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**GOVERNMENT OF INDIA**  
**CENTRAL PUBLIC WORKS DEPARTMENT**

**GENERAL SPECIFICATIONS**  
**FOR ELECTRICAL WORKS**

**PART-VII**  
**(DG SETS)**

**2013**



**PUBLISHED UNDER THE AUTHORITY**  
**OF**  
**DIRECTOR GENERAL, CPWD, NEW DELHI**

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## **A GOVERNMENT OF INDIA PUBLICATION**

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## FOREWORD

Central Public Works Department is responsible for the design, construction and maintenance of a large number of buildings of the Govt. of India.

Construction of multi-Storey building is on the rise all over India. Most of these buildings, are provided with extensive E & M and air conditioning services, which has mandated use of D.G. Sets of uninterrupted power supply to most of the service.

The first edition of General Specifications for Electrical Works - Part VII (D.G. Sets) were released in 2006. Since then, there have been considerable improvement in technology of the D.G. Sets and its controls. This has mandated a revision in the Specifications.

The new specifications have incorporated the changes in exhaust pipe work, AMF panel, Engine control panel, foundations for D.G. Sets etc. A new chapter on Synchronisation of D.G. Sets on common bus bar has been added.

These revised specifications were drafted by a team of officers consisting of Shri Mukesh Vij, CE(E), Sh. S.K. Chawla, CE(E) and Sh. C.K. Varma, CE(E) with a view to update the Specifications to meet latest available system and the requirements of Building Performance.

I acknowledge the efforts put in by members of the Specifications Committee under the chairmanship of Sh. R.K. Singhal, Spl. DG(NR) in reviewing the revised specification and finalizing these specification. I also acknowledge the efforts of Sh. S.S. Garg, SE(E) TAS, Member Secretary and his team of the officers for contributing towards making the publication available in a short period of time.

Suggestions for modifications as well as errors and omissions may be sent to SE(E)TAS, office of the Chief Engineer CSQ(E), CPWD, Vidyut Bhawan, New Delhi.

In case of any discrepancy between English and Hindi versions, the English version shall be held valid.

Place : New Delhi  
Dated : 26.02.2013

  
(Ashok Khurana)  
Director General  
CPWD, New Delhi



राकेश कुमार सिंघल  
विशेष महानिदेशक (उत्तरी क्षेत्र)  
**RAKESH KUMAR SINGHAL**  
SPECIAL DIRECTOR GENERAL (NR)



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## PREFACE

The Central Public Works Department (CPWD) is a 158 years old institution and is principal agency of the Government of India responsible for creating assets and providing comprehensive services including planning, designing, construction and maintenance of office and residential buildings as well as other infrastructures of various ministries, departments of Government of India, autonomous bodies and public sector enterprises. Its activities are spread throughout the country.

With the scarcity of land for construction in urban areas, multistory construction of buildings are on the increase. Most of these buildings are provided with extensive E&M equipments, Air conditioning services and lifts. Due to frequent power failure, use of DG Sets for most of these services has become essential.

First set of CPWD Specifications for DG Sets were released in 2006. Since then there have been considerable improvements in technology of the DG Set and its control. This has mandated a revision in the Specifications.

The new specifications have incorporated the changes in exhaust pipe work, AMF Panel, Engine control panel, foundations for DG Sets, etc. A new chapter on Synchronization of DG Sets on common bus has been added.

I am grateful to Shri Ashok Khurana, Director General, CPWD for reposing trust in me to undertake this work and express my deep appreciation to Sh. Mukesh Vij, CE(E), Sh. S.K. Chawla CE(E) and Sh. C.K. Varma, CE(E), for drafting these specifications.

I acknowledge the efforts put in by members of the specification committee, in making the present specification technically update, modern & user friendly.

I also express my deep appreciation to Sh. S.S. Garg, SE(E) TAS, Sh. R.R. Meena, EE(E) TAS, Sh. V.K. Yadav, AE(E) TAS, Sh. P.P. Singh, AE(E) TAS, who made their sincere efforts to update and making the publication available in very short time.

Errors or omissions, and suggestions for improvement, if any, may kindly be brought to the notice of the Superintending Engineer (E) TAS, Office of the Chief Engineer (E) CSQ, CPWD, New Delhi -01.

Place : New Delhi

Dated : 26.02.2013

(R.K. Singhal)

Spl. Director General (NR), CPWD  
and Chairman, Specifications Committee(E&M)

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17	Sh. S.S. Garg, SE(E)TAS, CSQ(E)	Member Secretary

## REFERENCES OF AMENDMENTS

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# CHAPTER 1

## GENERAL

### 1.1 INTRODUCTION

#### 1.1.1 Scope

1.1.1.1 These specifications cover the general specifications pertaining to diesel engine driven generating sets & their installation.

1.1.1.2. These General Specifications cover the equipments and materials for the DG Sets, their testing and/ or inspection as may be necessary before their dispatch from their respective works, their delivery at site, all preparatory works, assembling, installation and adjustments, commissioning, final testing, putting into operation and handing over of the complete system.

1.1.1.3 These General Specifications are subject to revision from time to time.

1.1.1.4 Each DG Set installation work has its own particular requirements. These General Specifications shall be supplemented with tender specifications as may be required for a particular work. The tender specifications, wherever they differ from these 'General Specifications', shall have over-riding value and shall be followed for that particular work. A specimen NIT for DG Set works is appended at Appendix 'IV' for general guidance.

#### 1.1.2 Related Documents

These General Specifications shall be read in conjunction with the General conditions of contract. These General Specifications shall also be read in conjunction with the tender specifications, schedule of work, drawings and other documents connected with the work.

#### 1.1.3 Site Information

The tenderer should, in his own interest, visit the site and familiarise himself with the site conditions before tendering. For any clarification, tenderer may discuss with the Engineer-in-Charge.

### 1.2 CONFORMITY WITH STATUTORY ACTS, RULES, STANDARDS AND CODES

- (i) All components shall conform to relevant Indian Standard Specifications, wherever existing, amended to date. A list of such standards is appended in Appendix 'V'.
- (ii) All electrical works shall be carried out in accordance with the provisions of Indian Electricity Act, 2003 and Indian Electricity Rules, 1956 as amended up to date. They shall also conform to CPWD General Specifications for Electrical Works, Part-I (Internal), 2013 and Part-II (External), 1994 and Part IV (Sub-station), 2013, as amended up to date.

### **1.3 SAFETY CODES AND LABOUR REGULATIONS**

- (i) In respect of all labour employed directly or indirectly on the work for the performance of the contractor's part of work, the contractor at his own expense, will arrange for the safety provisions as per the statutory provisions, B.I.S recommendations, factory act, workman's compensation act, CPWD code and instructions issued from time to time. Failure to provide such safety requirements would make the tenderer liable for penalty for Rs. 200/- for each violation. In addition the Engineer-in-charge, shall be at liberty to make arrangements and provide facilities as aforesaid and recover the cost from the contractor.
- (ii) The contractor shall provide necessary barriers, warning signals and other safety measures while executing the work of DG Set installation, cables etc. or wherever necessary so as to avoid accident. He shall also indemnify CPWD against claims for compensation arising out of negligence in this respect. Contractor shall be liable, in accordance with the Indian Law and Regulations for any accident occurring due to any cause. The department shall not be responsible for any accident occurred or damage incurred or claims arising there from during the execution of work. The contractor shall also provide all insurance including third party insurance as may be necessary to cover the risk. No extra payment would be made to the contractor due to the above provisions thereof.

### **1.4 WORKS TO BE ARRANGED BY THE DEPARTMENT**

Unless otherwise specified in the tender documents, the following works shall be arranged by the Department:

- (i) Space for accommodating all the equipments and components involved in the work. However, watch and ward shall be responsibility of the contractor.
- (ii) Power supply (Single/three phase).

### **1.5 WORKS TO BE DONE BY THE CONTRACTOR**

Unless otherwise mentioned in the tender documents, the following works shall be done by the contractor and therefore, their cost shall be deemed to be included in their tendered cost-whether specifically indicated in the schedule of work or not: -

- (i) Foundations for equipments including vibration isolation springs/ pads,
- (ii) Making good all damages caused to the structure during installation and restoring the same to their original finish.
- (iii) Minor building works necessary for installation of equipments, foundation trench for fuel line & cable, making of opening in walls or in floors and restoring them to their original condition/ finish and necessary grouting etc. as required.
- (iv) All supports for exhaust & water pipes, chimney, bus trunking (if included in scope of contract), cables, anti-vibration pads etc. as are necessary.
- (v) All electrical work and neutral earthing, body earthing, required for engine & alternator, main board/ control panels, and control wiring including loop earthing, if specified in Schedule of Work.

- (vi) All pipes, bus trunking and/ or cable connections.
- (vii) POL i.e. HSD oil and lub. oil for diesel engine for testing & commissioning for 12 hours i/c 1hr of 10% overloading at OEA/ OEM works shall be arranged by the contractor. POL i.e. HSD oil and lub. oil for trial run of 4 Hrs. at site at available load shall be arranged by the department.
- (viii) Painting of all exposed metal surfaces of equipments and components with appropriate colour.
- (ix) Clearance/ Approval of the complete installation from CPCB/ State Pollution Control Board, Central Electricity Authority (CEA)/ Local Bodies and other licensing authorities, wherever required.

## **1.6 RATES**

- 1.6.1 The rates quoted by the tenderer, shall be firm and inclusive of all taxes (including works contract tax), duties and levies and all charges for packing, forwarding, insurance, freight and delivery, installation, testing, commissioning etc. at site including temporary constructional storage, risks, overhead charges, general liabilities/ obligations etc. but exclusive of Service Tax, which shall be reimbursed on production of documentary proof of actual payment against this contract/ work.
- 1.6.2 Octroi exemption certificate will be issued by the department if required by the contractor. However, the department is not liable to reimburse the octroi duty in case exemption certificates are not honoured by the concerned authorities.
- 1.6.3 The contractor has to carry out routine and preventive maintenance as per manufacturer's standards for a period of 12 months from the date of handing over. However, all consumables (fuel/ lube oil etc.) including filters will be supplied by the department.

## **1.7 POWER SUPPLY AND WATER SUPPLY**

### **1.7.1 Power Supply**

- (i) Unless otherwise specified, 3 phase, 415 volts, 50 Hz power supply shall be provided by the department free of charge to the contractor at one point for installation at site suitable for 10 KW load. Termination switchgear however, shall be provided by the contractor. Further extension if required shall be done by the contractor.
- (ii) The contractor shall not use the power supply for any other purpose than that for which it is intended for. No major fabrication work shall be done at site. Power shall be used only for welding/ cutting works. The power supply shall be disconnected in case of such default and the contractor shall then have to arrange the required power supply at his cost.

### **1.7.2 Water Supply**

Water supply shall be made available to the contractor by the Department free of charge at one point.

**1.8 MACHINERY FOR ERECTION**

All tools and tackles required for unloading / handling of equipments and materials at site, their assembly, erection, testing and commissioning shall be the responsibility of the contractor.

**1.9 COMPLETENESS OF THE TENDER, SUBMISSION OF PROGRAMME, APPROVAL OF DRAWINGS AND COMMENCEMENT OF WORK**

**(i) Completeness of the tender**

All sundry equipments, fittings, assemblies, accessories, hardware items, foundation bolts, supports, termination lugs for electrical connections, cable glands, junction boxes and all other sundry items for proper assembly and installation of the various equipments and components of the work shall be deemed to have been included in the tender, irrespective of the fact that whether such items are specifically mentioned in tender documents or not.

**(ii) Submission of programme**

Within fifteen days from the date of receipt of the letter of acceptance, the successful tenderer shall submit his programme for submission of drawings, supply of equipment, installation, testing, commissioning and handing over of the installation to the Engineer-in-Charge. This programme shall be framed keeping in view the building progress.

**(iii) Submission of Drawings**

The contractor shall submit the drawings to the Engineer-in-Charge as per clause 1.19 of this specification for approval before start of work.

**(iv) Commencement of Work**

The contractor shall commence work as soon as the drawings submitted by him are approved. The drawings are to be submitted by the contractor within 15 days of stipulated date of start, and shall be approved by the Engineer-in-Charge within 10 days of receipt in his office.

**1.10 DISPATCH OF MATERIALS TO SITE AND THEIR SAFE CUSTODY**

The contractor shall dispatch materials to site in consultation with the Engineer-in-Charge. Suitable lockable storage accommodation shall be made available free of charge temporarily. Watch & ward however, shall be the responsibility of contractor.

Programme of dispatch of material shall be framed keeping in view the building progress. Safe custody of all equipment/ items supplied by the contractor shall be the responsibility of the contractor till final taking over by the department.

**1.11 CO-ORDINATION WITH OTHER AGENCIES**

The contractor shall co-ordinate with all other agencies involved in the work so that the work of other agencies is not hampered due to delay in his work.

## **1.12 INDEMNITY**

The successful tenderer shall at all times indemnify the department, consequent on this works contract. The successful tenderer shall be liable, in accordance with the Indian Law and Regulations for any accident occurring due to any cause and the contractor shall be responsible for any accident or damage incurred or claims arising there from on the department during the period of erection, construction and putting into operation the equipments and ancillary equipment under the supervision of the successful tenderer in so far as the latter is responsible. The successful tenderer shall also provide all insurance including third party insurance as may be necessary to cover the risk. No extra payment would be made to the successful tenderer on account of the above.

## **1.13 QUALITY OF MATERIALS AND WORKMANSHIP**

- (i) The components of the installation shall be of such design so as to satisfactorily function under all conditions of operation.
- (ii) The entire work of manufacture/fabrication, assembly and installation shall conform to sound engineering practice. The entire installation shall be such as to cause minimum transmission of noise and vibration to the building structure.
- (iii) All equipment and materials to be used in work shall be manufactured in factories of good repute having excellent track record of quality manufacturing, performance and proper after sales service.

## **1.14 CARE OF THE BUILDING**

Care shall be taken by the contractor during execution of the work to avoid damage to the building. He shall be responsible for repairing all such damages and restoring the same to the original finish at his cost. He shall also remove all unwanted and waste materials arising out of the installation from the site of work from time to time.

## **1.15 INSPECTION AND TESTING**

1.15.1 The successful tenderer will arrange staff/fuel/POL for test run at his cost.

### **1.15.2 Inspection and Testing of DG sets of capacity more than 200 KVA**

1.15.2.1 For DG sets of capacity more than 200 KVA, testing shall necessarily be carried out at factory/ manufacturer premises in presence of representative of the Department.

1.15.2.2 For testing, following procedure will be followed: All major items/ equipments i.e. engine & alternator in assembled condition, associated electrical control panels etc. shall be offered for inspection and testing at factory/ manufacturers works. The successful tenderer shall give a notice of minimum two weeks for carrying out such tests. The Engineer-in-charge/ or his authorized representative shall witness such inspection & testing at mutually agreed date. The cost of the representative's visit to the factory will be borne by the Department.

1.15.2.3 The department also reserves the right to inspect the fabrication job at factory and the successful tenderer has to make arrangements for the same.

1.15.2.4 DG set will be tested on load of unity power factor for the rated KW rating. During testing, each of the D.G. sets covered under scope of work, shall be operated for

a period of 12 hours on the rated KW at DG set's KW rating including one hour on 10% overload after continuous run of the 12 Hours. During testing all controls/ operations safeties will be checked and proper record will be maintained. Any defect/ abnormality noticed during testing shall be rectified. The testing will be declared successful only when no abnormality/ failure is noticed during the testing. The DG set will be cleared for dispatch to site only when the testing is declared successful by authorised representative/ Engineer-in-Charge.

- 1.15.3 Inspection and Testing of DG sets of capacity equal to or less than 200 KVA**
- 1.15.3.1 For DG sets of capacity equal to or less than 200 KVA, testing shall necessarily be carried out at site. However, initial inspection can be done at factory/manufacturer works before dispatch at site of work at the discretion of Engineer-in-Charge as per details given at 1.15.2.2 above. All major items/ equipment i.e. engine & alternator in assembled condition, Electrical control panel etc. shall be offered for initial inspection at factory/ manufacturers works. The cost of the Engineer's visit to the factory will be borne by the Department. After initial inspection, DG Set and associated Electrical panel equipments shall be cleared for dispatch at site.
- 1.15.3.2 Copies of all documents of routine and type test certificates of the equipment, carried out at the manufacturers premises shall be furnished to the Engineer-in-charge and consignee.
- 1.15.3.3 After completion of the installation work in all respects, the contractor shall offer the DG Sets for testing. Testing shall be carried out exactly as per Clause 1.15.2.4 mentioned above.
- 1.15.3.4 The requirement of testing of DG Set at manufacturer's premises, in presence of representative of the Department, can be dispensed with/ waived off, keeping in view the exigency of works, with the prior approval of the Chief Engineer. However, test certificates of the particular DG Set on full load, as mentioned in Clause 1.15.2.4 above, shall be submitted at the time of delivery of DG Set at site.
- 1.15.4 Trial Run/ Running-in-Period**
- After successful testing of the DG Set, a trial run at available load will be carried out for 120 Hours or 15 Days whichever is earlier. The DG Set will be operated and a log of all relevant parameters will be maintained during this period. The arrangement of staff for trial run/ running in period will be made by the successful tenderer. However, diesel shall be provided by Department. The contractor will be free to carry out necessary adjustments. The DG Set will be said to have successfully completed the trial run, if no break-down or abnormal/ unsatisfactory operation of any component of the entire installation included in the scope of work of the contract, occurs during this period. After this the DG Set will be made available for beneficial use. After the DG Set has operated without any major break-down/ trouble, it shall be taken over by the department subject to guarantee clause of the contract. This date of taking over of the DG Set, after trouble free operation during the trial run/ running-in period, shall be the date of acceptance/ taking over.
- 1.15.5 Safety measures**
- All equipments shall incorporate suitable safety provisions to ensure safety of the operating personnel as per manufacturers' standard practice.

**1.16 STATUTORY CLEARANCE(S)**

Approval/ clearance of the complete installation shall be obtained by the contractor from CPCB/ State Pollution Control Boards/ Local Bodies/ Central Electricity Authority (CEA) other licensing authorities wherever required. However, application shall be made by Department and any statutory fee, as applicable, shall be paid by Department directly to the govt. authorities concerned.

**1.17 GUARANTEE**

All equipments shall be guaranteed, against unsatisfactory performance and/ or break down due to defective design, workmanship or material, for a period of 12 months from the date of taking over the installation by the department. The equipments or components, or any part thereof, so found defective during guarantee period shall be forthwith repaired or replaced free of cost, to the satisfaction of the Engineer-in-Charge. In case it is felt by the department that undue delay is being caused by the contractor in attending the defect/ fault removed, the same will be got done by the department at the risk and cost of the contractor. The decision of the Engineer-in-charge in this regard shall be final.

**1.18 PAYMENT TERMS**

1.18.1 The following percentage of contract rates shall be payable against the stages of work shown herein:

<i>Stage of Work</i>	<i>Engine-Alternator Set &amp; AMF Panel</i>	<i>All other items</i>
I After initial inspection (wherever specified) & delivery at site in good condition on pro-rata basis	85%	75%
II On completion of pro-rata installation	10 %	20%
III On commissioning and completion of successful running in period & taking over of the DG set by the department.	5 %	5 %

1.18.2 Deduction of Security Deposit shall be governed by standard/ relevant clauses of CPWD-7/8.

**1.19 TENDER DRAWINGS, DRAWINGS FOR APPROVAL & COMPLETION DRAWINGS**

**1.19.1 Tender Drawings**

The drawings appended with the tender documents are intended to show space allotted for various equipments. The equipments offered shall be suitable for installation in the spaces shown in these drawings.

**1.19.2 Drawings for Approval on Award of the work**

The contractor shall prepare & submit three sets of following drawings and get them approved from the Engineer-in-charge before the start of the work. The approval of drawings however does not absolve the contractor not to supply the equipments/ materials as per agreement, if there is any contradiction between the approved drawings and agreement.

- (a) Lay out drawings of the equipments to be installed including control cables, fuel/ lube oil pipes and supports/ structure for exhaust piping, Chimney and bus ducts/ cable trays.
- (b) Drawings including section, showing the details of erection of entire equipments.
- (c) Electrical wiring diagrams from engine-alternator set to Electrical control panel, Electrical control panel to essential LT board including the sizes and capacities of the various electrical/ control cables and equipment.
- (d) Dimensioned drawings of Acoustic enclosure/ Engine-Alternator set and Electrical control panel.
- (e) Drawings showing details of supports for pipes, chimney cable trays, ducts etc.
- (f) Any other drawings relevant to the work.

1.19.2.1 ***Drawings/Documents to be furnished on completion of Installation***

Two sets of the following laminated drawings shall be submitted by the contractor while handing over the installation to the Department. One set shall be laminated on a hard base for display in the DG set room/room where AMF panel is installed and another set shall be displayed in Junior Engineer's room. In addition, drawings will be given on Compact Disc (CD):

- (a) DG set installation drawings giving complete details of all the equipments, including their foundations.
- (b) Line diagram and layout of all electrical control/AMF panels giving switchgear ratings and their disposition, cable feeder sizes and their layout.
- (c) Control wiring drawings with all control components and sequence of operations to explain the operation of control circuits in AMF panel/PCC.

- 1.19.2.2 (i) Manufacturer's technical catalogues of all equipments and accessories.
- (ii) Operation and maintenance manual of all major equipments, detailing all adjustments, operation and maintenance procedure.

**1.20 AFTER SALES SERVICES**

The contractor shall ensure adequate and prompt after sales service free of cost during guarantee period, and against payment after the guarantee period is over, in the form of maintenance, spares and personnel as and when required during normal life span of the equipments and shall minimize the breakdown period. In case of equipment supplied by other manufacturers the firm shall furnish a guarantee from the manufacturer for the same before the DG Set installation is taken over.

## CHAPTER 2

### TECHNICAL

#### 2.1 SCOPE

This section deal with unloading procedures, location, standard capacities and climatic conditions for DG set installation.

##### 2.1.1 Unloading

###### 2.1.1.1 *Gensets without Acoustic Enclosure*

2.1.1.1.1 Genset should not be lifted from engine and alternator hooks. These are designed for lifting individual items only. Normally, provision for Genset lifting is provided on base-rails. The Genset should be unloaded from base rail by lifting with proper Genset lifting tackle or nylon sling/steel rope of suitable capacity and crane so as to ensure no damage to oil sump, air cleaner, radiator pipes etc.

2.1.1.1.2 Genset should be covered with polyethylene or tarpaulin during installation to ensure that water does not enter inside.

2.1.1.1.3 Spreader bar/ spacer plate of suitable size may be required to avoid damages to Genset components.

2.1.1.2 DG set with Acoustic enclosures are provided with lifting hooks.

##### 2.1.2 Location

###### 2.1.2.1 *DG Sets with Acoustic Enclosure*

DG sets up to 1000 KVA capacity are required to be supplied with acoustic enclosure as per CPCB norms. DG Set with acoustic enclosure shall preferably be installed outside the building (including terrace subject to structural feasibility) & location should be finalized in consultation with the Architect. However, DG set should be as near to the substation as possible i.e. as near to Essential LT Panel as possible. Associated AMF panel/ Electrical panel of the DG Set can be located inside the acoustic enclosure or outside the acoustic enclosure as per manufacturer standard. In case, AMF/ Electrical panel has to be installed outside the acoustic enclosure, location of room to house AMF/ Electrical panel should be decided in consultation with the Architect so that it shall be as near to the acoustic enclosure as possible. Specially, in case of connection through bus trunking, care should be taken for aesthetics.

2.1.2.2 **DG Sets without Acoustic Enclosure**

2.1.2.2.1 In case of DG Sets beyond 1000 KVA capacity i.e. when DG set is supplied without acoustic enclosure, room of appropriate size should be provided to house the DG Set. The DG set room should be as near to the substation as possible (i.e. as near to Essential LT Panel as possible). While deciding the room layout, typical 2-meters free space around Genset is recommended for proper heat dissipation and ease of service. However, to avoid hot air re-circulation, radiator cooled engines should have maximum possible space in the front. Minimum 1.5 meter free space is must. A typical Genset room is shown in Figure 1.

2.1.2.2.2 As far as possible, installation of DG Set should be avoided in basement. In cases where installation of D.G. Set in basement is unavoidable, due care of supply of adequate amount of air required for proper operation of D.G. Set shall be taken.

2.1.3 **Nominal ratings of DG Sets**

DG Sets are normally available in following standard capacities:

(Ratings in KVA)

7.5	10	12.5	15	17.5	25	30	35	40	50	62.5
75	82.5	110	125	140	200	225	250	320	350	380
415	450	500	550	600	625	700	750	1010	1250	1500

Capacity output of DG Set should be specified in tender in terms of "Prime Power Rating at 0.85 load factor" as per Clause 13.3.2 of ISO-8528 (Part-1), titled 'Reciprocating internal combustion engine driven alternating current generating sets: Part-1: Application, ratings and performance' (See Appendix 'I'). However, depending upon the particular application & use, 'Continuous' or 'Standby' rating can be specified.

2.1.4 **Climatic Conditions**

The output of DG Set shall be specified in tender documents under actual site conditions. The tenderer has to certify that the engine & alternator meets the capacity requirement after de-rating as per IS/ BIS.

2.1.5 DG Set upto 1000 KVA capacity should be type tested for Noise and Emission norms/standards as per CPCB as per Appendix 'II' and Appendix 'III' .

2.2 **DIESEL ENGINE**

**Scope:** This section covers engine rating, standard components of a diesel engine including exhaust piping.

2.2.1 **Diesel Engine**

2.2.1.1 **Engine Rating**

The engine shall be of standard design of the original manufacturers. It should be 4 stroke cycles, water cooled, naturally aspirated/ turbo charged (as per manufacturer standard), diesel engine developing suitable BHP for giving a power rating as per ISO 8528- Part-1 in KVA at the load terminals of alternator at 1500 rpm at actual site conditions.

The engine shall be capable for delivering specified Prime Power rating at variable loads for PF of 0.8 lag with 10% overload available in excess of specified output for one hour in every 12 hours. The average load factor of the engine over period of 24 hours shall be 0.85 (85%) for prime power output.

The testing procedure shall be as mentioned in para 1.15.

The engine shall conform to IS:10000/ ISO 3046/ BS:649/ BS 5514 amended up to date.

2.2.1.2 Necessary certificate indicating the compliance of the above capacity requirement for the engine model so selected along with compliance of Noise and Emission norms as per latest CPCB guidelines for DG set capacity up to 1000 KVA, should be furnished from the manufacturers along with the technical bid. (Refer Appendix 'II' for noise norms and Appendix 'III' for emission norms). However above 1000 KVA DG set, manufacturers shall furnish certificate that the Engine for the DG set complies with the CPCB Emission norms.

2.2.1.3 The engine shall be fitted with following accessories subject to the design of the manufacturer:

- (i) Dynamically balanced Fly wheel
- (ii) Necessary flexible coupling and guard for alternator and engine (applicable only for double bearing alternator)
- (iii) Air cleaner (dry/ oil bath type) as per manufacturer standard,
- (iv) A mechanical/ electronic governor to maintain engine speed at all conditions of load. (see Clause 2.2.1.4)
- (v) Daily fuel service tank of minimum capacity as per Table below, fabricated from M.S. sheet with inlet, outlet connections air vent tap, drain plug and level indicator (gauge) M.S. fuel piping from tank to engine with valves, unions, reducers, flexible hose connection and floor mounting pedestals, twin fuel filters and fuel injectors. The location of the tank shall depend on standard manufacturers design.

**Table I : Recommended Minimum Capacity of Daily Fuel Service Tank**

S.No.	Capacity of DG set	Minimum Fuel Tank Capacity
(i)	Upto 25 KVA	100 Litres
(ii)	Above 25 to 62.5 KVA	120 Litres
(iii)	Above 62.5 KVA to 125 KVA	225 Litres
(iv)	Above 125 KVA to 200 KVA	285 Litres
(v)	Above 200 KVA to 380 KVA	500 Litres
(vi)	Above 380 KVA to 500 KVA	700 Litres
(vii)	Above 500 KVA to 750 KVA	900 Litres

(vi) Dry exhaust manifold with suitable exhaust residential grade silencer to reduce the noise level.

(vii) Suitable self-starter for 12 V/ 24 V DC.

- (viii) Battery charging alternator unit and voltage regulator, suitable for starting batteries, battery racks with interconnecting leads and terminals.
- (ix) Necessary gear driven oil pump for lubricating oil, priming of engine bearing as well as fuel systems as per manufacturer recommendations.
  - (x) Naturally aspirated/ turbo charger (as per manufacturer standard)
  - (xi) Lubrication oil cooler
  - (xii) Lubrication oil filters with replaceable elements
  - (xiii) Crank case heater as per manufacturer recommendations
- (xiv) Fuel injection: Engine should have suitable fuel injection system in order to achieve low fuel consumption
- (xv) Fuel control solenoid
- (xvi) Fuel pump with engine speed adjustment
- (xvii) Engine Control Panel: fitted and having digital display for following:
 

(a) Start/stop key switch.	(f) Battery charging indication
(b) Lube oil pressure indication	(g) Low lub. Oil trip indication
(c) Water temp. indication	(h) High water temp. indication
(d) RPM indication	(i) Over speed indication.
(e) Engine Hours indications	
- (xviii) All moving parts of the engine shall be mechanically guarded in such a manner that a human finger cannot touch any moving part.
- (xix) Radiator/ Heat Exchanger System/ Remote Radiator(delete whichever is not applicable)
- (xx) Any other item not included/ specified but is a standard design of the manufacturer

2.2.1.4 **Governor**

Mechanical governor of class A2 for up to and including 200 KVA capacity and Electronic governor of class A1 for capacity above 200 KVA, as per ISO 3046/ BS 5514 with actuator shall be provided as per standard design of manufacturer. Governor shall be a self contained unit capable of monitoring speed.

2.2.1.5 **Frequency Variation**

The engine speed shall be so maintained that frequency variation at constant load including no load shall remain within a band of 1% of rated frequency.

2.2.1.6 **Fuel System**

It shall be fed through engine driven fuel pump. A replaceable element of fuel filter shall be suitably located to permit easy servicing. The daily service tank shall be complete with necessary supports, gauges, connecting pipe work etc. In case of Top Mounted tanks, non return valves are must in fuel supply and return line of specified value. Pipe sealant should be used for sealing for all connections. No Teflon tape to be used. If piping length is more than 10 meters, detail engineering is required in consultation with OEM/ Manufacturers.

#### 2.2.1.7 **Lubricating Oil System**

It shall be so designed that when the engine starts after a long shut down lubrication failure does not occur. Necessary priming pump for the lub. oil circuit as per recommendation of manufacturer shall be installed, to keep bearings primed. This pump shall be normally automatically operative on AC/ DC supply available with the set.

#### 2.2.1.8 **Starting System**

This shall comprise of necessary set of heavy duty batteries 12V/ 24V DC (as per manufacturer standard), and suitable starter motors, axial type gear to match with the toothed ring on the fly wheel. A timer in the control panel to protect the starter motor from excessively long cranking runs shall be suitably integrated with the engine protection system and shall be included within the scope of the work. Battery capacity shall be suitable for meeting the needs of starting system (as three attempt starting), as well as the requirements of control panel, indications and auxiliaries such as priming pump as applicable etc. The scope shall cover all cabling, terminals, including initial charging etc. The system shall be capable of starting the DG set within 20-30 sec., even in winter condition with an ambient temperature down to 0°C.

#### 2.2.1.9 **Battery Charger**

The battery charger shall be suitable to charge required numbers of batteries at 12V/ 24 volts complete with, transformer, rectifier, charge rate selector switch, indicating ammeter & voltmeter etc. Connections between the battery charger & batteries shall be provided with suitable copper leads with lugs etc.

#### 2.2.1.10 **Piping Work**

All pipe lines and fittings and accessories requirement inside the room/ enclosure and outside for exhaust piping shall be provided by the contractor. This shall include necessary flexible pieces in the exhaust, fuel, lub. oil and water lines as are necessary in view of the vibration isolation requirement in the installation. Piping of adequate size shall be used for lub. oil of the material as per manufacturer standard. However, only M.S. pipes for the exhaust shall be used. For fuel lines within the acoustic enclosure, PVC braided pipe as per manufacturer recommendations can be used. However, for fuel lines outside the acoustics enclosure only MS pipe be used.

The pipe work shall be inclusive of all fittings and accessories required such as bends, reducers, elbows, flanges, flexible connections, necessary hardware etc. The installation shall cover clamps, supports, hangers etc. as are necessary for completing the work. However, the work shall be sectionalized with flanged connections as are necessary for easy isolation for purposes for maintenance of unit as approved by Engineer-in-charge.

#### 2.2.1.11 **Common Bed Plate**

Engine and alternator shall be directly coupled or coupled by means of flexoplate/ flexible coupling as per manufacturer standard design and both units shall be mounted on a common bed plate together with all auxiliaries to ensure perfect alignment of engine and alternator with minimum vibrations. The bed plate shall be suitable for installation on suitable anti-vibration mounting system.

2.2.1.12 **Exhaust System:** (wherever applicable)

2.2.1.12.1 **Exhaust Piping:** All M.S. Pipes for exhaust lines shall be conforming to relevant IS. The runs forming part of factory assembly on the engine flexible connections up to exhaust silencer shall be exclusive of exhaust piping item. The work include necessary cladding of exhaust pipe work using 50 mm thick Loosely bound resin (LBR) mattress/ mineral wool/ Rockwool, density not less than 120 kg/m<sup>3</sup> and aluminium cladding (0.6 mm thick) for the complete portion. The exhaust pipe work includes necessary supports, foundation etc. to avoid any load & stress on turbo charger / exhaust piping. The exhaust pipe shall be \*run along the existing wall of the building duly clamped/\*supported on independent structure for which, the design and Drawing for such structure shall be got approved from the Engineer-in-charge.

- 2.2.1.12.2
- (a) Exhaust system should create minimum back pressure.
  - (b) Number of bends should be kept minimum and smooth bends should be used to minimize back pressure.
  - (c) Pipe sleeve of larger dia. should be used while passing the pipe through concrete wall & gap should be filled with felt lining.
  - (d) Exhaust piping inside the Acoustic Enclosure/ Genset room should be lagged with asbestos rope along with aluminium sheet cladding / insulated as per clause 2.2.1.12.1 to avoid heat input to the room.
  - (e) Exhaust flexible shall have it's free length when it is installed. For bigger engines, 2 flexible bellows can be used.
  - (f) For engines up to 500 KVA, only one bellow is required. However, if exhaust pipe length is more than 7 m then additional bellow/ provision for expansion should be provided.
  - (g) 'Schedule B' MS pipes and long bend/elbows should be used.
  - (h) The exhaust outlet should be in the direction of prevailing winds and should not allow exhaust gases to enter air inlet/ windows etc.
  - (i) When tail end is horizontal, 45 Degree downward cut should be given at the end of the pipe to avoid rain water entry into exhaust piping.
  - (j) When tail end is vertical, there should be rain trap to avoid rain water entry. If rain cap is used, the distance between exhaust pipe and rain cap should be higher than diameter of pipe. Horizontal run of exhaust piping should slope downwards away from engine to the condensate trap. Silencer should be installed with drain plug at bottom.

2.2.1.12.3 **Optimum Silencer Location:** Location of the silencer in exhaust system has very definite influence on both reduction of noise and back pressure imposed on the system. The preferred silencer locations are given in the Table below, where L is length of the total exhaust system measured from exhaust manifold in meters. Please note that locating the silencer as per optimum silencer location is not mandatory. For high rise buildings, suitable arrangements may have to be provided in consultation with acoustics engineer.

<i>Optimum Location of Silencer (In meters)</i>		
	<i>In-line Engine</i>	<i>'V' Engine</i>
Best	2L/5	(4L – 1.5) / 5
Second best	4L/5	(2L – 4.5) / 5
Worst Location of Silencer	L/5 or 3L/5 or at tail end of Exhaust piping	(3L - 10) / 5 or at the tail end of Exhaust piping

2.2.1.12.4 *Exhaust Stack Height:* In order to dispose exhaust above building height, minimum exhaust stack height should be as follows:-

(a) **For DG set up to 1000 KVA :-**

$$H = h + 0.2 \times \sqrt{KVA}$$

Where H = height of exhaust stack h = height of building

(b) **For DG set above 1000 KVA :-**

30 m High or 3 m above the building height, which ever is higher.

2.2.1.12.5 Care should be taken to ensure that no carbon particles emitted due to exhaust leakage enters and deposits on alternator windings and on open connections.

2.2.1.12.6 *Support to Exhaust Piping:* Exhaust piping should be supported in such manner that load of exhaust piping is not exerted to turbocharger.

#### 2.2.1.13 **Air System**

It is preferable to provide vacuum indicator with all engines to indicate choked filter. Maximum air intake restrictions with clean and choked filters should be within prescribed limit as per OEM/ manufacturer recommendation for the particular model of the engine. Gensets should be supplied with medium duty/ heavy duty air cleaners (specify one only). (Heavy duty air cleaner should be used for installations in dusty or polluted surroundings.)

#### 2.2.1.14 **Cooling System**

2.2.1.14.1 System should be designed for ambient temperature of 40 Deg.C.

2.2.1.14.2 Water softening/ demineralizing plants should be used, if raw water quality is not acceptable.

2.2.1.14.3 Coolant should be used mixed with additive (in suitable proportion) as per recommendation of OEM /Manufacturer for various engine models.

2.2.1.14.4 Radiator fan flow should be free from any obstruction.

2.2.1.14.5 For radiator cooled DG Set, proper room ventilation should be planned at the time of construction of DG room.

2.2.1.14.6 Remote Radiator can be used in case of basement installation where fresh air may not be available. The proper location of remote radiator is very essential for the successful and efficient operation of remote radiator. In this the cooling media is ambient air. So in order to obtain maximum efficiency from remote radiator, it is necessary to get fresh air in its surrounding. The horizontal distance of remote radiator from engine should not exceed 10 Meter.

2.2.1.14.7 For the dusty or polluted surroundings (as radiator gets clogged) and/ or bigger capacity Gensets (say 1000 KVA and above), installation of Cooling System with Heat Exchanger system may be used.

2.2.1.14.8 Optional items as under may be included as per site requirement at the discretion of Technical Sanctioning authority:

(i) **Cooling System**

(a) Remote Radiator

- (b) Jacket Water Heater
- (c) Crankcase Oil Heater
- (d) After cooler jacket turbo charger electrical pre heat systems.
- (ii) **Fuel System**
  - (a) Fuel Water Separator
  - (b) Auxiliary Fuel Pump
- (iii) **Exhaust System**
  - (a) Industrial Grade Muffler
  - (b) Residential Grade Muffler
  - (c) Critical Grade Muffler
  - (d) Super Critical Grade Muffler
- (iv) **Start System**
  - (a) Battery Warmer Plate
  - (b) Battery Charger
    - Automatic Float Equalizing
    - Trickle

## 2.3 ALTERNATOR

**Scope :** This section covers technical requirement of the alternator.

### 2.3.1 Synchronous Alternator

Self excited, screen protected, self regulated, brush less alternator, Horizontal foot mounted in Single/Double bearing construction (specify one only) suitable for the following:

Rated PF.	: 0.8 (lag)
Rated voltage	: 415 volts
Rated frequency	: 50 Hz
No. of Phases	: 3
Enclosure	: SPDP
Degree of protection	: IP-23
Ventilation	: Self ventilated air cooled
Ambient Temperature	: 40° C Maximum
Insulation Class	: F/H
Temperature Rise	: Within class F/H limits at rated load
Voltage Regulation	: +/- 1%
Voltage variation	: +/- 5%
Overload duration/capacity	: 10% for one hour in every 12 hours of continuous use.
Frequency variation	: As defined by the Engine Governor (+/- 1% )

Excitation	: Self / separately excited (Self excitation upto 750 KVA and separately excited system above 750 KVA)
Type of AVR	: Electronic
Type of Bearing and Lubrication arrangement	: Anti-friction bearings with Grease lubrication
Standard	: IS 4722 & IEC:34 as amended upto date.

2.3.2 Alternator should be able to deliver output rating at actual site conditions.

2.3.3 The alternator above 500 KVA capacity shall be fitted with suitable Nos. Resistance Temperature Device (RTD) & Bearing Temperature Device (BTD) alongwith space heaters. The terminal of space heaters will be wired to terminal box and the temperature scanner shall be provided in control panel for scaling the winding and bearing temperature.

2.3.4 **Excitation**

The alternator shall be brushless type and shall be self/ separately excited, self-regulated having static excitation facility. The exciter unit be mounted on the control panel or on the alternator assembly. The rectifier shall be suitable for operation at high ambient temperature at site.

2.3.5 **Automatic Voltage Regulators (AVR)**

In order to maintain output terminal voltage constant within the regulation limits i.e. +/- 1%, Automatic voltage regulator unit shall be provided as per standard practice of manufacturer.

2.3.6 **Fault tripping**

In the event of any fault e.g. over voltage/ high bearing temperature/ high winding temperature or an external fault, the AVR shall remove the excitation voltage to the alternator. An emergency trip shall also be provided.

2.3.7 **Standards**

The alternator shall be in accordance with the following standards as are applicable.

- (i) IS 4722/ BS 2613 : 1970. The performance of rotating electrical machine.
- (ii) IS 4889/ BS 269 rules for method of declaring efficiency of electrical machine.

2.3.8 **Performance**

Voltage dip shall not exceed 20% of the rated voltage for any step load or transient load as per ISO 8528 (Part-1). The winding shall not develop hot spots exceeding safe limits due to imbalance of 20% between any two phases from no load to full load.

The generator shall preferably be capable of withstanding a current equal to 1.5 times the rated current for a period of not more than 15 seconds as required vide clause 14.1.1 of IS 4722:1992.

The performance characteristics of the alternator shall be as below:

(a)	Efficiency at full load 0.8 P.F.	(i)	Upto 25 KVA – not less than 82%
		(ii)	Above 25 KVA and upto 62.5 KVA – not less than 86%
		(iii)	Above 62.5 KVA & upto 250 KVA – not less than 90%
		(iv)	Above 250 KVA – not less than 93.5%
(b)	Total distortion factor		Less than 3 %
(c)	(i) 10% overload		One hour in every 12 hrs of continuous use.
	(ii) 50% overload		15 seconds.

#### 2.3.9 **Terminal Boxes**

Terminal boxes shall be suitable for U.G. cables/ Bus Trunking. The terminal box shall be suitable to withstand the mechanical and thermal stresses developed due to any short circuit at the terminals.

#### 2.3.10 **Earth Terminals**

2 Nos. earth terminals on opposite side with vibration proof connections, non-ferrous hardware etc. with galvanized plate and passivated washer of minimum size 12 mm dia. hole shall be provided.

#### 2.3.11 **Space Heaters**

Alternators of capacity more than 500 KVA shall be provided with suitable space heaters to maintain the winding temperature automatically such that it does not absorb moisture during long idle periods. The heater terminals shall be brought to a separate terminal box suitable for 230 V AC supply and a permanent caution notice shall be displayed.

### 2.4 **MANUAL/ AMF PANEL, BATTERIES AND ELECTRICAL SYSTEM**

**Scope:** This section covers technical and functional requirements of Manual/ AMF Panel, Battery/ Electrical System.

#### 2.4.1 **Location of Panel**

##### 2.4.1.1 ***DG Set with Acoustic Enclosure***

Associated AMF panel/ Manual panel of the DG Set can be located inside the acoustic enclosure or outside the acoustic enclosure as per manufacturer's standard. In case, AMF/ Manual panel has to be installed outside the acoustic panel, location of room to house AMF/ Manual panel should be decided in consultation with the Architect as near to the acoustic enclosure as possible. In case of connection through bus trunking, care should be taken for aesthetics vis-à-vis surrounding.

##### 2.4.1.2 ***DG Set without Acoustic Enclosure***

In case of DG Set is supplied without acoustic enclosure, Manual/AMF electrical control panel should be located inside the sub station building.

## 2.4.2 **Type of Control Panel**

Control panel shall be either manual type or AMF type as per the requirement of work to be decided by NIT approving authority.

### 2.4.2.1 **Manual Control Panel**

The control panel shall be fabricated out of 1.6 mm sheet steel, totally enclosed, dust, damp and vermin proof wall mounted/ free standing floor mounted type with IP-53 degree of protection & front operated.

The Standard control panel shall consist the following instruments:

- (a) Composite meter for digital display of :
  - (i) Voltage
  - (ii) Current
  - (iii) Power factor (for 15 KVA and above)
  - (iv) Frequency (for 15 KVA & above)
  - (v) Energy Meter (for 15 KVA & above)
- (b) HRC fuses of suitable rating.
- (c) One MCB of suitable rating for DG sets up to 45 KVA rating or Switch Disconnector Fuse Unit (SDFU) for higher ratings.
- (d) Push button-switch or ON/ OFF Switch for ON and OFF operation
- (e) Pilot lamps one No. in case of single phase DG sets and 3 numbers in case of three phase DG sets.
- (f) Battery charger complete with voltage regulator, Voltmeter and Ammeter for charging the battery from external mains. This will be in addition to the battery charging alternator or dynamo fitted on the engine.
- (g) Instrument fuses.

All the components in the control panel shall be properly mounted, duly wired and labeled. Suitable terminals are to be provided for panel incoming and outgoing connections.

### 2.4.2.2 **AMF Control Panel**

2.4.2.2.1 **General Features:** The control panel shall be fabricated out of 1.6 mm thick sheet steel, totally enclosed, dust, damp and vermin proof free standing floor mounted type & front operated. It shall be made into sections such that as far as feasible, there is no mixing of control, power, DC & AC functions in the same section and they are sufficiently segregated except where their bunching is necessary. Hinged doors shall be provided preferably double leaf for access for routine inspection from the rear. There is no objection to have single leaf hinged door in the front, all indication lamps, instruments meter etc. shall be flushed in the front. The degree of protection required will be IP-42 conforming to IS 2147.

2.4.2.2.2 **Terminal Blocks and Wiring:** Terminal blocks of robust type and generally not less than 15 Amps capacity, 250/500 V grade for DC upto 100 V and 660/ 1100 volts grade for AC and rest of the junction shall be employed in such a manner so that they

are freely accessible for maintenance. All control and small wiring from unit to unit inside the panel shall also be done with not less than 2.5 sqmm copper conductor PVC insulated and 660/ 1100 volts grade. Suitable colour coding can be adopted. Wiring system shall be neatly formed and run preferably, function wise and as far as feasible segregated voltage wise. All ends shall be identified with ferrules at the ends.

- 2.4.2.2.3 *Labeling:* All internal components shall be provided with suitable identification labels suitably engraved. Labels shall be fixed on buttons, indication lamps etc.
- 2.4.2.2.4 *Painting:* The entire panel shall be given primer coat after proper treatment and powder coating with 7 tanks process before assembly of various items.
- 2.4.2.2.5 *Equipment requirements:* The control cubical shall incorporate into assembly general equipment and systems as under:
- (a) Control system equipments and components such as relays, contactors, timers, etc. both for automatic operation on main failure and as well as for manual operation.
  - (b) Equipment and components necessary for testing generating set's healthiness with test mode and with load on mains.
  - (c) Necessary instruments and accessories such as voltmeter, power factor meter, KW meter, KWH meter, Ammeter, Frequency meter etc. in one energy analyzer unit with selector switch to obtain the reading of desired parameters.
  - (d) Necessary indication lamps, fuses, terminal blocks, push buttons, control switches etc. as required.
  - (e) Necessary engine/ generating set shut down devices due to faults /abnormalities.
  - (f) Necessary visual audio alarm indication and annunciation facility as specified.
  - (g) Necessary battery charger.
  - (h) Necessary excitation control and voltage regulating equipment. (Alternatively provided on the Alternator itself).
  - (i) Necessary over head bus trunking terminations all internal wiring, connections etc. as required.
  - (j) Breakers as specified in the schedule of work.
- 2.4.2.2.6 *System Operation:* The above mentioned facilities provided shall afford the following operational requirements.
- 2.4.2.2.6.1 *Auto Mode:*
- (a) A line voltage monitor shall monitor supply voltage on each phase. When the mains supply voltage fails completely or falls below set value (variable between 80 to 95% of the normal value) on any phase, the monitor module shall initiate start-up of diesel engine. To avoid initiation due to momentary disturbance, a time delay adjustment between 0 to 5 second shall be incorporated in start-up initiation.
  - (b) A three attempt starting facility shall be provided 6 seconds ON, 5 seconds OFF, 6 seconds ON, 5 seconds OFF, 6 seconds ON, 5 seconds OFF, 6 seconds ON, if at the end of the third

attempt, the engine does not start, it shall be locked out of start, a master timer shall be provided for this function. Suitable adjustment timers be incorporated which will make it feasible to vary independently ON-OFF setting periods from 1-10 seconds. If alternator does not build up voltage after the first or second start as may be, further starting attempt will not be made until the starting facility is reset.

- (c) Once the alternator has built up voltage, the alternator circuit breaker shall close connecting the load to the alternator. The load is now supplied by the alternator.
- (d) When the main supply is restored and is healthy as sensed by the line voltage monitor setting, both for under voltage and unbalance, the system shall be monitored by a suitable timer which can be set between 1 minute to 10 minutes for the load to be transferred automatically to main supply.
- (e) The diesel alternator set reverts to standby for next operation as per (a), (b) and (c) above.

2.4.2.2.6.2 *Manual Mode:*

- (a) In a manual mode, it shall be feasible to start-up the generator set by the operator on pressing the start push button.
- (b) Three attempt starting facility shall be operative for the start-up function.
- (c) Alternator circuit breakers close and trip operations shall also be through operator only by pressing the appropriate button on the panel and closure shall be feasible only after alternator has built up full voltage. If the load is already on 'mains', pressure on 'close' button shall be ineffective.
- (d) Engine shut down, otherwise due to faults, shall be manual by pressing a 'stop' button.

2.4.2.2.6.3 *Test Mode:*

- (a) When under 'test' mode pressing of 'test' button shall complete the start up sequence simulation and start the engine. The simulation will be that of mains failure. Sequence 2.4.2.2.6.1(a) and (b) shall be completed.
- (b) Engine shall build up voltage but the set shall not take load by closing of alternator circuit breaker. When the load is on the mains, monitoring of performance for voltage/ frequency etc. shall be feasible without supply to load.
- (c) If during test mode, the power supply has failed, the load shall automatically get transferred to alternator.
- (d) Bringing the mode selector to auto position shall shut down the set as per sequence of 2.4.2.2.6.1(d) provided main supply is ON. If the mains supply is not available at that time, the alternator shall take load as in (c) above.

2.4.2.2.7 *Engine shut down and alternator protection equipment:* Following shut down and protection system shall be integrated in the control panel.

(a) *Engine:*

- (i) Low lubricating oil pressure shut down. This shall be inoperative during start up and acceleration period.

- (ii) High coolant (water) temp. shut down.
- (iii) Engine over speed shut down.
- (b) *Alternator Protection:* Following protection arrangement shall be made:
  - (i) Over load
  - (ii) Short circuit
  - (iii) Earth fault
  - (iv) Over voltage

2.4.2.2.8 *Monitoring and Metering Facilities:*

- (a) Necessary energy analyzer unit for visual monitoring of mains, alternator and load voltage, current, frequency, KWH, power factor, etc.
- (b) A set of visual monitoring lamp indication for:
  - (i) Load on set
  - (ii) Load on mains
  - (iii) Set on test (Alternator on operation duty, Alternator on standby duty).
  - (iv) Set of lamp for engine shut down for over speed, low lub. oil pressure and high coolant water temperature, overload trip of alternator, earth fault trip of alternator, engine lock out and failure to start etc. All these indications shall have an audio and visual alarm. When operator accepts the alarm, the hooter will be silenced and the fault indication will become steady until reset by operating a reset button.

2.4.2.2.9 *Operating Devices:* A set of operation devices shall be incorporated in the front of panel as under:

- (a) Master Engine Control Switch: This shall cut off in 'OFF' position DC control to the entire panel, thus preventing start-up of engine due to any cause. However, battery charger, lamp test button for testing the healthiness of indication lamps, DC volt meter / ammeter etc. shall be operative. It shall be feasible to lock the switch in OFF position for maintenance and shut down purposes.
- (b) Operation selector switch OFF/AUTO/MANUAL/TEST position.
- (c) Energy analyzer unit for display of various electrical parameters like voltage, current, frequency, KW, power factor, etc.
- (d) A set of push button as specified.
- (e) Relays, contactors, timers, circuit breakers as required.
- (f) Necessary battery charger with boost/ trickle selector, DC voltmeter and DC ammeter.

2.4.2.2.10 *Compatibility with 'Building Management System'(BMS):*

PLC compatibility and required nos. of Input/ Output terminals points should be provided in the AMF control panel.

### 2.4.3 **Battery/ Electrical System**

2.4.3.1 Batteries supplied with Genset are generally dry and uncharged. First charging of uncharged batteries is very important and should be done from authorized battery charging centre. Initial charging should be done for 72-80 hours.

2.4.3.2 Batteries should be placed on stands and relatively at cool place.

2.4.3.3 Battery capacity and copper cable sizes for various engine capacity are recommended as indicated in the table below. Cable sizes shown are for maximum length of 2 m. If length is more, cable size should be selected in such a way that voltage drop does not exceed 2 V. However capacity as recommended by manufacturer may be taken.

<i>DG Set Capacity</i>	<i>Battery Capacity (AH)</i>	<i>Cable Size (Material Copper) Sq. mm</i>	<i>Electrical System (Volts)</i>
Above 500 KVA	360	70	24
Above 125 KVA upto 500 KVA	180	70	12
Above 82.5.KVA upto 125 KVA	180	50	12
Above 62.5 KVA upto 82.5 KVA	150	50	12
Above 25 KVA upto 62.5 KVA	120	50	12
Upto 25 KVA	88	35	12

2.4.3.4 For AMF applications, a static battery charger working on mains supply is recommended to keep the batteries charged at all times.

2.4.3.5 1.5 sq.mm copper wire should be used for wiring between junction box and Control Panel.

### 2.4.4 **Cabling**

2.4.4.1 Power cabling between alternator and control panel and control panel and change over switch to mains should be done with recommended cable sizes.

2.4.4.2 Typical cable sizes for 415 V application are provided in Appendix VI.

2.4.4.3 As far as possible, for DG Set of capacity 750 KVA & above connection between alternator to AMF panel & AMF Panel to Essential panel shall be through bus-trunking. For exposed/ outdoor bus trunking protection requirement should be IP-55.

2.4.4.4 If LT panel is part of tender of the DG Set jobs of 500 KVA & above, LT Panel specified, should be one of the reputed brands.

2.4.4.5 Overheating due to loose thimbling / undersize cables causes most of electrical failures, hence correct size of cable and thimbles should always be used, if cable is specified.

2.4.4.6 While terminating cables, avoid any tension on the bolts/ busbars (if cable is specified). While terminating R, Y& B phase notations should be maintained in the alternator and control panel for easy maintenance.

2.4.4.7 Crimped cables should be connected to alternator and control panel through cable glands, if cable is specified.

- 2.4.4.8 Multi-core copper cables should be used for inter connecting the engine controls with the switchgear and other equipments.
- 2.4.4.9 For AMF application, multicore 1.5 sq.mm flexible stranded copper cable for control cabling should be used.
- 2.4.4.10 It is recommended to support output cables on separate structure on ground so that weight of cables should not fall on alternator/ base rail.
- 2.4.4.11 External wirings, when provided for remote voltage / excitation monitoring/ droop CT etc. shall be screened sheathed type. Maximum length of such wiring shall not exceed 5 meters.
- 2.4.4.12 *Alternator Termination Links*
- 2.4.4.12.1 For proper terminations between links and switchgear terminals, the contact area must be adequate. The following situations should also be avoided as they lead to creation of heat sources at the point of termination:
  - (i) Point contact arising out of improper position of links with switchgear terminals [Figure 2(i)].
  - (ii) Gaps between busbars / links and terminals being remedied by connecting bolt/stud [Figure 2(ii)]. In such cases the bolt will carry the load current. Normally these bolts / studs are made of MS and hence are not designed to carry currents.
- 2.4.4.12.2 Adequate clearance between busbars / links at terminals should be maintained (IS 4232 may be referred to for guidelines).  
Figure 2(iii) indicates the quality of different configurations.
- 2.4.4.12.3 Improper termination will lead to local heat generation which may lead to failure.

## **2.5 FOUNDATION**

**Scope:** This section covers details of foundations for DG set with or without acoustic enclosures.

### **2.5.1 Genset with Acoustic Enclosure**

- (a) For DG Sets installed inside the DG Set Room - A PCC foundation (1:2:4, M-20 grade) of approximate depth 150 mm above the finished Genset Room Floor level is required so as to provide leveled surface for placement of the acoustics enclosure. The length and breadth of foundation should be at least 250 mm more on all sides than the size of the enclosure. Genset should be mounted on AVM's inside the enclosure.
- (b) For DG Sets installed outside in open area - APCC (1:2:4, M-20 grade) foundation of weight 2.5 times the operating weight of the Genset with enclosure or as recommended by the Genset manufacturer OEM/OEA, whichever is higher, is required to be provided and is included in scope of work for SITC of Genset. 300 mm of this foundation height should be above the ground level. The length and breadth of foundation should be at least 250 mm more on all sides than the size of enclosure. Genset should be mounted on AVM's inside the enclosure.

Design of the foundation as recommended by the OEM shall be submitted by the contractor before execution of work along with the drawings as mentioned in section 1.19.

**2.5.2 Genset without Acoustic Enclosure**

- 2.5.2.1 Genset should not be installed on loose sand or clay.
- 2.5.2.2 Foundation should be designed considering safe bearing capacity of soil. Vibration isolators (AVMs) should be provided to reduce vibration transmission to the surrounding structure.
- 2.5.2.3 Depths of PCC (Plain Cement Concrete) for typical soil condition have been shown in the table below. However structural engineer should be consulted to verify the data depending upon soil condition.

<i>DG Set Capacity (KVA)</i>	<i>Typical Depth of PCC Foundation (For soil bearing capacity 5000 kg/sqm)</i>
750-2000	600 mm
625	400 mm
320-500	400 mm
200-320	400 mm
82.5 -200	400 mm
Upto 82.5	200 mm

- 2.5.2.4 Foundation level should be checked diagonally as well as across the length for even flatness. The foundation should be within  $\pm 0.5$  Degree (angle) of any horizontal plane.

**2.6 ACOUSTIC ENCLOSURE**

**Scope :** This section covers technical requirements of the acoustic enclosures.

- 2.6.1 As per CPCB norms, restriction has been imposed for new DG sets upto 1000 KVA for noise level (see Appendix 'II'). Therefore, in terms of these norms, acoustic enclosure should be type tested at the climatic conditions specified in para 2.1.4 through one of the authorized laboratory.
- 2.6.2 **Installation**
  - 2.6.2.1 Acoustic enclosures are supplied with built in Anti Vibration Mountings (AVMs). As such Genset can be installed directly on the leveled surface.
  - 2.6.2.2 Exhaust piping outlet should not be turned towards window / ventilator of home or occupied building. Provision of rain cap should be ensured.
  - 2.6.2.3 The acoustic enclosure placement should be such that there is no restriction in front of air inlet and outlet from canopy.
- 2.6.3 **Service Accessibility**
  - 2.6.3.1 Genset / Engine control panel should be visible from outside the enclosure.

- 2.6.3.2 Routine / periodical check on engine / alternator (filter replacement and tappet setting etc.) should be possible without dismantling acoustic enclosure.
- 2.6.3.3 For major repairs / overhaul, it may be required to dismantle the acoustic enclosure.
- 2.6.3.4 Sufficient space should be available around the Genset for inspection and service.
- 2.6.4 **General Design Guidelines**
- 2.6.4.1 To avoid re-circulation of hot air, durable sealing between radiator and canopy is must.
- 2.6.4.2 Ventilation fans are must for the Gensets cooled by heat-exchanger/cooling tower system.
- 2.6.4.3 Exhaust piping inside the enclosure must be lagged (except bellow).
- 2.6.4.4 Temperature rise inside the enclosure should not be more than 5°C for maximum ambient above 40°C and it should be below 10°C for ambient below 40°C.
- 2.6.4.5 There should be provision for oil, coolant drain and fill. Fuel tank should have provision for cleaning.
- 2.6.4.6 The enclosure should be designed to meet the total air requirement for the D.G. Set at full load at site conditions as recommended by the engine manufacturer.
- 2.6.5 **Specifications for Acoustic Enclosure**
- 2.6.5.1 The acoustic enclosure shall be designed and manufactured conforming to relevant standards suitable for out door installation exposed to weather conditions, and to limit overall noise level to 75 dB (A) at a distance of 1 mtr. from the enclosure as per CPCB norms under free field conditions.
- 2.6.5.2 The construction should be such that it prevents entry of rain water splashing into the enclosure and allows free & quick flow of rain water to the ground in the event of heavy rain. The detailed construction shall conform to the details as under:
- 2.6.5.3 The enclosure shall be fabricated out the CRCA sheet of thickness not less than 1.6 mm on the outside cover with inside cover having not less than 0.6 mm thick perforated powder coated CRCA sheet.
- 2.6.5.4 The hinged doors shall be made from not less than 16 SWG (1.6 mm) thick CRCA sheet and will be made air tight with neoprene rubber gasket and heavy duty locks.
- 2.6.5.5 All sheet metal parts should be processed through 7-tank process.
- 2.6.5.6 The enclosure should be powder coated.
- 2.6.5.7 The enclosure should accommodate the daily service fuel tank of the D.G. Set to make the system compact. There should be provision of fuel gauge, which should show the level of the fuel even when the DG Set is not running. The gauge should be calibrated. The fuel tank should be filled from the out side as in automobiles and should be with a lockable cap.
- 2.6.5.8 The batteries should be accommodated in the enclosure in battery rack.

- 2.6.5.9 The canopy should be provided with high enclosure temperature safety device.
- 2.6.5.10 The acoustic lining should be made up of high quality insulation material i.e. rockwool/ glass/ mineral wool/ PU foam of appropriate thickness & density for sound absorption as per standard design of manufacturer's to reduce the sound level as per CPCB norms. The insulation material shall be covered with fine glass fiber cloth and would be supported by perforated M. S. Sheet duly powder coated / GI sheet/ aluminium sheet.
- 2.6.5.11 The enclosure shall be provided with suitable size & No. of hinged type doors along the length of the enclosure on each side for easy access inside the acoustic enclosure for inspection, operation and maintenance purpose. Sufficient space will be provided inside the enclosure on all sides of the D.G. set for inspection, easy maintenance & repairs.
- 2.6.5.12 The canopy should be as compact as possible with good aesthetic look.
- 2.6.5.13 The complete enclosure shall be of modular construction.
- 2.6.5.14 The forced ventilation shall be as per manufacturer design using either engine radiator fan or additional blower fan(s). If the acoustic enclosure is to be provided with forced ventilation then suitable size of axial flow fan (with motor and auto-start arrangement) and suitable size axial flow exhaust fan to take the hot air from the enclosure complete with necessary motors and auto start arrangement should be provided. The forced ventilation arrangement should be provided with auto stop arrangement to stop after 5 minutes of the stopping of D.G sets.
- 2.6.5.15 The acoustic enclosure should be suitable for cable connection/connection through bus-trunking. Such arrangements on acoustic enclosure should be water proof & dust-proof conforming to IP-65 protection.
- 2.6.5.16 The inside of enclosure should be provided with at least two nos. 28 W-T5 fluorescent tube light luminaire controlled by a 5A switch for adequate lighting during servicing etc. of the DG Set. The power supply to this luminaire should be from the load side of the AMF Panel so that it can remain energized under all conditions.

## CHAPTER 3

### SYNCHRONIZATION

#### 3.1 SCOPE

This section covers synchronization of DG sets as required (to be decided by NIT approving authority) and comprises of running of DG set in parallel i.e. their synchronization on common bus bar, auto load sharing and auto load management.

#### 3.2 PLC PANEL

Operation of DG sets shall be monitored and controlled by PLC panel i.e. Programmable logic controller based logic panel. In case of mains failure, this logic panel shall control auto changeover from mains to DG Sets supply and interlocking of ACBs, auto synchronizing and auto load management functions along with annunciation for alternator control and protection.

The logic panel shall be provided with a total manual over ride facility. There shall be Smooth transfer of DG set operation from PLC to manual system & vice versa without any interruption/tripping. The logic panel shall be complete with all Auxiliary Relays, Timers, Contactors, Programmable logic controller, control wiring, interconnections etc. with 2.5 sq.mm. PVC insulated, 1.1 KV grade copper conductor wires.

#### 3.3 CONTROL PHILOSOPHY

##### 3.3.1 Automatic Start & Stop of Engine

The system should come in operation after sensing of grid failure and automatically control the start & stop of engines, depending on the predefined load setting in the PLC. In case engine does not start in the first cranking, two more auto commands should be given with proper intervals. Even then if engine fails to start, indication must appear on MMI (Man Machine interface). In the event the engines are under loaded i.e. load sensed is capable of being catered by less than the capacity of running DG sets then command must be given to stop required number of excess DG sets after running idle for short duration. Provision to select no. of DG sets to be started and synchronised at no load to cope up with sudden load without tripping the DG's should also be inbuilt into the system.

##### 3.3.2 Automatic Synchronisation

The facility of synchronisation will be available in both Auto & Manual mode. In normal circumstances the auto synchronisation will work, however if due to any reason auto synchronisation fails repeatedly the facility for closure of ACB must be available automatically. In manual mode ACB will be closed by panel push button.

##### 3.3.3 Automatic Load Sharing

The load sharing will also be automatic, by sensing both active & reactive power.

### 3.3.4 **Back up Protection**

The system should also have following inbuilt protection other than external relays in synchronization panel:

Reverse power, Reverse KVAR, Over Current, Under voltage, Over voltage, Under frequency, Over frequency, synchro-check & earth fault relay except differential relay. Due to any electrical fault PLC shall trigger the master trip relay.

These PLCs will be state of the art equipments using latest technology and of most rugged and reliable design. Since they shall be operating in the harsh & unfriendly environment of DG room, they will be suitable to operate trouble free in those conditions. The chosen equipment should be able to withstand high temperature, humidity & voltage fluctuations, thus making it suitable for the operating conditions described above.

### 3.5 **SEQUENCE OF OPERATION**

The following sequence of operation shall be achieved through PLC based logic panel in addition to hardware interlocks as well as software interlocks:

- (i) Selection of any generator as a lead generator to achieve the uniform running hours of all generators.
- (ii) Three attempts to start the engine of lead generator. In case the engine fails to start or does not achieve the requisite speed within the predetermined time, PLC system declares engine of generator faulty. In this event PLC automatically selects next generator as the lead generator.
- (iii) The PLC system automatically selects starting sequence of other generators on the basis of the lead generator being selected by the operator.
- (iv) Before issuing close command to lead generator air circuit breaker, PLC checks that ACB of any other generator is not in close position. Then PLC system gives close command to lead generator ACB. The PLC system tries two times with interval of 5 secs. to close the ACB. Simultaneously, it also gives starting command to next generator engine in queue depending upon load.
- (v) The speed, excitation, frequency and voltage of incoming generator is controlled identically as per the lead generator starting sequence described above, except closing of ACB.
- (vi) When the lead generator KW crosses more than the 85% of rated capacity of DG set, the PLC system performs synchronization sequence for paralleling of generator prior to switching on of the ACB of 2nd generator. When the KW of 2nd generator crosses 80% of rated capacity of DG set then the PLC system performs synchronization sequence for paralleling of next generator prior to switching on the ACB of 3rd generator and similar sequence to be followed for other DG sets.
- (vii) The last incoming generator ACB is tripped when PLC system senses that the total load on the system is less than the specified load and stops the engine after 5 minutes of idle running.
- (viii) DG sets will start and stop automatically depending on the pre defined load setting in the PLC & also all DG sets will operate in load sharing mode.

## CHAPTER 4

### EARTHING

#### 4.1 EARTHING

**Scope:** This section covers the earthing requirement of DG Set installations. Copper plate earthing (Neutral Grounding) shall be provided for DG Sets of capacity 500 KVA or above, whereas G.I. plate earthing (Neutral Grounding) shall be provided for DG Sets below 500 KVA capacity. The body earthing shall generally be of G.I.

- 4.1.1 The generating set and all associated equipments control and switch gear and switch gear panels must be earthed before the set is put into operation.
- 4.1.2 Four numbers earth sets for each DG Sets are required as under:  
- 2 earthing sets for Genset/ control panel body.  
- 2 earthing sets for neutral.
- In case there are more than one DG Set in one location, independent two nos. neutral earthing shall be provided for each DG set. However, two nos. earthing sets shall be common for the body earthing of DG Sets, Control Panel, AMF Panel and Essential LT Panel.
- 4.1.3 Earthing job should be carried out per General Specifications for Electrical Works, (Part 1-Internal), 2013 .
- 4.1.4 Copper or GI strips of suitable size shall be used for earthing as detailed hereunder for interconnection:
- 4.1.4.1 DG Set of 500 KVA capacity or above:- Copper strip
- 4.1.4.2 DG Set below 500 KVA capacity:- GI strip
- 4.1.5 For Gensets with AVM's between engine/ alternator and base rail, the body earthing must be done at the engine/ alternator and not at base-rail.
- 4.1.6 Genset should be earthed at two distinct points through a conductor strip having cross-section suitable to carry the short circuit (three phase dead short circuit with ground) current without burning out in conformity to General Specifications for Electrical Works (Part 1-Internal), 2013 in vogue.
- 4.1.7 Earth Bus: For body earthing, an earth-bus shall be provided.
- 4.1.8 In case, DG Set is being installed inside the substation building or near to the sub-station, for body-earthing of DG set, AMF Panel and Essential Panel, earth bus provided for sub-station shall be used.
- 4.1.9 Test joints should be provided for testing the earthing as and when required.
- 4.1.10 For further details of Earthing work, like size of plate/ earth strip, depth of earthing, method etc., please refer "CPWD General Specifications For Electrical Works (Part 1-Internal), 2013 in vogue.

## **APPENDIX I**

### **INTERNATIONAL STANDARD ISO 8528-PART 1**

RECIPROCATING INTERNAL COMBUSTION ENGINE DRIVE  
ALTERNATING CURRENT GENERATING SETS

#### **PART 1**

#### **APPLICATION, RATINGS AND PERFORMANCE**

*Groupes electrogenes a courant alternaut entraines par moteurs alternatifs  
a combustion interne—*

*Partie 1 : Application, caracteristiques et performances*

## FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject on which a technical committee has been established has the right to be represented on that committee. International organization, governmental and non-governmental, in liason with ISO, also take part in the work. ISO collaborates closely with the International Electro technical Commission (IEC) on all matters of electro technical standardization.

Draft international Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

International Standard ISO 8528-1 was prepared by Technical Committee ISO/TC 70, Internal combustion engines, Sub-Committee SC 2, Performance and tests.

ISO 8528 consists of the following parts, under the general title Reciprocating internal combusting engine driven alternating current generating sets.

- Part 1: Application, ratings and performance
- Part 2: Engines
- Part 3: Alternating current generators for generating sets
- Part 4: Controlgear and switchgear
- Part 5: Generating sets
- Part 6: Test methods
- Part 7: Technical declarations for specification and design
- Part 8: Low-power general purpose generating sets
- Part 9: Measurement and evaluation of mechanical vibration
- Part 10: Measurement of airborne noise —Enveloping surface method
- Part 11: Security generating sets with uninterruptible power systems

Parts 7, 8, 9 and 10 are in course of preparation. Part 11 is at an early stage of preparation and may be split into two parts.

# RECIPROCATING INTERNAL COMBUSTION ENGINE DRIVEN ALTERNATING CURRENT GENERATING SETS

## PART 1

### APPLICATION, RATINGS AND PERFORMANCE

#### 1. SCOPE :

This part of ISO 8528 defines various classifications for the applications, ratings and performance which arise out of the combination of generating sets consisting of a reciprocating internal combustion (RIC) engine, alternating current (a.c.) generator, controlgear, switchgear and auxiliary equipment. It applies to a.c. generating sets driven by RIC engines for land and marine use, excluding generating sets used on aircraft or to propel land vehicles and locomotives.

For some specific applications (for example, essential hospital supplies, high-rise buildings, etc.) supplementary requirements may be necessary. The provisions of this part of ISO 8528 should be regarded as a basis.

For other reciprocating-type prime movers (e.g. sewage-gas engines, steam engines), the provisions of this part of ISO 8528 should be used as a basis. The generating sets according to this International Standard are used to generate electrical power for continuous, peak-load and standby supplies. The classifications laid down in this part of ISO 8528 are intended to help understanding between manufacturer and customer.

#### 2. NORMATIVE REFERENCES

The following standards contain provisions, which, through reference in this text, constitute provisions of this part of ISO 8528. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 8528 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and IO maintain registers of currently valid International Standards.

ISO 3046-1:1986, *Reciprocating internal combustion engines-Performance – Part 1: Standard reference conditions and declarations of power, fuel consumption and lubricating oil consumption.*

ISO 8528-2:1993, *Reciprocating internal combustion engine driven alternating current generating sets - Part 2 : Engines.*

ISO 8528-3:1993, *Reciprocating internal combustion engine driven alternating current generation sets - Part 3 : Alternating current generators for generating sets.*

ISO 8528-4:1993, *Reciprocating internal combustion engine driven alternating current generating sets - Part 4 : Control gear and switchgear.*

ISO 8528-5:1993, *Reciprocating Internal combustion engine driven alternating current generative sets - Part 5 : Generating sets.*

IEC 34-1:1983, *Rotating electrical machines - Part 1: Rating and performance.*

IEC 298:1990, *A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 KV and up to and including 52 KV.*

IEC 439-1:1985, *Low-voltage switchgear and controlgear assemblies - Part 1: Requirements for type-tested and partially type-tested assemblies.*

IEC 439-2:1987, *Low-voltage switchgear and controlgear assemblies – Part 2: Particular requirement for busbar trunking systems busway.*

### **3. SYMBOLS AND ABBREVIATIONS**

- P Power in kilowatts
- $P_r$  Total barometric pressure, in kilopascals
- $T_{er}$  Charge air coolant temperature, in kelvins
- $T_r$  Air temperature, in kelvins
- t Time, in seconds
- $\varnothing_r$  Relative humidity, as a percentage
- a.c. Alternating current
- COP Continuous power
- LPT Limited-time running power
- PRP Prime power

### **4. OTHER REGULATIONS AND ADDITIONAL REQUIREMENTS**

- 4.1 For a.c. generating sets used on board ships and offshore installations which have to comply with rules of a classification society, the additional requirements of the classification society shall be observed. The classification society shall be stated by the customer prior to placing of the order.

For a.c. generating sets operating in non-classed equipment, such additional requirements are in each case subject to agreement between the manufacturer and customer.

- 4.2 If special requirements from regulations of any other authority (e.g. Inspecting and/or legislative authorities) have to be met, the authority shall be stated by the customer prior to placing of the order.

Any further additional requirements shall be subject to agreement between the manufacture and customer.

### **5. GENERAL DESCRIPTION**

#### **5.1 Generating set**

A generating set consists of one or more RIC engines to produce mechanical energy and one or more generators to convert the mechanical energy into electrical energy together with components for transmitting the mechanical energy (e.g. couplings, gearbox) and, where applicable, bearing and mounting components.

### **5.1.1 Prime movers**

These may be of two types:

- compression ignition engines, and
- spark-ignition engines.

Depending on the application of the generating set the following criteria, among others may be important for the selection of the prime mover to be used:

- quality of fuel and fuel consumption;
- exhaust gas and noise emission;
- speed range;
- mass and dimensions;
- sudden loading and frequency behaviour;
- short-circuit characteristics of the generator;
- cooling systems;
- starting systems;
- maintenance;
- waste heat utilization.

### **5.1.2 Generators**

These may be of two types:

- synchronous generators, and
- asynchronous generators.

Depending on the application of the generating set, the following criteria, among others, may be important for the selection of the generator to be used:

- voltage characteristics during starting, nominal operation and overload operation, as well as, after load changes taking into account the power factor;
- short-circuit behaviour (electrical, mechanical);
- efficiency;
- generator design and type of enclosure;
- parallel-operation behaviour;
- maintenance.

### **5.1.3 Controlgears and Switchgears**

Equipment for control, switching and monitoring is combined into controlgear and switchgear systems, for the operation of the generating set.

### **5.1.4 Auxiliaries**

Auxiliaries are items of equipment essential for pre-operation of the generating set, such as :

- starting system;
- air intake and exhaust gas systems;
- cooling system;

- lubricating oil system;
- fuel system (including fuel treatment where applicable);
- auxiliary electrical power supply.

## **5.2 Power station**

A power station comprises one or more generating sets and their auxiliary equipment, the associated controlgear and switchgear and, where applicable, the place of installation (e.g. a building, an enclosure or special equipment for protection from the weather).

## **6. APPLICATION CRITERIA**

### **6.1 Modes of operation**

The mode of operation of the generating set may affect certain important characteristics (e.g. its economical and reliable operation, the intervals between maintenance and repair), and shall be taken into account by the customer when agreeing the requirements with the manufacturer (see also clause 11).

#### **6.1.1 Continuous operation**

Continuous operation is operation of a generating set without a time limit, but considering the maintenance period.

#### **6.1.2 Limited-time operation**

Limited-time operation is operation of the generating set for a limited time.

NOTE 1 : The demand for electrical power from the connected equipment is supplied from the mains and only in the event of failure of the later is it supplied by an internal generating set. If there is a failure in the normal power supply, the internal generating set, operating as a back-up or emergency supply, provides a supply temporarily or for a limited time for:

- (a) Safety equipment (e.g. during the evacuation of a building)
- (b) Connected equipment which is important for the purposes of operation, to maintain emergency operation
- (c) The entire group of connected equipment or part thereof. The electrical power generated is used to cover a peak demand (peak- load operation). There is no mains supply and the generating set is only operated from time to time.

### **6.2 Site Criteria**

#### **6.2.1 Land use**

Land use covers generating sets, either fixed, transportable or mobile, which are used on land.

#### **6.2.2 Marine use**

Marine use covers generating sets used on board ships and offshore installations.

### **6.3 Single and Parallel Operation**

Generating sets may have two types of operation, defined in 6.3.1 and 6.3.2.

### **6.3.1 Single operation**

Single operation refers to a generating set, irrespective of its configuration or modes of start-up and control, which will operate as the sole source of electrical power and without the support of other sources of electrical supply.

### **6.3.2 Parallel operation**

Parallel operation refers to the electrical connection of a generating set to another source of electrical supply with the same voltage, frequency and phase to share the power supply for the connected network. The characteristics of the mains supply, including range and variation of voltage, frequency, impedance of the network, etc., shall be stated by the customer.

#### **6.3.2.1 Parallel operation by generating sets**

In this type of operation, two or more generating sets are electrically connected (not mechanically connected) after having been brought into synchronism. Generating sets with different outputs and speeds can be used.

#### **6.3.2.2 Operation in parallel with mains**

In this type of operation, one or more parallel-operating generating sets (as described in 6.3.2.1) are electricity connected to a mains supply.

NOTE 2 : In the case of a public mains, permission for parallel operation has to be obtained from the public electricity board. Protective equipment has to be harmonized.

NOTE 3 : This also applies to generating sets which, in order to check the start up, have to run supplying power into the mains for a time period laid down by the generating set manufacturer.

## **6.4 Modes of start-up and control**

The modes of start-up and control involved in the operation of a generating set are normally:

- starting,
- monitoring,
- voltage and frequency adjusting and synchronization where applicable,
- switching, and
- stopping.

These can be fully or partly manual or automatic (see also ISO 8528-4).

### **6.4.1 Manual operation**

Manual operation covers generating sets which are started and controlled manually.

### **6.4.2 Semi-automatic operation**

Semi-automatic operation covers generating sets in which some of the functions are started and controlled manually and the remainder automatically.

### **6.4.3 Automatic operation**

Automatic operation covers generating sets which are started and controlled automatically.

## **6.5 Start-up time**

Start-up time is the time from the moment when power is first required to the moment when it is first available. It shall meet the demands of the particular application.

### **6.5.1 Generating set with no specified start-up time**

This is a generating set where, due to the conditions under which it operates, the start-up time is of no importance. Such generating sets are normally started manually.

### **6.5.2 Generating set with specified start-up time**

This is a generating set where the start-up time is specified; starting is normally automatic. Such generating sets may be further classified (see 6.5.2.1 to 6.5.2.3).

#### **6.5.2.1 Long-break set**

This is a generating set with a specified start-up time (defined in seconds). The time between a power supply failure and power from the generating set being available is fairly long. In this case the entire set is started from the stationary condition after power is demanded.

#### **6.5.2.2 Short-break set**

This is a generating set with running electrical machines where the power supply is interrupted while the necessary switchgear change-over takes place, for a time defined in milliseconds. A source of stored mechanical energy is used to supply power to the connected equipment for a short period necessary to start and accelerate the RIC engine.

#### **6.5.2.3 No-break set**

This is a generating set with continuous rating electrical machines that ensure an uninterrupted supply of power in the event of mains failure. A source of stored mechanical energy is unable to supply powers to the connected equipment for a short period and, where necessary to start and accelerate the RIC engine. As the drive is transferred from one power source to another there may be temporary deviation in frequency.

## **7. PERFORMANCE CLASSES**

Four performance classes are specified to the various requirement of the supplied electrical systems see 7.1 to 7.4.

### **7.1 Performance class G1**

This is required for application where the connected loads are such that only basic parameters of image and frequency need to be specified.

#### **EXAMPLES**

General-purpose applications (lighting and other simple electrical loads).

### **7.2 Performance class G2**

This is required for applications where the demands on voltage characteristics are very much the same as for the commercial power system. When load changes occur, there may be temporary but acceptable deviations of voltage and frequency.

#### **EXAMPLES**

Lighting systems, pumps, fans and hoists.

### **7.3 Performance class G3**

This is required for applications where the connected equipment may make severe demands on frequency, voltage and waveform characteristics.

#### **EXAMPLES**

Telecommunications and thyristor-controlled loads. It should be especially recognized that both rectifier and thyristor-controlled loads may need special consideration with respect to their effect on generator-voltage waveform.

### **7.4 Performance class G4**

This is required for applications where the demands made on the frequency, voltage and waveform characteristics are exceptionally severe.

#### **EXAMPLES**

Data-processing equipment of computer systems.

## **8. INSTALLATION FEATURES**

Requirements to meet local regulations may affect the design of the generating set. They shall be taken into account by the customer and manufacturer in addition to the installation features given in 8.1 to 8.5.

### **8.1 Installation configurations**

The installation configurations in 8.1.1 to 8.1.3 may or may not have all necessary auxiliary equipment integrally mounted.

#### **8.1.1 Fixed**

This configuration includes all generating sets which are permanently installed.

#### **8.1.2 Transportable**

This configuration includes all generating sets not permanently installed or mobile.

#### **8.1.3 Mobile**

This configuration includes all generating sets having an integral chassis fitted with wheels whereby the generating set is mobile.

### **8.2 Generating Set Configurations**

In order to simplify contractual information for various RIC engine driven generating set applications, some typical set configurations are given below:

- A: without baseframe;
- B: with baseframe;
- C: with baseframe, integrally mounted controlgear, switchgear and auxiliaries;
- D: configuration as given in C with enclosure (see also clause 9);
- E: configuration as given in C having an integral set of wheels or mounted on a trailer (see also 8.1.3).

### **8.3 Types of Mounting**

The type of mounting (see 8.3.1 to 8.3.3) should be agreed between the customer and the generating set manufacturer.

### **8.3.1 Rigid Mounting**

This is mounting the generating set without the use of resilient mountings. If foundations for mounting generating sets are set up on substrates of low elasticity, for example corktiles, with no resilient layers, inserted, the method of mounting is considered to be rigid.

### **8.3.2 Resilient Mounting**

This is mounting the generating set with the use of resilient mountings. For special application (e.g. marine or mobile), restrained resilient mountings may be required.

#### **8.3.2.1 Fully resilient mounting**

Fully resilient mounting is mounting the RIC engine and the generator resiliently on a baseframe or a foundation with components to provide insulation against vibration.

#### **8.3.2.2 Semi-resilient mounting**

Semi-resilient mounting is mounting the RIC engine resiliently with the use of components to provide insulation against vibration and mounting the generator rigidly on a baseframe or a foundation.

#### **8.3.2.3 Mounting on resilient foundation**

This is mounting the generating set on resilient foundation (damping mass) which is isolated from the load-bearing foundation by, for example, anti-vibration mounts.

## **8.4 Connection between Engine and Generator**

The connection between the RIC engine and the a.c. generator is determined by the type of components transmitting the power and the assembly between the engine and the generator. It depends on the design of the engine, generator and mounting, the power and the speed.

### **8.4.1 Coupling Arrangements**

Typical coupling arrangements are rigid, torsionally rigid, flexible, torsionally flexible or clutch coupling.

### **8.4.2 Assembly Arrangements**

The assembly between the RIC engine and the generator may be with or without flange housing.

## **8.5 Additional Installation Features—Weather Effects**

### **8.5.1 Inside Installation**

This is installation of the generating set in places where it is not exposed to the direct effects of weather. Consideration shall be given to maximum and minimum room temperatures.

### **8.5.2 Outside Installation with Protection from Weather**

This may be sub-divided into:

- installation in a protective enclosure;
- installation under a protective roof.

### 8.5.3 *Open-air Installation*

This is installation in the open, fully exposed to the weather.

## 9. EMISSIONS

When a generating set operates, it produces emissions including noise, vibration, heat, waste gases and electromagnetic disturbances. Any applicable legislation relating to the protection of the environment and to the health and safety of personnel shall be taken into account by the manufacturer and customer at the time of agreeing a performance specification.

## 10. STANDARD REFERENCE CONDITIONS

In determining the rated power of the generating set, it should be noted that different standard reference conditions apply to the engine, a.c. generator and switchgear. For conditions on site, see clause 11.

10.1 For the rated power of the RIC engine, the following standard reference conditions apply in accordance with ISO 3046-1:

- total barometric pressure,  $P_r$  : 100 kPa (1000 mbar)
- air temperature,  $T_r$  : 298 K (25 °C)
- relative humidity,  $\phi_r$  : 30%
- charge air coolant temperature,  $T_{er}$  : 298 K (25 °C)

10.2 For the rated power of the a.c. generator, the following standard reference conditions apply in accordance with IEC 34-1 and ISO 8528-3:

- cooling air temperature : below 313 K (40°C)
- coolant temperature at cooler inlet: below 298 K (25°C)
- altitude: up to 1000 m above sea level.

10.3 For the ratings of the controlgear and switchgear equipment, the following standard reference conditions apply in accordance with IEC 298, IEC 439-1 and IEC 439-2:

- ambient temperature, temporary maximum 313 K (40°C)
- relative humidity: 50% at 313 K (40°C)
- altitude: up to 2000 m above sea level

## 11. SITE CONDITIONS

The site conditions under which a generating set is required to operate may affect certain characteristics of the set; they shall be taken into account by the customer and manufacturer.

These conditions shall be clearly defined by the customer and any particular hazardous conditions, such as explosive atmospheres or flammable gases, shall be described. Such characteristics may include but are not limited to those indicated in 11.1 to 11.9.

NOTE 5 : In cases where the site conditions are unknown, and if not otherwise specified, the following nominal site conditions should be used:

- total barometric pressure: 89, 9 kPa (for altitude above sea level 1000 m)
- ambient temperature: 313 K (40°C)
- relative humidity: 60%

**11.1 Ambient Temperature**

The customer shall inform the manufacturer of the upper and the lower ambient temperature limits at which the generating set will operate.

**11.2 Altitude**

The customer shall inform the manufacturer of the altitude above sea level at which the generating set will operate. However, it is preferable to have exact values of the barometric pressure on site.

**11.3 Humidity**

The customer shall inform the manufacturer of the humidity values related to the temperature and pressure on site (see 11.1 and 11.2).

**11.4 Sand and dust**

The customer shall inform the manufacturer if a generating set is required to operate in a sandy, dusty or other physically polluted atmosphere, as special requirements may be necessary in order to obtain satisfactory performance and operation. Any increased maintenance due to these conditions should be noted by the customer.

**11.5 Marine Environment**

Special consideration is necessary when generating sets are required to operate in a marine environment. This may also apply to generating sets on land but operated at a coastal site. The environment shall be clearly stated by the customer.

**11.6 Shock and Imposed Vibration**

If the generating set is required to operate under conditions where shock and/or vibration may occur (for example, earthquake on the one hand and externally imposed vibration from adjacent reciprocating machinery on the other), this shall be clearly stated by the customer.

**11.7 Chemical Pollution**

If the generating set is required to operate under conditions where chemical pollution exists, the nature and extent of this shall be clearly stated by the customer.

**11.8 Radiation**

Various kinds of radiation may affect some of the components of the generating set, and such components may need special protection and/or a special maintenance programme. Any such condition of operating shall be specified by the customer.

**11.9 Cooling Water/Liquid**

If the generating set has water/liquid cooled heat exchangers, the customer shall state the minimum and maximum temperatures (and, where necessary, the chemical composition and quantity) of the secondary (external) transfer liquid.

**12. POWER ADJUSTMENT FOR AMBIENT CONDITIONS**

To determine the appropriate generating set ratings, the customer shall specify the operating conditions prevailing at the site.

- (a) site barometric pressure (highest and lowest readings available or, if no pressure data are available, the altitude above sea level);

- (b) the monthly mean, minimum and maximum air temperatures during the hottest and coldest months of the year;
- (c) the highest and lowest ambient air temperatures around the engine;
- (d) the relative humidity (or alternatively the water vapour pressure or the wet and dry bulb temperature) ruling at the maximum temperature conditions;
- (e) the maximum and minimum temperatures of the cooling water available.

When the operating conditions differ from the standard reference conditions given in clause 10, any necessary adjustment to the RIC engine, a.c. generator or switchgear rating shall be made in order to determine the rated power of the generating set.

For generating sets to be installed on board ships intended for unrestricted service, according to the International Association of Classification Societies (IACS), the rated power shall be based on the nominal ambient conditions as specified in ISO 3046-1: 1986, 7.4.2.

### **13. POWER RATING DEFINITIONS**

#### **13.1 General**

The power of the generating set is the power output available at the generating set terminals excluding the electrical power absorbed by the essential independent auxiliaries. (See also ISO 8528-2:1993, 5.1 and ISO 8528-3:1993, clause 5)

#### **13.2 Power Ratings**

Power ratings of generating sets shall be expressed in kilowatts at rated frequency and a power factor ( $\cos \varnothing$ ) of 0.8 lagging unless otherwise stated.

The power rating classifications are necessary for the generating set manufacturer's declaration concerning the power which the generating set will deliver under the stated operating conditions.

#### **13.3 Kinds of Power Output**

The generating set manufacturer shall be responsible for determining the power output according to 13.3.1 to 13.3.3 [see figures (i) to (iii)] in accordance with the service and maintenance schedule specified by the engine, a.c. generator and controlgear and switchgear manufacturers.

For all kinds of power output, defined in 13.3.1 to 13.3.3, it is necessary to provide additional engine power for governing purpose only (e.g. transient load conditions and suddenly applied load). This additional engine power is usually 10% of the rated power of the generating set and shall not be used for the supply of electrical consumers.

This additional engine power is not identical to the overload power for RIC engines as defined in ISO 3046-1.

The power limit of a generating set [see figures (i) to (iii)] depends on the power limit of the RIC engine, e.g. fuel stop power, taking into account the efficiency of the a.c. generator.

### 13.3.1 Continuous Power (COP)

Continuous power is that which a generating set is capable of delivering continuously for an unlimited number of hours per year between the stated maintenance intervals and under stated ambient conditions, the maintenance being carried out as prescribed by the manufacturers. [See figure (i)].

### 13.3.2 Prime Power (PRP)

Prime power is the maximum power available during a variable power sequence, which may be run for an unlimited number of hours per year, between stated maintenance intervals and under the stated ambient conditions, the maintenance being carried out as prescribed by the manufacturers.

The permissible average power output ( $P_{pp}$ ) [See figure (ii)] during a 24 h period shall not exceed some percentage of the prime power to be stated by the RIC engine manufacturer. When determining the actual average power output  $P_{pa}$ , powers of less than 30% of the prime power shall be taken as 30% and time at standstill shall not be counted.

The actual average power,  $P_{pa}$  is calculated as follows:

$$P_{pa} = \frac{P_1 t_1 + P_2 t_2 + P_3 t_3 + \dots + P_n t_n}{t_1 + t_2 + \dots + t_n}$$
$$= \frac{\sum_{i=1}^n P_i t_i}{\sum_{i=1}^n t_i}$$

where  $P_1, P_2 \dots P_n$  is the power at the  $t_1, t_2 \dots t_n$

NOTE 6 : The customer should be made aware that if any of these conditions are not fulfilled the RIC engine life will be reduced.

NOTE 7 : Time periods at standstill do not enter into the formula.

NOTE 8 : The period of running at prime power is expected to be long enough to enable the generator to reach thermally stable conditions.

### 13.3.3 Limited-time Running Power (LTP)

The limited-time running power is the maximum power which a generating set is capable of delivering for up to 500 h per year of which a maximum of 300 h is continuous running, between stated maintenance intervals and under the stated ambient conditions, the maintenance being carried out as prescribed by the RIC engine manufacturers. It is accepted that operation at this rating will affect the life of the set. [See figure (iii).]

NOTE 9 : The period of running at limited-time running power is expected to be long enough to enable the generator to reach thermally stable conditions.

NOTE 10 : The customer should be made aware that if any of these conditions are not fulfilled the RIC engine life will be reduced.

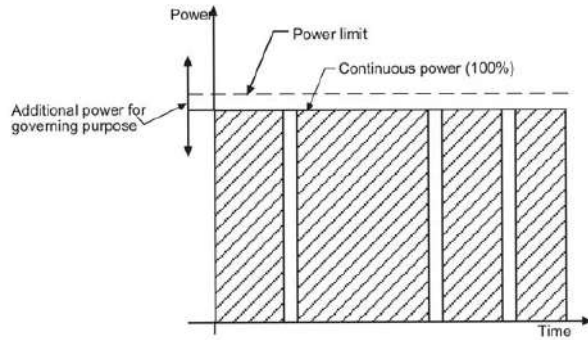


Fig. (i) Illustration of continuous power

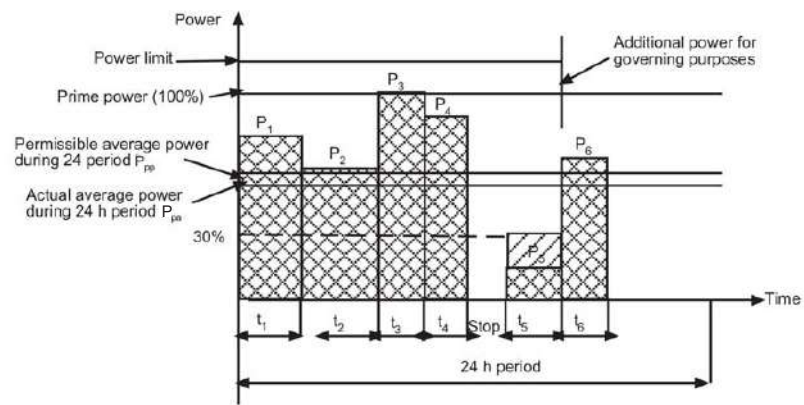


Fig. (ii) Illustration of prime power (not to scale)

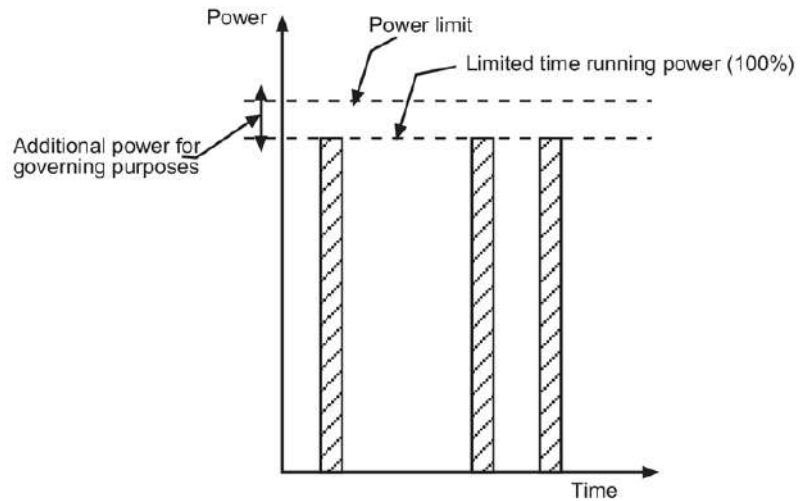


Fig. (iii) Illustration of limited-time running power

## **14. OPERATING PERFORMANCE**

### **14.1 Starting Temperature**

The RIC engine manufacturer shall state the minimum temperatures at which the generating set will start with the starting system and start aids - provided.

### **14.2 Load Acceptance**

When load is suddenly applied to a generating set there will be transient deviation in voltage and frequency. The magnitude of these deviations will depend both on the magnitudes of the active power (in kilowatts) and reactive power (in kilovars) changes, relative to the total available capacity and to the dynamic characteristics of the generating set. (See also ISO 8528-5 and ISO 8582-5)

If load acceptance capability is an important requirement, then it shall be clearly stated by the customer.

### **14.3 Cyclic Irregularity**

The cyclic irregularity imposed on the generator by the RIC engine combustion process may cause modulation of the voltage. (See ISO 8528-3).

### **14.4 Generator Temperature Rise**

The temperature rise of the generator windings of a generating set may be an important factor limiting the long-term reliability of a generating set. An increase in allowable temperature rise may be possible if the generating set is to be used on a limited time basis.

### **14.5 Fuel and Lubricating Oil Consumption**

The manufacturer shall state the consumption of fuel and lubricating oil, if verification of fuel consumption is required, the method of measurement shall be agreed between the customer and manufacturer, as outlined in ISO 3046-1. Statements of fuel consumption shall be made with reference to the electrical power available at the terminals, taking into account the electrical power required for the essential independent auxiliaries (see ISO 3046-1) and the power loss in the a.c. generator for a given power and power factor. The lower calorific value of the fuel shall be stated.

### **14.6 Minimum Running Hours**

The capacity of fuel and lubricating oil tanks may impose a limit on the generating set running hours. The manufacturer shall state the minimum running hours together with power delivered of the generating set without replenishment, if such tanks are provided.

### **14.7 Regulation**

#### **14.7.1 Frequency Regulation**

The steady-state and transient frequency regulation may be an important requirement when specifying the performance of a generating set. If this is the case, then it shall be clearly stated by the customer.

#### **14.7.2 Voltage Regulation**

It is necessary to consider both steady/state and transient voltage regulation when specifying a generating set. It must also be noted that the nature of the load current waveforms imposed on the generating set may affect the voltage waveform and the steady-state voltage accuracy. If voltage regulation is an important requirement, then it shall be clearly stated by the customer.

## APPENDIX II

### CPCB NORMS FOR NOISE LEVEL

*(This is download from website of CPCB)*

#### SYSTEM & PROCEDURE FOR COMPLIANCE WITH NOISE LIMITS FOR DIESEL GENERATOR SETS (UPTO 1000 KVA)

##### 1. SCOPE

This document lays down the system & procedure for compliance with noise limits for new diesel generator sets (upto 1000 KVA) vide notification G.S.R.371 (E), dated 17th May, 2002, at serial no.94 (paragraph 1 & 3) issued by the Ministry of Environment and Forests, Government of India. The details are covered as under:

- Part - I : Noise Limits, Applicability and Other Requirements
- Part - II : Certification System & Procedure
- Part - III : Test Procedure

##### 2. CONTENTS

- PART I : NOISE LIMITS, APPLICABILITY AND REQUIREMENTS
- PART II : CERTIFICATION SYSTEM AND PROCEDURE
  - 1.0 Model Family
  - 2.0 Selection of Certification Agency
  - 3.0 Application for Type Approval
  - 4.0 Type Approval.
  - 5.0 Certificate of Type Approval
  - 6.0 Modifications in the Product Model
  - 7.0 Verification of Conformity of Production (COP)
  - 8.0 Sample size and Decision Criteria for Verification of COP
  - 9.0 Certificate for Conformity of Production
  - 10.0 Consequences of Non-Compliance
- PART III : TEST EQUIPMENT AND PROCEDURE
  - 1.0 General
  - 2.0 Procedure
- ANNEXURE – I Application for Type Approval
- ANNEXURE – II Certificate of Type Approval (Specimen)
- ANNEXURE – III Certificate of Conformity of Production (Specimen)
- ANNEXURE - A

## APPENDIX III

### CPCB NORMS FOR EMISSION LEVEL

*(This is download from website of CPCB)*

#### SYSTEM & PROCEDURE FOR COMPLIANCE TO EMISSION LIMITS FOR NEW DIESEL ENGINES (UP TO 800 KW) FOR GENSET APPLICATIONS

##### 1. SCOPE

This document lays down the requirements, system & procedure for compliance to the rules vide notification no. G.S.R. 371 (E), dated 17th May, 2002, at serial no. 95, for emission limits for new diesel engines (up to 800 kW) for genset applications, issued by Ministry of Environment and Forests, Government of India. The details are covered as under:

- Part I - Emission Limits, Applicability and Other Requirements
- Part II - Certification System and Procedures
- Part III - Testing Equipments and Procedures

##### 2. CONTENTS

PART I : EMISSION LIMITS, APPLICABILITY AND OTHER REQUIREMENTS

PART II : CERTIFICATION SYSTEM AND PROCEDURE

1. Model Family
2. Selection of Certification Agency
3. Application for Type Approval
4. Type Approval
5. Certificate of Type Approval
6. Modifications in the Engine Model
7. Verification of Conformity of Production (COP)
8. Sample Size and Decision Criteria for Verification of COP
9. Certificate of COP Verification
10. Consequences of Non-Compliance

PART III : TEST EQUIPMENT AND PROCEDURES

ANNEXURE - I : Test Fuel Specifications

ANNEXURE - II : Application for Type Approval / Description to be given at the time of COP

ANNEXURE - III : Certificate of Type Approval (specimen)

ANNEXURE - IV : Certificate of Conformity of Production (specimen)

**APPENDIX IV**

**SPECIMEN NIT**

**(Note:** The NIT approving authority may make changes in the specimen NIT depending upon the exigencies/ specific requirements of the work)

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**NIT (PART-I)**

**TECHNICAL CUM COMMERCIAL BID**

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<i>Item</i>	<i>Page No.</i>	<i>Remarks</i>
1. NIT CPWD 6		To be attached by NIT approving authority
2. Press Notification		To be attached by NIT approving authority as per CPWD Works Manual amended up to date.
3. CPWD 7/8 Schedule alongwith upto date correction slips		To be attached by NIT approving authority as per CPWD Works Manual
4. Commercial and Additional Conditions		As per e-tender
5. Technical Specifications for DG Set		
6. Schedule of work		
7. Technical Particulars		
8. List of Technical Literature/Catalogues		
9. Acceptable Makes		

**PRESS NOTIFICATION**  
**TO BE ATTACHED BY NIT APPROVING AUTHORITY**  
**AS PER CPWD WORKS MANUAL**

## COMMERCIAL AND ADDITIONAL CONDITIONS

### 1.0 General

1.1 This specification covers manufacture, testing as may be necessary before dispatch, delivery at site, all preparatory work, assembly and installation, commissioning, putting into operation of DG Sets.

### 1.2 Location

The DG Set will be installed at \_\_\_\_\_ (To be filled by NIT approving authority).

1.3 The work shall be executed as per CPWD General Specifications for Electrical Works (Part VII DG Sets–2013), as per relevant IS and as per directions of Engineer-in-Charge. These additional specifications are to be read in conjunction with above and in case of variations, specifications given in this additional conditions shall apply. However, nothing extra shall be paid on account of these additional specifications & conditions as the same are to be read alongwith schedule of quantities for the work.

1.4 The tenderer should in his own interest visit the site and familiarise himself with the site conditions before tendering.

1.5 No T&P shall be issued by the Department and nothing extra shall be paid on account of this.

### 2.0 Commercial Conditions

#### 2.1 Type of Contract

The work to be awarded by this tender shall be treated as indivisible works contract.

#### 2.2 Submission and Opening of Tenders

2.2.1 The tender is in two parts:

- (a) Part I – Technical cum Commercial Bid
- (b) Part II – Price Bid

2.2.2 Tender documents consisting of Part-I & Part-II (i.e. Technical-cum-Commercial Bid and Price Bid) will be issued against application accompanied with earnest money in prescribed format to only eligible contractors and who are pre-qualified by the competent authority.

2.2.3 The date of sale, receipt and opening of the sealed technical-cum-commercial bids will be notified to all such tenderers in advance. The technical-cum-commercial part will have to be submitted by the tenderers complete with the following:

Complete tender documents (Part-I), as purchased from CPWD or downloaded from website including the schedule of work (without indicating the price) duly signed in token of acceptance of all terms and conditions along with Part-II (Price Bid). Prices should be indicated/filled only in "Price Bid" part and should be placed in separate sealed envelope clearly superscribed "Price-Bid". The tenderers will have to fill up their rates only in the price bid issued by the department. Tenders in which the price bids are given in any other format are liable to be rejected. The abstract of cost will be required to be filled in.

Complete technical particulars of all equipment & materials as per list attached.

- 2.2.4 The tenderers are advised not to deviate from the technical specifications/ items, commercial terms and conditions of NIT like terms of payment, guarantee, arbitration clause, escalation etc.
- 2.2.5 The Part-I of the tender documents i.e. Technical-cum-Commercial bid only, shall be opened on the due date and time, as specified in form CPWD-6 in the presence of tenderers or their authorised representatives.
- 2.2.6 Scrutiny/ evaluation of the Technical-cum-commercial bid shall be done by the department in consultation with any agency as deemed necessary. In case it is found that the technical-cum-commercial bid of a tenderer is not in line with NIT specifications, requirements and/or contains many deviations, the department reserves the right to reject the technical bid of such firm(s) without making any reference to the tenderer(s).
- 2.2.7 Necessary clarifications required by the department shall have to be furnished by the tenderer within the time given by the department for the same. The tenderer will have to depute his representative to discuss with the officer(s) of the department as and when so desired. In case, in the opinion of the department a tenderer is taking undue long time in furnishing the desired clarifications, his bid will be rejected without making any reference.
- 2.2.8 After obtaining clarifications from all the tenderers, the department may modify the technical & commercial conditions/ specifications if required, and will intimate the same to the tenderers, whose technical-cum-commercial bids are acceptable. At the same time, date and time of opening of price-bid will also be intimated. A tenderer will also not be allowed to withdraw or modify any condition at a time after the technical bids have been accepted and the decision to open the price bid has been taken by the department unless revised bid is allowed due to measure changes made during negotiations on technical-bid.
- 2.2.9 The Part II of the tender i.e. price bid will be opened by the Executive Engineer (E) in the presence of the interested representatives of the tenderers who wish to be present.
- 2.2.10 The department reserves the right to reject any or all the price bids and call for fresh prices/ tenders as the case may be without assigning any reason.
- 2.2.11 *Validity*  
Tenders shall be valid for acceptance for a period as prescribed in CPWD-6 from the date of opening of price bid.
- 2.2.12 *Completion of period*  
The completion period indicated in the tender documents is for the entire work of planning, designing, supplying, installation, testing, commissioning and handing over of the entire job to the satisfaction of the Engineer-in-charge.

**Note :- NIT approving authority shall modify above Commercial conditions as per uptodate guidelines issued for e-tendering by the department.**

## TECHNICAL SPECIFICATIONS

The work shall be carried out as per CPWD General Specifications for DG Set Works, 2013 as amended upto date along with the following changes, CPWD General Specifications for Electrical Works Part-I, II & IV, as amended upto date, relevant IE rules, and as per directions of Engineer-in-Charge. For electrical panels, CPWD General Specifications for Electrical Works Part-IV shall be applicable.

**Note: Any deviations from CPWD General Specifications for DG Set Works, 2013 may be given by the NIT approving authority. In case there is no deviation, no deviations should be mentioned below this note.**

## **SCHEDULE OF WORK ABSTRACT**

**NAME OF WORK : TO BE FILLED IN BY NIT APPROVING AUTHORITY**

Sub Head A	Equipments	Rs.	Note : Amount not to be filled in.
Sub Head B	Earthing	Rs.	

**MODEL NIT (PART-I) (FOR TECHNICAL BID)**

**SCHEDULE OF QUANTITY**

**Name of Work : (To be filled by NIT approving authority)**

<i>S.No.</i>	<i>Description of Work</i>	<i>Qty.</i>	<i>Rate</i>	<i>Unit</i>	<i>Amt.</i>
	<b>Sub-head 'A' (Equipments)</b>				
1.	Providing, Installing, Testing and Commissioning of 'Silent Type' Diesel Generating set alongwith having Prime Power Rating of ——— KVA, 415 volts at 1500 RPM, 0.8 lagging power factor at 415 V suitable for 50 Hz, 3 phase system & for 0.85 Load Factor and consisting of the followings:				
	<b>Note : Rate/Amount columns on each page of schedule of work to be crossed by NIT approving authority.</b>				
<b>(a)</b>	<b>Diesel Engine:</b>				
	Diesel engine 4 stroke water cooled, electric start, of suitable BHP at 1500 RPM suitable for above output of alternator at 40 Degree C, 50% RH & at 1000 Meter MSL and conforming to BS 5514, BS 649, IS 10000, capable of taking 10% over loading for one hour after 12 hours of continuous operation. The engine will be fitted complete with all the required accessories.				
<b>(b)</b>	<b>Engine mounted Instrument Panel fitted with and having digital display for following:</b>				
	(i) Start-stop switch with key				
	(ii) Water temperature indication				
	(iii) Lubrication oil pressure indication				
	(iv) Lubrication oil temperature indication				
	(v) Battery charging indication				
	(vi) RPM indication				
	(vii) Over speed indication				
	(viii) Low lub. Oil trip indication				
	(ix) Engine Hours indication				
<b>(c)</b>	<b>Alternator :</b>				
	Synchronous alternator rated at ——— KVA, 415 volts at 1500 RPM, 3 phase 50 Hz, AC supply with 0.8 lagging power factor at 40 Degree C, 50% RH & at 1000 Meter MSL. The alternator shall be having SPDP enclosure, brushless, continuous duty, self-excited and self-regulated				

S.No.	Description of Work	Qty.	Rate	Unit	Amt.
	through AVR conforming to IS: 4722/BS 2613 suitable for tropical conditions and with class-F/H insulation.				
<b>(d)</b>	<b>Base Frame &amp; Foundation:</b>				
	Both the engine and alternator shall be mounted on suitable base frame made of MS channel with necessary reinforcement which shall be installed on suitable cement concrete foundation and vibration isolation arrangement as per recommendations of manufacturer.				
<b>(e)</b>	<b>Fuel Tank:</b>				
	Daily service fuel tank of — liters capacity fabricated out of 3 mm thick M.S. sheet complete with all standard accessories and fuel piping between fuel tank and diesel engine with MS class 'C' pipes of suitable dia. Complete with valves, level indications & accessories as required as per specifications.				
<b>(f)</b>	<b>Exhaust System:</b>				
	Dry exhaust manifold with hospital exhaust silencer and catalytic convertor.				
<b>(g)</b>	<b>Starting System:</b>				
	12V/24V DC starting system comprising of starter motors: voltage regulator and arrangement for initial excitation complete with suitable nos. of batteries (25 plates, 180 Amp. Hour capacity lead acid type) as required as per specifications.				
<b>(h)</b>	Accoustic and weather proof enclosure with arrangement for fresh air intake for cooling of the engine & alternator, extraction, discharging hot air in to the atmosphere as per specifications.		Sets	Set	
2***	Fabricating, Installing, Testing & Commissioning of automatic mains failure control including auto by-pass panel, suitable for — KVA silent type DG set complete with relays, timers, set of CTs for metering & protection and energy analyser to indicate currents, phase and line voltages, frequency, power factor, KWH, KVARH & provision for overload, short circuit, restricted earth fault, under frequency, control cabling from AMF panel to diesel engine and elsewhere if required, all complete and inter locking including the following:				

S.No.	Description of Work	Qty.	Rate	Unit	Amt.
(a)	— Nos. — Amp., 4 pole Switch Fuse Disconnecter Unit** / 4 pole manual draw-out**/ motorised electrically operated draw out** with cradle type 3 position ACB with electromagnetic/ electronic** release for O/C & E/F and shunt trip.				
(b)	Auto/Manual/Test/Off selector switch				
(c)	2 Nos. over voltage relay, 2 Nos. reverse power relay and 2 Nos. under voltage relay.				
(d)	3 Sets of current transformers 15 P 10 accuracy for protection and 15 VA class-I for metering				
(e)	Energy analyser unit to indicate current voltage frequency power factor and KWH				
(f)	Indicating lamps for load on mains and load on set				
(g)	Fuse for instruments				
(h)	Battery charger, complete with transformer/rectifier, D.C. voltmeter and ammeter, selector switch for trickle, off and boost and current adjustment.				
(i)	Main supply failure monitor				
(j)	Supply failure timer				
(k)	Restoration timer				
(l)	Control unit with three impulse automatic engine start/stop and failure to start lockout.				
(m)	Impulse counter with locking and reset facility.				
(n)	ON/OFF/Control circuit switch with indicator				
(o)	Audio/Video annunciation for				
	(i) High water temperature				
	(ii) Low lubricating oil pressure				
	(iii) Engine over speed				
	(iv) Engine fails to start				
	(v) Full load/maximum load warning		Sets	Set	
3.	Supplying and fixing exhaust gas piping of suitable dia. welded black MS, B Class pipe conforming to IS:3589 cut to required lengths and installed with necessary bends, supports and clamps, anti-vibration mountings, insulation of exhaust system with mineral wool/Rockwool, 50 mm thick wiremesh & aluminum cladding etc., as required as per specifications.		Mtrs.	Mtrs.	
	<b>Total of Sub-head 'A'</b>				

S.No.	Description of Work	Qty.	Rate	Unit	Amt.
	<b>Sub-head 'B'</b>				
1.	Laying of one number PVC insulated & PVC sheathed/XLPE power cable of 1.1 KV grade, of size not exceeding 25 sq. mm. in the existing RCC/HUME/STONEWARE/METAIL Pipe, as required.			Mtrs.	
2.	Laying of one number PVC insulated & PVC sheathed/XLPE power cable of 1.1 KV grade, of size exceeding 25 sq. mm. but not exceeding 400 sq. mm. in the existing RCC/HUME/STONEWARE/METAL Pipe, as required.			Mtrs.	
3.	Laying of one number PVC insulated & PVC sheathed/XLPE power cable of 1.1 KV grade, of size not exceeding 25 sq. mm. in the existing masonry open duct, as required.			Mtrs.	
4.	Laying of one number PVC insulated & PVC sheathed/XLPE power cable of 1.1 KV grade, of size exceeding 25 sq.mm. but not exceeding 400 sq. mm. in the existing masonry open duct, as required.			Mtrs.	
5.	Laying and fixing of one number PVC insulated and PVC sheathed/XLPE aluminium conductor power cable of 1.1 KV grade, of size not exceeding 25 sq.mm. on surface, as required.			Mtrs.	
6.	Laying and fixing of one number PVC insulated and PVC sheathed/XLPE aluminium conductor power cable of 1.1 KV grade, of size not exceeding 25 sq.mm. but not exceeding 120 sq.mm on surface, as required.			Mtrs.	
7.	Laying and fixing of one number PVC insulated and PVC sheathed/XLPE aluminium conductor power cable of 1.1 KV grade, of size exceeding 120 sq. mm but not exceeding 300 sq.mm etc. on surface, as required.			Mtrs.	
8.	Fabricating and installing following size of perforated M.S. Cable trays including horizontal and vertical bends, reducers, tees, cross members and other accessories as required, and duly suspended from the ceiling with M.S. suspenders, including painting etc., as required of size _____ mm width x _____ mm. depth x 1.6 mm thickness			Mtrs.	

S.No.	Description of Work	Qty.	Rate	Unit	Amt.
9.	Bus Trunking: Supplying, installation, testing and commissioning of — Amps. bus trunking arrangement in convenient sections complete with aluminium busbars for use on 3 phase, 4 wire, 415 volts, A.C. supply for the following current carrying capacity, including jointing of sections, flexible joints, expansion joints, bends, and earthing with 2 runs of aluminium strips etc. as required.				
		Mtr.		Mtrs.	
	<b>Total of Sub-head 'B'</b>				
	<b>Sub-head 'C' Earthing</b>				
1.	Earthing with GI/Copper** earth plate 600 mm x 600 mm x 6 mm/600 mm x 600 mm x 3 mm thick** including accessories, providing masonry enclosure with cover plate having locking arrangement and watering pipe etc. (but without charcoal or coke and salt) complete as required.				
		Sets		Set	
2.	Extra for using charcoal and salt for G.I./Copper plate** earth electrode as required.				
		Sets		Set	
3.	Providing & Fixing 25 mm x 5 mm GI/Copper strip** in 40 mm size medium class G.I. Pipe from earth electrode in ground, as required.				
		Mtrs.		Mtr.	
	<b>Total of Sub-head 'C'</b>				

\*\* Strike out whichever is not applicable

\*\*\* The item of Panel may be suitably modified, if Manual Panel is required.

## ANNEXURE 'A' OF MODEL NIT

### SCHEDULE OF TECHNICAL PARTICULARS

Sl. No.

**I. Engine**

1. Make
2. Model/ISS reference
3. No. of cylinders
4. Rated R.P.M.
5. Method of Starting
6. Aspiration Method
7. BHP
8. Specific Fuel oil consumption (gm/BHP/hr.)
9. Lub. Oil recommended
10. Lub. Oil pressure
11. Qty. of lub. oil required
12. Time required for starting
13. Lub. oil sump capacity
14. Nos. of exhaust pipe required.
15. Dia. of exhaust pipe
16. Whether meets CPCB norms for Emission
17. Fuel Consumption at full load
18. Any other data.

**II. Alternator**

1. Make
2. Enclosure Details
3. Full Load output in KVA
4. Full Load output in KW at 0.8 PF

5. Designed over load capacity at max. ambient temp.
6. Efficiency at full load
7. Class of Insulation of rotor
8. Class of Insulation stator

**III. General:**

1. Overall Length of DG set L x W x H
2. Overall Weight of DG set
3. Noise Level of DG Set at one Metre  
with Acoustic Enclosure

**IV. AMF Panels**

1. Make
2. Type (Floor/Wall mounted)
3. Overall dimensions (L x B x H)
4. Finish

**V. Generator Control Panel:**

1. Make

**VI. Acoustic Enclosure:**

1. Make
2. Size
3. Details of Acoustic lining Material & Make

**ANNEXURE 'B' OF MODEL NIT**

**LIST OF TECHNICAL LITERATURE & CATALOGUE AND ANY OTHER INFORMATION**

The tenderer should furnish the list of technical literature & catalogues of the equipments offered.

<i>Sl. No.</i>	<i>Data / Information</i>	<i>Remarks</i>
1.		
2.		
3.		

**Date:**

**Signature of Tenderer**

## ACCEPTABLE MAKES

<i>Sr. No.</i>	<i>Item</i>	<i>Makes</i>
1	Engine	:
2	Alternator	:
3	Relays	:
4	Contactors	:
5	M.S. Pipes	:
6	Anti Vibrations Mountings	:
7	Batteries	:
8	Control Cables and other Cables	:
9	Power Cable	:
10	ACBs	:
11	Switch Disconnecter Fuse Units (SDFUs)	:
12	Ammeter / Voltmeter	:
13	Current Transformer	:
14	Glass Wool	:
15	Cable Tray	:

**Note:** The acceptable reputed makes of equipments/components to be given by NIT approving authority.

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**NIT (PART-II)**

**PRICE BID**

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# SCHEDULE OF WORK ABSTRACT

**NAME OF WORK : TO BE FILLED IN BY NIT APPROVING AUTHORITY**

Sub Head A      Equipments                      Rs.                      Note : Amount not to be filled in.

Sub Head B      Earthing                                      Rs.                      .....

.....

## MODEL NIT (PART-II) (FOR PRICE BID)

### SCHEDULE OF QUANTITY

**Name of Work : (To be filled by NIT approving authority)**

S.No.	Description of Work	Qty.	Rate	Unit	Amt.
	<b>Sub-head 'A' (Equipments)</b>				
1.	Providing, Installing, Testing and Commissioning of 'Silent Type' Diesel Generating set alongwith having Prime Power Rating of ——— KVA, 415 volts at 1500 RPM, 0.8 lagging power factor at 415 V suitable for 50 Hz, 3 phase system & for 0.85 Load Factor and consisting of the followings:				
	<b>Note : Rate/Amount columns on each page of schedule of work to be crossed by NIT approving authority.</b>				
<b>(a)</b>	<b>Diesel Engine:</b>				
	Diesel engine 4 stroke water cooled, electric start, of suitable BHP at 1500 RPM suitable for above output of alternator at 40 Degree C, 50% RH & at 1000 Meter MSL and conforming to BS 5514, BS 649, IS 10000, capable of taking 10% over loading for one hour after 12 hours of continuous operation. The engine will be fitted complete with all the required accessories.				
<b>(b)</b>	<b>Engine mounted Instrument Panel fitted with and having digital display for following:</b>				
	(i) Start-stop switch with key				
	(ii) Water temperature indication				
	(iii) Lubrication oil pressure indication				
	(iv) Lubrication oil temperature indication				
	(v) Battery charging indication				
	(vi) RPM indication				
	(vii) Over speed indication				
	(viii) Low lub. Oil trip indication				
	(ix) Engine Hours indication				
<b>(c)</b>	<b>Alternator :</b>				
	Synchronous alternator rated at ——— KVA, 415 volts at 1500 RPM, 3 phase 50 Hz, AC supply with 0.8 lagging power factor at 40 Degree C, 50% RH & at 1000 Meter MSL. The alternator shall be having SPDP enclosure, brushless, continuous duty, self-excited and self-regulated				

S.No.	Description of Work	Qty.	Rate	Unit	Amt.
	through AVR conforming to IS: 4722/BS 2613 suitable for tropical conditions and with class-F/H insulation.				
<b>(d)</b>	<b>Base Frame &amp; Foundation:</b>				
	Both the engine and alternator shall be mounted on suitable base frame made of MS channel with necessary reinforcement which shall be installed on suitable cement concrete foundation and vibration isolation arrangement as per recommendations of manufacturer.				
<b>(e)</b>	<b>Fuel Tank:</b>				
	Daily service fuel tank of — liters capacity fabricated out of 3 mm thick M.S. sheet complete with all standard accessories and fuel piping between fuel tank and diesel engine with MS class 'C' pipes of suitable dia. Complete with valves, level indications & accessories as required as per specifications.				
<b>(f)</b>	<b>Exhaust System:</b>				
	Dry exhaust manifold with hospital exhaust silencer and catalytic convertor.				
<b>(g)</b>	<b>Starting System:</b>				
	12V/24V DC starting system comprising of starter motors: voltage regulator and arrangement for initial excitation complete with suitable nos. of batteries (25 plates, 180 Amp. Hour capacity lead acid type) as required as per specifications.				
<b>(h)</b>	Accoustic and weather proof enclosure with arrangement for fresh air intake for cooling of the engine & alternator, extraction, discharging hot air in to the atmosphere as per specifications.		Sets	Set	
2***	Fabricating, Installing, Testing & Commissioning of automatic mains failure control including auto by-pass panel, suitable for — KVA silent type DG set complete with relays, timers, set of CTs for metering & protection and energy analyser to indicate currents, phase and line voltages, frequency, power factor, KWH, KVARH & provision for overload, short circuit, restricted earth fault, under frequency, control cabling from AMF panel to diesel engine and elsewhere if required, all complete and inter locking including the following:				

S.No.	Description of Work	Qty.	Rate	Unit	Amt.
(a)	— Nos. — Amp., 4 pole Switch Fuse Disconnecter Unit** / 4 pole manual draw-out**/ motorised electrically operated draw out** with cradle type 3 position ACB with electromagnetic/ electronic** release for O/C & E/F and shunt trip.				
(b)	Auto/Manual/Test/Off selector switch				
(c)	2 Nos. over voltage relay, 2 Nos. reverse power relay and 2 Nos. under voltage relay.				
(d)	3 Sets of current transformers 15 P 10 accuracy for protection and 15 VA class-I for metering				
(e)	Energy analyser unit to indicate current voltage frequency power factor and KWH				
(f)	Indicating lamps for load on mains and load on set				
(g)	Fuse for instruments				
(h)	Battery charger, complete with transformer/rectifier, D.C. voltmeter and ammeter, selector switch for trickle, off and boost and current adjustment.				
(i)	Main supply failure monitor				
(j)	Supply failure timer				
(k)	Restoration timer				
(l)	Control unit with three impulse automatic engine start/stop and failure to start lockout.				
(m)	Impulse counter with locking and reset facility.				
(n)	ON/OFF/Control circuit switch with indicator				
(o)	Audio/Video annunciation for				
	(i) High water temperature				
	(ii) Low lubricating oil pressure				
	(iii) Engine over speed				
	(iv) Engine fails to start				
	(v) Full load/maximum load warning		Sets	Set	
3.	Supplying and fixing exhaust gas piping of suitable dia. welded black MS, B Class pipe conforming to IS:3589 cut to required lengths and installed with necessary bends, supports and clamps, anti-vibration mountings, insulation of exhaust system with mineral wool/Rockwool, 50 mm thick wiremesh & aluminum cladding etc., as required as per specifications.		Mtrs.	Mtrs.	
	<b>Total of Sub-head 'A'</b>				

S.No.	Description of Work	Qty.	Rate	Unit	Amt.
	<b>Sub-head 'B'</b>				
1.	Laying of one number PVC insulated & PVC sheathed/XLPE power cable of 1.1 KV grade, of size not exceeding 25 sq. mm. in the existing RCC/HUME/STONEWARE/METAL Pipe, as required.			Mtrs.	
2.	Laying of one number PVC insulated & PVC sheathed/XLPE power cable of 1.1 KV grade, of size exceeding 25 sq. mm. but not exceeding 400 sq. mm. in the existing RCC/HUME/STONEWARE/METAL Pipe, as required.			Mtrs.	
3.	Laying of one number PVC insulated & PVC sheathed/XLPE power cable of 1.1 KV grade, of size not exceeding 25 sq. mm. in the existing masonry open duct, as required.			Mtrs.	
4.	Laying of one number PVC insulated & PVC sheathed/XLPE power cable of 1.1 KV grade, of size exceeding 25 sq.mm. but not exceeding 400 sq. mm. in the existing masonry open duct, as required.			Mtrs.	
5.	Laying and fixing of one number PVC insulated and PVC sheathed/XLPE aluminium conductor power cable of 1.1 KV grade, of size not exceeding 25 sq.mm. on surface, as required.			Mtrs.	
6.	Laying and fixing of one number PVC insulated and PVC sheathed/XLPE aluminium conductor power cable of 1.1 KV grade, of size not exceeding 25 sq.mm. but not exceeding 120 sq.mm on surface, as required.			Mtrs.	
7.	Laying and fixing of one number PVC insulated and PVC sheathed/XLPE aluminium conductor power cable of 1.1 KV grade, of size exceeding 120 sq. mm but not exceeding 300 sq.mm etc. on surface, as required.			Mtrs.	
8.	Fabricating and installing following size of perforated M.S. Cable trays including horizontal and vertical bends, reducers, tees, cross members and other accessories as required, and duly suspended from the ceiling with M.S. suspenders, including painting etc., as required of size _____ mm width x _____ mm. depth x 1.6 mm thickness			Mtrs.	

S.No.	Description of Work	Qty.	Rate	Unit	Amt.
9.	Bus Trunking: Supplying, installation, testing and commissioning of — Amps. bus trunking arrangement in convenient sections complete with aluminium busbars for use on 3 phase, 4 wire, 415 volts, A.C. supply for the following current carrying capacity, including jointing of sections, flexible joints, expansion joints, bends, and earthing with 2 runs of aluminium strips etc. as required.				
		Mtr.		Mtrs.	
	<b>Total of Sub-head 'B'</b>				
	<b>Sub-head 'C' Earthing</b>				
1.	Earthing with GI/Copper** earth plate 600 mm x 600 mm x 6 mm/600 mm x 600 mm x 3 mm thick** including accessories, providing masonry enclosure with cover plate having locking arrangement and watering pipe etc. (but without charcoal or coke and salt) complete as required.				
		Sets		Set	
2.	Extra for using charcoal and salt for G.I./Copper plate** earth electrode as required.				
		Sets		Set	
3.	Providing & Fixing 25 mm x 5 mm GI/Copper strip** in 40 mm size medium class G.I. Pipe from earth electrode in ground, as required.				
		Mtrs.		Mtr.	
	<b>Total of Sub-head 'C'</b>				

\*\* Strike out whichever is not applicable

\*\*\* The item of Panel may be suitably modified, if Manual Panel is required.

## APPENDIX V

### LIST OF RELEVANT INDIAN / INTERNATIONAL STANDARDS

<b>(A) Generating Set</b>		
ISO 8528	Part - I	Application, rating and performances.
	Part - II	Engines
	Part - III	A.C. Generator for generating set
	Part - IV	Control gear & switch gear
	Part - V	Generating Sets
	Part - VI	Test methods
	Part - VII	Technical declaration for specification and design
	Part - VIII	Low power general purpose generating sets
	Part - IX	Measurement and evaluation of mechanical vibration
	Part - X	Measurement of Airborne Noise - Enveloping surface method
	Part - XI	Security generating sets with uninterruptible power system
<b>(B) Engines</b>		
IS 10000 (Naturally Aspirated)	Part - I 1980	Methods of tests for I.C. Engines Part - I - Glossary of terms relating of test method
	Part - II 1980	Standard reference condition
	Part - III 1980	Measurements for testing units and limits of accuracy.
	Part - IV 1980	Declaration of Power, Efficiency, fuel consumption, lubricating oil consumption.
	Part - V	Preparation for tests and measurement of wear
	Part - VI	Recording of test results.
	Part - VII	Governing test for constant speed engines and selection of engines for use with electrical generators.
	Part - VIII	Performance tests
	Part - IX	Endurance test
	Part - X	Tests for smoke level, limit and correction for smoke level for variable speed.

	Part - XI	Information to be supplied by the purchaser to the manufacturer and information to be supplied by the manufacturer alongwith the engine.
	Part - XII	Specimen test certificates
	Part - XIII	Recommendations on nature of tests required for functional changes in critical components.
BS 5514	Part 5 - 1979	Reciprocating Internal Combustion engines,
ISO-3046	Part V 2001	Performance, torsional vibrations.
	Part - I 2002	Declaration of powers, fuel and lubrication oil consumption and test methods.
	Part - 3 - 1989	Test measurement
	Part - 4 - 1997	Speed Governing
	Part - 6 - 1990	Overspeed protection.
BS 649		Reciprocating Internal Combustion engines, performance, torsional vibrations.
<b>(C) Alternator</b>		
IS 4889/BS - 269		For declaring efficiency of electrical machines.
IS 4722 - 1992		Capability of machine to withstand over current/overload.
IS – 13364	Part I 1992	Alternator - Voltage Regulation upto 20 KVA
IS – 13364	Part II 1992	Alternator - Voltage Regulation above 20 KVA to 80 KVA
IEC 34 -1 - 1983		Rotating Electrical machines - Rating & Performance
IP – 21	IS - 4691/85	Alternator (Degree of Protection)
<b>(D) Acoustic Enclosure</b>		
IS – 8183		Insulation material for sound absorption.
ISO 3744	1998 (E)	Acoustics - Determination of sound power levels of noise sources.
ISO 8528	Part - 10 1998 (E)	Measurement of Air borne noise by enveloping surface method.
ISO 9614 -	1993 Part - I	Requirement of grade - II. Accuracy for insulation.
ISO 9614 -	1996 Part - II	Requirement of grade - II. Accuracy for insulation.
<b>(E) Control Panel/ AMF Panel</b>		
IS -2147 1962		Degree of protection.
IS – 4722		H.V. testing for panel

## APPENDIX VI

### TYPICAL CABLE SIZES FOR DG SETS

<i>KVA Rating</i>	<i>Amp Rating</i>	<i>Cable size sq.mm. X runs</i>		
450	626	240 x 3	150 x 4	95 x 5
380	529	400 x 2	185 x 3	120 x 4
320	445	300 x 2	150 x 3	95 x 4
285	396	225 x 2	120 x 3	70 x 4
250	348	400 x 1	185 x 2	95 x 3
225	313	400 x 1	150 x 2	
200	278	300 x 1	--	--
180	250	240 x 1	--	--
160	223	185 x 1	--	--
140	195	150 x 1	--	--
125	174	120 x 1	--	--
100	139	95 x 1	--	--
82.5	115	70 x 1	--	--
75	104	50 x 1	--	--
62.5	87	35 x 1	--	--
50	70	25 x 1	--	--
30	42	16 x 1	--	--
25	40	10 x 4	--	--
20	40	10 x 4	--	--
15	32	6 x 4	--	--
25 (Single Phase)	125	50 x 2	--	--
20 (Single Phase)	80	35 x 2	--	--
15 (Single Phase)	63	25 x 2	--	--

## APPENDIX VIII

### TESTING OF DG SET AT OEM WORKS

S. No.	Description of the Item	Details
1.	Name of the work	
2.	Name of the Agency	
3.	Name of the OEM	
4.	Address of OEM	
5.	Mean height from Sea Level (a) of site (b) of OEM works	
6.	Max. Ambient Temperature (a) at site (b) at OEM Works	
7.	Relative Humidity (a) (b)	
8.	Make, model & capacity of engine (a) Requirement of de-rating/ up-rating of engine of DG set and alternator	
9.	Make, model & capacity of the alternator	
10.	De-rating/up-rating capacity of the alternator at OEM works	
11.	Theoretical full load current in amperes at power factor of testing load	

12.	Test Results on various parameters		Voltage	Power Factor	Frequency	Engine Oil pressure	Radiator Water Temp.	Test	Current in	Amp	Any other observation during testing of DG set
		1st Hr.						R	Y	B	
		2nd Hr.									
		3rd Hr.									
		4th Hr.									
		5th Hr.									
		6th Hr.									
		7th Hr.									
		8th Hr.									
		9th Hr.									
		10th Hr.									
		11th Hr.									
		12th Hr.									
13.	Balancing of DG Set										
14.	Batteries used (make, AH rating & Capacity)										
15.	Fuel tank capacity										
16.	If acoustic enclosure is provided db75 level at 1.0 mt. distance from DG set										
17.	Acoustic enclosure specification										
18.	AMIF panel										

Deptt. Officer's Signature

Contractor's Signature

Signature of OEM's Engineer

# TYPICAL GENSET ROOM LAYOUT

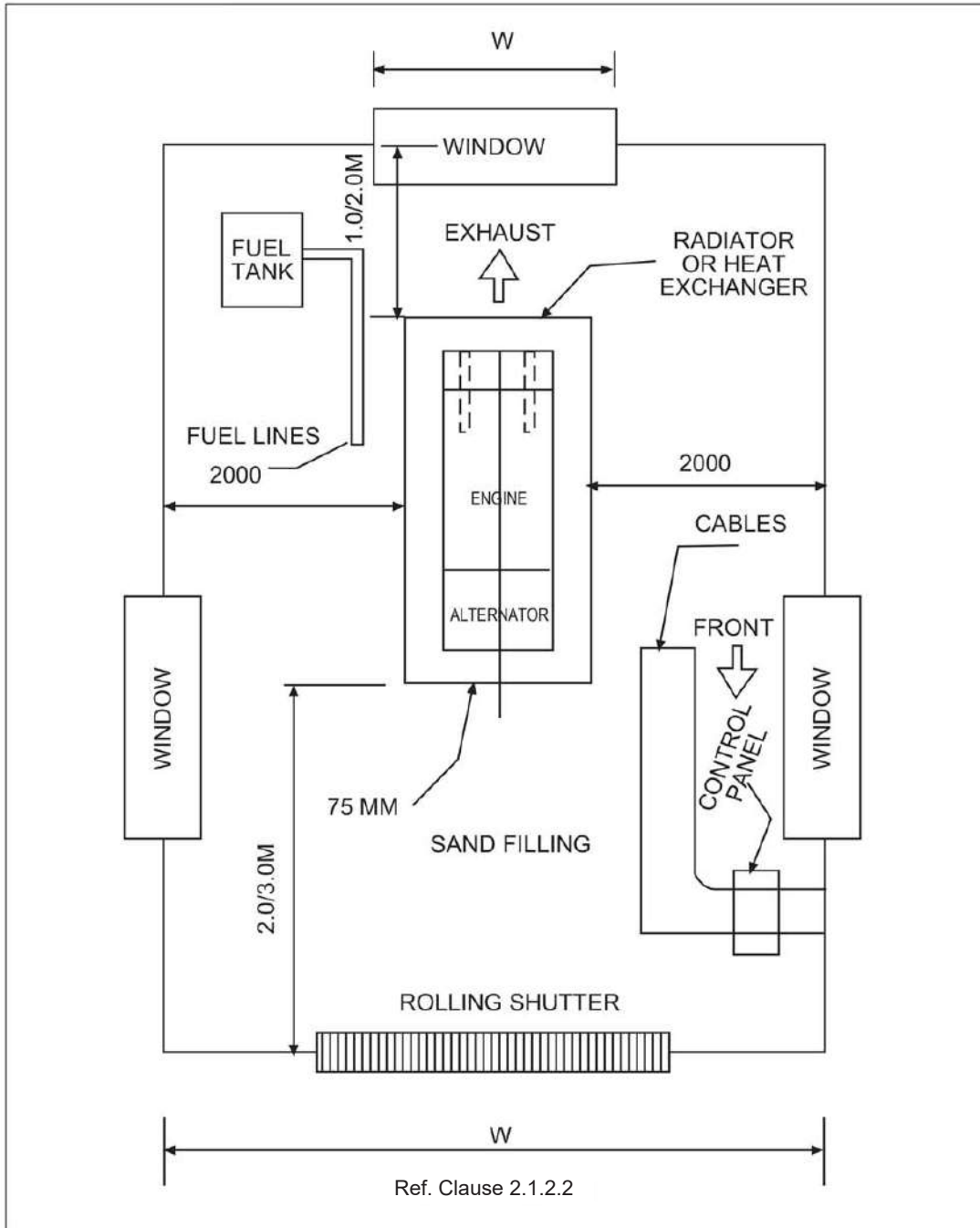
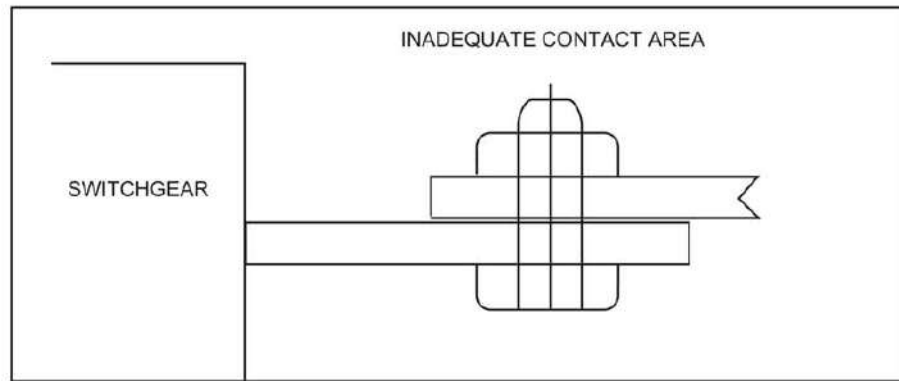


Fig. 1

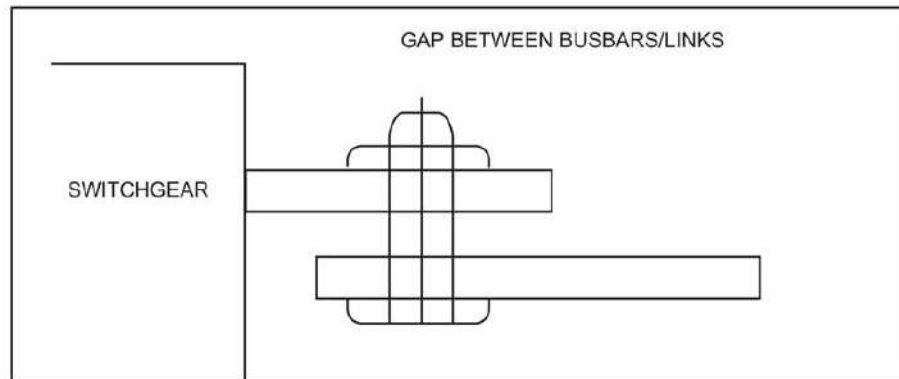
NOT TO SCALE

## ALTERNATOR TERMINAL LINKS



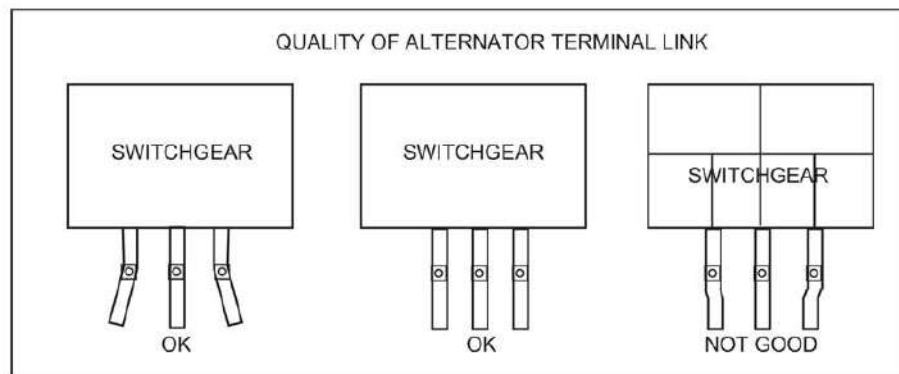
Ref. Clause 2.4.4.12.1

(i)



Ref. Clause 2.4.4.12.1

(ii)



Ref. Clause 2.4.4.12.1

(iii)

Fig. 2