

All platforms and galleries shall be designed with a minimum headroom clearance of 2200 mm and shall have a minimum width of 1500 mm clear passageway and shall be enclosed by hand-railing on both sides. Ladders are only to be provided as an extra means of escape.

All aspects of platforms, stairways, ladders and other access ways shall comply with the requirements of applicable DIN standards, BNBC or equivalent.

#### B0.6.12 Hazardous areas, fire fighting & prevention systems

##### **Hazardous areas**

The Contractor shall take full account of any special requirements concerning the nature, handling and storage of all fuels, flammable gases and chemicals etc., and provide plant, equipment, buildings and other services accordingly, including all facilities to ensure the safety of the operating and maintenance personnel.

The Contractor shall provide drawings to define all the hazardous zones taking account of all sources of hazards under normal and abnormal operating conditions (regardless of whether or not these areas are specifically listed in the specification). The zoning philosophy shall be subject to the approval of the Employer. All equipment necessary for mounting in these areas shall meet the requirements of BS 5345 or equivalent.

In particular, equipment directly concerned with Plant which may give rise to a hazardous situation shall be designed to IEC 60079 Zone 1 or 2 requirements with electrical connection safety barriers or intrinsically safe equipment equivalent to VDE 0171 Type Exi. Where required by the Employer/Engineer, certification shall be provided to confirm the suitability of the equipment and devices.

The Contractor shall be responsible for ensuring that all electrical equipment installed in any hazardous zone is designed and tested to suit the relevant zone classification and shall be to the approval of the Employer. Cables shall not be laid in trenches etc. with fuel pipe work.

All electrical equipment part of a following system installed in hazardous areas shall be of flame/explosion proof type:

- fuel oil handling systems
- burner operating floors
- turbine lubrication oil tank area
- generator sealing oil tank area
- diesel generator area
- hydrogen bottle house
- others required by the above standards.



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All equipment offered for use in the above areas shall have the necessary certification by the appropriate National Certification Bureau and its proposed application shall fully comply with all conditions of the certificate.

At least all electrical equipment part of the systems in hazardous area as stipulated in the specification shall be of flame/explosion proof type. For other systems the approach as described by the Bidder/Contractor can be applicable.

All electrical equipment associated with any part of a system within the following areas shall be of dust explosion proof type:

- station bunker rooms,
- conveyor transfer towers,
- 3 meters radius from coal feeders, pulverizers and the center point of pulverized fuel pipes.

**Fire Fighting & Prevention Systems**  
See Section B12.

**B0.6.13 Maintenance isolation**

All major equipment shall be arranged to facilitate safe isolation from all hazards for maintenance purposes. In addition all valves must be capable of being locked either in the open or closed position by means of a chain and padlock.

Non return valves are not acceptable as a means of isolation.

**B0.6.14 Materials**



**B0.6.14.1 General material requirements**

All materials shall be new and of the best quality for use in the conditions and the variations in river water quality (refer to **Part C Annexes**), the temperature and pressure that will be encountered in service without undue distortion or deterioration or the setting up of undue strains in any part that might affect the efficiency and reliability of the Plant.

All materials shall correspond either to the approved standards and the respective code number or to exact analysis data, and full information concerning properties and applied heat, chemical and mechanical treatment shall be submitted.

Special attention must be paid to eliminating the possibility of corrosion resulting from galvanic effects. Design, selection of materials and all methods of erection shall be such as to keep these effects to a minimum.

Materials complying with codes and standards listed below shall be used for the design and construction work.

Unless the materials meet these codes and standards the equivalent ASME/ASTM standard shall be used.

### Materials and standards

|     |    |                                     |                                                                                                                |                                                                                                                            |
|-----|----|-------------------------------------|----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| (A) | a. | Structural Steel Built-up Members   | DIN EN 10 027-1<br>Formerly DIN 17 100 and EN 10 025                                                           | all steel brands S235 and S355<br>Formerly St. USt 8, RS137-2, St37-3, St52-3, or Fe360B, BFU, BFN, C & D, and Fe S10      |
|     | b. | Structural Steel Hot Rolled Members | DIN 1024 Series<br>DIN 1025 Series<br>DIN 1026 Series<br>DIN 1027 Series<br>DIN 1028 Series<br>DIN 1029 Series | all steel brands S235 and S355,<br>Formerly St. USt 8, RS137-2, St37-3 and St52-3, or Fe 360B, BFU, BFN, C & D, and Fe S10 |
|     | c. | Structural Steel Tubes              | DIN EN 10 210-1, 2                                                                                             | S235 and S355                                                                                                              |
|     | d. | Crane rail                          | DIN 4132                                                                                                       |                                                                                                                            |
| (B) | a. | Bolts and Anchor Bolts              | DIN ISO 898, DIN 18 800-1                                                                                      | 4.6 ( $f_y \geq 240 \text{ N/mm}^2$ ) 5.6 ( $f_y \geq 300 \text{ N/mm}^2$ )                                                |
|     | b. | High Strength Bolts                 | DIN ISO 898, DIN 18 800-1                                                                                      | 8.8 ( $f_y \geq 640 \text{ N/mm}^2$ )<br>10.9 ( $f_y \geq 900 \text{ N/mm}^2$ )                                            |
|     | c. | Stud Bolts                          | DIN 32 500, Part 1 & DIN 18 800-1<br>DIN 32 500, Part 3 & DIN 18 800-1                                         | 4.8 ( $f_y \geq 320 \text{ N/mm}^2$ )<br>St 37-3 per DIN 17 100, ( $f_y \geq 350 \text{ N/mm}^2$ )                         |
| (C) |    | Electrodes for Arc Welding          | DIN 1913/ DIN EN 499                                                                                           |                                                                                                                            |
| (D) |    | Ordinary Portland Cement            | DIN 1164-1 / 1164-2<br>EN 197-1                                                                                |                                                                                                                            |
| (E) |    | Reinforcing Bars                    | DIN 488-2 / 488-4                                                                                              |                                                                                                                            |

### Material properties and allowable strengths

#### • Concrete steel reinforcement

High yield steel deformed bars, types as per DIN 488-2  
The max. bar length shall be 12 m.

- **Concrete steel fabric reinforcement**

Reinforcement quality

Wire of grade 500 ( $f_y = 500 \text{ N/mm}^2$ ) as per DIN 488

Welding of reinforcement as per DIN 4099.

- **Fabric types**

Preferred range of designated fabric types: see part 4 of DIN 488.

- **Concrete grade and specified strength**

Concrete for blinding grade C12/15 as per DIN 1045. Min. thickness of blinding = 75 mm.

Concrete for all other structures grade 25/30 as per DIN 1045.

All concrete grade 30/37 or higher as well as special qualities, like waterproofed concrete, have to be mixed in accordance with a special design concept, approved by a third party assessment.

- **Concrete cover to reinforcement bars**

The minimum concrete cover for durability to any reinforcing bar shall be in accordance with ZTV-K, Section 6.

Concrete grade 25/30 as per DIN 1045 are minimum requirements, if not mentioned otherwise.

**Note:**

- a) Cover noted is to the outside bar regardless of whether it is main or secondary reinforcement.
- b) For concrete exposed to brackish water, brine and seawater splashing a special design concept is required.
- c) For water or liquid retaining structures, the cover should be reviewed in conjunction with design, to limit the allowable crack widths. Linings could also need to be applied.

**Structural steel**

DIN 18800 / DIN 18801 / DIN 18807 shall be followed.

For all above mentioned material standards, the equivalent standards as per BS, ASME/ASTM are also accepted.

## **B0.6.14.2 Specific requirements for high temp./high pressure part materials**

The purpose of this part is to provide the additional requirements for the purchase, manufacturing and fabrication of:

- austenitic stainless steels used for high temperature superheater and reheater tubing,
- ferritic/ martensitic steels used for high temperature pressure parts.



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All manufacturers and suppliers of the base metals, from raw materials until finished products, shall be ISO 9001:2000 certified for the duration of the contract or being renewed during the duration of the contract as appropriate.

Only seamless tubes and pipes are acceptable for power piping. For low pressure systems (< 6 bar (g)) welded pipes will be accepted. Welded pipes may be used for sizes above DN500 if the design pressure and design temperature are such that it calls for pressure rating of ASME 300 class or below. The fittings shall correspond to ASTM A234 with Grade corresponding to the pipe material. The welded pipes provided shall be of certified source.

All materials and manufacturing procedures shall be certified by an independent 3<sup>rd</sup> party. The approval shall be part of the quality documentation.

The use of SA213-T24 material for membrane walls is not accepted.

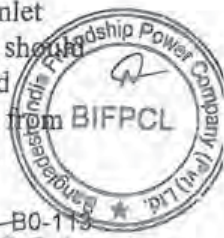
The material SA213-T23 is known for cracking sensitivity. It shall be demonstrated and documented in the final data package that all such materials are free from any cracks and that all hardness values are within the required limits.

For SA213-T23 the Contractor must provide a detailed procedure for the calculation, design, purchase, manufacturing, erection, cleaning and pressure testing of this material. The relevant ASME code cases must be respected.

For SA213 T91 and SA335 P91 the latest stress values and the latest information according to ASME code cases must be used. Also the EPRI „Guidelines and Specifications for High-Reliability Fossil Power Plants Best Practice Guideline for Manufacturing and Construction of Grade 91 Steel Components“ shall be respected.

Bidder/Contractor at his sole discretion may use ASME SA-335, P-92 or approved equivalent material for superheater/reheater headers and interconnecting piping, i.e. for the components which are outside the flue gas path. However, use of T92 material for boiler tubes is not permitted.

In case it is proposed by the Bidder/Contractor to use ASTM-A-335, P-92 or equivalent material, Bidder/Contractor shall furnish a certificate of provenness of the material certifying the usage and satisfactory performance of the proposed material in main steam/hot reheat piping for a reference plant (or applicable unit of reference plant) having rated main steam and/or hot reheat steam temperature at turbine inlet at least equal to or higher than the rated main steam and/or hot reheat steam temperature at turbine inlet envisaged by the Bidder/Contractor. Such reference plant(s) (or unit) should have been executed by the Bidder/Contractor himself or by others and should have been under operation for at least 50,000 hours or 6 years from date of commissioning of the applicable unit (of the reference plant).



Maximum allowable stress values for ASME SA-335; P-92 or approved equivalent material as per code shall be reduced by 10% for calculating the thickness of pressure parts.

For SA335 P92 the Contractor shall provide a detailed procedure for the calculation, design, purchase, manufacturing, erection, cleaning and pressure testing of this material. The relevant ASME code cases must be respected. SA213-T92 may be used for header nipples outside of the flue gas pass, while meeting the above mentioned requirements for quality control.

The details on preheating for welding and PWHT shall be stated in detail. Special consideration shall be given to record the metal temperatures during manufacturing, erection and operation.

In case of any repair of any of such materials at site the 3<sup>rd</sup> party engineer must be involved concerning the proposed repair method.

#### B0.6.15 Pre-service cleaning and protection of plant equipment

This clause covers mechanical and pre-service cleaning and protection of the plant items and equipment at the Manufacturer's workshop and at site that are not subsequently to be painted.

Cleaning of fabricated component items shall be carried out after fabrication and final heat treatment or welding at manufacturers' works or at site, as appropriate.

In the event of the surfaces not being cleaned to the Employer's satisfaction, such parts of the cleaning procedures or agreed alternatives as are deemed necessary to overcome the deficiencies shall be carried out at the Contractor's sole expense.

Mechanical cleaning as opposed to alternative chemical cleaning is the preferred method for workshop cleaning except where this is precluded by design or access considerations.

Machined surfaces shall be protected during the cleaning operations. For recleaning small areas, hand cleaning by wire brushing may be permitted. Wire brushes used on austenitic materials shall have austenitic steel bristles.

Austenitic stainless steels, copper and aluminium alloys, cast iron, bimetallic and metallic/plastic items, and components fabricated by spot welding or riveting shall not be chemically cleaned. All weld areas shall be suitably stress-relieved before chemical cleaning.

At an appropriate time, the Contractor shall submit drawings of temporary pipework necessary to carry out the pre-service cleaning simultaneously with a list of works to be carried out on the pipelines, heaters, feedwater

tanks, vessels etc. to connect the temporary pipework with the parts of equipment to be cleaned.

Further, the Contractor shall submit at the same time the basic draft of the cleaning procedure and of the treatment of wastes.

Not less than six months prior to the commencement of any site cleaning, the Contractor has to submit programs covering all procedures, lists of chemicals, calculations which quote the velocities, temperatures hand-pipework forces and movements imposed during site cleaning.

All necessary equipment, provisions, chemicals etc. are to be provided by the Contractor.

All tests, analyses, etc. as required are to be performed by the Contractor.

Besides this, the Contractor shall take over all responsibility for the treatment and disposal of wastes according to the local law and to the satisfaction of the Employer.

The date at which cleaning of plant equipment will be carried out at site shall be notified to the Employer at least 20 days in advance.

The Contractor shall take all necessary precautions to ensure that the internal surfaces of all plant are kept clean and free from injurious matter during erection.

When all plant has been erected and lagged or at such other time as may be agreed with the Employer for sub-assemblies, the installation shall undergo a procedure for site cleaning proposed by the Contractor and subject to the approval of the Employer.

#### B0.6.16 Welding

All pressure part welding must follow the requirements of ASME and connected standards.

Welding work and related heat treatment as well as inspections and test shall be performed in accordance with the specific and approved welding procedure specifications (WPS) and the respective material specifications.

WPS shall be prepared in accordance with relevant ASME standards, endorsed by 3<sup>rd</sup> party / inspector and submitted to the Employer.

Welding plans have to be prepared by every manufacturer for his scope of work.

No welding shall be undertaken until the applicable WPS and Procedure Qualification Record (PQR) are approved by the Employer.



The PQR shall be qualified in accordance with relevant ASME standard. Welding procedures must be qualified by a qualified independent testing authority engaged by the manufacturer.

Welding procedures shall be qualified in accordance with the requirements of the construction code/specification for the Item of plant concerned and in the case of critical plant items the tests shall be witnessed by an internationally recognized inspection authority.

Welders shall be qualified in accordance with the requirements of the construction code/specification for the Item of plant concerned for all types/positions of welding he may perform.

Welder tests shall be carried out in accordance with the approved standards within Contractor's scope. Test results are available for review in the work-shops.

If at any time in the opinion of the Employer the work of any welder appears questionable, such welder is required to pass additional qualification tests to determine his ability to perform the type of work on which he is engaged. Any welder failing the retest may, at the discretion of the Employer be disqualified from further welding on items under this Contract.

The 2 first production welds of every welder shall be 100% examined by volumetric NDE and only when the results are acceptable, shall the welder be released for production welding.

A system of positively identifying the work of each welder shall be maintained and any welder whose work is the subject of multiple rejections shall be required to undergo a requalification test. Any welder failing the retest may, at the discretion of the Employer's Representative be disqualified from further welding on items under this contract.

Welded fabrications shall be stress relieved when specified by the applicable standard or for dimensional stabilization prior to machining.

Copies of temperature charts referenced with load items shall be included in the test certification supplied for the relevant items.

All welds shall be visually examined and shall be of smooth contour, free from cracks, undercut and other significant defects. Wherever possible the interior of tubes etc. shall be examined using a suitable optical device where necessary. The manufacturer shall make every effort to avoid any contamination of the tube interior during the manufacturing process. To ensure the tubes are free from obstruction and debris the tubes shall be cleared with a sponge being blown through.

Fillet welds shall be checked for size using suitable gauges which shall be available for use on request by the Employer's Representative during an inspection visit.

For single side butt welds, all root passes shall be welded using a TIG welding process.

Preheating shall be in accordance with the applicable WPS and the respective material specification. The preheat temperature shall be in function of welding process, wall thickness, type of welding consumables, ambient temperature and climatic conditions

Welding performed outside a workshop is authorised if an approved wind and rain protection (welding bay) is installed around the working place. Anyway, when ambient temperatures falls below 5°C, preheat is required for all ferritic materials and thicknesses. Gas burners or oxy-fuel torches can be used for pre-heating. Preheat shall be maintained over a distance of not less than 4 times the nominal thickness with a minimum of 75mm on either side of the weld. If the material required pre-heating, the same pre-heating shall be done for oxy-fuel or plasma cutting.

Welding consumables such as TIG-rods, electrodes, wires shall be clearly marked in order to avoid any mix-up of material grades. Positive Material Identification to be carried out on where a doubt for mix-up exists.

Any post welding heat treatment (PWHT) shall be performed in accordance with an approved procedure. The procedure shall describe the method, the heat treatment parameters (e.g. holding temperature and time, heating/cooling rates, heated/insulated band...), the number and location of thermocouples, records and calibration. The procedure shall be available on Site and or in the workshops.

Before welding and/or heat treating valves, valve-manufacturer instructions shall be taken into consideration.

In the case of sensitive materials, grinding of the welds or other grinding work may only be carried out with special grinding wheels so as to avoid overheating or an increase in the hardness of the material.

Welding defects of all kinds must be documented and be available to the Employer on Site or in the workshop.

The Contractor maintains and makes available to the Employer or his representative, both at works and Site, adequately indexed records of all welds, weld inspections, weld controls and repair.

Please refer also to **Section B0** for "Manufacturing tests".



Additional welding requirements for welding of civil steel structures are stated under **Section B9**.

## **B0.6.17 Mechanical equipment**

### **B0.6.17.1 Pumps**

#### **General**

All pumps shall be designed for continuous operation unless otherwise specified.

Pumps shall be installed in positions convenient for operation and servicing. Where multiple pump installations are required, each pump and its associated equipment shall be arranged in such a manner as to permit easy access for operation, maintenance and pump removal without interrupting plant operation.

Pumps installed for parallel operation or as stand-by sets are to be of identical design, i.e. interchangeable.

Lifting lugs and eyes and other special tackle shall be provided as necessary to permit easy handling of the pump and its components.

#### **General design and construction**

All pumps shall be designed to withstand a test pressure of 1.5 times the maximum possible pump shutoff pressure under maximum suction pressure conditions. If a pump can operate at sub-atmospheric suction conditions, the entire pump shall be designed for full vacuum.

All pump shafts shall be of ample size to transmit the maximum possible output from the prime mover. The pump shaft and coupling are to be so dimensioned that the maximum permissible torque of the shaft is higher than the maximum transmissible torque of the coupling. Directly coupled pumps shall be used preferably.

Renewable wear rings shall be provided at points of running clearance and shall be made from appropriate materials.

All pumps and accessories in contact with the pumped fluid shall be constructed of materials specifically designed for the conditions and nature of the pumped fluid, and be resistant to erosion and corrosion.

Product water flushing lines and drains are to be supplied for each pump handling the prevailing river water to avoid corrosion if the pump is in operation for extended periods.

The pump glands or mechanical seals shall be so arranged that repackaging or fitting of replacement seals can be carried out with the minimum of disruption to plant operation. In case of operating under vacuum conditions liquid sealing is to be provided.

The pump casing shall preferably be split for ease of maintenance and be designed such that the impeller and shaft are capable of being withdrawn from the casing without disturbing any of the main pipework and valves carrying the pumped fluid. In general, all horizontal pumps with draw-out-rotors are to be fitted with a coupling to facilitate disassembly without removing the motor. Pull-out design of the shaft shall be applied to vertical wet pit and dry pit pumps as well.

Each horizontal pump shall be mounted with its drive on a common base plate of rigid construction. Vertical pumps are to be provided with foundation frames. In case of submersible pumps suitable frames shall be provided in the pump sump. It shall however be possible to remove these pumps without entering the sump.

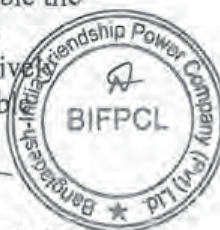
Pumps must be carefully set to ensure that the net positive suction head available under all operating conditions will be adequate for the type of pump employed. The NPSH values are to be referred to the least favourable operating conditions - lowest atmospheric pressure, lowest level of water on the suction side of the pump, and highest temperature of the pumped fluid. An adequate safety margin of normally greater than 1 m to the max NPSH required shall be provided unless and otherwise specified for specific pump. Pumps shall operate smoothly throughout the speed range up to their operating speeds. The first coupled critical speed must be at least 20% higher than the maximum operating speed. The determination of the shaft diameter and the distance between two consecutive bearings must include a sufficiently large safety margin to satisfy this condition.

Where necessary, the pumps are to be fitted with devices to ensure a minimum throughput.

### **Bearings**

For large pumps the bearings shall be of automatic oil lubricated sleeve type, unless otherwise specified. Bearings on vertical shaft pumps shall be so spaced to prevent shaft whipping or vibration under any mode of operation. Vibration sensors and temperature measurements incl. temperature transmitters for continuous monitoring shall be provided for large pumps.

Bearings housings on horizontal shaft pumps shall be designed to enable the bearings to be replaced without removing the pump or motor from its mounting. Bearing housings on horizontal shaft pumps shall be effectively protected against the ingress of water, pumped fluid and dust by suitable nonferrous deflectors.



All bearing oil wells shall be fitted with visual oil level indicators. Non-pressure-oil lubricated bearings shall be equipped with constant level oilers.

#### **Pumps characteristics**

When several pumps are installed for the same service, they shall be suitable for unrestricted parallel operation.

The pump flow/head characteristics shall be such that within the operation range the head will continuously increase with decreasing flow, maximum head (shut off head) being at least 10% higher than the duty point head.

Unless otherwise specified all pumps shall be capable of operating at 110% of the rated capacity at the rated delivery head. Maximum size impellers for the pump body in question shall not be quoted for. By installation of a new impeller a head increase of 5% minimum shall be possible. The performance of the drive motor is to be determined according to the above mentioned technical requirements and to the requirements as specified in the electrical part.

#### **Fittings**

All pumps shall be installed with isolating valves, a non-return valve and suction and discharge pressure gauges unless otherwise stated. Accessible couplings shall be supplied with removable type guards.

Coupling halves shall be machine matched to ensure accurate alignment. Couplings as well as gears must have a rated capacity of at least 120% of the maximum potential power transmission requirement.

All pumps other than submersible pumps shall have temporary strainers fitted in the suction pipework during all initial running and commissioning phases. Permanent strainers shall be provided where specified.

Venting valves shall be fitted to all pumps at suitable points on the pump casing unless the pump is self-venting, due to the arrangement of the suction and discharge nozzles. Drainage facilities shall be provided on the pump casing or adjacent pipework to facilitate the dismantling of pumps.

All positive displacement pumps shall be fitted with a discharge relief valve capable of passing the maximum pump delivery flow.

### **B0.6.17.2 Piping and accessories**

#### **Design criteria**

The pipework shall be designed, fabricated, erected, inspected and tested on the basis of the applicable standards and codes, and the additional requirements as set out below.

For the plant water and cooling water system GRP is preferred, Bona-Pipe and coated carbon steel is acceptable. For saline water and the water treatment systems LPP piping will be accepted also. If a carbon steel system is offered, a cathodic protection system shall be employed for inside and



outside. For steel underground piping where cathodic protection is not feasible coal tar epoxy coating shall be applied. For painting and coating see chapter painting specification. A sufficient corrosion allowance shall be considered.

Plant water and cooling water piping system: If these pipes are buried cathodic protection system shall be employed for inside and outside. Further communicating lines (from above ground to underground and vice versa) will have to be provided with respective insulation joints. In any case protection against corrosion must be provided. GRP or other appropriate material is required.

Screening channel in the plant water pumping station as well as other equipment installed in pumping stations: In case all piping of mild steel is used require cathodic protection.

GRP piping shall be laid under the responsibility and supervision of the GRP pipe manufacturer.

The maximum flow velocities for the individual media must not be exceeded at maximum throughput (unless expressly specified in the documents or proven by the Contractor):

| Type of Pipework                                                              | Max. Velocity |
|-------------------------------------------------------------------------------|---------------|
| <b>Steam lines:</b>                                                           |               |
| High-pressure live steam lines ( $PN \geq 63$ )                               | 60 m/s        |
| HP / LP turbine bypass lines                                                  | 100 m/s       |
| Intermediate-pressure steam lines ( $PN 25/40$ )                              | 40 m/s        |
| Low-pressure steam lines above 5 bar                                          | 35 m/s        |
| Low-pressure steam lines < 5 bar                                              | 25 m/s        |
| Vacuum lines                                                                  | 80 m/s        |
| Saturated steam lines                                                         | 20 m/s        |
| BFP drive turbine exhaust                                                     | 80 m/s        |
| <b>Water lines (Feedwater, Plant water / cooling water, condensate etc.):</b> |               |
| Feedwater suction lines                                                       | 0.5-2.5 m/s** |
| Feedwater discharge lines                                                     | 3-5 m/s       |
| Other suction lines                                                           | 1.5 m/s       |
| Other discharge lines                                                         | 3.0 m/s       |
| River water lines                                                             | 3.0 m/s       |
| <b>Fuel lines:</b>                                                            |               |
| Fuel oil / LDO suction lines                                                  | 1.0 m/s       |



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| Type of Pipework         | Max. Velocity |
|--------------------------|---------------|
| Fuel/oil / LDO discharge | 2.0 m/s       |
| Air Lines:               |               |
| Compressed air lines     | 15.0 m/s      |
| Combustion air lines     | 20 m/s        |
| flue gas lines           | 18 m/s        |

\*\* The design and routing of the feedwater suction lines must be optimized considering the allowable velocity of depressurization caused by load changes.

The maximum velocity for the LP extraction shall not exceed 60 m/s. For those media/systems where no maximum velocity is given in the specification, the maximum velocity shall be proposed by the Contractor and is subject to approval by BIFPCL during the basic/detailed engineering.

In addition pressure drop criteria shall govern the sizing of the key lines.

Nominal diameters (DN), nominal pressure (PN) and wall thicknesses shall be standardized.

Nominal diameters of < DN 25 shall not be used for pipe lines except for instrument lines, chemical dosing and analysis lines.

For the design of safety valves installed downstream of reducing stations, high pressure bypass valves or equivalent control valves, the maximum throughput of the fully open reducing or bypass valve including injection water quantity is to be taken as the basis for calculation. All cross Sections and lines for safety devices that protect against excess pressure (safety valves, rupture discs and similar items) must be designed to ensure the necessary blow-off rate and fault free functioning.

The design pressure is equal to the response pressure of the devices protecting the piping. In the case of pump discharge lines a pressure corresponding to 1.1 times of the shut-off head of the pump at the ambient temperature is to be taken as the minimum design pressure. The plant water and cooling water systems must be designed according to the water hammer calculation.

The design temperature is the highest possible fluid temperature occurring in the length of line concerned. Possible tolerances of the temperature control system and any temperature allowances provided by the requirements of the standards shall be considered.

For live steam lines the design pressure of the boiler shall be taken as the design pressure of these lines up to the inlet of the turbine main stop valves. In addition to the required wall thickness in accordance with calculations, a corrosion allowance of 3 mm shall be added for unprotected carbon steel, 1.5 mm for alloy steel and 0.5 mm by stainless steel.

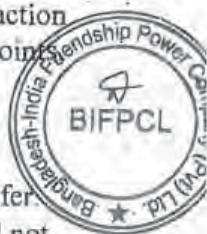
For the cold reheat piping downstream of the connection to the HP bypass exhaust, the selection of the design temperature shall also consider the case that the HP bypass station is operated for limited period without spray injection. The Contractor shall prove both operating cases: Operation of HP bypass with spray attemperation and without spray attemperation (limited time period). Both cases shall not lead to any damage to the cold reheat piping and downstream pressure part.

For the piping systems with a nominal pressure specified as  $PN > 40$  as in DIN 2401 or equivalent and for vacuum systems, the drainage and ventilation facilities shall be fitted with double valves.

All vents, drains or dump points with more than 10 bar/100 °C operating pressure/temperature shall lead to the flash tanks and into funnels at visible points with covers.

#### **Guidelines for the design and construction of pipework and accessories**

- Design and construction of all parts of the power piping shall be according ASME B31.1 (Power Piping).
- Other piping and accessories should correspond to the present state of the art and shall be based on the latest standards and medium properties.
- The pipework and its accessories shall be designed and arranged so that all parts subject to operation and maintenance can be operated, inspected, maintained and replaced without difficulty and with a minimum of effort. All important parts must be accessible.
- Provisions to allow for isolation and for access must be foreseen on all parts subject to acceptance by the local authorities.
- None of the forces and moments transmitted by the pipes to connected machines, apparatus and other components must exceed the maximum permissible values, given by the manufacturers of these items. Attachments to turbine foundations shall be carried out only as agreed with the turbine manufacturer.
- All steam traps shall be provided with a bypass and lines which open to a funnel.
- As far as expansion joints and other parts of pipework are concerned it shall be borne in mind that differential settlement can occur. The reaction forces and moments of the piping system to be withstood by fixed points, walls, foundations and other civil structures shall be reduced to the utmost minimum by suitable means (e.g. expansion joints shall be provided where required).
- The pipe support structures shall be designed to minimize heat transfer.
- The installed pipework with its supports and other components shall not obstruct gangways (min. 1500 mm wide), maintenance, escape routes etc. Overhead piping shall have a minimum vertical clearance of 2.3 meters, 8 meters above main access roads and 6 meters above any other roadways.
- Pipe spools for HP steam, feedwater piping and all steel pipes  $\geq DN 400$  shall be cleaned internally prior to delivery by shot blasting at the



workshop with iron particles to SA2 1/2 or by acid cleaning, and shall be properly protected against corrosion.

- Pipe ends and branch connections of underground piping shall be sealed temporarily during installation if the connecting pipe is not immediately installed.
- The Contractor shall submit a detailed description of proposed steam blowing and other cleaning procedures for all pipelines, and no part of this work shall be started until these procedures have been approved by the Employer. Temporary silencers shall be provided for this.
- The cleaning of water - steam system shall comply to VGB R513e „Internal Cleaning of Water-Tube Steam Generating Plants and Associated Pipework“
- The Employer reserves the right to require the Contractor to modify any of his cleaning procedures if found necessary to obtain acceptable results. The Contractor shall furnish, install and dismantle all temporary pipes, hangers, anchors, etc. required for cleaning all piping systems.
- To the extent that hot fluids can accumulate in pipe Sections isolated for maintenance purposes (including control valves with injection water), drains with hand-operated shut-off valves are to be provided for the safety of the personnel (block and bleed systems). Furthermore the Contractor shall safeguard the piping systems against over-pressurization caused by thermal expansion of blocked-in fluids by adequate means.

### **Welding**

- All welding shall be carried out according to relevant standards. The welding procedures of the Contractor shall be supplied before execution of welding works to the Employer for approval. For quality reasons as many welds as possible are to be carried out in the workshop.
- Welding ends of all piping must be carefully prepared before welding. The type of butt welding ends of valves, control devices, orifices, etc. shall be specified by the Contractor and must be given to the manufacturers of these components in due time prior to their start of work if necessary/postweld heating treatment. If there are differences in the wall thickness and/or different materials of piping and valves with butt-welding ends, the necessary transition pieces must be provided by the manufacturer of the valves.
- Socket welds are not permitted for lines above DN 50, for corrosive media lines or for lubricating oil lines.
- After completion of the weld joint, the welder must mark with indelible crayon his identity number and the last two digits of the year in which the work was completed on the pipes. The Contractor shall keep a record of welders.
- Testing of piping and welding shall be as per ASME standard. Minimum requirements for testing of welds are specified in Section B0.7.2.

### **Welding tests.**



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### Piping

- The Contractor shall provide suitable thimbles and flashing where pipelines pass through floors and walls. Floor thimbles shall be installed to provide 90 mm projection above the finished floor surface.
- A stress analysis shall be performed for all piping systems  $DN \geq 50$  with an operating temperature  $\geq 100$  °C.
- For cross country low pressure piping with a straight length of more than 200 m a stress analysis shall also be conducted.
- The piping stress and flexibility analysis shall be based on the relevant standards. Recalculation must be taken into consideration as built condition, actual weight and dimensions.
- Tubes, pipes, bends and fittings shall be produced and tested in accordance with the applicable international standards (ASME/ASTM, EN, etc.).
- All pipe lengths under this package, including piping where alloy steel is used shall be subjected to 100 % ultrasonic examination as per material specification standard with acceptable notch depth of 5% of the selected wall thickness (1.5mm maximum) except for the following piping system: LP piping not under "ASME B31.1 Power Piping" for not dangerous and not explosive media.

### Noise abatement measures

The Contractor shall take all necessary measures to limit noise in accordance with the requirements. On no account shall the sound level exceed the values as mentioned under the relevant subsection.

If this requirement cannot be met by adequate construction of the pipework and valves concerned, sound absorbing housing or insulation have to be provided. Where pipework and valves are installed outdoors, the above mentioned requirement may be fulfilled, if necessary, by providing silencers at the safety valve outlets and at the blowing out lines.

### Pipe supporting elements

As used herein, the term "hangers and supports" shall include all hanger assemblies, support assemblies, constant support hangers, anchors, guides, sway braces, vibration dampers, trays, brackets, attachments, miscellaneous structural steel and other items required to support the piping in a proper manner.

For supporting points up to 25% variation and 40 mm movement variable spring supports shall be selected.

Constant support type spring assemblies shall be provided at all locations where it is necessary to avoid transfer of stress from that support to another support or to an equipment terminal, and at other support locations where vertical movements of the piping are too large to be properly handled by variable support springs. Constant support spring assemblies shall be of a design that will compensate for the normal variation in the supporting force of the helical coil springs, thus providing constant supporting force through-



out a total travel range which shall be at least 20 mm greater than the actual maximum movement of the piping.

Constant support assemblies shall be equipped with a means of locking the spring(s) against movement during erection, hydrostatic testing etc. The use of counterweights in substitution for support spring assemblies will not be permitted.

Support spring assemblies shall be of the enclosed spring type, and shall have an embossed on factory load indication scale showing the hot (operating) and cold (ambient) positions. Each spring assembly shall incorporate an adjustable hanger rod coupling to permit load adjustment. All support springs shall be designed to permit at least  $\pm 10\%$  field load deviation from the factory calibrated load.

The supporting force provided by variable support type spring assemblies shall not change by more than 20% between the cold and hot positions, and supports of this type shall not be used at any point where such a change in supporting force cannot be safely permitted. Variable support spring assemblies shall incorporate springs with maximum working range length in order to reduce the overall length of the assembly.

All pipe hangers and support stands shall be attached to the piping and structural supports such that they will be vertical when the piping is at hot operating condition. So far as practicable, hangers and supports shall be of the same type and component assembly.

All hangers shall be carefully adjusted. After Plant start-up checks shall confirm that all hangers and supports are in the correct position.

The Contractor shall prepare a complete documentation of all pipe hangers and supporting elements. These documents shall contain the following information:

- 
- loads, forces and moments, and their directions at all supports, hangers at normal operating conditions, etc.
  - magnitude and directions of the movements at the loading points
  - measurements of the loading points referred to the axes of the buildings
  - item No. of the supports, hangers etc. according to the piping group
  - material specification for the supporting parts.

#### Trace heating

Trace heating shall be provided for fuel oil pipes and other pipes as required. Electric type trace heating is preferred. The referenced Site Conditions as well as media properties shall be base for the design.

#### Protection of buried pipework systems

All buried pipework of steel or cast iron or other materials prone to corrosion shall be protected from corrosion by cathodic protection.



The design of the cathodic protection system(s) shall be executed by a specialist and authorized company. The designed cathodic protection shall be a completely functioning system in all respects according to the state of the art and shall also include the appropriate equipment for measurements.

For the plant water and cooling water piping system only: If these pipes are buried cathodic protection system shall be employed for inside and outside. Further communicating lines (from above ground to underground and vice versa) will have to be provided with respective insulation joints. In any case protection against corrosion must be provided. GRP or other appropriate material is required.

### B0.6.17.3 Valves, steam traps, condensate drainers, safety valves

The Contractor shall design and supply all valves and their accessories required for the safe, efficient and sound operation and maintenance of the Plant based on the appropriate standards. They shall comply as a minimum with the design criteria of the relevant piping.

For reasons of Plant standardization, the Contractor shall co-ordinate types and makes of all valves in his supply and that of his subsuppliers.

Design, construction, fabrication and testing of the valves shall be in accordance with the ASME B16.34. The stipulations of this Section will take precedence if these are more stringent than the approved standards.

All valves shall be suitable for the media and for the service conditions and those performing similar duties shall be interchangeable.

Acceptance certificates for valves shall follow EN 10204 or approved equivalent codes.

The following types of valves are recommended:

- globe valves up to and including DN 50
- gate valves DN 65 and above
- butterfly valves DN 400 and above as metal seated type for LP steam and exhaust steam (DN 65 and above as soft seated type for waterlines (cooling water, process water etc., operating temp. max. 180 °C)
- lift check valves up to and including DN 50
- swing check valves DN 65 and above
- Ball valves DN 25 and above.  
(fuel oil, natural gas, compressed air)

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DN means 'diameter nominal'.

In vacuum service and wherever otherwise necessary to prevent the entry of air, valves shall be provided with suitable sealing facilities. Where applicable, the valves must be suitable for outdoor installation under consideration of the special climatic and environmental conditions of the site.

Unless otherwise agreed, all valves shall be fitted with the spindle in upright position.

All valves shall be positioned so as to be readily accessible for operation and maintenance from permanent floors, catwalks or platforms. Where required, valve spindles shall be lengthened to have the hand-wheel at a height approximately 1 meter above the operation level. All underground valves shall be installed in concrete culverts.

All valves shall be closed in a clockwise direction when looking at the face of the handwheel. The valves shall have rising spindles and non rising handwheels. Plastic valve handwheels will not be accepted.

HP- and large size gate valves to be opened under differential pressure shall be equipped with pressure equalizing valves (globe valves).

All valves shall be fitted with indicators to determine the valve position. In the case of valves fitted with extended spindles, indicators shall be fitted both to the extended spindle and to the valve spindle.

All globe valves shall be equipped with throttling cones with parabolic characteristic.

In general, LP safety valves, butterfly valves, ball valves and orifices as well as all control valves shall be flanged. All valves including valves as mentioned above for steam, feedwater and condensate, HP safety valves (inlet side) shall have welded ends, corresponding to the connected pipes. Also all valves on heater drains and vents and in vacuum systems shall be welded.

Design of valves and materials used must comply with the relevant standards. They must be chosen in accordance with the requirements to be met and to corresponding pipework.

For limiting handwheel forces, for control and operation purposes it may be necessary to install gears and drives.

The maximum handwheel force of 500 N must not be exceeded.

The Contractor shall furnish and install steam traps at each low point. Each steam trap installation shall include a permanent strainer of 20 x 20 mesh



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size, upstream and downstream globe valves and a globe valve as free drain. Steam traps shall be supplied with weld ends. Steam traps shall preferably be of the thermodynamic, thermostatic or bimetallic type with multistage nozzles and selected to suit the service conditions.

Traps which incorporate internal screens or check valves will also be accepted.

Each trap shall be sized to provide ample capacity at the minimum working differential pressure, and to open the orifice at maximum working differential pressure.

Condensate drainers such as used on LP saturated steam or compressed air lines shall be of the ball-float type.

HP gate valves shall be equipped with self sealing lid covers. The self-sealing lid covers shall be equipped with a safety device at the body with shut-off valve and interlocking system. This system must be approved by the authorities.

All valves of the HP/IP piping systems shall be suitable for pickling/acid cleaning (special temporary inserts).

The valves for live steam, HP feedwater and HP injection water shall be made of forged steel. Forged steel or cast steel bodies shall be used for the remaining systems. Valves made of gray cast iron are not acceptable.

Acceptance certificates for piping components and valves shall follow EN 10204.

At the economizer inlet a non-return valve shall be installed, but not shut-off valve.

#### **Technical requirements of Butterfly Valve:**

Applicable standard:

- ASME B16.10 2009 Face-to-Face and End-to-End Dimensions Valves
- ASME B16.34 2009 Valves - Flanged, Threaded, and Welding End
- ASME B31.1 2012 Power Piping
- API 609 2009 Butterfly Valves: Double Flanged, Lug- and Wafer-Type
- API 609 2009 Butterfly Valves: Double Flanged, Lug- and Wafer-Type
- ISO 5752 1982 Metal valves for use in flanged pipe systems - face to face and centre to face dimensions
- ISO 80000-1 2009 Quantities and units
- EN 10204 2004 Materials Testing Certificates

Valves assemblies shall be designed for the pressure and temperature rating of the class specified in the Piping Material Classes and Valve List.

Hydrostatic testing for valves shall be in accordance with ASME B16.34 and API 598.

Carbon steel having carbon contents of more than 0.25% shall not be used in Welded construction valves.

Lug type valves shall not be used.

Valve stem packing, trim and bonnet gasket material shall be manufacturer's standards, unless otherwise specified.

The maximum force requested at the hand wheel shall not exceed 300N (30kgf).

The manually operated valves in the sizes and pressure classes shall be provided with a gear operator as minimum.

- Class Butterfly
- 150 DN 200 & larger
- 300 DN 150 & larger

Gear operator type: Worm-gear type

All valve actuators shall have local indicators fitted to show whether the valves are in an open or shut position. Where extended spindles are used, indicators shall be fitted to both the extended spindle and to the valve spindle.

Plastic or bakelite valve hand-wheels are not permitted.

The stops limiting the travel of any valve in the "open" or "shut" position shall be arranged externally to the valve body.

All valves shall be closed by turning the hand-wheel in the clockwise direction when looking on top of the hand-wheel.

The face of each hand-wheel shall be clearly marked with the words "open" and "shut" in English, with adjacent arrows to indicate the direction of rotation to which each refers.

Each valve hand-wheel shall be fitted with a name-plate of an approved material, indicating in English the valve reference number and function. The name-plate shall incorporate the colour code corresponding to the particular service of the piping.

*Handwritten signature*



#### B0.6.17.4 Thermal insulation

##### General

The thermal insulation shall be designed and installed in accordance with AGI, VDI and DIN or equivalent standards, considering the following minimum requirements:

Insulation shall be provided for personnel protection, heat conservation, noise reduction and for prevention of the formation of condensation on all pipework and equipment whose external surface temperature exceeds 60 °C.

For personnel protection all surfaces with a temperature above 50 °C and which are within the reach of personnel shall be provided with protection insulation and the maximum insulation surface temperature shall be 60 °C.

- All insulation material has to be made from non-asbestos materials.

Following design criteria for insulation shall apply: Design ambient temperature:

- Inside buildings: Ambient temperature of 40°C and wind speed of 0.5 m/s
- Outside buildings: Ambient temperature of 45°C and wind speed of 0.25 m/s

Thickness of the insulation shall be calculated according to ASTM C-680. The Emissivity of the cladding shall be 0.2.

##### Type of insulation materials

The mats shall be stable in shape, chemically inert, free of sulfur and alkali, resistant to water and steam, non-flammable and capable of withstanding continuous exposure to the pipe design temperature. The mats used for insulation of stainless steel equipment shall have a chloride content of less than 0.15%. Under no circumstances may asbestos or asbestos containing materials be used.

The material will have the following physical/chemical properties ( $\pm 10\%$  allowance):

- service temperature up to 650 °C
- density 120 kg/m<sup>3</sup>
- water adsorption 0.5% weight
- specific heat capacity 0.84 kJ/kg °C
- compressive strength 20 kPa
- conductivity versus temperature:

Average temperature

Blanket (W/m °C)

|     |       |
|-----|-------|
| 0   | 0.034 |
| 50  | 0.040 |
| 100 | 0.048 |



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| Average temperature | Blanket (W/m °C) |
|---------------------|------------------|
| 150                 | 0.058            |
| 200                 | 0.070            |
| 250                 | 0.083            |
| 300                 | 0.100            |

For temperatures above 300°C the conductivity required shall be determined by linearly extrapolation of the values presented in the above table.

- conductivity allowance is limited to + 5%.

For special purposes such as for turbines, boilers, etc. spray type insulation or insulation brickwork (for example calcium silicate) may also be applied. The special insulation materials shall be stated by the Contractor and their design shall match the overall design and guarantee the requirements stated in the specifications.

#### Type of insulation setting materials

The surface cladding shall be made of aluminium sheets, manufactured in sheets with the following minimum thickness:

- Outer insulation diameter up to 150 mm Sheet thickness 0.7 mm
- Outer insulation diameter up to 450 mm Sheet thickness 0.9 mm
- Tanks and other large equipment Sheet thickness 1.2 mm

Tank tops shall be provided with insulation strong enough to support a man's weight.

The sheets shall be secured and connected at the longitudinal seams with at least five stainless steel self-tapping screws per meter run.

Plain sheets for flat surfaces shall not exceed 1 meter square and shall be stiffened by crimping.

At the longitudinal and circumferential joints, the sheets shall overlap by at least 50 mm so as to drain off the liquid and not to trap the liquid in the insulation.

Places at which the metal sheets are penetrated for pipe hangers, thermometer sockets, etc. shall be sealed with funnel-shaped recesses or sheet metal rims.

The seams and penetrations of any sheet metal insulating jacket installed outdoors as well as in the boiler and turbine house in areas with risk of water spray etc., shall be sealed against penetration of water by means of a suitable silicon based sealant.



In the case of pipe insulation thicknesses greater than 60 mm, where insulation blankets are used spacers shall be provided at maximum intervals of 950 mm to ensure a uniform insulating thickness on all sides and a perfectly circular shape of the sheet metal jacket. The sheet metal jacket shall be supported by support webs (for pipe diameters below 100 mm) and enclosed support rings (for pipe diameters 100 mm and above). If the enclosed support rings are not provided with ceramic spacers, the spacers made of steel shall be insulated with one heat insulation strip in the case of operating temperatures of up to 200 °C, and with two heat insulation strips where the operating temperature exceeds 200 °C.

To provide protection against contact corrosion, the external circumference of the support ring shall be fitted with heat insulation tape 1 mm thick with two woven edges.

#### **Insulation of flanges, valves and fittings**

All flanges, valves and fittings shall be provided with two-piece or multi-part caps made of aluminium sheet of the specified thickness. Each piece or part shall be double jacketed and the various parts shall be held together by quick release clamps or lever hooks to facilitate assembly and disassembly.

All caps of the welded-in fittings shall be made longer by approximately twice the insulation thickness so that the welding seams will be exposed after removal of the cap.

All manholes shall be provided with heavy duty hinged covers which are to be protected from overheating and corrosion. Such covers shall be secured with easily accessible clamps. In addition, metallic stand-offs shall be provided for personnel protection.

#### **Insulation of tanks and process equipment**

Tanks and process equipment shall be insulated in the same way as pipes, except that the insulating material shall not be attached by wire but by using strong galvanized steel bands.

Spacers shall be welded to process equipment only if this is essential for satisfactory retention of the insulation. Welding of spacers to process equipment is subject to approval by its manufacturer in writing.

#### **Insulation for personnel protection**

Wherever insulation is necessary only for the protection of personnel, it shall be applied around that portion of the pipeline length or to that surface of the equipment that is located within 2.50 m above the passage way floor, or within 1.20 m horizontally to the side or at the end of any floor, platform, walkway, stair or ladder.

Where necessary, drain lines and valves shall be provided with a contact guard of minimum 30 mm thickness against accidental contact, and this shall be installed in the same way as the other insulation.



Where insulation is provided for heat conservation it shall reduce the heat loss to an economic minimum. The maximum heat loss shall be  $200 \text{ W/m}^2$  at an ambient temperature acceptable at  $30^\circ\text{C}$  and a wind speed of  $2 \text{ m/s}$ . For personnel protection all surfaces with a temperature above  $50^\circ\text{C}$  and which are within the reach of personnel shall be provided with protection insulation. The maximum insulation surface temperature shall be  $60^\circ\text{C}$ .

#### B0.6.17.5 Vessels

All vessels shall be designed in accordance with the applicable standards and regulations.

The Contractor is held responsible for the correct design and dimensioning of the apparatus.

Connections shall be provided for all pipework, together with connection and tapping points for instrumentation. Manholes, vents, drains, safety devices and any platforms necessary for safe operation and easy maintenance have to be included in design and supply.

If under any operation conditions vacuum can occur in the vessels, they shall be designed for max. pressure and full (= 100%) vacuum.

The welding factor for all vessels is fixed to  $v = 1.0$ . The minimum wall thickness should not be less than 10 mm, and an appropriate corrosion allowance based upon the particular material, but not less than 1 mm.

Instrumentation and control equipment shall be provided according to the safe service requirements. A minimum requirement is to equip each vessel with a local level indicator, a temperature and a pressure indicator.

Manholes shall be provided as follows:

1. manholes (minimum nominal bore 600 mm) for vessels of 1.0 meter diameter and above
2. handholes (minimum size 200 mm) for vessels below 1.0 meter diameter

All nozzles shall be provided with flanges and shall be so arranged that practical pipe connections are possible. The stub length for all stub pipes shall be at least 200 mm, measured from the tank wall to the flange sealing surface. In the case of insulated vessels, the length shall be chosen so that there will be a clear space of at least 100 mm between the cover of the insulation and the underside of the flange. Nozzles below DN 25 are not acceptable.

For insulated vessels, provisions must be made for fixing and supporting the insulation.



All tank internals must be replaceable through the manhole unless by approval of the Employer. Prefabricated vessels must as a minimum have a coat of primer applied before transport. They shall be cleaned and internally dry. All openings must be secured closed before transport.

Tank and vessel capacities given for process relevant documents and for basic design calculations shall be *usable net* volumes and shall be in the relevant documents clearly referred as such.

#### B0.6.17.6 Heat exchangers

Heat exchangers are to be designed, manufactured and erected in accordance with the applicable standards.

Only proven products shall be delivered. No cast iron components are permitted.

It must be possible to install and remove the heat exchangers without undue difficulty. Lifting lugs and eyes and other special tackle shall be provided to permit easy handling.

Tubular heat exchangers or plate and frame type heat exchangers are acceptable where no specific requirements expressed. Where necessary the tubes are to be protected by impact shields. An adequate number of visual inspection ports are to be provided in critical areas to facilitate condition monitoring.

Unless otherwise specified, all heat exchanger tubes and casings must be designed to withstand 1.2 times the zero flow pressure of the relevant pump at cold conditions, or 1.2 times of the maximum positive operating pressure, as applicable. The test pressure must be 1.5 times the design pressure.

The heat exchangers shall be designed for the maximum temperature incurred plus 20 K.

Heat exchangers must be capable of continuous unrestricted operation with up to 10% of plugged tubes, and a corresponding factor of conservatism, at least this amount must be used in the design of the heat transfer areas.

Considerable importance will be attached to the ease of cleaning the heat exchangers.

Where any heat exchanger part in contact with liquid can be isolated, and there is a possibility of being heated from the other side, safety valves are to be provided for pressure relief.

Pipes from drains, vents and safety valves are to be grouped together, and routed to easily observable points equipped with covered funnels or to the flash tanks.



The overall design and conception of the heat exchangers and accessories is to be such that they are suitable for the degree of automation envisaged for the individual system.

#### B0.6.17.7 Instrument and service air

To meet the compressed air requirements of the Plant two different compressed air systems, - instrument air and service air, will be provided.

The service and instrument air system shall produce and deliver compressed air for the following main consumer of the Power Plant and desalination plant:

- Service air for atomization of HSD (High Speed Diesel) and for operation of mechanical air tools, wrenches and other consumers during all operation modes of both units and for maintenance purposes.
- Instrument air for all pneumatically operated plant instrumentation and control devices and other consumers. The instrument air quality shall meet ISO 8573-1 Class 2".

For detail instruction on compressed air see **B12 Part 7**.

#### B0.6.17.8 Cranes, hoists and lifts

##### B0.6.17.9 Cranes

For erection and maintenance works, overhead travelling crane per unit shall be installed in:

- One EOT Crane for each turbine hall (Refer the below note)
- One EOT crane for the compressed air station building.

Note: If Bidder/Contractor intends to provide one EOT crane then turbine generator stator shall be moved by special device (to be handed over with special tools).

For handling of the generator stator the following alternative is also acceptable: Tandem/combined operation of two turbine hall EOT cranes for which the necessary arrangements shall be provided. In such case the combined capacity of two EOT cranes shall not be less than the 105% of weight of generator stator, including the weight of lifting beam with swiveling equipment and slings.

HP heater shall be moved by turbine hall crane.

For erection and maintenance works in the plant water screening and pumping station two (2) travelling bridge cranes shall be installed, one for pump and header bay area and one for screening plant area. The cranes shall



be calculated and designed in accordance with the principles of DIN or equivalent standards.

EOT crane shall only be used in closed pumphouses.

For installation and repair works in the cooling water pumping station one (1) gantry crane shall be installed.

Additional overhead travelling cranes are to be installed in pump houses, central work shop and all other locations and buildings for equipment of this Contract where cranes are needed. Refer also to the individual technical sub-sections of this specification.

The nominal carrying capacity of the cranes must be such that the heaviest object to be lifted including the spreader bar and other necessary auxiliary lifting devices can be transported with safety.

Cranes with a span of more than 8 m and/or a nominal carrying capacity of more than 5 t shall be in the form of double-girder cranes with the crab running on top.

Smaller cranes shall be in the form of single-girder cranes with the crab running on the lower flange or in the form of suspension cranes.

Cranes with a nominal carrying capacity of 30 t and above shall be fitted with an auxiliary hoist.

The overhead travelling cranes shall be fitted with gangways on the crane bridges or with gangways fitted to the sides of the crane.

The end-carriages of all cranes shall generally be of welded box-girder construction. Buffers shall be provided at the faces on the end-carriages. The end-carriages shall also be fitted with wheel-breakage supports designed to prevent derailment as well.

The deflection of the crane bridges at nominal load shall not exceed  $1/1000$  of the span for cranes with capacity of 50 t or more, or  $1/900$  of the span for cranes below 50 t capacities.

The crab assemblies shall be of rigid steel construction. Buffers shall be provided at the faces of the crabs.

The crabs shall as far as possible be covered with smooth sheet-metal and fitted with handrails.

The crane switchgear shall be accommodated in switchgear cabinets to be arranged on the crane bridge.



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The crane and crab running wheels shall be made of cast or forged steel and shall have double flanges. The wheels should have rolling bearings lubricated for life.

For cranes used for the removal and installation of pump rotors in vertical pumps (e.g. cooling water pumps), it is important to ensure that there is no lateral drift of the hook during lifting and lowering.

All cranes shall be equipped with pendant control units. The pendant control units shall be suspended on the bridge so that they can travel along it independently of the crab.

All pendant control panels shall be fitted with rocker-type or push-button switches for the crane functions. A key switch and an emergency stop switch shall also be provided on each panel. Additional switches or push buttons shall be provided as required.

The crane and crab drives are to be designed as two-corner drives with electric gear motors. 2 (two) motors are to be provided for the crane drives. The crab drives may consist of one motor and universal joint shaft.

All travelling and traversing drives are to incorporate pole-reversible squirrel-cage gear motors with sliding armature and brake.

The lifting gear may consist of standard electric hoists with sliding armature motor and cone brake or disc brake.

The precision speed control shall be provided for all crane and lifting gears.

Speeds for cranes shall be as below:-

- For TG hall crane-
  - Main hoist - 1.6 m/min (creep speed 0.16 m/min thro VFD)
  - Aux hoist - 7.5 m/min (creep speed 0.75 m/min thro VFD)
  - CT - 15 m/min (creep speed 1.5 m/min thro VFD)
  - LT - 30 m/min (creep speed 3.0 m/min thro VFD)
- For other cranes-
  - Main hoist - 3 m/min
  - CT - 10 m/min
  - LT - 10 m/min



#### B0.6.17.10 Hoists

Hoists shall be provided throughout the entire installation where machines or other components provided under this contract are to be installed, removed, repaired, serviced or transported and these parts are not in the working area of a crane (refer also to the individual technical subsections of this specification).

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The final number of hoists to be supplied will be proposed by the Contractor, according to the requirements of the equipment. The Contractor has to include in his offer the number of hoists for the whole Plant. Any necessary change of hoists must not lead to any price change of the contract price.

The hoists used shall be standard production hoists.

The hoists shall be designed and calculated in accordance to applicable standards.

The nominal carrying capacity of the hoists and of their attachment points shall be such that the heaviest object to be lifted can be transported with safety.

For electric hoist, trolley travel speed and hoist speed shall be 15 m/min and 6 m/min respectively.

Manual hoists shall take the form of chain tackle blocks with load and drive chains. The crabs shall be fitted with a drive also operated by a chain. The runways shall be designed according to approved standards.

Electrically driven hoists and crabs shall be equipped with squirrel-cage motors. An inching control shall be provided on all electrically driven hoists and crabs.

The crab power supplies shall be in the form of sheet-steel-enclosed safety power tracks, which can be easily bent to follow the form of the hoist runways.

Electrical switchgear and control gear shall be mounted directly on the hoists in cabinets.

The electric hoists shall be operated by pendant control units fitted with pushbutton or rocker-type switches, which shall be fixed to the hoists in such a way that safe operation is guaranteed.

The control panels shall be equipped also with a key-operated switch and a mushroom-shaped emergency "off" switch.

Limit switches shall be fitted to all lifting and travel gear.

The electrically operated hoists shall be installed in a permanent location.

Where hoists are not easily accessible by simple means such as ladders or mobile scaffolds, maintenance platforms with means of access shall be provided.



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#### B0.6.17.11 Lifts

One (1) lift in each steam generator building for goods transport (minimum capacity 3,000 kg) and one (1) no. conventional passenger elevator in each the steam generator building for personnel transport (minimum capacity 16 persons and minimum 1,100 kg) shall be installed, reaching the highest accessible platform. Outdoor hoisting arrangements shall be included at one side of each boiler house for lifting long items of up to 4,000 kg.

Further Elevators shall be provided in the following building, reaching the highest floor of these buildings:

- 2 x elevators TG building
- 1 x elevator for service building
- 1 x elevator for crusher house
- 1 x elevator for highest transfer point before main plant.

For administration building 2 x nos. of 16 person capacity (minimum 1,100kg), panoramic type elevator shall be provided.

Lift for light material store shall be provided as follows:

- Quantity = 1
- Type = Goods lift
- Capacity = 1,000 kg.
- Speed=0,5 m/s.

The basic requirements for conventional passenger elevators are:

- Capacity: 16 person (minimum 1,100 kg)
- Speed: 1 m/s

The lift installations shall be designed as cable-operated lifts with traction machine. The car shall be provided with automatic telescope sliding doors.

The lifts shall be designed, manufactured, erected and tested according to OSHA (Operational Safety and Health Administration) and applicable standards.

During the construction period, the sides of the cars (without doors) and the floor of the cars shall be provided with protective coverings (hardboard panels or similar). The protective coverings shall be removed by the Contractor after the construction period.

The motors and switchgear must be designed for at least 180 starts/stops per hour. The type of enclosure of the switchboards and motors shall comply with the relevant requirements of Section B0.



## B0.6.18 Electrical equipment and works

### B0.6.18.1 Standards

The design and manufacture of all electrical equipment shall comply with the latest editions of the IEC Recommendations if not specified otherwise elsewhere in the specification. Compliance with ANSI/IEEE/NEMA, BS, EN or VDE standards will only be accepted in case no applicable IEC standards are available and subject to approval by the Employer/Engineer.

The Plant shall comply with:

- the Essential Electrical Requirements of the PPA
- the latest edition of the Electricity Grid Code of the Bangladesh Energy Regulatory Commission; and
- the Great Britain Grid Code.

In case of contradictions the order of precedence shall be as follows:

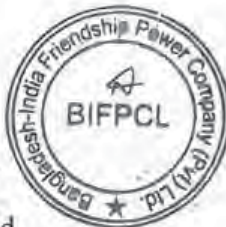
- Essential Electrical Requirements of the PPA;
- Electricity Grid Code of the Bangladesh Energy Regulatory Commission;
- Great Britain Grid Code.

Any other requirements of BPDB/PGCB shall also be considered (if available).

### B0.6.18.2 Voltage levels

The following voltage levels shall apply:

- 400 kV and 230 kV, 50 Hz connection voltage to the public grid
- 18 to 27 kV, 50 Hz generator voltage, depending on manufacturer's standard
- 11 kV  $\pm$  6%, 50 Hz voltage for motors equal to/bigger than 1500 kW and for power distribution within the Plant
- 3.3 kV  $\pm$  6%, 50 Hz voltage for motors equal to/bigger than 160 kW and for power distribution within the Plant
- 240/415 V (+/-) 10%, 50 Hz standard voltage for power supplies to small electric power consumers and motors below 160 kW lighting and domestic power outlets
- 240/415 V (+/-) 10%, 50 Hz voltage for power supply of essential electric power consumers - the system shall be operated with ungrounded neutral
- 220 V DC  $\pm$  10%/-15% voltage for emergency users of electricity, like turbine emergency oil pumps, circuit breaker control, inverters



- 240/415 V  $\pm$  10%, 50 Hz      uninterrupted voltage supplies to consumers, which require uninterrupted infeed like DDCMIS components, control actuators, burner control panels, VDUs.
- 24 V DC  $\pm$  15%      for power supplies to the DDCMIS system components
- 24 V  $\pm$  10%, 50 Hz      for erection work in enclosed plant items of metal

The general arrangement of the particular voltage level for each part of the Plant within the scope of the Contract and the connections of the power supply systems can be seen from the Key Single Line Diagram (Annex E).

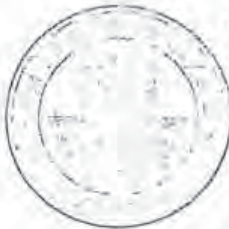
### B0.6.18.3 Insulation levels

- The 400 kV system shall be designed to limit the switching surge overvoltage to 2.3 p.u. and the power frequency over-voltage for the 400 kV system and the 230 kV system to 1.5 p.u. The lightning arrestors associated with the 400 kV reactors shall be of 336 kV.
- Following insulation levels shall be considered:

|   | Description                                          | 400 kV   | 230 kV | Generator * | 11 kV | 3.3 kV |
|---|------------------------------------------------------|----------|--------|-------------|-------|--------|
| 1 | Highest voltage for equipment                        | 420      | 245    | 24 or 36    | 12    | 3.6    |
| 2 | Power frequency withstand voltage                    | 650*/630 | 460    | 50 or 70    | 28    | 10     |
| 3 | Lightning impulse withstand voltage                  | 1425     | 1050   | 145 or 170  | 75    | 40     |
| 4 | Switching impulse withstand voltage (phase to earth) | 1050     | -      | -           | -     | -      |

\* According to manufacturer standard

The creepage distance of the outdoor insulators shall be minimum 31 mm/kV.



- 400 kV level:
  - rated switching impulse withstand voltage 1050 kV (phase-to-earth);
  - rated lightning impulse withstand voltage 1425 kV;
  - \*rated power frequency withstand voltage for GIS 650 kV and for transformers 630 kV.
- 230 kV level:
  - rated short duration power-frequency withstand voltage 460 kV;
  - rated lightning impulse withstand voltage 1050 kV.
- Remark: The insulation coordination study shall be carried out by the Contractor.



#### B0.6.18.4 Installation conditions and protection class for electrical operational equipment and control and monitoring equipment

If not specified otherwise the electrical operational equipment must be designed to meet protection classes stated below.

Switchgear, housings for electrical equipment and electrical equipment itself must be designed according to IEC 60529 at least to:

- Class IP 41 if located indoors in air-conditioned/ventilated areas
- Class IP 42 for ventilated enclosure of DDCMIS equipment if located indoors in air-conditioned/ventilated areas with suitable cannope ontop to prevent ingress of dripping water
- Class IP 22 for non-ventilated enclosure of DDCMIS equipment if located indoors in air-conditioned/ventilated areas with suitable cannope ontop to prevent ingress of dripping water
- Class IP 54 if located indoors
- Class IP 65 for all I&C field devices
- Class IP 55 for motors located outdoors and in indoor areas with high dust and humidity
- Class IP 65 for other outdoor electrical and control system equipment such as cubicles or panels with additional measures) if located outdoors in accordance with IEC 60529 (degrees of protection provided by enclosures (IP Code) or equivalent). The additional measures shall consist of sunshades, protection covers against splashing water, additional sealing, special acid resistive coating etc., depending upon the particular site conditions at the place of installation, subject to the approval of the Employer.
- Class IP 21 if located indoors with open doors.

The lamps for external lightning and internal lighting of not completely closed buildings must have protection class IP 55W. Furthermore for dust prone areas the lamps shall have protection class IP 65.

Electrical operational equipment which must be installed in areas exposed to danger from explosions must have the required explosion-proof design appropriate to the flash-point group classification of the explosive mixture as laid down in IEC 60079. Attention must be paid with respect to the use of electrical operational equipment in workshops and storage premises exposed to the risk of explosions.

In all rooms and areas where the local and operational conditions and surroundings can lead to the accumulation of gases, vapors, mists or dusts which, in combination with air, form explosive mixtures, the operational equipment and installations to be used in these circumstances must be of explosion-proof design. All operational equipment must be designed to comply with the class of protection dictated by the ignitable mixture (e.g. compression-proof casing, external ventilation, inherent safety, etc.).



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Electrical operational equipment should be located indoors in adjoining buildings rather than inside buildings or other structures exposed to the risk of explosion. Whenever operational equipment has to be installed within areas liable to the risk of explosion, protection against explosion must, in general, be applied wherever explosive mixtures can arise. In this connection, the ignition of explosive mixtures must be reliably prevented by adopting the correct choice of design and construction of the operational equipment and the incorporation of supplementary safeguards where applicable.

Electrical, chemical, thermal and mechanical influences must on no account impair, in any way, the protection afforded against explosion. In particular the high ambient temperatures and the influence of nearby heat sources at the installation point must be taken fully into account.

#### B0.6.18.5 Protective measures, earthing and lightning protection

In view of the potential dangers of electrical power, the following measures are required for the protection of life, equipment and materials. Basically, all 'live' parts, i.e. all parts of electrical, operational equipment at an electrical potential above or below earth potential when in operation, and with a rated voltage over 24 V, must be insulated or covered so that they cannot be touched accidentally.

In addition, measures must be taken by the Contractor to prevent the occurrence or persistence of excessively high contact potentials on conductive parts of electrical operational equipment (frames etc.) brought about by faults in insulation.

For installations up to 1000 V, voltages over 50 V are considered to be excessive contact voltages. Within enclosed electrical installations, with voltages over 1000 V, the contact potential shall be according to the values given in EN 50522 (VDE 0101-2) Earthing of power installations exceeding 1 kV: enclosure B.

The following rules and regulations are to be observed in carrying out protective measures and in earthing procedure:

- IEC 60079 and 60364 for installations up to 1000 V,
- EN 50522 (VDE 0101-2) Earthing of power installations exceeding 1 kV:

In areas exposed to the hazard of explosion, the protective measures outlined in IEC 60079 and IEC 61241 are to be adhered to in the erection and installation of electrical plant and equipment.



#### B0.6.18.5.1 Protective measures for installations up to 1000 V

##### **Protection against direct contact**

All 'live' parts of electrical operational equipment that can be reached by hand must be protected against direct contact either by means of insulation or through constructional design, position or arrangement, or by means of special devices. If, in the case of enclosed switchgear or control cabinets, access is required in the course of normal operation (e.g. for replacing fuses), protection against direct contact must still be ensured when the switchgear or control cabinet has been opened up.

##### **Protective insulation**

Protective insulation is to be provided by means of additional insulation over and above the insulation provided for operational purposes. This measure must prevent the occurrence of a dangerous contact potential.

##### **Use of low voltages as a safety measure**

This safeguard applies to all equipment, which is required to operate in metal enclosures, boilers, tanks etc. The operational voltage of tools and lighting equipment must not exceed 24 V AC.

Isolating transformers shall be provided by the Contractor for the purpose of producing the protective low voltage. A separate 24 V system will not be provided.

##### **Connection of the neutral**

The LV network shall be of the TN type, i.e. the LV neutrals of the auxiliary transformers are earthed directly.

Neutralization (protective multiple earthing) is intended to prevent the persistence of an excessively high contact potential on conductive parts of the installation which do not form part of the actual operating circuit.

Protective multiple earthing as a protective measure requires the neutral to be earthed close to the transformer. However, wherever possible the neutral shall be earthed at the main LV board. In this case the connection transformer to LV main board shall be carried out as TN-C type, i.e. three phases plus PEN:

The LV system for symmetrically as well as unsymmetrical connected power consumers shall generally be of the TN-S type, i.e. a five wire system. The separation of N and PE shall be carried out at the main LV board. Because of the clear demarcation between the neutral conductor N, carrying operational current, and the protective earthing conductor PE, which - under non-fault conditions - carries no current, NO connection between either N and PEN or N and PE is permissible beyond the point of separation of the PEN conductor into PE and N.



The LV system for supply of essential consumers (emergency diesel supply) shall be of IT type. All required isolating transformers shall be included in the scope of supply.

The neutral conductor is to be insulated in the same manner as the phase conductors. The use of constructional parts of the switchgear as a neutral conductor is not permitted.

All earthing conductors have to be rated depending on the value of earth-fault current (see EN 50522 (VDE 0101-2) enclosure D). Separate installed earth conductors must be at least 16 mm<sup>2</sup> for copper and 100 mm<sup>2</sup> for galvanized flat-iron.

The earth electrode resistance shall ensure that potential contact will not be higher than 50V (see IEC 60364 - 4 -41).

#### B0.6.18.5.2 Protective measures for installations over 1000 V

##### **Protection against contact**

At least the following measures are to be taken for all parts that are 'live' when in operation:

- Protection outside of closed electrical operating areas:
  - complete protection from all sides against contact, the degree of protection shall be at least IP23D according IEC 62271-202 and IEC 60529
  - protective devices may only be removed by means of tools.
- Protection inside closed electrical operating areas:
  - protection against contact with 'live' parts within reach of personnel,
  - protection against accidental contact outside the reach of personnel.

The above-mentioned measures for protection against contact are also to be applied to 'dead' parts of the Plant where, in the case of a fault, a dangerous contact potential might arise, however, where the parts must not be connected to the protective earthing system for operational reasons.

##### **Protection against contact voltages**

Protective earthing is to be used as a safeguard against excessively high contact potentials for conductive parts of the installation, which do not form part of the operational circuit. Here, all normally 'dead' parts equipment and apparatus shall be earthed if it is possible for them to come into contact with 'live' parts as a result of faults due to the occurrence of surface leakage paths, arcs or direct connections to a 'live' part of the equipment.

In considering the dimensioning of the protective earthing system, the thermal loading and voltages on the earthing equipment are decisive factors and these should be based on the maximum possible earthing current, which can arise.



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### Connection of the neutrals

- 400 kV system: neutrals of the 400 kV windings of the transformers shall be directly grounded
- 230 kV system: neutrals of the 230 kV windings of the transformers shall be directly grounded
- 11 kV system: neutrals of the 11 kV windings of the transformers shall be grounded by means of 400A resistors
- 3.3 kV system: neutrals of the 3.3 kV windings of the transformers shall be grounded by means of 400A resistors.

## B0.6.18.6 Earthing and lightning protection

### B0.6.18.6.1 Earthing and potential equalization system

The earthing system and potential equalization shall comply with the following standards:

- IEC 60364-4-41: Electrical Installation of Buildings – Protection for Safety: Chapter 41: Protection Against Electric Shock
- IEC 60364-5-54: Electrical Installation of Buildings – Part 5-54: Selection and Erection of Electrical Equipment - Earthing Arrangements, Protective Conductors and Protective Bonding Conductors
- EN 50522 (VDE 0101-2): Earthing of power installations exceeding 1 kV
- VDE 0845, Part 1: Protection of Telecommunication Systems Against Lightning, Electrostatic Discharges and Over-voltages from Electric Power Installations; Provisions Against Over-voltages

- IEC 61643: Low-voltage Surge Protective Devices
- For earthing, protective earthing, functional earthing, potential equalization and lightning protection-potential equalization, a common system shall be established.

Within all buildings, internal earthing rings shall be installed. These shall be linked by way of connection tags to the foundation ground and outdoor earthing system.

All system and plant components which are to be earthed as well as electrical components, like protection and control cubicles, sub-distribution boards, control systems, motors and transformers, shall be connected to the earthing rings/bars. All steel structures within a welded Section shall be connected to the main earthing system.

At pipelines for flammable liquids or gases, earthing tags shall be provided at each flange. All bolted flanges shall be bridged using a flexible braided copper conductor. Each pipe shall be connected at least once to the main earthing system.

No framework parts or other structural components shall be used for the ground bus.

An earthing cable shall be included in all main cable runs. Protective earthing and potential equalization of electronics cubicles, frameworks, racks etc. shall be executed as follows:

- Earthing rings shall be installed in the I&C rooms as buses, to be connected at several locations – at least two – to the earthing network.
- For each row of cubicles, at least two connections shall be made to the earthing ring. Cubicles in a row shall all be connected by conductors to each other.
- If cubicles are attached to a raised platform flooring of steel structural parts, it shall be ensured that these are electrically connected to each other throughout the area. The raised floor shall be connected to the earthing ring at several locations, and as a minimum at two corners of the room.

#### Foundation earthing

All buildings, including those with a steel skeleton, shall be equipped with foundation earthing. The foundation earthing shall be installed in addition to reinforcement that is likewise connected together with braided conductors.

The foundation earthing shall be used in connection with the other earthing systems like protective, operational, functional and lightning protection earthing.

In the case of pile foundations, earthing rods of the same length as the piles shall be installed along with the foundation piles at intervals of around 10 m and connected at around every 2 m to the pile reinforcement using braided conductors. The earthing rods shall project beyond the top of the piles and then be connected to the earthing system of the ring foundation.

In addition to the closed ring of the foundation earthing system, a net of mesh size around 10 x 20 m shall be embedded in the bottommost concrete layer. The foundation earthing shall be connected to the reinforcement by a braided conductor at intervals of about 2 m.

At intervals not exceeding 20 m, and with at least two in every room, connection tags from the foundation earthing shall be foreseen for connecting the internal earthing ring. Connection tags shall likewise be foreseen for connection to the external earthing system and to the lightning rods. Optionally, lightning rods can be connected to the external ring



earthing, with connections then made from this ring earthing to the foundation ground by way of the internal earthing ring at intervals not exceeding 20 m.

#### **Earthing material**

- Refer to Part B7.

#### **Screening**

The measures described in the following serve for screening and potential control within (see EN 50522 (VDE 0101-2) Annexes E and F) and for lessening overvoltages.

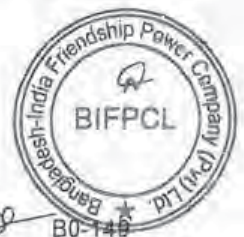
- For reinforced concrete buildings, at each corner of the building including the bottom slab, an additional mesh of rebars, of approximate mesh size 10 x 10 m, shall be provided at the topmost reinforcement. The meshes shall be produced by welding. This additional reinforcement, connected so that it is electrically conducting, may be dispensed with if it is ensured that the existing reinforcement is so connected by welding at appropriate points that it is electrically conducting.
- At intervals corresponding to the mesh-width, earthing wires from the reinforcement shall be incorporated into the building pillars, rising from the foundations to the roof, and so welded that they are continuous. These earthing wires shall terminate at the roof parapet. The meshes and earthing wires shall be welded to each other.
- For steel skeleton buildings, equivalent measures shall be taken. Framework Sections shall be welded to make up a defined, electrically conducting connection or shall be bolted together so that they are electrically conducting.
- Metal façades and coverings shall be preferred over non-conducting materials and at their topmost and bottommost points shall be connected at an adequate frequency to the lightning protection system.
- Reinforcement of cable ducts of reinforced concrete shall be connected to parallel running earthing cables. These earthing cables shall be connected to the screen of the building earthing system or to the foundation earthing system.

#### **B0.6.18.6.2 Lightning protection**

All buildings and structures shall be equipped with a lightning protection system. Lightning protection level I (LPL) according to IEC 62305 shall be considered.

The building lightning protection system is to be executed according to:

- IEC 62305-1
- IEC 62305-3 and
- IEC 62305-4



and alongside protection of human life to prevent damage not only to buildings, but also to electrical and electronic installations.

All buildings and structures are to be protected against lightning strikes by means of lightning collectors and conductors. The collectors are to be arranged in such a way that, as far as possible they collect all lightning strokes without these directly striking the parts to be protected. This condition is considered to have been fulfilled if no point on the roof surface is more than 5 m away from a collector. Collector lines suffice as collectors, e.g. along the ridge and at gables and eaves.

Ridge conductors must be taken right to the end of the ridge. Moreover roof conductors should run as natural continuations of all main conductors. Conductors at the gable extremities or eaves must be laid in the closest possible proximity thereto. In the case of steel-framed structures the ridge conductors must be connected to the roof supporting structure at least every 20 m. Lower level annexes are also to be provided with collectors.

Roof lines and other conductors are to be laid and fixed in such a way that they can withstand the stresses expected from storms, lightning strokes, roof work, etc.

One main conductor between the lightning collectors mounted on the top of the building and the potential grading ring laid in the ground is to be provided every 20 m of the before-mentioned lightning collector. The maximum spacing between conductor fixings may not exceed 1 m for horizontal runs and 1.2 m for vertical runs.

#### **Lightning protection material**

In case of buildings with steel structures and sheet steel cladding, the steel columns and the sheet steel cladding shall be used as lightning conductor. In case of masonry buildings or buildings with concrete structure, external lightning conductors made of copper or stainless steel shall be used. Lightning arrestors (arrestor tips and roof conductors) or Lightning air terminal shall also be made of copper or stainless steel rods. The conductor supports of the lightning protection system must be copper or bronze. Nuts and bolts at isolating or other points which are to remain detachable must be made of copper-nickel-silicon-bronze.

#### **B0.6.18.7 Technical conditions for high voltage motors**

If not specified otherwise all electric motors must be designed to meet IP 54 enclosures.

All motors with rated power (referred to 40° C ambient temp.) of 160 kW and above must be designed as HV motors.



### B0.6.18.7.1 Constructive features

The following constructive features shall apply:

- a. Climatic protection provisions for mounting in the open in a humid and hot climate. Insulation class F. During operation at rated power of the driven machine, the motor insulation must only be stressed in accordance with the requirements of class B insulation.
- b. Motor parts made of iron internally and externally sandblasted and surface-protected.
- c. Paint finish resistant to chemicals and seawater.
- d. Bolts with adequate corrosion protection.
- e. All joint faces and gaps sealed.
- f. Anti-condensation heating to be switched into operation when the motor feed circuit is in the 'off' position. Heater supply power 'on' indicating lamp is to be provided.
- g. Special treatment of windings with resin impregnation plus immersion in varnish.
- h. Varnish-insulated laminations.
- i. Pressboard material protected by varnishing.
- j. For motor ratings the cooling air available at the specific location has to be considered.

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 3000 kW or above can be Closed Air Circuit Water cooled (CACW). CW motors can be screen protected drip proof (SPDP) type.

- k. Condensation outlets to be provided at the lowest point in the housing.

Design and construction of the motors shall comply with IEC 60034-1, 60034-5 or VDE 0530 and DIN 40050.

### B0.6.18.7.2 Electric features

The following electric features shall apply:

- a. Motor rating to be at least 110% of the maximum required electric power consumption of the driven machine.
- b. Continuous delivery of rated power at voltages of 90 - 110% of the rated voltage and allowable frequency range within the limits of thermal class F.
- c. Rated power output at ambient temperatures existing at the particular site of installation and under continuous running conditions.
- d. All motors shall be designed as 3-phase squirrel-cage motors suitable for direct on line starting. It must be possible, with 100% residual voltage, to switch them on to a large and stable power supply network without incurring damage or deformation. The motors must still be capable of



faultless running up to speed with a voltage drop to 80% of rated voltage and rated loading.

However, 75 % starting voltage shall be allowed for motors above 4000 kW. Mill motor being high starting torque motor, is specially designed and shall be suitable to operate at 85% rated voltage for 1 minute only, provided that the mill motor is suitable for starting/running with voltage variations for which aux. power supply system is designed.

- e. Motor starting current must not exceed 5.5 times rated current (referred to motor rating at 45 °C ambient temperature) for motors up to 2 MW and must not exceed 4.5 times rated current (referred to motor rating at 45°C ambient temperature) for motor ratings above 2 MW. The voltage drop at direct-on-line starting should be limited to 20% at the motor terminals except rating above 4000 kW. However starting of any motor shall not cause tripping of any other consumer. However, Bidder/Contractor is free to design his system with starting currents up to 600% maximum.
- f. From the cold state four consecutive starts up to full speed must be possible. The second start must be possible immediately after the first start, the third 20 minutes after the second, the fourth 20 minutes after the third.
- g. A minimum frequency of starting cycles of 1000 per year must be guaranteed.
- h. In general, motors must be capable of running without overheating when subjected to three consecutive starts within one hour after having run for an extended period on a voltage of 95% nominal voltage. Thereby the second start must be possible immediately after the first start and the third 30 minutes after the second start. In individual cases where operation depends on signals from pressure switches or other such sources, then a more severe duty with respect to the frequency of starting cycles per hour shall be necessary and the design of the motors must be carried out accordingly.

#### B0.6.18.7.3 Protective features

The following protective features shall apply:

- a. High voltage motors must be fitted with measuring points for the determination of slot and bearing temperatures.
- b. Six Pt 100 resistance thermometers (2 per phase) are to be provided for slot temperature measurement, and a double thermocouple or resistance thermometer per bearing must be provided for bearing temperature measurement. Type of temperature elements shall be finalized by the manufacturer.
- c. Each Pt 100 shall be connected, potential free, to a terminal strip. The connections to the thermometer as well as the associated over-voltage cutouts shall be brought into separate terminal boxes.



- d. Where motors have closed-cycle cooling, temperature-measuring points must be fitted in the cold air stream.
- e. The winding temperatures have to be detected with RTD's at high temperature and alarm to be produced, at extra high temperature the motor to be tripped.
- f. All motor gaps and joints between it and other units must be sealed.
- g. Earthing clamps at both sides of the stator have to be provided.
- h. All HV motors bearings shall be equipped with vibration sensors for vibration monitoring.

Considering the rating of CHP HT motors vibration monitoring is not required. For Coal Crushers vibration isolation & monitoring shall be provided.

- i. Temperature transmitter to be provided for all temperature measuring devices.

#### B0.6.18.7.4 Other features

##### **Terminal Boxes**

The main terminal boxes on the high voltage side shall be provided with a pressure relief joint for the purpose of reducing the danger of an accident as a result of short-circuits, and shall be fitted with a terminal block suitable for any desired type of connection.

Cable connecting boxes must be longitudinally divided to facilitate fitting of cable sleeves and end caps. Protection class shall be IP 55.

Inside the terminal box an earthing clamp for connection of the cable shield must be foreseen.

The opened terminal boxes must have provision for local earthing to be carried out.

All terminal boxes shall be provided with a removable undrilled gland plate. The gland plates shall be of non-magnetic material if single core cables are to be installed.

##### **Connections, star-point terminal boxes etc.**

All motors must have the star-point connection brought out separately to terminals.

For all motors with a rating of 2000 kW or above a differential relay for winding protection shall be provided and installed in the associated switch-gear. In that case the star-point connection shall be brought out separately to terminals. The differential current transformers are to be designed to class 5 P10 with a rating matched to the protection system. The CT's shall be accommodated in the star-point terminal box.



**Coupling**

The motor shaft halves of the couplings, finish-bored, balanced, and complete with key ways are to be drawn on to the motor shaft and balanced out together with the rotor.

**Cooling**

Air cooling for the motors is the preferred method. Where water-cooling is applied, conditioned and treated, water shall be used.

Motor air exchanger circuits should be suitable for the prevailing atmospheric conditions, i.e. ambient temperature, content of humidity and salt in the air, etc. are to be considered.

**Running quality**

The running quality must be within the classification of "Class C, Zone A" according to the ISO 10816-1 or equivalent, i.e. the vibration velocity must be not greater than 1.8 mm/s (rms).

**Reverse speed**

If reverse running, can occur in the case of equipment driven by a motor (e.g. cooling water pump), the motor must be designed for maximum, possible reverse speed.

A reverse rotation alarm and starting-circuit interlock are to be provided to ensure that the equipment cannot be started while running in reverse.

**Lubrication**

All MV and HV Motors shall preferably be equipped with on-line lube oil purification and auto-grease facility. These systems shall preferably be procured from one single manufacturer.

The above requirements of the specification to be considered only as a preferred solution. However OEM recommendation will be accepted.

**B0.6.18.8 Technical conditions for low voltage motors**

If not specified otherwise all motors must be designed to meet IP 55 enclosure according IEC60034-5.

All motors with rated power (referred to 40 °C ambient temp.) less than 160 kW must be designed as LV motors with premium efficiency class IE3.

The equipments which are only operating for short period shall not be covered under IE3 such as:

- a) Sootblower Motors- operates only during sootblowing sequence
- b) Seal air fan motor for damper sealing operation-operated only during maintenance.



#### B0.6.18.8.1 Constructive features

The same features as for high voltage motors shall apply.

Anti-condensing heating shall be provided for motors of 55 kW and above.

#### B0.6.18.8.2 Electric features

All motors shall be designed as 3-phase squirrel-cage motors suitable for direct on line starting.

The motors must be capable of being switched on to a large and stable network and with phases in opposition.

The electric features a), b) and c) of high voltage motors also apply here.

Motors starting current must not exceed 7.0 times rated current (referred to the motor rating and 45 °C ambient temp).

The Starting current of LV Motor (IE3) shall be inline with IEC 60034-30. Applicable de-rating factor for design temperature of 45 Deg C shall also be applied.

#### B0.6.18.8.3 Protective features

An earthing clamp inside the terminal box has to be provided.

#### B0.6.18.8.4 Other features

##### **Cable leads**

All cable connecting boxes are to be designed to meet the requirements of IP 55 or IP 58 protection class respectively.

The cable connecting boxes are to be installed easily accessible on the motor. The connecting boxes must be capable of being turned by 90° or 180° and of being opened up longitudinally. The connection boxes are to be fitted with a terminal block.

##### **Shafts**

Where not otherwise specified, motors must be fitted with a free shaft end.

##### **Protection against explosion hazards**

Low-voltage motors, which are to be installed in areas exposed to the risk of explosion, must comply with the rules laid down in VDE 0165/0170/0171 for explosion-proof design in relation to the flash-point group classification for the particular explosive mixture.

#### B0.6.18.9 DC motors

The use of DC motors is to be avoided and must be agreed by the Employer. The maximum starting current must not exceed 1.8 of the rated motor current (referred to the motor rating at 45 °C ambient temperature). However any other value of starting current proposed by Bidder/Contractor during basic/detailed engineering shall be subject to Employer's approval

#### B0.6.18.10 . Actuator drives

As far as applicable the above "Technical conditions for low voltage motors" shall apply.

In addition, all actuators for valves, dampers etc are to be fitted with socket and plug of well-established make to IEC 60309 or equivalent for the power cable connection. For the control cable connection separate socket and plug shall be provided.

Self-cooling at respective ambient temperature conditions is mandatory, Fan cooling is not accepted.

Actuators shall have integrated starters. Regulation type shall be continuous modulation type (min. 3000 starts per minutes).

#### B0.6.18.11 Frequency converters

##### **General**

On the basis of the requirements of the driven equipment, the Contractor shall design, supply, install and commission a complete, fully operative, variable-speed converter drive (frequency converter and motor, for motors up to 400 kW, for motors 400 kW and above in addition to the converter a converter transformer shall be provided).

Converters made by reputable manufacturers are to be used.

##### **Technical requirements**

The design of the converter (maximum continuous rating) is to be based on the maximum shaft output required by the equipment assembly.

Maintenance work and cable connections must always be possible from the front of the converter cubicles

The terminals on the input and output sides are to be rated such that parallel cables can be connected.

The converter allows the speed of three-phase asynchronous motors to be adjusted steplessly. It must be fully equipped for remote control and monitoring in the control room.

An on-load disconnecter and a power contactor are to be provided at the power input of the converter.

For motors with a rating up to 400 kW the frequency converter shall be designed in at least a six-pulse circuit on both the line and motor sides.

Frequency converters using Insulated Gate Bipolar Transistors (IGBTs) should preferably be provided on both the line and the motor sides.

For motors with a rating above 400 kW the converter should be designed in a 12 pulse circuit supplied via converter transformer.

The converter is to be disconnected if the voltage drops to less than 80% of the rated voltage or if one or more phases of the line voltages are missed. When the line voltage is restored, the converter is to be connected again automatically, providing the break in the power supply did not last longer preferably than 5 seconds. The Plant check back signals (floating change-over contacts) must continue to be received during this period, while alarms are to be suppressed. It must be possible for the converter to be connected at any coasting-down drive speed and with in-phase voltages. The specified frequency set point is to be resumed automatically.

If the voltage reduction or the power failure lasts for a long time, the drive must remain switched off; in this case, it must subsequently only be possible to switch it on again either manually or by means of the higher order control.

The converters are to be designed for 10% more than the maximum power output required by the system. The purpose of regulating the converter is to ensure that the indirect current and voltage remain within the permissible limits during all control processes. This should apply both when the motor is started up and when the speed is adjusted during operation.

Forced ventilated converters are to be equipped with redundant fans (two double fans).

Flow monitors (not air vanes) are to be used to monitor the fans. Positive control is to be provided for fan drives with a master drive.

#### **Converter transformers**

The transformer shall meet the requirements in the IEC standards 60076-11 and 60146-1-3, shall be of cast-resin type and are to be installed in protective casings made of sheet steel, cooling method AN, thermal insulation class F (utilized according to class B only), type of protection at least IP 21.

The transformer output shall correspond to the power requirement of the frequency converters.



It should be possible to vary the high-voltage side within a range of  $2 \times \pm 2.5\%$ , by means of reversible clamp connectors. The connections on the high-voltage side have to be carried out using cables.

Busbar connections with short-circuit protection are to be provided to the current converters on the low-voltage side.

Suitable earthing studs are to be provided for maintenance purposes (earthing and short-circuiting).

All accessories - especially sensors and terminal connections - must be arranged so that they are readily accessible.

The windings must be flame-retardant and self-extinguishing. The cast-resin mixture must not contain any flame-inhibiting additives which develop toxic vapors or gases either under the influence of secondary fires or in the electric arc. A report on this subject has to be enclosed with the bid.

#### **Moisture-proof design:**

It must not be necessary to dry the winding after shut-off periods. The protection against voltage surges and short circuits, the noise levels and the freedom from partial discharges up to twice the rated voltage must be verified by means of type tests.

The windings are to be protected by means of a temperature monitoring system, comprising the following minimum components:

- 3 PTC resistors (1 for each phase)
- 1 tripping unit with isolated change-over contacts for remote signalling (alarms).

Temperature transmitter to be provided for all temperature measuring devices

#### **Instrumentation and control**

The instrumentation is subdivided into a local Section in the converter cubicle and into a "remote" Section in the control room. All the measures necessary to enable the drive to be remote-controlled and remote-monitored must be implemented, i.e. all the 24 V DC interposing relays which are required to convert the on/off commands from the instrumentation and control system, signal transducers, etc (see also "remote control and remote indications" below).

A suitable automatic compensation facility is to be provided, to ensure that the transfer between LOCAL mode and REMOTE mode is bumpless in both directions. The emergency shutdown function of the equipment must act on the converter directly, regardless of whether 'local' or 'remote' mode is set.



### Local instrumentation and control

The following are to be provided as a minimum in the converter cubicle:

#### Controls

- a) Local/remote converter control (key-operated switch)
- b) "On" and "off" converter controls
- c) Set point adjuster (speed)
- d) Incoming master switch, "on-off"
- e) All the controls necessary for internal converter settings and adjustments, as specified by the manufacturer

#### Indications, signals, monitoring

- a) Line voltage indicator
- b) Output frequency
- c) Output current
- d) Operating status signals, in accordance with the specifications of the instrumentation and control supplier, though at least "Ready", "Drive running" and "Zero and set speed reached"
- e) Motor temperature monitor - alarm Motor temperature monitor - shut-down
- f) Signals concerning internal operating states of the converter, in accordance with the manufacturer's standards, though at least:
  - Overtemperature
  - Line voltage monitoring
  - Line undervoltage
  - Overcurrent
  - Control voltage monitoring
  - Converter protection
  - Fan monitoring
  - Incoming air temperature
  - Motor feeder interruption
  - Motor feeder-short circuit
  - Earth fault
  - Motor blocked
  - Other faults.

#### Remote control and remote indications

Account must be taken of the following types of remote control and indication in the control room, and suitable interposing relays, transducers and switchgears are to be provided in the cubicle:

- a) Converter "on/off" and "local/remote"
- b) Set point adjuster for speed (4 - 20 mA)
- c) Remote indication for speed as 0/4 - 20 mA standard signal
- d) Motor current as 4 - 20 mA standard signal
- e) Combined fault
- f) Remote indication of the set speed potentiometer as a 0/4 - 20 mA standard signal
- g) All Switchgear faults and "Racked-Out" events



h) Other controls and indications

All event signals and check back signals must be made available on the terminal strip as floating change-over contacts.

**System perturbation**

The perturbation caused by the voltage harmonics in the feeding three-phase system, which are a result of the converter drives, must not exceed the specified limit values, i.e. 5% for the 5th harmonic voltage, 4% for the 7th and 2% for each of the 11th and 13th. IEC 60801.1 - 60801.4 are also to be observed in this connection. The system perturbations are to be curbed by means of suitable measures if necessary. The contractor is responsible for demonstrating conformance with the above-mentioned limit values.

**B0.6.18.12 Cable and cable trays**

**B0.6.18.12.1 Cable laying and routing requirements**

The Contractor responsible for cable routing and laying has to observe a strict unit separation. The cables must be routed in different cable channels or, as the minimum requirement, on different cable trays, so that in case of a fire or any accident in a cable channel or tray two units will not be affected. Further in case of two critical drives of the same unit with both drives operating in normal conditions cable for the same shall be routed through two completely redundant routes.

On vertical cable risers, walls and ceilings the cables must be secured with corrosion-resistant cable clips (e.g. cable clamps with cable protecting cable sleeves).

Cable risers near gangways or in electrical rooms that are exposed to possible mechanical damage are to be protected up to 1 meter from ground by suitable metal cover.

All holes in ceilings, floors and wall made for cable routing must be sealed fire-resistant, when the cables have been laid. This also applies to switchgear panels and cubicles, passages between cable ducts, at vertical risers etc. As there is an increased danger of fire during the construction period the holes shall be fire-resistant sealed at that stage already. This applies especially to vertical runs.

When the cables are no longer supported on cable trays or risers etc. the power, DC and instrument transformer cables must generally be run singly in galvanized steel conduit. With lighting cables, measuring and control cables and telephone cables, several similar cables can be run in one conduit. Surface-mounted conduits must be secured every 1.5 m.



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The control and communication cables must be laid sufficiently apart from the power cables so that no interference will occur and the transmission of fault signals is excluded. For this purpose the following minimum separations are to be observed:

- 300 mm between low voltage power cables and measuring and control cables at voltages of 60 V and below,
- 300 mm between power cables and measuring and control cables at voltages above 60 V,
- 600 mm between medium voltage power cables and measuring and control cables at voltages of 60 V and below.

The laying of cables outside of buildings should be preferably on cable bridges that preferably are to be naturally ventilated.

If the cables are laid in the ground, after excavating the trench a layer of sand must be introduced. On the sand the cables are laid separately from each other according to voltage systems. The cables must be laid at a depth of 0.8 m at least. The trench is filled with sand and covered with concrete covers or bricks. The thermal resistance of the backfilling shall not exceed 150 Kcm/W. A ground temperature of 28 °C has to be considered. Where cables have to pass under streets cable duct blocks with a suitable bore(s) should be provided. The marking of cable routes by cable warning tapes must be provided.

When laying the cables on cable trays, cable risers, cable channels, etc. and when choosing the size of the cables care must be taken that sufficient ventilation is available and that there is no possibility of thermal overheating, or strain on the cables.

Cables that must move with connected apparatus owing to thermal expansion (e.g. boilers) must be provided in a flexible form or they must have sufficient slack at the location.

All the ends of the cables must be prepared according to the particular requirements of the manufacturers and connected to existing terminal strips, terminal screws, apparatus terminals, etc.

The necessary cable sealing ends and the stripped and fanned-out cable ends, where no sealing ends are provided, must be fixed to the appropriate supporting structures.

#### B0.6.18.12.2 General cable construction requirements

The medium and low voltage cables shall be of Fire Retardant Low Smoke (FRLS) with XLPE insulation. For cables that are exposed to ambient temperatures above 60°C, teflon or silicone cables are to be provided.

For safety related equipment fire survival cables shall be provided.



The cables must be suitable for laying indoors, in the open (direct or indirect sunlight), in ducts, on trays, in the ground and in water. The cables must be resistant to solar radiation, the effect of oil, seawater, bacterial action, insects and rodents. Outer sheaths are to be manufactured from non-combustible or flame retardant low smoke material.

Manufacturers testing standard related to resistance to solar radiation, effect of oil, seawater, bacterial infection, insects and rodents, will be accepted.

All cables must be provided at both ends, at every 20 m and every bend with identification in the form of numbered labels corresponding to the coding system. The individual cores will be numbered or identified by colour-coding.

The cables must be laid to ensure that they can be replaced or renewed in a simple manner.

#### B0.6.18.12.3 Medium voltage (MV) power cables

The design of the MV cables shall be screened, stranded, single-core or three-core copper conductor cables of FRLS with XLPE insulation. The cable shall be sealed with a red, non-fading PVC outer sheath. Three-core cables shall be designed with individually screened cores.

The MV power cables must be designed for the thermal and short-circuit characteristics of the electrical systems, taking into consideration the following minimum short circuit duration:

- for incoming cables and cables to sub-distribution: fault clearing time of the back-up protection.
- for all other cables: the fault clearing time of the main protection.

The cables must be terminated and connected to the indoor metal-clad switchgear or the sealing ends are installed in cable connection hoods mounted on the power transformers.

In the event of outage of the air-conditioning plants of the switchgear buildings the internal and external conditions will become the same. Therefore, sealing ends are to be used which shall be suitable for the maximum conditions at site.



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#### B0.6.18.12.4 Low voltage (LV) power cables

The low voltage power cables shall be standard single and multi-core cables of FRLS with copper conductor and XLPE insulation.

To ensure the elimination of excessive contact potentials on any object, effective earthing must be carried out as a safety measure and suitable 3-core, 4-core and 5-core low voltage power cables must be provided. The minimum conductor cross-section of the low voltage power cables is 2.5 mm<sup>2</sup>. If 3 1/2-core cables are used, the reduced conductor for protective neutral must have a cross-section of at least 16 mm<sup>2</sup>. In lighting systems (especially discharge lighting circuits) the use of a reduced conductor for the protective neutral is to be avoided.

Depending on the site conditions the DC cables must be single-core, 2-core or 4-core. Between batteries or rectifiers and the DC switchgear single-core power cables should in general be used.

The LV power cables must be designed for the dynamic and thermal characteristics of the electrical system and for continuous operation.

#### B0.6.18.12.5 Current carrying capacity of power cables

The ratings for continuous loading of the cables shall be calculated according to the relevant IEC regulations. The Contractor must submit corresponding tabulations for all cables to be used.

The maximum voltage drop under normal conditions shall not exceed 2.5%.

Voltage drop during starting shall be considered as 15% & during running 3%.

The voltage drop between the MCC and the terminal of the load shall not exceed 2.5%. It is assumed that the switchgear and the MCC are connected by bus-bars/- ducts means the voltage drop is very low.

The voltage drop for MV Cable Shall be limited to 3% and for LV Cables:

- The voltage drop on the LV cables from Main Distribution to subdistribution shall not exceed 2.5%
- The voltage drop up to the LV motor terminals shall not exceed 5% at normal operation and 15% during starting.

#### B0.6.18.12.6 Measuring and control cables above 60 V/ instrument transformer cables

For voltages above 60 V the cables shall be of Fire Retardant Low Smoke (FRLS) with PVC insulation and a mini-mum conductor cross-section of

1.5 mm<sup>2</sup>. If they lead to outlying buildings, cables with a common core screen and protection against induction must generally be used.

For instrument transformer cables inside buildings the minimum conductor cross-section must be 2.5 mm<sup>2</sup>.

Instrument transformer cables leading to outlying buildings must have a minimum size of 4 mm<sup>2</sup> and must generally have a common core screen.

The maximum voltage drop shall not exceed 2%.

#### B0.6.18.12.7 Measuring and control cables below 60 V

For voltages up to 60 V, measuring and control cables shall be of FRLS with PVC insulation and shall have stranded or solid copper conductors of minimum 0.8 mm diameter. Multi-pair control cables with paired lay-up of the leads and lay-up of the pairs themselves shall be used.

Instrumentation cables shall be identified by colour codes and bank marking as per VDE 0815.

Wherever necessary, e.g. for all cables leading outside the relay rooms and/or control rooms, the control cables shall have a common screen (Al-foil or Cu-foil).

Cables must generally have appropriate electrical protection against inductive/resistive influences and lightning.

The required compensating wires for temperature measurements must be at least 0.5 mm<sup>2</sup>.

The maximum voltage drop shall not exceed 2%.

The individual cores of the multi-pair control cables shall be identified by numbers or a colour coding system.

Minimum size of 0.5 sq mm shall be considered for wiring including for control cabinets.

#### B0.6.18.12.8 Fiber optic cables (FOC)

All fiber optic cables as well as their deployment and the entire test procedure shall comply with IEC 60794. The cables shall be able to operate continuously in temperatures up to 70°C. The fiber optic cables shall be loose tube type with the fibers fed into tubes. The tubes shall be sufficiently strong to hold their shape and provide protection for the fibers against deformation and friction. Each fiber shall be colour coded acc. to IEC 60304.



Buried fiber optic cables shall always be laid inside adapted conduits. Installation shall ensure rodent protection and be water tight. The conduits system shall supply all equipment necessary for the deployment acc. to FOC manufacturer's specification. Occupancy shall allow future cable installation.

For out-door applications cables shall be suited for out-door deployment, longitudinally water tight, filling material standardized for all cables, yield minimum 3,000 N.

The fiber optic cables shall be complete with non metallic strain relief elements. Fiber optic cables that are installed outdoors shall be armored. Cables used indoors shall be reinforced with a steel wire braid.

Graded index fibers cables and monomode fiber cables shall comply with IEC 24702:

Graded index fibers cables shall consist of always 24 fibers

- fiber - type 50/125  $\mu\text{m}$ , OM-3.

Monomode fiber cables shall consist of always 24 fibers

- fiber - type 9/125  $\mu\text{m}$ , OS-1.

19" patch panels shall be used for termination, connectors shall be LC-Duplex as standardized by IEC 61076-3-106 var. 4. All fibers shall be terminated / connected.

Each fiber of all FOC shall be deployed and tested according to IEC 60794. Resulting test protocols of all single fibers of all FOC shall be handed over to the Employer, stating all details in written.

#### B0.6.18.12.9 Cable supporting structures

##### Construction requirements

Basically, pre-fabricated cable trays, cable risers, hanger rods, screws, clamps and all fixing material of corrosion-resistant finish, hot-dip galvanized, shall be used. If in certain sections the use of trays and risers is not possible, cable racks are to be provided in such places. These shall be made of corrosion-resistant, steel angle Sections, hot dip galvanized. The steel angles must be cut to size on site and exposed cut surfaces must be suitably treated on the spot to prevent corrosion before being fitted. The minimum requirement for this treatment is the application of an anti-corrosion layer of zinc coating.

All cable tray T-junctions, cross-overs, vertical and other shelving, bends, etc. must consist of pre-fabricated tray elements so that crushing of the cables at these transition points is avoided.

The cables laid on the trays must be carefully arranged and ordered. All cable tray routings consisting of several individual cable trays that are located outside buildings and exposed to the sunlight shall be provided with sun-shades made of the material as described for the cable tray equipment. In all areas where an accumulation of coal dust must be expected, e.g. coal handling plant, conveyor belt ways, bunker area, the cable trays shall be installed vertically.

The trays and risers must be installed in such a way that in accessible manways an escape route at least 800 mm wide by 2100 mm high is available for the personnel.

For safety reasons the lower parts of the hanger rods and all other exposed parts in manways and escape routes must be fitted with plastic covers.

In indoor installations hot dip galvanized material with an average coating thickness according to ASTM A123/123M is to be used.

In all external areas, in semi closed buildings and in areas with corrosive gas or steam, Fibre Reinforced Plastic (FRP) cable trays tested according to international standards shall be provided.

The cable trays must be designed to ensure that there is 5% spare space on all trays when commissioning and handing-over is complete.

The fixing materials for the cable trays and risers must be corrosion-resistant or at least be hot-dip galvanized. The rods, brackets and risers must be fitted with appropriate support brackets to be fixed to anchor rails or fixed by dowels and screws in walls and ceilings.

Welding to steel structures and the welding together of hot-dip galvanized cable-laying accessories is not permitted.

After completion of the cable-laying work the maximum deflection of the cable trays shall not exceed 2.5 mm per 1.5 m (specified distance between two hanger rods).

#### B0.6.18.13 EMC measures

All EMC measures shall ensure that during subsequent operation, no impermissible malfunctions or damage to equipment occurs due to violating electromagnetic compatibility.



The description of the measures is not limited to this chapter, but also forms a part of other chapters, in particular "Protective measures", "Earthing and lightning protection" and "Cabling".

The EMC requirements are set out in the following.

Under consideration of the conditions and constraints, the equipment used shall emit the lowest interference signals and exhibit the highest immunity to interference.

All equipment items shall operate properly when connected to networks with a power supply corresponding to the maximum permissible tolerances as laid down in EN 50160 (as regards, harmonics, voltage fluctuations etc.).

Priority is given to reducing sources of interference.

Additionally, by means of high-capacity screening, generation of overvoltages due to inductive or capacitive coupling shall be reduced. Influencing by electrical and magnetic fields shall be reduced.

Earthing and potential equalization systems designed for low-impedance shall reduce generation of overvoltages due to ohmic coupling. If EMC resulting from the measures named above is still not adequate, further measures shall be taken within buildings, for example by isolation and suppressor circuits.

Thanks to the lightning protection and screening measures taken at the buildings, within them an EMC protection zone is formed.

All installations penetrating this protection zone, that is where they pass through the external walls of buildings, shall be incorporated into a lightning protection-potential equalization system as close as possible to the points of entry and exit of the building. This applies also for conductors carrying a potential. At entry or exit, these shall be included in the lightning protection-potential equalization system by way of suppressor circuits.

Cable runs to outdoor plant components and between buildings may also be screened by appropriate measures, and so form a part of the protection zone. If this is done, the suppressor circuit can be dispensed with.

A suppressor circuit shall be provided at all low-voltage main distribution boards.

Overvoltage protection shall be foreseen within the power supply for both central and distributed power supplies to electronic cubicles.

All conductive parts of the structures and installation within the scope of the contract must be connected to the main earthing system.



All steel Sections or frames must be provided with at least two earthing straps for every frame or Section that is fabricated from parts welded together. The earthing straps shall be located at the ends of the beam Section or frame Section in every case.

The Contractor must provide earthing straps in front of and behind the screwed connection in every case and these straps must be interconnected, using stranded copper, and connected, at least at one point, to the main earthing system, except the Contractor verifies that the type of screwed connection applied is a permanent electrically conducting one. Tanks and vessels containing flammable liquids or gas shall be earthed by a connection to the earthing grid or by bonding to earthed metal structures.

Each pipe shall have a minimum of one connection to the earthing system. In areas where flammable vapor-air mixtures may exist, electrically isolated Sections of metallic piping shall be connected to the earthing grid.

All flange connections in these lines shall be bridged by flexible stranded copper. Earthing tabs shall be provided at each flange.

When connecting differing materials together the required material transition plates must, in general, be inserted. All connecting materials must be corrosion-proof and suitable for the conditions prevailing at the installation point.

Railway lines, together with electrically conducting pipelines leading outside the power station place must be insulated or be fitted with intermediate insulating links or elements.

Each cable tray and cable riser of less than 20 m length have to be earthed once; structures of more than 20 m length have to be earthed twice.

#### B0.6.18.14 Requirements for local cubicles and local housings for e.g. switchgear, control, measurement and signalling equipment

Steel-clad cubicles and enclosures with fixed, integral switchgear and apparatus must be provided.

The switchgear cubicles must be partitioned off and incorporate a busbar system, the necessary instruments, control switches, switch panels of the individual switch and apparatus chambers. The main busbars are to be installed on the rear face, top side of the switchgear cubicle in a lockable shuttered compartment.

Connections to switching devices, MCB's fuses etc. are to be made from these busbars. The lower part of the cubicle will house the terminal strips and connecting blocks, the clamps for the cable terminals and, if required parallel connection copper straps for the connection of more than 2 cables in parallel. An adequate number of ball studs must be provided within the



switchgear cubicle suitable for earthing the main and distribution busbars as well as the switchgear itself by means of portable earthing and short circuiting equipment (to be provided once per switchgear panel row).

The space in the interior of the cubicles must be divided into a Section with 'live' parts, 'live' switching elements etc. and a Section with control and measuring equipment. The Sections are to be separated by reinforced sheet-steel.

Care must be taken that in the event of arcing hot gases will not escape to the front of the cubicles (the operational side).

Ammeters are to be provided on the cubicle front panel for the cubicle feeders and the supply outlets for motors higher than 55 kW or motors of lower rating, but particularly important for the process. A single voltmeter with 4-position voltmeter changeover switch must be provided for measurements of busbar voltage between each phase and neutral. Measuring instruments should, in general, be square in shape.

All cubicles, cabinets, panels, etc. shall be designed for an ambient temperature of 40 °C (outside the enclosure) in non-air conditioned areas. Special precautions shall be taken in the design of electronic devices for protection and control systems housed in the cubicle in order to allow for these conditions.

Heating elements are to be provided generally in each local cubicle or cabinet and shall be humidity controlled.

It must be possible to disconnect power supplies to the cabinets by means of manually operated power circuit-breakers (MCBs).

For easy monitoring and a rapid grasp of the operational state, collared mimic diagrams with the required switch position indicators, apparatus symbols and pilot lamps must be provided in every case on main process cubicles and switchgear cubicles. Lamp test facilities for all signed lamps connected shall be provided. All cubicles shall be provided with the required earthing screws.

Plastic-insulated, stranded conductors must be used for wiring within the switchgear cabinets, which must be numbered at each end with special tabs so that change by mistake is impossible.

Preferably plug-in type auxiliary relays are to be used. Apparatus being sensitive to impact must be protected against shock and vibration.

On completion of hand-over the cubicles must contain at least 5% of fully fitted spare terminal capacity and 5% of spare space for the future installation of extra equipment. It shall be possible to replace indicating lamps on the front panels of cubicle feeders and motor-supply outlets



without isolating the equipment concerned. Furthermore the control system must be designed in such a way that lamps operate at less than their rated voltage in order to avoid their being overheated.

Incoming and outgoing cables have to be fixed by suitable metallic cable glands.

#### B0.6.18.15 Local control points and level control cabinets

##### B0.6.18.15.1 General

Any electrical consumer unit, which is not controlled automatically or from the central control room, is to be fitted with a suitable local control cabinet. The local control cabinets are to be installed in the immediate vicinity of the motor drive to be controlled.

Pump motors, which are level controlled locally, will be given an automatic and manual control. The respective level control cabinets are to be fitted in the immediate vicinity of the pump motors, gauge glasses or level monitoring instruments.

##### B0.6.18.15.2 Construction requirements

In general local control cabinets and level control cabinets with plastic casings resistant to impact, sand, light and water, mounted on walls or hot-dip galvanized supporting constructions, are to be provided. Hot-dip galvanized casings will be acceptable.

Protection class must be at least IP 54 if installed indoors and IP 55W if located outdoors. The necessary earthing terminals must be provided for earthing purposes.

The cabinets must be equipped with the necessary mini circuit breakers, fuses, auxiliary relays, power contactors, terminal blocks and cable attachment components.

For motors with pre-selection control (operation/stand-by) operation hours counters are to be provided.

In hazardous areas, the necessary explosion proof control cabinets and level control equipment must be provided in accordance with IEC 60079, IEC 61241 and VDE 0165/170/171.



### B0.6.18.15.3 Local control points

The local control points are to be equipped as the minimum requirement with:

- ON button
- OFF button
- Running lamp
- FAULT LAMP
- TRIP HEALTHY indication
- Lamp test.

When two motors are installed, serving as operation and stand-by unit, then in addition to a double set of the above items, the following equipment has to be installed as the minimum requirement:

- MOTOR 1 - MOTOR 2 (running motor/stand-by motor) pre-selection switch,
- automatic transfer to the stand-by motor in case of failure of the running motor.

### B0.6.18.15.4 Level controls

In the case of pump motors controlled by levels, in addition to the level control in each case the MANUAL - AUTOMATIC selector switch and the necessary local points are to be fitted. Control of individual pump motors must be effected as follows as the minimum requirement:

- MANUAL- AUTOMATIC selector switch
- level control with maximum and minimum contacts
- low level contact on motor - OFF
- bottom maximum contact on motor - ON
- top maximum contact as warning to the central control room
- low-low level contact as pump dry-running protection and alarm signal to the central control room
- local control point with ON and OFF button, running and fault lamp.

When two pump motors are installed for the same purpose the control is to be effected as follows, as a minimum requirement:

- MANUAL - AUTOMATIC selector switch
- PUMP 1 - PUMP 2 (running pump / stand-by pump) pre-selection switch
- level control with three high level contacts:
  - first (1): high level contact for pre-selected ON
  - second (2): high level contact for alarm signal to the central control room
- low level contacts for pumps OFF
- low-low level contacts as pump dry-running protection and alarm signal to the central control room

- local control and lamps as listed above for local control cabinets, for each motor

#### B0.6.18.16 Terminal boxes and terminal cabinets

In order to minimize the amount of cables and distribution of signals and to centralize connections in the Plant, terminal boxes or, wherever necessary, by larger amounts of terminals, terminal cabinets shall be fitted on all the necessary

- cable crossover terminal points
- central collecting points for individual analog and binary signals and local transmitters
- signal collecting and distribution points for fire alarm, telephone, loudspeaker and clock system
- central distribution points for local signals.

Terminal boxes and cabinets must at least have class of protection IP 54 if installed indoors and IP 55W if installed outdoors and must be equipped with the necessary terminal strips, cable glands and fittings components for the connection of the cables.

The necessary earthing terminals are to be provided for the earthing of the boxes and cabinets.

In any area subject to the danger of explosion, the necessary explosion-protected terminal boxes and cabinets are to be provided in accordance with IEC 60079 and IEC 61241 and VDE 0165/0170/0171.

#### B0.6.19 Instrumentation and control equipment

##### B0.6.19.1 Main design criteria

This Section applies to the design of the general Instrumentation and Control equipment. The following general requirements shall be strictly observed with regard to design and execution. In the event of contradictions the Contractor shall be responsible for obtaining written clarification from the Employer/Engineer.

Reference within this Section does not automatically indicate that the particular form of instrumentation is required on this project or will be acceptable for a particular application. The particular requirements for control and instrumentation shall take preference in the event of any disagreement between the two Sections.

Only requirements for technical performance of the equipment are stated herein, whilst the detailed requirements of the tasks to be performed by the control systems and the scope of delivery for each individual item of plant is stated in the relevant Sections of this specification.

This specification does not however relieve the Contractor of his responsibility for the basic design and execution of the instrumentation and control system per scope of supply in relevant Sections of this specification. The rules of good engineering practice and the relevant approved standards and regulations shall be observed.

A consistent instrumentation and control philosophy shall apply throughout the Plant and shall be implemented in terms of a range of equipment exhibiting a minimum diversity of type and manufacture. The objective shall be to standardize all measurement and control equipment throughout the Plant in order to rationalize operation, maintenance and reduce spares holding.

Generally equipment shall be supplied from one composite range of measurements and control equipment as marketed by a reputable manufacturer of international standing and shall have a minimum of two years operational use on similar projects. Where particular equipment is not included in the products of the manufacturer thus necessitating diversity of supply, this equipment shall be identified by the Contractor. The equipment shall be of modern, compact design incorporating the latest developments in proven technology. All instruments whether for local indication or remote transmission shall be of good quality and shall have an accuracy and repeatability appropriate to their duty. All fittings shall use metric threads.

Measurement and control instruments shall be matched to the main plant equipment ratings in all aspects. Instrument ranges, installation codes of practice and precautionary measures for safety of the Plant and the operating and maintaining personnel shall be observed.

Special attention shall be paid to the Plant safety. As a general rule, measuring points and measuring equipment for critical protection shall be separate from and not combined with measuring equipment for the automatic control equipment.

The material of all equipment installed in pipes, tanks, etc., shall correspond to the material of the relevant pipes, tanks etc. and shall fully meet the requirements regarding safety and operational conditions of the media to be measured. All the equipment shall be suitable for the location in which it is to be mounted and in particular all outdoor equipment shall be suitable for the prevailing climatic conditions.



The diversity of makes and types shall be kept to a minimum. The Employer/Engineer reserves the right to stipulate make and type following award of contract.

Any equipment to be installed within potentially explosives atmospheres shall comply with the requirements of international standards and codes, e.g. IEC-60079, NEC 500 etc.

The instrumentation and control equipment shall have high electro-magnetic and radio frequency interference immunity and shall not be affected by portable radio transmitters operated in the vicinity of the equipment. Any limitations shall be stated.

- All instruments shall be protected by cases. The cases shall have enclosure classification not less than IP 42 according to EN 60529 when mounted indoors in totally enclosed rooms with provision for limited ingress of dust, IP 54 else in a enclosed building and IP 55W for mounting outdoors.

Electronic instruments shall not be located close to hot lines, vessels or other hot equipment. Ambient sun temperatures exceeding 80 °C shall not result in calibration difficulties or rapid deterioration of electronic components.

#### B0.6.19.2 Distributed Digital Control, Monitoring and Information System (DDCMIS)

The Plant will be controlled generally through a DDCMIS. The DDCMIS contains of process stations, operator workstations, engineering workstations, archiving facilities and signal exchange to management and third party systems. In general the DDCMIS will be DCS based hardware only in some exceptions PLC based systems may be applied.

For detailed technical specification and design requirements please refer to **Section B8** of this technical specification.

#### B0.6.19.3 Programmable logic controllers

Programmable logic controllers (PLC) shall be deployed in subsidiary installations and systems of higher complexity and shall provide a more open access for operation. Standard products of PLC manufacturers shall be used for which software developed by the process suppliers and proven for the specialized process is available.

The diversity of makes and types shall be kept to a minimum. The Employer/Engineer reserves the right to stipulate make and type following award of contract.

The use of auxiliary packages with PLCs or local controls for ancillary plants or systems shall be limited and minimized. Only some special cases can be considered subject to the Employer/Engineer's approval. Typical and acceptable reasons for a specialized control system can be high speed of response or special safety requirements, which may require a separate safety-related system.

For signal exchange with the main DCS, PLCs shall be compatible with this system. Depending on the amount of information to be exchanged, parallel or serial interfacing shall be considered. The sequence of events signals should be directly physically connected to Sequence of Events Recording System (SER).

If only few signals are to be exchanged, parallel interfacing is preferred. Binary signals shall be exchanged via volt free signals. Analogue signals (4 - 20 mA) must be suitably decoupled.

If serial interfacing is used, the interface equipment between the PLC and the DCS must be capable of communication using an industrial standard protocol. The transmission baud rate shall be selected dependent on the application (minimum 19200 baud or higher). If commands are issued from the DCS to the PLC, the time between operator command input and PLC signal output shall not be more than 1.5 seconds. The same requirement goes for answer back signals from the PLC and updating of displays of analogue values coming from the PLC on the DCS monitor displays.

As a minimum requirement, the offered serial link shall have a data integrity checking and retransmission facility in case of error detection, independent of the DCS or external system software. Hardware and software failures during data transmission shall be monitored and alarmed onto the DCS.

The communication link shall be redundant. In case of failure in the communication, quick manual automatic switch-over to the standby communication link shall be possible with automatic switchover and fault reporting and diagnostic facilities.

The functions realized in the PLC and the method by which they are invoked shall be represented graphically similar to IEC 61131-3.

Additionally, a verbal program description supported where required for easy understanding of complex functions with functional diagrams according to IEC 60848 shall be provided.

Programming devices with keyboard, VDU and printer for ease of programming, effective on-line monitoring and diagnostic functions, together with the necessary equipment to write in and to erase EPROMs shall be provided.

The Contractor shall guarantee that spare parts for the offered PLC system will be available for at least 15 years after commissioning of the Power

Plant as well as upward/forward compatibility for future upgrades of the system. If necessary, the Contractor shall provide successive system upgrades to ensure spare part compatibility for that time span.

For local operation and monitoring a panel or desk mounted Human Machine Interface (HMI) unit, operable by keypad or touch screen with LED-displays shall be provided. Protection class of panel mounted HMI (front side) shall be IP 22 according to IEC 60529.

#### B0.6.19.4 Control cubicles

DCS, PLC hardware and other associated control equipment shall be installed in suitable control cubicles. The cubicles shall be set up in local switchgear/ electronic rooms (CER or LER) or in local control centers (LCC). The protection class required is specified under **Section B0.6.18**.

Outdoor installed cubicles shall be provided with thermostatically controlled heating elements in order to prevent the formation of condensate which may occur due to large variations of ambient conditions, if necessary. Adequate lighting and sockets for hand tools protected by 30 mA Residual Current Differential Switch (RCDS) shall also be provided for cubicles and panels, if necessary.

The cubicles shall be secured in such a way that failure of one node cannot cause the failure of the whole system.

The required control elements and displays (annunciation and status lights, analogue displays, switches etc.) shall be so configured that as far as possible they can be viewed from the associated secondary system. Should it be necessary to place the control and monitoring elements in the field, these shall be installed in separate, robust housings (protection class IP 55W). All alarms/ annunciations shall as well be available in DCS.

In preference LED displays shall be used. Ease of access and operation of the equipment shall be ensured.

Visual display unit (VDUs) will be employed for field operation and monitoring.

All cubicles shall be adequately ventilated in order that the heat generated by the equipment mounted there shall remain within the specified limits, even in the case of high ambient temperatures that may occur in the event of failure of the air-conditioning system.

Locally installed cubicles shall be suitable for the location in which they are situated and shall provide adequate protection against dust, moisture or mechanical damage for the equipment mounted therein. Cubicles shall be designed in such a way that vibrations of the building shall be absorbed to a large extent. Sunshades shall be provided for all cubicle located outdoors.



Cable connections to cubicles, panels and desks shall be made via suitable seals so as to prevent the ingress of dust, vermin or the propagation of a possible fire. During installation period, a provisional sealing of cable penetrations shall be ensured.

#### B0.6.19.5 Racks, junction boxes

##### **Marshalling racks**

Separate cubicle type marshalling/ termination panels shall be provided, i.e. field signals shall not be terminated in the rear side of the system cabinets.

Open type racks constructed of angle steel may be used for the marshalling and termination of low voltage control cables within the Central Electronics Rooms (CER & LER). Cubicle type marshalling racks may also be considered.

For voltages exceeding 60 V, a suitably separated Section with isolation cover shall be provided.

##### **Instrument racks**

Wherever possible, instruments and devices, e.g. transmitters, thermo element cold junctions, terminal boxes, located in the field, shall be mounted on local instrument racks. The instrument racks shall be installed with due regard to control engineering needs, material-saving assembly and easy accessibility for maintenance and checking work, and shall be constructed of standard angle Section steel.

##### **Junction boxes**

In order to simplify local collection of cables and distribution of signals and to centralize connections in the Plant the junction boxes shall be fitted on all the necessary:

- cable crossover terminal points,
- electrical actuators,
- central collecting points for individual analog and binary signals and local transmitters,
- central distribution points for local signals.

The necessary intermediate terminal boxes must at least have degree of protection IP 55 in accordance with EN 60529 and must be equipped with the necessary terminal strips and attachment components for the connection of the cables. The necessary earthing terminals shall be provided for the earthing of the boxes. In hazardous areas, terminal boxes shall be in accordance with EN 50019 or 50020, depending on zone classification.

After commissioning, the junction boxes, marshalling racks, instrument racks, etc. must contain at least 10% of spare space. The Contractor shall furthermore provide at least 10% of fully fitted spare terminal capacity.



#### B0.6.19.6 Mimic diagrams

Mimic diagrams shall be offered where specified or alternatively where their presence would assist Plant operators in assimilating the operational state of the Plant.

Where used, the mimic diagram shall harmonize with the other equipment in the control room. Mimic diagrams shall be of the mosaic type.

On mimic diagrams for electrical systems, the different voltage levels shall be distinguished by the use of mosaic elements having an inlaid coloured strip. These elements shall be fitted together to show the location of the different busbars. The operational position of circuit breakers and isolators shall be indicated by semaphore indicators, and the operation of switchgear from the mimic diagram shall be by means of discrepancy switches or pushbuttons designed to operate in a similar manner.

On process mimic diagrams, methods shall be used to clearly indicate the path of the various media, the preferred technique being by means of raised plastic strips which shall have a distinctive colour. Also a uniform scheme of colours for different media shall be adopted.

Where pushbuttons are proposed for operation, enabling pushbuttons shall also be provided and it shall require the operation of both the pushbutton actuating the device and the enabling pushbutton to operate the device.

The Contractor shall propose the mimic colour code for process and electric system identification of the P&ID and electric single line mimics in the VDU or mimic panel.

#### B0.6.19.7 Power supply and fusing

The power supply for the equipment requiring uninterrupted supply (UPS) (e.g. emergency valves, flame monitors, measuring and control system, recorders, printers, VDUs, OWS and servers) shall be taken from the safe AC as described in other parts of the specification, especially **Section B0** and **Section B7**.

The 24 V DC independent supply systems shall be provided for the control cubicles of independent control systems. Ni-Cd or lead-acid planté batteries shall be used in the main plant area whereas in offsite plant areas only Ni-Cd batteries shall be used.

The 24 V DC systems shall consist of 2 sets of power supply with each set consisting of 1 x 100% battery charger, 1 x 100% batteries for 1 hour duty and 1 x 100% DC distribution board.

