

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.

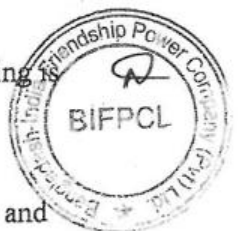
Cooling

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.

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.

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 40 °C ambient temp).

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 40 °C ambient temperature).

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.



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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

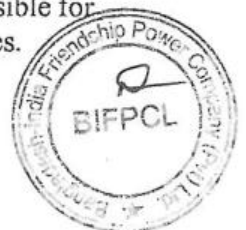
All event signals and check back signals must be made available on the terminal strip as floating change-over contacts.

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.



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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.

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.



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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

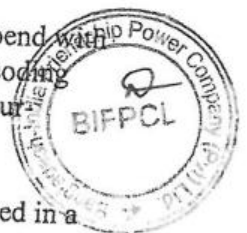
The medium and low voltage cables shall be of Fire Retardant Low Smoke (FRLS) with XLPE insulation. For cables that are exposed to ambient temperatures above 60°C, teflon or silicone cables are to be provided.

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.

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.

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 mm². If 3 1/2-core cables are used, the reduced conductor for protective neutral must have a cross-section of at least 16 mm². 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%.

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 minimum conductor cross-section of 1.5 mm^2 . 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^2 .

Instrument transformer cables leading to outlying buildings must have a minimum size of 4 mm^2 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^2 .

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.



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 μm , OM-3.

Monomode fiber cables shall consist of always 24 fibers

- fiber - type 9/125 μm , 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.

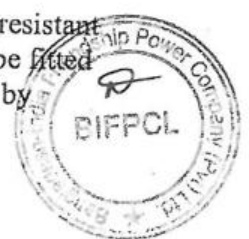
For safety reasons the lower parts of the hanger rods and all other exposed parts in manways and escape routes must be fitted with plastic covers.

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 not complete 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 three 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.

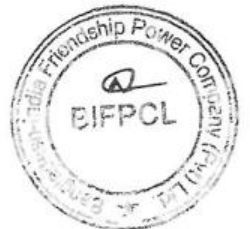
The diversity of makes and types shall be kept to a minimum. The Employer/Engineer reserves the right to stipulate make and type following award of contract.

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

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. control actuators, 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.

Each individual consumer shall be provided with an infeed from each set with diode decoupling at the consumer.

The supply voltages for the control cubicles within the central electronic rooms (CER & LER) shall preferably be 24 V DC and must be arranged as separately fused double infeeds. The individual feeders can serve either a single cubicle or several cubicles combined as a logical group.

Intelligent Battery health management system shall be provided for each set of 24VDC power supply system and UPS batteries (except mini-UPS). It shall be connected to DCS.

All battery systems shall be provided with a manual discharge resistance bank.



All equipment shall be adequately protected against overcurrent by means of fuses or other current protection devices. The main power supply fuses shall be located in functional groups within separate power distribution cubicles. Fuse ratings and time characteristics shall be such that in all cases, a fault within an individual item will cause the fuse associated with that item to rupture and thus disconnect that item from the power supply, before the main fuse is affected.

Failure of a main fuse shall affect the overall operation of the Plant as little as possible and shall be indicated in the central control room (CCR) by means of an alarm. This alarm shall state the identity of the failed main fuse.

Failure of an individual cubicle, module or component fuse shall be indicated by a general alarm and a detailed diagnostic message. The Section of the control cubicle in which the fuse is located shall be indicated. It shall also be possible to locate visually the fuse that has failed.

The design of the electrical power supplies and fusing system must ensure that any faults in modules or other devices, which may block sequence logic interlocks, automatic control systems or other control systems, are restricted to the system in which the fault has occurred.

All electronic devices shall be protected against transient voltage levels which would otherwise damage the device.

B0.6.19.8 Transmitters

All transmitters shall have an impressed output signal of 4 - 20 mA corresponding to zero to full range input. However, digital communication shall also be acceptable.

Generally, 2-wire transmitters shall be used. If for some special purposes (e.g. analyzers) 230 V AC power supply is required, the output circuit shall be isolated.

As far as possible, all transmitters shall be of the SMART-type. This applies also to field mounted temperature transmitters.

All transmitters shall be fitted with a local analog indicator displaying appropriate physical units which may be read clearly from an easily accessible position.

Transmitters with accuracy class "0" or better must be used. The repeatability shall be within a range of $\pm 0.1\%$ of full span.

The output signal of all transmitters must be independent of the burden of the transmitter output circuit including cable resistance over a wide range.



The removal of connected devices must not open the transmitter output circuit or cause malfunction of this circuit. In the case of failure and return of the supply voltage within a measuring circuit, no false signals endangering the system shall be issued. All transmitters shall be individually fused. If not specified otherwise, local parameterization at the transmitter or via modem and PC/laptop or hand held communicator using HART-protocol shall be possible.

For the continuous remote position indication of valves, dampers etc. also transmitters with impressed output signal of 4- 20 mA shall be employed.

All transmitters shall be suitable for field installation and shall have strong, moisture and dustproof cases of IP 65 or better according to EN 60529. This applies also for temperature transmitters when installed in the field.

Diaphragm seals shall be provided to serve as a barrier for corrosive process fluids, slurries or highly viscous oils. The seal shall be of the flanged type, suitable for the same conditions as those for the transmitter. The material selection shall be according to the requirements of the fluids to be measured. The seal shall be provided with a flushing connection.

Transmitters to be used in hazardous areas shall be explosion proof. Suitable intrinsically safe circuits are to be provided in accordance with EN 60079-11.

All transmitters potentially subjected to vacuum shall be capable of withstanding 100% vacuum without damage.

No stress shall be imposed through the connections between Plant and the transmitter. As far as possible, the transmitters shall be grouped together into enclosed racks or panels for easy access. Sunshades shall be provided for all outdoor panels.

Individually installed transmitters shall have their own weather proof enclosure of robust construction and be suitable for the proposed environment. All field equipment terminals shall be wired to a terminal box using screwed connections.

Transmitters shall be provided with all necessary isolating, vent and blow-down valves and facilities shall be provided for the connection of test instruments at the input and output of each transmitter, to enable calibration to be carried out.

In general limits (for alarms or switching actions) shall be derived from the analogue measurement value in the DCS (use of switches shall be avoided). Where binary signals cannot be derived from an analog value, **binary transmitters** e.g. temperature switches, pressure switches etc. may be used. Indicators with integrated limit switches are allowed within package units. Preferably limit switches shall be of the proximity type.

All switches shall be of robust design and reliable performance. Temperature switches, pressure switches, level switches, and etc. shall be of the snap-action and change over type. The switches shall have an adjustable switching hysteresis. Parity checks shall be supplied for switches.

The set point and the deadband (reset point) of each switch shall be adjustable from inside the case, over the full range specified. The set point and reset point shall be indicated on the adjusting mechanism.

For the sensing of level in tanks, vessels or bunkers float switches, vibration level switches or other suitable switching devices with conductive or capacitive electrodes shall be provided.

For monitoring of machine coolant or lubricant flow (dry running protection) suitable flow or level sensors shall be employed.

The switches shall be housed in robust, dust and moisture proof cases having glanded cable entries and shall be suitable for the ambient conditions local to the equipment on which they are mounted.

B0.6.19.9 Temperature measurements

Glass thermometers, bi-metallic and capillary remote thermometers are to be used for local temperature measurement. For both, class 1.0 shall be provided.

Glass thermometers are to be inserted into pockets provided for the purpose. The use of mercury is forbidden.

Capillary remote thermometers shall be with a case diameter of preferably 160 mm and must be mounted on fixtures or instrument panels in such a way that they are protected from vibration, jarring and sprayed water. The capillary tube must be laid in a protected position.

If possible, resistance thermometers (Pt-100) in accordance with IEC 60751 shall be used for remote measurements. All resistance thermometers shall be wired according to the four-conductor principle.

Otherwise, thermocouples with appropriate heat resistance in accordance with DIN IEC 60584-1 or equivalent may be used for remote measurements.

All thermocouples shall be of the quick response type, ungrounded and preferably of double element type.

Thermocouples shall be arranged in such a way that the ambient temperature of the head is lower than 100 °C, and that the measuring inserts can easily be exchanged.

All thermocouples and extension leads shall be terminated with a suitable gland and the conductor to sheath resistance shall be greater than 100 M-Ohms when tested after termination.

Thermometers and thermocouples shall generally be fitted in protective wells. They shall be provided with weatherproof terminal heads and shall be installed so as to totally prevent the ingress of foreign matter.

High speed response pockets shall be provided for all applications involving control of critical process temperatures.

Where more than one temperature measurement e.g. for redundant loops, recording, indication, automatic control is to be made at one location, individual protective wells with sensors shall be provided at the common place of measurement. Protective wells for unoccupied test measuring points shall be arranged with the opening inclined downwards wherever possible and shall be provided with a screw-on protection cover.

Insofar as local conditions or extreme temperature do not require otherwise, screw-in immersion wells for exhaust gas and air shall meet the following requirements:

- nominal length not less than 0.5 m
- attachment of the well in the wall of the exhaust gas channel or air duct must be gas-proof.

For the measurement of temperature of other media the following requirements shall be observed:

For all pipework a minimum immersion depth of 55 mm in the internal pipeline cross-section and a minimum distance of 15 mm from the opposite pipe wall must be provided. If the diameter of the pipeline does not allow the thermometer to be inserted perpendicular to the pipe axis while still maintaining the above mentioned measurements, another solution must be found in cooperation with the Employer/ Engineer. When determining the lengths of the insertion and connecting tubes the insulation thickness is to be taken into consideration.

For all remote temperature measurements (i.e. for RTDs and TCs) transmitters shall be installed locally in a transmitter protecting box on a DIN rail.



B0.6.19.10 Pressure measurements

Pressure gauges of class 1.6 or better must be used. The standard measuring ranges must be selected with regard to the maximum operating pressure.

A pressure instrument installed for measurement of steady pressure at varying pressure shall operate in a band centered on 60% of its maximum range.

When the pressure impulse line is liquid filled the measuring unit shall be compensated for static head. The head correction shall be stated on the unit.

Pressure gauges shall have a dial size of 160 mm and shall be located in such a way that they can be easily observed or shall be combined in groups on local gauge boards or cubicles.

Pressure gauges shall be resistant against vibrations. Furthermore, pressure gauges shall be designed in such a way that the measured value may reach the end of the indicating range without affecting the calibration of the gauge.

Pressures to be remotely indicated, recorded or used for automatic control loop inputs shall be measured by means of pressure transmitters (refer to relevant part of **Section B0**).

Pressure measurement tapping points shall generally be in accordance with the specification for the pipeline in which they are installed and shall be equipped with one, and for high pressure installations (45 bar) two, isolating valves arranged directly at the tapping point. Excluded from this stipulation are measuring points for vacuum and measuring points for combustion air and exhaust gas.

Piping shall be of approved quality and sized for the particular service. In all cases the pipe size shall be chosen to ensure strength and freedom from blockage. Instrument impulse pipework shall be manufactured from a suitable grade of stainless steel to the approval of the Employer/Engineer.

Pressure transmitters for remote measurement shall not be mounted directly at the tapping point, but shall be arranged at a distance from the tapping point by means of enclosures. The impulse line between tapping point and transmitter shall be arranged in such a way as to form a siphon loop, when steam pressure measurements are involved.

A valve combination or multiway cock shall be provided directly on each pressure gauge or transducer connection. They shall be equipped with a connection for test gauges, and it shall be possible to shut off the test connection without isolating the service pressure gauge at the same time.



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Open blowdown / drain connections shall not be arranged within panels and local equipment. Instead it shall be led to a drain external to the panel. All valves shall be installed so that they are accessible for in-situ maintenance from a floor or permanent structure landing.

Transmitters are to be protected from the measuring media, if required.

In addition to the above requirements, special valve block equipment shall be provided, where differential pressure is to be measured. Alternatively, differential pressure type transmitter can be considered.

B0.6.19.11 Flow measurements

Remote flow measurements of water, steam, combustion air, flue gas etc. shall, unless otherwise specified, be carried out by means of differential pressure, ultrasonic, electromagnetic, annubar, coriolis, turbine meters, oval-wheel flow meters.

The transmitters shall be as specified under **Section B0**. Changes in density, pressure or temperature of the measured medium shall be compensated wherever necessary.

Tags on orifice plates shall be stamped with the basic design information (i.e. flow rate, pressure and temperature of the passing fluid, the orifice diameter and the pressure differential generated).

Primary elements such as orifices or nozzles located in steam or high pressure feed water pipes shall be of the weld-in type. Material, dimensions and installation of orifices, nozzles and tapping points etc. shall be in accordance with the specification for the pipes in which they are installed.

Isolating valves shall be provided at the tapping points of the orifices/ nozzles. In the case of steam flow measurements condensing vessels (steam traps) shall be provided between the tapping point and the isolating valve.

The material and dimensions of the piping shall conform to those laid down for the piping concerned. The welds shall be executed in such a manner as to avoid turbulence that can affect the measurement.

In order to achieve exact installation, the vendor supplying the orifice plate or nozzle for high pressure pipes shall install the orifice plate or nozzle in its own works in a Section of pipe of about 3.5 times the pipe diameter (1.0 x NB in the outlet, 2.5 x NB in the inlet). For orifice plates or nozzles installed in pipes with a nominal bore smaller than 80 mm, complete meter runs shall be supplied.



Orifice plates and nozzles shall be manufactured of ANSI 316 Stainless Steel unless specified otherwise. Orifice plates shall be sized according ISO 5167-2.

Orifice plates shall be sized for a d/D ratio not less than 0.20 and not greater than 0.70. Higher rather than lower d/D ratio are preferred to minimize line restrictions. All sizing calculations shall be submitted to the Employer/ Engineer for approval.

Tags on orifice plates shall be stamped with the basic design information (i.e. flow rate, pressure and temperature of the passing fluid, the orifice diameter and the pressure differential generated).

Venturi tubes according to ASME MFC-3M shall only be considered when operating economy requires low permanent pressure losses.

The erection welding seams shall be executed in such a manner that no turbulence, which will affect the measurement, can occur.

Rectangular venturi tubes may be considered where other measuring devices are impossible or impractical (e.g. in large rectangular air duct of boilers).

For flow measurements in LP-systems e.g. water or condensate, orifice plate installation using slip-on orifice flanges shall be provided. All orifice plates for installation between flanges shall have their own tapings for differential pressure measurements incorporated in the plate. Simple orifice plates with the tapings situated in the pipe are not allowed. The flow direction shall be consistently marked on the orifice or nozzle by means of an arrow.

Special conditions may dictate the use of devices such as:

- venturi tubes for low pressure gases
- pitot tubes such as Annubar.



Ultrasonic flow sensors shall provide a double transmitter/ receiver system and be for installation with a calibrated pipe. The tube lining material shall be as required for the fluid and its temperature and be as specified in other chapters of this **Section B0**. The use of ultrasonic clamp on flow meters shall be avoided and requires dedicated approval of the Employer/ Engineer. The accuracy shall be 1% of the calibrated span. An overpressure security shall be provided of 50% above the maximum pressure range.

Electromagnetic measurements may be used for flow measurements of inhomogenous liquids with or without solids content in completely filled pipes. The limits of application of the measuring system due to the medium parameters planned on a case-by-case basis shall be observed. Inductive flow sensors shall be of alternating field or pulsating DC field type and be for inline installation with a pipe.

The tube lining material shall be as required for the fluid and its temperature and be as specified in other chapters of this **Section B0**. The accuracy shall



be 1% of the calibrated span. An overpressure security shall be provided of 50% above the maximum pressure range.

Coriolis measurements shall be used for mass flow measurements of homogenous liquids and gases without solids content in completely filled pipes, in particular for natural gases, fuel oils and solvents as well as other media with fluctuating densities. The accuracy shall be typically at 0.5% of the measured value.

B0.6.19.12 Level measurements

Where detection of discrete levels is required, the simple float operated switch should be used, however each switch shall have snap action with limited hysteresis to prevent contact bounce caused by small fluctuations in level. For sumps the level should be measured using non-contactive measuring principles such as ultra sonic with local control box.

Switches used for level detection shall provide facilities for testing the mechanical and electrical operation of the switch without its removal from the process. Isolation by means of shut-off valve will be allowable during testing.

Generally, the use of switches shall be avoided. Instead limit values shall be derived from analog transmitters.

For measurement of large storage tanks, the load indication and transmitting mechanism shall be located at the base of the tank.

For the measurements of boiler separator water level, feed water tank levels etc., differential pressure transmitters shall preferably be used.

The transmitters shall be as specified under **Section B0**.

For special applications such as chemical tanks, techniques such as ultrasonic, radar, capacitance probes, etc. should be considered. For level measurement in tanks with underpressure (vacuum) guided wave radar shall be used.

For level measurement of the fabric filter (FF) hopper dust radio frequency (RF) / Capacitance type level switch can be considered.

For measurements where a reference leg of process fluid is used, the design of the system shall ensure that the reference leg is fully maintained at its prescribed height during all conditions of process level change and changes in process conditions and the density of the reference leg does not vary from that of the process fluid due to temperature changes or other reasons.

All measurement transmitters for differential pressure shall be provided with:



- shut-off valves to be arranged directly at the condensing vessels and active pressure tapping points
- valve blocks enabling the transmitter to be isolated from the active pressure and enabling the transmitter zero point to be checked
- separate blow-off valves for cleaning the active pressure tubes.
- 2 ways for relative pressure, 5 ways for DP.

The aforementioned valves shall be of the weld-in type.

Where a standpipe exists, the level transmitters or level switches must be connected to the standpipe by means of shut-off valves, so that the units can be replaced easily in service.

Local level indicators for water shall be provided with an illumination device and indicators shall be designed so that the water column can be seen as whole, i.e. level indicators only showing the level as a point will not be accepted. Level indicators shall be equipped with shut-off valves which permit exchange or replacement of glasses or mica during operation.

The indicating range of local level indicators shall cover all switching points of level switches mounted on the tank or similar as a minimum requirement.

On all forms of measurement all parts of the switch, transmitter, etc. in contact with the process fluid shall be made of material compatible with the process fluid. Stainless steel shall normally be used for all corrosive duties.

B0.6.19.13 Analysers and monitoring systems

B0.6.19.13.1 Analyses of steam and water (SWAS)

The steam and water analyzer core instruments shall comply with EPRI (Electric Power Research Centre Inc.) guidelines.

The main analyzers for steam and water shall be arranged in groups in such a way that excessively long process pipes will not be necessary.

If required by the medium to be analyzed, all samples shall be adequately cooled and pressure reducing devices shall be provided where necessary. Manual sampling shall be possible.

A protective device shall be incorporated in the sample cooler to isolate the analyzer in the event of excessive temperature.

In order to eliminate the influence of conditioning agents on the conductivity measurement, cation filters shall be provided. The cation filters shall have visible colour indicators to show when they have to be regenerated.



For all analyzers temperature compensation shall be provided, with the temperature sensor being an integral part of the probe.

Chlorine residual monitors and hypochlorite concentration meters shall preferably be able to measure high and low concentrations. Measurement of hypochlorite concentration shall not be affected by the presence of other oxidizing components in the sample.

Individual or multiple prefabricated analyzer installations shall be used to reduce site installation work. This prefabrication shall include sample conditioners, analyzers, air and electrical distribution, cooling water distribution or coolant circulating system all piped and wired on a common frame. Interconnecting pipework and accessories shall be of stainless steel. The arrangement shall permit testing of the entire assembly before dispatch to site and shall be arranged for convenient removal from on-line operation to facilitate routine maintenance and calibration.

The sampling system shall include but not be limited to all probes, valves, filters, coolers, drainage facilities, flow regulators, flow meters, piping and pumps as necessary, to give the analyzer a representative and suitably conditioned sample.

Analyzers shall be provided as follows:

Sample Point

Condenser make up water
Condensate pump discharge water
Condensate at deaerator inlet water
Deaerator effluent water
Economizer inlet water
Boiler blow down steam
Saturated steam
Main steam
HP5 heater drain water
Closed cooling water

Analyzing Required

specific Conductivity
pH, cation Conductivity, DO
pH, specific Conductivity
pH, DO
pH, cation Conductivity, DO
pH, specific Conductivity
cation Conductivity, SiO₂, Na
cation Conductivity
pH, specific Conductivity
pH, specific Conductivity

Note:

DO: Dissolved Oxygen

Chemical reagent for the sampling system commissioning period but not exceeding 180 days shall be provided.



Each automatic analysis sampling point shall be provided with a manual sampling point to permit a sample to be easily taken. Manual sampling shall not interrupt automatic sampling. All sampling lines shall be run to common sampling racks on which shall be fitted all the analysis associated equipment.

The sampled points of analyzers shall be indicated and monitored at the local panel.

The corresponding analogue measuring signals (4-20 mA) and the status signals (24V DC) shall be transmitted over serial link to the DCS.

The SWAS system, for both Units should be located at ± 0.0 meters in an air conditioned room.

B0.6.19.13.2 Effluent Monitoring

The operational philosophy of water supply/ distribution system shall be based on a continuous Possur river water quality analysis, potable water quality monitoring, sampling and analyzing concept and shall consider preventive and active measures against water pollution and adaption of operating mode(s) to changes in water conditions.

Sample Extraction for Laboratory Analyses:

A tapping shaft for extraction of samples for laboratory analyses shall be provided and installed at the various measuring locations, before the waste waters are mixed with the circulating cooling water and discharged to the sea.

Continuous Effluent Monitoring:

A continuous monitoring shall also be implemented for water quality measurements of all kinds of discharges to the river.

The sensors for continuous monitoring of effluent parameters shall be located within the sample-tapping shaft. Additionally flow and temperature sensors shall be mounted within the discharge lines.

Following kind of analyzers shall be considered at least:

- pH analyzer
- conductivity analyzer
- chemical oxygen demand (COD) analyzer
- biological oxygen demand (BOD) analyzer
- total suspended solid (TSS) analyzer
- oil in water (OIW) analyzer



The corresponding electronic equipment shall be mounted in a weatherproof container to be located nearby the point of measurement at the discharge pipes of waste water.

The corresponding analogue measuring signals (4-20 mA) and the status signals (24V DC) shall be transmitted by multicore cables to the DCS.

B0.6.19.13.3 Potable water quality monitoring system

Water quality control and monitoring of the Plant's drinking water shall be performed at the Plant interface (downstream the potable water tanks).

The water quality monitoring system shall at least consist of, but not be limited to the following online metering, measurement, sampling and analyzing equipment, including data acquisition and data storage facilities:

- alkalinity
- conductivity metering
- pH monitoring
- temperature measurement
- turbidity monitoring
- residual chlorine monitoring
- TDS (computed value)
- LSI (computed value)
- sampling points and equipment for potable water sampling at the online measuring units.

B0.6.19.13.4 Quality monitoring for fuel

For fuel oil a sampling point for discontinuous manual analysis shall be provided for the facility at the fuel oil storage tanks.

B0.6.19.13.5 Analysis of exhaust gas (CEMS)

The analysis of O₂, CO, CO₂, NO_x, SO₂, particulate matter (opacity) in the exhaust gas shall be performed by appropriate analyzers of proven type.

The equipment shall be constructed for operation in dusty and humid environments at high ambient and exhaust gas temperatures. The use of equipment capable of multi-parameter measurement shall be considered.

The reliability and response time of the O₂-analyzer shall be of the quality required for closed-loop control. The accuracy of the system shall be better than 2.0% of the span and the drift shall be not more than 0.1% O₂ per week. A zirconium oxide measuring cell shall be used. Maintenance shall not be more than once a week.

Analyzers provided shall have auto-calibration for zero and span as well as self-diagnostic functions. Analyzers and sensors can be of extraction or insitu type.

All equipment of the continuous emission monitoring system (CEMS) shall be suitable for operation in dusty and humid environments at high ambient and flue gas temperatures. Continuous Emission Monitoring System (CEMS) shall be provided for each unit.

If sampling of exhaust gas is used, sampling probes shall preferably be vertically installed on the top of horizontal exhaust gas ducts, in order to avoid blockages.

In order to keep the sampling lays to acceptable limits the analyzers shall be located close to their sample take-off point, so that easy access to the sample take-off point and to the analyzers shall be provided for maintenance.

The exhaust gas sampling lines shall be heated to prevent condensation and shall not form a siphon in the case where condensate may be collected during heater failure. Condensate drainage facilities shall be provided at the analyzers.

Generally, the analyzers and the sampling probe equipment shall be suitable for mounting in ambient plant conditions, e.g. within a standard cubicle. However, if this is not feasible, the equipment shall be mounted in an air-conditioned room or container.

Power failure and system failures of analyzers shall be monitored in the DCS by a group alarm.

Measured values and certain status signals shall be processed by an emission evaluation computer via serial interface, to be installed within the central control room. The emission data shall be calculated, converted, printed out and stored according to the governmental requirements. Possibilities for on-line data readout for authorities shall be provided.

B0.6.19.13.6 Ambient air quality monitoring system (AAQMS)

An ambient air quality monitoring system shall be provided consisting AAQMS stations and metrological stations. A centralized data acquisition PC shall be installed to collect all information from the AAQMS. The AAQMS stations shall be suitably distributed on the Plant area.

The AAQMS stations shall contain at least the following:

- Analyzers for SO_x, NO_x, CO, O₃, mercury
- Multi gas calibration system
- PC based data logger



- UPS
- Suspended particulate monitors (TSP)
- Sampling inlet heads

Metrological station shall include at least:

- Metrological sensors such as wind speed, wind direction, air temperature, relative humidity (rH), solar radiation, rain gauge
- Metrological mast

All ambient gas analyzers and dust monitors shall conform to the US EPA reference of equivalent method. A proof of approvals and certificates of the compliance of internationally reputed agencies such as US EPA, German TUV, etc shall be provided.

A sampling system compatible with the analyzers shall be provided. The system shall be compatible with analyzers for Pb (which the Employer may procure in the future). The system shall have the facility for moisture removal.

Built-in calibration facilities shall be provided for all analyzers. To cross check the built-in calibration facilities of the analyzers/ monitors, a standard multi-gas calibration system for each AAQMS station with fast response time shall be provided.

The metrological sensors for wind speed and wind direction shall have an accuracy of 2% of full scale. The accuracy of the relative humidity sensor shall be 3% for the range between 10 and 90% rH.

The rain gauge shall be of self recording type and of reputed make. Electronic recording facilities shall be provided. The instrument shall have automatic functions for computing rainfall for pre-set time periods. The gauge shall be rugged and be of material resistant to atmospheric corrosion. The accuracy shall be 1% for rainfall ranges above 125 mm/hr and 5% below this value.

A metrological mast shall be provided for mounting of the metrological sensors. It shall be complete with all necessary hangers and holders along with electrical earthing for the installation of the sensors. Material and construction of the mast shall be robust and shall be resistant to atmospheric corrosion.

There shall be PC based data loggers for each AAQMS station. The entire data capture and mean value calculation as well as control of analyzers shall be through user friendly software and operate on the latest Windows operating system. Diagnostic features shall be included in the software and any unauthorized access shall be prevented by appropriate measures such as password protection.



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