international size A3. 3 sets hard prints & 2 nos. CD of O&M Manual shall be provided by CAS supplier. Bidder has to ensure the connectivity of compressed air system with DDCMIS.		
35.0	All the materials stored in the open or dusty location must be covered with suitable weatherproof and flame-proof covering material wherever applicable.		
36.0	The consumables and other supplies likely to deteriorate due to storage must be thoroughly protected and stored in a suitable manner to prevent damage or deterioration in quality by storage.		
37.0	As the transit of compressor to project site and also the storage of Compressors at project site is in CAS supplier scope, CAS supplier shall ensure the protection of Compressors during transit and storage at site. A.) In order to prevent corrosion during shipping, following needs to be ensured and for this a note to be included in QAP's of Compressors. - Compressor to be tested with Oil (as per OEM recommendation), a film of which remains behind on shafts, gears and bearings. - Silica gel or equivalent adsorbent bags, to be placed inside compressor to absorb any traces of moisture. The compartments are closed off airtight as per OEM recommendation. - The vent holes are closed off with moisture repellent adhesive tape. - Instruments & Microprocessor panel is protected as per OEM recommendation. B.) Steps pre-installation - Periodically, renewing the silica gel bags/ equivalent material at least once in six months or as recommended by OEM, whichever is less. - Periodically, renewing the preservative oil-film by rotating the main drive coupling by hand during a few minutes in correct rotation direction, this will ensure re-distribution of oil film on bearings balls, rollers and drive gears. Same to be repeated at least once a month or as recommended by OEM, whichever is less. C.) Steps post-installation - Installation & commissioning of Sequential panel is must in order to avoid long idleness of compressors. - Automatic provision shall be provided to replace wet air inside compressor with the dry air as per OEM recommendation.		
38.0	Incase, any major fault/ failure occurs in Compressor & Dryer, CAS supplier shall visit project site and carry further course of action as specified in Annexure-A.		
39.0	The scope of service under training of Employer's engineers shall include a training module covering the areas of Operation & Maintenance. Training module shall enable these personnel to individually take the responsibility of operating and maintaining the system in a manner acceptable to the Employer. Training on Erection methodologies for all the Sub-packages, System and Equipment's associated with the EPC Package, including a visit to power plant construction site. The exact details, extent and schedule for training shall be as finalized during detailed engineering and shall be subject to Employer's approval. The scope of services under training shall also necessarily include training of Employer's Engineering personnel covering entire scope for the package. This shall cover all disciplines viz, Mechanical, Electrical, C&I, QA etc. and shall include all the related areas like Design familiarization, training on product design features and product design software of major equipment and systems, engineering, manufacturing, erection, commissioning, training on operating features of equipment, quality assurance and testing, plant visits and visits to manufacturer's works, exposure to various kinds of problems which may be encountered in fabrication, manufacturing erection, welding etc. In all the above cases, the lodging and boarding of the Employer's personnel shall be at the cost of Bidder. The Bidder shall make all necessary arrangements towards the same. For training purposes, 15 working days (excluding all intervening holidays) per person shall be provided. Location of classroom training for engineering shall be at Design/Engineering office. Classroom training for erection/O&M shall be at location of Manufacturers' works.		
40.0	The bidder scope covers the Annual maintenance contract (AMC) for Preventive / Breakdown maintenance of Compressed air system (Refer Annexure-A).		
41.0	EXCLUSIONS		
	Compressor House – Civil Building		
	Pipe trench		
	EOT Crane - 8T capacity		
	Power Cable, lugs & glands at BHEL end equipment		
	Ventilation		
	Fire Protection		
	GENERAL TECHNICAL REQUIREMENT - C&I		
1	Complete C&I system for Compressed Air System is in bidder scope of supply. Items not specifically mentioned however required for the completeness of the system shall be supplied by bidder.		
2	Integrated microprocessor based control system along with suitable operator interface shall be provided for each Instrument Air Compressor, Service Air Compressor & their Dryers. All instruments like PT, DPT, TT, and other instruments outside the compressor skid those shall be hooked-up to BHEL DCS system shall be Profibus type. Instruments within skid shall be as per OEM standard. Further, critical signals shall be monitored through soft link between combobox (used for integrating the soft communication among various compressors) and DCS (DCS in BHEL scope). MODBUS Protocol shall be used to establish connectivity with DCS. In addition to the soft link, provision for hardwired START, STOP and LOAD & UNLOAD commands from DCS to all the compressors & their status feedbacks to DCS shall also be provided. Bidder to furnish the configuration diagram of control system of compressor showing communication with DCS along with the bid. Bidder to furnish signal exchange list (Annexure-E) between DCS and compressed air system in BHEL format attached elsewhere.		
3	Compressors operation and bearing temperature / vibration monitoring in main DCS shall be through redundant bus serial link interface between Compressor control system and DCS.		
4	Instruments used for PG test: The control system and devices (Actuators, instruments) shall be conventional for this areas/application. Scope of supply of PG test instrument, if applicable, shall be in bidder's scope.		

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5	Bidder to provide Profibus PA protocol compatible PT (Pressure Transmitters), DPT (Differential Pressure Transmitters), TT (Temperature Transmitters) and Flow/Level Transmitters (DP type) for entire Compressed air system (CAS). Instruments within skid area are acceptable as per OEM standard subjected to Customer approval during detail engineering.	
6	VOID	
7	Profibus based electronic positioner (as per standard and proven practice of valve OEM) is to be provided with all the pneumatically operated control valves (if applicable).	
8	The Profibus protocol design shall be further validated by BHEL and approved by Customer during detailed engineering and any variation/changes required based on DDCMIS system requirements and actual field installation, operational philosophy etc. shall be considered by bidder without any implications.	
9	The scope of C&I cable shall be referred in Electrical scope split sheet in Electrical portion of the specification. FO Cable from Combox to DCS for softlink shall be in BHEL scope.	
10	Bidder to include all the instruments required for the package along with fittings, accessories and valve manifold. All fittings shall use metric threads. Use of process actuated switches shall be avoided unless unavoidable.	
11	Vibration monitoring system (VMS) for HT motors is in BHEL scope. Bidder to provide provisions in compressor canopy for cable & access for mounting of probe/ sensors at motor DE & NDE by BHEL at project site. VMS for centrifugal compressors is in bidder's scope and signals for the same shall be terminated in compressor panel for control and monitoring purpose. VMS for centrifugal compressors shall be as per OEM recommendation.	
12	Bidder to note that Profibus DP based IMC in LV SWGR/MCC shall be provided by BHEL.	
13	Redundancy of instruments to be provided by bidder shall be as follows :- (i) Triple redundancy for all analog and binary inputs required for protection of system/drives. (ii) For all other control functions outside skid, dual redundancy of the sensors shall be provided by the bidder.	
14	Bidder to provide Junction Boxes in field for termination of all the instruments.	
15	Bidder to note that all transmitters (except Profibus compatible transmitters) shall be smart type and shall have 4-20mA DC signal with superimposed digital communication (HART).	
16	Bidder to provide at least 20% spare terminals in Junction boxes, LIE/LIRs etc.	
17	All the transmitters supplied by Bidder shall be LIE/LIR mounted. The LIE/LIRs shall be in bidder's scope of supply.	
18	All the instruments having contact with corrosive media shall be provided with chemical/diaphragm seal.	
19	For transmitters, electronics items etc. all weather canopy/ rack enclosures shall be provided by Bidder for protection from direct sunlight and rain for open locations. For applications where transmitter location is not accessible, the transmitter shall have separate sensor unit and electronic unit for such applications. It should be mounted at accessible location.	
20	All field instruments/analyzers/actuators/sov/control valves etc. shall be hooked with DDCMIS based control system as per requirement mentioned elsewhere in the specification.	
21	The necessary root valves, impulse piping, drain cocks, gauge-zeroing cocks, valve manifolds and all the other accessories required for mounting/erection of these local instruments shall be furnished, even if not specifically asked for, on as required basis. Double root valves shall be provided for all pressure tapping where the pressure exceeds 40 Kg./sq.cm.	
22	All measuring instruments/equipment/analysers and subsystems offered by the Bidder shall be from reputed experienced manufacturers (from BHEL/customer approved vendor list) of specified type and range of equipment, whose guaranteed and trouble free operation has been proven. Further, all instruments shall be of proven reliability, accuracy, and repeatability requiring a minimum of maintenance and shall comply with the acceptable international standards.	
23	VOID	
24	230 V AC UPS/ 415 V AC power supply shall be provided by BHEL at single point. Further, distribution to various instruments/equipment of the system shall be in bidder's scope. Bidder to include necessary power distribution board in his scope. Any power supply other than the above, if required by any instrument/equipment has to be derived by the bidder from the above supply & all necessary hardware for the same shall be in bidder's scope. Further, bidder to furnish UPS load data during detailed engineering in BHEL format.	
25	VOID	
26	Bidder to perform tests of C&I items/instruments/systems as per Quality plans/type test attached in the specification.	
27	The instruments,equipment offered by the bidder shall be as per the approved sub-vendor list mentioned elsewhere in the specification.	
28	Bidder's presence is required for 3 Man days (Excluding travel time) at EDN Bangalore during FAT of DDCMIS for certifying correctness & completeness of implementation of Control logic. Intimation regarding FAT shall be given 2 days in advance. All the expenses like boarding, lodging and travel, air fare etc. shall be in bidder's scope.	
29	Bidder's presence is required for 15 Man days (in two visits) at site during commissioning of DDCMIS for assistance related to process correctness. Three visits shall be made with total 10 Man days (excluding travel time) in which one visit shall be of 5 man days each. All the expenses like boarding, lodging and travel, air fare etc. shall be in bidder's scope.	
30	Bidder shall furnish Instrument Schedule, Control Scheme, I/O list, Drive list, Cable Schedule, Cable interconnection, Instrument/SOV/Analyzers Installation diagram, Instrument/Analyzer datasheets, JB grouping, SOV grouping, Annunciation list, List of Instruments/devices for Profibus/HART, configuration diagram for Profibus based actuators/instruments in BHEL approved format. Also, editable database format like MS Excel, MS Access etc. of these documents shall also be provided by bidder.	
31	Bidder shall provide complete Instrumentation for control, monitoring and operation of entire CAS package. The requirements given are to be read in conjunction with detailed Technical specification. Further, in case of any discrepancy in the requirement, the more stringent requirement as per interpretation of BHEL/customer shall prevail without any commercial implication.	
32	All electric actuators, pneumatic control valves, Junction Boxes, Solenoid boxes and Local control panels which are not installed inside building, suitable canopy shall be provided and design of canopy shall be submitted during detailed engineering for approval to BHEL/Customer.	

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33	Local Instrument Enclosures (LIEs) and Local Instrument Racks (LIRs) complete with all fittings, mountings & accessories, drains and Utility Lighting, Cable & Grounding cable etc. shall be provided by the bidder. The Degree of Protection of LIE and JB of LIE/LIR shall be IP-55. The instrument racks shall be constructed from 1.6 mm sheet plate and shall be free standing type constructed of suitable 3 mm thick channel frame of steel and shall be provided with a canopy to protect the equipment mounted in racks from falling objects, water etc. The canopy shall not be less than 3 mm thick steel and extended beyond the ends of the rack.	

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SPECIFIC TECHNICAL REQUIREMENT - MECHANICAL		
1.0	The compressed air system shall consist of Instrument Air compressors, Air Drying Plants (ADPs), Service Air compressors, Air receivers, interconnecting compressed air piping, cooling water piping, drain piping, fittings, valves, instruments, compressor & dryer inbuilt micropocessor control panels, sequential panel in the compressor house.	
2.0	Three (03) numbers (2 working+ 1 standby) oil free, rotary screw/centrifugal type air compressors for instrument air duty for the complete plant each of 55Nm ³ /min. capacity & 8.0 kg/cm ² (g) discharge pressure with intercooler, aftercooler, lubrication system, automatic drain traps (zero purge loss type) and other accessories. Motor shall be free issued by BHEL at compressor supplier's works.	
3.0	Three (03) numbers (2 working + 1 standby) Air Drying Plants (one for each instrument air compressor) of 55 Nm ³ /min. capacity with all interconnecting piping, valves, fittings, etc. The Air drying plant, at its rated capacity, shall be designed to deliver continuously air at dew point of minus (-) 40 deg C at atmospheric pressure and the Quality of dry outlet air to conform to Instrument Society of American Standard S7.3 "Quality Standard for Instrument Air". Discharge pressure available at the outlet of Air drying Plant shall be minimum 7.5 Kg/cm ² (g).	
4.0	Two (02) numbers (all working) oil free, rotary screw/centrifugal type air compressors for service air duty for the complete plant each of 55Nm ³ /min. capacity & 8.0 kg/cm ² (g) discharge pressure with intercooler, aftercooler, lubrication system, automatic drain traps (zero purge loss type) and other accessories. Motor shall be free issue by BHEL at compressor supplier works. In addition, the service air (SA) compressor may be used for instrument air system connecting ADP with service air compressor in case of failure of instrument air compressor.	
5.0	Air Receivers - The design pressure and temperature shall be minimum 10 Kg/cm ² (g) and 50 deg.C respectively. Receivers shall be designed in accordance with Section VIII, Division 1 of ASME Code or equivalent. Relief valves shall be provided to suit compressor capacity and set pressure of the same shall be atleast 10% above working pressure. The spring in relief valve shall not reset for any pressure more than 10% above or below the design set pressure. Each receiver shall be provided with pressure indicator, temperature indicator and drain connection with electrically operated automatic drain trap arrangement with isolation and bypass valves. The drain trap shall be timer based. Manual draining facility shall also be provided in the drain trap. The material of construction of shell, dished ends, flanges, etc of the air receivers shall be of carbon steel as per IS:2062 or equivalent.	
5.1	One number of air receiver of minimum capacity 10 m ³ at the discharge of each air compressor (Total: 05 numbers).	
5.2	One number unit air receiver of minimum capacity 10 m ³ for each unit to be located in TG building. (Total: 01 numbers). Height of Unit air receiver shall be limited to 4M.	
5.3	One number unit air receiver of minimum capacity 10 m ³ for each unit to be located near ESP Buffer Hopper Area for Ash Handling System. (Total: 01 numbers).	
5.4	One number (1) of air receiver of minimum capacity 10 m ³ for Fly ash storage Silo area and Ash classification system to be located near Silo Utility building.	
5.5	One number (1) of air receiver of minimum capacity 02 m ³ for DM plant to be located in Water Treatment Area.	
6.0	All the equipments shall be designed for continuous duty as well as for intermittent operation. Frequent start/stop of the system shall neither result deterioration in performance nor damage to the equipment.	
7.0	The compressors and Air Drying plants shall operate under the following ambient conditions. i. Minimum temperature : 10 deg. C ii. Maximum temperature : 50 deg. C iii. Design condition (Temperature : 45 deg.C & 75% RH) iv. Height above MSL (m) : 230 M	
8.0	The condensate drainage system of air compressors & air drying plant must be designed to handle the maximum possible moisture load generated when ambient humidity reaches 85% during monsoon.	
9.0	The compressor capacity & discharge pressure of instrument air system and service air system shall be identical.	
10.0	The heat exchangers are DMCW cooled and the maximum cooling water temperature at compressor coolers inlet shall be 38 deg. C. The temperature rise of cooling water in the heat exchangers of the Compressed air system shall be limited to 5-10 deg C. Pressure drop in cooling water network (inlet T.P. to Outlet T.P.) within Compressor house shall be limited to 10MWC.	
11.0	Noise level shall not exceed 85 dBA to a reference level of 0.0002 microbar when measured at a distance of 1.5 meter above the floor and 1m horizontal distance. Required acoustic enclosures may be provided to meet the above condition. The discharge blow-off silencer and intake silencers shall be designed to meet the above noise limitation level. For eventual noise, from the discharge line, accessories and/or ancillary equipment which are not included, a correction factor of (+) 8 dBA maximum shall be allowed for background & ambient noise.	
12.0	Vibration level of screw compressor shall be as per VDI-3836. However, velocity vibration shall be limited to 10 mm/sec (rms). Vibration level of centrifugal compressor shall be as per manufacturer standard & proven practice.	
13.0	Air Compressors (Screw /Centrifugal type) shall be designed for continuous operation with high efficiency to satisfy the performance requirement. As more than one compressor with drive is specified, satisfactory operation in parallel shall be ensured without any uneven load sharing, undue vibration, keeping noise level within permissible limits for a number of compressors working simultaneously in the same room. Parallel operation of compressors shall be possible without any undue vibration and noise.	
14.0	The flow in compressed air piping shall be designed for the design capacity of each compressor (FAD) and the flow in header and ring mains to be designed for the total capacity of working compressors & dryers. Similarly, the flow in cooling water piping shall be designed for the design capacity of each compressor/dryer and the flow in header and ring mains to be designed for the total capacity of working compressors & dryers.	
15.0	All hot vessels/pipelines/ valves shall be insulated to restrict the outside temperature within 60 deg.C or less with mineral wool (or equivalent), GI wire netting and aluminum cladding/cover by bidder.	
16.0	The canopy (Centrifugal/ Screw compressor) shall be designed to cater the load of air filter with 100% choked condition.	
17.0	SCREW AIR COMPRESSORS	

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17.1	CODES AND STANDARDS - The design, manufacture, testing and performance of the various components of the rotary screw type air compressors shall comply with the requirements of relevant codes (IS-5456, IS-10431 [part -1], ASME PTC-9, IS-6206, IS-5727, ISO-1217 and CAGI).	
17.2	DESIGN AND CONSTRUCTION	
a.)	The compressor shall be oil free multistage, horizontal, water cooled, rotary screw type, heavy duty, rugged construction. Their speed shall be so selected as to result in low maintenance and trouble-free operation under specified conditions.	
b.)	Each compressor unit shall be complete with electric motor drive of suitable capacity. Driver rating shall be minimum 110% of compressor rated BkW at rated conditions.	
c.)	The rotor and shaft shall be made of forged steel. The stator (casing) shall be of Cast-Iron (IS-210) construction with integral jacket cooling. The rotors shall be dynamically balanced to reduce vibration.	
d.)	The seal rings and retainers shall be of stainless steel construction and be free for radial self adjustment along the rotor shafts.	
e.)	Bearings shall be high precision antifriction type IS- 25 Grade 84). The axial thrust load shall be minimized by dividing the axial load of compression on the main and auxiliary bearings through suitable balancing arrangement.	
f.)	Lubrication system shall be as per manufacturer standard practices.	
g.)	Any superior material & type (as per proven practice and relevant standard) of various components of screw compressor is also acceptable.	
h.)	Gears shall have a rating of AGMA-12 or equivalent. Speed increasing gears between the motor and compressor stages shall consist of a common helical gear driving the pinion of each stage. Helical timing gears shall be mounted on the rotor shafts to maintain accurate relative rotor position.	
18.0	CENTRIFUGAL AIR COMPRESSORS	
18.1	CODES AND STANDARDS - The design, manufacture, testing and performance of air compressors and accessories shall comply with the requirements of one or more of the relevant codes as applicable (IS-2825, IS-4503, CAGI, IS-5727, IS-6206, ASME-PTC-10, API 672 and IS-11727).	
18.2	DESIGN AND CONSTRUCTION	
a.)	Each compressor unit shall be complete with electric motor drive of suitable capacity. Driver rating shall be minimum 110% of compressor rated BkW at rated conditions or BkW at unthrottled minimum ambient temperature whichever is higher	
b.)	Air Compressors shall be oil free centrifugal air compressors with non-contact air/oil seals, each capable of delivering continuously rated volume flows at rated delivery pressure. Compressor components shall be interchangeable as far as possible.	
c.)	The rotor shaft shall be made of Stainless Steel. The rotors shall be dynamically balanced to reduce vibration. The gaskets shall be of asbestos free material. Any superior material & type (as per proven practice and relevant standard) of various components of screw compressor is also acceptable.	
d.)	Each compressor shall be provided with Inlet Guide Vane (IGV) control for suction air volume control.	
e.)	Each compressor shall be provided with coupling guard with fixing arrangement.	
f.)	Proper and robust supporting arrangement shall be provided from foundation/ floor for overhang casing, oil coolers, air piping, cooling water piping, oil piping, etc.	
g.)	Compressors shall be provided with adequate safety, protection control system including anti surge protection with bypass valve etc. and auto dual control (either; controlled for constant pressure or constant volume flow). The duty points shall be at least 15% away from the anti surge line.	
h.)	Compressor shall have 25% minimum turndown capability (at 45 deg C & 75% RH). Compressor shall be provided with IGV at the suction flange.	
19.0	INTERCOOLER, AFTERCOOLER & OIL COOLERS (FOR SCREW/CENTRIFUGAL)	
a.)	Intercoolers & after coolers shall be designed in accordance with Section-VIII, Division 1 of ASME Code or equivalent.	
b.)	Outlet temperature of air from intercooler shall be suitable to suit the equipment and outlet temperature of air from the compressor house outlet header shall be limited to 45 deg.C. Design pressure of coolers shall be 10 Kg/cm ² (g).	
c.)	Coolers shall be provided with removable tube bundle design in accordance with design code TEMA Class C and shall be constructed with removable shell cover. However, plate type oil coolers as per OEM standard & proven design are also acceptable.	
d.)	The coolers shall be designed for maximum heat load and atleast 10 percent design margin shall be provided in the number of tubes.	
e.)	Adequately sized safety valves shall be provided for both intercoolers and after coolers. However, in case of centrifugal compressors, safety provisions as per manufacturer's standard & proven design are also acceptable.	
f.)	Each intercooler and aftercooler shall be provided with moisture separator units with suitable baffling. Moisture separator units shall be equipped with a level gauge glass with isolating cock.	
g.)	Electrically operated automatic drain trap stations with bypass and isolating valves shall be provided for moisture separators for automatically draining of condensed moisture. The drain trap shall be timer based. Manual draining facility shall also be provided in the drain trap.	
h.)	Cooler shells, channels and covers shall be of carbon steel (SA 285 Gr C / SA 516 Gr 70). Tube sheet shall be of Brass or SS and the tubes shall be of Admiralty brass or Aluminium brass or Copper or SS 304. However, any superior material as per proven practice and relevant standard is also acceptable.	
20.0	INTAKE AIR FILTER AND SILENCER - Filters with multiple elements quick removal type for easy cleaning shall be provided at suction of each air compressor and also be of heavy-duty dry type. The filters shall be complete with integral silencers. Separate silencers, if specified, shall be provided. The filtering elements shall be easily removable for cleaning. The filters shall be designed for an efficiency of not less than 99% for particles 2 microns and larger.	
21.0	AIR DRYING PLANT	
a.)	Hot unsaturated compressed air shall be used for regeneration of exhausted desiccant in Heat of compression type ADP. Regeneration of desiccant shall be achieved by Heat of compression method without any air purge loss.	

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b.)	Each ADP shall be provided with two adsorber towers each sized for design drying cycle of minimum 8 hours. After this period, the adsorber tower which was under drying mode shall be put under regeneration/reactivation mode while the other tower will take over the drying duty. The change of drying mode to reactivation mode or vice-versa shall be automatic with provision for manual operation also. The change over from one mode to another shall be through automatic solenoid operated valves.	
c.)	HOC type drier, the reactivation shall be achieved by the heat of the compressed air itself. The hot unsaturated compressed air from the outlet of last stage of compressor shall be passed through the adsorber tower. The moist air shall be cooled in dehumidifier and passed through the second adsorber for final drying. The design reactivation cycle/period of the tower shall be less than 8 hours including cooling period for desiccant for both the types of ADP.	
d.)	Each ADP shall be provided with two (2) numbers of 100 percent capacity pre-filters and two (2) numbers of 100 percent capacity after-filters at the upstream & downstream of towers. The filtering media shall be of ceramic candle type elements designed to withstand atleast 50% of static pressure as differential pressure. However, as per manufacturer's standard & proven design, any superior material to the material specified is also acceptable. The prefilters shall be provided with automatic electrically operated drain trap arrangement with isolation and bypass valves.	
e.)	The electric heaters (if required) (2x100% capacity for each ADP) shall be provided with thermostatic control for heater and relief valve for safety and shall be flanged type to facilitate easy replacement of element. Each electric motor driven blower (2x100% capacity for each ADP) shall be provided with individual dry type filters at inlet.	
f.)	The adsorber tower shall be designed with sufficient cross-sectional area resulting low air velocity and pressure drop. Minimum 20% of desiccant depth shall be provided as free board in adsorber vessels. Adsorber vessels to be provided with suitable number of inspection/sight windows of "Persplex" for observation of adsorbent condition. Desiccant filling and removal connections shall be provided for the adsorber vessels.	
g.)	The coolers/heat exchangers/ dehumidifiers of ADP shall be designed & constructed as per the requirements specified for "Intercoolers, After coolers & Oil coolers" above.	
h.)	All pressure vessels such as pre-filters, after-filters, adsorber vessels, heaters, heat exchangers/de-humidifiers / coolers etc associated with ADP shall be designed in accordance with Section-VIII, Division 1, of ASME Code or equivalent. The pressure vessels shall be provided with air tight gasketed manholes/handholes and relief valves.	
i)	Quantity of desiccant to be calculated shall take into account residual moisture content at the end of regeneration cycle.	
j)	Desiccant shall be activated alumina only and adsorption capacity and density of the same shall not be more than 8% and 900 kg/m3 respectively.	
k)	In case of Heat of compression type, adsorbers shall be sized so that even when the compressor is operating at part load, complete regeneration shall be achieved within the cycle time and quality of air (dew point) shall be maintained throughout the design cycle period. Complete ADP equipments shall preferably be mounted on a skid. Required sample connections in piping be provided for sampling of air at desired locations.	
l)	Non-lubricated two way / three way / four way valves ball valves with pneumatic actuators be provided. The material of Construction for various components of ADP shall be as per manufacturer's proven standard.	
m)	HOC dryers of single rotating drum type design using packed desiccant with in-built regeneration and adsorption compartments are also acceptable in place of specified twintower type dryers, if the design ensures specified performance guarantee. In case, the CAS supplier offers such a type, the same shall be of proven design. The control & instrumentation requirements specified is applicable for such design also.	
22.0	CONTROL PHILOSOPHY	
22.1	The CAS supplier shall include controls & instrumentation to facilitate safe, reliable and efficient operation of air compressors, air drying plant & CAS as a whole. The controls, protection, interlock and instrumentation system shall meet the minimum requirements mentioned in the specification and shall be subjected to approval of the BHEL & Customer during post award engineering stage.	
22.2	The minimum requirements are specified herein and the same shall be elaborated by CAS supplier. The CAS supplier shall include controls & instrumentation to facilitate safe, reliable and efficient operation for the system. The controls, protection, interlock and instrumentation system offered by the contractor shall be subjected to approval of the BHEL & Customer during post award engineering stage.	
22.3	Any of the compressor and Air drying Plant may be selectable for "shutdown", "working" or "standby" duty.	
22.4	On tripping of working equipment, the standby equipment shall come into operation automatically in case of very low air pressure in the system. All abnormal conditions used for tripping the compressor or any other equipment shall be provided with pre-trip audio-visual indication/annunciation in the control panel.	
22.5	An electrically operated automatic valve shall be provided on cooling water return line of each compressor & dryer which will automatically shut off the cooling water supply, in case any of the compressor/dryer is not running for more than set time duration. Suitable interlock shall also be provided for opening the valve before starting of any of the compressor.	
22.6	The following indications shall be made available in the control panels for repeating the same in main plant Control System / Panels. (a) Status of each compressor (b) Instrument air pressure low/high (c) Service air pressure low/high (d) Dew point of instrument air (e) Status of each ADP	
22.7	Lube oil pressure and temperature in the oil circuit of compressor shall be automatically controlled.	
22.8	Automatic motor overload control system shall be included to permit continuous operation of compressors at minimum ambient air without exceeding the name plate rating of the motor.	

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22.9	Whenever the operation of an auxiliary equipment is interlocked with main motor running status, the actual feedback from HT switchgear needs to be considered instead of start/stop command. Proper logging of abnormal conditions should be ensured in compressor system itself with adequate alarms/annunciations on compressor local panel as well as plant DCS. The logged data should be easily retrievable at later stage for any analysis. Control of the compressors should be designed in such a manner it comes to fail safe condition during unhealthy conditions or malfunctioning of any input external to compressor. For example, to save the compressor from further damages, cooling water supplies should not be stopped/ air intake valve should not be closed, if the compressor is running under abnormal condition or proper status feedback from HT switch gear is not available.	
22.10	Screw /Centrifugal compressor	
a.)	Each compressor shall be in the control panel to operate either in Base duty (Auto Load- Unload) or Standby duty (Auto On-Off) mode in case of Screw and unload/modulate/energy optimization (Auto Dual Mode) in case of centrifugal. In "Base duty" mode, whenever air supply from compressors exceeds the demand, control system shall operate the load-unload circuit at a predetermined set pressure, throttle the inlet valve and open the blow off valve. The compressor shall run in unloaded condition. When system pressure drops due to more demand, the load-unload circuit shall operate again to bring the compressor to 100% load after closing the blow -off valve. In "Stand-by" mode the compressor shall automatically assist base load compressors during periods of peak air demand. When air pressure in the system reaches a pre-set lower limit, compressor should start in unloaded condition and the compressor shall be fully loaded. When the pressure in the system rises to pre-set high value, the compressor shall be unloaded and shall run in idling mode for a specific period (set by a timer). The compressor may be loaded to full load in case of drop in system pressure or compressor may be stopped in case the system pressure does not drop and compressor continues to idle for more than a pre-set time.	
b.)	The control system shall provide warning to the operator that a hot-start condition exists for the motor driver and adequate cool-down period has not occurred after the motor was shut down.	
c.)	The alarms and shutdown scheme mentioned below are suggestive and shall be provided as per manufacturer's standard practice meeting the safe operational requirement of the equipment/system each compressor: (a) "Air temperature high" at inlet to last stage - Alarm & trip (b) "Low lube oil pressure" - Alarm & trip (c) "High Lube oil supply temperature" - Alarm & trip (d) "High oil filter differential pressure" - Alarm (e) "Low lube oil level in lube oil sump" - Alarm (f) "High inlet air filter differential pressure" - Alarm & trip (g) "Low cooling water flow to air compressor" - Alarm	
23.0	Air Drying Plant	
a.)	Sequential operation of the adsorber towers & air compressors shall be controlled automatically with a provision for manual take over.	
b.)	Change over of tower from drying mode to regeneration mode shall happen automatically if the dew point is high at the outlet of ADP sensed by the dew point (using aluminium oxide probe) meter/sensor. Automatic operation during regeneration, starting and stopping of blowers, starting and stopping of heaters, etc shall be timer controlled. During the process, in case, operation is taken over manually from the panel through push button or selector switch, the sequential operation shall start with the manual initiation for each of the steps.	
c.)	The control system shall provide the (as minimum) alarms, "High Reactivation air temperature", "Low Reactivation air temperature", "Low cooling water flow", "Low air pressure at the outlet of ADP" and "High dew point at the outlet of ADP". Adequate number of temperature elements etc. shall be provided for measurement and monitoring of the same.	
d.)	For rotary drum type Air drying plant, control philosophy as per manufacture's standard and proven practice is also acceptable.	
24.0	For Centrifugal compressors, as per OEM recommendation, Start-up air compressor and air dryer along with piping, valves, instruments etc. shall be provided by CAS supplier. Additionally, tapping from instrument air main header shall also be taken and connected to the start-up compressor outlet piping along with valves and instruments and shall be used in case of outage of start-up compressor / dryer.	
25.0	CAS supplier to note that RTD/BTD of HT motor of air compressor shall be terminated to temperature scanner / microprocessor (one for each compressor to be provided by CAS Supplier) mounted on compressor itself. Interlocks and protection for RTD/BTD of compressor motor has to be provided from compressor panel itself.	
26.0	Control and Instrumentation – Individual compressor control shall be through compressor mounted microprocessor based control panel. Each compressor shall be interfaced with DCS through gateway / convertor for start, stop, load and unload from common control room (CCR) including giving input for developing software at DCS (by BHEL EDN) and hardware link for status monitoring, start/stop, load/unload from CCR. Interface module for the overall control of compressed air system through DDCMIS shall be provided by CAS Supplier.	
27.0	Sequential panel for ensuring equal no. of running hours of each IA & SA set of compressors shall be provided by CAS Supplier.	
28.0	Junction Box for cable termination purpose shall be provided by CAS Supplier.	
29.0	HT motors for Instrument Air and Service Air Compressors, which are not in bidder's scope of supply, bare motors only shall be supplied as free issue by BHEL to successful bidder at its Works. HT motors shall be of BHEL make. The responsibility for satisfactory operation for combined performance of compressors & motors shall rest with the bidder only as if, the drive motors also have been supplied by the bidder. Also, once the motors are delivered at successful bidder's works / factory, any damage to motor shall be bidders' responsibility and rectification work shall be carried by bidder at its own cost. Further insurance of these motors after delivered at bidder's works shall be in bidder scope in line CAS package insurance, as per insurance terms & conditions defined under GCC.	
30.0	Foot cum flange mounted motors shall be of 1500 RPM only. While foot mounted motors shall be 3000/ 1500 RPM.	
31.0	Couplings, base plate, foundation bolts, any other fittings, etc. as required shall be supplied by the bidder only. BHEL shall supply motors to successful bidder works for shop testing of compressors with job motors.	
32.0	CAS supplier scope also includes - Pipe supporting structure over the insert plate for pedestal supported pipe, wall supported pipe, insert plate and supporting structure for floor supported pipe. All MS structures for cross overs, valve, instrument, equipment operating and maintenance platform; approach ladder for access to pit/ trench. All Equipment base plate, foundation anchor bolts.	

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33.0	Paint required for painting of all items under the package for corrosion protection and to meet color coding required by customer.	
34.0	SCOPE OF SERVICES: Scope of services by CAS supplier shall include but not necessarily limited to the following: 1.) Erection & Commissioning of Compressed Air System (Refer Annexure-C). 2.) Unloading, Storage, handling and transportation at site. 3.) Pre commissioning & Commissioning activities for Compressed Air System. 4.) Trial operation, AMC for storage and Preventive / Breakdown maintenance , PG Test & handover of Compressed Air System.	
35.0	CAS supplier shall terminate compressed air piping at common IA header and common SA header downstream of air receiver closer to pipe rack/pedestal (around 5.0 m from compressor house building).	
36.0	Depending upon the size and system pressure, joints in compressed air pipe work shall be screwed or flanged. The flange shall be welded with the parent pipe at shop and shall be hot dip galvanized before dispatch to site. Alternatively, the flanges on GI pipes may be screwed-on flanges also.	
37.0	Piping material - Compressed air (Instrument & service air) - ASTM A-53 type E Gr. B galvanized/ IS 1239 Gr heavy galvanized/IS 3589 Gr 410 galvanized. Galvanized shall be to IS- 4736 or equivalent.	
38.0	Piping material - Equipment cooling water - IS-2062 Gr.-E-250B/ASTM A-36/ASTM A-53 type 'E' Gr. B/IS-3589 Gr. 410 /IS-1239 Heavy.	
39.0	Valve material - Compressed air & Cooling water application - Valve body material shall be cast carbon steel for sizes 65 mm NB & above and gun metal or forged carbon steel for sizes 50 NB and below.	
40.0	Refer P&ID of CAS attached under compliance dwgs.	
41.0	Annual maintenance contract (AMC) for Preventive / Breakdown maintenance of Compressed air system (Refer Annexure-A) is in CAS supplier scope.	
42.0	Performance test for all the compressors shall be carried out at shops with job motor only.	

ANNEXURE-A

ANNUAL MAINTENANCE CONTRACT SERVICES

The bidder scope covers the Annual maintenance contract (AMC) for Preventive / Breakdown maintenance for a period of One (1) year from the date of successful commissioning of Compressed air system.

AMC scope also covers all regular maintenance by certified and trained service engineers. Total Six visits (06) (Including 2 Breakdown visit) shall be provided in a year and each visit shall consist of 1 to 2 days, depending upon the nature of work.

1.0 Scope of Work & Supply:

The scope of work and supply includes:

1. To carry out Preventive Maintenance checks as per mentioned schedule provided by bidder ensuring min. one routine visit per quarter, to attend Air compressors, its motor, Air dryer and all its accessories.
2. In case of breakdown, bidder shall depute qualified Service manpower and rectify the same with in strict time frame, not exceeding 48 hours.
3. Following operational spares are in CAS supplier scope
 - a) Lube oil (Qty. for 1 Lot in Ltr. shall be as per oil tank capacity for One Compressor) - 5 Lot
 - b) Lube oil filters with seals - 10 Nos.
 - c) Air filters with gaskets - 10 Nos.
 - d) Service kit including seals, washers and rings for inter cooler & after cooler - 5 Nos.

Spares, consumables, maintenance kits etc. required for preventive AMC / breakdown shall be provided to successful bidder's service provider by BHEL on the written request basis. Any specific item not available in BHEL inventory, shall be provided by bidder on mutual settlement of related commercial issues.

2.0 Detail description of major equipment: -

S. NO.	EQUIPMENT	MAKE & MODEL	Qty.
1	AIR COMPRESSOR WITH MOTOR (55 Nm ³ /min. @ 8.0 kg/cm ² (g))	As per Bidder	5 nos. (4W+ 1S)
2	AIR DRYER (55 Nm ³ /min. @ 8.0 kg/cm ² (g))	As per Bidder	3 nos. (2W+ 1S)

3.0 General Checklist for Air compressor: -

The checklists are intended for general description of work to be carried out. They are not intended to cover all minute details. The work shall be executed in accordance with Manufacturer's O&M Manuals and modern techniques. Preventive Maintenance checks includes but not limited to as specified below:

MAINTENANCE OF SCREW COMPRESSOR

- Carry out external cleaning of equipment.
- Check the oil level in the tank if low top-up with oil.
- Change the lube oil & lube oil filter element.
- Check the tightness of foundation bolt & take corrective action, if applicable.

- Check the coupling gear installed between compressor and motor.
- Check & clean the air breather in oil tank.
- Setting and checking of safety valves
- Pressure switch setting, Trips condition checking.
- Blow down valve functioning and repairing if necessary
- Clean the inlet air filter / oil filter element.
- Checking / cleaning of all heat exchangers.
- Checks the leakage in oil line, water line and airline if found then rectify the same.
- Cleaning of cooling water inlet line strainer, back flushing of air and oil cooler, air purging oil scavenging & connecting tube, Cleaning & servicing of moisture separator installed at compressor outlet, cleaning of all moisture & dust separating filter elements as prescribed by manufacturer.
- Check for Electrical connections intact.
- Check for compressor control panel as per manufacturer recommendation.
- Any other maintenance as recommended by manufacturer.

MAINTENANCE OF AIR DRYER

- Carry out external cleaning of equipment.
- Clean the suction filter/ moisture strainer.
- Check the tightness of foundation bolts & take corrective action if required.
- Assisting for inspection / repair / servicing during expert visit as per instructions.
- Check change over valve.
- Check for any leakages in pipeline.
- Check for Electrical connections intact.
- Equipment external and internal cleaning.
- Any other maintenance as recommended by manufacturer.

4.0 Tools and tackles

Tools and tackles required for handling the component will be provided to the Bidder (successful bidder) on the written request basis. Bidder shall not claim any delay or compensation due to unavailability of these items, if any. In such cases bidder need to arrange the required tools and tackles at his own cost.

- 5.0** Bidder is to arrange all the safety gears like helmets, air plugs, safety shoes etc. during the maintenance.
- 6.0** In case of breakdown, Bidder is to depute service manpower within 48 hrs. without fail.
- 7.0** For Breakdown Maintenance, Bidder is to service and operate the compressor with satisfactory operating parameters within a week (6 working days) of reporting.
- 8.0** Bidder is to submit the Servicing Report (SR) of completed Breakdown Maintenance.
- 9.0** If any damage to the equipment and its accessories due to improper maintenance by bidder shall be recovered from the bidder.

ANNEXURE-B: LIST OF OPERATIONAL SPARES

Sl.no	Description	Qty. (Each Equipment)			Unit	Total Quantity to be supplied
		Initial fill (at vendor works)	During Storage Period at Project Site/ Prior commissioning	During Equipment Operation/ Prior PG Test		
A						
A.1	Lube oil	Included	NA	1 Lot	Lot/Compressor	5 Lot
A.2	Lube oil filters including gearcase filter with seals	Included	1 Lot	1 Lot	Lot/Compressor	10 Lot
A.3	Air filters (intake filter, gearcase filter, control panel filter)	Included	1 Lot	1 Lot	Lot/Compressor	10 Lot
A.4	Service kit including seals, washers and rings for intercooler & after cooler	NA	NA	1 Lot	Lot/Compressor	5 Lot
B	AIR DRYER					
B.1	Filters for Air Dryers (as applicable)	Included	1 Lot	1 Lot	Lot/Dryer	6 Lot

Notes:

- 1.) Wherever "Lot "is mentioned, one Lot of the spares of that equipment/item shall be for complete replacement of that particular item for one equipment.
- 2.) The following consumable/spare items shall be supplied at least 15 days prior to the Performance Guarantee (PG) Test of the Air Compressors and Air Dryers, considering the shelf life of such items.

In case any of these items are supplied earlier than the above-mentioned period, resulting in a reduction of their effective shelf life before the PG Test, the bidder shall, at their own cost, replace such items with fresh items having the full specified shelf life. Such replacement shall be carried out without any commercial implication or impact on the project schedule/delivery to BHEL.

ANNEXURE-C

INSTRUCTION MANUALS

The vendor shall submit Instruction Manuals for all the equipments covered under the Contract. The Instruction manuals shall contain full details required for erection, commissioning, operation and maintenance of each equipment. The manual shall be specifically compiled for this project. The Contract shall not be considered to be completed for purposes of taking over until the final Instructions manuals have been supplied to the Employer. The Instruction Manuals shall comprise of the following.

A) ERECTION MANUALS

The erection manuals shall be submitted at least three (3) months prior to the commencement of erection activities of a particular equipment/system. The erection manual should contain the following as a minimum.

- a) Erection strategy.
- b) Sequence of erection.
- c) Erection instructions.
- d) Critical checks and permissible deviation/tolerances.
- e) List of tools, tackles, heavy equipments like cranes, dozers, etc.
- f) Bill of Materials
- g) Procedure for erection and General Safety procedures to followed during erection/installation.
- h) Procedure for initial checking after erection.
- i) Procedure for testing and acceptance norms.
- j) Procedure / Check list for pre-commissioning activities.
- k) Procedure / Check list for commissioning of the system.
- l) Safety precautions to be followed in electrical supply distribution during erection.

B) OPERATION & MAINTENANCE MANUALS

a) The manual shall be a two rim PVC bound stiff sided binder able to withstand constant usage or where a thicker type is required it shall have locking steel pins, the size of the manual shall not be larger than international size A3. The cover shall be printed with the Project Name, Services covered and Volume / Book number Each section of the manual shall be divided by a stiff divider of the same size as the holder. The dividers shall clearly state the section number and title. All written instructions within the manual not provided by the manufacturers shall be typewritten with a margin on the left hand side.

b) The arrangement and contents of O & M manuals shall be as follows:

1) Chapter 1 - Plant Description: To contain the following sections specific to the equipment/system supplied

- (a) Description of operating principle of equipment / system with schematic drawing / layouts.
- (b) Functional description of associated accessories / controls. Control interlock protection write up.
- (c) Integrated operation of the equipment along with the intended system. (This to be given by the supplier of the Main equipment by taking into account the operating instruction given by the associated suppliers).
- (d) Exploded view of the main equipment, associated accessories and auxiliaries with description. Schematic drawing of the equipment along with its accessories and auxiliaries.
- (e) Design data against which the plant performance will be compared.
- (f) Master list of equipments, Technical specification of the equipment/ system and approved data sheets.
- (g) Identification system adopted for the various components, (it will be of a simple process linked tagging system).
- (h) Master list of drawings (as built drawing - Drawings to be enclosed in a separate volume).

2) Chapter 2.0 - Plant Operation: To contain the following sections specific to the equipment supplied

- (a) Protection logics provided for the equipment along with brief philosophy behind the logic, Drawings etc.
- (b) Limiting values of all protection settings.
- (c) Various settings of annunciation/interlocks provided.
- (d) Startup and shut down procedure for equipment along with the associated systems in step mode.
- (e) Do's and Don'ts related to operation of the equipment.
- (f) Safety precautions to be taken during normal operation. Emergency instruction on total power failure condition/lubrication failure/any other conditions.
- (g) Parameters to be monitored with normal value and limiting values.
- (h) Equipment isolating procedures.
- (i) Trouble shooting with causes and remedial measures.
- (j) Routine testing procedure to ascertain healthiness of the safety devices along with schedule of testing.
- (k) Routine Operational Checks, Recommended Logs and Records.
- (l) Change over schedule if more than one auxiliary for the same purpose is given.
- (m) Preservation procedure on long shut down.

(n) System/plant commissioning procedure.

3) Chapter 3.0 - Plant Maintenance- To contain the following sections specific to the equipment supplied.

(a) Exploded view of each of the equipments. Drawings along with bill of materials including name, code no. & population.

(b) Exploded view of the spare parts and critical components with dimensional drawings (In case of Electronic cards, the circuit diagram to be given) and spare parts catalogue for each equipment.

(c) List of Special T/P required for Overhauling /Trouble shooting including special testing equipment required for calibration etc.

(d) Stepwise dismantling and assembly procedure clearly specifying the tools to be used, checks to be made, records to be maintained etc. Clearance to be maintained etc.

(e) Preventive Maintenance schedules linked with running hours/calendar period alongwith checks to be carried out.

(f) Overhauling schedules linked with running hours/calendar period alongwith checks to be done.

(g) Long term maintenance schedules

(h) Consumables list alongwith the estimated quantity required during normal running and during maintenance like Preventive Maintenance and Overhauling.

(i) List of lubricants with their Indian equivalent, Lubrication Schedule including charts showing lubrication checking, testing and replacement procedure to be carried daily, weekly, monthly & at longer intervals to ensure trouble free operation and quantity required for complete replacement.

(j) Tolerance for fitment of various components.

(k) Details of sub vendors with their part no. in case of bought out items.

(l) List of spare parts with their Part No., total population, life expediency & their interchangeability with already supplied spares to NTPC.

(m) List of mandatory and recommended spare list along with manufacturing drawings, material specification & quality plan for fast moving consumable spares.

(n) Lead time required for ordering of spares from the equipment supplier, instructions for storage and preservation of spares.

(o) General information on the equipment such as modification carried out in the equipment from its inception, equipment population in the country / foreign country and list of utilities where similar equipments have been supplied.

After finalization and approval of the Employer, the O & M Manuals shall be submitted as indicated in Annexure-D. The Contract shall not be considered to be completed for purposes of taking over until the final Instructions manuals (both erection and O & M manuals have been supplied to the Employer.

If after the commissioning and initial operation of the plant, the instruction manuals (Erection and /or O &M manuals) require modifications/additions/ changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Employer for records and number of copies shall be as mentioned in Annexure-D.

PLANT HANDBOOK AND PROJECT COMPLETION REPORT

PLANT HANDBOOK

The Contractor shall submit to the Employer a preliminary plant hand book preferably in A-4 size sheets which shall contain the design and performance data of various plants, equipments and systems covering the complete project including

- i) Design and performance data.
- ii) Process & Instrumentation diagrams.
- iii) Single line diagrams.
- iv) Sequence & Protection Interlock Schemes.
- v) Alarm and trip values.
- vi) Performance Curves.
- vii) General layout plan and layout of main plant building and auxiliary buildings
- viii) Important Do's & Don't's

The plant handbook shall be submitted within twelve (12) months from the date of award of contract. After the incorporation of Employer's comments, the final plant handbook complete in all respects shall be submitted three (3) months before startup and commissioning activities.

PROJECT COMPLETION REPORT

The Contractor shall submit a Project Completion Report at the time of handing over the plant.

DRAWINGS

- a) i) All the plant layouts shall be made in computerized 3D modelling system. The Employer reserves the right to review the 3D model at different stages during the progress of engineering. The layout drawings submitted for Employer's review shall be fully dimensioned and extracted from 3D model after interference check.
- ii) All documents submitted by the Contractor for Employer's review shall be in electronic form (soft copies) along with the desired number of hard copies as per Annexure-D. The soft copies shall also be submitted.
- iii) Final copies of the approved drawings along with requisite number of hard copies shall be submitted as per Annexure-D.

b) All documents/text information shall be in latest version of MS Office/MS Excel/PDF format as applicable.

c) All drawings submitted by the Contractor including those submitted at the time of bid shall be in sufficient detail indicating the type, size, arrangement, weight of each component for packing and shipment, the external connection, fixing arrangement required, the dimensions required for installation and interconnections with other equipments and materials, clearance and spaces required between various portions of equipment and any other information specifically requested in the drawing schedules.

d) Each drawing submitted by the Contractor (including those of sub-vendors) shall bear a title block at the right hand bottom corner with clear mention of the name of the Employer, the system designation, the specifications title, the specification number, the name of the Project, drawing number and revisions. If standard catalogue pages are submitted the applicable items shall be indicated therein. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be in metric units.

e) The drawings submitted by the vendor (or their sub vendors) shall bear title block in addition to vendor's (their sub-vendor's) own drawing number. Employer's drawing numbering system shall be made available to the successful bidder to enable him to assign Employer's drawing numbers to the drawings to be submitted by him during the course of execution of the Contract.

Similarly, all the drawings/ documents submitted by the Contractor during detailed engineering stage shall be marked "FOR APPROVAL" or "FOR INFORMATION" prior to submission in line with **Suggestive MDL**.

Further, space shall be identified on each drawing for Approval stamp and electronic signature.

f) The furnishing of detailed engineering data and drawings by the Contractor shall be in accordance with the time schedule for the project. The review of these documents/ data/ drawings by the Employer will cover only general conformance of the data/ drawings/ documents to the specifications and contract, interfaces with the equipments provided by others and external connections & dimensions which might affect plant layout. The review by the Employer should not be construed to be a thorough review of all dimensions, quantities and details of the equipments, materials, any devices or items indicated or the accuracy of the information submitted. The review and/ or approval by the Employer/ Project Manager shall not relieve the Contractor of any of his responsibilities and liabilities under this contract.

g) After the approval of the drawings, further work by the Contractor shall be in strict accordance with these approved drawings and no deviation shall be permitted without the written approval of the Employer.

h) All manufacturing, fabrication and execution of work in connection with the equipment / system, prior to the approval of the drawings, shall be at the Contractor's risk. The Contractor is expected not to make any changes in the design of the equipment /system, once they are approved by the Employer. However, if some changes are necessitated in the design of the equipment/system at a later date, the Contractor may do so, but such changes shall promptly be brought to the notice of the

Employer indicating the reasons for the change and get the revised drawing approved again in strict conformance to the provisions of the Technical Specification.

i) Drawings shall include all installations and detailed piping layout drawings. Layout drawings for all piping of 65 mm and larger diameter shall be submitted for review/ approval of Employer prior to erection. Small diameter pipes shall however be routed as per site conditions in consultation with site authority/ representative of Employer based on requirements of such piping indicated in approved/ finalised Flow Scheme/ Process & Instrumentation Diagrams and/or the requirements cropping up for draining & venting of larger diameter piping or otherwise after their erection as per actual physical condition for the entire scope of work of this package. Assessing & anticipating the requirement and supply of all piping and equipment shall be done by the contractor well in advance so as not to hinder the progress of piping & equipment erection, subsequent system charging and its effective draining & venting arrangement as per site suitability.

j) As Built Drawings After final acceptance of individual equipment / system by the Employer, the Contractor will update all original drawings and documents for the equipment / system to “as built” conditions and submit no. of copies as per Annexure D.

k) Drawings must be checked by the Contractor in terms of its completeness, data adequacy and relevance with respect to Engineering schedule prior to submission to the Employer. In case drawings are found to be submitted without proper checking by the Contractor, the same shall not be reviewed and returned to the Contractor for re-submission. The contractor shall make a visit to site to see the existing facilities and understand the layout completely and collect all necessary data/ drawings at site which are needed as an input to the engineering. The contractor shall do the complete engineering including interfacing and integration of all his equipment, systems & facilities within his scope of work as well as interface engineering & integration of systems, facilities, equipment & works under Employer's scope and submit all necessary drawings/ documents for the same.

l) The Contractor shall submit adequate prints of drawing / data / document as per Annexure-D. The Employer shall review the drawings and return soft copy to the Contractor authorizing either to proceed with manufacture or fabrication or marked to show changes desired. When changes are required, drawings shall be re-submitted promptly, with revisions clearly marked, for final review. Any delays arising out of the failure of the Contractor to submit/rectify and resubmit in time shall not be accepted as a reason for delay in the contract schedule.

m) All engineering data submitted by the Contractor after final process including review and approval by the Project Manager/ Employer shall form part of the contract documents and the entire works covered under these specifications shall be performed in strict conformity with technical specifications unless otherwise expressly requested by the Project Manager in writing.

ANNEXURE-D

S. No.	Description of Drgs./Docs.	No. of Prints	No. of Portable Hard Disk
1	Drawings, Data sheets, Design calculations, Purchase specifications and other documents		
	First submission and submission with major changes		
	▪ Layout (A0&A1 sizes)	3	-
	▪ Other Drawings/Documents (A0 & A1 sizes)	3	-
	▪ P&ID (All sizes)	3	-
	a) Final drawings/documents (Directly to site)	3	2
	b) "As Built" Drawing/Documents (Directly to site)	3	2
	c) Analysis reports of Equipments / piping / structures components/system employing software packages as detailed in the specifications.	2	2
2	Erection Manual (Directly to site)	3 sets	2
3	Operation & Maintenance manual i) First Submission	0	--
	ii) Final Submission (Directly to site)	3 sets	2
4	Plant Hand Book i) Final Submission	1	1
	Commissioning and Performance Test Procedure manual i) First Submission	1 set	--
5	ii) Final Submission (Directly to site)	3 sets	2

S. No.	Description of Drgs./Docs.	No. of Prints	No. of Portable Hard Disk
6	Performance and Functional Guarantee Test Report i) First Submission	1 sets	—
	ii) Approved Copies (Direct to Site)	3 sets	2
7	Project Completion Report (Directly to site)	3 sets	2

Format for Soft signal exchange between DCS and PLC/Microprocessor based system

Format for Soft signal exchange between DCS and PLC/Microprocessor based system



TITLE :
**ELECTRICAL EQUIPMENT SPECIFICATION
FOR
COMPRESSED AIR SYSTEM
DARLIPALI STPP, STAGE-II (1X800 MW)**

SPECIFICATION NO.
VOLUME NO. : **II-B**
SECTION : **I**
REV NO. : **00** DATE : 13.08.2026
SHEET : 1 OF 3

**TECHNICAL SPECIFICATION
FOR
COMPRESSED AIR SYSTEM
(ELECTRICAL PORTION)**

	TITLE : ELECTRICAL EQUIPMENT SPECIFICATION FOR COMPRESSED AIR SYSTEM DARLIPALI STPP, STAGE-II (1X800 MW)	SPECIFICATION NO.
		VOLUME NO. : II-B
		SECTION : I
		REV NO. : 00 DATE : 13.08.2026
		SHEET : 2 OF 3

1.0 EQUIPMENT & SERVICES TO BE PROVIDED BY BIDDER:

- a) Services and equipment as per “Electrical Scope between BHEL and Vendor”.
- b) Any item/work either supply of equipment or erection material which have not been specifically mentioned but are necessary to complete the work for trouble free and efficient operation of the plant shall be deemed to be included within the scope of this specification. The same shall be provided by the bidder without any extra charge.
- c) Supply of mandatory spares as specified in the specifications of mechanical equipments.
- d) Electrical load requirement for COMPRESSED AIR SYSTEM (all AC & DC loads at different voltage levels like 415V AC, 240 V AC, 220 V DC etc).
- e) All equipment shall be suitable for the power supply fault levels and other climatic conditions mentioned in the enclosed project information.
- f) Bidder to furnish list of makes for each equipment at contract stage, which shall be subject to customer/BHEL approval without any commercial and delivery implications to BHEL.
- g) Various drawings, data sheets as per required format, Quality plans, calculations, test reports, test certificates, operation and maintenance manuals etc shall be furnished as specified at contract stage. All documents shall be subject to customer/BHEL approval without any commercial implication to BHEL.
- h) Motor shall meet minimum requirement of motor specification.
- i) Vendor to clearly indicate equipment locations and local routing lengths in their cable listing furnished to BHEL.
- j) Cable BOQ worked out based on routing of cable listing provided by the vendor for “ both end equipment in vendor’s scope”shall be binding to the vendor with +10 % margin to take care of slight variation in routing length & wastages.

2.0 EQUIPMENT & SERVICES TO BE PROVIDED BY PURCHASER FOR ELECTRICAL & TERMINAL POINTS:

Refer “Electrical Scope between BHEL and Vendor”.

3.0 DOCUMENTS TO BE SUBMITTED ALONG WITH BID

- 3.1 The electrical specification without any deviation from the technical/quality assurance requirements stipulated shall be deemed to be complied by the bidder in case bidder furnishes the overall compliance of package technical specification in the form of compliance certificate/No deviation certificate.
- 3.2 No technical submittal such as copies of data sheets, drawings, write-up, quality plans, type test certificates, technical literature, etc, is required during tender stage. Any such submission even if made, shall not be considered as part of offer.



TITLE :
**ELECTRICAL EQUIPMENT SPECIFICATION
FOR
COMPRESSED AIR SYSTEM

DARLIPALI STPP, STAGE-II (1X800 MW)**

SPECIFICATION NO.
VOLUME NO. : II-B
SECTION : I
REV NO. : 00 DATE : 13.08.2026
SHEET : 3 OF 3

4.0 List of enclosures :

- a) Electrical scope between BHEL & vendor (Annexure –I)
- b) Technical specification for motors.
- c) Datasheets & quality plan for motors.
- d) Electrical Load data format (Annexure –II)
- e) BHEL cable listing format (Annexure –III)

ELECTRICAL SCOPE BETWEEN BHEL AND VENDOR**PACKAGES : COMPRESSED AIR SYSTEM****SCOPE OF VENDOR: SUPPLY, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT****PROJECT: DARLIPALI STPP, STAGE-II (1X800 MW)**

<u>S.NO</u>	<u>DETAILS</u>	<u>SCOPE SUPPLY</u>	<u>SCOPE E&C</u>	<u>REMARKS</u>
1	11 kV/ 6.6 KV / 3.3 KV / 415 V Switchgear	BHEL	BHEL	240 V AC (supply feeder)/415 V AC (3 PHASE 4 WIRE) supply shall be provided by BHEL based on load data provided by vendor at contract stage for all equipment supplied by vendor as part of contract. Any other voltage level (AC/DC) required will be derived by the vendor.
2	Local Push Button Station (for motors)	BHEL	BHEL	Located near the motors.
3	Power cables, control cables and screened control cables for a) both end equipment in BHEL's scope b) both end equipment in vendor's scope c) one end equipment in vendor's scope	BHEL BHEL BHEL	BHEL Vendor BHEL	1. For 3.b) & c): Sizes of cables required shall be informed by vendor at contract stage (based on inputs provided by BHEL) in the form of cable listing. Finalisation of cable sizes shall be done by BHEL. Vendor shall provide lugs & glands accordingly. 2. Termination at BHEL equipment terminals by BHEL. 3. Termination at Vendor equipment terminals by Vendor.
4	Junction box for control & instrumentation cable	Vendor	Vendor	Number of Junction Boxes shall be sufficient and positioned in the field to minimize local cabling (max 10-12 mtrs) and trunk cable.
5	Any special type of cable like compensating, co-axial, prefab, MICC, etc.	Vendor	Vendor	Refer C&I portion of specification for scope of fibre Optical cables if used between PLC/ microprocessor & DCS.
6	Cable trays, accessories & cable trays supporting system. 100/50 mm cable trays/Conduits/Galvanised steel cable troughs for local cabling	BHEL Vendor	BHEL Vendor	Local cabling from nearby main route cable tray (BHEL scope) to equipment terminal (vendor's scope) shall be through 100/ 50 mm. cable trays/ conduits/ Galvanised steel cable troughs as per approved layout drawing during contract stage.
7	Cable glands, lugs & bimetallic strip for equipments supplied by Vendor	Vendor	Vendor	1. Double compression Ni-Cr plated brass cable glands 2. Solder less crimping type heavy duty tinned copper lugs for power & control cables.
8	Conduit and conduit accessories for cabling between equipments supplied by vendor.	Vendor	Vendor	Conduits shall be medium duty, hot dip galvanised cold rolled mild steel rigid conduit as per IS: 9537.
9	Lighting	BHEL	BHEL	--
10	Equipment grounding (including electronic earthing) & lightning protection	BHEL	BHEL	Refer note no. 4 for electronic earthing
11	Below grade grounding	BHEL	BHEL	--
12	Motors with base plate and foundation hardware	Vendor	Vendor	Makes shall be subject to customer/ BHEL approval at contract stage.
13	Mandatory spares	Vendor	-	Vendor to quote as per specification.

ELECTRICAL SCOPE BETWEEN BHEL AND VENDOR**PACKAGES : COMPRESSED AIR SYSTEM****SCOPE OF VENDOR: SUPPLY, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT****PROJECT: DARLIPALI STPP, STAGE-II (1X800 MW)**

14	Recommended O & M spares	Vendor	-	As specified elsewhere in specification
15	Any other equipment/material/service required for completeness of system based on the system offered by vendor (to ensure trouble free and efficient operation of the system).	Vendor	Vendor	--
16	a. Input cable schedules (C & I) b. Cable interconnection detail for the above c. Cable block diagram	Vendor Vendor Vendor	- - -	Cable listing for Control and Instrumentation Cable and electronic earthing cable in enclosed excel format shall be submitted by vendor during detailed engineering stage.
17	Cabling layout drawings	BHEL/ Vendor	-	a. In case of Compressor are HT motors, cable tray/trench layout inside compressed air building shall be prepared by BHEL. Vendor to furnish drawing (both in print form as well as in AUTOCAD) of compressor room layout clearly indicating all motors, panels, JB's etc. which require cabling along with their terminal box/location/ Foundation etc. b. In case of Compressor are LT motors, for ensuring cabling requirements are met, vendor shall prepare & submit cable tray/trench & equipment layout (both in print form as well as in AUTOCAD) of the complete plant (including electrical area) indicating location and identification of all equipment requiring cabling for BHEL review & approval.
18	Electrical equipment GA drawing	Vendor	-	For necessary interface review.

NOTES:

1. Make of all electrical equipments/items supplied shall be reputed make & shall be subject to approval of BHEL/customer after award of contract.
2. All QPs shall be subject to approval of BHEL/customer after award of contract without any commercial implication.
3. In case the requirement of junction box arises on account of power cable size mismatch due to vendor engineering at later stage, vendor shall supply the junction box for suitable termination.
4. Vendor shall indicate location of Electronic Earth pit in their Civil assignment drawing.

ANNEXURE III

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SUB-SECTION-B – 02

MOTORS

	MOTORS																				
1.00.00	GENERAL REQUIREMENTS																				
1.01.00	This chapter has to be read in conjunction with sub-section B-0 "General electrical specification" of Technical specification Section- VI, Part-B and Sub-Section-IIB Electrical system/Equipment of Technical Specifications Section-VI, Part-A" Degree of Protection Degree of protection for various enclosures as per IEC60034-05 shall be as follows :- <table><tr><td>i)</td><td>Indoor motors</td><td>-</td><td>IP 55</td></tr><tr><td>ii)</td><td>Outdoor motors</td><td>-</td><td>IP 55 (Additional Canopy to be provided)</td></tr><tr><td>iii)</td><td>Cable box-indoor area</td><td>-</td><td>IP 55</td></tr><tr><td>iv)</td><td>Cable box-Outdoor area</td><td>-</td><td>IP 55</td></tr></table>	i)	Indoor motors	-	IP 55	ii)	Outdoor motors	-	IP 55 (Additional Canopy to be provided)	iii)	Cable box-indoor area	-	IP 55	iv)	Cable box-Outdoor area	-	IP 55				
i)	Indoor motors	-	IP 55																		
ii)	Outdoor motors	-	IP 55 (Additional Canopy to be provided)																		
iii)	Cable box-indoor area	-	IP 55																		
iv)	Cable box-Outdoor area	-	IP 55																		
2.00.00	CODES AND STANDARDS																				
	<table><tr><td>1)</td><td>Three phase induction motors</td><td>:</td><td>IS15999/IEC:60034</td></tr><tr><td>2)</td><td>Single phase AC motors</td><td>:</td><td>IS 996/ IEC:60034</td></tr><tr><td>3)</td><td>Crane duty motors</td><td>:</td><td>IS:3177, IS/IEC:60034</td></tr><tr><td>4)</td><td>DC motors/generators</td><td>:</td><td>IS:4722, IS/IEC:60034</td></tr><tr><td>5)</td><td>Energy Efficient motors</td><td>:</td><td>IS 12615, IEC:60034-30</td></tr></table>	1)	Three phase induction motors	:	IS15999/IEC:60034	2)	Single phase AC motors	:	IS 996/ IEC:60034	3)	Crane duty motors	:	IS:3177, IS/IEC:60034	4)	DC motors/generators	:	IS:4722, IS/IEC:60034	5)	Energy Efficient motors	:	IS 12615, IEC:60034-30
1)	Three phase induction motors	:	IS15999/IEC:60034																		
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4)	DC motors/generators	:	IS:4722, IS/IEC:60034																		
5)	Energy Efficient motors	:	IS 12615, IEC:60034-30																		
3.00.00	TYPE																				
3.01.00	AC Motors: a) Squirrel cage induction motor suitable for direct-on-line starting. b) Continuous duty LT motors upto 50 KW Output rating (at 50 deg.C ambient temperature), shall be super Premium Efficiency class-IE4, 50-200 KW shall be of Premium Efficiency class – IE3, conforming to IS 12615, or IEC:60034-30. HT motors shall have minimum design efficiency of 95 %. However, tolerance on this efficiency value shall be applicable as per IEC 60034 c) Motor operating through variable frequency drives shall be suitable for inverter duty with VPI insulation. Also these motors shall comply the requirements stipulated in IEC: 60034-18-41 and IEC: 60034-18-42 as applicable.																				
3.02.00	<table><tr><td>DC Motors</td><td>Shunt wound.</td></tr></table>	DC Motors	Shunt wound.																		
DC Motors	Shunt wound.																				
4.00.00	RATING																				
	(a) Continuously rated (S1). However, crane motors shall be rated for S4 duty, 40% cyclic duration factor. (b) Whenever the basis for motor or driven equipment ratings are not specified in the corresponding mechanical specification sub-sections, maximum continuous motor ratings shall be at least 10% above the maximum load demand of the driven equipment under entire operating range including voltage and frequency variations.																				
5.00.00	TEMPERATURE RISE																				
	Air cooled motors (AC &DC) 70 deg. C by resistance method for thermal class 155(F) insulation. Water cooled 80 deg. C over inlet cooling water temperature mentioned elsewhere, by resistance method for thermal class 155(F) insulation.																				
6.00.00	OPERATIONAL REQUIREMENTS																				

6.01.00	Starting Time
6.01.01	For motors with starting time upto 20 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 2.5 secs. more than starting time.
6.01.02	For motors with starting time more than 20 secs. and upto 45 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 secs. more than starting time.
6.01.03	For motors with starting time more than 45 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
6.01.04	Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.
6.02.00	Torque Requirements
6.02.01	Accelerating torque at any speed with the lowest permissible starting voltage shall be at least 10% motor rated torque.
6.02.02	Pull out torque at rated voltage shall not be less than 205% of rated torque. It shall be 275% for crane duty motors.
6.03.00	NOT USED
7.00.00	DESIGN AND CONSTRUCTIONAL FEATURES
7.01.00	Suitable single phase space heaters shall be provided on motors rated 30KW and above to maintain windings in dry condition when motor is standstill. Separate terminal box for space heaters & RTDs shall be provided. However for flame proof motors, space heater terminals inside the main terminal box may be acceptable.
7.02.00	All motors shall be either Totally enclosed fan cooled (TEFC) or totally enclosed tube ventilated (TETV) or Closed air circuit air cooled (CACA) type. However, motors rated 3000KW or above can be Closed air circuit water cooled (CACW). The method of movement of primary and secondary coolant shall be self-circulated by fan or pump directly mounted on the rotor of the main motor as per IEC 60034-6. However VFD driven motors can be offered with forced cooling type with machine mounted fan or pump driven by separate electric motor. Motors and EPB located in hazardous areas shall have flame proof enclosures conforming to IS:2148 as detailed below
	(a) Fuel oil area : Group – IIB
	(b) Hydrogen generation : Group - IIC or (Group-I, Div-II as per plant area NEC) or (Class-1, Group-B, Div-II as per NEMA /IEC60034)
7.03.00	Winding and Insulation
	(a) Type : Electrolytic grade Copper conductor, Non-hygroscopic, oil resistant, flame resistant Insulation.
	(b) Starting duty : Two hot starts in succession, with motor initially at normal running temperature. However , conveyor motors shall be suitable for 3 consecutive hot starts
	(c) 11kV, 6.6 KV & 3.3 kV AC motors : Thermal class 155 (F) insulation. The winding insulation process shall be total Vacuum Pressure Impregnated i.e resin poor method. The lightning Impulse & interturn insulation surge withstand level shall be as per IEC-60034 part-15.
	(d) 240VAC, 415V AC & 220V DC motors : Thermal Class (F) or better
7.04.00	Motors rated above 1000KW shall have insulated bearings/housing to prevent flow of shaft currents.
7.05.00	Motors with heat exchangers shall have dial type thermometer with adjustable alarm contacts to indicate inlet and outlet primary air temperature.
7.06.00	Noise level for all the motors shall be limited to 85 dB(A) except for BFP motor for which the maximum limit shall be 90dB(A) (Tolerance limits as per IS/IEC shall be applicable on specified values). Vibration

	shall be limited within the limits prescribed in IS:12075 / IEC 60034-14 . Motors shall withstand vibrations produced by driven equipment. HT motor bearing housings shall have flat surfaces, in both X and Y directions, suitable for mounting vibration pads. Contractor shall ensure the adequate size of vibration pads for mounting of suitable vibration sensors.
7.07.00	In HT motors, at least four numbers simplex / two numbers duplex platinum resistance type temperature detectors shall be provided in each phase stator winding. Each bearing of HT motor shall be provided with 3 numbers duplex RTDs connected to three numbers dual input transmitters with display. However for air compressor, being high speed drive, each motor bearing shall be provided with minimum two numbers of duplex RTDs connected to two numbers dual input transmitters with display unit.
7.08.00	Motor body shall have two earthing points on diagonally opposite sides.
7.09.00	11 KV motors shall be offered with: i) Separable Insulated Connector (SIC) as per IEEE 386. The offered SIC terminations shall be provided with protective cover. SIC termination kit shall be suitable for fault level of 25 KA for 0.17 seconds. OR ii) Dust tight phase segregated double walled (metallic as well as insulated barrier) Terminal box-PSTB shall be suitable for fault level of 50KA/40KA for 0.12 seconds (Fault level shall be as per system fault level for 11 KV system defined elsewhere in the specification). Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non-magnetic material for single core cables) shall be provided.
7.10.00	3.3/6.6 KV motors shall be offered with dust tight phase segregated double walled (metallic as well as insulated barrier) Terminal box. Alternately Elastimold type Terminal box should also be accepted as per OEM standard proven practice. Contractor shall provide termination kit for the offered Terminal box. The offered Terminal Box shall be suitable for fault level of 250 MVA/500MVA for 0.12 sec for 3.3/6.6KV respectively. Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material for single core cables) shall be provided.
7.11.00	The spacing between gland plate & centre of bottom terminal stud shall be as per Table-I.
7.12.00	All motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.
7.13.00	The motors shall be suitable for bus transfer schemes provided on the 11kV, 6.6 KV, 3.3 kV /415V systems without any injurious effect on its life.
7.14.00	For motors rated 2000 KW & above, neutral current transformers of PS class shall be provided on each phase in a separate neutral terminal box.
7.15.00	NOT USED.
8.00.00	NOT USED.
9.00.00	CW motor shall be designed with minimum power factor of 0.8 at design duty point.
10.00.00	TYPE TEST
10.01.00	HT MOTORS LIST OF TYPE TESTS TO BE CONDUCTED The following type tests shall be conducted on each type and rating of HT motor (a) No load saturation and loss curves upto approximately 115% of rated voltage (b) Measurement of noise at no load. (c) Momentary excess torque test (subject to test bed constraint). (d) Full load test(subject to test bed constraint) (e) Temperature rise test at rated conditions. During heat run test, bearing temp., winding temp.,coolant flow and its temp. shall also be measured. In case the temperature rise test is carried at load other than rated load, specific approval for the test method and procedure is required to be obtained. Wherever ETD's are provided, the temperature shall be measured by ETD's also for the record purpose.

10.02.00	LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED The following type test reports shall be submitted for each type and rating of HT motor - Degree of protection test for the enclosure followed by HV and no load run test. - Terminal box-fault level withstand test for each type of terminal box (phase side only) of HT motors only. - Lightning Impulse withstand test on the sample coil shall be as per clause no. 4.3 IEC-60034, part-15 - Surge-withstand test on inter-turn insulation shall be as per clause no. 4.2 of IEC 60034, part-15 LT Motors LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED The following type test reports shall be submitted for each type and rating of LT motor of above 100 KW only - Measurement of resistance of windings of stator and wound rotor. - No load test at rated voltage to determine input current power and speed - Open circuit voltage ratio of wound rotor motors (in case of Slip ring motors) - Full load test to determine efficiency power factor and slip - Temperature rise test - Momentary excess torque test. - High voltage test - Test for vibration severity of motor. - Test for noise levels of motor(Shall be limited as per clause no 7.06.00 of this section) - Test for degree of protection and - Overspeed test. - Type test reports for motors located in fuel oil area having flame proof enclosures as per IS 2148 / IEC 60079-1 10.03.00 All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price. 10.04.00 The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet. TABLE - I DIMENSIONS OF TERMINAL BOXES FOR LV MOTORS <table border="0"> <thead> <tr> <th style="text-align: left;">Motor MCR in KW</th><th style="text-align: left;">Minimum distance between centre of bottom terminal stud and gland plate in mm As per manufacturer's practice.</th></tr> </thead> <tbody> <tr> <td>UP to 3 KW</td><td></td></tr> <tr> <td>Above 3 KW - upto 7 KW</td><td>85</td></tr> <tr> <td>Above 7 KW - upto 13 KW</td><td>115</td></tr> <tr> <td>Above 13 KW - upto 24 KW</td><td>167</td></tr> <tr> <td>Above 24 KW - upto 37 KW</td><td>196</td></tr> <tr> <td>Above 37 KW - upto 55 KW</td><td>249</td></tr> <tr> <td>Above 55 KW - upto 90 KW</td><td>277</td></tr> <tr> <td>Above 90 KW - upto 125 KW</td><td>331</td></tr> <tr> <td>Above 125 KW-upto 200 KW</td><td>385/203 (For Single core cables only)</td></tr> </tbody> </table>	Motor MCR in KW	Minimum distance between centre of bottom terminal stud and gland plate in mm As per manufacturer's practice.	UP to 3 KW		Above 3 KW - upto 7 KW	85	Above 7 KW - upto 13 KW	115	Above 13 KW - upto 24 KW	167	Above 24 KW - upto 37 KW	196	Above 37 KW - upto 55 KW	249	Above 55 KW - upto 90 KW	277	Above 90 KW - upto 125 KW	331	Above 125 KW-upto 200 KW	385/203 (For Single core cables only)
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Above 55 KW - upto 90 KW	277																				
Above 90 KW - upto 125 KW	331																				
Above 125 KW-upto 200 KW	385/203 (For Single core cables only)																				

For HT motors the distance between gland plate and the terminal studs shall not be less than 500 mm.

PHASE TO PHASE/ PHASE TO EARTH AIR CLEARANCE:

NOTE: Minimum inter-phase and phase-earth air clearances for LT motors with lugs installed shall be as follows:

Motor MCR in KW	Clearance
UP to 110 KW	10mm
Above 110 KW and upto 150 KW	12.5mm
Above 150 KW	19mm

	TECHNICAL SPECIFICATION DARLIPALI STPP STAGE-II (1X800 MW)	PE-TS-521-555-A001	
		Issue No: 01	
		Rev. No. 00	
		Date :13.08.2026	
TECHNICAL DATA - PART - A			
SL.NO	DESCRIPTION	UOM	DETAIL
1.0	DESIGN CODES & STANDARDS		
1.1	Three phase induction motors :		IS15999, IEC:60034, IS: 12615, IS: 325
1.2	Single phase AC motors		IS:996, IEC:60034
1.3	Energy Efficient motors		IS 12615, IEC:60034-30
1.4	Mechanical Vibration of Rotating Electrical Machines with Shaft Heights 56 mm and Higher - Measurement, Evaluation and Limits of Vibration Severity		IS 12075/IEC 60034-14
1.5	Designation of Methods of Cooling of Rotating Electrical Machines		IS 6362
1.6	Designation for types of construction and mounting arrangement of rotating electrical machines		IS 2253
2.0	DESIGN /SYSTEM PARAMETERS		
2.1	Rated voltage	V	415
2.2	Frequency	Hz	50
2.3	Permissible variations for		
a)	Voltage	%	+/-10
b)	Frequency	%	(+)-3 to (-)5
c)	Combined	%	10 (absolute sum)
2.4	Short time rating for terminal boxes for 0.25 sec	kA	50
2.5	Type of motors		Squirrel cage induction motor
a)	Non-VFD		Suitable for direct on line starting
b)	VFD (if applicable)		Suitable for inverter duty
2.6	Efficiency class		Continuous duty LT motors upto 50 KW Output rating (at 50 deg.C ambient temperature), shall be super Premium Efficiency class-IE4, 50-200 KW shall be of Premium Efficiency class – IE3, conforming to IS 12615, or IEC:60034-30.
2.7	Rating		
a)	Motor duty		Continuously rated-S1
b)	Design margin over continous max. demand of the driven equipment (min)		10%
3.0	CONSTRUCTION FEATURES		
3.1	Winding		Electrolytic grade Copper conductor.
3.2	Enclosure Details		
a)	Degree of protection		
i)	Indoor motors		IP 55
ii)	Outdoor motors		IP 55 (Additional Canopy to be provided)
b)	Method of ventilation		Totally enclosed fan cooled (TEFC) or totally enclosed tube ventilated (TETV) or Closed air circuit air cooled (CACA) type.
3.3	Insulation		

a)	Class		Class 'F' or better with temperature rise limited to class 'B'.
b)	General Characteristics		Non-hygroscopic, oil resistant, flame resistant Insulation.
c)	Special Characteristics		VPI insulation for VFD motors
3.4	Bearings		-Grease lubricated ball or roller bearings for Horizontal motors Grease lubricated ball or roller bearings or combined thrust and guide bearing for Vertical motors.
3.5	Main terminal box		
a)	Type		-Motor terminal box shall be detachable type and .
b)	Location		located in accordance with Indian Standards clearing the motor base- plate/ foundation
c)	Terminal		Terminals shall be stud or lead wire type, substantially constructed and thoroughly insulated from the frame.
d)	Phase marking		The terminals shall be clearly identified by phase markings, with corresponding direction of rotation marked on the non-driving end of the motor.
e)	DOP		Same as motor
f)	Rotation		360 Deg. rotatable in steps of 90 Deg.
g)	Space heater		Motors rated 30KW and above shall have space heater. Separate terminal box for space heaters & RTDs shall be provided.
h)	Cable glands/ lugs/ gland plates		-Gland plates of thickness
i)	Size		As per cable size used.
ii)	Lugs		Solderless crimping type heavy duty copper lugs.
iii)	Glands		double compression Ni-Cr plated brass glands.
iv)	Gland plate thickness		3 mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material for single core cables)
3.6	Earthing points suitable for connection		
a)	No. of points on motor body		Two earthing points on opposite sides with two separate and distinct grounding pads complete with tapped holes, GI bolts and washers.
b)	No. of points on motor terminal box		One earthing point complete with tapped holes, GI bolts and washers.
c)	Earthing Flat size (Indicative)		Motor Earthing Terminal will be suitable for termination of Earthing Flat size (tentative) indicated below. Final size will be confirmed by BHEL during contract stage.
i)	LT Motors above 125 KW		50 x 6mm GS flat
ii)	25 KW to 125 KW		25 x 6mm GS flat
iii)	1KW to 25 KW		25 x 3mm GS flat
iv)	Fractional kW		8 SWG GS Wire

3.7	Paint shade (Corrosion proof paints of colour shade)		- RAL 5012 (Blue). -The thickness of finish coat shall be minimum 50 microns (minimum total DFT shall be 100 microns). However, in case electrostatic process of painting is offered. minimum paint thickness of 50 microns shall be acceptable for finish coat.Epoxy based paint with suitable additives shall be used.
3.8	Minimum distance between gland plate & centre of bottom terminal stud		UP to 3 KW As per manufacturer's practice. Above 3 KW - upto 7 KW 85 mm Above 7 KW - upto 13 KW 115 mm Above 13 KW - upto 24 KW 167 mm Above 24 KW - upto 37 KW 196 mm Above 37 KW - upto 55 KW 249 mm Above 55 KW - upto 90 KW 277 mm Above 90 KW - upto 125 KW 331 mm Above 125 KW-upto 200 KW 385/203 mm (For Single core cables only)
3.9	Minimum inter-phase and phase-earth air clearances with lugs installed		UP to 110 KW 10mm Above 110 KW and upto 150 KW 12.5mm Above 150 KW 19mm
4.0	PERFORMANCE PARAMETERS		
4.1	Starting requirement		
a)	Minimum permissible voltage as a percentage of rated voltage, at start to bring the driven equipment upto rated speed		a) Up to 85% of rated voltage for ratings below 110 KW b) Up to 80% of rated voltage for ratings from 110 KW to 200 KW
b)	Maximum locked rotor current		As per IS 12615
c)	Starting duty		Refer motor specification.
d)	The locked rotor withstand time under hot condition at highest voltage limit		a) atleast 2.5 secs. more than starting time(for motors with starting time upto 20 secs. at minimum permissible voltage during starting) b)atleast 5 secs. more than starting time(for motors with starting time more than 20 secs. and upto 45 secs. at minimum permissible voltage during starting) c) more than starting time by at least 10% of the starting time(For motors with starting time more than 45 secs.at minimum permissible voltage during starting) Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.
e)	The ratio of locked rotor KVA at rated voltage to rated KW shall not exceed the following (without any further tolerance)		(a) From 50KW & upto 110KW : 11.0 (b) From 110 KW & upto 200 KW : 9.0
4.2	Torque (percent of full load torque)		1) Accelerating torque at any speed with the lowest permissible starting voltage shall be at least 10% motor rated torque. 2) Pull out torque at rated voltage shall not be less than 205% of rated torque.
4.3	Noise level (max.)		85 dB(A) at 1m from motor
4.4	Vibration shall be limited within the limits		As per IS 12075/ IEC 60034-14.
5.0	INSPECTION/TESTING		
5.1	LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED.		Refer motor specification.
5.2	The type test listed above should have been conducted within 10 yrs prior to 25.06.2024. (In absence of type tests reports or in case reports are not found to be meeting the specification/standards requirements, vendor shall conduct all such type tests without any commercial/delivery implication to BHEL according to the relevant standards and reports shall be submitted to the owner for approval.)		

5.3	The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.
5.4	All acceptance and routine tests as per the specification and relevant standards shall be carried out.Charges for these shall be deemed to be included in the equipment price.
5.5	For motor rating upto 50 KW, BHEL QP No. PE-QP-999-Q-006 Rev 02 is to be followed. For motor ratings above 50 kW NTPC Quality assurance plan will be followed.

	TECHNICAL SPECIFICATION DARLIPALI STPP STAGE-II (1X800 MW)	PE-TS-521-555-A001	
		Issue No: 01	
		Rev. No. 00	
		Date :13.08.2026	
TECHNICAL DATA - PART - B (SUPPLIER DATA TO BE FURNISHED AFTER AWARD OF CONTRACT)			
SL.NO		UOM	DETAIL
1.0	GENERAL		
i)	Manufacturer & Country of origin.		
ii)	Equipment driven by motor)		
iii)	Motor type		
iv)	Country of origin		
v)	Quantity	nos.	
2.0	DESIGN AND PERFORMANCE DATA		
i)	Frame size		
ii)	Type of duty		
iii)	Type of enclosure and method of cooling		
vi)	Type of mounting		
vii)	Direction of rotation as viewed from DE END		
viii)	Standard continuous rating at 40 deg.C. ambient temp. as per Indian Standard	(KW)	
ix)	(A) Derated rating for specified normal condition i.e. 50 deg. C ambient temperature	(KW)	
	(B) Rating as specified in load list	(KW)	
xi)	Rated speed at rated voltage and frequency	rpm	
xii)	At rated Voltage and frequency		
	a) Full load current	A	
	b) No load current	A	
xiii)	Power Factor at		
	a) 100% load		
	b) At duty point		
	c) 75% load		
	d) 50% load		
	e) NO load		
	f) Starting.		
xiv)	Efficiency at rated voltage and frequency		
	a) 100% load		
	b) At duty point		
	c) 75% load		
	d) 50% load		
xv)	Starting current(<i>inclusive of IS tolerance</i>) at		
	a. 100 % voltage	A	
	b. Minimum starting voltage	A	
xvi)	Starting time with minimum permissible voltage		
	a. Without driven equipment coupled	sec	
	b. With driven equipment coupled	sec	
xvii)	Safe stall time with 110% of rated voltage		
	a. From hot condition	sec	

	b. From cold condition	sec	
xviii)	Torques :		
	a. Starting torque at min. permissible voltage	(kg-mtr.)	
	b. Pull up torque at rated voltage.	(kg-mtr.)	
	c. Pull out torque	(kg-mtr.)	
	d. Min accelerating torque available	(kg-mtr.)	
	e. Rated torque	(kg-mtr.)	
xix)	Stator winding resistance per phase (at 20 Deg.C.)	Ohm	
xx)	GD ² value of motors		
xxi)	Locked rotor KVA input (at rated voltage)		
xxii)	Locked rotor KVA/KW.		
xxiii)	Bearings		
	a. Type		
	b. Manufacturer		
	c. Self Lubricated or forced Lubricated		
	d. Recommended Lubricants		
	e. Guaranteed Life in Hours		
	f. Whether Dial Type thermometer provided		
	g. Oil pressure Gauge/switch		
	i. Range		
	ii. Contact Nos. & ratings		
	iii. Accuracy		
xxiv)	Vibration		
	a) Velocity	mm/s	
	b) Displacement	microns	
xxv)	Noise level	db	
3	CONSTRUCTIONAL FEATURES		
i	Stator winding insulation		
	a. Class & Type		
	b. Tropicalised (Yes/No)		
	c. Temperature rise over specified max.		
	i. Cold water temperature of 38 DEG. C.		
	ii. Ambient Air 50 DEG. C.		
	d. Method of temperature measurement		
	e. Stator winding connection		
	f. Number of terminals brought out		
ii	Type of terminal box for		
	a. stator leads		
	b. space heater		
	c. Temperature detectors		
	d. Instrument switch etc.		
iii)	For main terminal box		
	a. Location		
	b. Entry of cables		
	c. Recommended cable size		
	d. Fault level	MVA	
iv)	Temperature detector for stator winding		
	a. Type		
	b. Nos. provided		
	c. Location		
	d. Make		
	e. Resistance value at 0 deg. C	ohms	

vi)	Paint shade		
vii).	Weight of(approx)		
	a. Motor stator (KG)		
	b. Motor Rotor (KG)		
	c. Total weight (KG)		
4	Relevant motor curves		

	MANUFACTURER/ BIDDER/ SUPPLIER NAME & ADDRESS	STANDARD QUALITY PLAN		SPEC. NO :	DATE:
		CUSTOMER :		QP NO.: PE-QP-999-Q-006, REV-02	DATE: 17.04.2020
		PROJECT:		PO NO.:	DATE:
		ITEM: AC ELECT. MOTORS UPTO 55KW (LV (415V))	SYSTEM:	SECTION: II	SHEET 2 of 2

		3.NAMEPLATE DETAILS	MA	VISUAL	100%	-	IS-325 / IS-12615 / APPROVED DATA SHEET	SAME AS COL. 7	TEST/ INSPN. REPORT	✓	P	V	-	
4.0	PACKING	SURFACE FINISH & COMPLETENESS	MA	VISUAL	100%	100%	AS PER MFG. STANDARD / (#)	AS PER MFG. STANDARD / (#).	INSPC. REPORT	✓	P	W	-	(#) REFER NOTE-8

NOTES:

1. Routine tests on 100% motors shall be done by the vendor. However, BHEL/ Customer shall witness routine tests on random samples. The sampling plan shall be mutually agreed upon.
2. For exhaust/ventilation fan motors of rating up to 1.5 KW, only routine test certificates shall be furnished for scrutiny.
3. In case test certificates for these tests on similar type, size and design of motor from independent laboratory are available, the same is valid for 5 years.
4. BHEL reserves the right to perform repeat test, if required.
5. After packing and prior to issue MDCC, photographs of items to be despatched shall be sent to BHEL for review.
6. In case of any changes in QP commented by customer at contract stage, same shall be carried out by bidder without any implication to BHEL/ Customer.
7. Project specific QP to be developed based on customer requirement.
8. For export job, BHEL technical specification for seaworthy packing to be followed.
9. Packing shall be suitable for storage at site in tropical climate conditions.
10. Latest revision/ year of issue of all the standards (IS/ ASME/ IEC etc.) indicated in QP shall be referred.

LEGENDS:

*RECORDS, IDENTIFIED WITH "TICK"(✓) SHALL BE ESSENTIALLY INCLUDED BY SUPPLIER IN QA DOCUMENTATION,

** **M:** SUPPLIER/ MANUFACTURER/ SUB-SUPPLIER, **B:** MAIN SUPPLIER/ BHEL/ THIRD PARTY INSPECTION AGENCY, **C:** CUSTOMER,

P: PERFORM, **W:** WITNESS, **V:** VERIFICATION, AS APPROPRIATE

MA: MAJOR, **MI:** MINOR, **CR:** CRITICAL

D: DOCUMENTATION

BHEL						BIDDER/ SUPPLIER		FOR CUSTOMER REVIEW & APPROVAL			
ENGINEERING			QUALITY			Sign & Date		Doc No:			
	Sign & Date	Name		Sign & Date	Name	Seal			Sign & Date	Name	Seal
Prepared by:	HEMA KUSHWAHA	HEMA KUSHWAHA	Checked by:		KUNAL GANDHI			Reviewed by:			
Reviewed by:	PRAVEEN DUTTA	PRAVEEN DUTTA	Reviewed by:	 RITESH KUMAR JAISWAL	RITESH KUMAR JAISWAL			Approved by:			

MOTOR

TESTS/CHECKS TEMS/COMPONENTS	Visual	Dimensional	Make/Type/Rating /General Physical Inspection	Mech/Chem. Properties	NDT /DP/MPI/UT	Metallography	Electrical Characteristics	Welding/Brazing(WPS/PQR)	Heat Treatment	Magnetic Characteristics	Hydraulic/Leak/Pressure Test	Thermal Characteristics	Run out	Dynamic Balancing	Routine & Acceptance tests as per IS-4722 /IS- 9283/IS 2148/IEC60034/IEC 60079-I/ IS-12615	vibration	Over speed	Tan delta, shaft voltage & polarization index test	Paint shade, thickness & adhesion
Plates for stator frame, end shield, spider etc.	Y	Y	Y	Y	Y				Y										
Shaft	Y	Y	Y	Y	Y	Y			Y										
Magnetic Material	Y	Y	Y	Y			Y			Y		Y							
Rotor Copper/Aluminium	Y	Y	Y	Y			Y		Y										
Stator copper	Y	Y	Y	Y			Y		Y			Y							
SC Ring	Y	Y	Y	Y	Y		Y	Y	Y										
Insulating Material	Y		Y	Y			Y					Y							
Tubes, for Cooler	Y	Y	Y	Y	Y				Y		Y								
Sleeve Bearing	Y	Y	Y	Y	Y				Y		Y								
Stator/Rotor, Exciter Coils	Y	Y	Y				Y	Y											
Castings, stator frame, terminal box and bearing housing etc.	Y	Y	Y	Y	Y			Y											
Fabrication & machining of stator, rotor, terminal box	Y	Y			Y			Y	Y										
Wound stator	Y	Y					Y	Y											
Wound Exciter	Y	Y					Y	Y											
Rotor complete	Y	Y					Y						Y	Y					
Exciter, Stator, Rotor, Terminal Box assembly	Y	Y					Y												

EPC PACKAGE FOR DARLIPALI STPP, STAGE-II (1X800 MW)	TECHNICAL SPECIFICATIONS SECTION – VI, PART-B BID DOC. NO. CS-9551-001-2	PART - B SUB-SECTION-VI E42- MOTORS	Page 1 of 2
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CLAUSE No.

CHAPTER NAME

Accessories, RTD, BTD, CT, Space heater, antifriction bearing, gaskets etc.	Y	Y	Y																
Complete Motor	Y	Y	Y												Y	Y	Y	Y1	Y

Note:

1. The manufacture is to furnish a detailed Quality Plan indicating the practices & Procedure followed along with relevant supporting documents during QP finalization. However, following methodology to be followed for Inspection Categorization:

Note for LT Motor:

i) Motor rating up to 50 KW: Inspection CAT- III : Acceptance of Motor up to 50 KW is based on COC of the Manufacturer and Main Contractor confirming as follows:

“It is hereby confirmed that the above mentioned motor /motors was/ were manufactured taking care of NTPC specific requirements regarding ambient temp., voltage frequency variation, hot s KVA/KW, temperature rise, distance between center of stud gland plate and tested in accordance with approved drawing /data sheets.”

ii) Motor rating above 50 KW & less than 75 KW: Inspection CAT- II as per NTPC approved MQP: Acceptance of Motor rating above 50 KW & less than 75 KW is based on NTPC rev report as per IS:12615 - 2018 (including latest revision) duly witnessed by main contractor along with COC of the Manufacturer and Main Contractor confirming as follows:

“It is hereby confirmed that the above mentioned motor /motors was/ were manufactured taking care of NTPC specific requirements regarding ambient temp., voltage frequency variation, hot s KVA/KW, temperature rise, distance between center of stud gland plate, space heater and tested in accordance with approved drawing /data sheets.”

iii) Motor rating 75 KW & above: Inspection CAT-I: As per NTPC approved MQP.

2. Additional routine tests for Flame proof motors shall be applicable as per relevant standard

3. Makes of major bought out items for HT motors will be subject to NTPC approval.

4. Y1 = for HT Motor / Machines only.

5. For LT Motors, stator core stack length & grade, no load loss and winding resistance w.r.t. type tested motor for IE2/IE3 shall be checked/verified in addition to Compliance of relevant standard IS:12615/IEC requirement. In case actual results are not within the tolerance limit as declared by manufacturer during QP submission, the motor shall be subjected to efficiency test.

EPC PACKAGE FOR DARLIPALI STPP, STAGE-II (1X800 MW)	TECHNICAL SPECIFICATIONS SECTION – VI, PART-B BID DOC. NO. CS-9551-001-2	PART - B SUB-SECTION-VI E42- MOTORS	Page 2 of 2
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SUB-SECTION-B – 10

~~CABLING EARTHING AND LIGHTNING PROTECTION~~

1.00.00 CODES AND STANDARDS

1.01.00 All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards/ codes as applicable.

IS:513	Cold rolled low carbon steel sheets and strips.
IS:802	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
IS:1079	Hot Rolled carbon steel sheet & strips
IS:1239	Mild steel tubes, tubulars and other wrought steel fittings
IS:1255	Code of practice for installation and maintenance of power cables upto and including 33 KV rating
IS:1367 Part-13	Technical supply conditions for threaded Steel fasteners. (Hot dip galvanized coatings on threaded fasteners).
IS:2147	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanising of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles
IS:3043	Code of practice for Earthing
IS:6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS:8308	Compression type tubular in- line connectors for aluminium conductors of insulated cables
IS:8309	Compression type tubular terminal ends for aluminium conductors of insulated cables.
IS:9537	Conduits for electrical installation.
IS:9595	Metal - arc welding of carbon and carbon manganese steels – recommendations.
IS:13573	Joints and terminations for polymeric cables.
BS:476	Fire tests on building materials and structures
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
DIN 46267 (Part-II)	Non tension proof compression joints for Aluminium conductors.
DIN 46329	Cable lugs for compression connections, ring type ,for Aluminium conductors
BS:6121	Specification for mechanical Cable glands for elastomers and plastic insulated cables.
	Indian Electricity Act.
	Indian Electricity Rules.

1.02.00 Equipment complying with other internationally accepted standards such as IEC, BS, DIN, USA, VDE, NEMA etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards alongwith copies of all official amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison.

2.00.00 DESIGN AND CONSTRUCTIONAL FEATURE

2.01.00 Inter Plant Cabling

2.01.01 Interplant cabling for main routes shall be laid along overhead trestles/duct banks. Cables from main plant to switchyard control room shall be laid in overhead trestles or duct bank. In case of Duct banks, pull-pits shall be filled with sand and provided with a PCC covering. Directly buried cables, if essential, shall not have concentration of more than 4 cables in one route. Cables crossing Railway line (if applicable) shall be laid underground through nearest culvert/through hume pipes/ overhead trestle. Necessary statutory clearance if required shall be taken by Bidder. All HT, LT and control cable shall be armoured.

2.01.02 Transformer yard

In transformer yard cables shall be laid in overhead trestle. The main cable routes coming out from Main plant building and crossing the Transformer yard shall be laid in overhead trestles. In transformer yard, trestle height for rail/road crossing shall be suitable for movement of Generator Transformer with bushing.

2.01.03 Trenches

PCC flooring of built up trenches shall be sloped for effective drainage with sump pits and sump pumps.

2.01.04 No sub zero level cable vault/trenches shall be provided below control building/switchgear rooms in main plant.

2.01.05 Cable Vault

The cable vault/ / cable spreader room space below the HT / LT switchgear room, Control Rooms, unit control equipment room, Programmer room, UPS, Charger & Battery Rooms, shall have **800 mm wide** and 2.1 m high movement passage all around the cable trays in the cable vault/ cable spreader room for easy laying/maintenance of cables.

Cable vaults shall be provided with adequate drainage facilities for drainage of fire water. Each cable vault should have at least two fire proof doors preferably diagonally opposite.. Exit signs shall be provided near doors for personnel escape in case of emergency

2.01.06 Boiler Area

Cable trays in boiler & ESP area shall be supported from the boiler and ESP structures. The same shall be coordinated with SG/ESP contractor. Cable trays in these areas shall be in vertical formation to avoid dust accumulation. No cable trenches shall be provided in boiler/ESP area.

2.01.07 Two separate cable routes shall be provided for cable routing of working and standby drives or different set/group (say 50% capacity) of auxiliaries.

2.01.08 OffSite Area

For feeder in bidder's scope for offsite areas, overhead cable tray arrangement shall be followed. However cable trenches/slit may also be acceptable, for some areas, if found to be required during detailed engineering.

2.01.09 Cable trenches provided shall be separated from fuel oil area to avoid oil accumulation. The cable slits to be used for motor/equipment power/control supply shall be sand filled & covered with PCC after cabling.

2.01.10 Sizing criteria, derating factors for the cables shall be met as per respective chapters. However for the power cables, the minimum conductor size shall be 6 sq.mm. for aluminium conductor and 2.5 sq.mm. for copper conductor cable.

2.01.11 Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to:

- Meet all safety requirements
- Safeguard against fire hazards, mechanical damage, flooding of water, oil accumulation, electrical faults/interferences, etc.

3.00.00 EQUIPMENT DESCRIPTION

3.01.00 Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.

3.01.02 Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant clause of this chapter.

3.01.03 Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be 3 mm.

3.01.04 Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of thickness 2 mm and shall be hot dip galvanized as per relevant clause of this chapter. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm.

3.01.05 The tolerance for cable tray and accessories shall be as per IS 2102 (Part-1).
Tolerance Class: - Coarse

3.02.00 Support System for Cable Trays

3.02.01 Cable tray support system shall be pre-fabricated out of single sheet as per enclosed tender drawings.

3.02.02 Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of two types : (i) C1:- having provision of supporting cable trays on one side and (ii) C2:-having provision of supporting cable trays on both sides. The support system shall be the type described hereunder:

- a) Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardwares such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.
- b) The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardwares fittings and accessories shall be prefabricated factory galvanized.
- c) The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvanized surface shall be brushed and red lead primer, oil primer & aluminium paint shall be applied.

- d) All steel components, accessories, fittings and hardware shall be hot dip galvanised after completing welding, cutting, drilling and other machining operation.
- e) The typical arrangement of flexible support system is shown in the enclosed drawings and described briefly below:
The main support channel and cantilever arms shall be fabricated out of 2.5 thick rolled steel sheet conforming to IS 1079.
- f) Cantilever arms of 170mm 320 mm, 620mm and 750 mm in length are required, and shall be as shown in the enclosed drawing. The arm portion shall be suitable for assembling the complete arm assembly on to component constructed of standard channel section. The back plate shall allow sufficient clearance for fixing bolt to be tightened with tray in position.
- g) Support system shall be able to withstand
 - weight of the cable trays
 - weight of the cables (75 Kg/Metre run of each cable tray)
 - Concentrated load of 75 Kg between every support span
 - Factor of safety of minimum 1.5 shall be considered

3.02.03 The size of structural steel members or thickness of sheet steel of main support channel and cantilever arms and other accessories as indicated above or in the enclosed drawings are indicative only. Nevertheless, the support system shall be designed by the bidder to fully meet the requirements of type tests as specified. In case the system fails in the tests, the components design modification shall be done by the Bidder without any additional cost to the Employer. The bidder shall submit the detailed drawings of the system offered by him along with the bid.

3.02.04 Four legged structure shall be provided wherever there is change in elevation and change in direction

3.02.05 **FOR COAL HANDLING PLANT/FGD PLANT/ ESP AREA THE FOLLOWING SHALL ALSO BE APPLICABLE:**

- a) All overhead cable routes shall be along the route of the conveyor gallery on separate supporting structures and cables shall be laid in vertical trays. The bottom of the steel shall be such that the existing facilities, movement of trucks/human beings etc. does not get affected. The cable trestle shall have a minimum 600mm clear walk way and shall have maintenance platforms as required. The bottom of the steel supporting structure shall be generally at 3.0M above the grade level except for rail/road crossings. However, at all road/rail crossings, the level of bottom of steel of the gallery shall be at least 8.0m from the top of road surface and 8.5 m from top of rail track. Tap offs from the overhead cable trestle can be through shallow trenches with prior approval of the Employer. Directly buried cable, if essential, shall not have concentration of more than 4 cables on one route.
- b) Cable trenches shall be provided only in Switchgear/MCC rooms.
- c) Cables shall not be routed through the conveyor galleries except for the equipment located in the conveyor galleries for a particular conveyor i.e. protection switches, receptacles etc. and bunker TP related conveyors.
- d) Cables for PCS and BSS shall be routed along the conveyors through GI conduits.

3.03.00 **Pipes, Fittings & Accessories**

- 3.03.01 Pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.) The size of the pipe shall be selected on the basis of maximum 40% fill criteria.
- 3.03.02 GI Pipes shall be of medium duty as per IS: 1239
- 3.03.03 Duct banks shall be High Density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes.
- 3.03.04 Hume pipes shall be NP3 type as per IS 458.
- 3.03.05 Flexible conduit shall be water proof, rust proof, made of heat resistant steel with temperature rating of 150 deg C. Conduit diameter shall be uniform throughout its length. Internal surface of the conduit shall be free from burrs and sharp edges. Conduits shall be complete with necessary accessories for proper termination of the conduit with junction boxes and lighting fixtures.
- 3.03.06 HDPE pipes and conduits shall be PE-80, PN-10 type as per IS 4984/IS 8008 part-I.
- 3.04.00 **Junction Boxes**
- 3.04.01 Junction box shall be made of Fire retardant material. Material of JB shall be Thermoplastic or thermosetting or FRP type. The box shall be provided with the terminal blocks, mounting bracket and screws etc. The cable entry shall be through galvanized steel conduits of suitable diameter. The JB shall have suitable for installing glands of suitable size on the bottom of the box. The JB shall be suitable for surface mounting on ceiling/structures. The JB shall be of grey color RAL 7035. All the metal parts shall be corrosion protected. Junction box surface should be such that it is free from crazings, blisterings, wrinkling, colour blots/striations. There should not be any mending or repair of surface. JB's will be provided with captive screws so that screws don't fall off when cover is opened. JB's mounting brackets should be of powder coated MS. Type test reports for the following tests shall be furnished:
- Impact resistance for impact energy of 2 Joules (IK07) as per BS EN50102
 - Thermal ageing at 70deg C for 96 hours as per IEC60068-2-2Bb
 - Class of protection shall be IP 55
 - HV test
- 3.04.02 Terminal blocks shall be 1100V grade, of suitable current rating, made up of unbreakable polyamide 6.6 grade. The terminals shall be screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals the screw shall be captive, preferably with screw locking design. All terminal blocks shall be suitable for terminating on each side the required cables/wire size. All internal wiring shall be of cu. Conductor PVC wire.
- 3.05.00 Terminations & Straight Through Joints**
- 3.05.01 Termination and jointing kits for 33kV, 11 kV, 6.6 KV and 3.3 kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be Pre-moulded type or heat shrinkable type. Further Cold shrinkable type termination and jointing kits are also acceptable. The Cold shrinkable type kits shall be type tested as per relevant standards. Calculation to withstand the required fault level shall also be furnished in case of cold shrinkable type kits. 33 kV, 11 kV, 6.6 KV and 3.3kV grade joints and terminations shall be type tested and Type test reports as per IS:13573 Part-II and IEC60502 shall be furnished. Also, heat shrink material shall comply with requirements of ESI 09-13 (external tests). Critical components used in cable accessories shall be of tested and proven quality as per relevant product specification/ESI specification. Cable

joints and terminations should be with FRLS properties as per IEC 60754-1&2. Kit contents shall be supplied from the same source as were used for type testing. The kit shall be complete with the tinned copper solderless crimping type cable lugs & ferrule or mechanical connectors (wherein bolts are tightened that shear off at an appropriate torque) as per DIN standard suitable for aluminium compacted conductor cables.

3.05.02 Straight through joint and termination shall be capable of withstanding the fault level of 21 KA for 0.12 Sec. with dynamic peak of 52 KA for 33 KV system & of 40 kA for 0.12 sec with a dynamic peak of 100 kA for 11 kV, 6.6 KV & 3.3 KV system. Straight through joints shall have provisions for shield connection and earthing wherever required and complete with all accessories and consumables suitable for storage without deterioration at a temperature of 50 deg. C with shelf life of more than five years. 1.1 kV grade straight through joints shall also be of proven design

3.05.03 1.1 KV grade Straight Through Joint shall be of proven design

3.06.00 **Cable glands**

Cable shall be terminated using double compression type cable glands. Testing requirements of Cable glands shall conform to BS:6121 and gland shall be of robust construction capable of clamping cable and cable armour (for armoured cables) firmly without injury to insulation. Cable glands shall be made of heavy duty brass machine finished and nickel chrome plated. Thickness of plating shall not be less than 10 micron. All washers and hardware shall also be made of brass with nickel chrome plating Rubber components shall be of neoprene or better synthetic material and of tested quality. Cable glands shall be suitable for the sizes of cable supplied/erected.

3.07.00 **Cable lugs/ferrules**

3.07.01 Cable lugs/ferrules shall be solderless crimping type suitable for power and control cables as per the DIN 46239. Aluminium solderless crimping lugs/ ferrules shall be used for Aluminium cables and Copper lugs/ferrules shall be used for Copper cables. Bimetallic washers or bimetallic type lugs shall be used for bimetallic connections.

Crimping tool for crimping (from 1.5sqmm cable to 630sqmm cables) above mentioned lugs shall be of Hexagonal Type crimp profile, with suitable die of crimp match code.

Characteristics of crimping tool:

- 1) To should generate enough pressure to pass pull out test as per IEC 61238-1. Relevant type test to be produced for the sizes specified in the tender.
- 2) Tool die shall be replaceable for assorted sizes and crimp code to be mentioned on both part the die
- 3) Tool should be compliant of testing according to IEC, UL and GS standards

Tool shall have features such as

- Auto retraction system
- Manual retraction stop
- Feedback signals for improper pressure
- Better battery capacity and with status display
- Flexible and rotating head for easy crimping

3.08.00 **Trefoil clamps**

3.08.01 Trefoil clamps for single core cables shall be pressure die cast aluminum or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc. Trefoil clamps shall have adequate mechanical strength, when installed at 1 mtr intervals, to withstand the forces generated by the peak value of maximum system short circuit current

3.09.00 **Cable Clamps & Ties**

- 3.09.01 The cable clamps/ties required to clamp multicore cables shall be of SS-316 material, 12mm wide, polyester coated ladder lock type. The clamps/ties shall have self locking arrangement & shall have sufficient strength. The cable clamps/ties shall be supplied in finished individual pieces of suitable length to meet the site requirements.
- 3.10.00 Receptacles**
- 3.10.01 Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped galvanised or of die-cast aluminium alloy of thickness not less than 2.5 mm. The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/column/structure, gland plate etc. The ON-OFF switch shall be rotary type heavy duty, double break, AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position. Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/copper wire of adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polyimide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with RCCB/RCD of 30mA sensitivity having facility for manual testing/checking of operation of RCCB/RCD. Location and Minimum no of RC type receptacle TG and SG area shall be provided as per Annex-I attached.
- 3.11.00 Cable Drum Lifting Jack**
- The jack for cable drum lifting shall be of screw type with 10 ton capacity. The cable drum jacks shall be manufactured from fabricated steel. The spindles supplied with the cable drum jack shall be manufactured using BSEN-24 grade steel bar with locking collars. Jack nests shall be of SG cast steel. Cable drum jack supplied shall have undergone load testing and reports for the same shall be submitted. At least Two Nos. of jacks shall be supplied for NTPC use. Contractor has to make arrangements for his own jacks for cable reeling/unreeling under his scope of installation.
- 3.12.00 Galvanising**
- 3.12.01 Galvanising of steel components and accessories shall conform to IS:2629 , IS4759 & IS:2633. Additionally galvanising shall be uniform, clean smooth, continuous and free from acid spots.
- 3.12.02 The amount of zinc deposit over threaded portion of bolts, nuts, screws and washers shall be as per IS:1367 . The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads shall have the required zinc coating on them as specified.
- 3.13.00 Welding**
- 3.13.01 The welding shall be carried out in accordance with IS:9595. All welding procedures and welders qualification shall also be followed strictly in line with IS:9595.
- 4.00.00 INSTALLATION**
- 4.01.00 Cable tray and Support System Installation**
- 4.01.01 Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures.
- 4.01.02 Horizontally running cable trays shall be clamped by bolting to cantilever arms and vertically running cable trays shall be bolted to main support channel by suitable bracket/clamps on both

top and bottom side rails at an interval of 2000 mm in general. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000mm in general. Fixing of cable trays to cantilever arms or main support channel by welding shall not be accepted. Cable tray installation shall generally be carried out as per the approved guidelines/ drawings. Vendor shall design the support system along with tray, spacing etc in line with tray loadings/drawings.

- 4.01.03 The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm unless otherwise indicated
- 4.01.04 The contractor shall fix the brackets/ clamps/ insert plates using anchor fasteners. Minimum size of anchor fasteners shall be M 8 X 50 and material shall be stainless steel grade 316 or better. Anchor fastener shall be fixed as recommended by manufacturer and as approved by site engineer. For brick wall suitable anchor fasteners shall be used as per the recommendations of manufacturer. Make of anchor fasteners subject to QA approval and the same shall be finalized at pre-award stage.
- 4.01.05 All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75 mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted/stenciled with identification numbers at every floor.
- 4.01.06 In certain cases it may be necessary to site fabricate portions of trays, supports and other non standard bends where the normal prefabricated trays, supports and accessories may not be suitable. Fabricated sections of trays, supports and accessories to make the installation complete at site shall be neat in appearance and shall match with the prefabricated sections in the dimensions. They shall be applied with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint.
- 4.01.07 In fire prone areas, like Boiler, TG, fuel oil area and any other strategic location etc, fire retardant paint to be applied after installation cables.

4.02.00 **Conduits/Pipes/Ducts Installation**

- 4.02.01 The Contractor shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All openings in the floor/roof/wall / cable tunnel/cable trenches made for conduit installation shall be sealed and made water proof by the Contractor.
- 4.02.02 GI pull wire of adequate size shall be laid in all conduits before installation. Metallic conduit runs at termination shall have two lock nuts wherever required for junction boxes etc.
- 4.02.03 Conduit runs/sleeves shall be provided with PVC bushings having round edge at each end. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed with Glass wool/Cement Mortar/Putty to prevent entrance of moisture and foreign material
- 4.02.04 Exposed conduit/pipe shall be adequately supported by racks, clamps, straps or by other approved means. Conduits /pipe support shall be installed square and true to line and grade with an average spacing between the supports as given below, unless specified otherwise

Conduit /pipe size (dia).	Spacing
Upto 40 mm	1 M
50 mm	2.0 M
65-85 mm	2.5 M
100 mm and above	3.0 M

- 4.02.05 For bending of conduits, bending machine shall be arranged at site by the contractor to facilitate cold bending. The bends formed shall be smooth.
- 4.03.00 Junction Boxes Installation**
- 4.03.01 Junction boxes shall be mounted at a height of 1200mm above floor level or as specified in the drawings and shall be adequately supported/mounted on masonry wall by means of anchor fasteners/ expandable bolts or shall be mounted on an angle, plate or other structural supports fixed to floor, wall, ceiling or equipment foundations.
- 4.04.00 Cable Installation**
- 4.04.01 Cable installation shall be carried out as per IS:1255 and other applicable standards.
- 4.04.02 For Cable unloading, pulling etc following guidelines shall be followed in general:
- a. Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture.
 - b. While laying cable, ground rollers shall be used at every 2 meter interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer. Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager.
- 4.04.03 Cables shall be laid on cable trays strictly in line with cable schedule
- 4.04.04 Power and control cables shall be laid on separate tiers inline with the approved guidelines/drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, H.T. cables shall be laid on top most tier and cables of subsequent lower voltage grades on lower tiers of trays. Single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil center lines and clamped at every one metre. All multicore cables shall be laid in touching formation. Control and instrumentation cable can be laid in 3 layers subject to maximum cable tray filling upto 80% tray depth only. Power and control cables shall be secured fixed to trays/support with cable clamps/ties with self locking arrangement. For horizontal trays arrangements, multicore power cables and control cables shall be secured at every five meter interval. For vertical tray arrangement, individual multicore power cables and control cables shall be secured at every one meter. After completion of cable laying work in the particular vertical tray, all the control cables shall be binded to trays/supports by cable clamps/ties with self locking arrangement at every five meter interval and at every bend. Fibre Optical cable shall be laid in trenches/trays or as decided by Employer
- 4.04.05 Bending radii for cables shall be as per manufacturer's recommendations and IS:1255.
- 4.04.06 Where cables cross roads/rail tracks, the cables shall be laid in hume pipe/ HDPE pipe/overhead trestle.

- 4.04.07 No joints shall be allowed in trip circuits, protection circuits and CT/PT circuits. Also joints in critical equipment in main plant area shall not be permitted. Vendor shall identify and accordingly procure the cable drum length.
- 4.04.08 In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to be made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.
- 4.04.09 Wherever few cables are branching out from main trunk route troughs shall be used.
- 4.04.10 Wind loading shall be considered for designing support as well Cable trays wherever required
- 4.04.11 Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures
- 4.04.12 The installation work shall be carried out in a neat workman like manner & areas of work shall be cleaned of all scraps, water, etc. after the completion of work in each area every day. Contractor shall replace RCC/Steel trench covers after the Installation work in that particular area is completed or when further work is not likely to be taken up for some time
- 4.04.13 **Separation**
At least 300mm clearance shall be provided between:
- HT power & LT power cables,
 - LT power & LT control/instrumentation cables
- 4.04.14 **Segregation**
- 1) Segregation means physical isolation to prevent fire jumping
 - 2) All cables associated with the unit shall be segregated from cables of other units
 - 3) Interplant cables of station auxiliaries and unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire. Power and control cables for AC drives and corresponding emergency AC or DC drives shall be laid in segregated routes. Cable routes for one set of auxiliaries of same unit shall be segregated from the other set
 - 4) In switchyard, control cables of each bay shall be laid on separate racks/trays
- 4.04.15 Minimum number of spare cores required to be left for interconnection in control cables shall be as follows:
- | No. of cores in cable | No. of spare cores |
|-----------------------|--------------------|
| 2C,3C, 5C | 1 |
| 6C-10C | 2 |
| 14C and above | 3 |
- 4.04.16 **Directly Buried Cables**
- a) Cable trenches shall be constructed for directly buried cables. Construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, supply and installation of brick or concrete protective covers, back filling and compacting, supply and installation of route markers and joint markers. Laying of cables and providing protective covering shall be as per IS:1255 and the enclosed drawings showing cabling details.
 - b) RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription

"Cable Joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.

4.04.17 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 20 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate. Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminum with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, the Contractor may also provide cable tags made of nylon, cable marking ties with cable number heat stamped on the cable tags. The cable tag requirements mentioned above shall prevail over Tag requirements mentioned elsewhere in this document for HT power, LT power & control cables.

4.04.18 While crossing the floors, unarmoured cables shall be protected in conduits upto a height of 500 mm from floor level if not laid in tray.

4.05.00 Cable Terminations & Connections

4.05.01 The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer" instructions, drawings and/or as directed by Project Manager. Cable joiner shall be qualified to carryout satisfactory cable jointing/termination. Contractor shall furnish for review documentary evidence/experience reports of the jointers to be deployed at site

4.05.02 Work shall include all clamps, fittings etc. and clamping, fitting, fixing, plumbing, soldering, drilling, cutting, taping, preparation of cable end, crimping of lug, insulated sleeving over control cable lugs, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job to the satisfaction of the Project Manager.

4.05.03 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for punching of gland plates, painting and touching up. Holes shall not be made by gas cutting. The holes shall be true in shape. All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively sealed by 2mm thick aluminium sheets.

4.05.04 Control cable cores entering control panel/switchgear/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with self locking type nylon cable ties with de interlocking facility to keep them in position.

4.05.05 All the cores of the control cable to be terminated shall have identification by providing ferrules at either end of the core, each ferrule shall be indelible, printed single tube ferrule and shall include the complete wire number and TB number as per the drawings. The ferrule shall fit tightly on the core. Spare cores shall have similar ferrules with suffix sp1, sp2, ---etc along with cable numbers and coiled up after end sealing.

4.05.06 All cable terminations shall be appropriately tightened to ensure secure and reliable connections.

5.00.00 EARTHING SYSTEM

5.01.00 Earthing system shall be in strict accordance with IS:3043 and Indian Electricity Rules/Acts. The earthing system shall be designed for a life expectancy of at least forty (40) years, for a

6. All metallic structures within a vicinity of two meters of the conductors shall be bonded to conductors of lightning protection system.
7. Lightning conductors shall not pass through or run inside GI Conduits.
8. Testing link shall be made of galvanized steel of size 25x 6mm.
9. Pulser system for lightning shall not be accepted.
10. Hazardous areas handling inflammable/explosive materials and associated storage areas shall be protected by a system of aerial earths.

7.00.00

TESTS

7.01.00

Type Test reports shall be furnished for the following

7.01.01

Type tests on Cable Trays support system

a) Test 1A:

On main support channel type-C2 for cantilever arms fixed on one side only. A 3.5 meter length of main support channel shall be fixed vertically at each end to a rigid structure as per the fixing arrangement as shown in the enclosed drawing. Eight (8) nos. 750 mm cantilever arms shall be fixed to the main channel and each arm shall be loaded over the outboard 600 mm with a uniform working load of 100 kg. Subsequently a point load of 100 kg shall be applied on arm 2. A uniform proof load on all the arms equal to twice the working load shall be then be applied. Deflections shall be measured at the points shown in the enclosed drawings and at the following load intervals:

- i. Working load
- ii. Working load + point load
- iii. Off load
- iv. Proof load + point load
- v. Off load

The deflection measured at working loads shall not exceed 16mm. The permanent deflection after removing the combination of working load and point load shall not exceed 10 mm at the arm tips and 6 mm on the channel. No collapse of the structure shall occur with a combination of proof load and point load applied

b) Test 1B

Test 1A shall be repeated with Eight Cantilever arms uniformly loaded and with the same point load on arm 2

Test 2: On Main support channel type -C2 for cantilever arms fixed on both sides

- a) **Test 2A:** A 3.5 m length of main support channel C2 for cantilever arms fixing on both sides shall be fixed at each end to rigid structure as per the fixing arrangement as shown in the enclosed drawing. Six (6), 750 mm cantilever arms shall be attached to each sides and each arm uniformly loaded to a working load of 100 kg over the out board 600 mm. A point load of 100 kg shall than be applied to arm 2, followed by a uniform proof load of twice the working load on all the arms; deflection shall be measured at points shown in the enclosed drawings at the following load intervals.

- i. Working load
- ii. Working load + point load
- iii. Off load
- iv. Proof load + point load
- v. Off load

The deflection measured at working loads shall not exceed 16mm. The permanent deflection after removing the combination of working load and point load shall not exceed

10 mm at the arm tips and 6 mm on the channel. No collapse of the structure shall occur with a combination of proof load and point load applied

- b) **Test 2 B:** The test 2 A shall be repeated with the assembly but with an asymmetrical load on the C2 column and point load applied to arm 8. The 100 kg and 200 kg uniformly distributed loads shall be applied to the upper three arms on one side and the lower three arms on the opposite side

Test 3: Tests on Channel Fixed on Beam/Floor

A length of main support channel section shall be fixed to steel structure/floor and have loads applied as shown in the drawing enclosed and as detailed below:

- a) **Test 3A:** A length of steel structure shall be rigidly supported. It should be fitted on a meter length of channel section using beam clamps welded/bolted. A point load of 1200 kg shall be applied to the centre point via two brackets. No distortion or pulling of the components shall take place
- b) **Test 3B:** With the components assembled as in Test 3A, two perpendicular point loads of 600 kg shall be simultaneously applied at positions 150 mm either side of the centre line, no distortion or pulling of the components shall take place
- c) **Test 3C:** With the components assembled as in Test 3A, a perpendicular point load shall be applied at a point 150 mm on one side of the centre line

The load shall be gradually increased to the maximum value that can be applied without causing distortion or pulling of the components. This value shall be recorded

Test 4 : Channel Insert Test

A 2.5 m length of C1 channel fixed to the concrete wall/ steel structure as per actual site installation conditions. 6 nos. of 750 mm cantilever arms shall be attached to C1 channel as shown in enclosed drawing. Each arm uniformly loaded to a working load of 100 kg over the out board 600 mm. A point load of 100 kg shall then be applied to arm 2, followed by a uniform proof load of twice the working load on all the arms; deflection shall be measured at points shown in the enclosed drawings at the following load intervals.

- i. Working load
- ii. Working load + point load
- iii. Off load
- iv. Proof load + point load
- v. Off load

The deflection measured at working loads shall not exceed 16mm. The permanent deflection after removing the combination of working load and point load shall not exceed 10 mm at the arm tips and 6 mm on the channel. No collapse of the structure shall occur with a combination of proof load and point load applied.

Test 5 : Channel nut slip characteristics (what ever applicable)

Tests 5A1,5A2,5A3 : A length of channel C1 section 200mm long shall have fitted bracket with the two bolt fixing as shown in drawing enclosed.

With loads applied at the position shown in drawing enclosed nut slip shall be determined with bolt torque of 30NM, 50 NM and 65 NM No fewer than three measurements shall be made for each torque setting.

A minimum loading of 720 kg shall be obtained before nut slip with bolt torque of 65 NM

Tests 5B1,5B2,5B3: The length of channel C1 section 200 mm long shall have fitted bracket with the one bolt fixing as shown in drawing enclosed. With loads applied at the position shown in drawing, nut slip shall be determined with bolt torques of 30 NM, 50 NM and 65 NM. No fewer than three measurements shall be made for each torque setting

A minimum loading of 350 kg shall be obtained before nut slip with a bolt torque of 65 NM

Test 6 Weld Integrity Test

After deflection test as per test 1A, 1B, 2, 3 & 4 weld integrity shall be checked by magnetic particle inspection to detect sub-surface cracks developed, if any.

7.02.02 Cable termination kit and straight through joints should have been tested as per IS:13573 for 3.3kV grade & above.

7.03.00 Routine/ Acceptance Tests

7.03.01 Routine Tests

- a) Routine tests as per specification and applicable standards shall be carried out on all requirements/items covered in the specification
- b) Physical & dimensional check on all equipments as per approved drawings/standards
- c) HV/IR as applicable
- d) Check/measurement of thickness of paint/zinc coating/nickel-chrome plating as per specification & applicable standard

7.03.02 Acceptance Test

- a) Galvanising Tests as per applicable standards
- b) Welding checks
- c) Deflection tests on cable trays

One piece each of 2.5m length of cable tray of 300mm & above shall be taken as sample from each offered lot. It shall be supported at both end & loaded with uniform load of 76 kg/meter along the length of cable tray. The maximum deflection at the mid-span of each size shall not exceed 7mm

- d) Proof load tests on cable tray support system
 - i. Tests on Main Support Channel shall be done if only C1 Channel are in scope of supply and cantilever arms shall be fitted on one side. This test shall be same as test 4 of type test.
 - ii. Test on Main Support Channel shall be done with C2 channel and cantilever arms fitted on both sides, if C2 channels are in scope of supply. This test shall be same as test 2A of type test. Then test (i) above shall not be done.
 - iii. Nut slip characteristic test (it shall support minimum load of 350kg before nut slips with a bolt torque of 65 NM). This test shall be same as test 5B3 of type test

The procedure for carrying out tests at “d” above shall be as per details given in Type Tests in specification thereafter Die-Penetration test shall be carried out to check weld integrity
- e) The above acceptance tests shall be done only on one sample from each offered lot.

8.00.00 COMMISSIONING

8.01.01 The Contractor shall carry out the following commissioning tests and checks after installation at site. In addition the Contractor shall carry out all other checks and tests as recommended by the Manufacturers or else required for satisfactory performance

8.01.02 **Cables**

- i. Check for physical damage
- ii. Check for insulation resistance before and after termination/jointing
- iii. HT cables shall be pressure tested (test voltage as per IS:7098) before commissioning
- iv. Check of continuity of all cores of the cables
- v. Check for correctness of all connections as per relevant wiring diagrams. Any minor modification to the panel wiring like removing/inserting, shorting, change in terminal connections, etc., shall be carried out by the Contractor.
- vi. Check for correct polarity and phasing of cable connections
- vii. Check for proper earth connections for cable glands, cable boxes, cable armour, screens, etc.
- viii. Check for provision of correct cable tags, core ferrules, tightness of connections

8.02.00 **Cable trays / supports and accessories**

1. Check for proper galvanizing/painting and identification number of the cable trays/supports and accessories.
2. Check for continuity of cable trays over the entire route.
3. Check that all sharp corners, burrs, and waste materials have been removed from the trays supports.
4. Check for earth continuity and earth connection of cable trays.

8.03.00 **Earthing and Lightning protection system**

1. Earth continuity checks.
2. Earth resistance of the complete system as well as sub-system.

9.00.00 **ELECTRICAL LAYOUT PHILOSOPHY:**

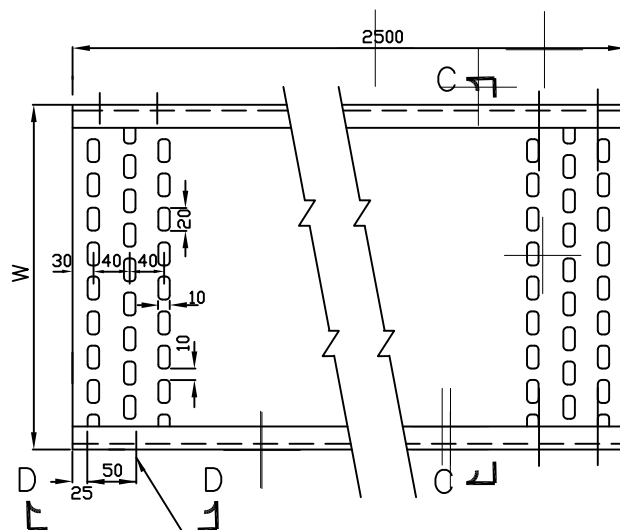
While developing the layout the bidder must give due consideration to the following requirements:

a) Adequate distance shall be maintained between the transformers. As basic guidelines following norms will be adhered to:

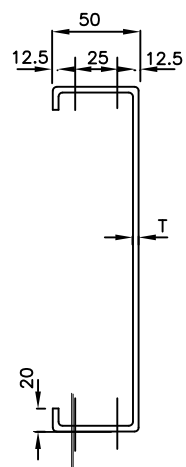
1. Transformers shall be separated from the adjacent building/structures and from each other by a minimum distance as defined below or by a fire wall of two hours of fire resisting of height at least 600 mm above bushing / pressure relief vent whichever is higher.

Oil capacity of individual transformer (in liters)	Clear separating distance (in meters)
5,000 to 10,000	8.0
10,001 to 20,000	10.0
20,001 to 30,000	12.5
Over 30,001	15.0

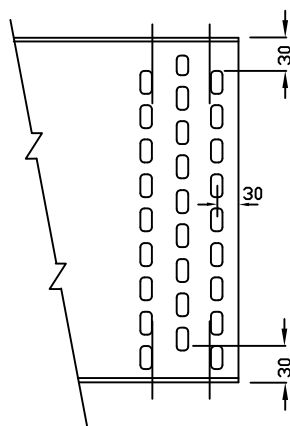
2. In case of auxiliary transformers having an aggregate oil capacity in excess of 2300 liters but individual oil capacity of less than 5000 liters, the maximum separating distance between transformers and surrounding building shall be at least 6M unless they are separated by fire separating walls or are protected by high velocity spray system



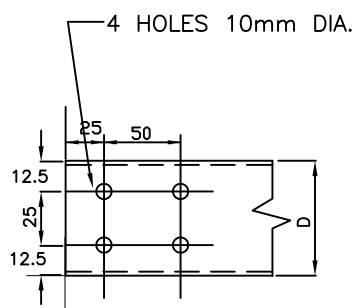
4 HOLES 10mm DIA.



SECTION-CC
(100/50 TRAYS)



ARRANGEMENT OF
PERFORATIONS



VIEW-DD
(100,50W TRAYS)

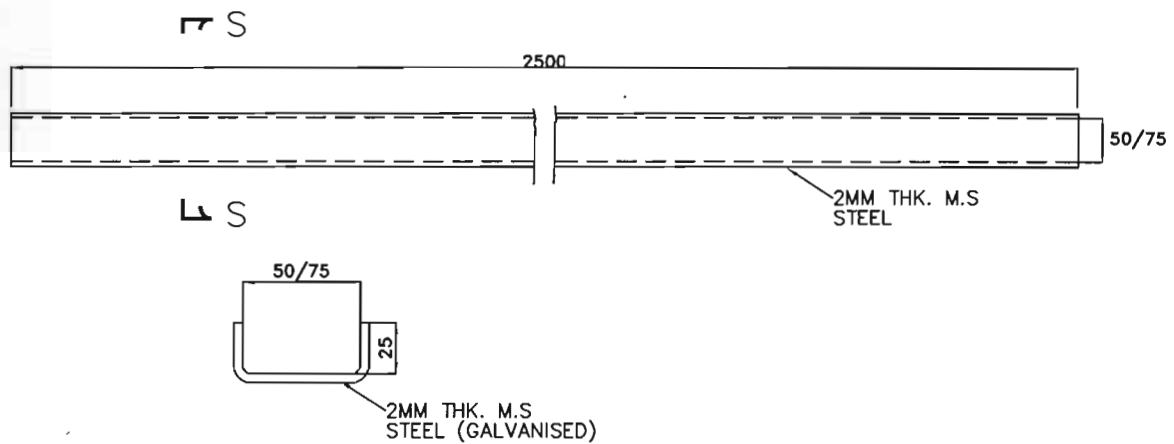
TRAY WIDTH W (mm)	100	50
TRAY DEPTH D (mm)	50	50
T (mm)	2	2

PERFORATED TYPE TRAY



TYPICAL DETAILS OF CABLE TRAYS AND
ACCESSORIES

DWG. NO.



SECTION S-S

CABLE TROUGHS

SEE GENERAL NOTES IN SHEET 11.



TYPICAL DETAILS OF
CABLE TRAY AND ACCESSORIES

BHEL DRAWING NO.
PE-DG-427-507-E005

SH 10 OF 11

REV 00

CABLE TYPE	
SI No.	CABLE TYPE
CABLE TYPE	G-TYPE
1	4PX0.5 sq mm
2	8PX0.5 sq mm
3	12PX0.5 sq mm
F-TYPE	
1	2PX0.5 sq mm
2	4PX0.5 sq mm
3	8PX0.5 sq mm
4	12PX0.5 sq mm
CONTROL CABLE	
1	3CX2.5 sq mm
2	5CX2.5 sq mm
3	12CX1.5 sq mm

		TECHNICAL SPECIFICATION DARLIPALI STPP PH-II (1X800 MW) COMPRESSED AIR SYSTEM		PE-TS-540-555-A001 Rev. No. 00 Date: AUG 2026	
TECHNICAL DATA - PART - A					
SL.NO	DESCRIPTION		UOM	DETAIL	
1.0	DESIGN CODES & STANDARDS				
1.1	Impulse pipes, tubes (material, rating)			ANSI B31.1, ANSI B31.1a, ANSI/ISA 77.70	
1.2	Valves (material, pr. Class, size)			ASTM A182/ASTM A105 as per ASME 16.34	
1.3	Fittings (size, rating, material)			ANSI B31.1, ANSI B31.1a, ASME B16.11	
1.4	Installation schemes			BS 6739-2009, ANSI/ISA 77.70	
1.5	Actuator			EN15714-2	
1.6	Fieldbus concepts			IEC 61158	
1.7	Instruments and apparatus for pressure measurement			ASME PTC19.2	
1.8	Electronic transmitters			BS-6447, IEC-60770	
1.9	Bourdon tube pressure and vacuum gauges			IS-3624	
1.10	Colors for ready mixed paints and enamels.			IS-5	
1.11	Annunciator Sequences and Specification			ISA-18.1	
1.12	Instrument and apparatus for temperature measurement			ASME PTC 19.3(1974)	
1.13	Temperature measurement by electrical Resistance thermometers			IS:2806	
1.14	RTD Sensor			IEC-751/ DIN-43760	
1.15	Type of Enclosures			NEMA ICS Part - 6 - 1978 (with Rev. 1 4/80) through 110.22 (Type 4 to 13)	
1.16	Racks, panels and associated equipment			EIA : RS - 310 C- 1983 (ANSI C83.9 - 1972)	
1.17	Protection class for enclosures, cabinets, control panels & desks			IS:2147 -1962	
1.18	Codes for Orifice plate Design				
	Orifice plate			ISO 5167	
	Flange Standard for Orifice plate			ASME B16.36	
2.0	DESIGN /SYSTEM PARAMETERS				
2.1	DATASHEET - PRESSURE TRANSMITTER, DIFFERENTIAL PRESSURE TRANSMITTER, DP BASED FLOW AND LEVEL TRANSMITTER				
	Output			Profibus PA complying to IEC 61158, digital output	
	Turndown ratio			50:1	
	Accuracy		%	0.06%	
	Stability (% of calibrated range)		%	+/-0.25% for 10 year	
	Diaphragm seal material			Suitable for process fluid	
	Diagram fill fluid			Inert liquid	
	Wetted parts			All wetted parts upto diaphragm seal shall be suitable for process application.	
	Housing			Metallic housing with durable corrosion resistant coating	
	Protection			Weather proof IP-67	
	Display			Integral digital display	
	Diagonstic feature			Required	
	Electrical connection			1/2" NPT (f)	
	Manifold			2/3 valve non integral manifold for PT and 5 valve non integral manifold for DPT	
2.2	DATASHEET - PRESSURE GAUGE, DIFFERENTIAL PRESSURE GAUGE				
	Sensing element			Bourdon for high pressure, diaphragm/bellow for low pressure	
	Sensing element material			SS316	
	Movement material			SS316	
	Body material			SS316	
	Dial size		mm	150mm	
	End connection		inch	1/2 inch NPT (m)	

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SL.NO	DESCRIPTION		UOM	DETAIL	
	Accuracy			±1% of span	
	Scale			Linear, 270° arc graduated in metric units	
	Range selection		%	Cover 125% of max. of scale	
	Over range test			Test pr. for the assembly shall be 1.5 to the max. Design pr. At 38°C.	
	Diaphragm seal material			Suitable for process fluid	
	Diaphragm fill fluid			Inert liquid	
	Wetted parts			All wetted parts upto diaphragm seal shall be suitable for process application	
	Housing			IP-55	
	Zero/span adjustment			External	
	Accessories			Blow out disc, siphon, snubber, pulsation, dampener, chemical seal, gauge isolation valve	
2.3	DATASHEET - LEVEL SWITCH				
	Repeatability		%	+/-0.5% of full range	
	No. of contacts			2 NO.+2NC. SPDT snap action dry contact	
	Rating of contacts		V, VA	60 V DC, 6 VA (or more if required by DDCMIS)	
	Elect. Connection			Plug in socket.	
	Set point adjustment			Provided over full range.	
	Dead band adjustment			Adjustable/ fixed as per requirement of application.	
	Enclosure			IP-55	
	Power Supply		V	24V DC	
	Sensing Element			Float type, conductivity type, Ultrasonic type as per suitability to the application	
	Material			316 SS	
	End connection			Manufacturer standard	
	Over range/ proof pressure		%	150% of maximum operating pr.	
	Accessories			All mounting accessories	
2.4	DATASHEET - TEMPERATURE TRANSMITTER				
	Transmitter Type			Profibus PA complying to IEC 61158 with EMC compatibility as per EN 61326, Dual input (Trip/Protection), Single Input (other application)	
	Compatibility			fully compatible with RTDs	
	Protection Class			IP-67	
	Display			Integral digital display	
	Diagonstic feature			self-indicating diagnostics	
	Operating ambient temperature (with display)		DegC	70 deg C	
	Operating ambient temperature (without display)		DegC	85 deg C	
	Electrical Connection		inch	1/2" NPT(F)	
	Composite Accuracy		%	RTD =<0.25% of 0-250 deg C span	
	Changeover facility			Bump less changeover to second sensor in case first sensor fails with alarm facility.	
	Composite accuracy Calculation			Accuracies of temperature transmitter for converting sensor input to output + temperature effect on these accuracies at ambient temperature of 50 deg C (based on the figure/ formula given in the standard product catalogue for span as specified for RTD).	
	Emergency/failure Measures			In case of failure (open or burn-out) of RTD, transmitter shall provide low temperature output.	
2.5	DATASHEET - RESISTANCE TEMPERATURE DETECTOR (RTD)				

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TECHNICAL DATA - PART - A					
SL.NO	DESCRIPTION		UOM	DETAIL	
	Type			Four wire, Pt-100 (100 Ohms resistance at zero degree Centigrade).	
	No. of element			Duplex	
	Housing			Diecast Aluminium	
	Protection Class			IP-65	
	Head			Head of TE to be provided with sufficient space and arrangement to mount head mounted temperature transmitter	
	Plug in connectors			Required	
	Terminal head			Spring loaded for positive contacts with the thermo well	
	Insulation and sheathing			Mineral (magnesium oxide) insulation and SS316 sheath	
	Calibration and accuracy			As per IEC-751/ DIN-43760 Class-A for RTD	
	Accessories			Thermo well and associated fittings	
2.6	DATASHEET - THERMOWELL				
	Design			One piece solid bored type of step-less tapered design	
	Material			SS316	
2.7	DATASHEET - TEMPERATURE GAUGE				
	Body Material			Die-cast aluminium	
	Material of bourdon/movement			316SS / 304SS	
	End connection			3/4" NPT (M)	
	Accuracy		%	± 1% of span	
	Dial Size		mm	150 mm	
	Scale			Linear, 270° arc graduated in °C	
	Range selection		%	Cover 125% of max. of scale	
	Over range test			Test pr. for the assembly shall be 1.5 to the max. Design pr. At 38°C.	
	Housing			IP-55	
	Zero/span adjustment			Required	
	Accessories			SS Thermowell	
2.8	DATASHEET - SOLENOID VALVE				
	Type			2/3/4 way SS 316/Forged Brass (depending on the application subject to Employer's approval during detailed Engg.)	
	Power supply			24 V DC + 10%.	
	Electrical connection			Plug and socket	
	Insulation			Class 'H'	
	IP Class			IP65	
	Limit switches (for open/close feedback)			Required	
2.9	DATASHEET - LIMIT SWITCH				
	Type			Inductive proximity type	
	Mounting arrangement			Inside the enclosure	
	Operating voltage Range		V	10-40 V DC	
	Sensing system			Inductive Proximity type , 2 Wire	
	Sensor Contact Type			NO	
	Reverse polarity and short circuit protection			Yes	
	IP Class-Sensor			IP67	
	IP Class-Enclosure(Switch box)			IP67	
	Cable entry-Enclosure(Switch box)			2 no-1/2" NPT	
	Casing material-Sensor			Brass /SS	

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TECHNICAL DATA - PART - A			
SL.NO	DESCRIPTION	UOM	DETAIL
	Enclosure(Switch box) Housing material		FRP or SS
	Operating Ambient temp(sensors)	DegC	-5 to 70 deg C
	Max allowed Voltage Drop across sensor	V	5 V
	Standard applicable		EN 60947-5-2 or equivalent.
	Applicable for		Manual valves and solenoid operated on-off valves
2.10	LOCAL INSTRUMENT ENCLOSURE AND LOCAL INSTRUMENT RACK		
	Scope		LIE and LIR complete with all fittings, mountings & accessories, drains and utility lighting, cable & grounding cable etc.
	Construction		
	Rack	mm	1.6mm sheet plate
	Frame	mm	3mm thick channel frame of steel
	Free standing type		Yes
	Rack		Yes, >=3mm thick steel, extended beyond the ends of the rack.
	Degree of Protection		IP-55 for LIE & JB of LIE/LIR
	Junction Box		Applicable
2.11	JUNCTION BOX		
	No. of ways		12/24/36/48/64/72/96/128
	Material and Thickness		4mm thick Fiberglass Reinforced Polyester(FRP)
	Type of terminal blocks		Rail mounted cage-clamp type suitable for conductor size upto 2.5 mm ² . A M6 earthing stud shall be provided.
	Protection Class		IP- 55 min. for indoor & IP-65 min for outdoor applications.
	Grounding		To be provided
	Color		RAL 7035
	Spare Terminals		At least 20% unused terminals
2.12	DATASHEET - FLOW SWITCH		
	Type		Paddle/Piston/Disk
	Wetted part material		Stainless steel or Hastelloy for acidic application
	End connection		a) Threaded upto 1" line size with integral Tee b) Flanged for line size > 1 ½"
	Enclosure Material		Stainless Steel
	Enclosure		IP-55
	Switch Configuration		2 SPDT (5A, 240 V AC, 0.5A, 220 V DC)
	Repeatability	%	2%
	Cable connection		½"NPTF
	Accessories		a) Tee, Counter flange, nuts & bolts, suitable gasket etc b) 1 ½" NPT cable gland. c) Stainless steel nameplate with alpha-numeric engraved for
2.13	DATASHEET - LOCAL CONTROL PANEL		
2.13.1	Construction		
	Type		Skid mounted
	Construction		Folded
	Devices & equipments		Panel enclosure, secondary instruments, annunciation system, selector switch, push buttons, indicating lamps/ led cluster, relays, MCBs, clamp on terminals, plug socket, panel light, space heater, nameplate, earth bus
	Enclosure sheet material		Cold rolled sheet steel
	Enclosure sheet thickness		Minimum 3.0 mm for load bearing sections (mounted with instruments)
			2.0 mm for doors

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TECHNICAL DATA - PART - A					
SL.NO	DESCRIPTION		UOM	DETAIL	
				Minimum 2.0 mm for other sections	
	Height			Minimum 1100 mm	
	Frame thickness			Minimum 3.0 mm	
	Internal plate thickness			2.5 mm	
	Gland plate thickness			3.0 mm	
	Cable gland			Double compression	
	Base channel			ISMC 100 with anti-vibration mounting & foundation bolts	
	Class of protection			IP-55	
2.13.2	Doors				
	Rear doors			Required with integral lockable handle	
	Door locking			Door when locked shall be held at minimum three places.	
	Type			Removable type with concealed hinges to facilitate maintenance work	
	Suitable pocket inside the door			Required for keeping the drawings / documents	
	Double door			Required with suitable glass windows as per the requirement.	
2.13.3	Power & control supply				
	Input power supply			415V 3 phase AC	
	No. Of feeders			Two	
	Control supply			230V AC	
	Additonal requirement for control supply			MCBs	
			Supervisory relay along with a pilot lamp to indicate control supply 'on'		
			Auto changeover unit mounted on panel		
2.13.4	Internal wiring				
	Voltage		V	1100 V	
	Material & size			PVC insulated copper multi strand wire /flexible of 1.5mm2, power cable 2.5sqmm	
	Routing and runs			Through PVC troughs, AC & DC wires shall be kept separately	
	Colour			Separate colours for AC & DC wires	
	Ferruling			Cross ferruling	
2.13.5	Painting details*				
	Painting shade & thickness - exterior / interior (these details shall be finalised during detailed engineering)			RAL 5012 & minimum 85 microns / glossy white & minimum 70 microns	
2.13.6	Gasket				
	At door & removable cover			Neoprene	
2.13.7	Ventilation system along with louvers				
	Cooling fan			2 x 100%, covered with removable wire mesh	
2.13.8	Terminal block				
	Type			Clip on, separate for AC & DC circuits	
	Voltage			1100 V	
	Tb points			Cage clamp	
	Mounting height from finished floor		mm	>=250 mm	
	Spare		%	20%	
	Identification strip			To be provided	

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TECHNICAL DATA - PART - A			
SL.NO	DESCRIPTION	UOM	DETAIL
2.13.9	Illumination		
	Light		Led tubelight
	Shrouded cover	W	15W minimum
	Operating power supply		240V 50 Hz AC
	Operable through		Panel door switch
	Power receptacle		15 Amp, 3-pin
2.13.10	Earthing studs		
	Termination to main station earth		Internally with 10 mm bolts at extreme ends for connection
2.13.11	Alarm annunciator system		
	No. Of windows	Nos.	Minimum 20
	Facia		Solid state discrete
	Hooter		10W
	Annunciator spare (with electronics)		10% spare window or minimum 2nos. Whichever is more
	Lamp test provision		Required
2.13.12	Mounting devices on panel		
	On front side		All operable and indicating devices
	Inside panel		Aux. Relays, terminal, PVC trough, MCBs etc.
	Easy access for operation / maintenance.		Required
2.14	DATASHEET - ROTAMETERS		
	TYPE		VARIABLE AREA METAL TUBE
	FLUID MEDIA		WATER/OIL
	TUBE BODY		SS316
	MATERIAL OF FLOAT		SS316
	INDICATOR		LINEAR SCALE
	ACCESSORIES		FLANGE, ORIFICE IN CASE OF BYPASS ROTA METER (FOR LINE SIZE ABOVE 100 MM)
	HOUSING PROTECTION CLASS		IP-55
	ACCURACY		+/- 2% OF MEASURED VALUE
2.15	DATASHEET - DEW POINT METER		
2.15.1	Sensor		
	Type		Capacitance type with change in output proportional to moisture present.
	Service		Dry Air
	Range		SS316
	Sensor Accuracy		Better than +/- 0.5%
	Operating Temperature		0 to 50 degree C.
	Operating Pressure		0-10 Kg./Cm2, suitable for process application.
	HOUSING PROTECTION CLASS		IP-55
	ACCURACY		+/- 2% OF MEASURED VALUE
2.15.2	Analyser		
	Input		Change in capacitance from dew point sensor.
	Display		Combined enclosure with two three-digit seven segments LED display with decimal point after two digits. LED height shall be 4 inches, clearly legible from a distance of atleast 10 meters.
	Range		SS316
	Display Accuracy		Better than +/- 2 Dehree C
	Mounting		Table top/Flush mounting, to be finalised during detailed engineering.
	Power Supply		240V AC, 50 Hz to be arranged by the contractor.
	Output		IP-55
	ACCURACY		5-20 mA DC capable of driving a load impedance of 500 ohms minimum

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TECHNICAL DATA - PART - A			
SL.NO	DESCRIPTION	UOM	DETAIL
2.16	DATASHEET - SIGHT FLOW GLASS		
	Type		Flapper nozzle type
	Body Material		SS304
	Flapper Material		SS316
	Cover plate Material		SS304
	Sight Glass/Window		Toughened Borosilicate
	Gasket		Neoprene
	End Connection		Flanged type(with nut and bolt)
	Flange Material		SS304
	Mating Flange		To be provided by bidder
	Material of Mating Flange		SS304
2.17	Painting color scheme - Impulse piping for water area/equipment		
	Impulse piping ground color scheme		Grey RAL 9002
	Identification Tag/band color scheme		Sea green, ISC no. 217
2.18	Painting color scheme - Impulse piping for Air		
	Impulse piping ground color scheme		Grey RAL 9002
	Identification Tag/band color scheme		Sky Blue, ISC no. 101
3.00	INSPECTION/TESTING		
	Type Test requirement		Yes
	Item-1		Electronic Transmitters
	Test & Standard -1		As per Standard, BS-6447 / IEC-60770
	Item-2		Orifice Plate
	Test & Standard -2		Calibration, ISO 5167
	Test to be specifically conducted		No
	NTPC's approval required. on Test certificate		Yes

	TECHNICAL SPECIFICATION DARLIPALI STPP PH-II (1X800 MW) COMPRESSED AIR SYSTEM		PE-TS-540-555-A001
			Rev. No. 00
			Date : AUG 2026
TECHNICAL DATA - PART - B (SUPPLIER DATA TO BE FURNISHED AFTER AWARD OF CONTRACT)			
SL.NO	DESCRIPTION	UOM	DETAIL
FOLLOWING DATA SHALL BE FILLED UP BY VENDOR FOR EACH INSTRUMENT			
1.0	MAKE		
1.1	MODEL		
1.2	TAG NO. / KKS NO.		
1.3	SERVICE		
1.4	QUANTITY		
1.5	OPERATING PRESSURE		
1.6	OPERATING TEMPERATURE		
1.7	DESIGN PRESSURE		
1.8	DESIGN TEMPERATURE		
1.9	RANGE		

	SPECIFICATION FOR LOCAL PANELS	SPECIFICATION NO.: PE-SS -999- 145 -054A	
		VOLUME	II B
		SECTION	D
		REV. NO. 03	DATE : 16-09-2013
		SHEET	1 OF 5

1.0 SCOPE

This specification covers the Design, Manufacture, Inspection and Testing at the manufacturer's works, proper packing for transportation and delivery to site, supervision, erection, and commissioning at site of Local Panels required for control and monitoring of the Auxiliary Plant & Equipment.

2.0 CODES AND STANDARDS

2.1 All the equipments specified herein shall comply with the requirements of the latest issue of the relevant National and International standards.

2.2 As a minimum requirement, the following standards shall be complied with:

- a) IS-6005 : 1998 : Code of practice for phosphating of iron and steel.
- b) IS-5 : 2007 : Colors for ready mixed paints and enamels.
- c) IS-1248:2003 : Direct Acting Indicating Analog Elec Measuring Instruments.
- d) IS/IEC 60947:Part 1:2004 : Low Voltage switchgear & control gear: Part-I (General Rules)
- e) IS-8828:1996 : Circuit breaker for household and similar installations.
- f) IS-13947 (Part-I):1993 : Low Voltage switchgear & control gear : Part-I (General Rules)
- g) ISA-18.1:1979 : Annunciator Sequences and Specification
- h) NFPA-496:2003 : Purged & Pressurised Enclosure for Electrical Equipment in Hazardous Locations.

3.0 TECHNICAL REQUIREMENTS

3.1 Panel Construction

3.1.1 The local panels shall house the secondary instruments, annunciation system, Single loop controller, Control switches / push buttons, indicating lamps/LED cluster, relays, timers and other devices required for operation and monitoring of the equipment locally.

3.1.2 The panels shall be of free standing type either welded construction on angle iron (minimum section of 50 x 50 x 4 mm) structure or folded construction by sheet metal formation depending upon the equipments to be mounted on it. The panels shall be robustly built and stiffeners as necessary shall be provided.

3.1.3 The panel shall be suitably reinforced to ensure adequate support for all instruments mounted thereon. All welds on exposed panel surfaces shall be ground smooth.

3.1.4 The salient features of construction shall be:

- Sheet material: Cold rolled sheet steel
- Frame thickness: Not less than 3.0mm
- Enclosure thickness: Not less than 3.0 mm for load bearing sections (Mounted with instruments)
2.0 mm for doors and Not less than 2.0 mm for others
- Panel Height: Not less than 2365 mm
- Gland plate thickness: 3.0mm
- Base channel: ISMC 100 with anti-vibration mounting & foundation bolts.

3.1.5 The panel shall be provided with rear doors with integral lockable handle. The door when locked shall be held at minimum three places. The door width shall not be more than 550mm. The doors shall be provided with suitable stiffeners to prevent buckling. The handle shall be on the right side of the door. The door shall be removable type with concealed hinges to facilitate maintenance work. Suitable pocket inside the door shall be provided for keeping the drawings / documents. Double door shall be provided with suitable glass windows, as per the requirement.

3.1.6 Suitable neoprene gasket shall be provided on all doors and removable covers. Suitable ventilation system along with louvers shall be provided at bottom and top of the doors covered with removable wire mesh.

	SPECIFICATION FOR LOCAL PANELS	SPECIFICATION NO.: PE-SS -999- 145 -054A	
		VOLUME	II B
		SECTION	D
		REV. NO. 03	DATE : 16-09-2013
		SHEET	2 OF 5

3.1.7 The class of protection shall be in accordance with IP-55.

3.1.8 All steel surfaces shall be cleaned by sand / pellet blasting, treated for pickling, degreasing and phosphating etc. by seven tank method. The panel shall have a high quality finish and appearance. The panel shall be painted with two coats of primer followed by two coats of epoxy / synthetic enamel based final paint of color shade and finish. Minimum thickness of the paint shall be 85 microns for external paint and 70 microns for internal paint.

3.1.9 The cable glands of the required size and type shall be supplied alongwith the Panel.

3.1.10 All operable and indicating devices shall be mounted on the front of the panel while aux. Relays / timers MCBs etc. required for realization of control logics shall be mounted on a mounting plate inside the panel. Auxiliary relays and timers etc. shall be grouped according to the control function. No operable or indicating devices shall be mounted below 750 mm and above 1800 mm (w.r.t. finished ground level). The devices shall be located in such a way so as to ensure easy access for operation / maintenance.

3.1.11 Single / dual control power supply feeders of voltage class as specified shall be provided by the purchaser. In case redundant power supply feeders are provided then auto changeover unit shall be mounted on the panel are in the panel supplier's scope. Where DC control power supply is specified an additional 240V, 50 Hz AC supply feeder for powering of space heater and lighting shall be provided by the purchaser. Suitable arrangement shall be provided inside the panel to receive and terminate the power supply feeder(s). For this purpose MCBs of suitable current rating shall be provided by the vendor. A supervisory relay along with a pilot lamp to indicate control supply 'ON' shall be provided on the panel. Any other power supply required for the operation of the devices mounted in the panel shall be arranged by the vendor.

3.1.12 The internal wiring shall be carried out with 1100 volt grade PVC insulated copper multi strand wire / flexible of 1.5mm² size. AC & DC wires shall be kept separate from each other. Separate coloured wires to be used for AC and DC circuits. All wires shall be properly numbered and identified with ferrules as per the Control scheme / wiring diagram. Wires shall be routed and run through PVC troughs.

3.1.13 Terminal blocks shall be clip on type, 1100 volts grade. Separate terminal blocks shall be used for AC & DC circuits. The terminals shall be suitable for terminating 0.5 mm² to 2.5mm² external cables. The TB points in terminal block shall be cage clamp type / screw type. The terminal for ammeters shall be provided with removable links for shorting CTs. Each terminal strip shall be provided with identification strip. The terminal shall not be mounted below 250 mm height from finished floor. The panel shall have ten (20) percent spare terminal.

3.1.14 The interior of each panel shall be suitably illuminated through fluorescent lamps / tube lights with shrouded cover of minimum 15W operable on 240V 50 Hz AC power supply through panel door switch. A 15 Amp. 3-pin Power receptacle shall be provided.

3.1.15 Suitable space heaters operable on 240 Volts 50 Hz AC power system shall be provided at the panel bottom. These shall be designed to maintain the panel temperature five (5) deg. C above the ambient temperature during maintenance shutdown. Suitable isolating and control devices comprising of MCB, thermostat etc. shall be provided for the space heater.

3.1.16 The panel shall be provided with a copper earth bus of 25 x 6 mm size running throughout the width of the panel. It shall be terminated internally with 10 mm bolts at extreme ends for connection to; main station earth. The panel mounted equipments / devices shall be connected to earth bus through green coloured PVC insulated stranded copper conductor of 2.5 mm² size.

3.1.17 Local Panel shall be provided with main name plate of 150 mm x 40 mm size having inscription of 20 mm height. The individual devices on the panels shall be as provided with separate name plate with inscription of 3 mm height. The instrument / devices shall be provided with stick on label plates inside the panel. The material of the main and individual labels shall be three (3) ply 3 mm thick Traffolyte

	SPECIFICATION FOR LOCAL PANELS	SPECIFICATION NO.: PE-SS -999- 145 -054A	
		VOLUME	II B
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		SHEET	3 OF 5

Sheet / 2 mm Anodised Aluminium Plate. The inscription shall be with white letters on black background on traffolyte sheet. The labels shall be fixed by self tapping non-rusting screws.

3.1.18 Vendor shall furnish electric load and heat load list (in case panel is to be placed in ac environment) of each panel.

3.2 Hazardous Area Panel Requirement

3.2.1 The Local Panel located in hazardous area shall be pressurized as per NFPA-496 requirements to render it non-hazardous. Alarms shall be provided for local and remote annunciation when pressurisation falls below 2.5 mm of water column. Protection shall be of type Z of NFPA-496. It shall not be possible to switch ON the power of purged section unless it is purged as per the recommendation of NFPA-496. Vendor must provide a protective device on the panel to protect the panel from over pressurisation.

3.2.2 Vendor shall supply pressurisation kit consisting of valves, restriction orifices, dual filter regulation, pressure gauges, pressure switches, rotameter etc. Pressurisation kit shall be surface mounting on a metal board and located outside the local panel. Pressurisation kit shall further consist of solenoid valve flow switch, timer blow off safety device etc., so as to make purging fully automatic. However final start shall be manual. Panel protection against over pressure to be provided as per NFPA-496.

3.2.3 Pressurised local control panel pressurization kit assembly design shall provide minimum leakage flow through the Local Control Panel. Panel venting shall be as per NFPA-496.

3.2.4 All components in the local panel like indicating instruments, push buttons switches, lamps etc., which are required to be energized without panel pressurization or before completion of purge cycle shall be explosion proof as per NEMA-7 & suitable for area classification.

3.2.5 All push buttons etc. requiring frequent operation during machine running shall have good positive sealing. Weatherproof housing or cover to be provided wherever necessary. Vendor shall provide pressurisation bypass switch outside explosion proof enclosure of pressurized panel with lamp indication. This shall be used only during maintenance. All hinges, screws, other non-painted metallic parts shall be of stainless steel material.

3.2.6 Provision to switch off manually all types of power shall be provided in the panel. In addition, it shall also be possible to switch off power circuits / components which are powered from motor control centre or control room manually in case of pressurization failure. All such cables from MCC and main control room shall be terminated in explosion proof boxes (NEMA-7).

3.3 Control & Monitoring devices

3.3.1 Instruments like Indicators, recorders, single loop controllers etc. as applicable and specified elsewhere for the plant / equipment shall be supplied and mounted on the panel.

3.3.2 Alarm Annunciator System

It shall be solid state discrete facia type having a sequence of ISA-S18.1A or as specified, opaque facia windows of 70 mm x 50 mm size, having two (2) lamps per window, and hooter of 10W, and provision for repeat group alarm at remote. The annunciator shall be provided with ten (10) percent spare windows or minimum two (2) windows along with electronics.

3.3.3 Relays

The relays shall be electromagnetic type suitable for specified control supply. Its contact configuration and rating shall be suitable for the specified control function. However minimum contact rating shall be 5 Amp AC & 2 Amp DC as applicable. There shall be ten (10) percent spare contacts.

3.3.4 Timers

The timers shall be electronic type suitable for specified control supply. Its contact configuration and rating shall be suitable for the specified control function. However, minimum contact rating shall be 5 Amp AC & 2 Amp DC as applicable.

	SPECIFICATION FOR LOCAL PANELS	SPECIFICATION NO.: PE-SS -999- 145 -054A	
		VOLUME	II B
		SECTION	D
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		SHEET	4 OF 5

3.3.5 Control / Selector Switches
Switches shall be Rotary Cam type with minimum of 5 Amps AC & 2 Amp DC continuous current rating. Selector switches shall be stay put type while control switches shall be spring-return-to-neutral type. Contact configuration and rating shall be as per the control function requirement. The switches shall be lockable type wherever specified. Each switch shall be provided with engraved plates indicating the switch position / functions.

3.3.6 Push Buttons / Indicating Lights
The push buttons shall be momentary action self-resetting type, however stop P.B. for unidirectional drives shall be provided with manual reset facility. Its contact configuration & rating shall be as required for the control function but minimum 2 NO + 2 NC of 5 Amp. AC rating. It shall have round coloured projecting tab and engraved escutcheon plate / inscription plate. Colour coding of push buttons shall be as under:

RED	Motor OFF / Valve CLOSE	YELLOW	Alarm acknowledge	Left Hand Side
GREEN	Motor ON / Valve OPEN	BLACK	Lamp test	Right Hand Side

Indicating lights shall be suitable for direct connections across specified power supplies. It shall be fitted with built in resistance to prevent circuit tripping on shorting of lamp filament. It shall be fitted with LED cluster type lamp replaceable from front.

GREEN	Motor OFF / Valve CLOSED condition	AMBER	Motor tripped	Left Hand Side
RED	Motor ON / Valve OPEN condition	WHITE	Normal / healthy	Right Hand Side

3.3.7 Ammeters
Ammeter shall be 96 x 96 mm size, 90 deg. deflection, 1.5% accuracy, 1 Amp. CT operated or with 4-20mA input and Flush mounting type as called for
Ammeters for motors shall have six (6) times folded scale at upper end to enable motor starting current indication

3.3.8 Miniature Circuit Breaker (MCB)
These shall be instantaneous magnetic trip type for short circuit in addition to current time inverse delayed thermal trip feature for over current protection. The housing of MCB shall be made of non-ignitable, high impact material. It shall have minimum short circuit rating of 9 KA for AC Voltages and 4 KA for DC Voltages.

3.3.9 Makes of various instruments / devices shall be as given below

1.	Alarm Annunciators	:	Procon / IIC
2.	Ammeters	:	AEP / IMP
3.	Control / Selector Switches	:	Alsthom / Kaycee / Siemens / L&T
4.	Push Buttons / Indicating Lamps	:	Siemens / L&T / Teknic / Alsthom
5.	Auxiliary Relays	:	Jyoti / Siemens / L&T / OEN
6.	Timers	:	L&T / Alsthom / Bhartiya Cutler Hammer
7.	MCBs	:	S&S Power Engg. / Indo Asian / MDS
8.	Terminal Blocks	:	Jyoti / Elmex

4.0 TESTING AND INSPECTION

4.1 The bidder shall adopt suitable quality assurance program to ensure that the equipments offered will meet the specification requirements in full.

4.2 BHEL's standard Quality Plan for LCP is enclosed with the specification. The bidder shall furnish his acceptance to BHEL's QP and submit the signed and stamped copy of QP along with the offer.

	SPECIFICATION FOR LOCAL PANELS	SPECIFICATION NO.: PE-SS -999- 145 -054A	
		VOLUME	II B
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		SHEET	5 OF 5

4.3 The vendor shall conduct the following tests as a minimum requirement:

4.3.1 Routine Tests

1. High Voltage (H.V.)
2. Insulation Resistance (I.R.)
3. Functional

4.3.2 Type Tests

1. Enclosure Class Test

5.0 SPARES AND CONSUMABLES

5.1 Commissioning Spares and consumables

The bidder shall supply all commissioning spares and consumables 'as required' during Start-up, as part of the main equipment supply.

5.2. Mandatory Spares

The bidder shall offer alongwith main offer, the Mandatory Spares as specified elsewhere in the specification. The Mandatory Spares offered shall be of the same make and type as the main equipment.

5.3. Recommended Spares

The bidder shall furnish a list of Recommended Spares indicating the normal service expectancy period and frequency of replacement; quantities recommended for 3 years operation alongwith unit rate against each item to enable BHEL/BHEL's Customer to place a separate order later, if required.

6.0 DRAWINGS AND DOCUMENTS

6.1 The bidder shall furnish the following documents in required number of copies along with the bid :

2. General Arrangement Drawing.
3. Catalogue and technical information for instruments and devices.
4. Quality Plan.

6.2 The vendor shall furnish the following documents in required number as agreed after the award of contract:

2. GA Drawing indicating layout of instruments, construction details, foundation details, cable gland plate alongwith cable glands and all details mentioned in this specification.
3. Control Schematic Diagram along with grouping of different terminals for various functions.
4. Catalogue and technical information for instruments and devices with selected options clearly marked.
5. O&M Manuals.
6. "As Built" Drawing.
7. CDs.

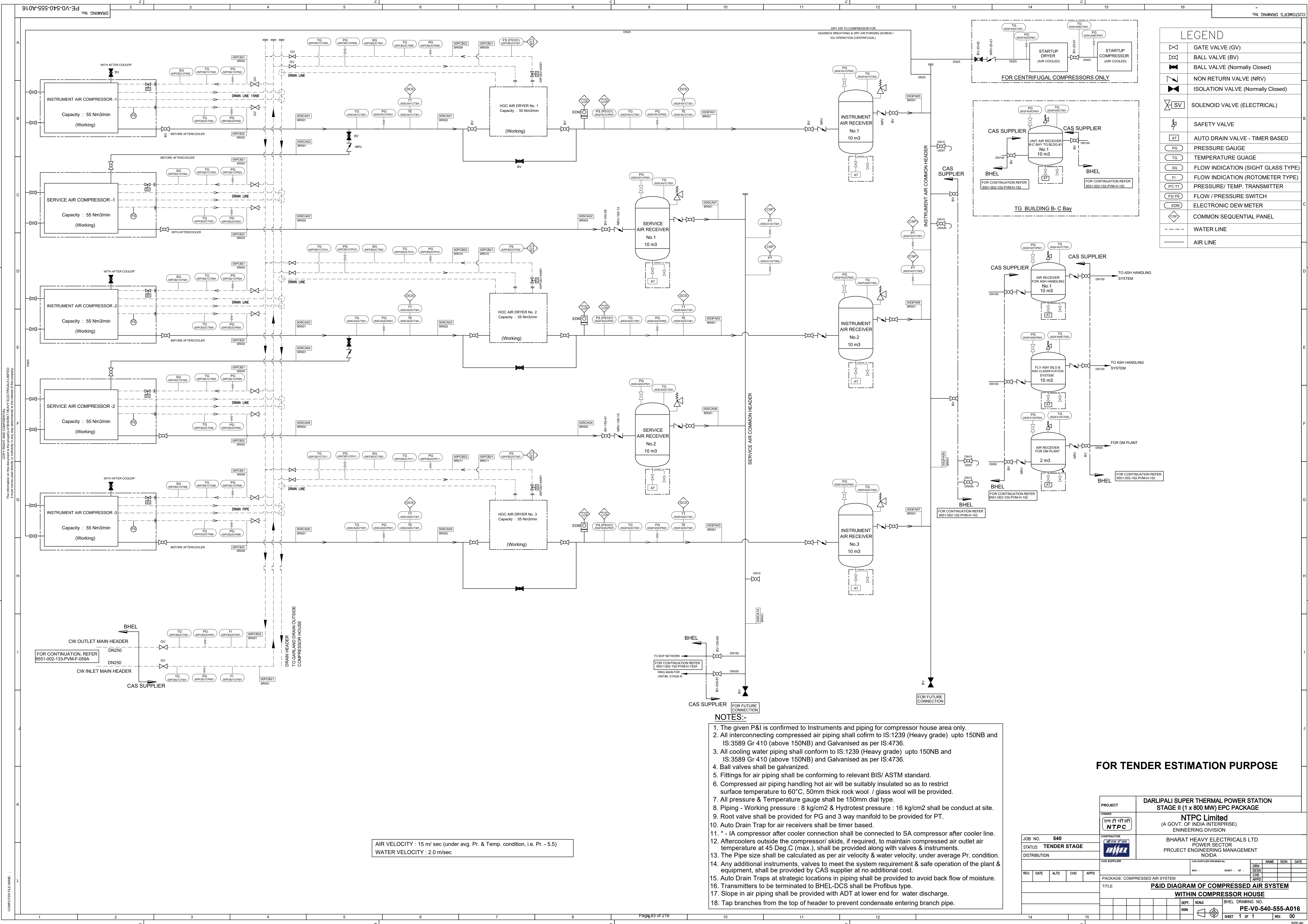
7.0 MARKING AND PACKING

7.1 Panel with all instruments / devices mounted on it shall be suitably packed & protected for the entire period of despatch, storage and erection against impact, abrasion, corrosion, incidental damage due to vermin, sunlight, high temperature, rain moisture, humidity, dust, sea-water spray (where applicable) as well as rough handling and delays in Transit and storage in open.

	TECHNICAL SPECIFICATION DARLIPALI STPP PH-II (1X800 MW) COMPRESSED AIR SYSTEM	PE-TS-540-555-A001
		Rev. No. 00
		Date: AUG 2026

COMPLIANCE DRAWINGS

1. COMPRESSOR HOUSE LAYOUT: PE-DG-540-555-A015
2. COMPRESSED AIR SYSTEM P&ID: PE-V0-540-555-A016
3. GA OF AIR RECEIVER- 10M3
4. GA OF AIR RECEIVER- 2M3
5. ELECTRICAL LOAD DATA FOR CAS
6. C&I DRAWINGS



LEGEND	
	GATE VALVE (GV)
	BALL VALVE (BV)
	BALL VALVE (Normally Closed)
	NON RETURN VALVE (NRV)
	ISOLATION VALVE (Normally Closed)
	SOLENOID VALVE (ELECTRICAL)
	SAFETY VALVE
	AUTO DRAIN VALVE - TIMER BASED
	PRESSURE GAUGE
	TEMPERATURE GAUGE
	FLOW INDICATION (SIGHT GLASS TYPE)
	FLOW INDICATION (ROTOMETER TYPE)
	PRESSURE/ TEMP. TRANSMITTER
	FLOW / PRESSURE SWITCH
	ELECTRONIC DEW METER
	COMMON SEQUENTIAL PANEL
	WATER LINE
	AIR LINE

- NOTES:-
1. The given P&I is confirmed to Instruments and piping for compressor house area only.
 2. All interconnecting compressed air piping shall conform to IS:1239 (Heavy grade) upto 150NB and IS:3589 Gr 410 (above 150NB) and Galvanised as per IS:4736.
 3. All cooling water piping shall conform to IS:1239 (Heavy grade) upto 150NB and IS:3589 Gr 410 (above 150NB) and Galvanised as per IS:4736.
 4. Ball valves shall be galvanised.
 5. Fittings for air piping shall be conforming to relevant BIS/ ASTM standard.
 6. Compressed air piping handling hot air will be suitably insulated so as to restrict surface temperature to 60°C, 50mm thick rock wool / glass wool will be provided.
 7. All pressure & Temperature gauge shall be 150mm dial type.
 8. Piping - Working pressure : 8 kg/cm² & Hydrotest pressure : 16 kg/cm² shall be conduct at site.
 9. Root valve shall be provided for PG and 3 way manifold to be provided for PT.
 10. Auto Drain Trap for air receivers shall be timer based.
 11. * - IA compressor after cooler connection shall be connected to SA compressor after cooler line.
 12. Aftercoolers outside the compressor/ skids, if required, to maintain compressed air outlet air temperature at 45 Deg.C (max.), shall be provided along with valves & instruments.
 13. The Pipe size shall be calculated as per air velocity & water velocity, under average Pr. condition.
 14. Any additional instruments, valves to meet the system requirement & safe operation of the plant & equipment, shall be provided by CAS supplier at no additional cost.
 15. Auto Drain Traps at strategic locations in piping shall be provided to avoid back flow of moisture.
 16. Transmitters to be terminated to BHEL-DCS shall be Profibus type.
 17. Slope in air piping shall be provided with ADT at lower end for water discharge.
 18. Tap branches from the top of header to prevent condensate entering branch pipe.

FOR TENDER ESTIMATION PURPOSE

PROJECT		DARLIPALI SUPER THERMAL POWER STATION STAGE II (1 x 800 MW) EPC PACKAGE	
OWNER		NTPC Limited (A GOVT. OF INDIA INTERPRISE) ENGINEERING DIVISION	
CONTRACTOR		BHARAT HEAVY ELECTRICALS LTD POWER SECTOR PROJECT ENGINEERING MANAGEMENT Noida	
JOB NO. 540		CAS SUPPLIER DRAWING NO.	
STATUS TENDER STAGE		REV. - SHEET - OF -	
DISTRIBUTION		DRN	
REV. DATE ALTD CHD APPD		DESN	
		CHK	
		APPO	
		PACKAGE: COMPRESSED AIR SYSTEM	
		TITLE P&ID DIAGRAM OF COMPRESSED AIR SYSTEM	
		WITHIN COMPRESSOR HOUSE	
		DEPT. SCALE BHEL DRAWING NO.	
		SIGN PE-V0-540-555-A016	
		SHEET 1 OF 1	
		REV. 00	

INSTRUMENT AIR COMPRESSOR	490kw	-----		2	1	B/C	U	N	C	Motor	15-20SEC	CAS						Refer notes (i), (ii) and (iii).
SERVICE AIR COMPRESSOR	490kw	-----		2	0	B/C	U	N	C	Motor	15-20SEC	CAS						
INSTRUMENT AIR DRYER AUXILIARY SUPPLY	2kw	-----		2	1	E	D	N	C	Panel	-----	CAS						415VAC
INSTRUMENT AIR COMPRESSOR AUXILIARY SUPPLY *	7.5kw	-----		2	1	D	S	Y	C	Aux. Pump Motor	-----	CAS						415VAC DG SUPPLY
SERVICE AIR COMPRESSOR AUXILIARY SUPPLY *	7.5kw	-----		2	0	D	S	Y	C	Aux. Pump Motor	-----	CAS						415VAC DG SUPPLY
INSTRUMENT AIR COMPRESSOR AUXILIARY SUPPLY	1.5kw	-----		2	1	E	S	Y	C	Panel	-----	CAS						230VAC UPS BY C&I
SERVICE AIR COMPRESSOR AUXILIARY SUPPLY	1.5kw	-----		2	0	E	S	Y	C	Panel	-----	CAS						230VAC UPS BY C&I
RECEIVER DRAIN ADT	0.5kw	-----		9	0	E	S	N	I	ADT	-----	CAS						230VAC
AFTER COOLER DRAIN ADT	0.5kw	-----		5	0	E	S	N	I	ADT	-----	CAS						230VAC
UTILITY COMPRESSOR *	9kw	9kw		1	1	D	S	N	I	Motor	5 SEC	CAS						415VAC
UTILITY DRYER *	1kw	-----		1	1	E	S	N	I	Panel	-----	CAS						230VAC

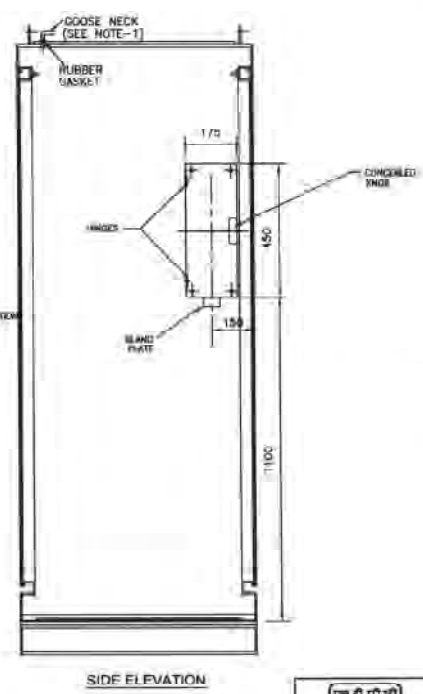
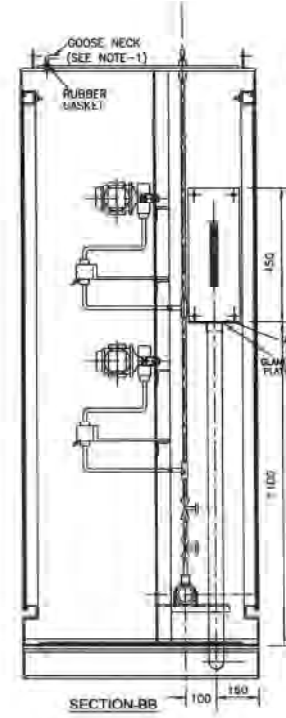
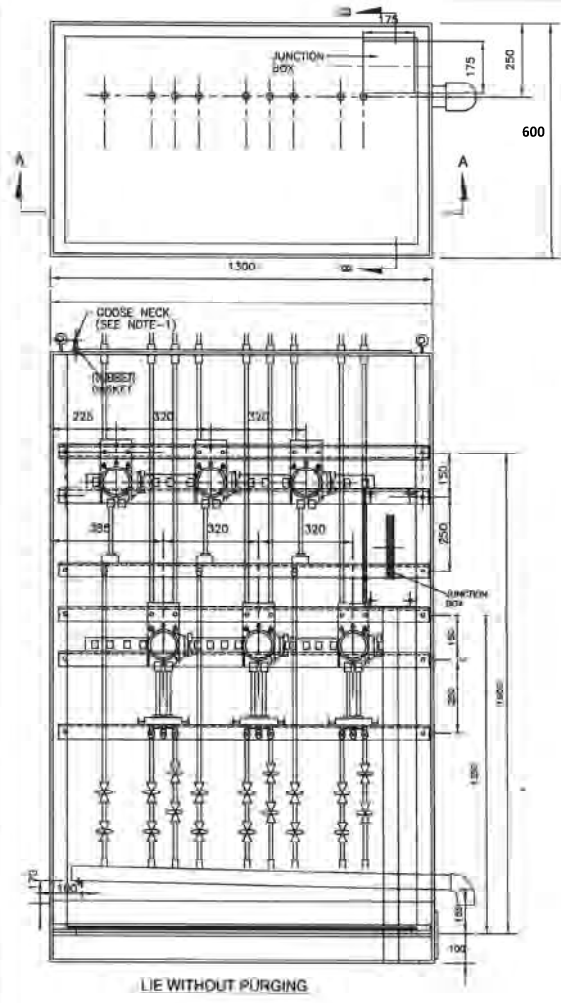
SEQUENTIAL CONTROL PANEL	0.5kw	-----		2	0	E	S	Y	C	Panel	-----	CAS						230VAC UPS BY C&I	

NOTES:

- i) Two starts in succession with the motor being initially at a temperature not exceeding the rated load temperature.
 - ii) Three equally spread starts in an hour the motor being initially at a temperature not exceeding the rated load operating temperature. (not to be repeated in the second successive hour)
 - iii) Suitable protection shall be included in the HT Switchgear logic to prevent frequent start stop of the compressor HT motors.
- IV) Air Receiver location- 5 Nos. near Compressor House; 1 No. in TG Hall; 1 No. in ESP area; 1 No. in ASH Silo area and 1 No. in DM Plant area.

*** Applicable in case of Centrifugal compressors only. Compressor type shall be confirmed after finalization of CAS supplier.**

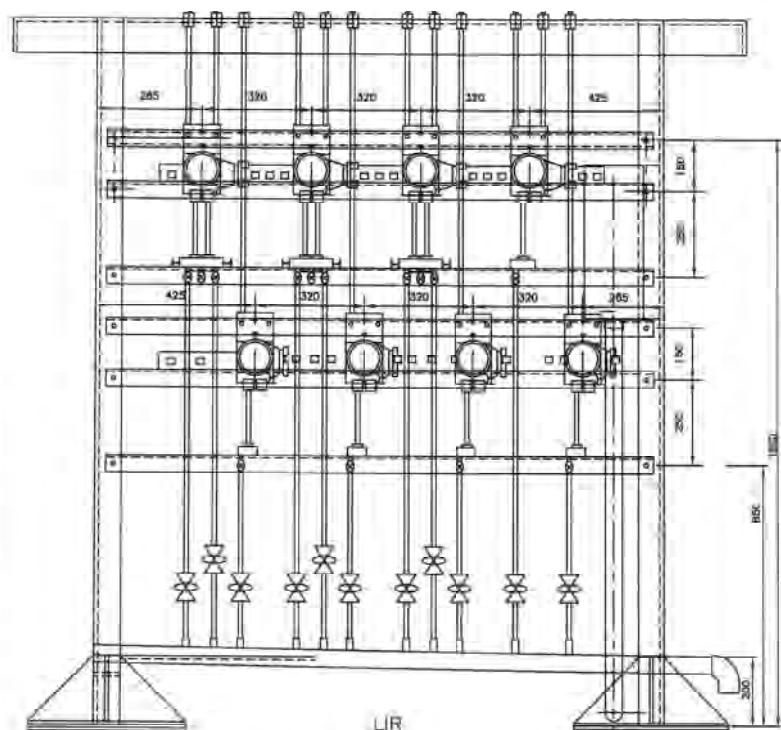
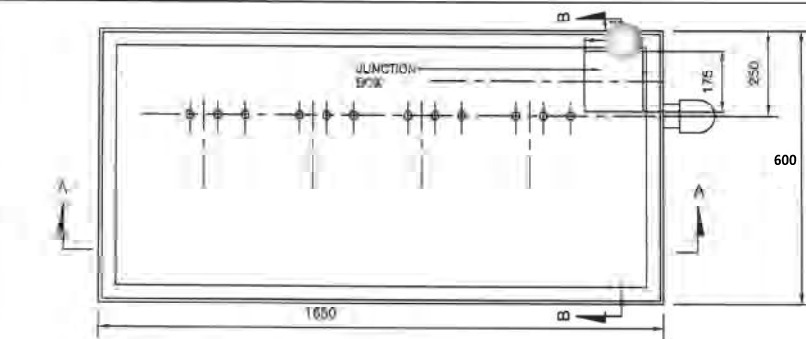
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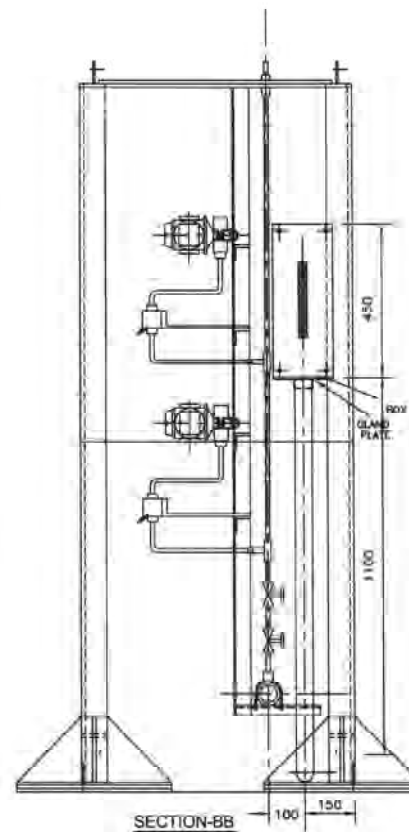
- NOTES**
1. TO BE PROVIDED FOR USE USED IN STEAM & WATER APPLICATION.
 2. MATERIAL OF JBS FOR LIE'S SHALL BE SAME AS THAT OF LIE.

FOR TENDER PURPOSE ONLY

प्र. ११११ NTPC NTPC LIMITED (A GOVERNMENT OF INDIA ENTERPRISE) ENGINEERING DIVISION									
PROJECT: TYPICAL THERMAL POWER PROJECT									
TITLE: TYPICAL GA OF LOCAL INSTRUMENT ENCLOSURE / RACK									
REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHECK	M	E	U	DATE	APPRO.
1	FIRST ISSUE							21.08.11	
SIZE: A2 SCALE: 1/1.5 DRG. NO: 0000-999-POI-A-084 SHEET 01 OF 03 REV. NO: B									



SECTION-AA
LIR WITHOUT PURGING

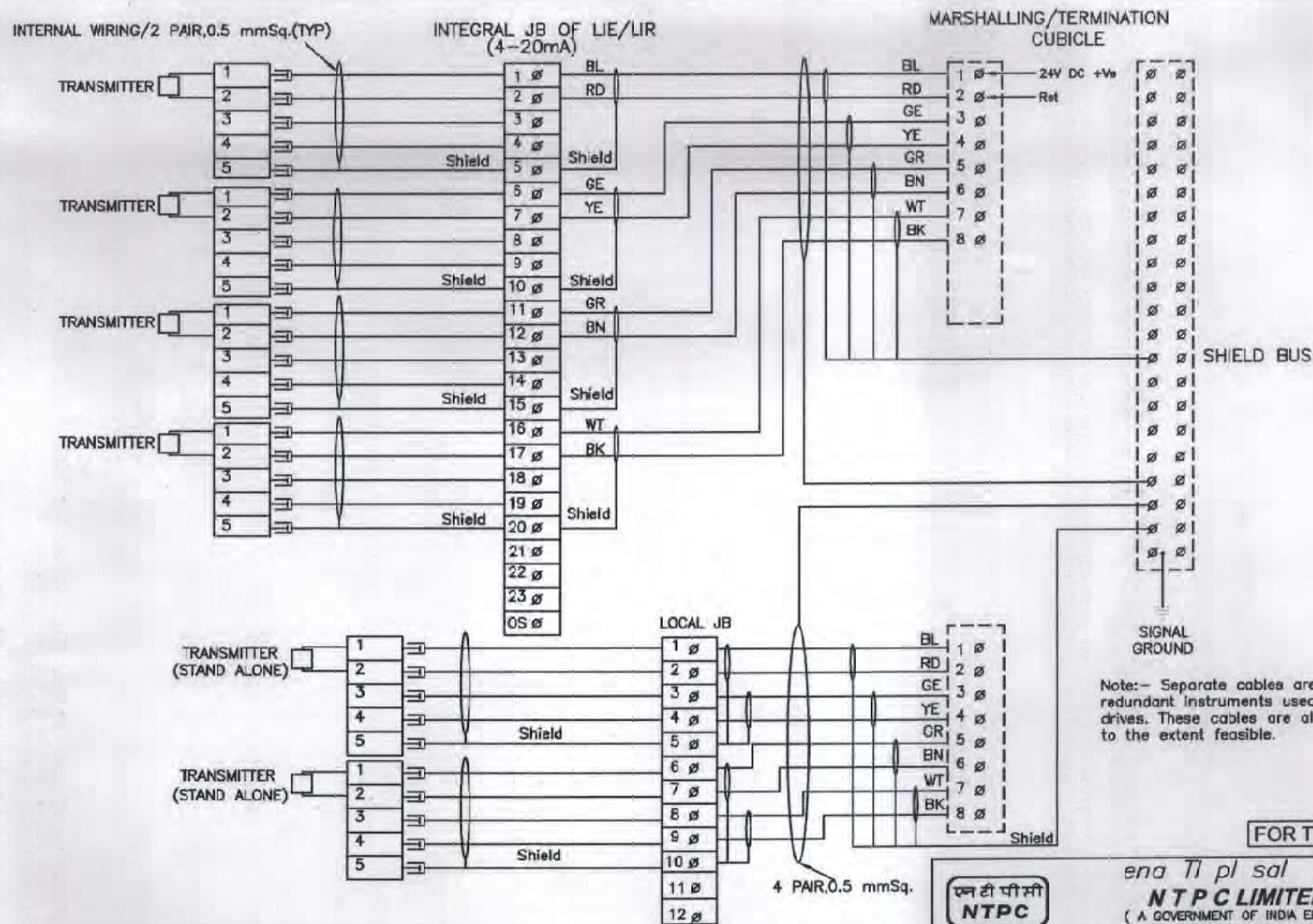


NOTE:-

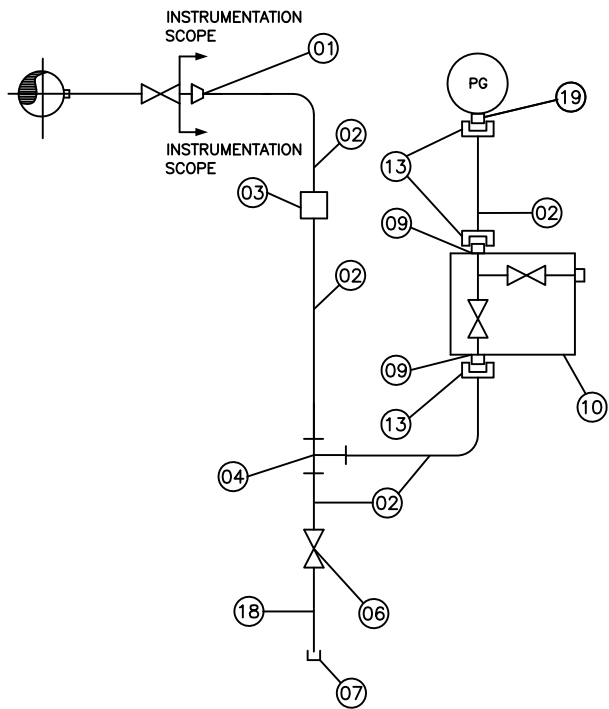
1) MATERIAL OF JBS FOR LIRs SHALL BE SAME AS THAT OF LIR.

FOR TENDER PURPOSE ONLY

												PROJECT		TYPICAL THERMAL POWER PROJECT					
												TITLE		TYPICAL GA OF LOCAL INSTRUMENT ENCLOSURE / RACK					
A		FIRST ISSUE												DATE	01.06.12				
REV. NO.	DESCRIPTION			DRAWN	DESIGN	CHKD.	M	E	C	CM	ARCH.	APPRO	DATE	SIZE	SCALE	DRG. NO.	REV. NO.		
							Cleared By							A3	N.T.E.	0000-999-POI-A-064	A		
																		04-03-06	

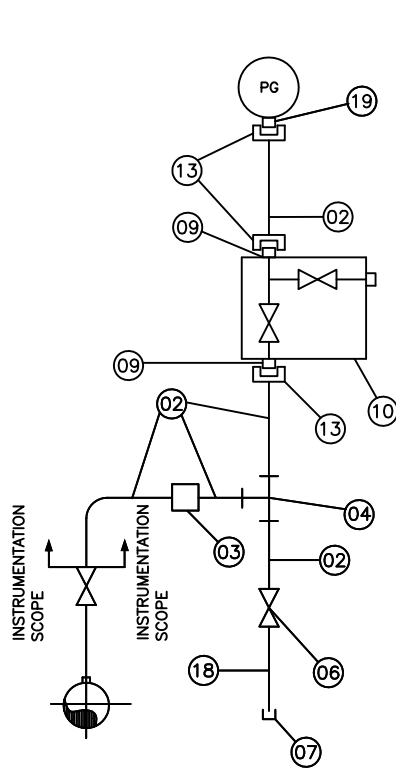


C	NOTE REGARDING CABLE IS ADDED.									10.12.13	PROJECT	TYPICAL THERMAL POWER PROJECT			REV. NO.
B	INTERNAL WIRING FOR LIE/LIR MOUNTED SHOWN WIRING OF STAND ALONE TXTR SHOWN									10.12.06	TITLE	INTERFACING OF FIELD INSTRUMENTS 4-20mA			
A	FIRST ISSUE									12.1.05					
REV.NO.	DESCRIPTION	DRAWN	DESIGN	CHKD.	M	E	C	C&I	ARCH.	APPD	DATE	SIZE	SCALE	DRG. NO.	REV. NO.
												A3	NTS	0000-999-POI-A-065	c
														SH 04 OF 14	

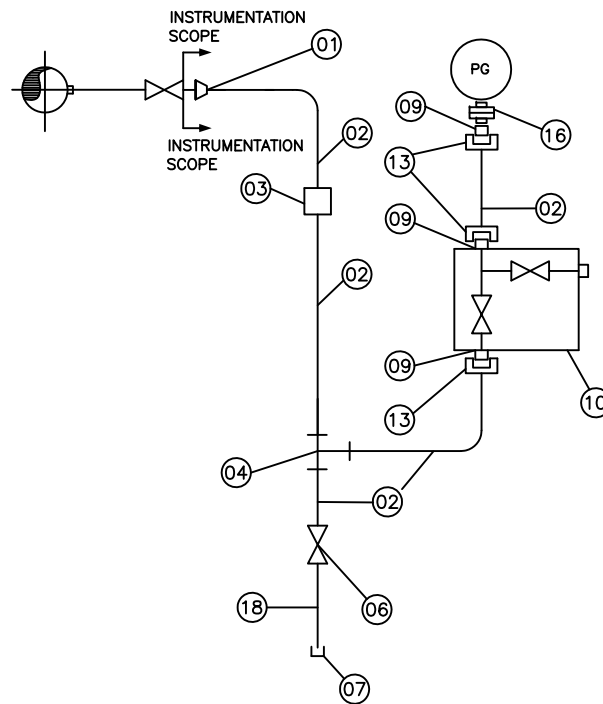


WATER SERVICE

	TITLE :-				DRG. NO.	PE-DG-999-145-IXXX		
	INSTRUMENT INSTALLATION DIAGRAM				REV. NO.	00	DATE	05.11.13
	PRESSURE GAUGES				SHT	3	OF	9



AIR SERVICE



WITH CHEMICAL SEAL
(FOR VISCOUS NON-CORROSIVE FLUID ONLY)

ITEM NO	ITEM/DESCRIPTION	MATERIAL	SIZE	QTY				
				WATER	STEAM	PULSATING	AIR	CHEMICAL
01	REDUCER (IF APPLICABLE)	SAME AS MAIN PIPE	1" X 1/2"SW	01	01	01	00	01
02	SEAMLESS PIPE	SAME AS MAIN PIPE	1/2"	A/R	A/R	A/R	A/R	A/R
03	FORGED COUPLING	SAME AS MAIN PIPE	1/2" SW	A/R	A/R	A/R	A/R	A/R
04	FORGED TEE	SAME AS MAIN PIPE	1/2" SW	01	01	01	01	01
06	FORGED GLOBE VALVE	SAME AS MAIN PIPE	1/2" SW	01	01	01	01	01
07	CAP	SAME AS MAIN PIPE	1/2" NPTF	01	01	01	01	01
09	ADAPTER – M TO M	SS316	M20X1.5M X 1/2" NPTM	02	02	02	02	03
10	TWO VALVE 3 WAY MANIFOLD WITH VENT PLUG	SS316	1/2" NPTF	01	01	01	01	01
11	SYPHON	SS316	1/2" SW	00	01	00	00	00
12	SNUBBER	SS316	M20X1.5M X M20X1.5F	00	00	01	00	00
13	NUT & TAIL PIECE WITH ANNEALED COPPER/SS304 WASHER	SS316	NUT SIZE : M20 X 1.5 WITH 100MM TAIL	03	03	03	03	03
16	CHEMICAL SEAL	SS316	1/2" NPTF X 1/2" NPTF	00	00	00	00	01
18	NIPPLE	SAME AS MAIN PIPE	1/2" NPTM X 1/2" SW	01	01	01	01	01
19	ADAPTER – M TO F	SS316	M20X1.5M X 1/2" NPTF	01	01	01	01	00



TITLE :-

INSTRUMENT INSTALLATION DIAGRAM

PRESSURE GAUGES

DRG. NO.

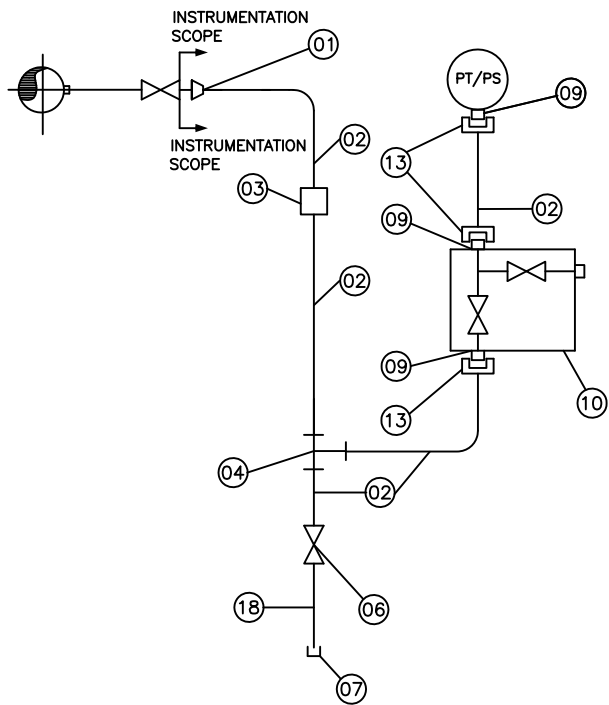
PE-DG-999-145-IXXX

REV. NO.

00 DATE 05.11.13

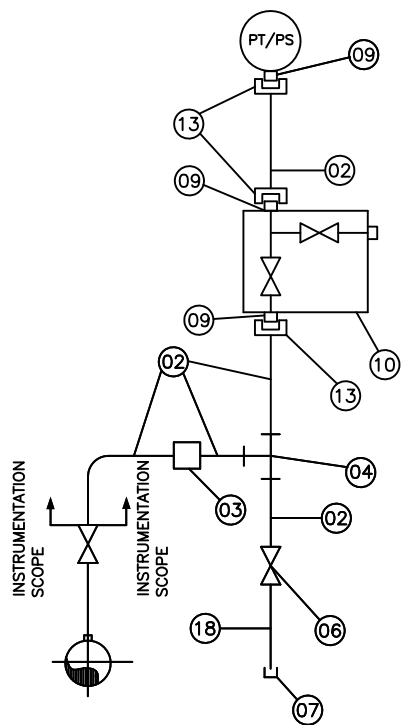
SHT

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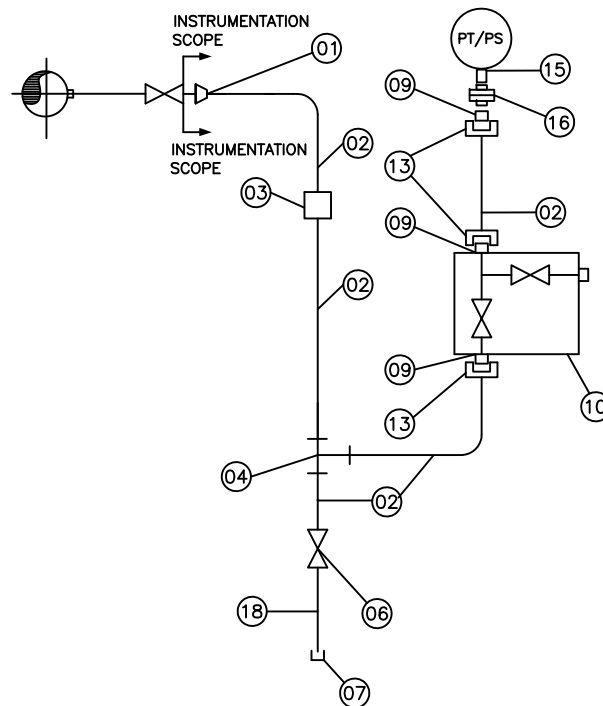


WATER SERVICE

	TITLE :-				DRG. NO.	PE-DG-999-145-IXXX		
	INSTRUMENT INSTALLATION DIAGRAM				REV. NO.	00	DATE	05.11.13
	PRESSURE SWITCHES/TRANSMITTERS				SHT	5	OF	9



AIR SERVICE



WITH CHEMICAL SEAL
(FOR VISCOUS NON-CORROSIVE FLUID ONLY)

ITEM NO	ITEM/DESCRIPTION	MATERIAL	SIZE	QTY				
				WATER	STEAM	PULSATING	AIR	CHEMICAL
01	REDUCER (IF APPLICABLE)	SAME AS MAIN PIPE	1" X 1/2"SW	01	01	01	00	01
02	SEAMLESS PIPE	SAME AS MAIN PIPE	1/2"	A/R	A/R	A/R	A/R	A/R
03	FORGED COUPLING	SAME AS MAIN PIPE	1/2" SW	A/R	A/R	A/R	A/R	A/R
04	FORGED TEE	SAME AS MAIN PIPE	1/2" SW	01	01	01	01	01
06	FORGED GLOBE VALVE	SAME AS MAIN PIPE	1/2" SW	01	01	01	01	01
07	CAP	SAME AS MAIN PIPE	1/2" NPTF	01	01	01	01	01
09	ADAPTOR – M TO M	SS316	M20X1.5M X 1/2" NPTM	03	03	03	03	03
10	TWO VALVE 3 WAY MANIFOLD WITH VENT PLUG	SS316	1/2" NPTF	01	01	01	01	01
11	SYPHON	CS	1/2" SW	00	01	00	00	00
12	SNUBBER	SS316	M20X1.5M X M20X1.5F	00	00	01	00	00
15	CONNECTOR – M TO M	SS316	1/2" NPTM X 1/2" NPTM	00	00	00	00	01
16	CHEMICAL SEAL	SS316	1/2" NPTF X 1/2" NPTF	00	00	00	00	01
13	NUT & TAIL PIECE WITH ANNEALED COPPER/SS304 WASHER	SS316	NUT SIZE : M20 X 1.5 WITH 100MM TAIL	03	03	03	03	03
18	NIPPLE	SAME AS MAIN PIPE	1/2" NPTM X 1/2" SW	01	01	01	01	01



TITLE :-

INSTRUMENT INSTALLATION DIAGRAM

PRESSURE SWITCHES/TRANSMITTERS

DRG. NO.

PE-DG-999-145-IXXX

REV. NO.

00

DATE

05.11.13

SHT

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