حديد الإمارات
emirates steel
a SENAAT company إحدى شركات صناعات

Integrated Management System

Engineering Standards

Electrical Equipment Engineering Standards

PRD-EE-GS-001

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1. PURPOSE

The purpose of the ES Engineering Standards is to provide information and guidelines for the design, erection, installation and commissioning of plant and equipment across ES Sites.

2. SCOPE

The standards referenced in this document are issued to all contractors and form an integral part of the contract documentation.

Compliance is mandatory by all Contractors, ES Departments and personnel, whilst designing, erecting, installing and commissioning plant and equipment within ES sites, and any deviations require the explicit written approval of ES.

3. DEFINITIONS / ABBREVIATIONS

ES - Emirates Steel

MOC - Management of Change

4. RESPONSIBILITIES

VP of Marketing & Strategy - Is responsible for approving the Standards, and delegating members of his department to review them on a periodical basis, and / or write new standards when deemed necessary.

Projects Construction Manager - Is responsible for ensuring that all projects undertaken within ES comply with these standards.

Engineering Manager Projects - Is responsible for revising the Standards as requested by the projects and operations departments.

5. DESCRIPTION

5.1 General Requirements

5.1.1 INTRODUCTION

The electrical equipment and installations in the United Arab Emirates shall comply with the requirements of this section of "Site Conditions, Site Regulations and Engineering Standards".

5.1.2 CLIMATIC AND ENVIRONMENTAL CONDITIONS

The climatic conditions are described in more detail in Section 2 of "Site Conditions, Site Regulations and Engineering Standards". The design criteria for electrical equipment shall be based on following external climatic conditions:

- Max. air temperature in shade: 50°C

- Min. air temperature in shade: 3°C
- Relative humidity: between 20% and 100%

Enclosures shall be resistant to the saline atmosphere close to the coast.

The C shall allow within the design and installation for the high ambient temperatures inside the Plant e.g. in higher levels of Steel Melt Shop can exceed 80°C and in the Rolling Mill over cooling beds can reach 110°C.

Switchgear, semi-conductor converter equipment and control gear shall be generally installed in air-conditioned substations, electrical and control rooms. Transformers shall preferably be oil filled and installed in outdoor pens provided with suitable sun shelters where necessary.

Where electrical equipment is installed within production areas but not in environmentally controlled areas, it shall be protected against the ingress of harmful levels of dust.

Oil-filled transformers mounted within buildings will only be accepted on the condition that stringent precautions are taken to limit, by automatic detection and extinguishing the propagation of fire. Interceptors shall be installed to ensure that any spilled or leaking oil cannot reach watercourses.

All field equipment and devices, which are not installed inside enclosed, air-conditioned rooms (e.g. electric motors, control boxes and limit switches) shall be designed and manufactured to suit the harsh environmental conditions of steelworks (e.g. high ambient temperature, fine abrasive and conductive dust, moisture, vibration, etc.).

5.1.3 STANDARDS

Electrical engineering, equipment and installation shall comply with relevant IEC, DIN/VDE, CEE, ANSI and IEEE standards.

5.1.4 SYSTEM STUDY

The Contractor shall carry out a system study for the power supply and distribution network of the new Plant and for parts influenced by the new Plant including the following:

- Power compensation study including calculations for reactive power compensation, level of individual harmonics, THD, flicker level, Power factor, Voltage Unbalance and voltage

fluctuations. The power quality levels shall be agreed with electrical authority (TRANSCO).and to comply with the latest valid issue of IEC 61000.

- Load flow studies for HV/MV distribution systems and LV load center's for all possible switching combinations.
- Protection coordination studies for selected operational conditions indicating any types of protection, relay characteristics, conditions required for the correct operation of the different protection measures taken, relay settings, etc.
- Calculation of short circuit and earth fault currents (including peak make) in different switching modes of the network.

5.1.5 DEVIATIONS

Any deviations from this engineering specification require written approval of Emirates Steel.

5.2 Grounding & Protection Systems

5.2.1 FIELD OF APPLICATION

This sub-section covers the general requirements for grounding and lightning protection installations for electrical systems, plant, equipment and buildings.

All metallic and conductive plant, structures and equipment, including structural steelwork, exposed reinforcing, bases, embedded steelwork, guards, handrails, crane and locomotive rails, fencing, supports and services shall be adequately grounded to prevent buildup of static electricity and to ensure safety in the event of electrical faults and lightning.

One or more separate earth electrodes shall be installed for the single point grounding of control and instrumentation equipment. Each electrode shall be connected to the general grounding installation at a single point only.

Grounding shall be used where required to suppress electromagnetic interference and transients caused by switching of power and electronic devices, electrical faults and lightning.

5.2.2 STANDARDS AND SPECIFICATIONS

The grounding shall be designed and installed in compliance with recognised national and international standards, including as a minimum:

- IEEE Std 142; Grounding of Industrial and Commercial Power Systems

- IEC 62305; Protection against lightning

5.2.3 LOW VOLTAGE EQUIPMENT

The star point of distribution systems shall be connected to earth via a bolted link at the primary distribution board.

Where a neutral conductor is provided for single phase supplies, it shall be insulated and run segregated from the circuit protective conductor and no further connections shall be made between the two.

The outer sheath of the grounding conductor shall be coloured green/yellow.
All switch cubicles, control cubicles, thyristor cubicles, regulation cubicles, control pulpits, control and signal boards where the operating voltage is 50V and above, shall be fitted with an earth bar or terminal to which incoming and outgoing protective conductors shall be connected. Where required, a separate instrument earth terminal, insulated from the cubicle earth, shall be provided.

Within an electrical substation, all non-current carrying metal parts such as metal enclosures and framework of individual cubicles, cubicle groups and equipment such as transformers, chokes, etc. shall be equipotential bonded to each other and to a wall mounted copper earth bar. The earth bar shall be connected to the incoming earth or local electrode by bolted links.

All earth connections shall be of sufficient strength and section to withstand short-circuits with damage or excessive heating.

5.2.4 MEDIUM VOLTAGE EQUIPMENT

Medium voltage substations (above 1000V) shall each have at least one buried earth electrode and an earth bar to which the electrode and all other necessary earth connections shall be made.

All earth connections shall be of sufficient strength and section to withstand short-circuits without damage or excessive heating.

5.2.5 PROTECTION AGAINST LIGHTNING

Protection against lightning in accordance with VDE 0185 regulations shall be implemented for equipment and building.

5.2.6 EQUIPOTENTIAL BALANCING

Equalizing of potential differences shall be achieved by connecting conductive parts within construction areas, e.g. columns, containers, pipelines with one another and with the protective conductor.

In transformer rooms, relay rooms and distribution rooms, potential balancing bars shall be provided (earthing bars with disconnecting links). To such balancing bars, all metal parts which under normal operational conditions are not connected to any voltage source shall be connected.

5.2.7 DESIGN OF GROUNDING EQUIPMENT

1. The total grounding resistance of the grounding system measured at any point on the system shall be <2 Ohm.
2. The design for grounding connections as well as the choice of materials shall be in accordance with normal international practice and shall take due account of the aggressive soil conditions at site. Generally, copper conductors shall be used for grounding systems.
3. All below ground earth connections shall be by exothermic weld.
4. A grounding ring shall be laid around every building. All grounding rings shall be connected to build a common grounding system. The building grounding ring can be implemented as foundation grounding with in concrete embedded galvanized flat steel with a minimum cross section of 100 mm^2. For such grounding systems the DIN-Standard 18014 shall be followed.
5. The neutral point of each low voltage transformer shall be connected to ground and to the neutral conductor busbar of the low-voltage switchgear. Transformer tanks shall also be connected to the grounding system of the substation.
6. Earth bars of HV, MV and LV switchgear shall be connected by at least at two points above ground to the grounding system. Both such grounding conductors shall be laid by separate routes in opposite directions if possible.
7. Metal fences and screens shall normally be connected to the common grounding system, subject to checking that possible step or touch voltage rises under short circuit conditions will be safe and present no danger to personnel. Where this is not so then a separate grounding system shall be provided for metal fences and screens.
8. Railway and crane tracks shall be connected to the common grounding system.
9. Multiple grounding connections shall be carried out above ground at grounding bar link positions.

10. All cable racks, tray, trunking and conduit shall be fitted with bolted links where necessary to ensure electrical continuity along cable containments and between adjacent containments.

5.3 High Voltage Switchgear

Under Electrical Authorities - Transco - specification for operation and maintenance

5.4 Medium Voltage Switchgear

5.6.1 GENERAL

1. FIELD OF APPLICATION

This section describes the design and functional requirements of medium-voltage switchgear for operating voltages above up to 33 kV at a frequency of 50 Hz.

2. STANDARDS AND SPECIFICATIONS

The following specifications, regulations and standards shall apply:

- IEC 62271 series; High-voltage switchgear and control gear

5.6.2 DESIGN

1. OPERATING CONDITIONS

Switchgear shall be installed in enclosed air-conditioned substations unless otherwise stated.

2. ELECTRICAL DATA

The main electrical data of each type of switchgear such as: -

- operating voltage
- frequency
- rated current of busbars
- short circuit current capacity
- peak withstand current

shall be unambiguously stated both in the single line diagrams and the data sheets. Minimum performance characteristics: -

a. 33 kV Distribution System

Switchgear type Gas insulated (GIS) or metal clad

- single busbar

Rated voltage 33 kV

Rated power frequency withstand - 70 kV voltage

Rated lightning impulse withstand - minimum 170 kV voltage

Rated short circuit capacity - 25 kA rms

Rated busbar current - to suit requirements

Rated incoming & coupling feeders - to suit requirements

Rated outgoing feeders - to suit requirements
Circuit-breakers type - SF6/ Vacuum to suit the requirement
Current and Voltage transformers - Cast resin
Ambient temperature - 40°C
Protection class - IP3X

b. 11 kV Distribution System

Rated voltage 11kV

Rated lightning impulse withstand - 75 kV

Rated short time withstand - 31.5 kA

Rated busbar current - to suit requirements

Rated incoming & coupling feeders - to suit requirements

Rated outgoing feeders - to suit requirements

Circuit-breakers - SF6 to suit requirements

Current and Voltage transformers - Cast resin

Ambient temperature 40°C

Protection class - IP3X

c. Motor Control Systems up to 11 kV

Rated power frequency withstand - Voltage dependent Rated lightning impulse withstand - Voltage dependent
Rated busbar current - to suit requirements
Rated busbar short circuit capacity - to suit requirements Rated incoming & coupling feeders - to suit requirements
Rated outgoing feeders - to suit requirements
Circuit-breakers - VCBs for incomers, feeders and large motor starters
Contactors - SF6/Vacuum contactors to suit the requirement
Ambient temperature - 40°C
Protection class - IP3X

3. SWITCHGEAR ASSEMBLIES

All switchgear shall be delivered as prefabricated equipment in vermin proof enclosures and in compartmentalized form.

a. CONSTRUCTION

GIS switchgear shall be installed for intake switchboards where power supply arrangements are unlikely to change during the life of the plant. The equipment should comprise as a minimum two incoming circuit breakers and a bus section circuit breaker in addition to the required number of feeders.

Apart from GIS switchgear, each switch panel shall consist of a stationary steel sheet enclosed cubicle with separate, isolated metal enclosed compartments for: -

- Busbars
- Circuit breaker
- Cable termination area
- Isolating and earthing switches
- Controls, protection and indication (relay compartment)

Circuit breakers will be fixed in their housing unless there are evident operational advantages in installing withdrawable switchgear.

The effects of arcing in any of these areas shall be confined to the place of origin and shall not lead to failures in any of the other compartments.

Each individual area shall be equipped with a pressure relief device, which under short-circuit or other disturbance conditions, equalizes excess pressure without danger to operating personnel or to equipment.

Motor Control Circuits shall be equipped with MCCBs/HRC fuses and vacuum contactors on a withdrawable trolley. A maximum of two motor starter units may be installed in one panel above each other. For each five installed motor starter units, a minimum of one spare trolley shall be provided.

Facilities shall be provided for padlocking circuit breakers and contactors in the off position. For safety reasons, access to all live and potentially live parts shall be prevented by lockable doors, bolted covers or other form of protective barriers.
Cable connection and busbar areas, whether installed separately or wall-mounted shall be easily accessible.

Measuring and control wiring shall be separated by internal compartmentalization from the high voltage area. Control cables shall enter the switchgear from the same direction as the power cables.

b. BUSBAR ENCLOSURE COMPARTMENT

The busbar enclosure compartment shall contain only busbars and their conductors.

c. CABLE CONNECTION COMPARTMENTS

The cable connection area shall be designed and constructed in such a way that when situated next to built-in equipment such as current transformers, voltage transformers and grounding equipment, there shall be sufficient and readily accessible space and access for the erection, installation and connection of cable terminations.

Suitable cable clamping and holding devices shall be provided and installed for the attachment and support of cables and cable terminations. A termination point for protective earthing shall be included.

Silicone rubber-push-on sealing ends or cold shrink silicone rubber termination kits shall be used for XLPE-cables.

d. SWITCHGEAR TRUCK (where applicable)

Between the circuit breaker enclosure and the busbar or cable connection area, there shall only be openings for the plug-in contacts of the circuit breaker. When the switchgear truck is disconnected, isolated and drawn-out, then safety shutters shall automatically cover the stationary plug-in contacts. Guides shall be provided to correctly locate the moveable switchgear truck in its fixed housing.

All switchgear trucks complete with circuit breakers shall be interchangeable without adjustment.

All main and secondary plug and socket contacts on the switchgear truck and on the switch panel shall be maintenance free.

There shall be three distinctly defined and labelled switchgear truck positions:

- Operating Position
- Isolated/Test Position

- Transport Position

The following interlocking conditions shall be fulfilled: >Operating Position:

Safe and reliable mechanical interlocking shall be provided to prevent the switchgear truck from being moved in or out of the operating position when the circuit breaker is in the switched-on position.

It shall not be possible to open the secondary plug-in contacts for auxiliary circuits between the switch panel and the switchgear truck when the switchgear truck is in the operating position.

>Isolated/Test Position:

In the isolated/test position, the clearance distances between the main plug and socket contacts shall be large enough and with an adequate safety margin to allow the complete truck to be HV pressure tested in accordance with the appropriate regulations for the voltage testing of insulation. The control wire circuits between the switch cubicle and the switchgear truck shall remain connected so that the circuit breaker can be safely opened and closed for test or other purposes.

The switchgear truck and switch cubicle shall be equipped with a suitable contact connection which provides a reliable and adequate ground connection between the truck and the switch cubicle with the truck in the operating and in the isolated/test position. Safe and reliable mechanical interlocking shall be provided to retain the switchgear truck in the isolated switch test position. Arrangements for padlocking in this position shall also be provided.

When the switchgear truck is between the isolated/test and the operating position it shall not be possible to switch on the circuit breaker.

e. CUBICLES WITH WITHDRAWABLE CONTACTORS (MOTOR STARTERS)

All similar contactor cubicles with withdrawable vacuum contactors shall be interchangeable without first having to be converted. The withdrawable inserts shall be equipped for interlocking in three defined and clearly labelled positions. The three interlocking positions shall be as described above in 2.3.4.

It shall be possible to safely change HRC-fuses without the need to insert additional insulation when a contactor is in the isolated/test position. On an HRC fuse

rupturing the associated contactor shall trip all phases and interrupt the circuit. This condition shall be indicated by a suitable device.

The motor starter units shall also be equipped as a minimum with a three-phase ammeter and a transmitter for active power (kW).

f. RELAY COMPARTMENT

All relays and associated equipment shall be mounted in such a way that no functional disturbances can arise from vibrations during circuit breaker operations (switching action). The front of the relay compartment shall be protected and closed off by a metal door which shall include a pane of safety glass.

All remote control, protection and monitoring functions shall be brought out to a field wiring interface terminal for serial connection to the SCADA.

In the relay compartment all necessary measuring, control and auxiliary equipment as well as terminal blocks for all auxiliary and field wiring shall be installed.

Terminals for current transformers shall have bridging facilities to shorten CT's out and to connect measuring devices.

Sufficient space shall be provided in wiring ducts and cable connection areas including 30% spare space.

Field wiring terminals shall be suitable for cores with a cross section of up to 6 sq. mm.

4. CIRCUIT BREAKERS

All circuit breakers shall have control selection switches for local and remote (SCADA) operation.

Each circuit breaker shall have a safe and reliable anti-pump device. This shall be designed in such a way that on repeatedly occurring on/off signals the off signal has priority. When on/off signals occur in rapid succession for operational reasons, the switching sequence shall be time limited to a safe elapsed time for carrying out each switching duty.

Each circuit breaker shall have a mechanical ON/OFF switch position indicator easily visible externally and a meter for counting the number of switching operations.

Upon a control voltage supply breakdown an easily reached and well visible means for manual emergency switching to the OFF position shall be provided.

For alarm, indications, and control purposes at least 10 auxiliary switch contacts (5 NC contacts and 5 NO contacts) shall be supplied and wired to a metalclad terminal block in the relay compartment

Open/close control and indication shall be provided for each switchgear panel and for remote location.

Thermostatically controlled anti condensation heating shall be provided in each cubicle.

5. MEDIUM VOLTAGE CONTACTORS

SF6/Vacuum contactors shall be used for medium voltage duty to suit the application and shall be capable of switching with an adequate safety margin for direct online starting of motors and for emergency switching off without delay in the event of a locked rotor or extended run-up.

For alarm indication and control purposes at least 10 auxiliary switch contacts (5 NC contacts, 5 NO contacts) shall be provided and wired to a metal clad terminal block.

Contactors for motor control shall be of suitable design to enable lower power output motors to be switched without damage to the motor windings.

Each motor starter unit shall be equipped with over voltage limiter.

6. CONTROL VOLTAGE SUPPLY

DC supply units consisting of valve regulated Nickel Cadmium cells or long life & maintenance free lead acid batteries, battery charger and DC distribution panel shall be installed in each medium voltage switch room for indication, tripping and closing of the switchgear. The control voltage shall be 110 V DC.

Separate MCB’s in each circuit breaker panel shall protect the main supply from a fault on an individual circuit breaker.

The battery capacity at each switch room shall be of adequate capacity to accommodate both the normal standing load (relays and indicator lamps) for a period defined below from the charger being switched off (at a minimum ambient temperature of 5 degrees centigrade and a maximum ambient temperature 50 degrees centigrade) and subsequently a simultaneous switching off of all the circuit breakers and contactors of the station followed by switching on in rapid succession. All switchgear shall operate correctly under these circumstances.

Where no standby generator is installed – minimum 8 hours
Where a standby generator is installed – minimum 2 hours

The closing, tripping and other auxiliary supplies shall be separately brought to one panel only of each section of a switch board and looped from panel to panel by internal bus wires. For each busbar section, there shall be separate control and tripping supplies.

The auxiliary supplies for each section of switchboard shall be protected by 2-pole miniature circuit breakers (MCBs) with auxiliary N/C contacts for indication purposes. The auxiliary contacts of all MCB's of the same circuit group, e.g. circuit breaker, isolator and earthing switch motor circuits, alarms, space heater, protective relay, supply, etc. shall be wired to group alarm terminals. The group alarms shall be connected to a common alarm monitoring system.

7. CURRENT TRANSFORMERS

CT's shall be dry type encapsulated in cast resin.

The accuracy class and rated burdens of the CTs shall be selected from the range of IEC 60185 and in accordance with requirements of the associated metering and protective systems with a reasonable allowance for burden design growth.

All CT secondary currents shall be rated 1A.

8. VOLTAGE TRANSFORMERS

Voltage transformers shall be provided for protective relay systems, voltage indication, synchronising facilities, synchro-check facilities, and energy metering, as detailed on the Single Line Diagram (refer to Schedule B).

Voltage transformers fitted on air insulated switchboards shall be encapsulated in cast resin, with primary protection provided by renewable fuses. The secondary winding shall be rated at 110V AC and shall have one point, the yellow phase or the star point, earthed. Secondary links and fuses shall be provided. It shall be possible to isolate the voltage transformer and/or change the HV fuses in safety without de-energising the switchboard.

(For SF6-insulated switchboards consideration may need to be given to accepting voltage transformers which are solidly connected to the busbars, are not withdrawable, and are not equipped with HV fuses. The Contractor will need to demonstrate the integrity and reliability of such an arrangement.)

The accuracy, class and rated burdens of the VTs shall be in accordance with requirements of the associated connected systems and be selected from the range of IEC 60185 standard ratios and VA ratings, with a reasonable allowance for burden design growth.

9. SURGE ARRESTERS

Surge arresters shall be installed at all medium voltage switchboards at risk from high switching transients, lightning or other

Surge arresters shall be installed within an explosion proof cubicle equipped with a transparent inspection window. Suitable remote surge counter devices shall be installed in such way that reading can be done without any risk for the personnel.

Surge arrester shall preferably be of zinc-oxide gap-less type with sufficient rated specific energy (KJ/kv) to ensure non-fragmenting operation when discharging any kind of surge.

10. MEASURING DEVICES

All instruments and meters shall be installed in such a way that they can be easily read. The measuring devices shall normally be 96 x 96mm size analogue indicators. Accuracy shall be 1%. Externally operated zero adjustment shall be provided. Digital indicators may also be acceptable depending on the application.

KWh/kVArh-meters shall be of electronic type including impulse output signals to indicate the power consumption. The accuracy shall be 0.5%.

Both incoming and outgoing circuits shall have energy meters to display current, voltage and power functions and be fitted with serial interface for remote monitoring.

11. PROTECTION RELAYS

Circuit breakers shall be shunt-tripped, and each breaker shall be provided with a Trip Supervision Relay to monitor the integrity of all sections of the trip circuit. A switchboard master alarm relay shall monitor the outputs of the trip circuit supervision relay (normally 'Trip Circuits Healthy' to be indicated), with auxiliary contacts for remote indication.

The protection relays shall be microprocessor based, multi-function programmable plug in type units in accordance with IEC 60255. The degree of enclosure of the front of the relay unit shall be IP54 minimum. If not otherwise specified, protection relays shall be suitable for connection to current transformers having 1-amp secondaries.

Each protection relay shall have clearly visible indication to show all parameters and actual measured values and indicate when the relay operates.

Using of only one type of relay for different applications is preferred. All units shall preferably have a standard data interface.

The number of relays installed in one panel shall be limited in such a way that enough space is left to accommodate all cables and cable termination properly. Approx. 30% space shall be included for future extensions and modifications.

For all motor control circuits, the relay combination shall include overload, instantaneous over current, earth fault, under voltage, single phasing, locked-rotor time, stator temperature from embedded temperature transmitters and re-start lock-out protections. Motors above 1.5 MVA shall also have differential protection.

Transformer feeders shall be fitted with inter-trip receive relays to accept restricted earth fault inputs from LV transformer ACBs and inter-trip send relays to trip the transformer LV circuit breaker if the HV trips.

Each protection relay shall be provided with a set of test sockets mounted on the relay panel for operational testing arranged so that each relay can be tested while still in service without interrupting its operation.

Following tripping of a switch by a protection relay it shall not be possible to reclose that switch until the concerned protection relay has been reset by hand.

Indication shall be provided to show operation of automatic re-set relays. It shall only be possible to cancel such indication by hand. This requirement also applies to other protection relays remote from the switchgear - for example Buchholz relays.

The Contractor shall utilise the blocking functions on protection relays to ensure that faulted equipment and cabling is isolated without unnecessary loss of supplies to other circuits.

12. POWER DISTRIBUTION SUPERVISORY UNIT - (SCADA)

A self-contained Power Distribution Supervisory System “SCADA” shall control and indicate the complete MV power distribution including MV feeders to distribution transformers and emergency power generators. The actual status of all installed MV circuit breakers, isolators and grounding switches shall be shown. A zoom function for detailed investigation shall be provided.

All measured values of (A, V, MW, MVAr, MWh, MVArh, Power factor, etc.), alarms and switch status shall be indicated. Alarms and switching actions shall be printed out with the actual time of the event.

All data shall be stored on non-volatile memory in a database over a minimum time period of one year. The database shall be user friendly and shall include a facility to create and printout any report over a given time period (daily, weekly, monthly and/or yearly) for any of the stored data.

A graphical package shall be included to show historical curves and trend curves of all data stored on the hard-disk or other storage media.

Colour hard-copy facilities shall be provided to print-out such curves.

For smaller distribution systems such functions can be integrated in the Process Automation System after approval by the Purchaser.

The SCADA shall be served by a UPS-system which will have an autonomy time sufficient to control switching under power failure conditions to avoid danger or plant damage. The uninterruptible supply shall normally be supplied from the central UPS system, where installed but otherwise shall have a capacity of not less the battery time of the emergency battery system as detailed in section 2.6

5.5 Low Voltage Switchgear

5.5.1 TANDARDS AND SPECIFICATIONS

The switchboards, switchboard components, the assembly and construction shall comply with the recommendations of the most recent additions of the following standards including but not limited to:

IEC 60439 Factory Built Assemblies of Low voltage Switchgear and Control gear for Voltages up to and including 1000V AC and 1200V DC

IEC 60529 Degrees of Protection provided by Enclosures

IEC 60947 Low Voltage Distribution Switchgear and Control Gear

IEC 60051 Direct Acting indicating Electrical Measuring Instruments and their Accessories

5.5.2 OPERATING CONDITIONS

The switchgears shall preferably be installed in enclosed air-conditioned substations. If this is not possible, other arrangements shall be agreed with the Purchaser. Under such circumstances the enclosure rating shall be increased to suit the environment but shall be not less than IP54.

5.5.3 ELECTRICAL DATA

The main electrical data of the switchgears such as:

- rated voltage,
- rated current,
- frequency,
- rated peak withstand current,
- rated short time (one second minimum) withstand current,
- minimum switching cycle of the circuit breaker or contactor,
- full load current under site conditions

shall be unambiguously stated in data sheets supplied by the manufacturer. All switchgear cubicle components shall be manufactured by a single reputable electrical company (e.g. ABB, Siemens, Schneider, and Cutler Hammer).

5.5.4 SWITCHGEAR ASSEMBLIES

All low voltage distribution systems shall employ Air Circuit Breakers (ACBs), Moulded Case Circuit Breakers (MCCBs) and Miniature Circuit Breakers (MCBs)

All switchgear shall comprise Type Tested Assemblies in compliance with IEC 60439. The switchgears shall be modular, prefabricated sheet steel of minimum 2mm thick enclosed cubicle type panels for floor mounting installation and consist of one or more vertical panels which make up a complete unit when bolted together.

Each complete assembly, including busbar system, internal cabling and switching devices, shall be fully rated for the prospective rms and peak fault currents anticipated.

The short circuit withstand requirements shall also consider the contribution of installed motor load in addition to the supply characteristics.

Each panel shall comprise separate compartments for busbars, equipment and cables. Partitions between equipment and busbar compartments and between cable and busbar compartments shall ensure operational safety in servicing. Steel side sheets between individual panel units shall be provided.

Switchgear shall be equipped with lifting lugs.

For circuit breakers of 630A and above an industry recognised practical limit for the number of circuit breakers installed into a single panel shall be applied. Consideration should be given to ease of maintenance & removal of the circuit breakers.

The design of all metal enclosed compartments shall prevent any possibility of excess pressure causing any danger to personnel or equipment on the occurrence of a short circuit.

Panels shall have gland plates for top or bottom entry for the number of power and control cables required. The gland plates shall be strong enough not to deform under the stress

applied by the installed cables and shall be non-magnetic where single core power cables could be terminated. Gland plates for incoming single core armoured cables shall be aluminium plate of minimum thickness 2mm.

Vertical cabling compartments shall be equipped to support and fix the cables.

Control and operation of each circuit breaker or contactor, including manual resetting of trip relays and reading of all built in instruments shall be possible with the access door closed.

Each withdrawable circuit breaker or motor starter unit shall be interlocked mechanically with the associated fixed cubicle framework in such a way that when plugged in and switched on it cannot move or change from the plugged in position during normal operation or under short circuit conditions or any other circumstances.

Control circuits for incoming feeder and coupling circuit breakers shall be designed in such a way that the interlocking to other breakers is not disturbed in case one of the breakers is moved to the test position or is completely withdrawn.

In the case of withdrawable units, the openings of the main and secondary plug in contacts shall be covered automatically by shutters after the withdrawable portion has been withdrawn so that contact with any live or potentially live voltage parts is not possible.

Circuit breakers, contactors, current and voltage transformers, relays, measuring instruments and meters, control and indications belonging to same circuitry shall all be accommodated in same equipment compartment.

All manually operated switches shall be lockable.

The minimum degree of protection of all switchgear shall be IP31. Where installed outside conditioned rooms, the switchgear must be suitable for the increased ambient temperature and have an increased degree of protection against fine dust typical of a desert environment. In such situation’s consideration shall be given to total exclusion of dust from control compartments, pushbuttons, keyboards etc. by means of flexible membranes.

All Load Centre's and MCCs shall have a serial interface where status, metering and alarms and control inputs can be transmitted to and from a central control room.

5.5.5 MAIN DISTRIBUTION PANELS (LOAD CENTRES)

Main distribution panels shall be designed for primary distribution of power for process plant or electrical services and shall have Degree of Separation to Form 4 as specified in IEC 60439.

System details for low voltage main distribution panels are:

System Voltage	400V; 50Hz, 3-phase for electrical services The three-phase low voltage for process and auxiliary plant may be higher to supply higher power motors
Short circuit rating	50 kA minimum prospective symmetrical RMS for 3 seconds
Minimum protection class	IP 31
Incoming Circuit breakers	Withdrawable. Adequately rated for transformer secondary current. Equipped with overload, short circuit protection and backup earth fault protection. Restricted earth fault or unit protection for transformers over 1600 kVA
Bus sections	Withdrawable unarmed circuit breakers
Outgoing circuits	Withdrawable above 400A, otherwise plug-in and readily replaceable. Fitted with multi-characteristic over-current and short-circuit protection

Where a main distribution panel is supplied via two transformers, key interlocking shall be installed to ensure than the panel cannot be stressed above its fault rating.

Panels shall be fitted with one unequipped spare compartment for each feeder circuit breaker frame size per four circuits installed, subject to a minimum of one spare compartment of each rating. The panel shall also be readily extensible in at least one direction.

Each panel shall have an earth bar connected the full length of the panel of minimum cross section 20x6mm.

Where fitted, the neutral bar shall be connected to the earth bar via a removable bolted link.

5.5.6 MOTOR CONTROL CENTRES (MCCs) WITH WITHDRAWABLE STARTERS

All production plant low voltage motors shall be supplied by MCCs with cassette mounted or swing-out starters with Degree of Separation to Form 4 as specified in IEC 60439 and the minimum requirements shown below:

1. Lockable incoming load breaking fault making isolator.
2. Busbars fault rated for both the supply fault input and the motor contribution.
3. Starter units for AC induction motors equipped with:
   - Compartment door interlocked to prevent access to live components
   - Circuit breaker for isolation and short-circuit protection
   - Contactors, speed/torque control and/or assisted starting devices as required for the function and duty of the motor/drive.
   - Overcurrent thermal trip relay
   - MCB supplied control voltage (maximum 110V - 50 Hz).
   - Pushbuttons, indicating lamps and all other necessary items for a complete unit.
   - Hours run indication and recording for drives over 75 kW
   - Ammeter for motors over 15 kW
   - Remote/Auto, Off, Local and Test control selection
   - The auxiliary contacts of all devices of the same circuit group, e.g. control voltage, circuit breaker, thermal overload relays, alarms, space heater, electronic equipment supply, etc. shall be wired to group alarm terminals. The group alarms shall be connected to a common alarm monitoring system
4. Withdrawable ACB or MCCB feeders for remote plant or MCCs equipped as specified in Section 5 above.

   Each MCC suite shall have two control transformers. In the event of a control transformer failure it shall be possible for the other to supply the whole MCC. Panels shall be fitted with one unequipped spare compartment for each feeder circuit breaker frame size per four circuits installed, subject to a minimum of one spare compartment of each rating. The panel shall also be readily extensible in at least one direction.

5.5.7 MOTOR CONTROL CENTRES (MCCs) WITH FIXED STARTERS

Where auxiliary process plant comprises multiple small drives less than 10 kW, MCCs with fixed starters may be used subject to the approval of the purchaser. Power components may be housed in groups in common compartments but in other respects the MCC shall conform to the requirements of Section 6 above.

The MCC shall have minimum Degree of Separation to Form 2B as specified in IEC 60439 and the minimum requirements shown below:

Busbars shall be separated from functional units by earthed metallic or non-metallic rigid barriers or partitions.

The incoming isolator shall be interlocked with the cubicle door to prevent access inside the cubicle unless the incoming supply is isolated. Nevertheless, all terminals and equipment above 24V AC or 60V DC shall be shrouded to IP2X or IPXXB minimum.

PLCs and other electronic equipment shall be installed in separate compartments segregated from the starter equipment and busbars.

Substantial detachable undrilled gland plates shall be provided for the termination of power and control cables. Each gland plate shall be electrically bonded to the cubicle earth bar.

5.5.8 LOCAL CONTROL PANELS

Each motor (excluding those supplied from variable speed drives where other safety measures shall be provided) shall have its own local isolator. This shall be rated to break the stalled current of the motor without damage and shall be fitted with auxiliary contacts to trip the drive and indicate that it has been operated. This requirement is being reviewed by EMIRATES STEEL

The panel enclosure shall withstand the local ambient conditions, made of non-corroding (Stainless Steel) high impact withstand material, have sufficient mechanical strength and degree of enclosure IP55 or higher.

5.5.9 OTHER REQUIREMENTS

1. CONTROL WIRING

The control wiring between compartments shall be routed in separate enclosed ducts accessible from the front of the switchgear cubicle.

Wires connected directly to the busbar shall be short-circuit proof and accommodated in separately enclosed ducts (PVC wiring ducts).

The minimum cross-section area of control wires shall be 1.5 mm2 and shall comprise flexible tri rated cable. Each wire shall be marked on both ends by ferrules carrying the circuit wire/termination number.

All terminal blocks for outgoing control wire connections shall be suitable for a conductor size of 1.5mm to 6 mm.

2. LABELS

The switchgear and each equipment compartment shall be equipped with permanent indelible labels including the electrical designation and description e.g. of the drive unit.

Additionally, all components (circuit breakers, contactors, relays etc.) inside the switchgear must have permanent identification labels matching those on the circuit diagrams and schematics. The labels shall be installed in such a way that they remain in position when a component is replaced.

3. CONTROL VOLTAGE SUPPLY

Control supplies for each Load Centre or MCC shall be via an adequately rated control voltage transformer for each switchgear or busbar section. Where two switchgear sections are separated by a bus section switch, each control transformer shall be capable of supplying both halves in the event of failure of the other.

The control voltage shall be 110V AC with one terminal connected to ground.

5.6 Low Voltage Equipment

5.6.1 GENERAL

All low voltage (up to 1000V) equipment components shall be manufactured by a single reputable electrical company having worldwide after sales services (e.g. ABB, AEG, SIEMENS, GE, Schneider, Cutler Hammer).

5.6.2 CIRCUIT BREAKERS

1. RATED CURRENT HIGHER THAN 630A

Circuit breakers for rated current higher than 630A shall be draw-out type air circuit breakers (ACBs) equipped with motor operating mechanism with stored energy feature. The ACBs shall comply as a minimum with IEC 60947; Low Voltage Switchgear and Control gear.

All circuit breakers shall have padlock facilities.

Adjustable electronic short circuit and temperature compensated thermal overcurrent releases shall be fitted directly to the circuit breaker and automatically trip all 3 phases of the circuit breaker simultaneously when the adjusted threshold setting value is reached. The releases fitted shall be readily exchangeable.

Adjustment of the releases shall be from the front of the panels without the necessity of withdrawing the circuit breaker portion from the fixed housing.

For indication purposes each circuit breaker shall be provided with minimum 1 NO and 1 NC auxiliary contacts.

2. RATED CURRENT MAX. 630A

Circuit breakers for rated current up to 630A shall be moulded case circuit breakers (MCCBs). The circuit breakers shall preferably be plug-in on a fixed base, or at least easily replaceable. In cases where they are used in motor starter units, the circuit breakers are to be installed into the cassettes of the starter units.

The MCCBs shall comply as a minimum with IEC 60947; Low Voltage Switchgear and Control gear.

The MCCBs shall be rated to withstand and break the prospective full short circuit current without the need for replacement.

3. MINIATURE CIRCUIT BREAKERS

Miniature circuit breakers (MCBs) shall be used in control and lighting circuits. They shall have Type C, D or K characteristics and minimum breaking capacity of 10 kA in compliance with IEC 60947-2 (IEC60947-4 for use with motor circuits).

5.6.3 CONTACTORS

Contactors for AC and DC operation shall be air brake electromagnetic type and shall be suitable for a minimum of 1 million operations and contactor size 00 for a minimum of 3 million operations. The contactors shall comply with IEC 60158-1.

The coils of the contactors shall be rated for 110V -50Hz maximum.

5.6.4 THERMAL OVERLOAD RELAYS

Thermal overload relays for motor starters shall incorporate protection against single phasing. They shall have adjustable settings and the range of adjustment shall be selected such that the motor may operate continuously at 100% rated current and such that inadvertent trips shall not occur during the motor start conditions.

Contactors with ratings of 630A or larger shall be fitted with electronic overload relays.

5.6.5 AUXILIARY RELAYS

The coils of auxiliary relays in AC-circuits shall be rated for 110V, 50Hz max. and 24V DC in case controlled directly by outputs of PLC subject to the switching limitations of the output.

5.6.6 TIME RELAYS

Only electronic time relays shall be used.

5.6.7 SPECIAL RELAYS

The Contractor shall submit technical details of all special relays proposed for the Purchaser's approval.

5.6.8 PUSH BUTTONS AND INDICATOR LIGHTS

The mounting diameter of the devices shall be dia. 22mm and the rated operational current Ie/AC-1 shall be minimum 10A. Indicator lamps shall be of LED type. The equipment shall be suitable for operations in a typical steel works environment.

5.6.9 MEASURING INDICATORS

All measuring indicators shall be installed in such a way that they can be read easily. The size of measuring indicators shall be 96 x 96mm with measuring accuracy to Class 1. Where LCD displays are used the character height shall be 8mm minimum.

5.6.10 FIELD DEVICES

All field devices (limit switches, proximity switches, level switches, pressure switches, temperature switches, tachometers, etc.) shall comply with applicable IEC or recognized national standards.

5.7 Primary Transformers

5.7.1 GENERAL

1. FIELD OF APPLICATION

This Specification describes the requirements for the design of high voltage primary distribution transformers.

2. SPECIFICATIONS AND REFERENCE MATERIAL

Recognized technical regulations apply to the design, in particular editions of the following specifications and standards currently valid: -

- IEC 60076; Power Transformers
- IEC 60542; Application Guide for On-Load Tap-changers
- IEC60076-8; Application Guide for Power Transformers

5.7.2 DESIGN

1. SERVICE CONDITIONS

The transformers will be installed outdoors.

2. ELECTRICAL DATA

The main electrical data for the transformers such as: -

- Primary and secondary connections
- Primary volts and amps
- Tap positions and steps
- Secondary volts, amps and MVA rating
- Impedance voltage

shall be specified and included on a schematic diagram.

A durable plate showing the diagram of connections and bearing the above information shall be permanently attached to the side of each transformer.

3. TYPE OF TRANSFORMER

The transformers shall be designed for ONAN/ONAF operation.

The transformer is to be provided with separate radiator banks, stop valves being provided in the connecting pipes between the tank and the radiator banks, at the tank end and at the radiator end to permit the disconnecting and removal of the transformer or radiator bank without having to drain off the oil.

The transformers shall have rotatable and lockable wheels mounted on rails at ground level for easy removal of the transformer. It shall be possible to remove the transformers by pulling them directly out of the transformer pens jacking up each wheel, turning each wheel by 90 degrees, locking the wheel in position and pulling the transformer on a second set of diagonal rails.

4. DESIGN AND PERFORMANCE

The transformer shall be designed for continuous operation at rated power without the risk of overheating any part of the equipment. It shall operate satisfactorily under sudden variations of load and voltage caused by short circuits on the system in which the transformer is connected and such variation of frequency that may occur.

5. MAGNETIC CIRCUITS

The core shall be constructed of grain orientated steel laminations. The arrangement of cores, framework and clamps shall ensure even mechanical pressure over the whole of the core laminations to prevent settling of the core in service.

The cores shall be designed and constructed in an approved manner to provide against accidental or slow development of short circuit paths through the core and framework. The framework and core bolts shall be efficiently insulated from the core so that circulating currents are reduced to a minimum.

6. WINDINGS AND WINDING CONNECTIONS

Windings shall be braced to withstand shocks due to rough handling and vibration in transport, short circuits, switching or other transients in service.

Star connections shall be made at the low voltage end of the windings. A connection shall be taken from the star point of the lower voltage winding to an insulated terminal within the LV cable box. [see Section 2.16 Earthing and Neutral Connection]

7. TAPPINGS

Each transformer shall be provided with taps on the higher voltage winding to permit voltage adjustment according to the range indicated in the specification. The tapping's shall be arranged at positions on the coils to preserve the electromagnetic balance of the windings at all voltage ratios.

Standard tapping ranges are ±10% in 1.25% increments.

8. VOLTAGE TAP CHANGER

The voltage tap changer shall be an on-load high speed resistor type for remote controlled automatic operation. The transformer shall be capable of its full output on all taps. The tap changer shall be suitable for operation with reverse current flow in the transformer.

9. VOLTAGE TAP CHANGER TANK

The tank shall be constructed suitable for attachment direct to the transformer tank by means of a suitably bolted oil tight joint. A bolted cover of adequate dimensions shall be provided for giving access to the selector switches and mechanism. The tap changer diverter switches shall be accommodated in a separate compartment. There shall be no oil connection between the diverter switch tank the selector switch chamber. A lifting device shall be provided for the diverter switch.

10. VOLTAGE TAP CHANGER DRIVING MECHANISM

The tap changing equipment shall be provided with a motor driven operating gear contained in a weatherproof and dust proof steel housing or kiosk fitted with the necessary heaters to prevent condensation. The gear shall be provided with the necessary limit switches and other devices to ensure that the equipment stops correctly at the various taps and does not over run the tapping range.

Provision shall be made to give an indication on the supervisory unit (SCADA) of:

(a) 'tap changer in progress' by means of an indicating lamp and

(b) 'position of tapping switches' both by clean contacts and by stepping resistors. A local mechanical indicator shall be provided to show the position of the tapping switches.

A mechanically operated counter shall be provided to record the number of tap changes.

A handle and changeover mechanism shall be provided for emergency manual operation, interlocked to prevent electrical operation when the handle is in position. The handle shall be located at a convenient height for operation.

11. MAIN CONNECTIONS AND DISCONNECTING LINKS

The primary and secondary transformer connections shall have a separate connection housing with a protection grade of not less than IP54. Access to normal non-SF_6 connection boxes shall be easy for maintenance. Disconnecting links shall be provided for all main cables to permit disconnecting for testing of either cables or transformer windings.

12. PRESSURE RELIEF DEVICE

A pressure relief device with trip contacts (Qualitrol or similar) shall be fitted to the transformer tank. A separate device shall be fitted to the tap changer tank.

13. CONSERVATOR

The oil conservator shall be mounted on top of the transformer in such a way that it can readily be detached for transport purposes and shall be fitted with a removable end. The conservator shall be of ample capacity for containing sufficient oil to allow for the transformer to work over its maximum permissible temperature range. The connection to the conservator shall be taken to the highest point of the transformer tank, the connecting piping to project 35 mm above the bottom of the conservator for the collection of moisture and sludge. Vent pipes shall be provided if required, to prevent the trappings of air pockets formed by sealing ends or bushings, etc.

Bladder type oil conservator (air bag) shall be supplied.

14. OIL LEVEL INDICATOR

A direct reading prismatic or reflex type of gauge shall be provided marked to indicate conservator tank 'empty' or 'full' and also marked to indicate oil level when the oil temperature thermometer indicates 15C°, 35°C, 25 ° 45°C, and 55°C the oil level gauge being calibrated during the temperature rise type test.

15. BREATHERS

A silica gel breather of an approved type shall be provided connected to the conservator and so arranged that it is readily accessible from the ground.

16. EARTHING AND NEUTRAL CONNECTION

Each tank shall be provided with a terminal suitable for connecting to the earthing system. Each core and tank cover shall also be earthed, by means of substantial connections to the tank.

The neutral connection point of the 230 kV windings shall be connected to the main transformer earth through an external bushing and an easily removable link to allow for testing of the 230 kV windings.

17. VALVES

High grade, all metal, oil drain valves are required for the following services: -

- Main tank
- Conservator tank
- Selector tank
- Diverter tank
- Drain for any other tank or tanks not covered by the above.
- Stop valve between main and conservator tank

- Stop valves between main tank and radiator bank(s).

18. TEMPERATURE INDICATORS

One maximum reading, thermometer fitted with two sets of contacts for Oil Temperature Alarm and trip shall be provided for measuring the oil temperature at the hottest spot.

Additionally, a free moving, hand reset pointer to indicate the highest temperature reached, shall be provided.

One maximum reading, image type, winding temperature indicator including the associated equipment for modulating the top oil temperature measurements with respect to the winding load variation thermal characteristic.

The indicator shall be fitted with two sets of contacts, one for alarm purposes and one for trip purposes. Additionally, a free moving, hand reset pointer to indicate the highest temperature reached, shall be provided.

A second winding temperature indicator with associated equipment complete with independently adjustable ’start’ and ’stop’ contacts for controlling the cooling fans. Additionally, 4-20 mA signals for oil temperature and winding temperature shall be provided.

19. GAS AND OIL ACTUATED RELAYS

The transformer shall be fitted with a two-float gas and oil actuated relay fitted in the pipe between the conservator tank and the main tank. A second two float relay is required between the tap changer selector tank and the conservator tank. If the design of the tap changer equipment is such that gas may be generated during normal operation in this chamber, a single float for trip only is required.

For protection of the air bag inside the conservator tank, a single float relay shall be fitted to monitor the negative pressure caused by the weight of the oil above the air bag. In case of a leakage in the air bag, the escaping air will displace the oil at the top of the tank causing the relay to operate. This shall give an alarm in the main control room.

The devices shall be fitted with two glass windows, one each side of the float, to facilitate the checking of the oil level. The above devices shall be connected by armoured multicore cables to a terminal board installed in the marshalling box.

A copper pipe shall be connected between the gas release point on the devices and an acceptable position at approximately 1.5m from ground level, fitted with a release cock so that samples of gas may be obtained safely whilst the transformer is energized.

When more than one device is fitted the surge trip and gas alarm contacts shall be routed separately to the marshalling box.

A pet cock shall be provided on the devices to permit the hydraulic testing of the trip contacts by injecting compressed air.

20. DRYING OUT AND TRANSPORT

The transformer shall be dried out at the Contractor's works. It shall be transported, erected and put into service without further drying out on Site.

Oil transformers shall be designed to suit the existing limitations of roads, ships, ports, railways etc. For this purpose, conservator vessels and breathers may be removed provided the transformer is temporarily sealed and pressurized with dry air to prevent ingress of moisture. A temporary pressure indicator shall be fitted for the transportation and removed during erection on site.

If owing to mishap in transport or other cause it shall be found necessary to remove the oil, or the oil shall become removed from the transformer to an extent sufficient to expose any part of the windings, the transformer shall be carefully dried out by the Contractor, and at the Contractor's expense before setting to work. The means to be employed for drying out shall be to the approval of the Purchaser but such approval shall in no way relieve the Contractor from any of his guarantees and liabilities.

21. CONTROL CUBICLES, MARSHALLING KIOSK AND CABLING

A weatherproof marshalling kiosk having two substantial padlock able handles shall be provided for control of the fans, thermometers and tap changer.

Interface cabling terminals shall be provided in the marshalling box for all outgoing control, protection and indication cables, current transformer, tap changer position and temperature measurements above.

All interconnecting power and control cables between the marshalling kiosk and the transformer equipment shall be supplied.

All cubicles shall be provided with anti-condensation heat.

5.8 Furnace Transformers

5.8.1 GENERAL

1. FIELD OF APPLICATION

This Specification describes the requirements for the design of furnace transformers.

2. SPECIFICATIONS AND REFERENCE MATERIAL

Recognized technical regulations apply to the design, in particular editions of the following specifications and standards currently valid: -

- IEC 60076; Power Transformers
- IEC 60542; Application Guide for On-Load Tap-changers
- IEC60076-8; Application Guide for Power Transformers

5.8.2 DESIGN

1. SERVICE CONDITIONS

The transformers will be installed Indoor.

2. ELECTRICAL DATA

The main electrical data for the transformers such as: -

- Primary and secondary connections
- Primary volts and amps
- Tap positions and steps
- Secondary volts, amps and MVA rating
- Impedance voltage
- Vector Group

Shall be specified and included on a schematic diagram.

A durable plate showing the diagram of connections and bearing the above information shall be permanently attached to the side of each transformer.

3. TYPE OF TRANSFORMER

The transformers shall be designed for OFWF operation.

The transformer is to be provided with separate radiator banks, stop valves being provided in the connecting pipes between the tank and the radiator banks, at the tank end and at the radiator end to permit the disconnecting and removal of the transformer or radiator bank without having to drain off the oil.

The transformers shall have lockable wheels mounted on rails and will be installed above furnace platform level. It shall be possible to remove the transformers by pulling it out of the transformer room and to be handled out the furnace bay using cranes.

4. DESIGN AND PERFORMANCE

The transformer shall be designed for a duty cycle as per the furnace design parameter (Tap to Tap & Power Off time).

5. MAGNETIC CIRCUITS

The transformer shall be designed with five columns constructed of grain orientated steel laminations. The arrangement of cores, framework and clamps shall ensure even mechanical pressure over the whole of the core laminations to prevent settling of the core in service. The cores shall be designed and constructed in an approved manner to provide against accidental or slow development of short circuit paths through the core and framework. The framework and core bolts shall be efficiently insulated from the core so that circulating currents are reduced to a minimum.

6. WINDINGS AND WINDING CONNECTIONS

Windings shall be braced to withstand shocks due to rough handling and vibration in transport, short circuits, switching or other transients in service.

7. TAPPINGS

The transformer shall be provided with taps to fulfil the furnace design working points with different scrap/DRI charge mix.

8. VOLTAGE TAP CHANGER

The voltage tap changer shall be an on-load high speed resistor type for remote controlled automatic operation. The transformer shall be capable of its full output on all taps.

The tap changer shall be suitable for operation with reverse current flow in the transformer.

9. TRANSFORMER OIL

Transformer oil shall be PCB free.

10. VOLTAGE TAP CHANGER DRIVING MECHANISM

The tap changing equipment shall be provided in a separate oil compartment and with a motor driven operating mechanism.

Tap changer shall be equipped with an oil filtering unit.

Provision shall be made to give an indication on the supervisory unit (SCADA) of:

(a) 'tap changer in progress' by means of an indicating lamp and

(b) 'position of tapping switches' both by clean contacts and by stepping resistors. A local mechanical indicator shall be provided to show the position of the tapping switches.

A mechanically operated counter shall be provided to record the number of tap changes.

A handle and changeover mechanism shall be provided for emergency manual operation, interlocked to prevent electrical operation when the handle is in position. The handle shall be located at a convenient height for operation.

11. MAIN CONNECTIONS AND DISCONNECTING LINKS

Connection from furnace metal clad to the transformer primary side shall be bus bars, and the secondary transformer connections shall be a flexible bus bar to the secondary current carrying copper connections,

12. PRESSURE RELIEF DEVICE

A pressure relief device with trip contacts (Qualitrol or similar) shall be fitted to the transformer tank. A separate device shall be fitted to the tap changer tank.

13. CONSERVATOR

The oil conservator shall be mounted on top of the transformer in such a way that it can readily be detached for transport purposes and shall be fitted with a removable end. The conservator shall be of ample capacity for containing sufficient oil to allow for the transformer to work over its maximum permissible temperature range. The connection to the conservator shall be taken to the highest point of the transformer tank,

Bladder type oil conservator (air bag) shall be supplied.

14. OIL LEVEL INDICATOR

A direct reading prismatic or reflex type of gauge shall be provided marked to indicate conservator tank 'empty' or 'full' and also marked to indicate oil level when the oil temperature thermometer indicates 15C°, 35°C, 25 ° 45°C, and 55°C the oil level gauge being calibrated during the temperature rise type test.

15. BREATHERS

A silica gel breather of an approved type shall be provided connected to the conservator and so arranged that it is readily accessible from the ground.

16. EARTHING AND NEUTRAL CONNECTION

Each tank shall be provided with a terminal suitable for connecting to the earthing system. Each core and tank cover shall also be earthed, by means of substantial connections to the tank.

The neutral connection point of the 230 kV windings shall be connected to the main transformer earth through an external bushing and an easily removable link to allow for testing of the 230 kV windings.

17. VALVES

High grade, all metal, oil drain valves are required for the following services: -

- Main tank
- Conservator tank
- Selector tank
- Diverter tank
- Drain for any other tank or tanks not covered by the above.
- Stop valve between main and conservator tank
- Stop valves between main tank and radiator bank(s).

18. TEMPERATURE INDICATORS

One maximum reading, thermometer fitted with two sets of contacts for Oil Temperature Alarm and trip shall be provided for measuring the oil temperature at the hottest spot. Additionally, a free moving, hand reset pointer to indicate the highest temperature reached, shall be provided.

One maximum reading, image type, winding temperature indicator including the associated equipment for modulating the top oil temperature measurements with respect to the winding load variation thermal characteristic.

The indicator shall be fitted with two sets of contacts, one for alarm purposes and one for trip purposes. Additionally, a free moving, hand reset pointer to indicate the highest temperature reached, shall be provided.

A second winding temperature indicator with associated equipment complete with independently adjustable ’start’ and ’stop’ contacts for controlling the cooling fans. Additionally, 4-20 mA signals for oil temperature and winding temperature shall be provided.

19. GAS AND OIL ACTUATED RELAYS

The transformer shall be fitted with a two-float gas and oil actuated relay fitted in the pipe between the conservator tank and the main tank. A second two float relay is required between the tap changer selector tank and the conservator tank. If the design of the tap changer equipment is such that gas may be generated during normal operation in this chamber, a single float for trip only is required.

For protection of the air bag inside the conservator tank, a single float relay shall be fitted to monitor the negative pressure caused by the weight of the oil above the air bag. In case of a leakage in the air bag, the escaping air will displace the oil at the top of the tank causing the relay to operate. This shall give an alarm in the main control room.

The devices shall be fitted with two glass windows, one each side of the float, to facilitate the checking of the oil level. The above devices shall be connected by armoured multicore cables to a terminal board installed in the marshalling box.

A copper pipe shall be connected between the gas release point on the devices and an acceptable position at approximately 1.5m from ground level, fitted with a release cock so that samples of gas may be obtained safely whilst the transformer is energized.

When more than one device is fitted the surge trip and gas alarm contacts shall be routed separately to the marshalling box.

A pet cock shall be provided on the devices to permit the hydraulic testing of the trip contacts by injecting compressed air.

20. DRYING OUT AND TRANSPORT

The transformer shall be dried out at the Contractor’s works. It shall be transported, erected and put into service without further drying out on Site.

Oil transformers shall be designed to suit the existing limitations of roads, ships, ports, railways etc. For this purpose, conservator vessels and breathers may be removed provided the transformer is temporarily sealed and pressurized with dry air to prevent ingress of moisture. A temporary pressure indicator shall be fitted for the transportation and removed during erection on site.

If owing to mishap in transport or other cause it shall be found necessary to remove the oil, or the oil shall become removed from the transformer to an extent sufficient to expose any part of the windings, the transformer shall be carefully dried out by the Contractor, and at the Contractor's expense before setting to work. The means to be employed for drying out shall be to the approval of the Purchaser but such approval shall in no way relieve the Contractor from any of his guarantees and liabilities.

21. CONTROL CUBICLES, MARSHALLING KIOSK AND CABLING

Control cubical having two substantial padlocks able handles shall be provided for control of the heat exchanger pumps, Tap changer, thermometers and tap changer filter unit.

All interconnecting power and control cables between the control cubical and the transformer equipment shall be supplied.

All cubicles shall be provided with anti-condensation heat.

5.9 Distribution Transformers

5.9.1 GENERAL

1. FIELD OF APPLICATION

This Specification describes the requirements for the design of distribution transformers.

2. SPECIFICATIONS AND REFERENCE MATERIAL

Recognized technical regulations apply to the design, in particular editions of the following specifications and standards currently valid: -

- IEC 60076; Power Transformers
- IEC 60146-1-3; Converter Transformers and Reactors
- IEC 600076-8; Application Guide for Power Transformers

5.9.2 DESIGN

1. SERVICE CONDITIONS

All oil filled transformers shall be installed outdoors

2. ELECTRICAL DATA

The main electrical data for the transformers such as: -

- Primary and secondary connections
- Primary volts and amps
- Tap positions and steps
- Secondary volts, amps and kVA rating
- Impedance voltage

shall be specified and included on a schematic diagram.

A durable plate showing the diagram of connections and bearing the above information shall be permanently attached to the side of each transformer.

3. TYPE OF TRANSFORMER

The transformers shall be 3-phase, double wound, step-down type ONAN and shall be mounted on plain wheels to facilitate easier movement. ONAF operation is not acceptable

Each distribution transformer shall have a separate HV, MV and LV circuit breaker. Grouping of transformers to a single circuit breaker is not acceptable. Oil transformers up to 2.5MVA shall be the hermetically sealed type.

All transformers shall be oil cooled unless alternatives are specifically approved by the Purchaser. If air-cooled transformers are approved for specific applications, they shall comply with the requirements of Section 2.19 below

Transformers supplying rectifier/inverter equipment shall be configured to minimise distortion of the electrical supply.

4. DESIGN AND PERFORMANCE

The transformer shall be designed for continuous operation at rated power without the risk of overheating any part of the equipment. It shall operate satisfactorily under sudden variations of load and voltage caused by short circuits on the system in which the transformer is connected and such variation of frequency that may occur.

5. MAGNETIC CIRCUITS

The core shall be constructed of grain orientated steel laminations.

The arrangement of cores, framework and clamps shall ensure even mechanical pressure over the whole of the core laminations to prevent settling of the core in service.

The cores shall be designed and constructed in an approved manner to provide against accidental or slow development of short circuit paths through the core and framework. The framework and core bolts shall be efficiently insulated from the core so that circulating currents are reduced to a minimum.

6. WINDINGS AND WINDING CONNECTIONS

Windings shall be braced to withstand shocks due to rough handling and vibration in transport and to short circuit, switching or other transients in service.

Star connections shall be made at the low voltage end of the windings. A connection shall be taken form the star point of the lower voltage winding to an insulated terminal within the LV cable box.

Vector grouping Dyn 11 is preferred.

7. TAPPINGS

Each transformer shall be provided with tapping's on the higher voltage winding to permit voltage adjustment in accordance with the adjustment range indicated in the particular specification. The tapping's shall be arranged at positions on the coils to preserve the electromagnetic balance of the windings at all voltage ratios.

The minimum tapping range shall be ±5% in 2.5% taps

8. INSULATION

The insulation of the windings and connections shall be entirely free from materials likely to soften, migrate, collapse or otherwise deteriorate under the combined action of pressure and hot liquid when the transformer is operating continuously at the maximum allowable temperature.

The interturn and inter-coil insulation shall be so designed that the stress is uniformly distributed throughout the winding under all operating conditions.

9. TANKS

Transformer tanks shall be constructed of steel plate, so stiffened as to withstand, without distortion, any stresses imposed during transit and in service.

No filling of defects will be permitted unless specifically approved. All welds and joints in the tank shall be completely liquid tight. Adequate access shall be provided for the inspection and painting of all external surfaces.

10. CABLE BOXES

Cable boxes with a degree of enclosure IP54 and terminals on the HV and LV sides of each transformer are preferred where practicable. Control terminal boxes shall be a minimum of IP54

The cable boxes shall be provided with gland plates of ample dimensions to accommodate mechanical cable glands for the cables and, where single core cables are terminated, shall be non-magnetic.

The cable boxes shall be of adequately sized to permit termination of the cable tails without imposing undue strain on the terminal bushing in any direction.

11. OFF-LOAD TAPPING SWITCH

Each transformer shall have an externally operated off-load tap changer switch, designed to withstand the effect of short circuits. The continuous rating shall not be less than the short time overload rating of the transformer.

The tap changer mechanism shall come to rest only when the switch is making full contact. Clear indication shall be given to the ratio at which the transformer is operating, and approved means shall be provided for padlocking the tap changer switch mechanism in the positions corresponding to each voltage ratio.

12. POSITION OF FITTINGS

Transformer fittings such as thermometer, rating plate, etc. shall be easily visible from one end or side only of the transformer.

13. THERMOMETERS

A pocket for a non-mercury thermometer to measure the cooling liquid temperature at the top of the transformer shall be provided on all transformers.

14. CONSERVATORS AND GAS AND OIL ACTUATED RELAYS

All transformers above 2.5 MVA shall be fitted with a conservator and Buchholz relay.

The transformer shall be fitted with a two-float gas and oil actuated relay fitted in the pipe between the conservator tank and the main tank.

The device(s) shall be fitted with two glass windows, one each side of the float, to facilitate the checking of the oil level.

The above devices shall be connected by armoured multicore cables to a terminal board installed in the transformer marshalling box.

A copper pipe shall be connected between the gas release point on the devices and an acceptable position at approximately 1.5m from ground level, fitted with a release cock so that samples of gas may be obtained safely whilst the transformer is energized.

When more than one device is fitted the surge trip and gas alarm contacts shall be routed separately to the marshalling box.

A pet cock shall be provided on the device to permit the hydraulic testing of the trip contacts by injecting compressed air.

15. OVERTEMPERATURE PROTECTION

All transformers above 2.5 MVA shall be fitted with oil temperature alarm and trip facilities.

One maximum reading, thermometer fitted with two sets of contacts for Oil Temperature alarm and trip shall be provided for measuring the oil temperature at the hottest spot. Additionally, a free moving, hand reset pointer to indicate the highest temperature reached shall be provided.

16. CONTROL CUBICLES, MARSHALLING KIOSK AND CABLING

Where Buchholz and/or oil temperature alarm and trip are provided a weatherproof marshalling kiosk having two substantial pad lockable handles shall be fitted for cable marshalling purposes. Interface cabling terminals shall be provided in the marshalling box for all outgoing control and indication cables.

All interconnecting power and control cables between the marshalling kiosk and the transformer equipment shall be supplied.

All cubicles shall be provided with anti-condensation heaters.

17. PROVISION FOR HANDLING

Approved lifting lugs shall be provided on the transformer to facilitate handling by crane. Jacking plates shall also be provided for lifting and jacking the complete transformer.

18. EARTHING

The core, tank covers, and radiators shall be earthed by means of substantial connections to the tank. Cable boxes, gland plates and any metal not intended to be live shall also be effectively bonded to earth. 12mm threaded welded stud tank terminals

shall be provided for connection of transformer parts to the tank and to the substation earthing system.

19. AIR COOLED TRANSFORMERS

Recognized technical regulations apply to the design, in particular editions of the following specifications and standards currently valid: -

- IEC 60726 Dry type power transformers

Where approval has been given by the Purchaser for the use of an air-cooled transformer the following conditions shall apply:

- The transformer shall be housed in an IP20 minimum enclosure with adequate cooling louvers. Alternately the transformer can be installed inside a specifically built structure such as a three-sided block or brick enclosure with a wire caged front.
- Access in either method shall be interlocked so that entry to the enclosure can only be gained when the controlling circuit breaker is isolated and circuit earth selected
- For either method special attention should be paid to the de-rating of the transformer for cooling purposes. AN type cooling is preferred, other types should be identified to EMIRATES STEEL and agreed on a case by case basis.
- The transformer shall be fitted with temperature devices embedded in both the HV and LV windings operating a thermal protection relay
- Both HV and LV windings shall be insulated by vacuum impregnated cast resin
- The transformer shall be convection cooled only
- The enclosure make up air shall be filtered to avoid the build-up of dust on horizontal surfaces

5.10 MOTORS

5.10.1 GENERAL REQUIREMENTS

1. FIELD OF APPLICATION

This section describes the design, construction and functional requirements for electric motors.

2. STANDARDS AND SPECIFICATIONS

Recognized technical standards, specifications and regulations and in particular, up to date editions of the following shall apply to the design:

- IEC 60034; Recommendations for Rotating Electrical machinery
- IEC 60072; Dimensions and Output ratings for Rotating Electrical Machines

- IEC 60079; Electrical Apparatus for Explosive gas Atmospheres

3. CONDITIONS FOR INSTALLATIONS

The motors shall be able to withstand all environmental conditions, even when installed outdoors, without any additional protection.

If additions such as shields or roofs for protection against rain (e.g. for V1 motors) or other auxiliary aids (e.g. flange drainage drilling for V3 motors) are necessary to meet these installation conditions then the costs of such additions shall be included in the unit price for such motors.

4. GENERAL DESIGN REQUIREMENTS

a. CASING

Cast iron casing with cooling fins for smaller types and sheet steel casing with either cooling fins or tubular cooling for larger types of motors shall be provided.

Corrosion proof screws shall be used for the attachment of all parts to the outside of the motor casing. All parts liable to corrode shall receive a corrosion proof base and cover coatings of protective paints.

Minimum enclosure protection: IP 54 (see below for terminal boxes).

b. TERMINAL BOXES

All terminal boxes shall fully meet the protection requirements of IP 55. Sealing gaskets if used shall be attached firmly to a part of the terminal box.

All connecting terminals, including the earth terminal shall be clearly identified.

c. BEARINGS

In so far as it is technically possible, roller bearings are preferred. The guaranteed life of each bearing shall be at least 30,000 operating hours.

Each motor with sliding or non-fixed roller bearings shall have a thrust bearing or other location guide, to allow the motor to be test run in an uncoupled condition.

Where circulating shaft currents may occur the coupling face and bearing pedestals if provided shall be insulated to prevent shaft and bearing circulating current flow.
Where motors are powered by variable speed drives, provision shall be made to minimise cavitation due to circulating high frequency currents. Larger drives, above

100 kW shall have insulated bearings. For main drive motors, shaft earthling brush shall be provided to prevent circulating current flowing to the connected equipment/load.

d. LUBRICATION

Lubrication for standard low voltage AC motors is to be by standard grease nipple, mill motor lubrication is via dedicated oil lubrication system

e. LIFTING LUGS

All motors weighing above 25 kg shall be equipped with lifting lugs.

f. MOTORS FOR HAZARDOUS AREAS

Motors designed in accordance with special requirements of IEC 60079, shall also have explosion proof temperature monitors and explosion proof anti-condensation heaters.

g. CLASS OF INSULATION

Insulation shall be to class F and the temperature rise shall be limited to that for class B.

All motors, irrespective of duty, shall have insulation immune to the high frequency switching pulses of variable speed drives.

h. MOTOR SPEED

High speed (>4 pole) motors shall be avoided. If it is not technically possible to use low speed motors, a justification for selecting high speed motor shall be made to the Purchaser.

The rotors of high-speed motors must be dynamically balanced complete with the fan and half coupling.

i. TEMPERATURE MONITORING

All high voltage motors, slip-ring motors, motors for hazardous areas and low voltage squirrel cage motors above 75 kW or for critical drives shall be equipped with a minimum of three embedded thermistors in the stator winding and temperature monitoring devices for alarm and protection.

5.10.2 LOW VOLTAGE AC MOTORS

1. OPERATING CONDITIONS

All motors shall continue to deliver their rated output at rated speed at simultaneous voltage and frequency changes of ±5% (voltage and frequency not moving in opposite senses simultaneously).

For each motor the number of starts and the time the motor is on load shall be considered in the selection of a suitable motor.

Each fixed speed motor shall be capable of withstanding locked rotor conditions with full starting current at rated voltage for a time which exceeds by 50% the normal run up time of that motor and its driven plant. As a minimum this withstand time shall be 10 seconds for a cold motor.

Motor windings and shafts shall be designed for direct online starting.

2. COOLING

Fixed speed motors shall be totally enclosed type, surface cooled with cooling fins and an enclosed cooling fan on the motor shaft (TEFC).

Fans shall be bi-directional so that cooling is independent of direction of rotation and they shall be made of non-rusting and no-sparking material.

Variable speed motors of constant torque characteristic will require separate cooling for running below nominal speed. Variable speed motors of quadratic torque characteristic should normally not require separate cooling for running below nominal speed, the decision being made on a case by case basis. Where additional cooling is installed, failure of the cooling drive shall instigate a delayed shutdown of the motor.

3. MOTOR TYPES

Low voltage AC motors shall be usually standard squirrel cage motors. In certain applications, slip ring motors or special motors (e.g. synchronous motors, servo motors) may be required.

If other than squirrel cage motors are proposed, full technical details shall be provided, and their use agreed upon with the Purchaser in advance.

All fixed speed motors exceeding 400 kW shall be medium voltage motors unless agreed otherwise in advance for specific processes with the purchaser

5.10.3 HIGH VOLTAGE AC MOTORS

1. OPERATING CONDITIONS

The motors shall continue to operate properly at simultaneous voltage and frequency changes of ±5% (Voltage and frequency not moving in opposite senses simultaneously).

Motors shall be suitable for direct online starting and shall be capable of starting three times in rapid succession in any one-hour period when cold and two times successively after first having reached the designed maximum temperature rise. In this (warm) condition, the first start shall begin 1.5 seconds after switching off and the second start 5 minutes thereafter.

Start interval protection relays shall be provided complete with any necessary timers or sensors to ensure these conditions are not exceeded.

Each motor shall be capable of withstanding a locked rotor conditions with full starting current at rated voltage for a time which exceeds by 50% the normal run up time of that motor and its driven plant. As a minimum this withstand time shall be 8 seconds for a cold motor.

Motor windings and shafts shall be designed for direct online starting.

Motors over 800 kW shall be designed and equipped for reduced voltage starting or be slip ring motors. The voltage drop at the switchgear busbar caused by direct online starting of motors shall be limited to max. 5% upon switching on.

2. COOLING METHODS

Motors shall have a cooling system of IC 0141 in accordance with IEC 60034-6.

3. STANDSTILL HEATING

In order to prevent condensation inside motors when stationary a built-in anti-condensation heater shall be provided for each motor. Energizing such a heater shall only be possible when the motor is switched off and stationary. The heater voltage shall be 110V AC.

4. BEARING SUPERVISION

Motors shall be equipped with measuring probes or pockets for monitoring bearing temperatures for pedestal bearings and other types of bearings where appropriate.

5. RUNNING HOUR METER

A running hour meter shall be provided for each motor.

5.10.4 MILL MOTORS

1. OPERATING CONDITIONS

Mill motors of every size shall be suitable for variable speed operation up to the designed maximum speed.

The motors shall meet the following requirements:

- Shunt connected excitation system (from separate converter).
- Insulation and bearings suitable for thyristor or other electronic device control.
- A minimum of six stator winding embedded thermistors plus pocket bearing temperature senders.

Each motor shall be selected to meet individual operating requirements and the following conditions:

- At operating speeds below full speed the heat dissipation rate shall keep temperature rises within the limits defined in IEC 60034.
- Suitable for either direction of rotation.
- Provision for installing and driving a tacho-generator or other items if required such as impulse generator, brakes, centrifugal switch or other items.

2. PERFORMANCE

The main drive motors shall be capable of carrying overloads defined in Part B Section 41 of NEMA Standard MG1-23 i.e.: -

- 115% of rated load continuously at rated voltage throughout the speed range.
- 125% of rated load for 2 hours at rated voltage throughout the speed range.
- The following momentary (1 minute) loads:

% of Base Speed	% of Rated Load	
	Occasionally Applied	Frequently Applied
100	200	175
200	200	160
300 or over	175	140

Other Mill motors shall have the following momentary (1 minute) loads: -

% of Base Speed	% of Rated Load	
	Occasionally Applied	Frequently Applied
100	150	140
200	150	130
300 or over	140	125

3. COOLING AND VENTILATION OF MAIN DRIVE MOTORS

The motors shall have cooling and construction codes designated in IEC 60034 IC81W (ICW37A81) or IC616 (IC0661) with a minimum degree of enclosure IP54. Other cooling methods shall be subject to approval by the Purchaser.

Each main drive shall be served by its own dedicated heat exchanger and cooling fan. Group cooling of motors is not acceptable. The flow of cooling water through the heat exchanger shall be controlled according to the motor temperature.

Precautions shall be taken against electrical damage caused by cooling water leakage.

All covers shall be arranged for easy removal should the air-cooling system fail. Make-up air shall be filtered.

Cooling air circulation shall not rely on armature rotation.

4. HEATERS

Internal low temperature 110V AC heaters shall be fitted in all motors identified as having significant down time periods greater than 24 hours. The heaters shall be installed in the lower half of the motor and shall have their own terminal box with an undrilled gland plate and marked 'HEATER'. The heater shall be interlocked so that the heater is switched off when the motor is running. Alternatively, this motor heating function can be provided from the VSD if available.

5.11 Convertors

5.11.1 GENERAL

1. FIELD OF APPLICATION

This section describes the design, construction and functional requirements of IGBT/IGCT/ Thyristors converter units for the supply to speed-controlled motors, operating either in 2 or 4 quadrant mode without circulating current.

2. STANDARDS AND SPECIFICATIONS

Recognized technical standards, specifications and regulations and in particular up to date editions of the following shall apply: -

- IEC 60146-1-1; Semiconductor converters, specifications of basic requirements
- IEC 60146-1-2; Application Guide

The effect of semiconductor switching on power supply quality shall be strictly controlled in compliance with Engineering recommendation IEC 61000 and current regulations and standards on Electromagnetic Interference (EMI).

High frequency switching pulses shall be blocked from interference with adjacent equipment and their effect on motor bearing erosion reduced to an acceptable level.

5.11.2 DESIGN

1. OPERATING CONDITIONS

Converter units shall be suitable for installation in air-conditioned electrical stations with a maximum temperature of 40ºC.

2. GENERAL ELECTRICAL DATA

Main drives shall comprise cycloconverter or VVVF Inverter (12 pulse) fed synchronous AC motors. DC Drives and DC motors shall be limited to special installations where alternative AC applications are unsuitable.

All units shall be suitable for a three phase, 50 Hz supply and shall incorporate microprocessor based digital control for variable speed drive applications. The units shall include also extensive monitoring, diagnostic and fault sensing circuits.

The power semiconductor devices be they GTO thyristors, IGCTs, IGBTs or other shall be already tried and tested in a heavy industrial environment and proved to be reliable in continuous use.

3. CONSTRUCTION

Converters shall be of modular design. One or more prefabricated converter units shall be mounted in a complete floor mounted sheet steel cubicle with a minimum degree of enclosure of IP21. The thyristor modules shall be mounted in permanently segregated compartments with the necessary space for inserting additional equipment.

The cubicles shall be suitable for installing either 'away from the wall', 'back to back', or 'at the wall'. Cable connection compartments shall be accessible from the front. The cubicles shall have openings in the base to accept the number of cables necessary.

Depending on service requirements the cubicles shall include the following:

- Feeder panels
- Power electronics with data control and gate firing electronics.
- Performance extensions including commutation choke.

a. FEEDER PANEL

The panel shall accommodate the AC control transformers, the auxiliary voltage outgoing circuit protection, control switches and control equipment and for smaller drive units also the circuit breaker and converter power transformer.

The field converter and optional equipment to suit the plant or drive application extensions shall be located in the same panel.

b. CONTROL EQUIPMENT

This cubicle(s) shall accommodate the power rectifying/inverting and suppression circuit components of thyristors with heat sinks, impulse transformers, chokes, capacitors and resistors together with the gate pulse and other digital control systems. The equipment shall be easily accessible and replaceable without disturbing the other components. The instrumentation shall be housed in a compartment in the upper part of the cubicle.

c. COOLING AND VENTILATION

Converter units having a full load rated output current of 100 amps or more shall be force ventilated and below this they shall be designed for continuous operation with natural ventilation. The ventilation fans shall have a protective cover. The noise level of such equipment shall be kept to acceptable level. If the combined noise level of all drive cooling fans is greater than 75dB then the converter units shall be installed in a separate room isolated from areas and equipment that are manned on a frequent basis such as PLC's and server rooms.

Water cooled Drive system are preferred for Main Drives.

Force ventilation shall be high integrity, with preference given to redundant systems. Forced air shall be filtered. Blocked filter alarms shall be fitted with remote indication

d. PROTECTIVE GROUNDING CONDUCTOR BARS

A protective conductor shall be taken to all compartments or their cables connecting areas along the entire length of the converter panel. It shall be properly and firmly connected both electrically and mechanically to all panels.

e. CONTROL WIRING

Control wires leading from cubicle to cubicle shall be in separate compartments accessible from the front of the switch equipment.

If control voltage bus bars are provided these shall be contained in separate compartments.

All terminals for outgoing control wire connections shall be suitable for accepting wires with a cross section of at least 4 mm^2.

f. CABLE CONNECTION COMPARTMENTS

For cable connection compartments adequate space shall be provided to have good access for the connection of cables from the front of the panel. Permanent fixed lugs shall be provided suitable for accepting the cables in each cable connection compartment.

Laying and wiring of cables as well as modifications to cabling within the panels shall be possible without danger, provided necessary safety precautions are observed during plant operation.

Sufficient mounting bars shall be provided inside each cable connection compartment for the attachment of cable clamps.

g. GENERAL TECHNICAL REQUIREMENTS

The units shall operate without interference for supply voltage fluctuations of -5% to +10% and for frequency fluctuations of ±2%.

All semi-conductor protection fuses shall be equipped with ’fuse blown’ detectors wired to a terminal box for remote indication.

Converter equipment shall be suitable for current loadings at least up to 1.5 times the rated value frequently applied and short time overloads up to 2.5 times the rated value.

h. CONTROL

Control of VF drives shall be microprocessor based with local HMI for diagnostic purposes.

For communication links to other systems an international recognized standard bus (e.g. Profi-Bus) shall be used. Depending on the required data transmission speed either a single master or multi-master bus of the same system family shall be used.

System configuration and start-up, service, diagnostics, operator process communication and visualization for such system shall be implemented with a user-friendly software package. The drive control system shall be programmed with software using standard flow chart symbols. Operator panels shall be provided for each panel to display measured values, status, fault messages and to allow straightforward modification of parameters.

4. CONTROL VOLTAGE SUPPLY

The control voltage shall be supplied by a control voltage transformer. The control voltage shall not exceed 110V AC.

One secondary output terminal of each such control voltage transformer shall be grounded.

In the case of an external voltage supply, the control voltage shall be fed into a feeder panel of the switching equipment externally and be looped from panel to panel by internal connections.

A separate feed to each busbar section shall be provided.

The auxiliary contacts of all devices of the same circuit group, e.g. control voltage, main circuit breaker, thermal overload relays, alarms, space heater, electronic equipment supply, etc. shall be wired to group alarm terminals. The group alarms shall be connected to a common alarm monitoring system.

5. INSTRUMENTS

All instruments shall be installed such that they can be easily read. Analog instruments shall be 96 x 96 mm and accuracy shall be Class 1. Each drive unit shall have a V-meter, A-meter and speed indication. Alternatively, and energy meter reading current,

voltage and power functions with minimum character display height of 8mm and remote interface shall be provided.

6. SHORT CIRCUIT AND OVERCURRENT RELEASE FOR CIRCUIT BREAKERS

Adjustable short circuit and thermal over current releases shall be provided and installed directly at the circuit breaker to trip upon reaching the adjusted setting values required. Such adjustable releases shall protect all three phases and be interchangeable.

Adjustments of the releases shall be from the front without withdrawing equipment from the cubicle. For signal purposes, auxiliary switch contacts (1 NO, 1 NC) shall be provided.

The electronic short circuit and overload protection shall have following features:

- Instantaneous acting releases, giving a switch tripping time of approx. 20 ms.
- Time delayed releases for selective purposes with time delays adjustable from 100 from 500 ms.
- The time delay shall only come into operation when the associated circuit breaker is closed and fully latched in the on position. On closing a circuit breaker on to an existing short circuit condition, the release shall operate instantaneously.
- The thermal over current release shall not be time delayed and it shall be temperature compensated (from 0°C to 50°C). A change over contact shall be included for signal purposes. All releases shall be completely suitable for withstanding short circuit conditions even when time delayed.

7. VARIABLE VOLTAGE CONVERTERS FOR DC MOTORS

These converters shall be for 2 or 4 quadrant operation, as required.

Four quadrant operation shall be achieved by means of double converter connection without circulating current.

The converters shall form a composite packaged programmable drive unit with the DC motor. Each unit shall incorporate a microprocessor/PLC which shall monitor and control the functioning of current and voltage/speed regulators as well as processing the digital signal for the overall speed control system.

8. VARIABLE FREQUENCY CONVERTERS FOR AC MOTORS

Converters shall be fully digital controlled with operation based on the pulse width modulation (PWM) technique for AC motor acceleration and braking in both directions

of rotation. For drives that require a high dynamic performance a vector control shall be integrated in the regulation system.

The converters shall be cycloconverters, without an intermediate Dc bus, or VVVF Inverter (12 pulse) for conversion to frequencies significantly lower than 50Hz. Where higher frequencies are required, they shall comprise a line DC converter unit and an inverter unit which shall incorporate gate turn-off (GTO) IGBTs, thyristors or power transistors.

Preference will be given to low los conduction devices

The efficiency of such drive unit shall be not less than 97%. Such drive unit shall always maintain a low harmonic content of the voltage and the currents even at a low-level converter output.

The basic requirements for the variable frequency drives are same as described above in more detail for DC drives.

5.12 Lighting

5.12.1 GENERAL

1. FIELD OF APPLICATION

This section describes the design, construction and functional requirements for lighting and small power equipment.

2. STANDARDS AND SPECIFICATION

Recognized technical standards, specifications and regulations in particular up to date editions of the following shall apply:

- IEC 60598 - Luminaires - General requirements and tests
- VDE 0710 - Luminaires with operating voltages below 1000V
- VDE 0712 - Specifications for accessories for hot and cold cathode fluorescent lamps with rated voltages up to 1000V
- DIN 5035 - Artificial lighting of interiors

5.12.2 LIGHTING

1. ILLUMINATION LEVELS

Lighting shall be designed to adequately meet the minimum requirements for levels of illumination listed in the following tables. Lighting calculations shall be based either on the efficiency grade or spot illumination method. An average reflection factor for a brightly illuminated space shall be assumed.

The calculated illumination levels shall exceed the nominal illumination levels as listed below. A factor of 1.43 according to DIN standard shall be considered for the calculated illumination level. Such factor shall consider the average lamp aging and dirt accumulation during operation.

	NOMINAL ILLUMINATION LEVELS
STEEL PLANT	
Melting Bay	120 Lux
Metallurgical Bay	120 Lux
Casting Bay	120 Lux
Platforms	120 Lux
Continuous Caster	250 Lux

	NOMINAL ILLUMINATION LEVELS
ROLLING MILL	
Reheat Furnace Area	250 Lux
Rougher/Edger Area	250 Lux
Finishing Mill	250 Lux
STORAGE AREAS	
Outdoors	15 Lux
Indoors	120 Lux
Indoors for small parts	250 Lux
TRANSPORT AND LOADING AREAS	
Conveyor belts	30 Lux
Transfer towers	60 Lux
Screening plants	120 Lux
Reloading point, general	30 Lux

Loading point	120 Lux

OTHER AREAS

Pump house	250 Lux
Outdoor pumps	60 Lux
Compressed Air Stations	120 Lux
Water Treatment Plants	120 Lux
Oxygen & Gas Plants	120 Lux

TRAFFIC ZONES

Street leading through Plant	5 Lux
Parking lots	12 Lux
Traffic routes	5 Lux

ELECTRIC STATIONS

Electric Rooms, Control Rooms	250 Lux
Computer Rooms	500 Lux
Outdoor switching equipment	30 Lux
Transformers Rooms (closed)	60 Lux

CONTROL ROOMS

Central Control Room, Observation Room	500 Lux
Other Control Rooms	250 Lux

OTHER ROOMS IN THE BUILDING

Construction and Drawing offices	1000 Lux
Other Offices	500 Lux
Social Rooms and Storage Rooms	120 Lux

WORKSHOPS Mechanical

Machining, rough medium precision tasks	300 Lux
Machining, high precision tasks	500 Lux
Welding	200 Lux
Assembly low precision	200 Lux
Assembly medium precision	300 Lux
Assembly high precision	500 Lux
Motor car workshops	300 Lux
Repair shops for small machines and appliances	500 Lux
Sub-assembly of heating and ventilation systems	200 Lux

Electrical

Assembly tasks, winding of coils and armatures with heavy gauge wire.	300 Lux
Assembly of telephones and small motors, winding of coils and armatures with medium gauge wire.	500 Lux
Assembly of high precision parts and of electric components	1500 Lux

Woodworking

Bench work, gluing, assembly	300 Lux
Work at woodworking machines, turning, chamfering, etc.	500 Lux

2. MINIMUM DESIGN REQUIREMENTS

a. LIGHTING FIXTURES

- **DISCHARGE LAMPS**

  Areas with a high headroom (steel and rolling mills, halls, storage rooms and parking lots) and street lighting shall be equipped with compensated sodium vapour lamps. Areas with a very high headroom shall be equipped with compensated sodium high pressure lamps. In the steel plant areas, only sodium lamps shall be used. Care shall be taken that the illumination in one complex is standardized. Mercury vapour lamps shall each have a rating of 400W for standardization purposes. For high-pressure sodium lamps 1000W is acceptable.

- **FLUORESCENT LAMPS**

  In open mill areas, fluorescent lighting shall supplement high bay lighting where required for specific task illumination and local area lighting.

  Air-conditioned rooms shall be equipped with fittings having white or white deluxe fluorescent lamps luminous flux 2400 lm. In rooms with an ambient temperature of over 30ºC amalgam-fluorescent tubes shall be used.

  Lighting ballast shall be high frequency electronic with power factor correction to 0.95 minimum.

- **PORTABLE TASK LIGHTING**

  Portable task lamps, each with a battery charger and battery of a suitable capacity for operating the search light for three hours without recharging, shall be provided and installed in electrical rooms and control rooms.

- **GENERAL REQUIREMENTS**

  All lamps and light fittings shall have a protective safety glass, non-flammable plastic or mesh covering. With the exception of offices, luminaires shall have a protective enclosure against dust, and where necessary water jets and spray.

  For the illumination of control rooms and pulpits, twin fluorescent tubes in anti-glare fittings shall be provided complete with dimmer switches. The number and distribution of points of lights shall provide a uniform level of illumination

  For external building illumination, lighting fixtures with high-pressure sodium lamps shall be used mounted on galvanized poles or wall mounted fixings at a height of about 10m. Wherever possible, lights shall be attached to building structures in preference to lighting poles.

  In areas with mobile plant, illumination level shall be 50 lux minimum with flood lights attached to building structures or high towers using HPS.

  For the illumination of special working areas and platforms, either twin fluorescent fittings or 250W floodlights shall be provided.

b. EMERGENCY LIGHTING

Emergency lighting shall be provided for:

- Production Areas
- Control and Observation Rooms
- Analysis Areas
- Transformer and Electrical Rooms
- Machine and Pump Rooms
- Workshops
- Stairways and Walkways.
- All emergency exits
- routes and muster points

The emergency lighting in each of the areas and rooms listed above shall be sufficient to provide safe egress.

In the event of power supply failure, the emergency lighting shall changeover to emergency battery power with a minimum autonomy time of 3 hours. The use of fittings incorporating their own battery packs and inverters is preferred to a central emergency battery system.

c. DISTRIBUTION PANELS FOR LIGHTING AND SMALL POWER

The power supply for lighting and socket outlets shall be from a number of wall mounted secondary distribution panels installed at various key points inside the plant areas. These panels each enclosed in sheet steel cabinets with lockable doors and two compartments for normal and emergency power supply (if applicable), shall be equipped with main circuit breaker, miniature circuit breakers (MCBs), contactors, switches, etc. The degree of enclosure shall be IP 54.

Distribution panels feeding the larger groups of lighting fixtures shall be switched by means of step contactors operated by pushbuttons. Such larger circuits shall also be equipped with earth leakage circuit breakers (RCBOs).

Timers or photo electric control (PEC) units controlling groups of luminaires shall operate via lighting contactors. Direct switching shall be used only when the PEC unit is integral with the luminaire and is used for switching that luminary.

The control voltage shall be 110V AC maximum.

d. INSTALLATION

Easy access shall be provided for all fixtures in such a way that cleaning of fittings and changing lamps can be carried out without danger.

Lighting fixture brackets, supports and other necessary items such as lighting columns and bases shall be made of galvanized iron or galvanized steel.

e. LIGHT SWITCHES

Each outdoor lighting group (for plant areas also) shall be switched automatically by a twilight switch. Indoor lighting shall be switched manually at entrances. For larger groups of lights, push-button operated contactors for step switching shall be included.

f. ENCLOSURE PROTECTION IN POTENTIALLY EXPLOSIVE AREAS

In hazardous areas, lamps and fittings in accordance with VDE 0165, VDE 0170, VDE 0171 and IEC 79 shall be provided.

g. MATERIAL SPECIFICATIONS

- **GENERAL ILLUMINATION OF BAY AREAS**

  High bay reflector units in lightweight alloy housings with high pressure mercury vapour (HQL) 400W lamps or high-pressure sodium lamps with power factor correction, safety glass cover, connection box and separately mounted control gear shall be provided. The degree of protection for the light fittings shall be IP54 and shall be suitable for ambient temperatures of 70ºC. Special design shall be considered for areas with very high ambient temperatures.

- **ILLUMINATION OF ELECTRICAL SUBSTATIONS**

  Rapid start, diffused lighting luminaires with double lamps in a light alloy housing and suitable for continuous row mounting shall be provided. The light fittings shall be supplied with straight standard 40W fluorescent lamps. The degree of enclosure shall be IP20.

- **ILLUMINATION OF SOCIAL ROOMS, SMALL ROOMS, CORRIDORS, ETC. WITHIN THE PLANT**

  Luminaires for damp interiors with corrosion resistant plastic, flame retarding housings with one straight standard 40W fluorescent lamp shall be provided. The degree of enclosure protection shall be IP 65 and shall be resistant to aggressive reactants.

  The light fittings shall be provided with diffusers and, if required, with reflector and/or wire guard.

- **ILLUMINATION OF ROADS AND PARKING AREAS**

  Lighting poles of 10m height with street lighting fixtures for high pressure sodium (NAV-T) 250W lamps shall be provided. Lighting poles shall be the slip base type to enable easy replacement of the lighting pole assembly.

- **EMERGENCY ILLUMINATION IN ELECTRICAL SUBSTATIONS**

  Emergency standby luminaires each with individual battery charger and battery shall be provided. Each luminaire battery/inverter shall have 3-hour autonomy time. Each fitting shall be suitably designed to permit the lamp and battery to be removed from the charger and used as a hand lamp. The battery box shall

contain a fully sealed maintenance free nickel cadmium battery of suitably capacity. The degree of enclosure shall be IP54.

- **EMERGENCY AND ESCAPE WAY ILLUMINATION IN OTHER BUILDINGS**
  Emergency standby light units each with built in nickel cadmium battery and one fluorescent lamp of 9W for 3 hours capacity shall be supplied.
- **LIGHTING SWITCHES**
  Push buttons shall be rocker operated, momentary contact industrial type. The housing shall be made from resistant moulded plastic with a degree of enclosure of IP65.

5.12.3 POWER OUTLETS

1. GENERAL

All areas shall be provided with an adequate number of permanently installed power outlets for operational and maintenance purposes.

2. 220V OUTLETS

All offices, corridors, amenity areas and similar, workshops, substations plant, rooms and control rooms shall be furnished with twin 220V outlets, flush mounted in offices and control rooms, for the powering of office equipment, maintenance, test and cleaning utensils.

Outlets shall be spaced and positioned as to supply all anticipated equipment without trailing leads causing a hazard to personnel.

3. WELDING OUTLETS

380V outlets rated 32A and 63A, 3 phase with degree of protection IP54 minimum shall be installed throughout production areas at approximately 20m spacing and conveniently sited at production plant locations.

4. INDUSTRIAL OUTLETS FOR 110V HAND TOOLS

a. OUTLETS

Industrial outlets for 110V hand tool shall be installed in all substations, workshops and plant rooms. The outlets shall be type IEC 309-2/CEE 17 rated 16A with a two pole and earth pin configuration.

b. 110V DISTRIBUTION TRANSFORMER UNITS

110V distribution for portable equipment shall be supplied from a purpose-designed 110V transformer enclosure with an earth screen between windings and centre-tap earthed 55V0-55V secondary winding.

The transformer primary winding shall be switched by an enclosure mounted isolator. Outgoing circuits shall be protected by MCBs especially suited to protection of 110V centre tapped supplies.

5.13 Reactive Power Compensation

5.13.1 STANDARDS AND SPECIFICATIONS

The equipment design shall consider the site conditions as stated in Standard 05-010; Electrical Equipment and Engineering - General.

All equipment and services shall comply with recognised national and international standards such as those listed below.

VDE Verband deutscher Elektrotechniker (Institution of German Electrical Engineers)
IEC International Electrical Commission
DIN Deutsche Industrie-Normen (German Industrial Standards)

Also, all equipment services shall comply with ADWEA standards.

In particular, the design of the compensation and correction equipment shall comply with the following documents, or their national equivalents:

- IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
- IEC 61000
- Engineering Recommendation G5/4; Planning levels for harmonic voltage distortion issued by the Energy Networks Association in the United Kingdom
- Engineering Recommendation P28; Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment issued by the Energy Networks Association in the United Kingdom
- Engineering Recommendation P29; Planning Limits for voltage unbalance equipment issued by the Energy Networks Association in the United Kingdom

5.13.2 STATIC VAR COMPENSATION [SVC]

1. ELECTRICAL REQUIREMENTS

Network study need to be performed & to agree with the following power quality limits with TRANSCO.

Flicker level	Pst99
Harmonic voltage distortion	THD

Individual Harmonics	H2/H21
Power factor	Cos phi
Volt Unbalance	%
Volt Fluctuation	%

The Contractor shall seek confirmation of the above parameters before commencing his design.

2. PLANT AND SYSTEM DATA

a. SYSTEM SUPPLY CHARACTERISTICS

Rated voltage: 220 kV

Maximum deviation of voltage ± 5% from rated level:

System fault level: Single Phase/Tree Phases to be agreed with TRANSCO

Rated frequency: 50 Hz ±2%

b. 33 kV-SYSTEM

Rated voltage 33kV

Step Down transformer: 220/33kV

Tap changer: On load

3. SVC-SYSTEM

a. High Frequency Switching System

The Voltage Source Controlled VAR Compensation system shall be installed to fulfil the agreed power quality levels with TRANSCO.

b. Voltage Source Converter

Voltage Source Converter (VSC) is based on transistors, so called IGBT's (Insulated Gate Bipolar Transistor). The converter and its transistors which are extended to power range of the converter in order to be suitable for the Flicker Compensator application.

A VSC is built up by an AC side, connected to the bus, and a DC side, connected to a capacitor bank. The capacitor provides enough energy for the converter to meet the most severe transients on the bus, which is an important source of flicker.

The converter is connected to the bus via a phase reactor. This reactor is of the same air core type, which is used for conventional harmonic filters and SVC's.

One advantage with the Voltage Source Converter is that it can instantaneously produce both capacitive and inductive reactive power. Since the furnace requires capacitive reactive power only, capacitor filter banks are connected in parallel with the converter, to provide a suitable reactive power offset. The filters banks support the converter in reducing harmonics on the furnace bus as well.

The compensator shall be built up of the following main components:

- VSC consisting water-cooled IGBT valve, DC capacitors, and series reactors. The IGBTs are cooled by means of water-to-water or a water-to-air heat exchanger.
- Filter capacitor banks.
- Control and protection equipment.
- MV Power distribution equipment.

c. Cooling System

The VSC valve shall be water cooled by means of a cooling system consisting of a pump unit with an outdoor heat exchanger through which the heat losses are dissipated. The pump unit is equipped with one or two pumps, depending on the redundancy requirements. The fine water system shall consist of two circuits, the main circuit and the water treatment circuit.

The cooling liquid (de ionized water) shall be circulated by the centrifugal pump through the main circuit to the IGBT valve and the outdoor heat exchanger. A strainer ensures that the cooling liquid doesn’t contain any particles when it enters the IGBT valves.

Important data of the fine water system shall be constantly monitored. Alarm and trip signals shall be given for flow, temperature, conductivity and expansion vessel water level. The flow in the water treatment circuit shall be visually indicated.

All parts of the fine water system in contact with de ionized water shall be made of noncorrosive materials to minimise the risk for corrosion and electrolytic effects as well as to keep the proper characteristic of the water.

d. Harmonic filters

With the total harmonic generation in mind, it shall be important to tune and rate the needed filters ensuring that for no situations a resonance mode will be hit where any significant harmonic generation by the furnace are present.

In specific, the furnaces generate 2nd harmonic currents. In absence of a 2nd harmonic filter a dangerous resonance will be the result, leading to possible transformer saturation, etc. The proposed 2nd harmonic filter is damped in order to, in a wide band, filter out the harmonics around the 2nd order. A special C-type configuration is here used for a reduction of the fundamental losses, which normally will be high in tuned damped filters for low harmonics.

The other proposed filters 3rd and high pass shall be needed for the filtering of the harmonics generated by the furnaces and from the VSC converter.

The total Mvar installed shall be divided between the different filters to yield the best performance. The proposed filter configuration will ensure that one of the main goals of the design work - that of avoiding the introduction of resonances – shall be met. The other main goal, to limit the harmonic distortion at PCC bus, will also be met with the proposed advanced SVC configuration.

e. Control and Protection System

Control and Protection system computerised and microprocessor-based control and protection system for industrial environment. System shall be complied with following functionality.

- Redundant controller
- Sequence of Events Recorder (SER) with 1 ms GPS resolution
- TFR functionality
- Build-in flicker indication function at EAF bus (at PCC as an option)
- Integrated protection functionality
- Prepared for Remote Access Service (RAS)
- Full graphical status presentation (HMI)

- Environmental proof controller cabinet
- GPS clock time synchronisation

A microprocessor-based control and protection system shall be complied with following features.

- High-speed digital programmable SVC Light control and protection system (duplicated for improved availability. One computer as hot standby).
- Optical interface for IGBT valve (Valve Control Unit)
- Operator Workstation (OWS)

Following protections shall be integrated in the system.

- Over voltage and under voltage protections for SVC Light
- Overcurrent, and overload protection for TCR – 2nd and 3rd filter bank
- Earth fault protection of SVC bus
- Overvoltage and unbalance protection for 2nd and 3rd filter Bank

f. Technical Data of Main Equipment VSC valve

Rated power	XX Mvar
Rated current for the IGBT	XXX A
Connection	1 x 3-phase
Cooling	Water
Erection	Indoor
Indoor temperature	+5 C to +40 C
Firing system	Fibre optic
IGBT type	XYZ FACTS
Standards	IEC 61954
Heat exchanger	
Cooling water (fresh) inlet	temp max 35 degrees C
IGBT cooling water (fine)	temp max 40 degrees C
Water circuit	closed
Water quality for IGBT cooling	demineralized, deionised
Standard	IEC
DC capacitors	

With internal fuses, discharge resistors (Within 10 minutes down to 75V), all-film technology, non-PCB, with star-point CT, assembled in racks and cans of stainless steel.

Cooling	Natural
Erection	Indoor
Standard	IEC 60871-1

VSC phase reactor coils

Type	air-core
Number of coils	3 x 1
Rated power, 3-phase	XXXX Mvar
Rated current	XXXX A
Cooling	Natural
Erection	Outdoor
Standards	IEC 60076-6

Filter circuits

Harmonic order	2nd 3rd	HPth
Rated voltage	XX XX	XX
kV		
Rated power	XX XX XX Mvar	

Filter capacitor

With internal fuses, discharge resistors (Within 10 minutes down to 75V), all-film technology, non-PCB, with star-point CT, assembled in racks and cans of stainless steel.

Cooling	Natural
Erection	Outdoor
Standard	IEC 60871-1

Filter reactors

Type	air-core
Number of coils	3 x 1
Cooling	Natural
Erection	Outdoor
Standard	IEC 60076-6

Filter resistors

Cooling	Natural
Erection	Outdoor
Standard	LatestIEC
Circuit breakers	
Type	SF6, Outdoor (LTB/D
recommended)	
Rated voltage:	XX kV
Rated nominal current:	XXXX A
Rated short time withstand current	XX kA
Capacitive Switching Class	C2
Standard	IEC 62271-100
Disconnectors with earthing switch	
Type	Vertical Break, Outdoor
Rated nominal current:	XXXX A
Operation	Manual
Standard	IEC 62271-102

5.13.3 BULK POWER FACTOR CORRECTION

Automatic power factor correction units shall be installed in the 11-kV primary substation to correct the power factor at 11 kV to 0.95 when the plant is running at maximum demand.

Power factor correction units shall be in automatically switched banks of maximum rating 500 kVA.

Power factor correction equipment at this level shall be installed in segregated areas

5.13.4 LOW VOLTAGE LOAD CENTRE COMPENSATION

The load center's shall be compensated either at the load center's or at the 11-kV distribution level.

Tuned filter circuits shall be used to reduce harmonics from inverters etc. and to eliminate parallel resonance.

The low voltage capacitors used in the tuned filters shall have internal discharge resistors, reactive power control units, contactors, cable terminals, etc. all completely housed in sheet steel panels. Alternatively, load centre panels may be used to house these items.

Rated voltage	3-phase, 50Hz voltage level to be advised by the Purchaser
Ambient temperature	40°C maximum in switch rooms

Protection class	minimum IP2x if installed in cubicles, otherwise shall be IP40.
Reactive power per stage	50 kVA for low voltage units.

5.14 Installation

5.14.1 GENERAL

1. FIELD OF APPLICATION

This section applies to the installation of electrical equipment.

2. SPECIFICATIONS AND REFERENCE MATERIAL

Recognized national and international technical standards, specifications and regulations, in particular up to date editions of the following shall apply:

- IEC 62305 - Protection against lightning
- IEC 60364 - Electrical Installations of Buildings
- VDE 0165 - Installation of electrical apparatus in hazardous areas

- Industrial Safety Standards and Codes
- IEEE Std. 142 (The Green Book) Grounding of Industrial and Commercial Power Systems

3. PROTECTIVE MEASURES

Protective measures shall be strictly in accordance with the standards listed above in section 1.2 above.

4. PROTECTION AGAINST CORROSION

All fixings shall be proofed against corrosion by their construction or by the application of permanent protective coatings. Connections between dissimilar materials shall not be the cause of corrosion through electrolytic action.

5. COLOUR CODING OF CONTROL EQUIPMENT

Control Equipment and Indication Lamps, pushbuttons, illuminated pushbuttons and indication lamps shall be colour coded according to IEC 60073. Illuminated push buttons shall not be used for EMERGENCY STOP purposes.

6. COLOUR CODING FOR CABLES, CORES AND CONDUCTORS (WIRES)

Colour coding shall be in accordance with current standards. Cabling or other equipment using colour codes that are no longer to current practice shall not be used. The earth core of any cable shall always be green yellow. In exceptional cases and after approval from EMIRATES STEEL, the colour coding of the protective conductor can be done with green/yellow PVC-sleeves.

For both HV and LV-cables the following cable outer sheath colour coding shall be adhered to strictly:

- High Voltage Power Cable -Red
- Low Voltage Power Cable -Black
- Control, Telephone, Intercom, etc., Cable -Grey
- Fire Alarm System Cable –red
- Intrinsically safe cable - blue
- Special Cables for High Temperatures -Red or white

5.14.2 INSTALLATION OF CABLES AND ELECTRICAL EQUIPMENT

1. CABLE SIZING AND INSTALLATION

All cables and cabling installations shall comply in respect of materials and installation practices with all requirements laid down in the standards, specifications and regulations listed for each individual application, irrespective of whether such requirements are specifically referred to in this document.

For sizing the cables, the current carrying capacity shall be reduced according to the method of installation and the ambient temperature. The Contractor shall present his calculations incorporating the derating factors used for the cable installation.

Cables or other wiring which unavoidably run parallel and close to hot pipes or other similar hot machinery or equipment shall be suitably protected in order to prevent damage to the cable insulation.

a. HIGH VOLTAGE CABLES

The selection of high voltage cables shall be according to the rated current multiplied by all derating factors, the network short circuit capacity and the fault clearance time.

The conductive material for all cables shall be copper. The insulation shall be cross linked polyethylene (XLPE) or ethylene propylene rubber (EPR). 33 kV and 11 kV cables shall be screened and single core or multi-core according to application.

Cable sheaths shall be zero halogen (LSOH) inside buildings.

The cables shall be armoured or otherwise fully protected against physical damage by rigid barriers.

b. LOW VOLTAGE CABLES

The conductive material for all cables shall be copper. The insulation shall be XLPE and single core or multi-core according to application.

Cable sheaths shall be LSOH inside buildings.

The cables shall be armoured or otherwise fully protected against physical damage by rigid mechanical barriers such as cable tray covers & conduits. Wire basket containment is not regarded as adequate mechanical protection.

c. SPECIAL CABLES FOR HIGH TEMPERATURES

For ambient temperatures exceeding 70°C silicon cables shall be used.

d. SPECIAL CABLES FOR THERMOCOUPLES

The cable type used shall be approved by the Purchaser.

e. PLC, CONTROL, ELECTRONIC, INSTRUMENTATION AND SIGNAL CABLES

Control cables shall be LSOH sheathed with the appropriate number of cores plus at least 20% spare.

Cables shall be specified according to duty, either as multi-core or multiple twisted pairs of conductors with a size between 0.75 mm^2 and 1.5 mm^2 including an overall screen. Analogue signal cables (e.g., signals 4-20 mA) shall be designed in accordance with VDE 0816.

f. CONTROL SYSTEM COMMUNICATION CABLES

The cable and fittings shall be as required by the control system manufacturer and subject to approval by the Purchaser. All cores shall be individually identified with numbers. Standard Field bus cabling shall be used with fibre optic over longer distances.

2. GENERAL INSTALLATION OF CABLES

In general, cable installations shall be carried out in one of the following three ways:

- **Class 1 - Flush/Concealed Installation:**

  For non-technical rooms such as offices, WC rooms, corridors and control rooms, an under-plaster plastic conduit system shall be installed. The system shall include all junction boxes for terminals, switches and socket outlets and contain all wiring of the lighting system.

- **Class 2 - Surface Mounted Installation:**

  In general, for switch houses, plant rooms, etc. a plastic conduit system, surface mounted with open bend fittings and detachable bend covers shall be provided. The

system shall contain cables of type NYY of similar for all system connection, lighting, socket outlets, etc. The equipment required for such an installation shall be of splash-proof design for surface mounting.

- **Class 3 - Surface Mounted Heavy Industrial Installation:**

  In general, for areas and rooms with severe environmental conditions such as melt shop, mill bays, workshops, cable cellars, hydraulic cellars and storage bays, etc. power cables of type NYY-J shall be installed either in hot dip galvanized protection conduits or armoured cable laid on cable racks. All terminal boxes, switches and socket outlets required for such installation shall be of moisture proof design.

3. UNDERGROUND CABLING

a. GENERAL

Underground cables shall normally be installed in buried multi-way duct banks. Installing the cables directly buried shall be limited to street lighting and some special applications and must be agreed well in advance with EMIRATES STEEL.

For underground cables either directly buried at an approved depth or cables in multi-way ducts directly buried at an approved depth an ambient temperature of 35°C shall be assumed.

Refer also to “EMIRATES STEEL Engineering Standard 03-090 of Civil & Structural Works Section 5.4”.

b. PREPARATION OF THE ROUTE

The cable route shall be marked out by the Contractor with materials furnished by him and in accordance with the installation plan.

For excavation and backfilling refer to “EMIRATES STEEL Engineering Standard 03-030 of Civil and Structural Works Section 2”.

c. LAYING MULTI-WAY DUCT BANKS

Refer to “Engineering Standard 03-090 of Civil and Structural Works Section 5.4.1”.

d. DIRECT BURIED CABLES

Refer to “Engineering Standard 03-090 of Civil and Structural Works Section 5.4.2”.

4. ABOVE GROUND CABLE INSTALLATION

a. GENERAL

Cables for above ground installation shall be armoured and laid in open cable racks, cable channels or single core in rigid galvanized steel conduits.

b. CABLE INSTALLATION ON CABLE RACKS AND CHANNELS

In case of more than ten cables running parallel in the same direction, galvanized cable trays shall be used. The trays shall be large enough to accommodate the required number of cables plus 25% spare for future use.

Cable ladders/trays for vertical and horizontal mounting shall be of hot dip galvanized type, 250-600mm in width with brackets for wall mounting.

The cable ways shall be fixed to suitable structures. For longer unsupported cable tray lengths U or double T steel shall be provided and fixed for such cable tray supports.

In vertical positions, the cable trays shall be mounted onto ladders at columns, pillars, etc. Parts likely to expand shall be attached firmly but provided with expansion joints. Expansion joints of ±10mm approximately every 8m shall be included for steel cable supporting accessories.

HV cable, low voltage power cable and control cable shall be always laid in separate groups. The distance between each group shall be not less than 300 mm. The minimum distance between two HV cables running parallel shall be not less than the diameter of the largest cable.

Single core cables in AC-systems shall be laid in trefoil formation and fixed with metallic bands to withstand the mechanical stress of a short circuit.

For the installation of power cables on cable trays or in channels only a single layer of cable shall be allowed. For control cables maximal three layers of cables are permissible. A minimum of 25% spare space shall be provided in conduits, trays and ducts.

The cables shall be laid with the necessary slack to permit expansion at expansion joint positions.

Cables shall be fastened to horizontal cable trays by LSOH clips and to vertical cable ways by means of double galvanized clips. In special cases cable clamps made from coated aluminium shall be used.

c. CABLE INSTALLATION IN CONDUITS

Within plant areas and buildings, the installation of cables in conduit shall be according to the standard of industrial good practice.

Protection pipes or conduits shall also be of hot dip galvanized steel with diameter of 16 to 37 mm. Only 70% of the inside diameter of conduits shall be used to accommodate cables. In exceptional cases up to three cables may be laid in one pipe.

All protective pipes and conduit installed above ground shall be fixed properly with suitable brackets.

If cable conduits are laid vertically a traction relief clamp shall be attached to support the cable at each 2m interval.

All protective pipes shall have PVC lips at the ends.

For extreme operating conditions, cables shall be installed in totally enclosed galvanized steel conduit. For areas with high ambient temperature, silicon cable with copper conductors shall be used.

5. LIGHTING AND SOCKETS

The changing of lamps illuminating the floor, runways or stages shall be possible without having to use large ladders. Only in cases where it is necessary or advantageous to install the lights higher up it is permissible to deviate from the normal height. However, the same height shall be kept for all lamps belonging to the same area or room.

Luminaires shall be connected individually via a connection box, which shall not be further than 1m away from the fitting.

For production and working areas socket panels IP54 shall be installed at a maximum spacing of 30m in production areas and 10m in workshop areas.

Power connection sockets shall consist of CEE round sockets (32A) 63A, five poles, if necessary, waterproof, which can be switched, and which have an interlocking device.

In rooms which require a specific number of sockets (e.g. the laboratories, workshops), the sockets shall be installed in accordance with the technological requirements along with the socket panels.

An underfloor system shall be installed in office rooms including auxiliary rooms. Four (4) sockets 110V and telecommunications connection sockets per office room (area max 20m^2) shall be provided. The sockets shall be installed in boxes flush with the floor.

Additionally, under every light switch a 110V, 16A socked shall be included. Sockets shall not be connected with the light circuits.

6. LABELLING AND MARKING

A circuit allocation plan showing circuit destination, contained in a plastic jacket, shall be attached inside every distribution panel.

All equipment installed by the Contractor shall be labelled in accordance with the drawings. Safety labels shall be installed at places required by local regulations. Design, layout and installation shall be in accordance with the relevant National Standards. Labelling shall be permanent and shall be securely fastened in position (not glued).

The cable numbers corresponding to the cable schedule shall be stamped into durable clearly legible label strips which shall be attached to all circuit and control cables installed at both ends of the cable. The label strips shall not be glued onto the cable. Individual cores of the cables must be marked with slide on ferrules at their termination.

5.14.3 INSTALLATION OF THE CABLES

1. TOOLS

All necessary cable rollers, tools and other aids for the installation of cables shall be supplied in sufficient quantity by the Contractor.

2. UNWINDING CABLES FROM CABLE DRUMS

Each cable drum shall be mounted on suitable cable jacks or stands with a horizontal spindle and brake to allow the drum to rotate as the cable is run out. After the cable drum battens have been removed the cable shall be carefully inspected for damage to the outside layer of cable.

When unwinding a cable, the drum shall be rotated by hand in order to avoid any tendency to stretch or tension the cable. Suitable arrangements for braking the cable drum when the cable is being run out shall be made to prevent any risk of runaway or dangerous kinks or loops forming in the cable.
In special cases and then only for shorter cable lengths the cable can be unrolled next to the cable trench then lifted and placed into the cable racks or trench when no drum jacks are available.

Dragging the cable along the ground shall be avoided in all cases.

When unwinding cable from a drum, care shall be taken especially when joints are necessary that the individual drum length are laid in the same direction, i.e. an E-end to meet the A-end of the next length, so that connection of similarly coloured or similarly marked conductors is possible within the joint.

3. LAYING OF THE CABLE

Each cable shall be led over cable rollers placed at distances of 1 to 4m to suit site conditions. At bends in the route, corner rollers placed in accordance with the minimum bending radius of the cable shall be used. A mesh stocking type or other approved type of cable grip for firmly but harmlessly gripping the cable shall be drawn over the end of the cable and held in place by a suitable binding. The traction rope shall be attached to the pulling eye of the cable grip. The cable end caps shall not be used for pulling under any circumstances.

The permissible minimum bending radius of each cable shall not be exceeded at any time while it is being laid.

If sufficient or no rollers are available, then the cable shall be supported at distances of 46m between supports by an acceptable substitute causing no harm to the cable.

Before drawing cables through the cable ducts (either multi-way or single pipes) checks shall be made to ensure that the ducts are clear. For pulling cables other than along a straight route an experienced Contractor’s supervisor shall be present to supervise the setting up of cable rollers at the corners in pulling-in points. The cables shall not rest on the edges at either ends of the pipe or multi-way ducts.

Pipes shall be flanged or a suitable base e.g. jute bolsters shall be pushed under the cable so that such packing lays flush and protects each cable from the edge of each pipe opening. The remaining cross section of each pipe shall be suitably sealed to prevent water or sand seeping in.

Cables in cable trenches shall be slightly snaked before and behind joint positions in order to accommodate any slight future ground settlement.

No more than 70% of the inside diameter of pipes and multi-way ducts shall be occupied by cables. Only one type of cable shall be laid in a duct, i.e. either HV cables or LV cables or control cables or telephone cables or signaling cables.

4. STRETCHING STRESS

Permissible pulling strain for unarmoured and steel armoured cables: -

- Outer diameter (Cables shall be pulled carefully.):
- Up to 15mm No stretching stress
- 16-30mm Approx. 250 kp
- 31-35mm Approx. 400 kp
- 56-90mm Approx. 700 kp

The pulling eye shall be attached to the conductors for cables with a metal sheath. Cables when pulled in by a pulling rope shall have the pulling-tension controlled by an inline dynamometer and when necessary the pulling tension shall be distributed along the cable at more than one point.

5. CABLE CUTTING

Cable ends shall be suitably protected by caps or other approved means after cutting. Each cable shall be measured for one length at a time and then cut. If joints are necessary in special cases, then these shall be entered into the cable installation plan and their positions measured and listed on the cable schedule.

Jointing of cables shall only be permitted where the route length exceeds maximum manufactured stock cable length that can be obtained. Where a joint occurs, for permitted reasons, the location shall be indicated with a permanent clearly visible durable site marker. Also, all joint locations shall be recorded in joints lists and clearly identified and positions shown by dimensioned sketches on all relevant cable installation drawings.

6. CABLE PROTECTION PIPES

At above ground cable outlets, cables shall be covered by a galvanized protective pipe (conduit), which shall extend at least 25 cm below and above the outlet. The inner diameter of each straight conduit shall be 25% larger than the cable diameter it is protecting and in the case of bent conduit, 50% larger than the cable diameter. Where there are several cables bunched through one such conduit, then the cable diameters shall be added arithmetically. Preferably 50 mm, 63 mm, 80 mm, 100 mm, 120 mm and 150 mm nominal size conduits shall be used.

If galvanized conduits are bent or widened cold, then the affected surfaces shall be painted afterwards with a cold zinc paste.

5.14.4 CABLE TERMINATIONS

1. HIGH VOLTAGE CABLES

The cable boxes or cable sealing ends for HV-cables shall be installed in full accordance with manufacturer's instructions. In the case of armoured cables the armouring shall be included in the protective measures. Cables shall be fully supported by a steel framework close to the termination. Cable ends and connections shall not be stressed by being pulled or by carrying weight and shall be completed in such a way that no dampness can penetrate.

2. LOW VOLTAGE CABLES

LV armoured cables shall be taken into the terminal box for a sufficient length to allow the armouring to be stripped back and connected to the grounding bolt in the terminal box. Copper screening tapes shall be cut off after passing through the terminal box gland and grounded.

Threaded type compression glands with rubber inserts to fit the cable diameter shall be provided to ensure that no dampness can penetrate into the terminal box.

Cables shall be fully supported by a steel framework close to the termination. Cables shall be terminated and clamped such that there is no pull on the terminals. Universal cable gland sealing rings are not permitted.

Screw type brass cable glands and fittings may be used in buildings or in closed rooms. Unused openings at terminal boxes, sockets, distributors, etc. shall be sealed off by a blind plug.

In the case of equipment installed in the open, cable entry shall be from below only.

At stations with an open cable cellar, the incoming cables shall be introduced to the switchgear through factory made cable openings. The opening shall be sealed air and watertight after the cables have been installed with fireproof sealant.

Each motor terminal box shall be connected in such a way that two outer conductors can be easily interchanged.

3. TERMINAL CONNECTIONS

Each control cable for motor control switchgear shall be flexible and connected to the withdrawable portion in such a way (sufficiently large loops) that there is no difficulty in moving the withdrawable portion from the operating position to the isolated/test position).

Every protective conductor connection shall be connected and clamped to the protective conductor bar in such a way that it is individually detachable without disturbing the other connections. This applies for all electrical equipment.

Every Neutral conductor belonging to an individual circuit shall be connected and clamped individually to the Neutral bar and be clearly marked to show that it belongs to a particular circuit.

Cables in panels shall be properly attached by means of suitable clamps.

In potentially explosive or hazardous zones all terminal connections shall be suitable and secure against self-loosening.

5.14.5 GROUNDING AND PROTECTIVE MEASURES FOR EQUIPMENT COMPONENTS

1. EARTH CONDUCTOR INSTALLATION

Earth conductor installation shall be carried out as follows:

- Trenches shall normally be excavated to a depth of 500 mm. After the earth conductors have been installed, such trenches shall be backfilled and sealed. Earth conductors around buildings shall be installed at a distance of one (1) meter from the foundations.
- Under streets, railroad tracks and paved surfaces, the earth conductor shall be laid in protective pipes or ducts.

- All grounding materials etc. insofar as not otherwise specified shall consist of copper with a lead type coating or similar for protection against corrosion where necessary.

All grounding connections below ground shall be by exothermic weld. Above ground they shall consist of two bolts and nuts made of hot dip galvanized or cadmium plated steel. Cadmiated washers shall be placed between the bolts and nuts.

Multiple connections of grounding conductors (at grounding busbars) shall be made above ground.

The metallic casings and frameworks of all individual items of electrical apparatus shall be connected with bare flat copper or round sheathed copper of adequate size to the grounding system.

For the grounding of distribution circuits for lighting and sockets fed from a common panel, the grounding of the panel is sufficient if the earth conductor of each distribution circuit is properly connected to the panel grounding bar using at least one washer and one spring washer at each connection point.

Grounding electrodes shall consist of flat copper mesh or interconnected vertical copper clad steel rods.

Building reinforcement shall be equipped with grounding rods in accordance with DIN 18014. The reinforcement grounding conductor shall be connected to the copper grounding system either by exothermic weld or above ground bolted corrosion proofed connections.

Where grounding conductors consist of stranded copper wire these shall be mechanically protected by a thick walled galvanized protective pipe at those places where such conductors come above ground.

2. GROUNDING AND PROTECTIVE CONDUCTOR CONNECTIONS

a. CABLES

For high voltage motors the copper screening wire of the HV cable to each motor shall consist of copper cross section capable of withstanding the maximum earth fault current without excessive temperature rise and be connected to the protective conductor terminal in the terminal box of the motor and to the common protective grounding system in the associated substation.

LV cables shall be earthed through the armouring or by a separate circuit protective conductor (CPC) capable of withstanding the maximum earth fault current without excessive temperature rise. The measure impedance shall be sufficient to ensure correct operation of protective devices within the maximum time specified by applicable standards.

The minimum size of CPC shall be 4 sq. mm.

b. LIGHTING DISTRIBUTION

When electrically insulated equipment components (joint boxes, terminal boxes) are used, then adjacent conductive parts (e.g. supporting structures, lighting posts) shall also be included in the protective grounding measures by their connection to the protective grounding conductor.

3. PROTECTION AGAINST LIGHTNING

Buildings and equipment shall be equipped with lightning protection equipment in accordance with IEC 62305; Protection against lightning.

5.15 Testing

5.15.1 TESTING AND ACCEPTANCE AFTER COMPLETED ASSEMBLY AND INSTALLATION OF ELECTRICAL EQUIPMENT

1. **GENERAL**

a. FIELD OF APPLICATION

This section describes the extent and types of tests and acceptance checks to be carried out by the Contractor following erection and installation of electrical equipment at site. The tests stipulated shall be taken as minimum requirements that can be extended at any time. The relevant safety rules, safety procedures and safety precautions shall always be observed and applied.

b. SPECIFICATIONS AND REFERENCE MATERIAL

Recognized technical standards, specifications and regulations and up-to-date editions of the following shall apply for carrying out tests:

- DIN VDE, in particular VDE 0100
- IEC, in particular, IEC 60364; Electrical Installation of Buildings
- Applicable Industry Safety Standards and Codes

5.15.2 TESTS

1. COMMISSIONING TEST PROCEDURES

a. GENERAL

All commissioning tests shall be described in a pro forma list with a check box. The box shall be checked with a tick (√) for the satisfactory completion of the test and a cross (X) for an unsatisfactory outcome of the test. N/A shall be inserted in the box if the test is not applicable.

A second box shall be provided for test results and measurements. A third box shall be for comments.

The pro forma sheets shall have space for the approval signatures of the commissioning engineer and EMIRATES STEEL's site representative.

- The objective of this standard is to ensure that every item or unit of plant, apparatus and equipment is in a condition to completely fulfil its operating function. The tests must guarantee that all material and items or units provided, and the type and manner of the installation are completely in accordance with the standards, specifications, and regulations applicable.
- At least two months before the beginning of the field tests, the Contractor shall issue a comprehensive schedule of tests and procedures for review and approval by EMIRATES STEEL.
- The Contractor shall advise EMIRATES STEEL of the date, time and place of each test at least one week before the test is due to commence.
- Test results shall be entered into test records. The form and layout of the test records proposed by the Contractor shall be submitted in advance and approved by EMIRATES STEEL.
- All test records shall be countersigned by EMIRATES STEEL. Three (3) certified copies of these test records shall be handed over to EMIRATES STEEL before cold commissioning.
- Test values which comply with the minimum criteria in accordance with the above standards but lie considerably (approx. 25%) lower than the average measured test values, shall be so marked in the records. Test values which do not come up to the minimum criteria, shall be marked with an X.
- After successful completion of tests, the Contractor shall submit three (3) test certificates, confirming that all such tests have been carried out in accordance with the specifications and that all criteria have been met.

2. COMMISSIONING OF POWER TRANSFORMERS

An initial close visual examination of each power transformer shall be made including a careful check to verify that all details on the transformer rating and diagram plate are in accordance with the contract specifications.

The connections to each phase at the higher and lower voltage sides and the grounding connections shall be checked to ensure these have been carried out in accordance with the specified installation requirements.

The oil conservator and tank, all vents, bushings, seals and cable terminations shall be checked for oil or gas leaks or penetration of water.

Each transformer breather, where fitted, shall be checked and recharged or replaced as necessary.

All auxiliary and other items including thermostatic cooling control where fitted shall receive thorough and comprehensive control and functional tests which shall include all protective and alarm equipment.

The testing of Buchholz protection shall be in accordance with details given by the manufacturer.

Where transformers are filled or topped up with oil at site, a breakdown test of oil samples taken from each oil drum or oil container shall be made before any such oil is transferred to the transformer tank, radiators and conservators. Only oil which has successfully passed the permitted breakdown test value shall be used for filling transformer tanks, radiators and conservators. The transformer shall be filled via a low-level valve and suitable oil filtration equipment.

Where transformers have been filled before delivery to site then oil samples shall be taken from each transformer at the lowest available sampling point and such oil samples checked as suitable by breakdown tests before the first start-up.

The insulation of each winding to earth shall be measured and recorded before start-up. The duration of each test shall be sufficient for the windings to become fully charged.

3. TESTING OF HV SWITCHGEAR

a. Following erection, a thorough visual check and examination shall be made of each HV switchgear unit. Additionally, examinations and checks shall be made to verify that:
   - All equipment has been completely delivered and correctly assembled; also, it corresponds in all respects with the contract specification and with the approved drawings and diagrams. For measuring transformers, relays and other current and voltage measuring devices particularly the transformer ratios shall be tested and checked for accuracy. Relay details shall be verified.
   - Incoming and outgoing feeders have been correctly connected in phase. Multiple busbar systems with bus coupling facilities shall also be checked to verify that such facilities provide in phase connections.
   - Cabling and grounding are in accordance with installation specifications. All control wire connections shall be checked against details in wiring diagrams. (Individual panel wiring will be checked in the factory of the manufacturer).

b. Before making live the insulation resistance of the busbars shall be measured by a high voltage insulation tester as follows:
   - All phases to ground,
   - Between all phases.

c. Before making live, each circuit breaker shall be checked and tested in the isolated/test position and later in the operating position as follows:
   - Numerous on and off circuit breaker switching operations by means of the local and the remote-control switches.
   - Checks to confirm that the circuit breaker cannot be plugged in or withdrawn when switched on.
   - Circuit breaker tripping tested by numerous simulated operations of every relay or release device. Similarly, every interlock shall be checked for fulfilling its purpose and its operation tested under every possible circumstance.

d. Every protection relay shall be tested at site with secondary current injection equipment and adjusted to the setting proposed by the Contractor’s Protection Coordination study.

e. The automatic changeover equipment at substations or other supply points with independent feeds shall be tested as follows:
   - The changeover function triggered by a simulated fault causing loss of supply voltage.

- Measurement of the changeover time without load.

4. TESTING OF LV SWITCHGEAR

a. After installation has been completed a thorough visual check and examination shall be made of every LV switchgear unit. The check and examination shall confirm that:
   - All equipment has been completely delivered and correctly assembled and corresponds in all respects with the Contractor's specification and with the approved drawings and diagrams. For thermal overload relays and release coils at switches such as circuit breakers and contactors the current ratings particularly, shall be carefully checked. When LV switchboards are delivered in individual sections which then must be erected and bolted together at site then all cross connections from section to section shall also be particularly carefully checked.
   - Incoming and outgoing feeders have been correctly connected in phase. Multiple bus bar systems with bus coupling facilities shall also be checked to verify that such facilities provide in phase connections.
   - Cable connections and grounding correspond to installation specifications. All control wiring and control wire terminations and connections shall be checked against details in the wiring diagrams.

b. Before start-up the insulation resistance of the bus bars shall be measured by an insulation tester as follows:
   - All phases to ground,
   - Between all phases.

c. After verifying the control voltage supply all control elements shall be checked for correct operation and the working of all interlocking arrangements checked for every interlocking requirement. The main circuit must remain disconnected and voltage free during these tests.

d. Inspection and checks of the following shall be made at the circuit breakers:
   - Each circuit breaker shall be withdrawn and then operated manually.
   - All adjustable release mechanisms shall be adjusted and set in accordance with relay data given in relay coordination documentation.

e. Before making live each circuit breaker shall be tested in the isolated/test position and later in the operating position as follows:
   - On and off switching operations by means of the local and remote-control switches and/or with the manual operations handle.

- Checks to verify that the circuit breaker cannot be plugged in or withdrawn when switched on (if this facility is provided).
- Circuit breaker tripping checked by numerous simulations of every relay or release device. Similarly, every interlock shall be checked for fulfilling its purpose and its operation tested under every possible circumstance.

f. The automatic changeover equipment at substations or other supply points with independent feeds shall be tested as follows:
- The changeover function triggered by simulated fault causing loss of supply voltage.
- Measurement of the changeover time without load.

g. The adjustment of all thermal over current relays for motors shall be checked before making live of the feeder switches. The relays shall be set according to the duty of the motor as calculated by the Contractor.

h. Where an LV motor feeder switch is equipped with a delayed restart relay, then all operational possibilities shall be checked including:
- Check that on loss of voltage, the contactor opens automatically. When the correct voltage again becomes available the contactor does not automatically reclose.

  Testing of the feeder switch 'immediate restart' condition:
- After loss of voltage and automatic opening of the contactor, if the correct voltage again becomes available within 25 seconds then the contactor shall reclose automatically provided it is safe to do so.

After completion of these checks and tests the function and settings in the documentation shall be amended as necessary and the protection settings recorded.

5. TESTING OF HIGH VOLTAGE (OVER 1000V) AC MOTORS

a. Every medium voltage motor shall undergo a thorough visual examination.
Additionally, examinations and checks shall be made to verify that:
- The motor is equipped with all parts specified in the order.
- The details on the motor data plate correspond with the motor list.
- The cable cores of the connecting cable have been connected in such a way that the correct direction of rotation of the motor on start-up is ensured.
- The arrows for direction of rotation on the motor and on the driven machine correspond with one another.

b. The insulation resistance of all motor windings shall be tested and measured. The measurements of insulation resistance shall be repeated after the power cable has been connected to the motor terminals.
c. Checks shall be made to verify that the cable connections and the grounding of the motors are strictly in accordance with installation specifications.
d. If the motor is equipped with auxiliary equipment such as bearing and winding temperature supervision, standstill anti-condensation heating, etc. then this auxiliary equipment shall also receive thorough functional tests.
e. The motor shaft shall be free to turn by hand. The alignment shall be checked and coupling gap clearances recorded.
f. During the initial test run, bearing temperatures, casing temperatures, speed and the motor no load currents shall be monitored. Noise and vibration levels shall be checked.
g. During test runs, process related interlocks shall not be bridged or defeated in any way unless the authorized responsible person gives approval.
h. For motors equipped with insulated bearings, it shall be checked that the driven machinery when lubricated with flushing oil also have the oil lines similarly insulated.

6. TESTING OF LV AC MOTORS

a. A thorough visual examination shall be made of every low voltage motor. Additionally, examinations and checks shall be made to verify that the details on the motor name plate correspond with those specified in the Contractor's motor schedule.
b. The insulation resistance of all motor windings shall be tested and measured before connection of cables. The measurements of insulation resistance shall be repeated after the power cable conductors have been connected to the motor terminals.
c. The direction of rotation the direction of the rotation arrows on the motor shall be confirmed.
d. If motors are equipped with auxiliary equipment (e.g. winding temperature supervision, etc.) then a thorough functional test of all such auxiliary equipment shall also be made.

7. TESTING OF DC MOTORS, SYNCHRONOUS AND INDUCTION MACHINES.

a. A thorough visual examination shall be made of every motor before connection of power and control cables. Additionally, examinations and checks shall be made to verify that:
   - The motor is equipped with all parts specified.

- The details on the motor data plate correspond with those specified in the motor list.
- Where applicable, the motor is certified for use in the hazardous area where it is installed in accordance with the hazardous area section of the documentation.
- Armature and field connections and power cables have been placed in such a way that the correct direction of rotation of the motor after assembly and installation is obtained.
- The arrows showing direction of rotation on the motor and on the driven machine correspond.

b. Insulation resistance of all motor windings shall be tested.

c. It shall be verified that the cable connections and the grounding of all motors corresponds in all respects with installation specifications.

d. If motors are equipped with auxiliary equipment (bearing and winding temperature supervision, standstill anti-condensation heating, anti-arcing supervision, independent air-cooling, pressure lubrication, etc.) then functional testing of all such auxiliary equipment shall be carried out.

e. Every motor above 300 kW shall be test run. During the test run, bearing temperatures, casing temperatures and the motor no load currents shall be monitored. Noise and vibration levels shall be checked. Before such a test run is made, the alignment (coupling play, etc.) shall be checked. Additionally, the coupling guard and other protection guards shall be in place. Process related interlocks shall not be bridged or defeated in any way unless the authorized responsible person gives approval.

f. During a test run of each DC-motor, its commutator, brush gear and brushes shall be observed for acceptable quiet running and sparking.

8. TESTING OF CABLES AND CIRCUITS

a. Every cable and every circuit shall undergo a thorough visual examination.

Additionally, examinations and checks shall be made to verify that:

- The cable or the circuit is certified for the operating voltage of the connected electric circuit.
- The cable for each particular circuit corresponds to the specifications and installation instructions and is as specified in the Contractor’s cable schedule.
- The cross section and the number of cores of each cable correspond with the details given in the cable schedule.

- The colours of the outer covering and of the cores of each cable correspond to the specification.
- Cables and wiring have been laid in accordance with contract and installation specifications (spacing, sand bedding, covering, cable markers stating cable numbers, clamps and supports, cable crossings, bend radius, proper connection of the N and PE, grounding of reinforcement, etc.).
- Spare ways in multi-way cable ducts are properly sealed off.
- All joints, cable boxes and sealing ends have been properly installed in accordance with the installation instructions of the cable manufacturers.
- Cables and wiring in equipment and apparatus where there is a high fire risk are suitably protected.
- Cable entry plates, supports and protective pipe ends are properly sealed against ingress of fire and water.

b. The cores and conductors of all cables and wiring after connecting at site shall be checked and verified against the cable schedules.

c. All HV cables with joints and all HV cables over 1000V shall receive a direct current (DC) voltage test in accordance with IEC 60501. Before such test the insulation of each cable to be tested including the cable sealing ends, cable boxes or other termination arrangements shall have been completed. However, the final connections from the cable termination arrangements to the switchgear or other electrical apparatus at either end of the cable under test shall be omitted. Additionally, confirmation shall be obtained or precautions taken to ensure that the test voltage value shall not overstress or otherwise in any way harm the switchgear or apparatus at either end of the cable under test or exceed the maximum allowed test value for cable joints and end terminations.

9. TESTING OF FIELD DEVICES AND APPARATUS

a. All field devices and apparatus such as motor control, emergency and interlocking switches, limit switches, contacts for pressure, level, flow, temperature, rotation, etc. signal devices, sockets, terminal boxes which are installed in the equipment shall undergo thorough visual examinations and checks to verify that:

- All equipment data plate details correspond with those specified in the Contractor’s data sheets and that the equipment has been installed strictly in accordance with the installation specifications.
- The equipment is certified for use in the hazardous area where it is installed in accordance with the hazardous area section of the documentation.

b. Every item shall be tested for the correct connections in accordance with the appropriate connection diagrams and cable schedules. The grounding connections shall also be similarly checked.
c. Insofar as the type of construction of each unit allows the function and operation shall be proved by simulation.

10. TESTING OF GROUNDING EQUIPMENT

a. Before the measurement of grounding resistance is carried out, all electrical equipment components shall undergo a visual examination to make sure that the grounding wires and conductors (including HV protective grounding wires and conductors) have the prescribed cross sections, have been laid correctly and without interruptions and have been properly and carefully connected. The grounding resistance shall be in accordance with IEEE and VDE requirements.

   It shall also be checked and verified that all metal works of plant and equipment and other constructional metal works, including steel foundations, base plates, walkway barriers and pedestrian bridges are connected with the grounding network in accordance with the equipotential and other requirements in the contract documentation.
b. The grounding resistance shall be measured at the following places:
   - At several important points of the grounding network without disconnecting the grounding connection.
   - At every branch of the grounding network or the electrical network.
   - The overall grounding resistance of the entire grounding system.

11. TESTING CONTROL VOLTAGE SUPPLIES AND BATTERIES

a. A thorough visual examination shall be made of every control voltage supply and battery unit. Careful checks shall be made to ensure that equipment's data plate details are in accordance with those specified in the contract specification. Additionally, it shall be verified that the equipment has been installed in accordance with installation specifications and the instructions of the suppliers.
b. Control voltage supply systems and battery units shall undergo a complete functional test. The prescribed charging current of each battery charging rectifier shall be set. The correct outgoing voltage of each control voltage supply unit and battery shall be verified.
c. The earth fault monitoring arrangements of the battery units shall be checked by simulation.

d. UPS systems (including static inverters, generators, DC and AC regulators, electronic changeover units) shall only be function tested in the presence of a qualified representative of the manufacturer. Tests shall include:
   - Voltage drop at gradual load changes (from 1 to 100%)
   - Short circuit test in the outgoing feeders to prove the selectivity of the protective devices.
   - Measurement of the changeover times including the error detection time.
   - Checking of the wave form for current and voltage.

   If necessary, further guarantee values shall be proven by measurements. The exact testing progress shall be agreed beforehand with EMIRATES STEEL.

12. TESTING OF THE LIGHTING INSTALLATIONS

a. Thorough visual examinations and checks shall be made of the entire lighting equipment to verify that:
   - The luminaires including accessories are certified for the hazardous area in which they are installed.
   - The numbers and types of luminaires correspond to the performance requirements of EMIRATES STEEL's Lighting standard.

b. Every lighting circuit shall be checked for correct operation. Emergency lighting equipment installed at important points shall be tested by fault simulation.

13. TESTING OF CONTROL AND INTERLOCKING SYSTEMS

a. A thorough visual examination of all parts belonging to this system (PLCs, control panels, relay panels, junction boxes, cabling, etc.) shall be made. Additionally, the following examinations and checks shall be made to verify that:
   - All parts have been delivered complete and properly installed, i.e. the equipment corresponds completely to the requirements of the order and installation specifications.
   - All control cables have been properly laid. The connection of every cable conductor shall be checked by reference to the appropriate diagrams and schedules.
   - The correct supply voltage is available at each feed in point.
   - All I/O-signals for PLCs are tested.

b. After completion of the above tests, every control and interlocking operation shall be simulated individually. During these functional tests only the control voltage shall be made available and all equipment main current carrying contacts (from the contactor

to the final performance relay to be controlled) shall remain de-energized. After completion of the tests all equipment shall be set for the nominal values prescribed in the Contract documentation.

14. TESTING OF ALARM AND SIGNAL SYSTEMS

A thorough visual examination shall be made of all items and parts belonging to each of these systems. Additionally, examinations and checks shall be made to verify that:

- All parts have been delivered complete and properly installed, i.e. the equipment corresponds to the contract and installation specifications.
- All control cables have been laid properly. The connection of every cable shall be checked by reference to the appropriate diagrams and cable schedules.
- The correct voltage is available at the inputs.
  a. Every consumer circuit connected to the outgoing circuits of electronic equipment shall be checked for short circuits.
  b. After completion of the above tests, every alarm and signal operation possible shall be simulated individually. All equipment (from the contactor to the signal equipment) shall be included in this functional test.
  c. For intrinsically safe signal circuits it shall be checked that each contactor and signal input is correctly specified for the type of hazardous area at the place of installation. It shall also be checked and verified that there is clear minimum separation between wiring and conductors of intrinsically safe circuits and other conductors.

15. OTHER TESTS

If other tests are to be carried out which are not listed in these specifications, special arrangements shall be made in accordance with the requirements.

6. SUPPORTING DOCUMENTS

NA

7. REVISION HISTORY

Issue No.	Date	Page/s	Cause of Revision
0	17.11.2019	All	First Issue