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डीजल इंजन एवं डीजल इंजन जनित्र के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR DIESEL ENGINE AND DG SET

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Abbreviations:

ASME	:	American Society of Mechanical Engineers
DG Set	:	Diesel Engine Generating Set
eDMS	:	Electronic Documents Management System
EEMUA	:	Engineering Equipment & Material User's Association
EQC	:	Equipment Qualification Criteria
FM	:	Factory Mutual
IC	:	Internal Combustion
ISO	:	International Organization for Standardization
PTR	:	Proven Track Record
UL	:	Underwriter's Laboratories Inc.
VDR	:	Vendor Data Requirement
VDOCS	:	Vendor Document Management System
VDM	:	Vendor Data Management

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SECTION 1 - GENERAL

1.1 SCOPE

1.1.1 This specification together with the attendant Data Sheets and other specifications/ attachments to inquiry / order defines the minimum requirements for the Diesel engine/ Diesel engine Generator (DG) sets and their accessories/ auxiliaries for general industrial purposes.

1.1.2 Vendor shall make all possible efforts to comply strictly to the requirements of this specification and other specifications/attachments to inquiry/order.

In case deviations are considered essential by the vendor (after exhausting all possible efforts) these shall be separately listed in the vendor's proposal under separate section titled as "List of deviations/exceptions to the inquiry document". Deviation shall be listed separately for each document with cross reference to Page No./Section/Clause No./Para etc. of the respective document supported with proper reasons for the deviation for purchaser's consideration. Any deviation not listed under the above section, even if reflected in any other portion of the proposal shall not be considered applicable.

No deviation or exception shall be permitted without the written approval of the purchaser.

1.1.3 Compliance with this specification shall not relieve the vendor of the responsibility of furnishing equipment and accessories/auxiliaries of proper design, materials and workmanship to meet the specified operating conditions.

1.2 CONFLICTING REQUIREMENTS

1.2.1 In case of conflict between this specification and the attendant data sheets, job specifications (if any) and other attached specification the following order of precedence shall govern:

1. Equipment Data Sheets
2. Job Specifications (if any)
3. This specification
4. Other referred codes and standards

1.3 DEFINITION OF TERMS

1.3.1 All the definitions as indicated in ISO:3046 shall apply for Diesel Engine.

1.3.2 All the definitions as indicated in ISO:8528 shall apply for DG set.

1.4 REFERENCED PUBLICATIONS

ISO:3046-1	Reciprocating Internal Combustion Engines - Performance Part 1: Standard reference conditions, declarations of power, fuel and lubricating oil consumptions and test methods.
ISO:3046-3	Reciprocating Internal Combustion Engines - Performance Part 3: Test measurements
ISO:3046-4	Reciprocating Internal Combustion Engines - Performance Part 4: Speed governing

ISO:3046-5	Reciprocating Internal Combustion Engines - Performance Part 5: Torsional vibrations
ISO:3046-6	Reciprocating Internal Combustion Engines - Performance Part 6: Overspeed protection
ISO:3046-7	Reciprocating Internal Combustion Engines - Performance Part 7: Codes for engine power
ISO:8528-1	Reciprocating Internal combustion engine driven alternating current generating sets; Part 1: Application, ratings and performance
ISO:8528-2	Reciprocating Internal combustion engine driven alternating current generating sets; Part 2: Engines
ISO:8528-5	Reciprocating Internal combustion engine driven alternating current generating sets; Part 5: Generating sets
ISO:8528-6	Reciprocating Internal combustion engine driven alternating current generating sets; Part 6: Test methods
IS:5571	Guide for selection and installation of Electrical equipment for hazardous area (other than mine)
IS:803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks
API650	Welded steel tanks for oil storage
ASME	The American Society of Mechanical Engineering Boiler and Pressure vessel code, Section VIII, Rules for Construction of Pressure vessels, and Section IX, Welding and Brazing Qualifications.

The editions of referenced publications that are in effect at the time of inquiry or at a date specified in the inquiry documents shall be applicable.

1.5 EQUIPMENT QUALIFICATION CRITERIA (EQC)

1.5.1 FOR DG SET

- 1.5.1.1 The DG set vendor shall either be the manufacturer of the offered diesel engine or an authorised packager/ dealer/ distributor of the manufacturer of offered diesel engine.
- 1.5.1.2 The proposed DG set shall be from the regular manufacturing/ supply range of the vendor and shall have sufficient proven track record without any problems. The proposed DG set shall not be a prototype machine or a scaled version of existing equipment.
- 1.5.1.3 The Diesel Engine of the offered DG set shall meet the requirements as specified in clause no. 1.5.2.1 to 1.5.2.4.

1.5.2 FOR DIESEL ENGINE

- 1.5.2.1 Unless otherwise specified elsewhere in the inquiry document, the Equipment Qualification Criteria (EQC) specified vide para 1.5.2 to 1.5.4 shall be applied for acceptance of the offered Diesel Engine model and its manufacturer.
- 1.5.2.2 The vendor shall be a regular and established manufacturer of Diesel Engine and shall also be the manufacturer of the proposed Diesel Engine having adequate design, engineering, manufacturing and testing facilities for the same.
- 1.5.2.3 The Diesel Engine model offered shall be from the existing manufacturing range of the vendor for industrial applications and already type tested at either manufacturer's works or outside. The Engine model offered shall meet the following minimum service and manufacturing experience requirements specified in clause 1.5.4 below.
- 1.5.2.4 The Diesel Engine proposed shall be identical in terms of Model no., Speed, ISO Power rating and similar in terms of Type of Fuel, Type of Cooling arrangement, Materials, Mechanical Design etc. as compared to at least ONE (1) unit of the proposed engine model which have been designed, manufactured, tested and supplied from the proposed manufacturing plant in the last TEN (10) years and shall have completed ONE (1) year of satisfactory operation at site as on bid due date.

1.5.5 Proven Track Record (PTR)

The vendor shall furnish PTR for the offered Engine model in the prescribed format attached with the inquiry document. Since this reference list will be used for establishing provenness of proposed model for operating under specified operating conditions, it is in vendor's own interest to select such references, where the proposed model is supplied and operating at conditions similar to those specified for item against which the proposed model is offered. In addition, manufacturer's catalogue and general reference list shall also be furnished for the proposed genset model and engine model.

SECTION 2 - BASIC DESIGN

2.1 GENERAL

- 2.1.1 The Diesel Engine shall be vendor's standard model meeting the requirements as defined in ISO:3046. It shall be 4 stroke cycles, water cooled, naturally aspirated/ turbocharged (as per manufacturer standard) suitable for delivering the power requirement of the driven equipment (alternator etc.) after taking into consideration the transmission losses, site de-ration and power requirements of auxiliaries and other parasitic loads.
[Engine Manufacturer's de-ration calculations for the specified site conditions in duly completed "Annexure-A" shall be furnished along with the bid. As a minimum, the vendor shall consider the de-ration due to ambient temperature, altitude, relative humidity, cooling water temperature, inlet and exhaust losses etc. De-ration factor shall be worked out as per ISO:3046. In case, there is no de-ration for the specified site conditions, the Engine Manufacturer's categorical statement along with proper technical justification shall be furnished along with the bid.]
- 2.1.2 Standard reference conditions for DG set/ diesel engine shall be as defined in ISO: 3046-1/ ISO: 8528-1.
- 2.1.3 The generator/ alternator used in the proposed DG set shall meet the requirements as specified in electrical specifications.

2.2 RATED POWER OUTPUT AND SPECIFIC FUEL CONSUMPTION

- 2.2.1 The power rating of the Genset is the net exportable power output available at the alternator terminals after deducting the electrical power consumed by the essential independent auxiliaries.
- 2.2.2 For gensets used for intermittent and emergency service, the power rating category shall be Prime Power Rating (PRP) as per ISO 8528-1 provided the actual average power output of genset over 24 hours of operation (excluding stop time) does not exceed 70% of the PRP or the permissible average power output confirmed by engine manufacturer, whichever is higher.
- 2.2.3 For gensets used for continuous service, the power rating category shall be Continuous Power Rating (COP) as per ISO 8528-1. The genset shall be offered to have their published COP rating equal or higher than the required rating. In case the COP rating is not published, the genset shall be offered to meet the required rating with 70% of the published PRP Rating.
- 2.2.4 Unless otherwise stated the power rating of the genset is the power output expressed in kilowatts at rated frequency and a power factor of 0.8 lagging. The genset rating indicated by the manufacturer in the Equipment Data Sheet shall be with no negative tolerance.
- 2.2.5 Specific fuel consumption shall be indicated with reference to the engine power required for delivering the rated electrical power at alternator terminal i.e. 100% rating of the genset plus the electrical power consumed by essential independent auxiliaries. The tolerances shall be as per ISO: 3046-1.
- 2.2.6 The vendor shall furnish with his proposal, a list of engine auxiliaries, which require electrical power. All such auxiliaries shall be further categorized on the basis of:
- If these are required to run continuously / intermittently.
 - If these are required to run before engine starting, during starting or required to run after start-up.
 - If the above are required to be fed from engine developed power (In such a case, feeding arrangement shall be in vendor's scope).
- The vendor shall clearly identify those auxiliaries, which will be required to be fed by the Purchaser.

2.3 ENGINE STARTING SYSTEM

- 2.3.1 Unless otherwise specified, the type of starting arrangement shall be battery starting.
- 2.3.2 Where the engine is specified/ offered with compressed air starting, the vendor shall specify the starting air pressure required for cranking. Unless otherwise specified the vendor shall also provide Two air compressors (one driven by a diesel engine and the other by electric motor) and air receiver(s). The system shall be provided with necessary instruments, controls and safety devices.
- Starting air compressors and its diesel engine driver shall be as per manufacturer's standard and shall be proven with adequate running experience. Vendor shall however furnish full technical details of air compressor unit and its instruments/ controls with the bid.
- The air receiver supplied by the Vendor shall be sized for at least six consecutive starts without recharging. Air receivers shall meet ASME Section VIII & IX specifications and be equipped with a safety valve, pressure gauge and drain valve.

- 2.3.3 Engines shall be capable of starting without the use of cold starting aids for ambient temperatures of 4°C and above.
The Vendor shall provide suitable cold starting aids with engines for quick starting at ambient temperatures below 4°C and such aids shall be clearly detailed out in the offer. Lubricating oil heaters shall not be used as a cold starting aid.
- 2.3.4 Where the engine is specified/ offered with battery starting arrangement, the starter shall be suitable for the specified electrical area classification. Where the engine is specified to be equipped with a dual starter, the synchronizing switch and the corresponding wiring/ connection with the starter shall be provided by the Vendor.
- 2.3.3 Where the engine is specified / required to start and/or stop automatically, the vendor shall provide the necessary controls (Automatic-cum-manual) in the engine panel, the inter-connecting wiring, piping/tubing from panel to the engine and the starting/stopping equipment. A pilot lamp shall be provided in the starting equipment/control panel to indicate that the controller is in automatic position. In the event the engine does not start after three attempts the controller shall stop further cranking and operate the audio visual alarm.
- 2.3.4 For engines requiring pre-lubrication immediately before startup, electric motor driven pre-lubrication pump connected to an emergency power source with timer, suitably interlocked with the starting system, shall be provided by the vendor. Unless otherwise specified the emergency power source shall be furnished by the vendor.
- 2.3.7 For engines which do not require pre-lubrication immediately before start, but require periodic pre-lubrication to keep engine lubricated for automatic start, an AC motor driven pre-lubrication pump with automatic start-stop and timers, set for specific running time to provide pre-lubrication after preset periods of intervals shall be provided by the vendor. The logic to establish the pre-lubrication shall be provided & implemented by the vendor in the engine control panel, supplied by them.
- 2.3.8 For engines, which have only manual starting/stopping, a vendor's standard manual pre-lube pump shall be provided, unless vendor does not recommend the same and proposes other means to be adopted for any pre-lubrication after prolonged shut down periods. Such means shall be explained in the bid.
- 2.4 ENGINE FUEL SYSTEM**
- 2.4.1 Fuel oil treatment system (if required) and fuel oil control system shall be supplied by the vendor. Unless otherwise specified, this fuel treatment system shall be of vendor's standard design proven for the specified type of fuel.
- 2.4.2 A separate fuel day tank(s) shall be provided for each DG set. For DG sets installed in room, the Fuel Day tank(s) shall be located outside the room, irrespective of the capacity/ size of the fuel day tank.
- 2.4.3 The fuel day tank, if provided, shall be, as a minimum, equipped with vent piping with flame arrester, shielded level gauge, strainer and a hand hole of not less than 150 mm diameter, besides the required fuel connections and a drain valve.
- 2.4.2.4 The height of installation of the day tank shall be indicated by the vendor in the general arrangement drawing. In case, Fuel Day tank is mounted above engine fuel connection level, a fuel float (surge) tank shall be provided along with its interconnecting piping/ hoses to ensure that the system does not permit gravity flow to the engine through fuel supply line during engine shutdown.

- 2.4.2.5 The Fuel day tank shall comply with the requirement of Design Code: AP1650/ IS803. Unless otherwise specified, for fire water pump application and all other applications, the capacity of the Fuel Day tank(s), as a minimum, shall be suitable for running of the engine at full load for six hours. The size of a single fuel day tank shall be limited to maximum of 990 liters & desired capacity as per above can be arrived at by interconnecting multiple tanks.

2.5 ENGINE JACKET COOLING SYSTEM

- 2.5.1 Engine jacket cooling system (primary circuit) shall be closed circuit liquid cooled type including circulating pump, make up tank, heat exchanger, temperature regulating device, engine outlet cooling water temperature high alarm & trip device etc.
- 2.5.2 The heat exchangers i.e. oil coolers and engine cooling water coolers can be of any one of the following types as specified in the inquiry:
- Water cooled shell and tube type.
 - Air cooled type i.e. Radiator type with engine driven or electric motor driven fan.
- 2.5.3 For radiator cooled engines with engine driven radiator fans, the radiator, temperature control valve, expansion tank, radiator guard and other necessary piping and valves shall be mounted on the engine base.
For remote mounted radiator system, vendor shall supply electric motor driven radiator fan and additional cooling water booster pump located in the engine return line. Height of the expansion tank in the closed circuit cooling shall be at the highest level in the complete circuit. Piping connections from cooling water outlet from the top of the Engine to the top portion of the radiator shall be continuously sloping towards the engine without any pockets.
- 2.5.4 Heat exchangers shall be of shell & tube type with secondary cooling medium (raw water/ or any other coolant specified in the inquiry) passing through the tubes. Heat exchanger shall be of vendor's standard design and sized for heat rejection of at least 15% greater than engine full load heat rejection.

2.6 COMBUSTION AIR INTAKE & ENGINE EXHAUST SYSTEM

- 2.6.1 The vendor shall prepare a layout drawing showing the layout and routing of air intake and engine exhaust piping/ducting, and include in his scope complete piping/ducting, nozzles, expansion joints and supports as required as per his layout and routing.
- 2.6.2 The type and location of air intake filter shall be vendor's standard and shall be suitable for the climatic/environmental conditions applicable to the site of installation of the engine.
- 2.6.3 In case the filter is located outside the engine building/ engine enclosure, vendor shall provide the following for the filter:
- Insect screen
 - Rain hood
 - Supporting structure with approach for maintenance.
- 2.6.4 Exhaust gas discharge shall be located away from inlet air and ventilation air intakes to prevent re-entry of offensive fumes and also should not cause discomfort to personnel or hazards to building or equipment.

- 2.6.6 Exhaust gas piping (as applicable) shall be provided with thermal Insulation & cladding for personnel protection. The insulation thickness shall be adequate to limit the surface temperature at cladding not exceeding 60 degC. The extent of insulation and cladding shall be at least up to 3m of height from grade including complete length of exhaust piping within engine room.
- 2.6.7 Unless otherwise specified, the height of the exhaust stack for DG set shall be as per guidelines provided in "Environmental Regulations on Engines for Generator set application and Generator sets" issued by Central Pollution Control Board (CPCB).
- 2.6.8 Unless otherwise specified, for the DG sets installed in a room, if a ventilation system is required/ recommended, the same shall be included in vendor's scope of supply. Vendor shall indicate the details of the ventilation system, if required, along with the proposed installation arrangement in engine room. The vendor, while designing the ventilation system, shall consider sufficient no. of air changes to maintain the temperature inside the engine room equal to ambient temperature.
- 2.6.9 DG sets not installed in room shall be supplied with enclosure for noise control and weather protection. The enclosure shall be provided with vendor standard ventilation system designed to maintain the temperature inside the engine room close to ambient temperature.

2.7 GOVERNING

- 2.7.1 The governing class shall be selected by the vendor suitable for meeting the voltage and frequency variations specified in Electrical specifications.
- 2.7.2 In case of parallel running generators (i.e. for generators required to run in synchronization), the governor and fuel injection pumps provided shall have identical characteristics.

2.8 NOISE AND EXHAUST GAS EMISSION

- 2.8.1 Unless otherwise specified, any applicable legislation/ statutory requirements relating to the protection of environment and to the health and safety of personnel, with regard to noise and exhaust gas emission, as applicable to the place of installation shall be fully complied with by the Engine manufacturer.

2.9 NAME PLATE

A name plate of 18Cr-8Ni stainless steel or Monel shall be attached by pins of a similar material to the Engine and to any other piece of major auxiliary equipment, in a location permitting easy visibility. The purchaser's item number, the vendor's name, serial number, rating and testing data appropriate to the unit shall appear on all name plates.

SECTION 3 - ACCESSORIES

3.1 COUPLINGS AND GUARDS

- 3.1.1 Couplings shall be sized for maximum continuous torque, which is based on the potential maximum power of the diesel engine.
- 3.1.2 Couplings shall be of flexible type, however for generators up to 1000KVA, the coupling may be accepted as per vendor standard based on their past field proved experience. The coupling used shall be successfully proven for the service being used. The service factor

used shall be conservatively selected for the maximum horsepower rating of the engine with a factor of not less than 1.7.

- 3.1.3 Non sparking guards are required over all moving parts. The guards shall be securely attached to the base plate on foundation by means of bolts. The guard shall be sufficiently rigid to withstand deflections as a result of bodily contact of nominally 100 kgs.

3.2 BASE PLATE

- 3.2.1 Unless otherwise specified, a common baseplate for the complete unit (engine and the alternator) shall be supplied by the vendor. A baseplate shall be a single fabricated steel unit, unless the purchaser and the vendor mutually agree that it may be fabricated in multiple sections.
- 3.2.2 When specified, the base plate shall be suitable for column mounting i.e. of sufficient rigidity to be supported at specified points without continuous grouting under structural members.
- 3.2.3 The base plate shall be provided with lifting lugs for a four point lift. Lifting the baseplate complete with all equipment mounted shall not permanently distort or otherwise damage the base plate or the machinery mounted on it.
- 3.2.4 The bottom of the base plate between structural members shall be open. When installed on a concrete foundation, accessibility for grouting under all load carrying structural members shall be provided.

3.3 SPECIAL TOOLS

When special tools and fixtures are required to disassemble, assemble or maintain the unit, they shall be included in the quotation and furnished as part of the initial supply of the machine.

3.4 INSTRUMENTATION

The vendor shall supply instrumentation and control system as specified in the inquiry. If in the opinion of the vendor, additional instruments, controls and safety devices are required, the vendor shall include the same in his scope of supply.

SECTION 4 - INSPECTION, TESTING AND PREPARATION FOR SHIPMENT

4.1 GENERAL

- 4.1.1 The Inspector representing Purchaser shall have entry to the plant while and wherever work for the equipment is being performed.
- 4.1.2 The Vendor shall have the responsibility of providing Purchaser's Inspector with all requisite facilities/ equipment for carrying out proper inspection and witnessing of test.

- 4.1.3 Engines of nominal rating up to 1000 kW shall be subjected to Engine Manufacturer's routine shop test and the test certificates shall be submitted to the purchaser's inspector for his review, provided the engine manufacturer is an ISO:9000 certified vendor. For all other cases, engines shall be witness tested in accordance with the latest edition of ISO:3046 unless otherwise specified in the inquiry/ order.

The routine load and fuel consumption test shall be of the following duration:

- | | | |
|---------------------------|---|-------------|
| a) Part Loads (50% & 75%) | - | ½ hour each |
| b) Full Load (100%) | - | 4 hours |
| c) 10% Overload | - | 1 hour |

After the specified tests have been completed satisfactorily, the fuel stop on the fuel injection pump shall be set and sealed at the specified site rating including provision for 10 percent overload.

- 4.1.4 The hydrostatic test certificates for the heat exchanger/intercooler, fuel tanks and other pressure vessels shall be furnished to the Purchaser's inspector for his review at the time of load testing of the diesel engine.
- 4.1.5 The engine control panel after assembly and wiring, shall be functionally tested at the sub-vendor's works in the presence of the Purchaser's Inspector.
- 4.1.6 In addition to the inspection and tests specified in clause no. 4.1.3 to 4.1.5 above, the genset shall be subject to Full Load Test for 4 hours & overload test of 1hr @ 110% load (if applicable) at genset vendor's shop.

4.2 PREPARATION FOR SHIPMENT

- 4.2.1 Immediately upon completion of all tests and inspections, all exposed machined surfaces shall be cleaned and coated with suitable rust preventive by the Vendor and the unmachined surfaces shall be painted by at least two coats of red oxide primer.
- 4.2.2 DG set along with its auxiliaries/ accessories shall be transported in assembled condition as far as possible.
- 4.2.3 All untapped openings shall be provided with 4 mm thick metal closures with full rubber gaskets and bolted by not less than 4 bolts. All connections including those for instruments, instrument leads, lubricating oil and the like shall be identified with securely attached tags indicating the type of connection, the instrument or the line description as applicable.
- 4.2.4 The equipment shall be crated for domestic/export shipment as specified in the data sheets considering for storage at job site for atleast 12 months. If any extra precaution is to be taken by the Purchaser for storage beyond 12 months the same shall be explicitly indicated in the operation and maintenance manuals. Lifting load-cut, and handling instructions shall be securely attached to the exterior of the largest packing in a well marked weather proof container. Upright position lifting points, weight (including packing) and dimensions shall be clearly identified with item nos., serial nos., package nos., and the names of the equipment.
- 4.2.5 Two copies of the manufacturer's installation and instruction manual per clause 5.2.5.2 shall be packed and shipped with the equipment.

SECTION 5 - VENDOR'S DATA

5.1 PROPOSALS

The vendor's proposals shall as a minimum include the following:

- (a) All data sheets, drawings and documents listed under "WITH BID" in the Vendor Data Requirement (VDR) Form enclosed with the inquiry.
- (b) Vendor's confirmation/ comments on post-order Vendor Data Requirements (Type of Documents, no. of prints and date needed) indicated in Vendor Data Requirement forms data sheets and specifications.
- (c) List of recommended commissioning spares included in the offer.
- (d) List of mandatory spares (where specified by the purchaser) included in the offer.
- (e) List of spare parts for two years normal operation shall be made separately including auxiliaries and drivers in the form of a table & shall show
 - i) Part name, description and number.
 - ii) Quantity installed in one unit.
 - iii) Quantity recommended per unit for 2 years normal operation.
 - iv) Quantity recommended for number of units of an item as specified in the inquiry.
 - v) Quantity recommended as insurance for the number of units of an item specified in the inquiry.
- (f) An itemized list of special tools included in the offer.
- (g) Any start-up, shutdown or operating restrictions required to protect the integrity of the equipment. These spares to be included as commissioning spares.
- (h) Any limitations of vendor's test-facility to carryout the specified tests.
- (i) A specific compliance statement that the scope of supply, the offered equipment/ systems and all its components are in strict accordance with the data sheets, job specifications, this specifications and all other attachments, except for specific deviations as listed in the proposal.

5.2 CONTRACT DATA

5.2.1 General

- 5.2.1.1 Drawings and data as required after purchase order is specified in Vendor Data Requirement. Vendor to note that the drawing/ document descriptions/ titles as given in the Vendor Data Requirement are generic in nature. It is possible that against one drawing/ document specified there are several drawings to be furnished by the vendor or vice versa.

Vendor to note that, the submission of all post order drawing & documents shall be done through EIL Electronic Document Management System (eDMS) portal. Vendor shall complete & forward the Document Control Index (DCI) to the purchaser (Destination & contact person as per order) through above eDMS portal.

This document shall list out in consolidated form all drawings and documents required by purchaser vide VDR as included in the purchase requisition. Any other data, drawing/ document as specified in Data Sheets and Specifications shall also be included by the vendor in the DCI. Against each drawing/document, vendor shall populate their list of document indicating the vendor's drawing numbers, titles, Rev. No. and schedule of submission.

This shall be the first document to be submitted by vendor within two weeks of order.

No drawing shall be taken up for review till DCI for the inquiry/order is finalized by vendor.

- 5.2.1.2 All transmittal letters (covers), drawings and data shall have a title block (in addition to vendor's standard title block) which shall as a minimum contain the following contract information:
- (i) Purchaser's and Consultant's Corporate Name
 - (ii) Project Name.
 - (iii) Equipment Name and Item No.
 - (iv) Purchase Order No.
 - (v) Purchase Requisition No.
- Title Block on drawings shall be placed on the lower right hand corner.
- 5.2.1.3 All vendor data/ drawings/ documents shall be in English Language and in Metric Systems.
- 5.2.1.4 Data specified in the VDR is the minimum requirements of Purchaser. Any additional document/ data required or requested by Purchaser for engineering or construction shall also be made available by the vendor.
- 5.2.2 **Co-ordination meeting**
 When specified, a co-ordination meeting shall be held at Purchaser's office, preferably within 4 weeks of order.
 An agenda shall be prepared for this meeting and would include the following points related to technical aspects.
- (a) Any clarifications required by the vendor on purchaser's order.
 - (b) Vendor Data Index & Schedule.
 - (c) Vendor Data Review/approval modalities.
 - (d) Sub-vendor lists proposed by vendor.
 - (e) Utility requirements.
 - (f) General Arrangement & layout drawings & purchaser's interface drawings.
- 5.2.3 **Drawings**
- 5.2.3.1 The timeframe within which the drawings are to be submitted by vendor are specified in Purchaser's inquiry/order.
- 5.2.3.2 The purchaser's review of the vendor's drawings shall not constitute permission to deviate from any requirements in the purchase order/specifications unless specifically agreed upon in writing. After the drawings have been reviewed, certified copies shall be submitted by vendor as a part of final documents (Technical Data Manual/Mechanical catalogues) in the specified quantity. All drawings must be clearly legible and shall be submitted A4 or A3 paper sizes (except overall layout/ Foundation/ GA drawings which shall be submitted in A2 paper sizes). Documents in higher paper size shall be submitted in exceptional circumstances or as indicated in the enquiry/ contract document(s).
- 5.2.3.3 Drawings/documents with following titles shall contain as a minimum the following information:
- a) **General Arrangement Drawing**
 A general arrangement drawing shall indicate:
 - i) Outline dimensions (minimum three views) (All principal dimensions).
 - ii) Location (in all three planes), size, type, rating and identification of all purchaser's interface connections including those of vents, drains, fuel, cooling water & Electrical/ Instrumentation.
 - iii) Direction of rotation viewing from the driving end.
 - iv) Weight of each assembly/ component.
 - v) The weight & location of centre of gravity of the heaviest assembly/components that must be handled for erection.

- vi) Identification and weight, dimensions of the heaviest assembly / subassembly / component required to be handled for maintenance.
- vii) Maintenance clearances and dismantling clearances.
- viii) Speed
- ix) Layout of auxiliary equipment and operating platform.
- x) Height of installation of the day tank (if applicable).
- xi) Make, Type and Size of couplings and the location of guards.
- xii) A list of reference drawings if any.
- xiii) A list of any special weather-protection and climatic features.

b) Foundation Drawings

A foundation drawing shall indicate complete information required for foundation design by purchaser including the following:

- a) Foundation bolt sizes & pipe sleeve details and pocket sizes & locations.
 - b) Type of grout material, its recommended make & grade.
 - c) Grouting thickness and other necessary technical details.
 - d) Static weight of each independently grouted item (such as diesel engine, gear box (if required), driven equipment, control panel etc.) and location of centre of gravity of each of such items in all three planes.
 - e) Weight distribution for each bolt/subsole-plate location and total static weight.
 - f) Dynamic loads, if any, caused due to various items grouted independently. (The cause of generation of such loads shall also be indicated).
 - g) The direction and magnitude of unbalance forces and moments (with their phase angles) generated by the out of balance of the rotating / moving parts of the machine at the relevant operating conditions. [These loads and their locations are to be given in all three planes. These shall be utilised for computing the amplitudes of vibration of the foundation].
 - h) GD^2 value of each item resolved to driver speed.
 - i) Maximum permissible amplitude of vibration on the foundation at the base level. (The location of the points on the foundation base where such amplitudes are not to be exceeded shall be given in all three planes). The reference of relevant code, if any, shall also be indicated.
 - j) Total mass of rotating parts.
 - k) Total mass of reciprocating parts.
 - l) Suggested dynamic factor and ratio of weight of foundation to weight of machine.
 - m) Short circuit loads caused in motor drivers.
 - n) Operating speed of the machine and the driving motor.
 - o) Scope of Supply of the Foundation Bolts (unless otherwise specified, by vendor).
 - p) Maximum permissible magnitude of the unbalance forces and moments generated by the out of balance of the rotating / moving parts of the machine as allowed by the relevant codes, if any. (The reference of such code, if any, shall also be indicated).
 - q) Recommended separation margin (if any), between the machine operating speeds and the natural frequencies of the machine foundation system along with the basis of such recommended separation margins.
- [Note: Unless otherwise indicated by vendor, the dynamic forces as given in e) & l) above are considered as additional static loads for designing the foundations statically. Such dynamic forces are not unbalance forces and therefore, these shall not be utilised for computing the amplitudes of vibration.]

c) Field Alignment Diagram

The diagram shall indicate the relative displacement to be kept between the centrelines of various equipment at the time of installation, so that under normal running conditions the equipment get fully aligned. This relative displacement should be decided on the basis of centreline temperature rise data of driver, gear box/ transmission system, driven equipment.

5.2.4 Data sheet

5.2.4.1 The Vendor shall provide completely filled in data sheets, first for "As Purchased" and then for "As Built". This shall be done by the vendor correcting and filling out the data sheets and submitting copies to the purchaser.

5.2.5 Technical Data Manual/Mechanical catalogues

5.2.5.1 Mechanical catalogue is a compilation of "As Built" drawings and data, manufacturing and test records, installation, operating and maintenance instructions.

5.2.5.2 Not later than two weeks after successful completion of all specified tests, the vendor shall furnish the required number of mechanical catalogues for the equipment, any auxiliaries and instruments that the vendor is providing. The mechanical catalogue shall include the following documents as a minimum:

- i) All drawings and data as listed in the vendor data index & schedule. (For drawings, where purchaser's approval is required, the final certified drawings shall be attached.) Sections shall be organized in a manner that data & drawings related to one subject is grouped together such as Mechanical, Electrical, Instrumentation etc.
- ii) All manufacturing, inspection and test data and records.
- iii) Installation and Instruction Manual
The vendor shall provide sufficient written instructions, including a cross-reference list of all drawings, to enable the purchaser to correctly install the equipment and prepare the equipment for start-up. It shall include any special information required for proper installation that is not on the drawings, special alignment or grouting procedures, utility specifications (including quantity) and all installation data.
- iv) Operation and Maintenance Manual
This manual shall provide sufficient written instructions and data to enable purchaser to correctly operate and maintain the equipment ordered. It shall include a section to cover special instructions for operation at extreme environmental and/or extreme operating conditions. The following shall be included in this manual:
 - a) Instructions covering start-up, normal shutdown, emergency shutdown, operating limits and routine operational procedures.
 - b) A description of equipment construction features and the functioning of component parts or systems (such as control, lubrication, etc.).
 - c) Outline and sectional drawings, schematics and illustrative sketches in sufficient details to identify all parts and clearly show the operation of all equipment and components and the methods of inspection and repair. Standardised sectional drawings are acceptable only if they represent the actual construction of the equipment.
- v) Following information shall also be included in the Mechanical Catalogue:
 1. Storage instructions for storing and preserving the equipment (including auxiliary units) at the plant site before installation of the same.
 2. Field test procedures and acceptance criterion.

5.2.5.3 Technical Data Manual/ Mechanical Catalogue shall be in Hard board folder(s) of size 265 mm x 315 mm (10½" x 12½") and shall not be more than 90 mm thickness; it may be of several volumes and each volume shall have a volume number, index of volumes & index of contents of that particular volume.

5.2.5.4 Title sheet (Top sheet) of each volume of mechanical catalogue shall contain the contract information(s) as defined under 5.2.1.2 besides the volume number.

- 5.2.5.5 In case order contains more than one item, separate dedicated Technical Data Manual/ Mechanical Catalogues shall be submitted for each item.
- 5.2.5.6 Two (2) sets of Final / "As-Built" drawings / documents shall also be submitted as electronic files on secondary storage media (CD-ROM / DVD-ROM disks).

ANNEXURE-A

Deration Calculation for Diesel engine in genset application

1. ISO Standard Power (as per ISO 3046-1) of the engine, (obtained after deducting power loss due to essential dependent auxiliaries) (P_{iso})
 P_{iso} : kW
2. Deration on account of site conditions (refer datasheet for ambient conditions) as per ISO 3046-1
 Temperature (around the engine and alternator) : kW
 Altitude (d1) : kW
 Humidity (d2) : kW
 CW temp (d3) : kW
 Inlet losses (d4) : kW
 Exhaust back press (d5) : kW
 Total Deration ($P_{deration} = d1+d2+d3+d4+d5$) : kW
3. Service Power (as per ISO 3046-1) of the Engine (i.e. at stated conditions)
 $P_{service} = P_{iso} - P_{deration}$: kW
4. Power Loss in the Alternator under stated conditions (P_{alt})
 P_{alt} [i.e. $KVA * pf(100 - \eta_{alt}) / \eta_{alt}$] : kW
5. Power consumed by essential independent auxiliaries (P_{aux})
 P_{aux} : kW
6. Any other Power Loss applicable to the offered genset (P_{misc})
 P_{misc} : kW
7. Net output required for electrical consumption (P_{output})
 $(P_{output} = \text{_____ kW (minimum)})$: kW
8. Actual Power Required from Engine (P_{actual})
 $P_{actual} = P_{output} + P_{alt} + P_{aux} + P_{misc}$: kW

Ensure that $P_{service} \geq P_{actual}$ and shall furnish calculations / supporting documents.

Note: As per Annex-A of ISO-3046-1, the following describes the typical list of auxiliaries:

1. Essential dependent auxiliaries (as applicable)
 - a) engine-driven L.O pressure pump;
 - b) engine-driven L.O scavenge pump for dry-sump engines;
 - c) engine-driven engine-cooling water pump;
 - d) engine-driven raw-water pump;
 - e) engine-driven radiator-cooling fan;
 - f) engine-driven engine-cooling fan for air-cooled engines;
 - g) engine-driven gaseous fuel compressor;
 - h) engine-driven fuel-feed pump;
 - i) engine-driven fuel-pressure pump for common rail or servo-injection system;
 - j) engine-driven scavenge-air blower and/or charge-air blower;
 - k) engine-driven generator, air compressor or hydraulic pump supplying power to items in sl. No. 2 below;
 - l) engine-driven cylinder lubricating pump;
 - m) air cleaner or air silencer (normal or special);
 - n) exhaust silencer (normal or special).

2. Essential independent auxiliaries (as applicable)
 - a) separately driven auxiliaries as defined above from Sl. no. a) to l).
 - b) governing or control system using power from an external source.
3. Non-essential dependent auxiliaries (as applicable)
 - a) engine-driven starting air compressor;
 - b) engine-driven generator, air compressor or hydraulic pump when supplying power to items not shown in sl. No. 2 above;;
 - c) engine-driven bilge pump;
 - d) engine-driven fire pump;
 - e) engine-driven ventilation fan;
 - f) engine-driven fuel-transfer pump;

Deration Calculation for Diesel Engine in Industrial application

1. ISO Standard Power (as per ISO 3046-1) of the engine, (obtained after deducting power loss due to essential dependent auxiliaries) (P_{iso})
 P_{iso} : kW
2. Deration on account of site conditions (refer datasheet for ambient conditions) as per ISO 3046-1
 Temperature (around the engine and alternator) : kW
 Altitude (d1) : kW
 Humidity (d2) : kW
 CW temp (d3) : kW
 Inlet losses (d4) : kW
 Exhaust back press (d5) : kW
Total Deration ($P_{deration} = d1+d2+d3+d4+d5$) : kW
3. Service Power (as per ISO 3046-1) of the Engine (i.e. at stated conditions)
 $P_{service} = P_{iso} - P_{deration}$: kW
4. Transmission losses in gear-box (P_{trans})
 P_{trans} : kW
5. Any other Power Loss applicable to the offered genset (P_{misc})
 P_{misc} : kW
6. Net output required for Mechanical drive (P_{output})
 $(P_{output} = \text{driver rating}^{\#})$: kW
[#: The driver rating shall be as calculated per respective specification]
8. Actual Power Required from Engine (P_{actual})
 $P_{actual} = P_{output} + P_{trans} + P_{misc}$: kW

Ensure that $P_{service} \geq P_{actual}$ and shall furnish calculations / supporting documents.

Note: As per Annex-A of ISO-3046-1, the following describes the typical list of auxiliaries:

1. Essential dependent auxiliaries (as applicable)
 - a) engine-driven LO pressure pump;
 - b) engine-driven LO scavenge pump for dry-sump engines;
 - c) engine-driven engine-cooling water pump;
 - d) engine-driven raw-water pump;
 - e) engine-driven radiator-cooling fan;
 - f) engine-driven engine-cooling fan for air-cooled engines;
 - g) engine-driven gaseous fuel compressor;
 - h) engine-driven fuel-feed pump;
 - i) engine-driven fuel-pressure pump for common rail or servo-injection system;
 - j) engine-driven scavenge-air blower and/or charge-air blower;
 - k) engine-driven generator, air compressor or hydraulic pump
 - l) engine-driven cylinder lubricating pump;
 - m) air cleaner or air silencer (normal or special);
 - n) exhaust silencer (normal or special).

आपातकालीन जनरेटर के लिये विनिर्देश

SPECIFICATION FOR EMERGENCY GENERATOR

6	27.06.14	REVISED AND ISSUED AS STANDARD SPECIFICATION	<i>RS</i> RS	<i>ANPS</i> ANPS	<i>BRB</i> BRB	<i>SC</i> SC
5	25.04.08	REVISED AND ISSUED AS STANDARD SPECIFICATION	SD	BRB	JMS	VC
4	12.03.03	REVISED AND ISSUED AS STANDARD SPECIFICATION	LSY	AAN	VPS	SKG
3	31.12.97	RE-AFFIRMED AND ISSUED AS STANDARD SPECIFICATION	RSG	VPS	SG	A.SONI
2	28.07.89	ISSUED AS STANDARD SPECIFICATION	AAN	VPS	SG/GNT	
Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
Approved by						

Abbreviations:

AC	Alternating Current
AMF	Automatic Start on Mains failure
AVR	Automatic Voltage Regulator
BIS	Bureau of Indian Standard
BS	British Standards
CACA	Closed circuit air cooling with air to air heat exchanger
CT	Current Transformer
DC	Direct Current
DG	Diesel Engine Driven Generator
DOL	Direct On Line
EIL	Engineers India Limited
GI	Galvanised Iron
IEC	International Electro-technical Commission
IEEE	Institute of Electrical & Electronics Engineers
IS	Indian Standard
KVA	Kilo Volt Amperes
MR	Material Requisition
NEMA	National Electrical Manufacturers Association
PCB	Printed Circuit Board
PMG	Permanent Magnet Generator
PO	Purchase Order
PT	Potential Transformer
PTR	Proven Track Record
PVC	Poly Vinyl Chloride
REF	Restricted Earth Fault
RTD	Resistance Temperature Detector
SWG	Standard Wire gauge
TPN	Three Phase and Neutral
VDE	Verband Deutscher Elektrotechniker

Electrical Standards Committee

Convenor:	Mr. B.R. Bhogal
Members :	Ms. S. Anand
	Mr. Parag Gupta
	Mr. M. K. Sahu
	Mr. A. K. Choudhary (Inspection)
	Ms. N. P. Guha (Projects)

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1.0 SCOPE

This specification defines the minimum requirements for the supply of self-excited Internal Combustion Engine driven Emergency Generator and associated electrics suitable for installation in Unclassified / Safe area.

Unless otherwise specified in the Material Requisition (MR) / data sheet, the emergency generator and associated electrics shall be complete with

- Alternator with brushless excitation system complete with AVR.
- Generator Control Panel to include AMF system, Auto / Manual control, synchronization and auxiliary devices, battery and charger. This panel shall also include generator breaker and generator protection relays if specified in the data sheet.
- Any other part / accessories not specifically mentioned above but considered necessary for safe and reliable operation.

2.0 CODES AND STANDARDS

- 2.1. The equipment shall comply with the requirements of latest revision of following standards issued by BIS (Bureau of Indian standards) unless otherwise specified.

IS: 5	Colors for ready mix paints and enamels
IS : 2253	Designation for type of construction and mounting arrangement of rotating electrical machines.
IS : 4722	Rotating electrical machines.
IS : 7372	Lead acid storage battery for motor vehicle.
IS : 7816	Guide for testing of insulation resistance of rotating machines.
IS : 12065	Permissible limits of noise level for rotating electrical machines.
IS : 13364	AC Generators up to 20 KVA driven by reciprocating internal combustion engine.
Part-I	
IS : 13364	AC Generators above 20 and up to 1250 KVA driven by reciprocating internal combustion engine.
Part-II	
IS/IEC 60947	Low voltage Switchgear and Control gear: General Rules.
Part-I	

- 2.2. In case of imported equipments, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.
- 2.3. The equipment shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.
- 2.4. In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.
- 2.5. In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the most stringent requirement shall govern and decision of owner in this regard shall be final.

3.0 SITE CONDITIONS

Generator shall be suitable for operating satisfactorily in humid and corrosive atmospheres found in refineries, petrochemical and other industrial plants. Ambient conditions shall be as specified in the Data Sheet. If not specifically mentioned therein, a maximum ambient temperature of 40° C and an altitude not exceeding 1000 meters above mean sea level shall be considered.

4.0 GENERAL REQUIREMENTS

- 4.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 10 years from the date of supply.
- 4.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

5.0 PERFORMANCE REQUIREMENTS

5.1 Name Plate Rating and Duty

Rating indicated in the datasheet indicates the continuous apparent power available at terminals, when operated inside the enclosure (for machines with acoustic enclosure) and at maximum ambient temperature, as specified in datasheet. Suitable de-rating shall be applied to account for temperature rise due to operation within enclosure.

The specified maximum ambient temperature shall be considered outside the enclosure for machines having acoustic enclosure. The temperature inside the acoustic enclosure shall be suitably considered by manufacturer taking care of temperature rise inside the acoustic enclosure during full load conditions. The enclosure ventilation system shall be designed along with the proposed alternator model so as to generate the rated power while operating inside enclosure.

- 5.2 The generator shall meet the required performance requirements specified in IS: 13364 (Part 1 & 2). The voltage characteristics of generator shall conform to the VG3 grade given in IS: 13364 (Part 1 & 2). For machines rated above 1250kVA, stipulations of IS:4722 shall be applicable.
- 5.3 Motorized potentiometer shall be provided where remote control of voltage is envisaged if specified in data sheet.

5.4 Parallel Operation

Where specified, generator and associated electrics shall be suitable for parallel operation amongst themselves, or with other generating sets or with other sources (Grid supply) at operating voltage and under the load conditions up to rated value and with the generator neutral solidly earthed.

5.5 Excitation Support System

Excitation system shall be provided with short-circuit support equipment to maintain three times the rated current for three seconds in case of short circuit to ensure proper fault clearance in outgoing feeders.

5.6 Noise

Statutory noise control requirements as applicable and as stipulated in the Mechanical Specifications shall be adhered to.

6.0 DESIGN AND CONSTRUCTION

- 6.1 Generator enclosure protection shall be IP – 23, as a minimum.
- 6.2 The generator shall be mounted on a common base frame together with prime mover unless otherwise agreed. The generator shall be provided with necessary lifting hooks and two earth terminals on opposite sides for connection to main earth grid.
- 6.3 Various generator winding (i.e. stator, rotor, exciter) shall be designed either for insulation Class ‘F’ with temperature rise up to Class ‘B’ or with Class ‘H’ with temperature rise up to Class ‘F’. The windings and overhangs shall be braced to withstand the short circuit forces.
- 6.4 Machines rated 1000 KVA and above shall have minimum six nos. RTDs (one per phase between the coil sides to measure winding temperature and one per phase at the base of slots to measure core temperature, each placed at 120° apart).
- 6.5 The stator winding shall be star connected and all windings shall be brought out to (3+3) insulated terminals in a terminal box with provision of CTs as per details given in the data sheet.
- 6.6 Where terminal box does not have sufficient space for accommodating CTs for protection, a separate cubicle shall be provided by vendor, irrespective of the machine rating. In such case all connections shall be brought to the cubicle, using cable / bus duct connection of sufficient rating. Apart from accommodating CTs, formation of star point and neutral tee off point shall be achieved in this cubicle. Out going power cable connection to owner’s power distribution board shall also be done in this cubicle.
- 6.7 Generators rated above 500 KVA shall be supplied with REF CT, unless otherwise specified in the data sheet.
- 6.8 Differential CTs shall be provided if specified in the data sheet.
- 6.9 Generators rated 1000kVA and above shall be provided with a separate neutral terminal box. Neutral cubicle shall contain various CTs for protection. A suitably rated generator breaker shall be provided, if specified in data sheet.
- 6.10 The terminal box (cs) and cubicles shall have sufficient space for the termination of quantity of cable or bus duct as specified in data sheet.
- 6.11 All terminals shall be stud type. The terminal boxes / cubicles shall be complete with tinned copper lugs and single compression nickel plated brass cable glands for the quantity and type of power cables as specified in the data sheet. Where single core cables are specified, gland plates shall be of non magnetic material (Stainless steel or Aluminum)
- 6.12 All parts and accessories shall be suitable to withstand stresses due to over speed / over load/ short circuit conditions specified.
- 6.13 **Bearings**
- 6.13.1 Bearings shall be grease lubricated ball or roller bearing or of the manufacturer’s standard type i.e. sleeve type supported with PTR. In all cases the bearings shall be chosen to give a minimum L-10 rating of 5 years (40,000hrs) at rated operating conditions.

- 6.13.2 Grease lubricated bearings shall be capable of grease injection from outside without removal of covers. The bearing boxes shall be provided with labyrinth seals to prevent loss of grease or entry of dust or moisture. When grease nipples are provided those shall be associated, where necessary, with appropriately located relief devices which ensure passage of excess grease through the bearings.
- 6.14 The direction of rotation of the rotor of the machine shall be compatible with that of the prime mover. A clear indication of the direction of rotation shall be given on either end of the machine.
- 6.15 Space heaters shall be installed within the enclosure. Location and maximum surface temperature of the heaters shall be such that no damage can be caused to any insulation. Heaters shall be suitable for operation on a single-phase 240 V AC supply unless otherwise specified.
- 6.16 Field winding shall have insulation class and temperature limitations as per para 6.3 above. The field winding shall be capable of operating at 125 % of rated field voltage for at least one minute starting from hot initial condition, i.e. stabilized temperatures at rated load conditions. (Rated field voltage is the voltage applied at the field winding for producing rated terminal voltage at rated load and speed).
- 6.17 All cabling on the generator skid shall be in GI perforated cable trays / conduits. All cables shall be identified close to their termination point. Single compression type cable glands shall be used for cable termination.
- 6.18 **Auxiliary Terminal Boxes**
- Separate Terminal boxes of sturdy construction shall be provided for Space Heater and other devices like RTDs, with sufficient space for connecting the cables as indicated in the requisition.
- 6.19 **Auxiliary Motors**
- All auxiliary motors shall be three phase, 415 V, 50 Hz squirrel cage type suitable for DOL starting. All motors shall have IP - 55 enclosures and shall conform to relevant Indian Standards.
- 6.20 **Battery Bank**
- 6.20.1 The battery shall be lead acid, high discharge automotive type suitable for engine starting duty and conforming to IS: 7372. The battery shall be placed on battery stands made of steel with suitable PVC coating. One no. each of the accessories viz. hydrometer, thermometer, cell testing voltmeter, pair of rubber gloves, spanner, acid resistant jug and funnel, teak wood holder for the hydrometer etc. shall be supplied with each battery set.
- 6.20.2 The battery capacity shall be adequate for six (3+3) consecutive starts of the engine under cold engine condition, without recharging, with additional 10% spare capacity. The auto starting system shall successively carry out 3 (three) automatic start attempts but if diesel engine fails to start even after three attempts then an alarm shall be annunciated on this account and remaining 3 (three) start attempts can be carried out manually as per operator's decision.

7.0 EXCITATION SYSTEM

- 7.1 The generator shall be self-exciting or with PMG, i.e. it shall generate its nominal voltage without the use of external power sources, even after long idle periods or after a short circuit. The generator shall be provided with brushless type solid state self-excitation system with automatic voltage regulator. The excitation system shall include the automatic voltage regulator, AC exciter and rotary rectifier.
- 7.2 The field of the exciter shall be fed from the stator winding and AVR. AC voltage generated in the AC exciter shall be rectified by the rotary rectifier assembly and fed to the main field circuits. The rotor winding of the AC exciter, the rectifier assembly, main field winding of the generator and other accessories on rotor parts shall be rigidly fastened to the shaft and the connection with different items shall be anti-loosening type. The exciter capacity shall be at least 20 % more than the maximum requirement at any time. The exciter winding shall be insulated as per para 6.3 above.
- 7.3 The rotary rectifier set shall consist of rectifiers, zener diodes, fuses, field discharge resistors, condensers, etc. Rotor circuit shall be designed to take care of rectification of AC voltage and for proper field suppression through discharge resistors. The rating of the Diode Bridge and armature shall be such that the full load rated current can be supplied with one branch in operation.
- 7.4 All components shall be mounted considering the effects of the centrifugal forces.
- 7.5 Automatic solid-state voltage regulator (AVR) shall be provided with the following features as a minimum:
- Short circuit protection
 - Auto voltage control
 - Manual voltage control. Unless supplier's standard design does not permit it which shall be supported with proper justification.
 - Voltage build up circuitry
 - Over voltage protection
- 7.6 The AVR can be installed either in the generator control panel or at the generator. In later case, the AVR shall be located in a separate housing or in a clearly segregated section of the main terminal box.

8.0 SYSTEM OPERATION

8.1 Modes of Operation

The emergency generator and associated electrics shall normally be in an unattended area. The control system shall be suitable for unattended operation. The control system shall operate in fail-safe mode and shall include all controls and protection necessary for the safe operation of the DG set. The generator and associated electrics shall function as per the following schemes:

- Auto start on mains failure scheme (AMF), if specified.
- Manual start in Service/Test mode
- Manual stop upon supply restoration

8.1.1 Automatic start on mains failure

This shall be effective in Auto position of Auto / Manual selector switch located in local control panel. The generator shall normally be at rest. Upon failure of normal supply, a start

impulse (in the form of changeover of a dry contact) shall be provided by others. Using this impulse, generator shall start automatically and rated speed and voltage shall be built up. Once the voltage-monitoring relay senses generator healthy voltage, an impulse shall be given for closing of generator breaker or contactor.

All accessories required for starting and completion of various sequence of operation for the above purpose shall be provided as part of generator.

8.1.2 **Manual start**

8.1.2.1 **In Service Mode**

This shall be effective in manual position of Auto/Manual switch and service position of service / test selector switch located in control panel. The scheme of operation shall be same as of auto mode as per clause 8. 1.1 above except that starting command shall be extended manually using the push button (instead of command from AMF sequence) from the local control panel. Provision shall also be kept for manual start from owner's remote control panel.

8.1.2.2 **In Test Mode**

This shall be effective in test position of service / test selector switch. The scheme of operation shall be same as that of manual start in service mode as per clause 8.1.2.1 above except that the closing command for generator breaker /contactor shall not be extended automatically.

If periodic load test-run of generator is envisaged as per data sheet, the generator breaker shall be closed manually after synchronization with grid.

DG shall have provision along with necessary hardware for setting load on DG (0 to 100%) during load test-run. Voltage signal shall be made available as below from bus side for synchronizing purpose :

For alternator having terminal voltage of 415V : $415V \pm 6\%$, $50Hz \pm 3\%$, TPN signal or $110V \pm 6\%$, $50Hz \pm 3\%$ TPN signal from PT secondary

For alternator having terminal voltage > 415V : $110V \pm 6\%$, $50Hz \pm 3\%$ TPN signal from PT secondary

8.1.3 **Stop upon restoration of grid mains supply**

If specified in data sheet, in auto mode, AMF panel shall issue a command for closing of grid breaker after synchronizing DG supply with grid. Once grid breaker is closed, AMF panel shall issue a command for opening of DG breaker. Voltage signal shall be made available as below from grid line side for synchronizing purpose :

For alternator having terminal voltage of 415V : $415V \pm 6\%$, $50Hz \pm 3\%$, TPN signal or $110V \pm 6\%$, $50Hz \pm 3\%$ TPN signal from PT secondary

For alternator having terminal voltage > 415V : $110V \pm 6\%$, $50Hz \pm 3\%$ TPN signal from PT secondary

Unless specified otherwise in the datasheet, DG set shall be stopped MANUALLY using push button. This shall be possible irrespective of the position of Auto / Manual selector switch which is located in generator control panel.

8.2 **Shut-down**

It shall be possible to manually stop the generator in all operational cases including emergency case by means of the push button provided in either generator control panel or Owner's remote panel.

8.3 Starting Time

Unless specified otherwise, the total time from the receipt of the starting impulse for the generator till the set reaches rated speed and generator reaches rated voltage shall not be more than 30 seconds. If this time is exceeded, an annunciation in the local control panel shall be provided with a facility for repeat annunciation in Owner's panel.

8.4 Black Start Facility

The generating unit shall be provided with all necessary 'black start' facilities. External power at 415 V TPN shall be made available by purchaser at one point for battery charging or any other auxiliary equipment operation during stand -still period of generator. This power shall not be available during start-up of the generator.

8.5 DC Control Supply

Unless it is specified that the DC control supply required for AMF/generator relay and control function is being provided by purchaser, all DC power supply requirement shall be met by DC system consisting of battery and battery charger of suitable capacity to be supplied by the DG set vendor.

If, the DC control supply for AMF / generator control panel is provided by purchaser, the engine starting motor and other such special duty DC load required for DG system package shall still be fed from the DC system battery & charger to be supplied by the DG set vendor. During stand still period of DG set, charger of DC supplies shall be energized from the 415 V feeder provided by purchaser as per para 8.4 above.

9.0 GENERATOR CONTROL PANEL

9.1 The local generator control panel for the generator shall include all interlock and controls for the generator and its auxiliaries and comprise of the following unless otherwise specified in the attached data sheet:

- a. Local circuit breaker and generator protection relays, if specified.
- b. Line Cubicle, as applicable.
- c. Neutral cubicle, as applicable, having protection CTs
- d. Metering CTs and CT/PTs for AVR
- e. Metering equipments
- f. Indicating instruments
- g. Synchronizing equipment, if specified
- h. Motor control gear section for generator auxiliaries
- i. Battery charger
- j. Any other accessory necessary for generator operation.

9.2 In case, a generator breaker is required to be supplied, it shall form part of the line cubicle. The breaker rating shall be as specified in the data sheet. This breaker shall serve the purpose of local isolation. The breaker shall be in draw out execution. In case of 415 V generators, breaker shall have four poles for isolation of phases and neutral.

9.3 All motor starters for DG set auxiliaries if required shall be 'direct-on-line' type in fixed execution.

9.4 The battery charger with rated power out put in excess of 1000 W (i.e. for rating more than 40 Amps at 24 V) shall be 3 phase full wave type as per EIL specification 6-51-0030.

9.5 Single Phase Charger

Chargers for DC power out put up to 1000 W shall be conforming to the following specifications:

- 9.5.1 The battery charger shall have 1-phase full wave controlled Rectifier Bridge with their protective devices. The charger shall be of solid state design, constant voltage type with current limiting feature suitable for automatic and manual, normal (float charging) and quick (boost) charging of batteries. The output voltage shall be stabilized to $\pm 1\%$ for mains variation of $\pm 10\%$ and load variation of 0 to 100%. The maximum ripple content in the charger output voltage shall be lower than the safe value recommended by battery manufacturer and in any case shall not exceed 5% with battery disconnected. The charger shall be sized for boost charging the battery within 10-14 hours.
- 9.5.2 The charger shall have auto as well as manual control facility. In auto mode, the charger shall automatically control the battery charging current/voltage to ensure optimum boost charging of the battery. After completion of boost charging, the charger shall switch to float charging mode without any manual intervention.
- 9.5.3 In the manual mode, it shall be possible to charge the battery at any desired current that is safe for the battery. A backup timer of 0-24 hours range shall be provided for switching the charger from boost to float mode after the set time, under any mode of operation.
- 9.5.4 Auto/manual selector switch, ON/OFF switch for incoming power supply, float/boost selector switch, potentiometer for control of output voltage and backup timer shall be provided on the front of the panel in addition to AC incoming voltmeter and ammeter with selector switch and DC output voltmeter and ammeter. Indication lamps for AC power on, charger in float, charger in boost, charger failure shall also be provided.

9.6 Generator Control Panel Construction

- 9.6.1 The generator control panel shall be free standing, metal enclosed fabricated with cold rolled sheet steel of 2mm thickness, dust and vermin proof type with a hinged door and having a degree of protection IP 41 unless otherwise specified. Power and control equipment shall be segregated inside the panel as far as practicable.
- 9.6.2 The maximum height of the operating handle / switches shall not exceed 1800 mm and the minimum height shall not be below 300 mm.
- 9.6.3 All hardware shall be corrosion resistant and bolts; nuts and washers shall be made of galvanized, zinc passivated or cadmium plated high quality steel.
- 9.6.4 Unless otherwise specified, the panel shall be suitable for bottom cable entry. Necessary removable type undrilled gland plate; single compression cable glands and cable lugs shall be provided with the panel.
- 9.6.5 All auxiliary devices for control, indication, measurement and alarm such as push button, control / selector switches, indicating lamps, metering instruments, annunciations etc. shall be mounted on the front door of the panel. Adequate number of potential free contacts shall be provided in the control panel for any remote control, monitoring of the generator.
- 9.6.6 All switches shall be load-break, heavy-duty type. All fuses shall be non-deteriorating HRC cartridge pressure fitted, link type. The contactors for auxiliary motor starters shall be of air-break type having AC-3 duty rating. Thermal overload relays shall be three element, positive acting, ambient temperature compensated type with adjustable setting range and built in protection feature against single phasing.

- 9.6.7 All indicating instruments shall be moving iron, flush mounting type and of 72 mm. x 72 mm. square pattern. As an option, vendor may offer digital meters.
- 9.6.8 All control/ selector switches shall be rotary back-connected type having a cam-operated contact mechanism with knob type handle. 'Stop' push buttons shall be stay-put type.
- 9.6.9 Wiring for power, control and signaling circuits shall be done with 660 V grade PVC insulated, BIS approved, flame retardant low smoke type, copper conductors. Minimum size of control wires shall be 1.5 mm². Clamp type terminals shall be acceptable for wires up to 10 mm² size and for conductors larger than 10 mm² bolted type terminals with crimping lugs shall be provided. A minimum of 10 % spare terminals shall be provided on each terminal block.
- 9.6.10 50 x 6-mm² Aluminum or equivalent copper earth bus shall be provided in the panel for connection to the main earth grid. All non-current carrying metallic parts of the mounted equipments shall be earthed. Doors and movable parts shall be earthed using flexible copper connections.
- 9.6.11 Engraved nameplates shall be provided for all devices mounted on the front of the panel. Nameplate or polyester adhesive stickers shall be provided for each equipment mounted inside the panel.
- 9.6.12 All metal surfaces shall be thoroughly cleaned of scale, rust, and grease etc. prior to painting. Cleaned surfaces shall be given two coats of primer and prepared for final painting. Final finish shall be free from all sorts of blemishes.

10.0 INSPECTION TESTING AND ACCEPTANCE

- 10.1 Unless otherwise specified, purchaser reserves the right to inspect and witness testing at the vendor's works as per the inspection test plan and the approved quality documents.
- 10.2 In the event, when the witness inspection is not carried out by purchaser as per approved inspection test plan, the tests shall anyway be completed by vendor and documents for the same shall be submitted to purchaser for scrutiny.

11.0 PACKING AND DESPATCH

- 11.1 All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The equipment shall be wrapped in polythene sheets before being placed in crates/cases to prevent damage to finish. Crates/cases shall have skid bottom for handling. Suitable lifting lugs etc. shall also be provided and lifting points shall be clearly marked on the package. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight, Owner's particulars (PO nos.) etc., shall be clearly marked on the package together with other details as per purchase order.
- 11.2 The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature unless otherwise agreed.

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SPECIFICATION FOR ENGINE STARTING BATTERY AND CHARGER

3	17.07.2013	REVISED AND ISSUED AS STANDARD SPECIFICATION	MHR	RS	UAP/JMS	DM
2	25.04.2008	REVISED AND ISSUED AS STANDARD SPECIFICATION	AP	NS	JMS	VC
1	16.09.2002	REVISED & RE-ISSUED AS STANDARD SPECIFICATION	VCB	JMS	VPS	AS
0	04.04.1997	ISSUED AS STANDARD SPECIFICATION	VCB	VPS	SG	A. SONI
Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
Approved by						

Abbreviations:

AC	:	Alternating current
Ah	:	Amperchour
BIS	:	Bureau of Indian Standards
BS	:	British Standards
DC	:	Direct Current
Hz	:	Hertz
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical & Electronics Engineers
IP	:	Ingress Protection
IS	:	Indian Standard
kA	:	KiloAmperes
LED	:	Light Emitting Diode
MSL	:	Mean Sea Level
NEMA	:	National Electrical Manufacturers Association
PCB	:	Printed Circuit Board
PIV	:	Peak Inverse Voltage
PO	:	Purchase Order
PVC	:	Polyvinyl Chloride
TPN	:	Three Phase and Neutral
VDE	:	Verband der Elektrotechnik, Elektronik und Information stechnik
V	:	Volt

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Mr. A. K. Chaudhary (Inspection)

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1.0 SCOPE

1.1 This specification covers the design, manufacture and testing at works of Engine Starting Battery and Charger System. The offered system shall form a part of a larger package involving a Diesel Engine as Prime Mover. It shall be completely integrated with and suitable for the engine starting power requirements. All equipment and accessories required for completeness of the system, whether specifically mentioned or not, but considered essential for satisfactory performance shall be included as a part of the system.

1.2 Each engine shall be provided with separate batteries, charger and distribution panel.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS unless specified otherwise:

IS 5	Colours for ready mixed paints and enamels
IS 1248 Parts-1,2,8,9	Direct acting indicating analogue electrical measuring instruments and accessories
IS 7372	Lead Acid Storage Batteries for motor vehicles
IS 12021	Control transformers for switchgear and controlgear for voltages not exceeding 1000V AC
IS 13703 Parts-1 & 2	Low voltage fuses for voltages not exceeding 1000V AC or 1500V DC

2.2 In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity Rules and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/ specifications/ data sheets and statutory regulations, the following order of decreasing priority shall govern:

- Statutory regulations
- Data sheets
- Job specifications
- This specification
- Codes and standards.

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of the art technology and a proven field track record. No prototype equipment shall be offered.
- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.
- 3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/ spares to enable the end user to place order for spares and services.
- 3.4 The vendor shall be responsible for design, engineering and manufacturing of the complete system to fully meet the intent and requirements of this specification and attached data sheets. The Battery Charger equipment shall be properly coordinated with the selected Battery to ensure complete compatibility.
- 3.5 The Battery shall meet the requirements of data sheets and specifications attached with the Material Requisition/ Bid document.

4.0 POWER SUPPLY AND SITE CONDITIONS

All equipment shall be designed to operate with power supply and site conditions as specified below and in the attached data sheet:

4.1 Power Supply

Unless specified otherwise, the following power supply shall be provided by purchaser at one point for each engine:

Voltage	:	415V $\pm$ 10%, TPN / 240V $\pm$ 10%, SPN
Frequency	:	50Hz $\pm$ 5%

4.2 Site Conditions

The Engine starting battery and charger shall be suitable for operating satisfactorily in humid and corrosive atmosphere found in fertilizer plants, refineries, petrochemical and gas processing plants, metallurgical plants and other industrial plants. Service conditions shall be as specified in the data sheets/job specification. If not specifically mentioned therein, a design ambient temperature of 40°C and an altitude not exceeding 1000m above MSL shall be considered, with minimum temperature of 10°C for battery sizing. Unless specified otherwise, all equipment shall be suitable for installation and operation on the package skid, which shall be located in a closed building with restricted ventilation.

5.0 REQUIREMENTS FOR BATTERY UNITS

- 5.1 The batteries shall be lead acid, high discharge automotive type conforming to IS 7372 and suitable for engine starting duty. The battery containers shall be of high quality translucent plastic/ hard rubber. Terminal posts shall be properly sealed to prevent electrolyte leakage. Venting device shall be anti-splash type. Batteries shall be placed on battery stands made of mild steel with suitable epoxy painting/PVC coating. All accessories like cell insulators, connectors, stand insulators etc. shall be supplied with each set. All hardware shall be suitably coated/ plated to prevent corrosion.

- 5.2 Ampere-hour capacity of the battery shall be selected based on the load cycle (to be decided by the vendor), Ageing factor of 0.8 and temperature correction factor for specified minimum temperature. The battery capacity shall be adequate for six consecutive starts of the engine under cold engine conditions without recharging, with an additional 10% spare capacity. All auxiliary loads for engine controls shall also be considered while defining the load cycle. Also, refer clause 8.0 for Engines for Fire Water Pumps.
- 5.3 The battery shall be suitable for being quick charged from a fully discharged condition to a fully charged condition within 10-14 hours.
- 5.4 The following accessories shall be provided for preventive and routine maintenance of the batteries at each location where the engines are to be installed:
- 1 no. Hydrometer (syringe type)
 - 1 no. Thermometer
 - 1 no. Cell testing voltmeter with leads (Center zero type)
 - 1 pair Rubber gloves
 - 1 no. Spanner
 - 1 no. Acid resistant jug and funnel
 - 1 no. Teak wood holder for the hydrometer.

6.0 REQUIREMENTS FOR BATTERY CHARGER

- 6.1 The charger shall be suitable for both float charging the battery while feeding all loads, other than engine starting motor, as well as for quick charging the battery from fully discharged condition to fully charged condition within 10-14 hours. The sizing of the battery charger shall be based on the maximum continuous rating required to meet the above conditions, with an additional 10% spare capacity. All DC loads for engine controls and continuously operating auxiliaries shall also be considered for this purpose.
- 6.2 The charger shall be of solid-state design, constant voltage and current limit type. The output voltage shall be stabilized to $\pm 1\%$ for mains variation of $\pm 10\%$ and load variation of 0 to 100%. Each load shall be fed through a separate independent feeder. However, a separate DC Distribution Board is not essential for this purpose and the outgoing feeder circuits can form a part of the charger panel.
- 6.3 The charger shall have a 3 phase full wave controlled rectifier consisting of thyristors, commutation circuits, diodes etc. and their protective devices. A suitable filter circuit shall be provided at the rectifier output to obtain a smooth DC output voltage. The maximum ripple content in the charger output voltage shall be lower than the safe value recommended by battery manufacturer, and in any case, shall not exceed 5% with battery disconnected.
- 6.4 The charger shall have auto as well as manual control facility through a lockable selector switch.
- 6.4.1 **Auto Mode**
- In the Auto mode, the charger shall automatically control the battery charging current/ voltage to ensure optimum quick charging of the battery. After completion of boost charging, the charger shall switch to float charging mode without any manual intervention.

6.4.2 Manual Mode

In the Manual mode, it shall be possible to charge the battery at any desired current, which is safe for the battery. Fine control of the output voltage/ current shall be possible.

6.4.3 In both Auto and Manual modes, the battery charging current shall be limited to a safe value as prescribed by battery manufacturer by means of adjustable potentiometer control. A backup timer of 0-24 hrs. range with no-volts hold feature shall be provided for switching the charger from quick charging to float charging mode after the set time, under any mode of operation.

6.5 The charger shall be complete with all interconnections within the panel. All connections shall be made using 660V grade copper conductor PVC/XLPE insulated wires/ cables with BIS marking for both power and control connections. Minimum 1.5mm² conductor size shall be used for control connections. However, control wiring for electronic circuits/ components may use flat ribbon cable or copper wire of minimum 0.5mm diameter. All control wiring shall be enclosed in PVC channels or otherwise neatly bunched together. Each wire shall be suitably identified at both ends by PVC ferrules. Crimping type lugs shall be used for termination.

6.6 All main and control transformers shall be natural air cooled, dry type suitable for location inside a panel. All semiconductor devices shall be natural air cooled with absolute case temperatures limited to 75°C at highest load and ambient temperature. PCBs shall be of copper clad glass epoxy laminate construction. PCB tracks shall be tinned and solder masked. PCBs shall be tropicalised to render them immune to dust, moisture and fungal growth.

6.7 Selection, sizing and suitability of all components used for various applications shall be vendor's responsibility and the rating of components shall be increased, if required, to suit associated components during execution of the order without any claim for extra price or time. Series-parallel combination of smaller devices to achieve specified rating shall not be acceptable.

6.8 A suitably sized earth bus of minimum size 25x3 mm² copper shall be provided at the bottom of the panel with provision to connect it to the owner's main earth grid at both ends.

6.9 The charger shall be preferably housed in a 1.6/ 2mm thick sheet steel enclosure having minimum IP-41 degree of ingress protection. The panel shall be free standing, floor mounted type with hinged doors and shall be suitable for bottom cable entry. The maximum and minimum operating height shall be 1800mm and 300mm respectively. Eyebolts shall be provided on the top cover for lifting. When removed, the eyebolts shall not leave any openings in the panel.

6.10 The charger panel surface shall be properly pretreated for final painting with 2 coats of epoxy paint of shade 631 as per IS 5/RAL 7032. Epoxy based powder coating of adequate thickness for rugged industrial use shall also be acceptable. Nameplates shall be of anodized aluminium or stainless steel.

7.0 CONTROL, PROTECTION, METERING AND INDICATION

The Charger shall be provided with the following features:

7.1 Controls

- Auto/ Manual selector switch
- ON/ OFF switch for incoming power supply
- Float/ Quick charging selector switch
- Potentiometer for coarse and fine control of output voltage
- Backup Timer.

7.2 Protection

- Fault protection on input and output circuits
- Suitable semiconductor fuses for all thyristors and semiconducting power devices.

7.3 Metering

- AC input voltmeter and ammeter with selector switch
 - DC output voltmeter and ammeter
- All meters shall be of 72mm square size with accuracy class 1.5.

7.4 Indication

The following minimum indications shall be provided:

- AC power ON (for each phase)
- Charger in 'Float Charging' condition (Yellow)
- Charger in 'Quick Charging' condition (Green)
- Charger failure (Amber)

Indicating lamps shall employ LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm. In addition, facility for remote indication of AC and DC failure shall be provided.

8.0 SPECIAL REQUIREMENTS

In addition to the above, Engines for Fire Water Pumps which are provided with backup manual starting using an electric starter motor, shall have the following features:

- 8.1 A separate identical battery bank shall be provided for Manual starting.
- 8.2 The charger shall be suitable for charging both battery banks for Automatic and Manual starting in position.
- 8.3 The battery charger shall be fully rated for trickle charging both the battery banks simultaneously.
- 8.4 Both battery banks for Automatic and Manual starting shall each be adequate for ten consecutive starts without recharging with a cold engine under full compression in place of six consecutive starts specified at clause 5.2.

9.0 INSPECTION AND TESTING

9.1 Batteries shall have been fully Type tested and certificates for the same shall be furnished. In addition, the batteries shall be tested as per applicable standards at battery manufacturer's works for the required duty cycle and other relevant acceptance tests.

9.2 High voltage withstand test (2 kV for 1 minute) shall be carried out on each charger.

9.3 Heat Run Test

Heat Run test at rated load and minimum supply voltage shall be carried out on each charger for a period not less than 8 hours. During the test, the temperature of electronic power devices should stabilize and remain constant for 1 hour, or the test shall be suitably extended until this is achieved.

9.4 Functional tests shall be carried out on each charger to check the design and operation.

9.5 All equipment shall be subject to inspection by EIL/owner or by an agency authorized by the owner, to assess the progress of work. The manufacturer shall furnish all the necessary information concerning the supply to EIL/owner's representative. EIL/owner's representative shall be given free access in the works from time to time for stage wise inspection and progress reporting. Four weeks advance notice shall be given to witness the final routine test and other tests as agreed upon.

10.0 PACKING AND DESPATCH

All the equipment shall be divided into multiple sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation, i.e. by ship/ rail or trailer. It shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO No.' etc., shall be clearly and indelibly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. In order to prevent movement of equipment/ components within the crates, proper packing supports shall be provided. A set of instruction manuals for erection, testing and commissioning, a set of operation and maintenance manuals and a set of final drawings shall be enclosed in a waterproof cover along with the shipment.

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SPECIFICATION FOR NUMERICAL RELAYS & SUBSTATION AUTOMATION SYSTEM

2	12-06-14	REVISED AND ISSUED AS STANDARD SPECIFICATION	AS	SV	BRB	SC
1	24-03-09	REVISED AND ISSUED AS STANDARD SPECIFICATION	SKM	AK	JMS	ND
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Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
Approved by						

Abbreviations:

AC	: Alternating Current	LCD	: Liquid Crystal Display
BS	: British Standard	LED	: Light Emitting Diode
BTD	: Bearing Temperature Detector	HMI	: Human Machine Interface
CBCT	: Core Balance Current Transformer	TCP-IP	: Transmission Control Protocol- Internet Protocol
CPU	: Central Processing Unit	MOG	: Magnetic Oil Gauge
CT	: Current Transformer	NEMA	: National Electrical Manufacturers Association
DC	: Direct Current	NO	: Normally Open
DCS	: Distributed Control System	OTI	: Oil Temperature Indicator
ECS	: Electrical Control Station	PC	: Personal Computer
EMI	: Electromagnetic Interference	PCB	: Printed Circuit Boards
FIFO	: First in first out	PLC	: Programmable Logic Controller
FO	: Fibre Optic	PT	: Potential Transformer
GPS	: Global Positioning System	PVC	: Poly Vinyl Chloride
HV	: High Voltage	REF	: Restricted Earth Fault
I/O	: Input/output	RSTP	: Rapid Spanning Tree Protocol
ICT	: Intermediate Current Transformer	RTD	: Resistance Temperature Detector
IDMTL	: Inverse Definite Minimum Time Lag	RTU	: Remote Terminal Unit
IEC	: International Electrotechnical Commission	SNTP	: Simple Network Time Protocol
IEEE	: Institute of Electrical and Electronics Engineers	SOE	: Sequence of event
IP	: Ingress Protection	VDE	: Verband Deutscher Elektrotechniker
IRIG- B	: Inter-Range Instrumentation Group Subcarrier Channel-B	WTI	: Winding Temperature Indicator
KEMA	: Keuring Electrotechnisch Materieel Arnhem		
LAN	: Local Area Network		

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Mr. Parag Gupta
Mr. M.K. Sahu
Mr. A.K. Chaudhary (Inspection)
Ms. N.P. Guha (Projects)

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1.0 SCOPE

The intent of this specification is to define the minimum requirement of design, manufacture, testing, packing and dispatch of numerical relays. The specification also defines the requirement of communication and integration for Substation Automation System.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of following IEC standards / equivalent Indian Standards, unless otherwise specified:

- IEC 60068 : Environmental Testing
- IEC 60073 : Basic safety principles for man machine interface, marking & identification – Coding principles for indicators and actuators
- IS/IEC 60529 : Degree of protection provided by enclosure (IP Code)
- IEC 60255 : Electrical relays
- IEC 61000 : Electromagnetic compatibility (EMC)
- IEC 61850 : Communication networks & systems in substations

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or more stringent than the applicable IEC / Indian standards.

2.3 The equipment shall also conform to the provisions of CEA regulations and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC / BS / VDE / IEEE / NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standard/ specification/ data sheet and statutory regulation, most stringent requirements shall prevail. However, Owner's decision in this regard will be final and binding.

3.0 SITE CONDITIONS

3.1 The relay shall be tropicalised, for satisfactory operation when installed in a panel located in a pressurised substation with restricted natural air ventilation, in tropical humid and corrosive atmosphere. Relay shall be designed to perform all its functions and operate under site conditions specified in numerical relay data sheet. If not specifically mentioned there in, a design ambient temperature of 40°C and an altitude not exceeding 1000M above the mean sea level shall be considered.

4.0 GENERAL REQUIREMENTS

4.1 The equipment offered shall be brand new with state of the art technology with proven field track record of similar type and model or model in same series with additional features. No prototype equipment shall be offered.

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment at least for 15 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.4 In case of relays manufactured outside India, the relay manufacturer through his Indian establishment or associate in India shall provide application, testing, commissioning, after sales service and other necessary support for minimum of 15 years to customer. Their Indian establishment or associate company in India shall also maintain adequate inventory of each type of relay or spares to meet the requirement arising during project execution and plant operation. Relay manufacturer shall possess a signed Memorandum of Understanding with their Indian associate for providing customer support

5.0 TECHNICAL REQUIREMENTS

5.1 Auxiliary Power Supply

Unless otherwise specified, numerical relays, data concentrator, Ethernet switches, gateway & HMI shall be suitable to accept both AC/DC supplies with range 110V to 240V with tolerance of $\pm 15\%$. The auxiliary power supply shall preferably be site-selectable requiring no additional hardware.

5.2 Basic Requirement and Construction Details

- 5.2.1 Relay shall be suitable for flush mounting. The relay enclosure front shall be dust tight having degree of protection minimum as IP5X.
- 5.2.2 Relay terminals shall be suitable for termination of 1.5/2.5/4 sq mm wires, for all hardwired connections.
- 5.2.3 Relay shall be modular with plug in type PCB for easy replacement. The relay terminals shall be easily accessible for testing and commissioning.
- 5.2.4 Current operated relay shall have provision for minimum 3 number phase CT inputs and 1 number CBCT input. Voltage operated relay shall have provision of minimum 3 numbers PT inputs. The exact number of CT and PT inputs shall be based on the schematic requirements, relays shall be selected accordingly.
- 5.2.5 CT shorting link shall be provided at terminal block as required.
- 5.2.6 All numerical relays shall have key pad/ keys to allow relay setting from relay front. All hand-reset relays shall also have reset button on relay front. Self reset or hand reset feature of the relay shall be software selectable and password protected.
- 5.2.7 Relay shall be suitable for 1 A or 5A CT secondary. CT secondary 1A or 5A shall either be software selectable or by providing suitable link. Selection between 1A or 5A should be possible at site.
- 5.2.8 Relays shall have self-diagnostic feature with indication of relay failure on relay front. Relay faults (Self- diagnostic) shall be communicated and annunciated to substation automation system.
- 5.2.9 Relays shall, as a minimum, have protection functions as per feeder equipment data sheets. Other functions such as metering and control shall be provided, if specified in data sheets/job specifications.

5.3 Software Security

The relays shall be provided with suitable security (pass word protection) against unauthorized WRITE ACCESS for change in relay setting. However it should be possible to view metering, protection settings, status and event data as READ ONLY without password protection.

5.4 Display and Indication

- 5.4.1 All relays shall have LCD display along with LED indications for display of settings, status, faults and events. Relays for generator protection, switchyard and GIS shall be provided with medium size LCD display having facility for graphical display of mimic with upto 15 objects on each page.
- 5.4.2 LCD display shall be backlit and temperature compensated up to 55°C for contrast and legibility.
- 5.4.3 Relays shall have 3 fixed LEDs for Relay ON/Control supply ON, fault trip & relay unhealthy apart from freely configured LEDs.

5.5 Protection Functions

5.5.1 Over Current/Earth Fault Protection

- i) This section describes over current & earth fault protection function, which mainly include different setting stages such as low set, high set and high set instantaneous (51, 50, 51N,

50N). Over current protection function provided should have IDMTL characteristic for low set and high set stages and definite time delay for high set instantaneous stage.

- ii) Over current relay shall be three phase type with 4 elements; 3 elements for inverse and definite time delay over current and one element for inverse and definite time delay earth fault current. Selection of inverse or definite time feature shall be user selectable.
- iii) The IDMTL characteristic (for 51 and 51N) shall be as per IEC. The inverse characteristics shall include normal inverse, very inverse, extremely inverse, long inverse and shall be soft ware selectable. Inverse element shall have two or more stages (low and high set) for selection of required inverse characteristic to achieve close protection as required.

Definite time characteristic shall have minimum 2 stages with adjustable current and time setting.

- iv) Relay shall also have separate current input from CBCT for measured earth fault current element. It shall be possible to connect earth fault element either through CBCT or to be connected residually. Minimum setting current for sensitive earth fault element shall be 1%.
- v) Directional overcurrent & earth fault element shall be provided, wherever required.
- vi) Voltage biased overcurrent / earth fault element shall be provided wherever required.

5.5.2 Motor Protection

- i) Motor protection relay shall have all protection function such as over current, thermal (over load), locked rotor current, zero sequence, negative sequence, maximum number of start, motor overload pre-alarm, motor re-acceleration, lock out, inhibit of over current protection during motor starting through contactor feeders, hour run count, inhibit start after elapse of maximum number of starts etc.
- ii) The relay shall be provided with 6 Nos. RTD and 2 Nos. BTD analog inputs, if specified in the data sheet / job specification. Alternatively, external RTD/BTD module having interface with numerical relay can be provided. The numerical relay with RTD / BTD inputs shall be suitable for shielded triad cable of conductor size 1.5sqmm copper, unless otherwise specified.
- iii) Separate motor differential protection shall be provided, wherever specified.

5.5.3 Transformer Protection

- i) In addition to overcurrent & earth fault function, wherever required, the main numerical relay shall also include standby earth fault protection function (51G) for the transformer. The standby earth fault shall operate from a separate neutral CT input and shall have definite time / IDMTL characteristics as per IEC.
- ii) Wherever the transformer requires restricted earth fault protection (64R), separate numerical relay shall be provided. 64R function can be included as a part of main differential protection relay (87T), unless otherwise specified. For details of transformer differential protection relay refer Cl. 5.5.6.
- iii) Transformer auxiliary protection (OTI/WTI/Buchholz/MOG etc) shall be included as a part of numerical relay.
- iv) Transformer differential protection shall be provided, wherever specified.

5.5.4 Generator Protection

- i) Medium Voltage Generators (415V) shall have all protection functions such as voltage restrained overcurrent (51V), standby earth fault (51G), negative sequence (46), Reverse power (32), under voltage (27), overvoltage (59), thermal overload (49), PT fuse failure monitoring function (60), generator differential (87G) as a minimum.
- ii) In addition to the above, HV generators (turbine / diesel engine driven) shall have additional protection functions such as rotor back up earth fault (64R)-1st and 2nd stage, low forward

power flow (37), loss of excitation (40), under frequency (81U), rate of change of frequency (df/dt) unless otherwise specified.

- iii) If specified in the datasheet, additional protection functions such as field overcurrent, over frequency (81O), back up impedance (21), over fluxing (99), out of step shall be provided as a part of generator protection numerical relay.
- iv) The generator protection functions can be included as a part of one numerical relay or a separate numerical relays can be provided.

5.5.5 Voltage Operated Protection Functions

- i) These functions include under voltage (27), over voltage (59), ON delay and OFF delay timers, phase sequence voltage, neutral displacement and Synchro-check functions etc.
- ii) The under voltage and overvoltage protective function shall have different stages with IDMTL and definite time characteristics.
- iii) If specified in datasheet, the relay shall have under and over frequency function along with frequency supervised Rate of change or average rate of change of frequency function.

5.5.6 Differential Protection

Suitable differential protection shall be provided as required as per data sheet / job specification for the specific application such as for generator, transformer, overall generator & transformer, motor, feeder, bus section etc. The following requirements, as applicable, shall be complied:

- i) Differential protection shall be either high impedance or low impedance type. In case of high impedance type, suitable non linear resistor shall be provided to limit the peak overvoltage.
- ii) Transformer differential protection shall have suitable harmonic restraint feature to avoid maltripping during switching.
- iii) For transformer differential protection, necessary correction for ratio error and for transformer primary and secondary vector grouping shall be taken care in the relay itself without additional ICTs. The required relay setting for this shall be programmable.
- iv) Bus differential relay shall have feature for CT supervision and check differential.
- v) In case separate hard-wired relay is used for check differential, the status/ event of same shall be communicated through the numerical relay provided for main differential application.
- vi) Unless otherwise specified, the differential relays such as generator differential, transformer differential, overall generator transformer differential, motor differential, feeder differential etc. shall be suitable for cable connection between CTs and relay using 2.5 sq.mm., Cu conductor, PVC insulated, armoured cable. However for differential protections provided for feeders having long lengths, armoured FO cable may be considered. In cases where FO cable is not suitable, shielded twisted pair cable of conductor size 1.5sqmm copper shall be specifically mentioned by the bidder in the offer for EIL/Owner's acceptance on case to case basis.

5.6 Metering Functions

The metering function shall be provided as required and same shall be built inside the numerical relays.

5.7 Control Functions

- 5.7.1 The control function shall be built inside the numerical relays. For this purpose relays shall have all graphical PLC/Boolean logic functions such that complete control logic of the feeder along with all necessary interlocks as required can be developed inside the relay.

5.7.2 Relays for motor feeder shall be equipped with all control functions and interlocks related to motor feeder. If reacceleration is a part of motor feeder, the control function shall also cover reacceleration logic.

5.7.3 Relays shall have sufficient integral I/Os to take care of complete feeder logic. External I/O module for implementation of logics is not acceptable.

5.8 Lock Out (86), Trip Circuit Supervision (95), Auxiliary Relays and Timer Functions

5.8.1 Unless otherwise specified the numerical relays shall have built in lock out function. For motor feeders additional built-in lockout element shall be provided to receive process trip signals. Lock out elements shall be self reset or hand reset and shall be software selectable.

5.8.2 The numerical relays shall have built in trip circuit supervision function, unless otherwise specified.

5.8.3 Auxiliary relays/ Timers function etc as required for control schematics shall be programmable as a part of numerical relay. The number of such elements as required for schematic shall be considered.

5.8.4 Timer function shall be programmable for both ON/OFF delays.

5.9 Disturbance/ Event Recording and Data Storage

5.9.1 Breaker trip/ close status, relay faults, trip values, event data and disturbance record data shall be stored in the relay in non-erasable memory or memory backed up by lithium battery. Under no circumstances such as withdrawal of power to the relays shall the status, data and events in the memory get erased. Unless otherwise specified, it should be possible to store total 10 seconds of disturbance recording and 200 sequence of event records. Subsequent events shall be overwritten following principle of FIFO.

5.9.2 All disturbances/ events shall be time stamped within the relay.

5.10 Input/ Output Interface, Filters and Galvanic Isolation

5.10.1 Voltage (through PT) input to relay, shall be 110V +/- 10%, unless otherwise specified.

5.10.2 Out put relays shall have 4 numbers spare NO contacts; each shall separately be programmable for either hand reset or self- reset.

5.10.3 Contacts of pushbuttons from field, interlocks from DCS/ other switchboards shall be wired to the relay as binary input using 1.5/2.5sqmm, multi core, copper conductor cables. The distance between push buttons/ interlock to switchboard may be considered as 1000m, unless otherwise specified. The pick-up voltage for BIs/BOs shall be site selectable. The additional components as required to overcome the cable capacitance effect shall be considered as a part of supply of relay. The binary input to relay from field contacts and interlocks shall be momentary type. Logic to latch the momentary contact, as required shall be built as a part of protection relay.

5.10.4 All I/Os shall have galvanic isolation. Analog inputs shall be protected against switching surges, harmonics etc.

5.11 Relay Communication

5.11.1 All numerical relay shall have RS232/RJ45/USB port on the front for hooking laptop.

5.11.2 At the rear numerical relays shall have suitable communication port for communication with data concentrator/ HMI/ Station bus. The type of port shall be selected based on method of communication (Serial or Ethernet) and type of physical transmission medium (twisted pair copper or fiber optic). For serial communication, the relay port shall be RS485 or FO (fiber optic) and for Ethernet (IEC 61850 based) communication same shall be RJ45or FO.

5.11.3 The communication protocol shall be selected to transfer all information including time stamp data from relay to data concentrator/ substation HMI. The relays shall communicate on industry open protocol such as IEC 60870-5-103/IEC 61850/ Modbus-RTU / Modbus TCP-IP or any other open protocol.

उच्च वोल्टेज स्विचबोर्डों के लिए मानक विनिर्देश SPECIFICATION FOR HIGH VOLTAGE SWITCHBOARDS

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Abbreviations:

A	Ampere
AC	Alternating Current
BIS	Bureau of Indian Standards
BS	British Standard
CNT	Close-Neutral-Trip
CPRI	Central Power Research Institute
CRCA	Cold Rolled Cold Annealed
CT	Current Transformer
DC	Direct Current
EPDM	Ethylene Propylene Diene Monomer
FRP	Fiber Reinforced Polyester
HV	High Voltage
Hz	Hertz
IAC	Internal Arc Classification
IEC	International Electro-Technical Commission
IEEE	Institute of Electrical & Electronics Engineer
IP	Ingress Protection
kV	Kilo Volt
kW	Kilo Watt
kWH	Kilo Watt Hour
LED	Light Emitting Diode
LOTO	Lock-Out Tag-Out
LSC	Loss of Service Continuity
MCB	Miniature Circuit Breaker
MCC	Motor Control Center
MCCB	Moulded Case Circuit Breaker
NEMA	National Electrical Manufacturers Association
NO	Normally Open Contact
NC	Normally Close Contact
PO	Purchase Order
PT	Potential Transformer
PU	Polyurethane
PVC	Poly Vinyl Chloride
RAL	Reichs-Ausschuss für Lieferbedingungen
SF ₆	Sulphur Hexafluoride
SWG	Standard Wire Gauge
VCB	Vacuum Circuit Breaker
VDE	Verband Deutscher Elektrotechniker
VFD	Variable Frequency Drive
VT	Voltage Transformer
XLPE	Cross linked Poly Ethylene

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1.0 SCOPE

This specification covers the design, manufacture, testing, packing and supply of indoor, drawout type High Voltage Switchboards up to and including 33 kV, incorporating Vacuum or SF₆ circuit breakers.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

IS: 5	Colours for ready mixed paints and enamels
IS: 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2071	High Voltage Test Technique
IS: 2544	Porcelain post-insulators for systems with nominal voltage greater than 1000V
IS: 2705	Current transformers
IS: 3156	Voltage transformers
IS: 3231	Electrical relays for power system protection
IS: 3427	AC Metal enclosed switchgear and control gear for rated voltages above 1kV up to and including 52 kV
IS: 3618	Phosphate treatment of iron and steel for protection against corrosion
IS: 5082	Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes
IS: 5578	Guide for marking of insulated conductors
IS: 6005	Code of practice for phosphating of iron and steel
IS: 9920	High voltage switches for rated voltage above 1kV
IS: 9921	AC disconnectors (isolators) and earthing switches for voltage above 1000V
IS: 10601	Dimensions of terminals of high voltage switchgear and controlgear
IS: 11353	Guide for uniform system of marking and identification of conductors & apparatus terminals
IS: 12729	Common High voltage Switchgear and Controlgear standards
IS: 13118	High Voltage Alternating Current Circuit Breakers
IS: 13703	Low voltage fuses for voltages not exceeding 1000V AC or 1500V DC.
IEC 60282-1	High voltage fuses – Current Limiting fuses
IS/IEC 60470	High Voltage Switchgear Alternating Current Contactors and Contactor based motor starters
IS/IEC 62271 (Part 1, 102, 105, 200)	High Voltage Switchgear and Controlgear
IEC 62271	High Voltage Switchgear and Controlgear

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

- Statutory regulations
- Data sheets
- Job specification
- This specification
- Codes and standards

3.0 GENERAL REQUIREMENTS

- 3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
- 3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.
- 3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

4.0 SITE CONDITIONS

- 4.1 The switchboards shall be suitable for installation and satisfactory operation in a pressurised sub-station or in a substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.
- 4.2 The switchboards shall be designed to operate under site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 40°C and an altitude not exceeding 1000 metres above mean sea level shall be considered.
- 4.3 All equipments described in this specification are intended for continuous duty operation, as per nameplate rating under the specified ambient conditions, unless indicated otherwise.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 Enclosure and Protection

- 5.1.1 The High Voltage Switchboard shall be metal-enclosed and shall comprise of standard pre-fabricated, cold-rolled, sheet steel units, assembled to form a rigid, freestanding, dead-front structure. As a minimum, 2mm (14 SWG) CRCA sheet steel shall be used for all front and rear doors and covers, and 1.6mm (16 SWG) CRCA sheet steel for inter-panel partitions. Wherever required, stiffeners shall be provided to increase stiffness of large size doors and covers.

As an alternative to CRCA, Aluzinc/pre-galvanised sheet steel can also be provided for internal inter-panel partitions only. However, all external surface shall be of CRCA with specified paint shade.
- 5.1.2 Vertical panels shall be assembled to form a continuous line-up of uniform height both for HV chamber as well as control chamber. Rear extension panels shall also be of full height.
- 5.1.3 The switchboards shall be totally enclosed and vermin-proof. If necessary, openings for natural ventilation shall be provided. These shall be louvered and provided with wire mesh having opening less than 1mm. Design of louvers/ opening shall be such that the arc does not come out in case of internal arc. The same shall be type tested for internal arc, as specified. The enclosure shall have complete protection against approach to live parts or contact with internal moving parts (IP-4X) as per IS: 3427.
- 5.1.4 All openings, covers and doors shall be provided with suitable Neoprene/ XLPE/ EPDM gaskets around the perimeter to make the switchboard dust and vermin proof.
- 5.1.5 Each unit of the switchgear shall have necessary internal sheet metal barriers to form separate compartments for circuit breaker, busbars, instruments and relays, cable connections etc. Compartments for cable connections shall allow cable termination and connection work with the switchgear energised. Suitable interlock shall be provided such that cable compartment can be opened only when earth switch is ON or Earthing truck is inserted.
- 5.1.6 The panel shall be internal arc tested as per IS/IEC 62271-200 requirements for full short circuit current and for a duration of 0.1 second (minimum) unless specified otherwise in job specification/ datasheet and shall be qualified to comply with all the 5 criteria as per IS/IEC

62271-200. Independent pressure relief devices shall be provided for all HV compartments, i.e. bus bar, cable and breaker compartments and each compartment shall have type test certificate for internal arc classification (IAC) as per IS/IEC 62271-200 for the short circuit current and duration as specified. IAC test shall be conducted on the offered panel variants such as smallest width panel, panel with louvers, panel with thermography window and any other variants (as applicable) as per job requirements. The panel shall also be AFI.R tested as per IS/IEC 62271-200 requirements.

- 5.1.7 All identical equipment and corresponding parts shall be fully interchangeable.
- 5.1.8 Safety barriers / shutters shall be provided to permit personnel to work safely within an empty compartment with the bus bars energised. Loss of Service Continuity (LSC) category of the switchgear shall be LSC2B as per IS/IEC-62271-200.
- 5.1.9 It shall be possible to extend the switchgear in either direction at a later date. Ends of bus bars shall be suitably drilled for this purpose. Panels at extreme ends shall have openings, which shall be covered with plates screwed to the panel. Details of drilled holes in bus bar and openings in the panels, provided for future extension shall be clearly shown in the vendor drawings.
- 5.1.10 The drawout carriage on the switchboard shall have three positions: "Service", "Test" and "Drawout" viz:
- "Full in" or "Service" position - In this position both power and control circuits shall be connected. This shall be the normal operating position of the circuit breaker.
 - "Test" position - The power contacts shall be disconnected in this position but the control connections shall not be disturbed, it shall be possible to close and trip the breakers in this position.
 - "Draw out" Position - both power and control circuits shall be disconnected in this position. Alternatively, "Test Position" with the secondary control circuit disconnected may be provided in lieu of "Draw out Position"

Circuit breaker operation shall be possible only in "Service" and "Test" positions. The circuit breaker shall be lockable in "Test" / "Draw-out" positions. Automatic safety shutters shall be provided to ensure the inaccessibility of all live parts after the carriage is drawn out.

There shall be a distinct overall door for the breaker compartment, which can be closed with the carriage in drawout position and it shall be lockable type.

- 5.1.11 All circuit breaker modules of the same rating shall be inter-changeable. Suitable interlocks shall be provided to prevent the following operations:
- "Plugging in" or "drawing out" of a closed breaker.
 - "Plugging in" a breaker with the earthing isolator closed.
 - "Closing" of the earthing isolator with the breaker "plugged in".
 - Pulling out the auxiliary circuit plug with the breaker in the service position. Pushing in the breaker to the service position, with the auxiliary circuit plug not in position.

Additionally, the following shall also be provided:

- All operations such as breaker rack-in, breaker rack-out, breaker On/Off, spring charging, earth switch On/Off etc. shall be possible only with panel door closed.
- Pad locking arrangement shall be provided for rack in operation of breaker as well as for the panel door meeting LOTO requirements.

LOTO arrangement shall include provision for the following:

- a) Provision for hooking lockout devices by multiple lock arrangement to prevent opening of panel door and racking-in of circuit breaker.

- b) Provision for attaching tag-out device for warning against energisation and to provide information regarding date of isolation, agency working on the equipment, etc.
 - c) Provision for Hasp such that the same shall be put-in and closed in the locking arrangement of the breaker/switch and panel door.
- 5.1.12 All hardware shall be corrosion-resistant. All joints and connections of the panel members shall be made by zinc-passivated high-quality Grade 8.8 or superior steel bolts, nuts and washers, secured against loosening.
- 5.1.13 Suitable eyebolts/ lifting clamps shall be provided for the lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panels.
- 5.1.14 If specified in datasheet, light/ arc/ pressure based sensors with controller shall be provided to quickly detect internal arc and immediately initiate tripping action.
- 5.1.15 Thermo-graphy window for infrared electrical inspection shall be provided if specified in the datasheet. The switchgear with thermo-graphy window shall be type tested and certified for internal arc faults as per IS/IEC 62271-200 requirements.

5.2 Accessibility

- 5.2.1 All relays, metering, and control components shall be mounted on the panel front only. However, auxiliary contact multiplier relays with auto reset can be mounted inside the panel.
- 5.2.2 The switchgear shall be considered to be accessible to authorized personnel having access all around and shall be tested for following type of accessibility as per IS/IEC 62271-200:

Type of accessibility where	:	AFLR
Accessibility type A	:	Restricted to authorised personnel only
F	:	for front side
L	:	for lateral side
R	:	for rear side

- 5.2.3 Checking and removal of components shall be possible without disturbing adjacent equipment. All equipment shall be easily accessible. It shall be possible to set all measuring relays and instruments in-situ without de-energising the switchboard. All mounted equipment shall have identification tags of self-sticking PVC tapes at the rear also. In addition, permanent identification details shall be provided on the panel. Mounting of relays for a particular breaker feeder panel shall be limited to that particular feeder only.
- 5.2.4 All terminals shall be shrouded with plastic covers to prevent accidental contact.

5.3 Bus Bar

- 5.3.1 The switchboard shall comprise of 3-phase bus bars which shall extend through all units of the switchgear line-up. The main bus bars shall have uniform cross-section throughout their length and shall be sized to carry continuously the rated current specified in the data sheet.
- 5.3.2 Bus bars shall be of high conductivity electrolytic aluminium or copper supported on insulators made of non-hygroscopic, non-inflammable material with tracking index equal to or more than that defined in Indian standards. Self supporting busbars can also be accepted provided the same is type tested design.
- 5.3.3 Bus bars shall be housed in a separate chamber and shall be accessible for inspection. Wire guards /cover shall be provided inside the enclosure to avoid accidental contact when the cover is removed.
- 5.3.4 Both bus bars and the supports shall be adequately sized and braced to withstand the specified short-circuit current for 1 second. Dynamic stresses shall be calculated on the basis of the specified peak short-circuit current. All bus supports shall be of non-carbonising material, resistant to acids and alkalis.

- 5.3.5 Bus bars shall be insulated by using heat-shrinkable sleeves suitable for withstanding heat under worst operating condition. The sleeves shall be rated to withstand the system line-to-line voltage for 1 minute. This shall be verified by a type test in which the line voltage will be applied between the sleeved main bus bar and an aluminium foil wrapped closely around the insulation over a length of at least 500mm.
- 5.3.6 All bus bar joints and all tap-off connections from the main horizontal bus bars shall be provided with removable FRP/PU/PVC shrouds. The material of the shrouds shall be flame retardant (FR).
- 5.3.7 Bus bars shall be prominently marked with Red, Yellow and Blue colour rings/ stickers for easy phase identification at regular interval and at every power tap off point.
- 5.3.8 The thermal design of the bus bars shall be based on installation of the switchgear in poorly ventilated conditions. The cooling air volume shall take into account only the bus bar enclosure.
- 5.3.9 The hot spot temperature of busbars, including joints, at design ambient temperature shall not exceed 90°C under normal operating conditions while for silver plated joints, the allowable maximum temperature shall be 115°C in line with IS/IEC-62271-1.
- 5.3.10 Only zinc passivated high tensile strength high-quality Grade 8.8 or superior steel bolts, nuts and washers shall be used for all busbar joints and supports.
- 5.3.11 The current rating as defined for switchboard and components in data sheet/job specification are for design ambient temperature at site conditions and for being inside the cubicle at fully loaded condition. The vendor shall suitably derate the nominal rating to suit the above condition.

5.4 HV Power Connections

- 5.4.1 The incoming power connection shall be through XLPE cables / busduct and outgoing power connection shall be through XLPE cables, as indicated in the data sheet. Ample space for connection of these cables shall be provided at the rear of the switchboards. In order to avoid accidental contact in the cable compartment while carrying out inspection by opening the rear cover, a removable expanded metal barrier/ wire mesh shall be provided in the cable compartment. In order to facilitate infra-red electrical inspection through thermography window, metal barrier/ wire mesh may not be provided. Unless otherwise specified, the power cable shall enter the switchboard from the bottom. Non-magnetic cable gland plates shall be provided for feeders wherever single core cables are used.
- 5.4.2 The switchboard shall be supplied complete with supports for clamping outgoing and incoming cables. The head-room available between cable gland plate and terminal lugs shall not be less than 600 mm for switchgear up to 11 kV, and 900 mm for 22 and 33 kV cables.
- 5.4.3 In case the standard panel depth cannot accommodate the specified number of cables, a rear extension panel of full height shall be provided. An earth strip shall also be brought to this extension panel.
- 5.4.4 Unless otherwise specified, all power cables shall enter the switchgear from the bottom.

5.5 Auxiliary Wiring and Terminals

- 5.5.1 Inside the cubicles, the wiring for control, signalling, protection and instrument circuits shall be done with BIS approved, PVC insulated, flame retardant low smoke (FRLS) type, copper conductor wire. The insulation grade shall be 660 V. The wiring shall preferably be enclosed in plastic channels or neatly bunched together. Wiring between HV breakers or cable compartments to relay and metering compartments shall be routed through flexible conduits.
- 5.5.2 A minimum of 10% spare terminals shall be provided on each terminal block. Conductors shall be terminated with adequately sized compression-type lugs for connection to equipment terminals and strips. Stranded conductors shall be soldered at the ends/ crimped with suitable

lugs before connections are made to the terminals. Sufficient terminals shall be provided on each terminal block to ensure that not more than one outgoing wire is connected per terminal. Terminal strips shall preferably be separated from power circuits by metal barriers or enclosures. All spare contacts of auxiliary relays, timers, etc shall be wired up to the terminals.

- 5.5.3 Each wire shall be identified at both ends by correctly sized PVC ferrules. Shorting links shall be provided for all CT terminals.
- 5.5.4 PVC insulated copper conductor of cross section 1.5 mm² may normally be used provided the control fuse rating is 10A or less. For 16A control fuse circuit 2.5 mm² copper conductors shall be used. Each wire shall be terminated at a separate terminal. CT Circuit wiring shall be done with 2.5 mm² copper conductors. Shorting links / suitable shorting arrangement for shorting CT secondary shall be provided.
- 5.5.5 Unless otherwise specified, all control cables shall enter the switchgear from the bottom.
- 5.5.6 Supporting facilities shall be provided for clamping the control cables.
- 5.5.7 All inter-panel control wiring within each shipping section shall be by switchgear vendor. The inter-panel wiring shall be taken through PVC sleeves or suitable grommets. For inter-panel wiring between the shipping sections, wires in rolls of the required length, connected at one point, shall be supplied with the panel for connection at site.

5.6 Control and Indication

- 5.6.1 Breaker tripping, closing and spring charging devices shall be fed with DC control power supply. The rated DC voltage shall be as specified in the data sheet. The power supply for breaker opening, closing and indication devices shall be arranged as follows:

- One DC feeder shall be provided for each bus section. The bus coupler panel may be fed from any of the two supplies.
- One separate, single-phase power supply shall be provided for each bus section for feeding space heaters, etc. Supply voltage shall be 240 V AC, unless otherwise specified.

Provision to receive DC and AC control supply shall preferably be provided in bus-coupler panel / bus PT panel.

- 5.6.2 Breaker positions (CLOSE, OPEN, spring-charged, test position, service position) shall be indicated mechanically. Electrical indications, with colours as given below, shall also be provided:

Breaker 'CLOSED'	:	Red lamp
Breaker 'OPEN'	:	Green lamp
Breaker 'Auto-trip'	:	Amber lamp
Trip circuit healthy	:	White lamp
Spring charging	:	Blue lamp

- 5.6.3 A common DC control supply fail indication shall be provided for each bus section with a blue coloured lamp.

5.7 Earthing Connections

All cubicles shall be connected to an earth bus bar running throughout the length of the switchboard. The minimum earth bus bar size shall be 30 x 6 mm² copper, up to short-circuit withstand capacity of 31.5 kA, and 50 x 6 mm² copper, for a short-circuit withstand capacity above 31.5 kA. All doors and movable parts shall be connected to the earth bus with flexible copper connections. Provision shall be made to connect the earthing bus bar to the plant earthing grid at two ends. All non current-carrying metallic parts of the equipment and components shall be earthed. The earth bus shall be brought back to the cable compartment,

- 5.11.5 All unpainted steel parts shall be Zinc passivated or suitably treated to prevent rust formation. If these parts are moving elements then they shall be greased. Aluzinc/ pre-galvanised sheet, wherever provided, need not be painted.

6.0 SWITCHBOARD COMPONENTS

6.1 Circuit Breakers

- 6.1.1 Vacuum or SF₆ circuit breakers shall be used in the switchboard. The exact type and rating of breakers shall be as indicated in the data sheet. Breaker transport trolleys required for cassette-mounted breakers shall be provided for each switchboard. Number of trolleys to be provided shall be as per data sheet.
- 6.1.2 Vacuum circuit breakers shall be designed to have low switching-over voltage levels and with a long switching life. The interrupter shall be leak-free.
- 6.1.3 In case of SF₆ circuit breaker, each pole shall be provided with a pressure switch to monitor the gas pressure with local indication / lockout, and remote annunciation in the event of SF₆ gas leakage.
- 6.1.4 The breakers shall have at least 6 normally open (NO) and 6 normally closed (NC) spare auxiliary contacts for purchaser's use. If these are not available, auxiliary relays shall be used to multiply the auxiliary contacts of the breakers.
- 6.1.5 The breakers shall have a motor-operated, spring-charging mechanism. It shall also be possible to charge the springs manually. The closing spring shall get re-charged (for subsequent closing) soon after a closing shot and prior to breaker tripping. In case the limit switch fails to cut out the spring-charging motor with the springs fully charged, the motor shall be automatically de-coupled or else positive isolation (at both ends) of power supply to spring charging motor shall be ensured. The control circuit shall be suitable for local as well as remote control. Breakers shall be trip-free and shall have an anti-pumping device. The breaker operating duty shall be O-3min.-CO-3min.-CO, unless otherwise agreed.
- 6.1.6 Operating Mechanism
- Electric power operating mechanism shall be motor wound spring charged stored energy type. However, manual-operating mechanism may be of the spring charging stored energy type or spring assisted type. For circuit breakers with electrical power operating mechanism, provision shall also be made for manual spring charging. Closing time of circuit breakers with manual operating mechanism shall be independent of the speed of the operating handle.
 - All stored energy operating mechanisms shall be equipped with the following features:
 - Failure of springs, vibrations or shocks shall not cause unintended operation of breaker or prevent intended tripping operation.
 - Closing of circuit breakers shall be prevented unless the spring is fully charged.
 - All electrical power operating mechanisms shall be suitable for remote operation and shall be equipped with following features:
 - Provided with motors operable on AC or DC control supplies as specified.
 - Provided with emergency manual charging facility. The motor shall be automatically, decoupled (mechanically) once the manual-charging handle is inserted.
 - Closing operation of circuit breaker shall automatically initiate charging of the spring for the next closing operation without waiting for tripping of circuit breaker.

- iv) Closing operation shall be completed once the closing impulse is given and the first device in the control scheme has responded even though the control switch / Push Button is released, provided no counter trip impulse is present.
- 6.1.7 Circuit breaker trip and closing coils, in case of electrically operated breakers, and trip coil in case of mechanically operated breakers and circuit breaker indication shall be suitable for satisfactory operation on a control supply system indicated in data sheets/job specification. Additional second shunt trip coil (operating on different control voltage supply) shall also be provided if specified in the datasheet.
- 6.1.8 All circuit breakers shall be provided with mechanically operated emergency trip device. This device shall be available on the front of the panel. Mechanically operated 'closing' device shall be provided for all breakers. However mechanical closing shall be inhibited for all circuit breakers in service position.
- 6.1.9 The breakers shall be provided with anti pumping & trip free feature. Each breaker shall be also provided with an operation counter.
- 6.1.10 For all HV VFD feeders, breaker shall be provided with one no. shunt trip coil and with undervoltage release. However, in case it is not possible to provide undervoltage release in the standard design, as an alternative, two shunt trip coils shall be provided. One shunt trip coil shall be suitable for switchgear DC control supply while second shunt trip coil shall be suitable for external AC control supply. The control supply voltage level shall be as specified in data sheet.
- 6.1.11 Metal Oxide surge suppressors shall be provided on all outgoing vacuum circuit breakers to limit the over voltage to a maximum of 2.2 p.u. rated peak line to earth voltage. Sizing calculations for surge suppressor shall be provided post order.
- 6.1.12 Line PT shall be mounted in a separate drawout carriage. In case of truck mounted breaker, line PT shall be provided in a separate panel.
- 6.1.13 The complete breaker assembly should have inter-changeability with breakers of identical ratings.
- 6.1.14 For switchgears specified with double tier circuit breaker arrangement, the outgoing feeder breakers shall have double tier arrangement and incomer breakers with Line/bus PT shall be housed in one vertical panel. In double tier arrangement, sheet steel partitions shall be provided for each compartment. Compartmentalization shall be such that maintenance of one breaker is possible without disturbing the adjacent breaker compartment. Suitable trolley(s) shall be supplied for drawing out the breakers in upper tier. The maximum height of the operating handle/switches/reset knobs/pushbuttons shall not exceed 1900 mm and minimum height shall not be below 300 mm.
- 6.1.15 An integral earthing system, or a separate earthing carriage/truck, shall be provided. In case of a separate earthing carriage, the necessary trolleys for bus-side and cable-side earthing shall be supplied. After withdrawing the circuit breaker, this can be inserted to facilitate earthing of cables and bus bars. Earthing truck shall be complete with the PT and voltmeter, giving audio-visual indication and solenoid interlock to prevent closing of bus side earthing truck on live busbars. Suitable interlock shall also be provided for Earthing switch. Earthing truck/ earthing switch operation shall be only with door closed.
Integral earthing truck/earthing switch shall be suitable for short time withstand current and peak withstand current rating equal to the corresponding breaker withstand rating.
- 6.1.16 Number and type of earthing trucks shall be as specified elsewhere.

6.2 Fuse Contactor Units

For outgoing feeders requiring fuse contactor (as specified in job specification/ datasheet), following shall be complied with:

Fuse contactors shall be fully drawable type.

Contactors shall comply with IS/IEC-60470 and shall be suitable for intermittent duty class 0.1 as well as for uninterrupted duties.

The minimum short circuit breaking capacity of the contactor shall be at least 6 kA at rated voltage.

Anti-pumping device (APD) shall be included to prevent "pumping actions" of mechanisms.

Overvoltage surge diverters shall be installed if required to keep high over-voltages during operating conditions within acceptable values.

Contactors for motor starters and capacitor Bank feeders shall be of the latched type. The tripping supply shall be obtained from the DC tripping and closing supply. Motor contactor panels shall be provided with restarting facilities as specified in job specification/ datasheet.

Fuse links shall be in accordance with IEC 60282-1 and shall have high rupturing capacity. They shall be short circuit current limiting type. Fuses shall be provided with striker pin arrangement tripping the contactor.

Fuses for motor starters shall have a time-current characteristic suitable for the method of starting.

Correct discrimination shall be established between fuse characteristics and contactor breaking capacities. This shall ensure that overload and fault currents are safely interrupted by the appropriate devices avoiding any risk of welding or other damage to the contactor.

6.3 Instrument Transformers

Current and voltage transformers shall be cast-resin insulated. The primary and secondary terminals shall be marked indelibly and easily approachable for termination and testing etc.

6.3.1 Current transformer

- i) Current transformers shall conform to IS: 2705. The short-time rating shall be equal to that of the switchboard. They shall be mounted on the stationary part of the switchboard. The CT ratings shall be as shown in the data sheet. Protective CTs shall have an accuracy class of 5P and an accuracy limit factor greater than 10. CTs for instruments shall have an accuracy class of 1.0 and an accuracy limit factor less than 5.0. For numerical relays having protection and metering functions, dual rated CT shall be provided suitable for protection class and metering class. One leg of the CTs shall be earthed. Separate CTs shall be provided for Differential and Restricted Earth fault protection.
- ii) All CTs shall be star connected. Interposing CT (ICT) shall be provided (if required) for differential protection of transformers having star-delta connection.
- iii) Proper access to each set of CTs shall be provided for repair / maintenance.

6.3.2 Potential transformer

- i) The potential transformers shall conform to IS: 3156. The potential transformers shall be of drawout-type, and shall be provided with 4 pole miniature circuit breakers with auxiliary contacts on the secondary side.

- ii) The drawout mechanism shall disconnect the PT from the busbars. The primary connection shall be disconnected before the PT becomes accessible. Neutral point of the star connected PTs both on the primary and secondary sides shall be earthed.
- iii) The PTs shall have an over-voltage factor of 1.9 for 30 seconds, and an accuracy class of 1.0 from 10% to 120% of normal voltage. PT selected shall be compatible with system grounding.
- iv) The primary rated voltage shall be equal to the rated voltage V of the system, or $V/\sqrt{3}$, if the PT is connected between phase and neutral.
- v) If not otherwise specified, the secondary voltage shall be 110 V, or $110/\sqrt{3}$ V. The burden and class of accuracy shall be as specified in data sheets. For directional relays, either a 3-phase 5-limb PT, or 3 single-phase PTs with secondary windings connected in open delta shall be provided.

6.4 Measuring Instruments

All analogue instruments shall be of square pattern, 96 x 96 mm, flush-mounted type. Measuring instruments shall be provided, as specified in the data sheet. All required auxiliary equipment such as shunts, transducers, CTs, PTs, etc, shall be included in the scope of the switchboard supplier. The accuracy class for all instruments shall be 1.0 as per IS: 1248.

Digital instruments shall also be acceptable, provided specific approval of EIL/Owner for make and model is obtained before placement of switchboard order.

6.4.1 Ammeters and voltmeters

Analogue meters shall be of moving-iron type. The range shall be as indicated on the drawings. Ammeters for motor feeders shall have a non-linear compressed scale above rated current to indicate motor starting current.

6.4.2 kW / kWh meters

The kW / kWh meters shall be suitable to measure unbalanced loads on a 3-phase, 3-wire system. The kW meters shall operate on a PT secondary voltage of 110 V.

6.4.3 Frequency meters

These shall be of direct-reading or digital type and shall operate on a PT secondary voltage of 110V. The standard range shall be 45-50-55 Hz.

6.4.4 Power factor meters

Power factor meters shall operate on a PT secondary voltage of 110 V. The CT secondary current shall be as shown on the relevant drawings. The standard range shall be 0.5 lead-1.0-0.5 lag.

- 6.4.5 Digital meters shall be provided, if specified in job specification/data sheets. All digital meters shall be highly reliable, accurate, compact and self powered. Digital meter data shall be saved in case of power failure. Field programming from front of the meter shall be possible and shall have RS232/485 port in case specified in the job specification/data sheet.

6.5 Relays

- 6.5.1 Type of relay i.e. electromechanical, static or numerical shall be as defined in data sheet / job specification.
- 6.5.2 All electromechanical protective relays shall be back-connected, of drawout type, suitable for flush mounting, and fitted with dust-tight covers. Alternatively, "plug-in" type relays will also be acceptable. Auxiliary relays are acceptable in fixed execution.

- 6.5.3 The protective relay cases shall have a provision for insertion of a test plug at the front for testing and calibration using an external power supply without disconnecting the permanent wiring. The insertions of the test plug shall automatically short circuit the CTs and permit extension of external power supply to the relay.
- 6.5.4 All protective relays shall have hand reset facility and clear operating indication, e.g. flags for electro-mechanical type relays or light emitting diodes for static/numerical type relays. It shall be possible to reset the flag without opening the relay case.
- 6.5.5 All tripping relays (electrical fault trip) shall be of lockout type with hand-reset contacts, and shall be suitable to operate on the specified voltage. These relays shall have self coil cut off contacts, and shall be provided with hand-reset operation indicators. However, for process trip, the lock out relay shall be self reset type. Tripping relays will be acceptable in non-drawout cases.
- 6.5.6 The tripping relay shall be suitable for satisfactory operation from 50% to 110% of the specified control supply voltage.

6.6 Auxiliary Equipment

6.6.1 Auxiliary relays and contactors:

Auxiliary relays and contactors shall generally be used for inter-locking and multiplying contacts. Auxiliary contacts shall be capable of carrying the maximum anticipated current.

6.6.2 Control Switches:

- i) All control switches shall be rotary type, having a cam-operated contact mechanism otherwise stated. Circuit breaker control switches shall be 3-position CNT, spring return to neutral from both Close and Trip positions. They shall have pistol-grip handles and shall be lockable.
- ii) Ammeter selector switches shall have a make-before-break feature on its contacts. The selector switch shall generally have four positions, three positions for reading 3-phase currents and the fourth position for OFF. The voltmeter selector switch shall also have four positions, three positions shall be used to measure phase-to-phase voltages and the fourth position shall be for OFF.

6.6.3 Timers:

For re-acceleration duty, timers unless otherwise stated, shall be pneumatic type and shall have adjustable time setting of 0-60 seconds. Alternatively static timer may be considered. The time settings, where specified, shall be accurately set before despatch of the switchboard. Timer provided for control of capacitor feeder shall have minimum setting of 0-5 minutes.

6.6.4 Indicating Lamps:

Clustered LED type indicating light with minimum 8mm diameter size shall be provided for indications. The LED shall have a low glow voltage protection and shall not glow on voltage leakage.

7.0 INSPECTION, TESTING AND ACCEPTANCE

- 7.1 During fabrication, the switchboard shall be subject to inspection by EIL / Owner, or by an agency authorised by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.
- 7.2 For testing requirements refer Inspection & Test Plan No. 6-81-1001.

8.0 PACKING AND DESPATCH

The switchboard shall be divided into several shipping sections for protection and ease of handling during transportation. All outgoing feeders shall be packed as separate shipping sections. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO number,' etc., shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should also be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed.