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TECHNICAL SPECIFICATION

Doc No: DSF-SPC-ELE-008

Rev. 1

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HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

ELECTRICAL SWITCHBOARDS

JUNE 2021

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REVISION HISTORICAL SHEET

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REFERENCE DOCUMENTS

- Job Spec. DSF-SPC-ELE-001
- Job Spec. DSF-SPC-ELE-004
- EU DIRECTIVE 2014/35/EU, LVD
[Low Voltage Directive]
- EU DIRECTIVE 2014/30/EU, EMC
[Electromagnetic Compatibility Directive]
- EN 60027
[Letter Symbols to be used in Electrical Technology]
- ELOT EN 60060
[High-voltage test techniques]
- BS EN 60073
[Basic and safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators]
- BS EN IEC 62271-102
[High-voltage switchgear and control gear. Alternating current disconnectors and earthing switches A.C.]
- ELOT HD 60364
[Low-voltage electrical installations]
- BS EN 60439-1
[Low-voltage switchgear and control gear assemblies. General rules]
- ELOT EN 60445 E5
[Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals and conductor terminations]
- ELOT EN 60446 E2
[Basic and safety principles for man-machine interface, marking and identification - Identification of conductors by colors or alphanumeric]
- EN 62271-206
[Gas-insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above]
- ELOT EN 60529
[Degree of Protection Provided by Enclosures (IP Code)]
- EN 62271-1
[Common specifications for high-voltage switchgear and control gear standards]
- IEC 60050
[International Electromechanical Vocabulary]



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- IEC TS 62271-304:2008
[Additional Requirements for Enclosed Switchgear and Control gear from 1 kV to 72.5 kV to Be Used in Severe Climatic Conditions]



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1. SCOPE

This specification covers the general requirements for the design, manufacturing, connection and testing of electrical metal-enclosed switchboards.

The general term switchboard applies to factory-built assemblies (FBA), such as switchgears, motor control centers, control gears and distribution gears, equipment and alike.

This specification applies to general purpose switchboards, for indoor installation in nonhazardous locations and corresponds to minimum requirements (*). Unless otherwise specified in the Material Requisition this specification shall apply to switchboards with rated voltages in the following bands:

- a) LV (Low Voltage) - up to and including 1 KV a.c. and 1,5 KV d.c. respectively (**).
- b) MV (medium voltage) - up to and including 72,5 KV a.c.
- c) HV (high voltage) - over 72,5 KV a.c.

Note: The Material Requisition shall be prepared by Contractor and approved by Owner / Consultant.

2. GENERAL

This specification is appropriate for use in conjunction with the Material Requisition.

Unless otherwise specified in the Material Requisition, Manufacturer/Vendor shall comply with the requirements of this Specification.

Should conflict exist between requirements of this specification and those of the Material Requisition, the latter shall govern: in case of doubt Manufacturer/Vendor shall apply to Contractor.

Any deviation shall be listed by Manufacturer/Vendor in his bid, with explanation of reasons and advantages of suggested solution.

(*) Reference ambient conditions, unless otherwise specified in the Material Requisition:

Temperature: max 40°C, max daily average 35°C; min -15°C. Relative humidity: max 70% at 40°C; higher values at lower temperatures e.g. 90% at 20°C. Condensation: moderate (occasionally due to temperature variations).

(**) The limit of low voltage stated by the Authority of the Country of installation must be considered if lower than that stated by IEC.



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2.1. CODES AND STANDARDS

Unless otherwise specified in the Material Requisition, the following recommendations and standards shall be applied:

ELOT EN Standards and IEC recommendations. The most important publications relevant the matter of this specification is:

- ELOT EN 60445 E5
- ELOT EN 60446 E2
- ELOT EN 60529
- EN 62271-1
- EN 62271-203
- BS EN 60073
- BS EN 61439-1:2011
- BS EN IEC 62271-102:2018
- IEC TS 62271-304:2008

Various publications relevant to apparatus, devices and components.

Codes and standards of the country of origin of switchboards and components shall be accepted, provided that the said authoritative standards are equal or more restrictive than **IEC Recommendations** or **ELOT EN Standards**, or than codes and standards called for in the Material Requisition and provided that Owner's approval is obtained.

In addition to the above, equipment must comply with Greek PPC requirements where applicable.

Units, electrical terms and definitions used in this specification and to be used by Vendor shall be in accordance with:

- **EN 60027**
- **IEC 60050**

Electrical diagrams shall be graphical symbols in accordance with relevant standards drawings and specifications.

Switchboards to be installed in Europe shall bear the CE mark with:

- The Certification of Conformity to EMC Directive (2014/30/EU)
- The Certification of Conformity to Low Voltage Directive (2014/35/EU).



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3. DESIGN CRITERIA

The design and construction of electric switchboards shall be such to ensure:

- a) Safety of personnel under all operating and expected fault conditions.
- b) Construction and operating reliability.
- c) Possibility of future extension.

3.1. EARTHQUAKE DESIGN CRITERIA

The earthquake withstand of the switchboards must comply with the safety and operability requirements of the plant and of particular loads of the plant.

4. SAFETY OF PERSONNEL

4.1. DEFINITIONS

Definitions in accordance with **ELOT HD 60364** are given here below for terms used in relation to safety of personnel:

Live part.

Any conductor or conductive part which is at a voltage in normal use.

Exposed conductive part.

A conductive part which can readily be touched and which is not a live part, but which may become live under fault conditions.

Extraneous conductive part.

A conductive part not forming part of the electrical installation.

Protection against direct contact (protection against shock in normal service or basic protection)

Prevention of dangerous contact of persons or livestock with live parts.

Protection against indirect contact (protection against shock in case of a fault or supplementary protection).

Prevention of dangerous contact of persons or livestock with:

- Exposed conductive parts.
- Extraneous conductive parts which may become live in case of a fault.



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4.2. GENERAL

Safety of personnel shall be assured by the prevention of direct and indirect contacts with live parts or moving parts under any operating and expected fault conditions and with live parts under maintenance conditions or occasional handling on switchboard.

4.3. PROTECTION AGAINST DIRECT CONTACT

General and partial protection shall ensure that personnel cannot come in contact with the live parts of the electric switchboard.

4.3.1. GENERAL EXTERNAL PROTECTION

The general external protection shall be achieved by means of permanent barriers of enclosures, which prevent any contact with the live parts.

The spacing, insulation level and mechanical strength shall be consistent with the stresses they may normally undergo.

- a) Switchboards with rated voltage level up to and including 1 kV A.C. or 1,5 kV D.C.

The following requirements shall apply:

- a. Degree of mechanical protection shall not be less than IP 3X (*).
- b. Barriers or enclosures may be of insulating material.

The total enclosure of live parts by insulating material shall be considered as a protection against direct contact, provided it has insulation properties consistent with the rated voltage level and keeps these properties under all operating conditions.

- b) Switchboards with rated voltage level higher than 1 kV A.C. or 1,5 kV D.C. The following requirements shall be applied:
- Degree of mechanical protection shall not be less than IP 3X (*).
 - Enclosures or barriers and internal partitions which may be accessible without the use of a tool shall be made of metallic conductive material, suitably earthed or bonded to earthed parts (***)).
 - Cables and conductors shall be with metallic screens or armouring.

* If a degree of mechanical protection higher than IP 3X is required, e.g. IP 4X and if not in conflict with other requirements, a degree of protection IP3X may be accepted only for particular devices such as lockets for test plugs, holes for control keys and alike.

** The use of insulating material for barriers and for internal partitions is permitted for switchboards with rated voltage up to and including 3 KV, if such type of construction is foreseen by the applied standard and with approval by Contractor and if permitted by local Authority.



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For both LV and MV switchboards grates and wire screens for ventilation and gas venting shall have openings not greater than 6 mm and shall not be located close to live parts.

4.3.2. PARTIAL PROTECTION

The partial protection shall prevent direct contact with live parts inside the enclosures, it shall be achieved by means of fixed barriers, cubicle subdivisions or screens, having mechanical protection degree not less than as specified in **para 4.3.1.**

Where necessary to make provision for removal of barriers, opening of enclosures or withdrawal of parts of enclosures (doors, casings, lids, covers and alike), removal, opening or withdrawal shall necessitate the use of a tool; keys shall not be considered as equivalent to the use of a tool from the point of view of prevention of accessibility.

Unless specifically required in the Material Requisition, the use of a padlock shall also not be considered equivalent to the use of a tool (padlocks may be used only if required for maintenance or similar operations).

4.3.3. ACCESSIBILITY TO INTERNAL PARTS

Accessibility to internal parts of the enclosures, where needed for occasional handling (such as replacing of fuses, lamps, setting or resetting of relays etc.) shall be permitted only if one of the following protective measures is assured:

- Automatic de-energization of all power and control circuits.
- Permanent protection of live parts by means of full insulation or by means of segregation as per para 4.3.1 *.

Only if the above protective measures are assured, removal, opening or withdrawal of barriers may be by means of handles, knobs and alike, i.e. without the use of a tool. The use of a key shall be considered equivalent to the use of handles, knobs and alike from the point of view of prevention of accessibility.

Handles or knobs shall be equipped with key locks only when required in the Material Requisition or when foreseen by the manufacturer's standard. In any case the key must not be removable in unlocked position; a warning tag shall monitor the accessibility to live parts.

De-energization of all live parts behind the barrier or enclosure shall be by means of an interlocking device.

* After removal of covering of indicating lamps a degree of protection not less than IP 2X may be accepted; holes with diameter slightly higher than 12 mm may be accepted for particular lamps, provided that Contractor's approval is obtained



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Restoration of the supply shall only be possible after replacement of barriers or re-closure of the enclosure.

Removal, opening or withdrawal shall initiate automatic switching-off before live parts behind the barrier or enclosure can be touched accidentally.

A second barrier with mechanical protection degree not less than as specified in **para 4.3.1** shall prevent direct contact with live parts which may be accessible after opening of doors or removal or withdrawal of barriers.

Automatic de-energization of power circuits shall be adopted as a safety provision only for circuits at a voltage level up to and including 400 V a.c, or 600 V d.c.

On MV switchboards metallic shutters shall be provided over busbar and circuit orifices to close them automatically and positively, when the equipment is moved into the isolated position or is completely withdrawn.

Where specified in Material Requisition or if required by Local Authorities, these requirements shall be applied also to LV switchboards.

4.4. PROTECTION AGAINST INDIRECT CONTACT

The protection against indirect contact shall prevent the personnel from the danger that may occur when exposed conductive parts or extraneous conductive parts become live. Such protection shall be achieved in the following ways:

- Direct earthing of the exposed conductive parts through protective conductor to the earth-bar.
- Equipotential connection of extraneous conductive parts with parts positively earthed to the earth-bar, e.g. by bolting with antivibration washers.
- Ensure electric continuity among the different conductive parts and to the earth-bar.

Every switchboard shall be provided with an earth-bar, suitable for the maximum expected earth fault current.

Suitable provisions shall be foreseen to connect the earth bus to the main earthing system of the installation.

All protective conductors shall be connected directly to this main bar.

The metallic parts usually handled, such as handles, hand-wheels etc. shall be either:

- Electrically connected very securely to the main earth-bar or to the metallic parts at earth potential or,
- Provided with supplementary insulation which insulates them from other conductive parts. Such insulation shall be suitable for the highest value of voltage of any circuit included in the switchboard.

This method shall apply only to LV switchboards.



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Metallic parts covered with a coat of paint or enamel are not considered as insulated, as far as the protection against indirect contact is concerned.

The circuit of the protective conductors shall not be interrupted by the removal of parts of the structure for maintenance or other reasons.

For doors, lids or similar on which live devices are mounted, the electric continuity of protective conductors shall be assured by a wire whose section has to be equal to the largest of the active wires to the supported devices.

The bolts, hinges etc, are generally sufficient to maintain the electric continuity, provided that no live device is mounted on them, and that bolts, hinges etc. are suitable to this scope.

In all withdraw able devices (for example the draw-out unit of motor control centers and alike) a positive and automatic protective connection shall be provided, preferably by sliding contact. The protective circuit shall always break after and make before the contacts of the related active circuits.

All parts of the protective circuit inside the switchboard shall be sized for the maximum expected dynamic and thermal stresses that can occur inside during normal and fault operation.

On MV switchboard draw-out type potential transformers shall always be equipped with suitable earth contacts on the primary and secondary terminals of the PTs and on relevant primary fuses. Such contacts shall make when the PTs are in withdrawn position and before access is obtained to the PTs cubicle.

5. CONSTRUCTION. OPERATION AND RELIABILITY

5.1. OPERATOR'S POSITION

All normal service operations shall be performed from the front of the switchboard. Inspections and alike are not considered normal service operations and may be from the rear.

5.2. OPERATOR'S ACCESSIBILITY

5.2.1. OCCASIONAL HANDLING

All internal parts of the switchboard that require accessibility for occasional handling, such as replacing of fuses, lamps, setting or resetting of relay etc., shall be accessible from the front.

5.2.2. MAINTENANCE ACCESS TO INDIVIDUAL UNITS

In the case of individual draw-out units (such as draw-out starters of motor control centers, MV circuit breakers, potential transformers and alike), accessibility to terminal boards and devices of the unit downstream of the isolating device shall be allowed without deenergizing the main busbars supplying that device.



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5.3. MECHANICAL DESIGN

The mechanical design of all enclosures and chassis shall be such as to ensure that they will not permanently distort during operation, faults, maintenance or installation and transport. The minimum sheet steel panel thickness shall be 1,5 mm.

All metallic parts shall be suitably protected against corrosion by means of surface treatment (galvanized, anodizing etc.) and/or painting.

Fasteners and hinges shall be of anticorrosive material and are not to be painted. Before painting, all metal enclosed switchboard shall be prepared by having the edges earth smooth and unless the sheet material has an integral anti-corrosive finish, the entire surface shall be sanded or sand-blasted to a smooth finish.

Immediately prior to painting, metal switchboard shall be cleaned with a degreasing solvent.

The minimum painting acceptable is one coat primer followed by two coats of finishing enamel. Surfaces shall be rubbed down between coats.

"Semi-gloss" or "egg-shell" finishes are preferred.

Switchboard internal surfaces shall have a coat of anticondensation paint, suitable for specified ambient conditions.

Unless otherwise specified in Material Requisition, the switchboard shall be provided with ventilation louvers and where specified, with anti-vermin screens.

When specified in Material Requisition, floor mounted switchboards shall be provided with a supporting subbase, to be buried in concrete.

Generally, the bottom of the switchboards shall be closed with easily removable gland plates; the gland plates shall be of sheet metal or insulating materials and, unless otherwise specified, they are to be supplied drilled. The mechanical degree of protection obtained with the bottom enclosure shall be as specified for lateral and top external surfaces.

Preferably throughout the switchboard and in all cases subject to vibration or shock, whether mechanical or electromagnetic in origin, bolts, nuts and studs shall be fitted with shake proof nuts, locking nuts, lock washers or similar.

All devices which are particularly sensitive to shocks and vibrations (such as relays, recorders and similar) shall be fitted with an antivibration mounting.

All withdrawable units of the same rating and function shall be fully interchangeable within the switchboard. This shall apply to circuit breakers, auxiliary and protective relays etc.

Preferably the fixed parts of each cubicle or withdrawable unit should be suitable for the maximum size of device that might be installed therein, and similarly for the connections.

If a main device, such as a circuit breaker, is employed at other than its full rated capacity, its cubicle shall be capable of accommodating auxiliary devices such as current transformers of a rating corresponding to the full rating of the main device.



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Each unit of a MV switchboard shall be segregated from the others by means of earthed metal barriers in order to:

- a) Ensure protection against direct contact with live parts.
- b) Minimize the effect of accidental arcing and/or fire.
- c) Prevent extraneous bodies from falling from one unit to another.

5.4. PERFORMANCE ON SHORT CIRCUIT

Each switchboard as a whole and any of its components shall be suitable for withstanding all the expected dynamic and thermal stresses produced by short circuit currents. Where current limiting devices, such as limiting fuses, limiting impedances, etc., are utilized, the above-mentioned stresses are referred to the limited currents downstream of the devices.

5.4.1. SHORT CIRCUIT WITHSTAND CAPABILITY

Generally, the short circuit withstand capability of a switchboard can be specified by:

- a) The maximum value of "prospective short circuit current" on the bus bars (r.m.s. value) the switchboard can withstand and:
 - Without specifying the "total break-time", when the short circuit protective devices (circuit-breakers or fuses) are downstream of the incoming terminals (i.e. the protective device on which the rating depends is part of the equipment);
 - With specifying the "total break-time", when the short circuit protective devices to be considered are by others upstream of the incoming terminals (i.e. outside the switchboards) and:
- b) The peak value and the symmetrical equivalent r.m.s. value of the expected short-circuit current for a short- time period of one second.

For short-circuit durations different than one second, the relation between current and time, unless otherwise stated by Vendor, shall be in accordance with the formula:

$$I_{SC}^2 \times t = \text{constant}$$

The short circuit withstand capability of a switchboard shall be extended to all its components, whatever may be the fault and wherever it may occur, except as limited in magnitude or duration by integral interposing devices; if the interposing device is controlled by a protection relay, the duration shall be considered to be at least 0,2 s or as specified. If protection is by limiting fuses, let-through energy shall be considered.

When a fault occurs inside a LV withdraw able functional unit, that unit may be damaged, provided that the withdrawal of the unit is still possible and that no part of the switchboard is damaged. In case of internal arcing fault, no external dangerous effects shall be permitted.



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5.4.2. LOW VOLTAGE SWITCHBOARDS

Incomers at Power Centers shall be sized with Rated Service short-circuit breaking capacity (Ics). Outgoing breakers shall be preferable current limiting type or breakers sized with Rated ultimate short-circuit breaking capacity (Ieu).

Utilization category shall be generally A for outgoings while shall be B for incomers and outgoings specifically intended for selectivity under short-circuit conditions.

Contactors and motor starters shall be Type 2 co-ordination under short-circuit conditions.

CTs and relevant devices connected to them (relays, regulators, instruments etc.) shall withstand the maximum expected short circuit current in the related main circuit.

5.5. COORDINATION OF PROTECTION

When the service conditions do not allow the shutdown of the switchboard on the occurrence of a fault in a branch circuit, the selection and setting of protective devices shall be such that those protective devices directly associated with the faulted circuit should function to open prior to protective devices associated with upstream circuits (e.g. on the incoming breakers). This is called "selective protection" or "selectivity". Selectivity is accomplished by coordination of the various circuit protective devices, commonly on a time-current basis.

On switchboards which incorporate power control units having fuses for short circuit protection, power contactors and overload protection relays, Vendor shall ensure that the point of take over between the time/current characteristic of the overload relays and the fuses is below the maximum breaking current of the contactor (In no case welding of contactor's contacts shall occur). Due allowance shall be made for the operating and manufacturing tolerances on the characteristics and for the minimum opening time of the contactor.

5.6. ELECTRICAL DESIGN

Power circuits phase sequence and geometrical arrangement.

Generally, the phase sequence shall be as follows:

L1, L2, L3, N from back to front, from top to bottom, and from left to right facing rear.

The incoming terminals shall be arranged to allow the easy reversing of the phase connections.

Correlation between alphanumeric notation, graphical symbols and colors (ELOT EN 60446 E2).

The following relationship shall be used, unless otherwise specified in the Material Requisition.



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| Designation of conductors | | Identification | | |
|---|----------|----------------|-----------|--|
| | | Alphanumeric | Graphical | Color |
| Supply A.C. system | Phase 1 | L1 | | Brown (Note 1) |
| | Phase 2 | L2 | | Black (Note 1) |
| | Phase 3 | L3 | | Grey (Note 1) |
| | Neutral | N | | Blue |
| D.C. system | Positive | L+ | + | Brown |
| | Negative | L- | - | Grey |
| | Mid-wire | M | | Blue |
| Protective conductor | | PE | | Green & Yellow |
| Earth Noiseless (clean) earth | | E | | Green & Yellow |
| | | TE | | Green & Yellow |
| Combined neutral and protective conductor | | PEN | | Green & Yellow with marking Blue at the termination or vice versa (Note 2) |

Note 1 Other colors according to ELOT EN 60446 E2 are accepted except to yellow, green and light blue in case of presence of Neutral Contactor.

Note 2 If the identification corresponding to the combined function is not adopted, for some reason, the identification of protective conductor shall be applied (green-yellow).

5.6.1. BUSBAR INSULATION AND ARRANGEMENT

Busbars, downcomers and connections shall be as specified in the Material Requisition.

The following insulation and arrangement shall be considered.

- Air insulated system: live parts are separated from earthed conductive parts and enclosures by full clearance and creepage distances specified in the applicable standards. The use of insulation applied to the live components is not precluded in such an installation, but none of it shall be considered the primary insulation.
- Insulated system: insulation rated at the maximum system voltage is applied to all live parts, including bolts and joints so to form operative protection and protection against direct contact (insulation can be considered as protection against direct contacts only for LV systems).
- Isolated system: barriers of insulating material are provided between phases, so that arc produced from an earth fault on one phase is prevented from spreading to another.
- Segregated system: is an isolated system in which the interphase barriers are earthed metal.



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- e) Phase-separated system: each phase is housed in a earthed metal enclosure so that no fault on one phase can spread to another, even when the metal enclosure is involved in the fault; i.e. when a single metallic division between phases is not considered as acceptable for the particular application.

The specified standard of busbar design, particularly their insulation, separation etc. and the provision of barriers shall be strictly applied to critical areas, such as bus-tie breaker transition busbars, busbar potential transformer connections, busbar cable connection and incoming cable to incoming circuit breaker connections.

Cable termination chambers or boxes relevant to connection of power cables with busbars or with incoming circuit breaker connections are also to be designed to the same standards as specified in the Material Requisition for the main busbars.

5.6.2. BUSBAR CONSTRUCTION

The material shall be copper or aluminum, of electrical purity as specified.

If primary insulation is applied directly to the busbars, it shall be capable of withstanding the temperature rise experienced under expected short time current conditions. Additionally, if any insulation applied to the busbars is used as part of the busbar support system, it shall be capable of withstanding any forces resulting from the expected short circuit current.

Each bolted joint shall contain a minimum of two bolts. Bolts shall be tightened to torque setting specified by Vendor during manufacture and shall be fitted with a friction grip, locking or lock nut, bell washer or similar. Locking compound is not acceptable.

The joint faces of copper busbar shall be tinned, cadmium or silver plated.

The joints face of aluminum busbars shall be suitable to keep original conductive and mechanical properties, to avoid chemical corrosion and attack; they shall be, e.g., silver plated or wire-brushed and treated with antioxidation compound before jointing. It shall be Vendor's responsibility to adopt suitable method for aluminum to aluminum and for aluminum to copper joints.

The resistance of any busbar containing a joint shall not exceed the resistance of a similar joint-free length by more than 50 $\mu\Omega$.

On MV switchboards the chambers containing busbars and connections shall be provided with arc resistant barriers at each cubicle joint to prevent arcs and arc-products in a faulted cubicle spreading to adjacent cubicles *.

* For MV switchboards the term "metal clad" switchboard means that components are arranged in separate compartments with metal enclosures intended to be earth`ed. Separate compartments shall be foreseen for the



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5.6.3. CUBICLE HEATERS

If specified, or deemed necessary by Vendor on account of the anticipated service conditions, each cubicle shall be provided with anticondensation heaters. Where heaters are fitted, a suitable terminal box and temperature control switch, with indicating lamp, shall be provided and mounted in an accessible position. Heaters shall be of the low-temperature, metal clad type.

5.6.4. STANDARDISING OF CIRCUITRY AND OF RELAYS

Preference shall be given to having each similar unit within a switchboard wired in an identical fashion, using identical wire colors, identification and schematic diagram. In switchboards incorporating withdrawable units, special devices such as timers and interposing relays required for individual units only, shall not be mounted on the withdrawable units, in order to reduce the number of typical units.

Generally, on switchboards in which units are used as motor starters, only relays and devices of general application for a typical unit may be mounted on the starter cubicle.

Devices common to more than one circuit and devices required for individual units only, such as reacceleration control relays, shall be mounted on common service cubicles within the switchboard.

5.6.5. CONTROL CIRCUITS

The control circuits of switchboard shall be designed so that any external control circuit current is limited to 2 A steady state or 10 A transiently. The minimum voltage used on any circuit external to the switchboard and internally shall be 50 V, unless the auxiliary device contacts are hermetically sealed or special control circuits are present (such as intrinsically safe circuits). Unless otherwise specified in the Material Requisition, control power shall be 110V d.c. and 230 V a.c. for LV MCC only.

5.6.6. AUXILIARY DEVICES

Each auxiliary device shall be installed and connected according to the recommendations of the relevant Manufacturer (e.g. clearances, position etc.) Vendor shall be responsible for ensuring that any boughtout device is employed correctly.

5.6.7. AUXILIARY CONTACTS

Vendor shall be responsible for the selection of the electric and functional characteristics of the auxiliary contacts.



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- a) Vendor shall properly select auxiliary contacts of the draw-out circuit-breakers, so that the directly actuated and the indirectly actuated contacts have a suitable function in respect of the operational and test conditions when the circuit-breaker is in "test position".
- b) Current carrying capacity and breaking capacity of auxiliary contacts, unless otherwise specified in the Material Requisition, shall be not less than as given in the following table.

| Circuit. | Control | Alarm and signaling |
|--|------------------|---------------------|
| Rated current (A) | 10 | 2 |
| <u>Breaking capacity (A) at 110V</u> d.c. or | 2 (inductive) | 0,5 (inductive) |

5.6.8. CONTACT MULTIPLYING RELAYS

The insertion of auxiliary relays multiplying contacts shall comply with "failure safety" criterion.

5.6.9. ELECTRICAL CONNECTIONS

The switchboard shall be provided at the bottom (at the top only when specified in Material Requisition) with drillings for the external connections and shall be completed with cable terminals suitable for relevant cables indicated in the Material Requisition or drawings.

5.6.10. DOUBLE RADIAL SUBSTATION ARRANGEMENT

If requested in the Material Requisition the switchboard which are to be used in a double radial system, shall be provided with a short circuit-proof separation between each section and the intermediate tie-circuit breaker unit.

Metallic barriers integrated with interposed fiber glass cushions or similar shall be used to prevent spread of short circuit or fire from one section to the tie-circuit breaker unit and to permit continuous operation of the unfaulted unit.

5.7. AUXILIARY CIRCUITS

The auxiliary circuits are to be protected against short circuit, except where such protection would endanger a major electric system or a part of it. The conductors and the equipment of such an auxiliary circuit must be arranged so that the possibility of short circuit is practically excluded.



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Within switchboard cubicles and enclosures, the auxiliary circuits shall be mechanically protected by means of suitable rigid or flexible conduits or channels; in MV switchboards conduits or channels shall be metallic and earthed.

Auxiliary conductors shall not be fixed directly to an earthed metallic part, but supported by insulating hooks or plastic clips.

Conduits and channels shall not be filled more than 50%.

The conductors of the auxiliary circuits shall be single core plastic insulated stranded copper wires; the minimum allowed cross section shall be 2,5 mm²; 1,5 mm² cross section shall be acceptable for alarm circuits only.

For particular types of protection, such as differential, where the windings on the secondary side of the current transformers are rated 5 A, they shall have at least 4 mm² cross section.

Flexible conductors shall be provided with compression type cable terminals.

No joints in conductors are allowed, unless made on the terminals of equipment and/or on terminal blocks.

The connections to equipment mounted on moving parts (such as doors, removable panels etc.) shall be made with extra flexible single core stranded copper wires.

Each conductor shall be identified at both ends by colored or numbered ferrules in conformity with schematic and/or wiring diagrams.

In MV switchboards and where required in the Material Requisition, protective relaying circuits shall be provided with testing terminal blocks or plugs, suitable either for fault simulations (secondary injection) in normal operating conditions, or for simulation of operation, such as automatic transfer.

In MV switchboards, the auxiliary circuits shall be provided with suitable isolating devices, in order to allow work on these circuits without any danger for the personnel or any untimely operation of the switchboard. Isolating position of such devices shall be easily visualized.

Where terminals of different relays and auxiliary devices are connected in parallel, they shall be interconnected where possible, on terminal blocks. Where looping is employed, the loop shall be closed to the originating terminal and each looping point shall be made with a double connector, so that the intervening device may be removed without breaking the connection to other devices.

Simple looping will be allowed only for alarm and signaling circuits, provided that looping conductor is continuous.

Auxiliary and control power supply circuits shall be preferably made by means of copper busbars, which continuously run through adjacent panels. Similar busbars are preferred for common control or measuring functions, such as load shed and alike.

Terminal strips for auxiliary circuits shall be of the composite type, fixed on standard profile.

Terminals fitted in accessible cubicles shall present protection against direct contact equivalent to



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5.8. CURRENT AND POTENTIAL TRANSFORMERS

In MV switchboard the CT's circuits are to be taken through terminal blocks fitted with suitable multiple test terminals.

In particular, the star point of CT's shall be provided on the terminal blocks and not by connections at the CT's terminals.

The secondary windings of PT's and CT's are to be earthed on the terminal blocks independently of the earthing of the exposed conductive parts of such transformers. The secondary terminals of the CT's will be normally earthed, except where otherwise required for particular conditions (e.g. differential protections).

The earthing of the PT's circuits shall be made as follows:

- a) On the start point of the secondary windings for the star connected PT's.
- b) On the middle for "V" connected PT's.
- c) On the first terminal corresponding to phase L1 for open delta connected PT's.

The secondary windings of the interposing and isolating PT's and CT's shall be earthed according to the relevant schematic and/or wiring diagrams.

Any metering set (PT.s, CT.s, meters, recorders etc.) which may be required by Local Power Supply Authority shall be officially tested and certified by the acknowledged testing institute. In addition:

- a) The connections between the instrument transformers and the metering instruments are to be taken through one or more testing terminal boxes, fitted with covers capable of being sealed.
- b) PT.s, CT.s and meters shall also be fitted with sealable terminal boxes.

5.9. TERMINALS AND CABLE TERMINATION ARRANGEMENT

Terminal racks and blocks shall be built up from separate terminals, each consisting of a screw clamp and a supporting insulator, arranged in such a manner to prevent direct contact with live parts.

The insulator shall be of non-hygroscopic material.

Each lead of a multicore cable and each conductor shall have its own terminal, unless special terminals suitable for multiple connections or fitted with equipotential cross connectors, are used.

For each type of the incoming and outgoing cables, suitable terminating arrangement (such as glands, terminators and compression fittings) shall be provided; such terminations shall be suitably arranged for the earthing of all metallic armour, sheaths, shields and tapes of the cables.

Special precaution shall be taken to ensure that no closed iron magnetic circuit is formed around



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single-core cables or around any cables liable to carry unbalanced load currents. This shall particularly apply to gland plates.

All terminal racks and blocks shall be mounted in accessible positions for inspection and maintenance; in all case they shall be spaced at least 300 mm from the floor.

As far as applicable, terminals for LV power circuits shall be of the composite type, fixed on standard profile.

5.10. MUTUAL INTERACTION

The devices shall be erected and connected so that interaction between them (such as heating, arcing, shocks, vibrations, energy fields etc.) do not affect their performance.

When the foreseen working conditions, in particular the temperature inside the cubicles, differ from those recommended for the protective devices, such as circuit-breakers, fuses, thermal relays etc., Vendor shall give all ratings and settings etc. of the devices at the actual working conditions and shall be responsible for ensuring that their performance is correct.

5.11. DRAW-OUT DEVICES AND ASSEMBLIES

Such devices and assemblies shall be equipped with a mechanical or electric latching interlock to prevent withdrawal or insertion when the associated switching device is closed. In particular, the insertion or withdrawal must not cause an accidental closing of the contacts.

Each position, "in service", "isolated", and "withdrawn" shall be well delineated, positively located and labeled.

5.12. POSSIBILITY OF FUTURE EXTENSIONS

Generally, possibility of future extensions shall be provided on both ends of the switchboards without making cuts or weldings.

Main and auxiliary busbars, shall be arranged for bolted connections to future extensions.

6. CONTROL DEVICES

6.1. GENERAL

Control switches, selector switches, isolators etc., shall be standardized through the switchboard. The rating, number of positions, etc., shall be as specified.

The direction of actuation, identification, color etc., of the control devices shall be in accordance with EN and IEC standards or in accordance with the Material Requisition.

6.2. LOCKING FACILITY



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Where a device is specified as being lockable, this facility shall be provided either by a padlock hasp on the panel front or a lock integral with the operating handle hub. Where the device is mounted on a portion of the switchboard separated from a lockable drive mechanism mounted on the door, the operation on the device, when the door is open, shall not be possible without the use of a tool and it shall not be possible to close the door unless the handle and the device positions match the open or de-energized condition.

When interlocking facilities shall be actuated between switchboards or equipment supplied by different Vendors, it shall be responsibility of Vendors to exchange due information.

7. INDICATORS AND RECORDERS

Unless otherwise specified in the Material Requisition, instruments shall be flush mounted, with accuracy 1,5% of full scale. All instruments on a switchboard shall be of similar type and present a uniform appearance.

Indicators shall preferably be of the circular scale (240°C approx.) type and shall have white scales with black subdivision and markings.

The quantity measured shall be clearly shown on the scale.

Voltmeters shall be of the expanded scale type.

Motor ammeters shall have a compressed overload scale to 6 times full load current.

Other ammeters shall have ordinary scales, but shall read to 125% of the relevant circuit rating.

Recorders shall be of the synchronous motor with spring reserve drive type. The spring reserve period shall be 12 hr.

On integrating type instruments, the integrating period shall be 15 minutes or as specified and, if of the recording type, at least the 4 previous readings shall be visible from the recorder front without removing its case.

Indicating lamps shall be replaceable from the front of the switchboard.

The maximum nominal lamp voltage shall be 110 V to earth. Unless otherwise specified lamps shall be color coded as follows:

| | |
|--------|-------------------------------|
| Green | device open or off |
| Red | device closed or on |
| Yellow | circuit healthy |
| White | position indication, lock out |

8. LABELING



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Labels shall be of plastic with black lettering with a white background, except for danger labels (e.g. on bus bar covers), which shall have red letters on a white background. Labels shall be screwed or similarly positively fixed to the switchboard: self-adhesive are not acceptable.

Item or alphanumeric identification code of main devices and auxiliary devices shall be clearly labeled.

Labels shall not be fixed to withdrawable or auxiliary devices.

9. TESTS

9.1. GENERAL

Unless otherwise specified in the Material Requisition, the tests shall be performed in accordance with BS EN 61439-1 for LV switchgears, BS EN IEC 62271-102 for MV switchgears and **ELOT EN 60060** - "High Voltage Test Techniques".

9.2. TYPE TESTS

The purpose of type tests is to check if all the design characteristics of electric switchboards of a certain type are strictly in accordance with the requirements stated by the applicable codes and standards, by this specification and by the Material Requisition.

Unless otherwise specified in the Material Requisition, a successful type test on a first production or representative prototype switchgear, where these are identical, may be accepted as valid for any other switchgear of identical type and configuration, without necessity of repeating it.

The type tests shall be carried out on a representative sample of the switchgear or on several sections of them, which have the same characteristics and configuration as the components of the switchboard to be supplied.

The type tests shall be carried out at Vendor's workshop and/or at an acknowledged testing Institute.

The type tests shall include:

- Impulse voltage dry tests (only for MV switchboards).
- Power frequency voltage dry tests.
- Temperature rise tests.
- Short circuit tests on main and earthing circuits.
- Mechanical operation tests.
- Checking of degree of protection against direct and indirect contacts. Complete checking of IP degree of protection.



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- Verification of clearances and creepage distances.

9.3. INDIVIDUAL ROUTINE TESTS

The individual routine tests shall be carried out in order to check that no defect exists either in the material used in a switchboard or in the construction of it. They will be performed at Vendor's workshop on each switchboard, when completed and fully assembled.

Switchboards including standard bought-out components and fittings used and mounted in accordance with the recommendations of the relevant Manufacturer, but without the direct assistance of the latter, must be individually tested by the switchboard's Vendor for correct operation.

Bought-out components and fittings employed outside the relevant manufacturer's recommendation shall be type tested to the applicable standard(s) by Vendor for the particular application envisaged.

The switchboard shall be tagged with Vendor's name and Vendor is responsible for the supply of the whole switchboard as a packaged unit (see para 11). The individual routine test at Vendor's workshop doesn't relieve Vendor from checking the board after the delivery on site (see **para 11**).

The individual routine test shall include:

- Power frequency voltage dry tests.
- Voltage tests on auxiliary circuits.
- Mechanical performance checking.
- Checking that the switchboard is in accordance with all order documents (specifications, Material Requisition, drawings etc.).
- Verification of wiring.
- Functional tests, including operation of and by all protection relays and other automatic systems (electric, pneumatic and hydraulic devices).
- Checking of the degree of protection against direct and indirect contact (IP degree of protection), for components not type tested only.

9.4. VOLTAGE AND SHORT-CIRCUIT TESTS

Tests shall be performed either on the whole switchboard with all its switching devices closed and all removable parts in their service position, or on a representative part of it; in this case the representative section shall be complete. Any special bus bar arrangement, such as a crossover or busbar transition section shall also be short circuit tested.

Where switchboards contain shutters of insulating material a further voltage test shall be made with removable parts in the removed position.

9.5. VOLTAGE TESTS FOR CONTROL AND AUXILIARY CIRCUITS



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Voltage tests for control and auxiliary circuits shall not be carried out with applied voltage values lower than one's specified here-below for any type of application, unless otherwise specified in the particular specification or in the Material Requisition.

Circuits up to and including 50 V a.c. and 75 V d.c. (extra low voltage circuits): 1kV.

Circuits up to and including 1000 V a.c. and 1500 V d.c. (low voltage circuits):

- 3 KV for wiring.
- $2 U + 1 \text{ kV}$ with a minimum of 1,5 KV (where U is the rated voltage in kV), for control and auxiliary equipment and devices (relays, selector switches, fuses, breakers etc.).

For particular equipment or devices which are not suitable to withstand the above specified test voltages, Vendor shall apply to Contractor.

Certain items designed for a lower test voltage shall be disconnected.

9.6. TEMPERATURE RISE TESTS

Tests shall be performed on the complete switchboard or on a part of it. In the case of switchboards consisting of multiple identical sections the tests shall be performed on at least three vertical sections wholly equipped in order to check the temperature rise of the busbars.

Such a test shall also be performed on each type of incoming and outgoing unit, when specified. Test arrangement shall permit to simulate true rated temperature conditions. In case of doubt Vendor shall apply to Contractor.

9.7. FUNCTIONAL TESTS

On any complicated circuit, Vendor shall arrange suitable provisional circuits and devices (push-buttons, signaling lamps, relays etc), in order to simulate all the devices which are outside the equipment, but interact with the circuits under test.

9.8. CHECKING OR RELAY SETTING

After testing, Vendor shall check that all devices are set in accordance with the design documents.

If seals on sub-supplied devices have to be broken for setting or to check their setting, Vendor should seek the agreement of the Sub-vendors to reseal the devices.

9.9. WAIVER ON TEST REQUIREMENTS

If Vendor can provide test-certificates of type-tests and/or other particular tests, applicable to the specified switchboard, parts or components and acceptable to Contractor, the relevant required tests can be omitted, provided that Vendor supplies such certificates and obtains the Contractor's approval before the date on which the tests are due.



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10. DRAWINGS AND TECHNICAL DOCUMENTATION

Official language, unit system, drawings and documentation, identification and folding shall be as shown in Specification "General Notes for Electrical Equipment and Materials" (**Job Specification DSF-SPC-ELE-001**).

Vendor shall show, on the switchboard one-line diagram, all the devices with relevant item number, type and/or catalogue number and main characteristics.

Schematic and wiring diagrams shall show identification numbers, letters and/or colors of all wires and terminals as built.

Vendor shall also show on his drawings the power and auxiliary cables, with the relevant identification numbers, letters and colors in accordance with Contractor's drawings and documents.

10.1. TOTAL JOULE-LOSSES

Vendor shall calculate the total joule-losses while all units of the switchboards are simultaneous operating at rated conditions, in order to provide data for the design of the ventilating and or conditioning system of the electric switch room.

10.2. SELECTIVITY STUDIES

Vendor shall furnish selectivity curves for all protective devices within his supply limits, including those on auxiliary circuits; the selectivity study shall include the relevant single line diagram, the time-current curves and the relays setting schedule, including every parameter on every device.

10.3. DIGITAL COMMUNICATION

The communication system wiring and parameters shall be designed with the relevant supplier for the communication system. It is included into the vendor's responsibility to contact the relevant communication system supplier for getting the communication parameters and the communication network principle. The Vendor shall furnish the detailed communication diagrams for all the digital devices within his supply limit.

11. PACKAGED UNITS

Each electric switchboard as intended in **para. 1** of this specification shall be considered as a packaged unit.

When it is delivered disassembled in two or more parts, the reassembly, interconnections of all power and auxiliary circuits pertaining to separate parts and final checks and tests which must be done on site, are to be considered as an integral part of the supply of the whole prefabricated assembly.



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Vendor's responsibility and scope of supply shall include the provisions for the necessary services of specialized personnel, devices and supervision required to reassemble the switchboard at site.

12. SPECIAL PURPOSE SWITCHBOARDS

Special purpose switchboards (e.g. explosion proof switchgears, weatherproof switchboards for outdoor installation etc.) shall further comply to this Specification with the additional requirements specified in particular Specification and/or in the Material Requisition.