SECTION - 2.5A

DIESEL GENERATOR SET
WITH ACOUSTIC ENCLOSURE

2.5.1 PREAMBLE

A. This section of specification defines the technical requirements for Standby or Prime rated DG Set 3 Phase, 4wire, 50Hz, 415V Radiator Type D.G. sets, in accordance with the requirements of the Contract Documents and codes.

2.5.2 SUMMARY

The scope of this section consists of but not necessarily limited to the following:

A. The contractor shall supply, deliver to site, hoisting into position, install, test and commission the standby power generating set together with the necessary controls and switchboards as specified and indicated in the Drawings. Protection circuits, control wiring and interlock circuits not specified or indicated in the Drawings, but deemed necessary for the safe operation of the generating system shall be provided without any additional cost to complete the system.

- Engine and Alternator.
- Relay, metering, neutral Contactor panels, etc.,
- Day Oil Fuel Tank.
- Exhaust pipe up to the wall, above the D.G. Sets
- All piping for fuel oil, lube oil, compressed air, within battery limit of D.G. Acoustic Enclosure along with necessary supports.
- Auto Mains Failure (AMF) Panels, D.G. Synchronizing Panel.
- All wiring and cabling from DG Sets to the D.G. Synchronizing Panels, AMF panels.
- Any other work connected with complete system commissioning.
- Moving the material from the Employer's store to Site for installation, if any.
- Submission of application/drawings to statutory authorities.
- Taking approval of statutory authorities.
- Provide manufacturer’s factory representative’s services, including coordination, start-up and testing supervision at site.
- Testing (factory and field), start-up supervision, training and providing necessary documentation and tools for operation.
- Carry out performance test run at site.

B. Scope of works listed below shall not be considered as comprehensive description of the Contract, but only as an indication of the extent of works.
C. Provision of Design Verification, detailed calculation, selection of equipment, working drawings , builder work drawings, supply, installation, testing, commissioning and handing over for the complete system Related to D.G. Sets to the requirement as stipulated in this specification and local government authority shall be in the contractor’s scope.
D. Provide TN-S System earthing as per IS:3043 to the complete the system.
E. The Contractor’s equipment layout must comply with the space allocated for the same and as allocated in the Tender drawings.
F. After hours testing of plant shall be provided.
G. Testing and commissioning of installation under normal operational conditions shall be conducted.
H. Priming and finishing coats painting to all metal pipe work and equipment as per the standards.
I. As-built drawings and operation / maintenance manual as detailed elsewhere in the specification shall be provided.
J. Seal the gaps between pipe sleeves and pipe work / conduit, etc. if any.
K. Two year warranty and maintenance service from the date of handover of the works shall be included in the offer.
L. Work shall be done as per clause Extent of services of General / Special Conditions of Contract (GCC / SCC).

M. Codes and Standards: The DG set shall be designed, manufactured and tested in accordance with the latest applicable sections of the IS/BS/ EC codes. Conflicts between referenced documents shall be identified to the **LODHA REPRESENTATIVE** in writing for resolution

Standard Code	**Description**
General Codes	
NBC 2005	National Building Code of India 2005
NEC 2011	National Electrical Code 2011
CEA 2010	Central Electricity Authority 2010
CFO-NOC	NOC from Chief Fire Officer
CPCB	MOEF Authority
Codes for Rotating electrical machines	
IS 2253	Designation for types of construction and mounting arrangement of rotating electrical machines
IS 4889	Methods of Determination of Efficiency of Rotating Electrical Machines
IS 6362	Designation of Methods of Cooling of Rotating Electrical Machines
IS 8223	Dimensions and Output Series for Rotating Electrical Machines
IS 12065	Permissible limits of noise level for rotating electrical machines
IS 12075	Mechanical Vibration of Rotating Electrical Machines with Shaft Heights 56 mm and Higher - Measurement, Evaluation and Limits of Vibration Severity
IS 14568 : Part 2	Dimensions and output series for rotating electrical machines Part 2 Frame numbers 355 to 1000 and flange numbers 1180 to 2360
IS 15999 : Part 2	Rotating Electrical Machines Part 2 Method of Tests Section 1 Standard Methods for Determining Losses and Efficiency from Tests (Excluding Machines for Traction Vehicles)
IS/IEC 60034 : Part 1	Rotating electrical machines : Part 1 Rating and performance
IS/IEC 60034 : Part 5	Rotating electrical machines : Part 5 Degrees of protection provided by the integral design of rotating electrical

	machines (IP CODE) – Classification
IS 4722	Routine test for alternator
Codes for Engine	
IS 1460	Automotive Diesel Fuel
ISO 8528/ ISO 3046	Reciprocating internal combustion engine driven alternating current generating sets
Codes for L.V. Switch-gears	
IEC 61439-1	General rules
IEC 61439-2	Power switchgear and control-gear assemblies
IEC 61439-3	Distribution boards intended to be operated by ordinary persons (DBO)
IEC 61439-4	Particular requirements for assemblies for construction sites (ACS)
IEC 61439-5	Assemblies for power distribution in public networks
IS 1570	Schedules for wrought steels for general engineering purpose
IS 5082	Material for data for aluminium bus bars
IS 13703	Low voltage fuses.
IS 2705	Current transformers.
IS 3156	Voltage transformers.
IS 1248	Electrical indicating instruments.
IS 13947: part 5	Low-Voltage Switchgear and Controlgear - Part 5 : Control Circuit Devices and Switching Elements - Section 2 : Proximity Switches
IS 3231	Electrical relays for power system protection.
IS 6875	Control switches and push buttons.
IS 694	PVC insulated cables for working voltages upto and including 1100V.

IS 5578	Guide for marking of insulated conductors.
IS 8130	Insulated Electric Cables and flexible cords
IS 3618	Phosphate treatment of Iron and steel for protection against corrosion.
IS 6005	Code of practice of phosphating of Iron and steel.
IS 5	Colours for ready mixed paints and enamels.
IS 10118	Selection installation and maintenance of Switchgear and control-gear
IS/IEC.60529	Degrees of protection provided by Enclosures
OISD-RP-149	Design Aspects for Safety in Electrical System.
IEC 60189	PVC insulation & PVC sheath for cables and control wiring.
IEC 61008	Residual Current Device (RCD)
IEC 60255	Electrical relays.
IEC 60269	Low-voltage fuses.
IEC 60715	Dimensions of low voltage switchgear and control gear. Standardised mounting on rails for mechanical support of electrical devices in switchgear and control gear installations.
IEC 62271	High Voltage Switchgear and Control gear
IEC TR 61641	Enclosed LV Switchgear and Control gear assemblies – guide for testing under conditions of arcing due to internal fault.
IEC 62052	Class 0.5, 1 and 2 alternating current watt-hour meters.
BS 6387	Specifications for performance requirements for cables required to maintain circuit integrity under fire conditions
Codes for Earthing	
IS 3043	Earthing Code of Practice
Code for Conduits/ Trunking / marking	

IEC 61537	Cable tray systems and cable ladder systems for cable management
IS:9537 (Part-II)	Steel Conduit and Fitting Accessories PVC Conduit and Fitting Accessories
IS 14927, IEC 1084.	Cable Trunking
IS 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.

2.5.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, foundation details, minimum clearances, installed devices and features, and performance for each type and size of DG indicated.

B. Danger/Warning labels shall have white lettering on a red background and shall be in English and Hindi. All other labels shall have black lettering on a white background. All labels shall be fixed by screws or rivets.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

D. Wiring Diagrams: Power, signal, and control wiring.
- Technical Details: Voltage, kVA, impedance ratings and characteristics, no load core loss, full load winding conductor loss, full load losses, efficiency at 25 percent, 50 percent, 75 percent and 100 percent rated loads, percent regulation with 80 percent and 100 percent power factor loads, sound level, tap configurations, insulation type and rated temperature rise

E. Qualification Data: For testing agency.

F. Source quality - control test reports.

G. Field quality-control test reports.

H. Certificates: Copies of all relevant certifications for the package equipment including bought out items.

I. Electrical Items on Drawing shall be represented by graphical symbols in accordance with IEC 60617

J. List of proposed makes, for the items listed in the tender.

K. Technical datasheets indicating overall dimensions & Catalogues of major items, highlighting the offered models.

L. Design drawing of residential silencer.

M. Day oil tank detailed design drawing

N. Structural support drawings.

O. To submit power controller (Synchronization module) drawings along with operation logic.

P. Supporting structure details of chimney etc.,

Q. Other documents and comments, if any.

R. General arrangement drawings, with all dimensions, showing: space requirements, weights (for transport and service conditions), requirements of civil works/ foundation, fixing and mounting facilities, connection devices, etc.

S. Electrical drawings, showing: power and control single line and functional/ control multi line diagrams, terminal blocks, components' list with make, type, quantity, etc.

T. Type Test certificates of all measuring kWh meters from.

U. Guarantee certificates.

V. Instruction & maintenance manuals, Catalogues etc.

W. Any other certificate/ report as called for by the Lodha/ Consultant.

2.5.4 INSPECTION AND TESTING AT MANUFACTURER PREMISES

The owner/ consultant may carry out inspection and testing at manufacturer's works. No equipment shall be delivered without prior written confirmation from Project Manager. All expenses relating to test including travelling, boarding & lodging of two personal one from Lodha and one from Consultant shall be borne by the contractor. Upon completion of work the performance test shall demonstrate the following among other things:

A. Equipment installed complies with specification in all respects and is of the correct rating for the duty and site conditions.

B. All items operate efficiently and quietly to meet the specified requirements.

C. All circuits are correctly protected and protective devices are properly coordinated.

D. All noncurrent carrying metal parts are properly and safely grounded in accordance with the specifications and appropriate codes of practice.

E. The contractor shall provide all necessary instruments and labour for testing. He shall make adequate records of test procedures and readings and shall repeat any tests requested by the Project Manager/ Consultant. Test certificate duly signed by an authorized person shall be submitted for scrutiny.

F. If it is proved that the installation or part thereof is not satisfactorily carried out then the contractor shall be liable for the rectification and retesting of the same as called for by the Project Manager/ Consultant. All tests shall be carried out in the presence of representative of Project Manager/ Consultant.

G. The above general requirements as to testing shall be read in conjunction with any particular requirements specified elsewhere. All tests shall be carried out by a test house approved by the Project Manager/ Consultant.

H. The contractor besides above test shall carry out witness test for performance at full load at PF of 0.8 over at least 12 hrs and 10% additional for an hour in case of Prime rated DG set.

I. The contractor besides above test shall carry out witness test for performance at full load at PF of 0.8 over at least 12 hrs in case of stand by rated DG set.

J. The contractor shall submit a site acceptance test format & procedure for approval.

K. The DG shall be tested in the presence of Owner's representative at Supplier's works in accordance with latest prevailing standards and codes. The successful passing of any such tests will not however prejudice the right of Purchaser to reject the DG and its accessories, if they do not comply with specifications when erected or perform complete satisfactory operation as intended. Supplier shall provide the test certificate for the bought out items used, if any in the assembly of DG

2.5.5 CONSTRUCTION

2.5.5.1 General

A. The DG Set are required to be supplied with acoustic enclosure as per CPCB norms.

B. Acoustically enclosed DG is to be kept inside a room having a supply louver and exhaust louver as per specified in drawings & BOQ.
C. The complete enclosure metal work shall be treated with 14 tank surface treatment processes and after that polyethylene based powered coating to prevent rusting.
D. The enclosure shall be provided with suitable air intake openings lined with noise attenuators and louvers designed to maintain steady air flow in to the enclosure and prevent ingress of external foreign matter.
E. Attenuators shall be placed on the hot air outlet and cooling air inlet. Exhaust silencers of residential type as required shall be mounted either on the top of, or inside the enclosure, exhausting to atmosphere and the enclosure to be equipped with all outlet baffles /attenuators shall be with corresponding mesh to allow sufficient airflow for the set to operate even under the harshest ambient conditions whilst maintaining specified noise levels .The louvers and attenuators should be so designed that maximum temperature difference between the ambient and inside of the enclosure is maintained at 10 deg C.
F. The enclosure shall be provided with high performance noise reduction, fire resistant and airtight doors with EPDM gaskets, robust hinges, door locks with keys and handles.
G. The above specifications are indicative and vendor shall guarantee that the enclosure is so specified and constructed to achieve a sound attenuation at one meter distance from the doors & louvers of Generator enclosure to be measured as per CPCB Norm / local pollution control board.
H. The enclosure must accommodate following items in it but not limited to below listed components
    1. Battery & battery charger
    2. Day tank
    3. AMF
    4. Auxiliaries supply (if any)
    5. control and monitoring
I. General Details:
    1. Acoustic canopy is of modular construction with provision to assemble and dismantle easily as per site conditions.
    2. There are no protruding parts
    3. The panels are fabricated out of CRCA sheet of Different sizes depends on suitability of fabrication. These panels are used for all sidewalls, top, doors and partitions as required and as shown in approved dwg during the time of finalising the contract.
    4. The sheet metal components are hot dip seven tanks pre-treated.
    5. To have long life the canopy is P P based powder coated.
    6. All nuts and bolts/ hardware are zinc coated
    7. The doors are hinge type and gasketed with high quality EDPN gaskets to avoid leakage of sound
    8. Sound proofing is done with high quality rock wool/ fire retardant foam of suitable thickness and density.
    9. Specially designed attenuators are provided to control sound at entry to canopy and exit from the canopy.
    10. Adequate ventilation is provided to meet the air requirement of engine and alternator.
    11. Adequate lighting is provided in the canopy.

J. Generator shall be rated stand-by duty. The rating stated shall be the nominal full load continuous rating and shall be at rated voltage, frequency, power factor and design temperature.
K. Design life for equipment shall be 20 years minimum when operated at rated load under the site conditions specified.
L. Guard all exposed hot or moving parts in accordance with ISO 12100.
M. The following materials are prohibited from use:
    1. Asbestos or asbestos based materials.
    2. Cadmium.
    3. Poly-chloryl-biphenols (PCB's).
    4. Lead.

N. DG set shall be Factory-assembled and -tested, engine-generator set.
O. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments:
P. Capacities and Characteristics:
    1. Power Output Ratings: Nominal ratings as indicated in the equipment schedules, with capacity as required to operate as a unit as evidenced by records of prototype testing
    2. Output Connections: Three-phase as indicated on the schedules

3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component
4. Comply with noise levels indicated in section B of this specification.

Q. Generator-Set Performance for Sensitive Loads:
1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance:
2. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
3. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load
4. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second
5. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load
6. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed
7. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds
8. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple.
9. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components
10. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load
11. Provide AREP excitation for power source to voltage regulator
12. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

2.5.5.1 CAPACITY

Actual power output shall be as shown in drawings and in schedule of quantities.

2.5.5.2 DIESEL ENGINE

A. The diesel engine shall be of the 4 stroke cycle, rating (stand by as specified in SOQ), multi-cylinder direct injection, compression ignition type operating at a speed of 1500 rpm and shall be silent, vibration free while in operation and comply Centre/ State Pollution Control Board and shall conform to BS:649/ 5514.

B. The engine shall be complete with radiator body jacket, lubricating oil pump, lubrication oil pressure gauge, tachometer, digital or electronic type governor, integrated hours-run recorder, over-speed trip and all other necessary auxiliaries.

C. The brake horse power of the engine with all attached accessories as specified shall not be less than that which is required by the full load rating of the alternator at site operating conditions taking into consideration losses, plus a reserve factor of at least 10%.

D. Generator set to be tested according to BS 7698-8. Engine for generating set to be in accordance with ISO 8528 and ISO 3046.
E. AC generator to be according to BS EN 60034-22.Provide completely documented ISO standard functional test report in accordance with BS ISO 8528-6.
F. Unless otherwise agreed in writing by the engineer the supply and extract air louvers shall be separated by a minimum distance of 1.5 x the overall length of the installed set.

2.5.5.3 FUEL SYSTEM

A. Fuel: High Speed Diesel
B. Maximum Piston Speed for Four-Cycle Engines: 9.5 m/s
C. Lubrication System: The following items are mounted on engine or skid:
    1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow
    2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe
    3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
D. Engine Fuel System:
    1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions
    2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
E. Governor: Adjustable isochronous, with speed sensing.

2.5.5.4 STARTING

A. Starting system of the standby generator shall be of a heavy-duty electric motor complete with a 24 V D.C. heavy-duty battery of at least 180 AH. The electric motor shall be capable of cranking the engine to achieve the rated speed in less than 10 seconds from the initiation of the starting process. The electric start battery shall be of adequate capacity for 3 successive starts. Time delay relays shall be incorporated to provide a rest period of 1-5 seconds (adjustable) before each successive start and a time lag period of 19-100 seconds (adjustable) before the system lock out due to failure of the 4th start to crank up the engine.

B. The generator set shall be provided with a micro-processor based control system which is manufactured to provide automatic starting, monitoring, and control functions for the generator set. Interface to BMS system according to point schedule on drawings shall be provided.

C. The control system shall include an engine governor control, which shall function to provide steady state frequency regulation. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.
D. Starting System shall be 24-V electric, with negative ground.
    1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in site conditions.
    2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
    3. Battery: Adequate capacity within ambient temperature range specified site conditions to provide specified cranking cycle at least three times without recharging.
    4. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
    5. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in site conditions Include accessories required to support and fasten batteries in place.
    6. The battery charger shall be housed in sheet steel cubicle of Angle Iron frame work with sheet steel panels of 1.6 mm thickness. Louvers shall be provided in the cabinet for the ventilation. The cubicle shall be painted in Siemens Grey shade RAL7032 of IS-5. Four wheels shall be provided at the base.
    7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
    8. Battery Charger conventional: Shall be trickle charging type.
        a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.

b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.

Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

E. Battery Charger: (SMPS)

a. Shall be housed in MS powder coated enclosure
b. Enclosure shall have suitable cooling arrangement by means of fans as required.
c. Shall be suitable for input voltage of 230V 50hz, TNS system
d. Shall have output voltage
    i. float mode 24 v ±5%
    ii. boost mode 28.0v

e. Shall have output current
    i. float mode 0 to 6 amps
    ii. boost mode 6 to 20 amps
f. Shall have load regulation ≤2%
g. Shall have line regulation ≤1%
h. Following protection shall be provided
    i. I/P under voltage shutdown 150vac
    ii. I/P overvoltage shutdown 280 vac
    iii. short circuit and overload
    iv. battery reverse
    v. o/p overvoltage
i. Indications
    i. mains on green
    ii. float green
    iii. boost red
    iv. battery reverse red

2.5.5.5 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified. Adjusting rheostat on control and monitoring panel shall provide plus or minus 2.5 percent adjustment of output-voltage operating band.

2.5.5.6 COOLING

A. The engine cooling system shall be of radiator type system to cool the engine as well as the body to minimize heat radiated into the generator room.
B. Cooling System Factory mounted radiator: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump:
    1. Coolant: Solution of ethylene-glycol-based antifreeze (if ambient conditions warrant) and water, with anticorrosion additives as recommended by engine manufacturer
    2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition
    3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer
    4. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet- and abrasion-resistant fabric:
    a) Rating: 345-kPa maximum working pressure with coolant at 82℃, and non-collapsible under vacuum

b) End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

C. Cooling System: The engine cooling system shall be of radiator type to cool the engine as well as the body to minimise heat radiated into the generator room. The cooling circuit shall exchange heat through a heat exchanger capable to remove the heat generated under continuous full load operation. Water cooled with Heat exchanger factory mounted on engine-generator set mounting frame and integral engine-driven coolant pump.

2.5.5.7 LUBRICATOR

A. The lubricating system shall be by a positive displacement oil pump providing a positive force feed to all lubricating points.
B. Ensure engine lubricating oil dipstick is accessible and marked to indicate maximum and minimum levels. Provide engine sump with accessible drain point or drain pipe, fitted with plug. Ensure lubricating oil system enables the engine to run continuously for period indicated at any load without replenishment.

2.5.5.8 EXHAUST SYSTEM

A. Provide exhaust system in accordance with manufacturer's recommendations and to meet characteristic requirements. Include all fittings, gaskets, joints and fixings to ensure safe exit of products of combustion.

B. Adequate sized piping and fittings shall be installed to carry the engine exhaust discharge into the atmosphere at a height as indicated in the drawings & as per the requirement of Center/ State Pollution Control Board or Pollution Control Committee as the case may be.

C. Hot dipped galvanised structural support and vibration arrestors for D.G. set chimney to specify along with drawing for statutory clearance.

D. Mufflers shall be installed to reduce the engine exhaust noise to a maximum of 5 dBA above ambient noise level at nearest area accessible to the public within 4m from Generator Room and at least 2m above floor level. Flexible connection shall be provided between the engine and the fixed piping.

E. The insulation used in the exhaust system shall be minimum 50mm thick Rockwool with density not less than 64kg/m3, and shall be cladded with 24SWG Aluminium

2.5.5.9 Silencer:

A. Residential type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

B. Silencer: residential type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements:
   1. Minimum sound attenuation of 25 dB at 500 Hz
   2. Sound level measured at a distance of 1m from exhaust discharge after installation is complete shall be 75 dBA or less.

2.5.5.10 FUEL PIPING AND FUEL TANK

A. The complete system shall include engineering, supply, installation, testing and commissioning of tank for storage of fuel, pumps, piping, valves and control system.
B. Fuel tank shall be undercarriage type within the acoustic enclosure. Fuel shall be transferred through a lift pump. Complete system shall be installed at factory premises & shall be brought to site as ready to commission stage.
C. fuel oil storage

1. Day Tank: Freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
2. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank:
3. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
4. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine
5. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level
6. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level
7. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve
8. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.

D. Service Storage Tank
1. Construct Service storage tanks which have a capacity not more than 990ltrs.
2. All service tanks will be supplied with the following:
   a) Oil drain valve
   b) Water drain valve
   c) Separate vent pipe or return pipe located at the higher end
   d) For oil draw-off and return lines fire valves will be provided
   e) Oil dipstick point
   f) BMS sensor link electronic level sensor manual gauge
   g) Filling pipes and connections
   h) Outlet and inlet valves.
3. Note that tanks must be of steel construction. Plastic tanks are not permitted. The tank shall be fabricated from mild steel plate to Grade CR 4 suitable for welding as BS 1449-1. Galvanised steel shall not be used. Welding to be as specified in BS 5135 Include all necessary lifting lugs. Thicknesses shall not be less than 1.2mm thick.
4. The tank shall be hydraulically pressure tested at works and finished externally with 2 coats of zinc rich primer prior to installation after first being wire brushed, degreased and being cleaned of all rust and scale.
5. The finish coat for the tanks shall be two coats of gloss paint and silver colour finish.

E. Pipes, Tubes, And Fittings
1. Oil lines shall be steel pipe to BS EN 10255:2004 -Non-alloy steel tubes suitable for welding and threading - technical delivery conditions. Fittings for steel pipe should be to BS EN 10241 – Steel threaded pipe fittings and threads shall be to BS 21 – Specification for pipe threads for tubes and fittings. Galvanised pipe or fittings must not be used.
2. Protective coating for underground piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
3. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

F. Fuel filter:
1. Provide on the common oil feed to the oil circulation pumps an 80mm diameter cast steel simplex oil filter with lift out replaceable bronze wire mesh elements
2. The filter will be a combined filter and water separator capable of removing particles down to 5 microns
3. The oil filter will be lever operated to allow the oil stream to be diverted separately through each filter element or as a combined flow through both. Each filter will be provided isolating valves on either side of the filter and a drain cock.

G. Tank Accessories
1. Tank manholes: 600 minimum diameter; bolted, flanged, and gasketed; centred on top of tank.
2. Threaded pipe connection fittings on top of tank, for fill, supply, return, vent, sounding, and gauging. Include cast-iron plugs for shipping.
3. Striker plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.
4. Lifting lugs: For handling and installation.

5. Ladders: Carbon-steel ladder inside tank, anchored to top and bottom, and located as indicated. Include reinforcement of tank at bottom of ladder.
6. Ladders: Carbon-steel ladder outside tank, anchored to top and side wall:
7. Cage: Include welded steel cage around ladders for tanks 4 m high or higher.
8. Supply tube: Extension of supply piping fitting into tank, terminating 150 mm above tank bottom and cut at a 45-degree angle.
9. Sounding and gage tubes: Extension of fitting into tank, terminating 150 mm above tank bottom and cut at a 45-degree angle.

H. Simplex Fuel-Oil Transfer Pumps
1. Listed and labelled for fuel-oil service by a testing laboratory
2. Type: Positive-displacement, rotary type
3. Impeller: Steel gear with crescent or Carbon vane
4. Housing: Cast-iron foot mounted
5. Bearings: Bronze, self-lubricating
6. Shaft: Polished steel
7. Seals: Mechanical
8. Base: Steel
9. 9Pressure relief: Built in
10. Discharge check valve: Built in.
11. Drive: direct, close coupled.
12. Controls:
    a. Run pump to maintain minimum manifold pressure with outdoor-air temperature less than 16 deg C
    b. Run pump on seven-day schedule
    c. Alarm motor failure
    d. Manual reset dry-run protection. Stop pump if fuel level falls below pump suction
    e. De-energize and alarm pump locked rotor condition
    f. Alarm open circuit, high and low voltage
    g. Indicating lights for power on, run, and off normal conditions
13. Interface with automatic control system and indicate the following:
    a. Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions
    b. Operating status
    c. Alarm off-normal status.
14. Motor: Comply with IP designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.
15. Motor sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
16. Capacities and characteristics: As detailed in schedules of equipment.

I. Liquid-Level Gauge System
1. Description: Calibrated, liquid-level gage system with probes or other sensors and remote annunciator panel.
2. Alarms specified in first paragraph below may be used as part of leak-detection system.
3. Annunciator panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in litres, and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
4. Controls: Electrical, operating on 24V ac.

J. Controls, Leak-Detection And Monitoring System
1. The fuel handling control system shall be part of a packaged system. The system shall interface to the BMS for start/stop and fault signals.
2. The pumps and day tank motorised valves shall be controlled by the high and low level sensors within each day tank. Each day tank shall be filled on demand. Each pump shall include an hours run meter within the control panel. The low level alarm shall indicate to BMS and fill point controls that the fuel storage is low and requires filling. The extra low level alarm shall shutdown the pump system and relay the level status and pump status to the BMS workstation as an ‘Urgent’ task.
3. Differential pressure switches across each strainer set shall initiate a fault at the panel and on the BMS to indicate the necessity for cleaning.

4. Differential pressure switches shall be fitted across the 'Duty' and 'Standby' pumps and shall be automatically switchover in the event of failure or manual shutdown. The fault and operational signal shall be provided for the BMS.
5. The BMS shall provide a fire alarm derived shut down signal which shall close all motorised controlled fire valves. A manual reset facility shall be provided adjacent the control panel.
6. Manually reset push buttons marked by a white plastic plate not less than 100mm long × 75mm high, with an inscription in 10mm red lettering stating "IN CASE OF FIRE STRIKE KNOB" shall be positioned at all exits from the following areas:
   a. Generator room.
7. Activation of one of these buttons shall close all motorized fire valve and stop the oil transfer pumps.
8. A screw down gate valve or gland cock shall be fitted at the lowest part of the underside of the tank. Un-lubricated plug valves shall not be used. Drain valves shall be of gunmetal or steel. Cast iron valves shall not be used. Drain valves and cocks shall be capable of being locked in the closed position.
9. Cable and Sensor System:
   a. Calibrated, leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil storage tanks and fuel-oil piping
   b. Include fittings and devices required for testing
   c. Controls: Electrical, operating on 24V ac
   d. Calibrated, liquid-level gage with probes or other sensors and remote annunciator panel
   e. Remote annunciator panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in litres, and overfill alarm. Include gage volume range that covers fuel-oil storage capacity
   f. Controls: Electrical, operating on 24-V ac.
10. Hydrostatic system:
    a. Calibrated, leak-detection and monitoring system with brine antifreeze solution, reservoir sensor, and electronic control panel to monitor leaks in inner and outer tank walls
    b. Include fittings and devices required for testing
    c. Controls: Electrical, operating on 24V ac
    d. Retain three subparagraphs below for an optional feature that replaces system described in "Liquid-Level Gage System" article
    e. Calibrated, liquid-level gage with probes or other sensors and remote annunciator panel
    f. Remote annunciator panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons (litres), and overfill alarm. Include gage volume range that covers fuel-oil storage capacity
    g. Controls: Electrical, operating on 24V ac.

2.5.5.11 INSTRUMENTS

An instrument panel mounted on the engine shall be provided and shall comprise the following flush-mounted instruments and gauges:

A. Lubricating oil pressure gauge

B. Tachometer, positive driven

C. Integrated Hour-run recorder

2.5.5.12 PROTECTION

Warning indication and automatic shut-down shall be provided for the following:

A. Low oil pressure shutdown and alarm

B. Low and high coolant temperature alarm

C. High coolant temperature shutdown

D. Fail to crank shutdown

E. Over cranking shutdown

F. Over speed shutdown

G. Low & high DC voltage alarm

H. Low battery alarm

I. Low fuel-day tank alarm

J. High and Low AC voltage shutdown

K. Under frequency shutdown

L. Over current and alarm and shutdown

M. Short circuit shutdown

N. Ground fault alarm

O. Overload alarm

P. Emergency stop

Q. Failure indication lights and alarm for all fault conditions shall be provided on control panel for restoring the operation to normal.

R. The starting circuit shall be disconnected in the event of any of the above shutdowns.

2.5.5.13 ALTERNATOR

A. General

Continuous output / Speed	:	As noted in SLD tender KVA / 1500RPM
Rated Power Factor	:	0.8 lag
Rated Voltage	:	415 V, 3Ph, 4 wire
No load regulations	:	± 1 %(440V at alternator terminals)
Rated frequency	:	50 Hz
Class of insulation	:	H (180℃ (IEC 60085))

B. Provide alternating current generating set driven by a reciprocating internal combustion engine in accordance with ISO 8528. The engine and alternator units will be provided as a composite factory assembled unit mounted on a one piece structural supporting skid.

C. The alternator shall be brush less synchronous drip proof, self-ventilated and screen-protected and directly coupled on to the diesel engine by flexible coupling and shall be continuously rated for site operating conditions and conform to codes as listed above.

D. The full load output voltage shall be 415 volts, 3 Phase, 4 wire, 50 Hz at 0.8 power factor with neutral solidly earth with the frequency maintained at 50 Hertz at all time under any load condition including transient overload due to motor starting etc.

E. The rotor shall consist of the main alternator field poles the brushless exciter and its rectifier module, all bolted on a common alternator shaft. The rotor shall be mechanically and electrically balance up to 135% of the rated speed. The insulation of the alternator shall be non-hygroscopic, Class "H" on the exciter, Class "H" on the stator and Class H on the rotating pole pieces.

F. The rectifier module of the exciter shall be impregnated with epoxy resin and shall be capable of withstanding without damage or deterioration of the thermal, centrifugal and other stresses that is experienced during normal or short circuit conditions. Rectifiers shall be of silicon type.

G. The voltage build up shall be of self-excitation using the residual voltage of the alternator through a solid-state voltage regulator. The voltage regulator shall be capable of maintaining the voltage regulation to ± 1% independent of power factor, heating and 5% of speed variation. The voltage output of the alternator shall also be capable of manual adjustable to ± 5% of the rated voltage.

H. The response of the voltage regulator shall be less than 10millisecond. The voltage dip shall not exceed 15% when a rated continuous load is supplied to the unloaded alternator and the correction time shall not exceed 200millisecond. When the rated load is withdrawn, the voltage overshoot shall not exceed 20%.

I. The automatic voltage regulator and the exciter shall be manufactured to withstand 50% overload at a constant terminal voltage.

J. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of motor current for not more than 10 seconds.

K. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

L. Isolation of load under fault conditions must be primarily achieved by instantaneously disconnecting the load from alternator

2.5.5.14 GENERATOR CONTROL PANEL

A. The generator control panel shall have all necessary instruments and accessories for operation and control of the generating set. On sensing the utility mains voltage dip to below said voltage, the control panel shall send a signal to start the generator. After 3 successive start and if the diesel generator is not started up, the alarm signal shall be activated.

2.5.5.15 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the Generator/DG control panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
B. Manual Starting System Sequence of Operation: Switching on-off switch on the Generator/DG control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
C. Remote start and remote shutdown: Provision shall be made in the control circuitry for remote start and remote shutdown signals for the diesel engine. Remote engine start shall be initiated by closing a normally open contact; remote engine shutdown will be initiated by opening a normally closed contact. Remote start and stop signals shall be available through an AMF panel

D. Indicating and Protective Devices and Controls:
   1. AC voltmeter.
   2. AC ammeter.
   3. AC frequency meter.
   4. DC voltmeter (alternator battery charging).
   5. Engine-coolant temperature gage.
   6. Engine lubricating-oil pressure gage.
   7. Running-time meter.
   8. Ammeter-voltmeter, phase-selector switch.
   9. Generator-voltage adjusting rheostat.
   10. Fuel tank high-level shutdown of fuel supply alarm.
   11. Generator overload.

E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

F. Common Remote Audible Alarm: it Include necessary contacts and terminals in control and monitoring panel.
   1. Over-crank shutdown.
   2. Coolant low-temperature alarm.
   3. Control switch not in auto position.
   4. Battery-charger malfunction alarm.
   5. Battery low-voltage alarm.

G. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
   1. Engine high-temperature shutdown.
   2. Lube-oil, low-pressure shutdown.
   3. Over-speed shutdown.
   4. Remote emergency-stop shutdown.
   5. Engine high-temperature pre-alarm.
   6. Lube-oil, low-pressure pre-alarm.
   7. Fuel tank, low-fuel level.
   8. Low coolant level.

H. Remote Alarm Annunciator: An LED labelled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush mounting type to suit mounting conditions indicated.
   Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labelled. Push button shall be protected from accidental operation.

2.5.5.16 MONITORING BY REMOTE COMPUTER :

A. Provides a Communication module in each unit to provide capability for remote monitoring of status, parameters, and alarms. The remote computer and the connecting signal wiring themselves are not included in this Contract. Include the following features:
   - Connectors and network interface units or modems for data transmission via RS-485 link.
   - The OEM shall have Software solution designed for control and monitoring of DG functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. The actual supply of this software is not included . The software solution shall under this contract. Permit storage and analysis of power-line transient records.

2.5.5.17 VIBRATION ISOLATION DEVICE

A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
   1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and levelling bolt that acts as blocking during installation.
   2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.5.5.18 DG CONTROLER BASED AUTOMATIC MAINS FAILURE / AUX. PANELS(AMF).

A. For panel construction refer section- B2. LOW VOLTAGE SWITCHGEARS/SWITCH BOARDS
B. AMF function of the DG set should be based on single / multiple inputs as noted in tender schematic.
C. Controller should be compatible for BACNET/MODBUS protocol.
D. AMF panels shall be fitted with a PLC based Digital Logic Controller which includes generator protection relays as noted in the Contract documents.
E. Provide necessary line voltage monitoring system at changeover panel/AMF panel.

2.5.5.19 DG SYNCHRONIZATION

A. This section covers synchronisation of DG sets as required and comprises of running DG set in parallel I.e. their synchronization on common bus bar, auto load sharing and auto load management. **Hard and redundant system shall be considered in DG synchronization. (Controlling by DG Sensing cable as well as BMS). Controller should be compatible for BACNET/MODBUS protocol.**
Annunciation Panel (indicating DG backed panel status) for indication and alarm should be a part of DG Synchronization panel.

B. PLC PANEL
   1. 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.
   2. Panel shall include for synchronisation check relay. OEM/bidder to provide acceptable voltage and frequency window for successful synchronisation.
   3. 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 interrupting/tripping. The logic panel shall complete with all auxiliary relays, timers, contactors, programmable logic controllers, control wiring, interconnections, etc. with suitable PVC insulated, 1.1kV grade copper conductor control wires.

C. CONTROL PHILOSOPHY
   1. Automatic start & stop
   2. The system should come in operation after sensing of EB 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 shall appear on annunciation panel/Human 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 tripping the DGs should also be part of inbuilt system.

D. 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 closure of ACB must be available automatically. In manual mode ACB will be closed by panel push button

E. Automatic Load sharing
   1. The load sharing will also be automatic, by sensing both active & reactive power.
   2. Load sharing and shedding logic to be prepare by DG contractor as per the project requirment.

F. Back up protection
   1. The system should also have following inbuilt protection other than external relays in synchronisation panel:

2. Reverse power, reverse kVAR, Over current, under voltage, over voltage, under frequency, restricted earth fault, over frequency, synchro-check & earth fault relay except differential relay. Due to any electrical fault PLC shall trigger the master trip relay.
3. These PLC will be start of the art equipment 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 below.

G. Sequence of operation

1. The following sequence of operation shall be achieved through PLC based logic panel in addition to hardware interlocks as well as software interlocks:
2. Selection of any generator as a lead generator to achieve uniform running hours of all generators.
3. Three attempts to start the engine of lead generator. In the case of engine fails to start or does not achieve requisite speed within the predetermined time, PLC system declares engine of generator faulty. In this event PLC automatically select next generators as the lead generators.
4. The PLC system automatically selects starting sequence of other generators on the basis of the lead generator being selected by the operator.
5. 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.
6. 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.
7. When the lead generator kW crosses more than 85% of rated capacity of DG set, the PLC system performs synchronisation sequence for paralleling of generator prior to switching on of ACB of 2nd generator and bus coupler as shown in SLD.
8. The last incoming ACB is tripped when PLC system senses that the total load on the system is less than the specified load and stops the engine 5 minutes of idle running. DG sets will start & stop automatically depending on the pre-defined load setting in the PLC & also all DG sets will operate in load sharing mode.

H. TRANSFER OF POWER FROM NORMAL TO GENERATOR POWER SUPPLY AND FROM GENERATOR SUPPLY TO NORMAL POWER AUTOMATICALLY
   1. In the case of failure of Utility fed normal power supply
   2. Generator to start after a prefixed time of three second on any of the following conditions:
      i. Total absence of voltage.
      ii. Failure of one or two phases.
      iii. Under voltage below 380 volts.
   3. After a lapse of 10-12 seconds normal power supply breaker to open and Generator supply breaker to close.
   4. All auxiliaries (D.G. Sets Radiator Fans, Pump etc.) to start & run automatically.
   5. In the case of emergency load requirement of up to 60% load, only one DG set will crank. If requirement exceeds 60% load, 2nd DG will and load manager will share equal load on each DG set.
   6. In case of blackout condition (complete utility shutdown), both DG set will start at the same time and load manager will share equal load on each DG.
   7. In case of DG overloading, load shedding can be done depending upon priority as mentioned in tender document.
   8. In the case of resumption of Normal Power supply :
      a. Breakers change back will be manually carried out at each MLTP
   9. Generator to over run for the three minutes and stop automatically.
   10. All auxiliaries to stop automatically.
   11. Generator to be ready for the next operation automatically.

2.5.5.20 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Air Circuit Break fitted with Microprocessor-based adjustable LSIG release to provide for time and current adjustment for Long, Short and Instantaneous time and current plus Ground Fault protection:
   1. Tripping Characteristic: Designed specifically for generator protection.

2. Trip Rating: Matched to generator rating.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signalled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:

C. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.

D. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.

E. As over-current heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.

F. Senses clearing of a fault by other over-current devices and controls recovery of rated voltage to avoid overshoot.

G. Ground-Fault Indication: it shall give Integrate ground-fault alarm indication with other generator-set alarm indications.

H. Please refer following specification which shall be read in conjunction with this specification:-

1. SECTION-2.7 LV SWITCHGEAR R1
2. SECTION-2.8 SURGE SUPPRESSOR R0
3. SECTION-2.12 EARTHING R1
4. SECTION-2.14 CONTAINMENT R1
5. SECTION-2.21 IDENTIFICATION LABEL P0
6. SECTION-2.6 LV CABLE R1

2.5.5.21 DG ROOM Ventilation

A. Tube Axial Fan

1. Fans shall be direct driven Tube axial type. Fans shall be complete with motor, drive arrangement, motor mount, and vibration isolation arrangement as per approved for construction shop drawings.
2. Casing shall be constructed of 14 gauge sheet steel. Fan casing and motor mount shall be of welded steel construction. Motor mounting plate shall be minimum 12 mm thick and machined to receive motor flange. Casing shall be provided with wide hinged doors which should open easily for removal of wheel, shaft and bearings. A small inspection door with handle and neoprene gasket shall also be provided. Casing shall have flanged connection on both ends for ducted applications. Support brackets for ceiling suspension shall be welded to the casing for connection to hanger bolts. Straightening vanes shall be aerodynamically designed for maximum efficiency by converting velocity pressure to static pressure potential and minimizing turbulence. Casing shall be primed and finish coated with enamel paint.
3. Rotor hub and blades shall be cast aluminum construction. Blades shall be die formed airfoil shaped for maximum efficiency and shall vary in width from hub to top to effect equal air distribution along the blade length. Fan blades mounting on the hub shall be statically and dynamically balanced. Maximum clearance between blade tip and fan housing at the specified duty blade setting shall be 5 mm. Rotor blades shall be whirl tested to a speed of 25% above the design operating speed and certification of the test shall be provided by the manufacturer. Extended grease leads for external lubrication shall be provided. Rotor shall be statically and dynamically balanced. The fan pitch control shall be manually readjusted at site upon installation for obtaining actual air flow values as specified and quoted.
4. Motor shall be squirrel cage, totally-enclosed, fan cooled, standard frame, constant speed, continuous duty, suitable for 415 ± 6% volts 50 cycles, 3 phase power supply as per latest IS specifications. Motor nameplate horsepower shall exceed brake horsepower by a minimum of 20%..Motors shall be quiet operation and motor speed shall not exceed 1500 rpm. For lowest sound level, fan shall be selected for maximum efficiency or minimum horsepower. Motor conduit box shall be mounted on exterior of fan casing, and lead wires from the motor to the conduit box shall be protected from the air stream by enclosing in a flexible conduit.
5. Motor starters shall be automatic direct on line for rating up to 7.5 H.P. and automatic Star Delta for motors 10 HP & above. The starters shall incorporate

(a) thermal overload
(b) under voltage protection
(c) single phase preventor are to be included in the prices of starter panels.

6. Drive to fan shall be direct driven.
7. Vibration Isolation: The assembly of fan and motor shall be suspended from the ceiling or mounted on walls by vibration isolators.
8. Accessories : The following accessories shall be provided with all fans:
   i. Outlet cone for static pressure regain.
   ii. Inlet cone.
   iii. Fan silencers, if required.
   iv. Wire guards on fan outlet / inlet not connected to duct work and shall be made freely accessible for maintenance.
   v. Fans shall be factory assembled and shipped with all accessories factory-mounted. For smoke extraction fans, the gaskets shall be suitable for continuous operation in an air stream temperature of 250℃ for two hour or 300^{0}C for one hour.

B. GI Ducting

1. Galvanizing shall be Class VIII – light coating of zinc, nominal 120gm/sq.m surface area and Lock Forming Quality prime material along with mill test certificates. In addition, if deemed necessary, samples of raw material, selected at random by Employer's Representative/consultant shall be subject to approval and tested for thickness and zinc coating at contractor's expense.

2. Fabrication of ducts shall be through well-conditioned Triplex lock former or multiple lock formers, conforming to relevant SMACNA Codes.

Rectangular Ducts G.S.	External Pressure 250 Pa		
	Duct Selection Length 1.2 Mtr. (4 feet)		
Mximum Duct Size	Guage	Joint Type	Bracing Spacing
1-750 mm	26	C & SS	Nil
750 - 1000 mm	26	4 Bolt Transverse Duct Connector - E (TDC) with built in sealant	Nil
1001 - 1200 mm	24	4 bollt TDC – E	Nil
1201 - 1500 mm	24	4 bollt TDC – H	Nil
1501 - 1800 mm	22	4 bollt TDC – H	Nil
1801 - 2100 mm	20	4 bollt TDC – J	Nil
2101 - 2700 mm	18	4 bollt TDC – J	Nil

'C'-cleat; 'S'-S cleat; 'SS'-Standing S cleat; 'AI' -Angle Iron in mm
*Distance of reinforcement/bracing from each joint. Bracing material to be same as of material used for joining of duct sections.

All exhaust air duct connected from DG to louver shall be 18G GI with MS flanges irrespective of DG size.

3. Fabrication Standards & Equipment

a. All duct construction and installation shall be in accordance with SMACNA standards. In addition ducts shall be factory fabricated utilizing the following machines to provide the requisite quality of ducts.
a. Coil (Sheet metal in Roll Form) lines to facilitate location of longitudinal seams at corners/folded edges only, for required duct rigidity and leakage free characteristics. No longitudinal seams permitted along any face side of the duct.
b. All ducts, transformation pieces and fittings to be made on CNC profile cutter for requisite accuracy of dimensions, location and dimensions of notches at the folding lines.
c. All edges to be machine treated using lock formers, flanges and rollers for turning up edges.
d. All ducts shall be fabricated and installed in workmanlike manner, generally conforming to relevant SMACNA Codes. Round exposed ducts shall be die-formed for achieving perfect circle configuration.
e. Ducts so identified on the Drawings shall be acoustically lined and insulated from outside as described in the section “Insulation” and as indicated in Schedule of Quantities. Duct dimensions shown on Drawings are overall sheet metal dimensions inclusive of the acoustic lining where required and indicated in Schedule of Quantities.
f. Ducts shall be straight and smooth on the inside with neatly finished joints. All joints shall be made air tight.
g. All exposed ducts up to 60 cm width within conditioned spaces shall have slip joints - or flanged joints. The internal ends of slip joints shall be in the direction of air flow. Ducts and accessories within ceiling spaces, visible from air conditioned areas shall be provided with two coats of mat black finish paint.
h. Changes in dimensions and shape of ducts shall be gradual. Air-turns (Vanes) shall be installed in all bends and duct collars designed to permit the air to make the turn without appreciable turbulence’s. Ducts shall be fabricated as per details shown on Drawings. All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees, or angles, of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.
i. All sheet metal connection, partitions and plenums required to confine the flow of air to and through the filters and fans shall be constructed of 18 gage GSS / 16 gauge aluminum, thoroughly stiffened with 25 mm x 25 mm x 3 mm galvanized steel angle braces and fitted with all necessary inspection doors as required, to give access to all parts of the apparatus. Doors shall be not less than 45 cm x 45 cm in size.
j. Plenums shall be panel type and assembled at site. Fixing of galvanized angle flanges on duct pieces shall be with rivets heads inside i.e. towards G S sheet and riveting shall be done from outside.
k. Self adhesive rubber lining minimum 5 mm thick instead of felt shall be used between duct flanges and between duct and duct supports in all ducting installation.
l. All ducts shall be installed generally as per tender Drawings, and in strict accordance with approved shop drawings to be prepared by the Contractor.
m. The Contractor shall provide and neatly erect all sheet metal work as may be required to carry out the intent of these Specifications and Drawings. The work shall meet with the approval of Owner’s site representative in all its parts and details.
n. All necessary allowances and provisions shall be made by the Contractor for beams, pipes, or other obstructions in the building, whether or not the same are shown on the Drawings. Where necessary to avoid beams or other structural work, plumbing or other pipes, and conduits, the ducts shall be transformed, divided or curved to one side (the required area being maintained) all as per the site requirements.
o. If a duct cannot be run as shown on the Drawings, the Contractor shall install the duct between the required points by any path available, in accordance with other services and as per approval of Owner’s site representative.
p. All duct work shall be independently supported from building construction. All horizontal ducts shall be rigidly and securely supported, in an approved manner, with trapeze hangers formed of galvanized steel rods and galvanized steel angle/channel under ducts at no greater than 2 meter centre. All vertical duct work shall be supported by structural members on each floor slab. Duct supports may be through galvanised steel insert plates left in slab at the time of slab casting. Galvanised steel cleat with a hole for passing the hanger rods shall be welded to the plates. Trapeze hanger formed of galvanized steel rods and angles/ channels shall be hung through these cleats. Wherever use of metal insert plates is not feasible, duct support shall be through dash /anchor fastener driven into the concrete slab by electrically operated gun. Hanger rods shall then hang through the cleats.

q. Ducting over furred ceiling shall be supported from the slab above, or from beams, after obtaining approval of Owner's site representative. In no case shall any duct be supported from false ceiling hangers or be permitted to rest on false ceiling. All

r. metal work in dead or furred down spaces shall be erected in time to occasion no delay to other Contractor's work in the building.

s. Where ducts pass through brick or masonry openings, it shall be provided with 25 mm thick TF quality expanded polystyrene around the duct and totally covered with fire sealant such as fire barrier mortar for complete sealing.

t. All ducts shall be totally free from vibration under all conditions of operation. Whenever duct work is connected to fans, air handling units or blower coil units that may cause vibration in the ducts, ducts shall be provided with a flexible connection, located at the unit discharge. Flexible connections shall be constructed of flame retardant, water proof, silicon rubber impregnated flexible connection at least 10 cm long securely bonded and flange bolted on both sides. Sleeve shall be made smooth and the connecting duct work rigidly held by independent supports on both sides of the flexible connection. The flexible connection shall be suitable for pressure at the point of installation.

u. Duct shall not rest on false ceiling and shall be in level from bottom. Taper pieces shall taper from top.

C. Fire retardant canvas Flexible Connections

A. Flexible connectors at inlet and discharge to air handling equipment shall be pre-assembled 0.7 mm galvanized steel with minimum of 150 mm width (exposed) fire resistant fabric. For higher pressure applications 25 mm of width of fabric shall be used for each 25 mm of static pressure.
Flexible connectors attached to acoustically treated ductwork shall be insulated with 25 mm Fibre glass insulation packed between flexible connector and 16 gauge (1.5 mm) galvanized steel housing. At equipment collar caulk between collar and flange on housing with 10 mm thick permanently flexible sealant. Care shall be taken to ensure that ducts on both sides of the connection are independently supported and that no "bridging" occurs.
The fabric shall be rated for use up he material shall also be impervious to moisture, dimensionally stable, and

B. Dampers
a. All duct dampers shall be opposed blade louver dampers of robust 16 G GSS construction and tight fitting. The design, method of handling and control shall be suitable for the location and service required.
b. Dampers shall be provided with suitable links levers and quadrants as required for their proper operation. Control or setting device shall be made robust, easily operable and accessible through suitable access door in the duct. Every damper shall have an indicating device clearly showing the damper position at all times.
c. Dampers shall be placed in ducts at every branch supply or return air duct connection, whether or not indicated on the Drawings, for the proper volume control and balancing of the air distribution system.

D. LOUVERS

a. Materials of Construction / Fabrication: Louvers shall generally be fabricated from extruded aluminum sections with mitered joints; unless otherwise stated or dictated by selection with minimum free area of 60%.

b. Finishing:

Louvers shall have anodized / polyester powder coated colored finish, selected to match with the surrounding architectural finishes.

c. Manufactures to submit performance data based on AMCA 500 - Test Method for Louvers, Dampers and Shutters

d. Construction :

Single angled louvers of 2.5 mm (12 gauge) thick, 100 mm (4 inch) deep blades set at 45° slope with centre baffle and return bend; set in heavy channel frame.

e. Accessories (for air intake):

i) Exterior flat flange for installation on walls

ii) 19 mm (3/4 inch) square mesh, bird screen; opposed blade, gang operated, volume control damper with removable key operator, adjustable from the grill face

iii) 100 mm (4 inch) panel type washable air filter

f. Accessories (for exhaust):
13 mm (½ inch) square mesh, bird screen

g. Louvers which are adjacent to the car park / habitable area shall be of accoustic type and shall be capable of reducing the noise levels upto acceptable limits as specified.

E. Sound Attenuators

1. Attenuators shall be installed in ducts in accordance with requirements of drawings and as included in Schedule of Quantities.
   a. Noise levels within conditioned spaces shall be not greater than those set out in schedule below :
   b. Noise Level Design Criteria

S.No.	Area Acceptable Noise	Levels (NC)
A.	Plant room Areas	45-50

2. Attenuators shall be of steel construction with casings out of minimum 22 G galvanized steel. Acoustic fill shall be inert, non-hygroscopic, vermin proof, fiber glass of required density adequately protected against corrosion and covered with 26 Gauge perforated aluminum sheet. Attenuators shall be supplied complete with flanges.
3. Acoustic performance of the attenuators (net insertion loss) shall meet or exceed the values listed below

	OCTAVE BAND CENTRE FREQUENCY HZ							
	63	125	250	500	1K	2K	4K	8K
Insertion loss dB 900 mm long attenuators	22	7	12	19	23	23		11
Insertion loss dB 1500 mm long attenuators	6	10	18	30	42	3 4	23	14

4. The pressure drop values of the silencers shall be indicated for each duty.
5. Manufacturers shall submit a test certificate for acoustic and aerodynamic performance of the attenuators. Attenuators shall be tested in accordance with ACMA test methods/BS 4718 and insertion loss and self-generated noise for each octave band and pressure drop shall be stated in the schedule.
6. Contractor shall submit detailed acoustic calculation along with sound attenuator selection.

F. Protective cladding

All piping and duct which are insulated shall be cladded with 26 G aluminium sheet

2.5.6 EXECUTION

2.5.6.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

2.5.6.2 INSTALLATION

A. All equipment and components shall be installed in strict compliance with manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring & fiber optic diagrams, schematics, physical equipment sizes, etc., before beginning system installation. Refer to the riser/connection diagram for all specific system installation /termination / wiring data.

B. The installation should be as per statutory requirements & as recommended by the major equipment manufacturer.

C. All minor civil works such as opening-up false ceiling, boxing, rack coverings, partition walls, making openings, cut-outs, chases, grooves, etc. in walls, floors, making good the civil work, construction brick/concrete pedestals, supports etc. including all materials required during installation shall be carried out by the contractor at no additional cost to the Employer.

D. All conduits, junction boxes shall be concealed throughout. Wherever conduits, trunking or raceways are already installed by the Employer, the cables/wires shall be installed through that. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period measures shall be taken to protect detectors and other items from contamination, physical damage and theft.

E. All termination at the panel & field equipment's shall be checked & rectified if required in coordination with the installation team.

F. Continuity Resistance value of cable (Megger value) shall be checked & recorded. It should show resistance in mega ohms.

G. Interference suppression arrangements shall be ascertained.

H. In general, the entire installation shall be inspected and all shortcomings shall be brought to the notice of the Project Manager/Engineer Necessary rectification shall be carried out by the installation engineer.

I. The system shall be tested as brought out in System Feature and Manufacturer's Manual. Handing over personnel shall co-ordinate with the system integrator. A handing over report shall be prepared. All tests conducted shall be repeated in the presence of the Employer's Representative. Operating Instructions/ Maintenance manuals shall be prepared and handed over to the Employer's Representative. As built drawing shall be part of this document. The Employer's Representative team shall be trained to operate and maintain the system.

J. Mains simulation tests shall be carried out. If required, adjustment to PLC digital logic controller shall be done. The tests shall be carried out for checkup sequential operation of following devices:
   i. Tripping power supply and load acceptance of the DG System
   ii. Manual transfer back of supply to mains and auto run-on of the DG system

K. Faults found tests of various devices shall be noted down and rectified.

L. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NBC 2016

M. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

N. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 1 inch on 4-inch- high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base.

O. Install black steel piping with welded joints for cooling water piping between engine-generator set and heat exchanger.

P. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector.

Q. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

R. Acoustic Treatment: Installation of acoustic panels and louvers complete as per the approved Dwg, site condition & the standards.

S. Piping System

1. Piping System Preparation
   i. Close equipment shutoff valves before turning off fuel oil to premises or piping section.
   ii. Comply with BS EN 60079 requirements for prevention of accidental ignition.

2. Indoor Piping Installation
   i. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
   ii. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
   iii. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
   iv. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
   v. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
   vi. F Install piping free of sags and bends.
   vii. Install fittings for changes in direction and branch connections.
   viii. Verify final equipment locations for roughing-in.
   ix. Comply with requirements for equipment specifications in Y10&Y11 Sections for roughing-in requirements.
   x. Conceal pipe installations in walls, pipe spaces, or utility spaces; above ceilings; below grade or floors; and in floor channels unless indicated to be exposed to view.
   xi. No pipe to pipe connections are allowed, it shall be strictly through the weldolet fittings.
   xii. Prohibited locations:
      a. Do not install fuel-oil piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts
      b. Do not install fuel-oil piping in solid walls or partitions.
   xiii. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
   xiv. Connect branch piping from top or side of horizontal piping.
   xv. Install unions in pipes DN 50 and smaller at final connection to each piece of equipment and elsewhere as indicated. Unions are not required on flanged devices.
   xvi. Do not use fuel-oil piping as grounding electrode.
   xvii. Install strainer on inlet side of fuel-oil pump.
   xviii. Install sleeves for piping penetrations of walls, ceilings, and floors.

xix. Install sleeve seals for piping penetrations of concrete walls and slabs.

xx. S Install cover plates for piping penetrations of walls, ceilings, and floors.

xxi. Valve Installation

a. Install manual fuel-oil shutoff valves on branch connections to fuel-oil appliance.

b. Install valves in accessible locations.

c. Protect valves from physical damage.

d. Install metal tag attached with metal chain indicating fuel-oil piping systems.

e. Identify valves.

f. Install oil safety valves at inlet of each oil-fired appliance.

g. Install pressure relief valves in distribution piping between the supply and return lines.

h. Install one-piece, bronze ball valve with hose end connection at low points in fuel-oil piping.

i. Install manual air vents at high points in fuel-oil piping.

j. Install emergency shutoff valves at building entry points.

3. Piping Joint Construction
   i. Ream ends of pipes and tubes and remove burrs.
   ii. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

4. Threaded Joints: Join pipe fittings and valves as follows:
   i. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified
   ii. Damaged threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

5. Welded joints: Construct joints using qualified processes and welding operators:
   i. Bevel plain ends of steel pipe
   ii. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

6. Flanged joints: Install gasket material, size, type, and thickness for service application. Install gasket concentrically positioned.

7. Fuel-Oil AST Installation
   i. Install tank bases and supports and comply with BS 799-5. Design supports and foundations to accept the loading that would occur if the tanks were completely full of water. Ensure that the bearing capacity of the ground has been assessed and is adequate for the proposed installation. Ensure that tanks are designed to take account of wind loadings including when empty.
   ii. Provide a suitable means to prevent moisture accumulation between the metal tank plates and the supports on which they rest. Use a waterproof mastic membrane.
   iii. Where vertical tanks are placed directly on foundations (e.g. vertical tanks), the foundation ring of the tank should be sealed to the foundation with a bitumastic compound. Shape compound so that water drains away from the toe of the tank.
   iv. Painting and cleaning should be in accordance with BS799-5. The external surfaces of the tanks should be thoroughly cleaned and free from rust, oil or grease and protected with a suitable rust inhibiting primer by the manufacturer. Use a zinc rich metallic priming paint to BS4652 and gloss finishing coat where indicated. Comply with requirements of BS54693 and BS6150.
   v. Ensure that gloss finishing paints are of machine finish grade having high adhesion, high resistance to solvents, mineral oils, chipping and impact damage.

vi. The following types of paint and preparations will be considered acceptable:

c. Ferrous metal - Internal - zinc rich primer to BS 5493 Table 4F Type PF3A (min 40% zinc phosphate) plus oil based flat finish

d. Ferrous metal - External or damp conditions - 2 Pack epoxy zinc phosphate primer to BS 5493 Table 4K Type KP1A.

vii. Internal surfaces should be wire brushed but not painted except for the underside of roof on large vertical tanks which should have a primer applied.

viii. Connect piping and vent fittings.

ix. Install ground connections.

x. Install tank leak-detection and monitoring devices.

xi. Install steel ASTs according to BS799.

xii. Install insulated and concrete-vaulted, steel ASTs according to BS799.

xiii. Fill storage tanks with fuel oil.

8. Transfer Pumps:
   i. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories
   ii. Set pumps on and anchor to concrete base.
   iii. Install two-piece, full-port ball valves at suction and discharge of pumps.
   iv. Install mechanical leak-detector valves at pump discharge.
   v. Install strainers on inlet side of simplex fuel-oil pumps.
   vi. Install check valve on discharge of simplex fuel-oil pumps.
   vii. Install suction piping with minimum fittings and change of direction.
   viii. Install vacuum and pressure gage, upstream and downstream respectively, at each pump to measure the differential pressure across the pump.

9. Liquid-Level Gage System Installation
   i. Install liquid-level gage system. Locate panel inside DG Room.

10. Leak-Detection And Monitoring System Installation
   i. Install leak-detection and monitoring system. Install alarm panel inside building where indicated:
   ii. Double-wall, fuel-oil storage tanks: Install probes or use factory-installed integral probes in interstitial space
   iii. Double-containment, fuel-oil piping: Install leak-detection sensor probes in fuel-oil storage tank containment sumps and at low points in piping
   iv. Install liquid-level gage.

11. Connections
   i. Install piping adjacent to equipment to allow service and maintenance.
   ii. Install unions, in piping DN 50 and smaller, adjacent to each valve and at final connection to each piece of equipment having threaded pipe connection.
   iii. Install flanges, in piping DN 65 and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
   iv. Connect piping to equipment with ball valve and union. Install union between valve and equipment.
   v. Install flexible piping connectors at final connection to burners or oil-fired appliances that must be moved for maintenance access.

12. Labelling And Identifying
   i. Nameplates, pipe identification, and signs

ii. Equipment nameplates and signs: Install engraved plastic-laminate equipment nameplates and signs on or near each service regulator, and service meter:

iii. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

iv. Install detectable warning tape directly above fuel-oil piping, 300 mm below finished ground level, except 150 mm below pavements and slabs. Terminate tracer wire in an accessible area, and identify as "tracer wire" for future use with plastic-laminate sign:

a. Piping: Over underground fuel-oil distribution piping

b. Fuel-oil storage tanks: Over edges of each UST.

13. Field Painting Of Above Ground Storage Tanks

i. After cleaning, remove dust or residue from cleaned surfaces.

ii. If surfaces develop rust before prime coat is applied, repeat surface preparation.

iii. Prepare surface of AST and supports and apply painting systems according to this specification "High-Performance Coatings" for severe environment high-gloss finish for ferrous metal.

ii. Field Painting Of Aboveground Piping

i. Paint exposed, exterior metal piping, valves, and piping specialties, except components with field applied paint or protective coating:

a. Alkyd System: MPI EXT 5.1D:

b. Prime coat: Alkyd anticorrosive metal primer

c. For a premium grade system, "MPI Manual" requires intermediate coat; delete intermediate coat for a custom grade system

d. Intermediate coat: Exterior alkyd enamel matching topcoat

e. Topcoat: Exterior alkyd enamel gloss

f. Colour: BS colour for oil (Brown).

iii. Damage and touch-up: Repair marred and damaged applied finishes with materials and by procedures to match original.

iv. Concrete Bases

i. Concrete bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions.

14. CONNECTIONS

i. Piping installation requirements as per IS Standards & vendor’s drawings.
ii. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
iii. Connect cooling-system water piping to engine-generator set and heat exchanger with flexible connectors.
iv. Connect engine exhaust pipe to engine with flexible connector.
v. Connect fuel piping to engines with a gate valve and union and flexible connector.
vi. Ground equipment as per to IS & IE rules.

2.5.6.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

All the testing and calibration shall be done using applicable standards and IPMVP protocols as required. PRE-COMMISSIONING CHECKS

C. Perform tests and inspections and prepare test reports.
DG sets shall be tested at varying loads at manufacturer's works/ site prior to dispatch of the sets to site. The performance tests at the works shall be carried out in presence of authorized representative from Lodha. Due notice for the programme of performance testing at works shall be given to the client to enable them to arrange for their representatives for this inspection to be at manufacturers works/ site for this inspection and testing.

First fill of Diesel shall be considered after site load testing.

The performance test on each DG sets shall be of minimum 12 hours duration. It should also include measurement of noise and emission as per standards and CPCB guidelines. Vibration measurement shall also be done as per engine manufacturer's recommendation and ISO – 8528 Part - 9.

All instruments, materials, consumables (fuel oil, lube oil etc.) load and labour required for carrying out of the test shall be provided by the Contractor. Following test acceptance criteria shall be applicable.

a.	Fuel consumption at 25%, 50%, 75%, 100% and 110% load.	±5% of guaranteed performance. Actual alternator efficiencies as determined in the manufacturer's works tests shall be used as the basis of calculation of specific fuel consumption ratio.
b.	Voltage regulation from no load to full load	± 1%
c.	Frequency regulation from no load to full load	± 0.5%
d.	Maximum water temperature	± 5% of guaranteed performance
e.	Maximum lube oil temperature	± 5% of guaranteed performance
f.	Minimum lube oil pressure	± 5% of guaranteed performance
g.	Lub Oil consumption	± 5% of guaranteed performance

The test profile for the factory acceptance tests shall be as follows:

Load%	Duration
0	15 mins
25	15 mins
50	15 mins
75	15 mins
100	7 hrs
110	1 hr

Also, following technical data shall be provided to Commissioning agent:-

a. Minimum thermal efficiency of DG set.

b. Auxiliary Power Consumption, kW.

c. Fuel Consumption (Lt/Hr) at 75% and 50% load.

d. Fuel consumption tolerance (shall not exceed by 5%).

e. Specific Fuel Consumption (Lt/kWH generated)

D. Tests and Inspections:

A. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

   a. Inspection shall be based on completed Record Drawings and system documentation that is required by NEC.

2. System Testing and Inspections as follows to be followed:

   a. Lubrication System
      1) Check, top-up or renew lubricating oil in the engine and turbo-charger systems
      2) Service the filters – check pressure drops; fit new elements and joints; clean bowls
      3) Take oil samples for laboratory analysis
      4) Inspect for leakages
   b. Fuel System
      1) Drain water and sediment from filter bowls and water traps
      2) Service the filters – renew elements and joint rings; clean bowls
      3) Check fuel pump(s) drives
      4) Service or renew fuel injectors
      5) Check injection pump timing
      6) Check / adjust control linkages between governors and injection pumps (where applicable)
   c. Cooling System
      1) Check coolant levels; top-up where necessary
      2) Check specific gravity of coolant mixture and its pH value
      3) Service raw water pumps; replenish oil cups; drain system; clean filters and refit.
      4) Service heat exchanger tube packs
   d. Air Induction System
      1) Check restriction indicators; reset after filters have been serviced
      2) Service air cleaners; wash elements in warm solution of detergent or paraffin (as applicable) check sealing rings; clean intake ducting
   e. Turbochargers
      1) Checks for security, and exhaust systems leaks
      2) Clean compressor and check bearings
      3) Check s for freedom or rotation
      4) Remove and check induction trunking
   f. Cylinder heads
      1) Check tightness of holding-down set bolts and nuts
      2) Check tappet clearances, adjust if necessary
   g. Switchgear
      1) Clean equipment and check all connections for tightness
      2) Test all main and control fuses (or protective devices)
      3) Check indicator lamps at all local and remote positions; replace were necessary
      4) Check the insulation resistance of all control wiring
      5) Check contact alignment, contact pressure and blow-out arc chutes
      6) Checking main and auxiliary connections for tightness
      7) Cleaning insulators and visually inspecting them for cracks
      8) Check insulation to earth of all auxiliary and control wiring; checking the resistance of shunt trip and closing coils
      9) Checking operation of power switching device from all control points, including emergency stopping stations from the protection relays.
   h. General
      1) Check condition and tension of drive belts
      2) Check electrical auxiliaries such as starter motors and battery charging alternators: grease bearings; clean slip rings; check bush gear

3) Check drain cocks and water traps on air starting systems, replenish air line lubricator with clean oil
4) Check operation of all alarm and shutdown switches
5) Investigate and rectify any incidents recorded in operating logs
6) Check crankcase breathers; clean filter elements

i. Completion checks
1) Clean exterior and check holding-down bolts/ dowels
2) Clean Air grilles / meshes and air filters (if fitted) replace filter elements if necessary
3) Inspect tubes of air cooled or water cooled heat exchangers; clean if necessary with compressed air or a non-metallic tube brush
4) Check security of terminals and clean out terminal boxes if necessary
5) Check insulation resistance and winding continunity
6) Check continunity of conditioned heaters
7) Check embedded (stator) temperature detector circuits
8) Check frame earth connections for security and continunity
9) Check natural earth connections for security and continunity
10) Grease bearings with OEM approved grease using a gun
11) Drain oil from sleeve bearings; inspect for signs of uneven wear or overheating; clean with flushing oil; record salient dimensions; refill with the specified grade oil, to the correct level
12) Check stator / rotor radial air gap readings and record results
13) Check all rotating diodes on brushless machines; care should be taken when screwing diodes back into their assemblies. Use a torque wrench for this purpose
14) Inspect the automatic voltage regulator; check for loose connections and retighten if necessary; dry out if moisture is present; remove any dirt with fine brush.

j. Battery
1) Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
2) Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
3) Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
4) Verify acceptance of charge for each element of the battery after discharge.
5) Verify that measurements are within manufacturer's specifications.
6) Verify specified rates of charge for both equalizing and float charging conditions.

k. Exhaust-System
1) Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
2) Exhaust Emissions Test: Comply with applicable government test criteria (MPCB/CPCB).

l. Voltage and Frequency Transient Stability Tests
1) Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.

m. Harmonic-Content Tests
1) Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

n. Noise Level Tests
1) Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.

o. Infrared Scanning
1) After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.

3) Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
4) Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

B. Coordinate tests with tests for transfer switches and run them concurrently.

C. Test instruments shall have been calibrated within the last 12 months, traceable to standards of and adequate for making positive observation of test results. Make calibration records available for examination on request.

D. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

E. Annual Test and Inspection: One year after date of Substantial carry out the following tests:

1. General
   a. Clean exterior and blow out any fitted air ducts
   b. Check sleeve bearing for wear; ensure lubrication holes and oil ways are not obstructed
   c. Check ball and roller bearings; renew if required; otherwise degrease; pre-oil and repack with OEM approved grease ready for reassembly
   d. Check rotors (main and exciter) for any signs of rubbing with their stators
   e. Examine the stator windings for any signs of visible damage
   f. Check the stator laminations are free from burrs and the that ventilation airways are free from obstructions
   g. Thoroughly clean all major components of the machine.
   h. Replace all gasket materials or sealing components where necessary
   i. Check cleanliness of all terminal boxes
   j. Check that sleeve bearings are filled with OEM specified oil

2. Switchgear
   a. Clean equipment and check all connections for tightness
   b. Test all main and control fuses (or protective devices)
   c. Check indicator lamps at all local and remote positions; replace were necessary
   d. Check the insulation resistance of all control wiring
   e. Check contact alignment, contact pressure and blow-out arc chutes
   f. Checking main and auxiliary connections for tightness
   g. Cleaning insulators and visually inspecting them for cracks
   h. Check insulation to earth of all auxiliary and control wiring; checking the resistance of shunt trip and closing coils
   i. Checking operation of power switching device from all control points, including emergency stopping stations from the protection relays.

F. Cable shall be tested at site for insulation between phases and between phase and earth for each length of cable, before and after jointing.

G. On completion of cable laying work, the following tests shall be conducted in the presence of the Employer representative.

1. Insulation Resistance Test(Sectional and overall)
2. Continuity resistance test.
3. Earth test.

H. Piping Field Quality Control

a. A Manufacturer's field service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

b. Perform tests and inspections.

c. Manufacturer's field service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

d. Tests and inspections:

1) Tank and pipe test pressures in this article are required by BS799. Verify requirements with authorities having jurisdiction

2) Tanks: Minimum hydrostatic or compressed-air test pressures for fuel-oil storage tanks that have not been factory tested and do not bear the QA code stamp or a listing mark acceptable to authorities having jurisdiction

3) Maintain the test pressure for one hour

4) Inspect and test fuel-oil piping according to BS799 and according to requirements of authorities having jurisdiction

5) Test liquid-level gage for accuracy by manually measuring fuel-oil levels at not less than three different depths while filling tank and checking against gage indication

6) Test leak-detection and monitoring system for accuracy by manually operating sensors and checking against alarm panel indication

7) Start fuel-oil transfer pumps to verify for proper operation of pump and check for leaks

8) Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment

9) Bleed air from fuel-oil piping using manual air vents.

e. Fuel-oil piping and equipment will be considered defective if it does not pass tests and inspections.

f. Prepare test and inspection reports.

E. TYPE TEST:- Copies of manufacturer's type test for the engine and the alternator of all ratings shall be enclosed along with the dispatch of the DG sets. The contractor shall provide all necessary instruments and labour for testing. He shall make adequate records of test procedures and readings and shall repeat any tests requested by the Construction Manager/ Lodha's Site Representative/ Consultant. Test certificate duly signed by an authorized person shall be submitted for scrutiny.

If it is proved that the installation or part thereof is not satisfactorily carried out then the contractor shall be liable for the rectification and retesting of the same as called for by the Construction Manager/ architect/ Consultant/ Lodha's Site Representative. All tests shall be carried out in the presence of representative of Construction Manager/ architect/ Consultant/ Lodha's site representative.

The above general requirements as to testing shall be read in conjunction with any particular requirements specified elsewhere. All tests shall be carried out by a test house approved by the Construction Manager/ Consultant/ Lodha's Site Representative. The contractor besides above test shall carry out witness test for performance at full load at PF of 0.8.

F. COMPLETION CERTIFICATE
On completion of the Generator installation, a certificate shall be furnished by the contractor countersigned by the licensed electrical supervisor under whose direct supervision the installation was carried out. This certificate shall be in the prescribed form as required by the local supply authority.

G. TRAINING OF OWNER'S PERSONNEL FOR OPERATION AND MAINTENANCE
Upon completion of all work and all tests, the Contractor shall furnish necessary operators, labour and helpers for operating the entire installation for a period of fifteen (15) working days of ten (10) hours each, to enable the Owner's staff to get acquainted with the operation of the system. During this period,

the contractor shall train the Owner's personnel in the operation, adjustment and maintenance of all equipment installed.

The contractor must provide the training manuals for the operational staff prior to commissioning process. The draft training manuals must be submitted which shall be reviewed and approved by CA. Training manuals must clearly mention the training plan and the scope of training.

H. **BUILDING AUTOMATION SYSTEM (BAS) INTEGRATION**

The scope of Generator Contractor shall include the provision for BAS compatibility in the system equipment as following for the future interface to Building Automation System if any.

a. Stop/ Manual/ Auto switches along with potential free contacts for monitoring the manual operation status (wherever applicable), to be provided for those equipment whose start/ stop is controlled by Building Automation System.

b. Potential free 'NO' contacts for monitoring 'Run' status of equipment wherever required.

c. The installation of current transformer & Transducer along with wiring between Current Transformer & Transducer up to the terminal block shall be provided by the DG contractor.

d. Provide all necessary relays, contactors, current and potential transformers required by BAS system. CT's for BAS system shall be of 15 VA rating and of metering class. Also, adequate space in the panels shall be provided for mounting of electrical transducers as required.

It is to be clearly understood that the final responsibility for the sufficiency, adequacy and conformity to the contract requirements, lies solely with the Generator Contractors.

I. DEMONSTRATION

A. General: Manufacturer's factory-authorized service representative to train Employer's personnel in the operation of the DG Set.
B. Equipment: Check operation of each unit with Employer's personnel present and before Substantial Completion. Determine that operational systems and devices are functioning properly.
C. Instruction: Instruct Employer's personnel in proper use, maintenance, adjustment and repair of each system.

SCHEDULE OF TECHNICAL DATA

1. DG SET **(To be filled by the Bidder)**

a. Engine make

b. Alternator Make

c. Operating Duty

c. KVA Rating

d. KW rating

e. BHP Rating

f. Physical Dimensions

i. Length (mm)
ii. Width (mm)
iii. Height (mm)

g. Shipping Weight (Kg)

h. Engine Lube Capacity (Ltrs)

i. Fuel Consumption at NTP

i. 100% loading (ltrs/hr)
ii. 75% loading (ltrs/hr)
iii. 50% loading (ltrs/hr)

j. No. of Cylinder / Stroke

k. Power Factor

l. Efficiency (%)

m. System back Pressure (KPA)

n. Exhaust Flange

o. Exhaust Gas Flow Rate (CFM)

p. Compression Ratio

q. Heat Rejection to Exhaust System (KW)

r. Heat Rejection to Cooling System (KW)

s. Total Radiated Heat (KW)

t. Exhaust Temperature (℃)

2 AMF / SYNCHRONIZING & AUXILIARY PANEL

2.1 SWITCHGEAR CUBICLE

REFER LV PANEL DATA SHEET

3. WATER PIPING

a. VALVES & STRAINER — MAKE — MATERIAL

i. Butterfly valves

ii. Gate valve

iii. Globe valve

iv. Check valve

v. Ball valve

vi. Ball valve with strainer

vii. Balancing valve

viii. Pot Strainer

ix. Y-Strainer

b. Pressure Gauge

i. Make

ii. Range

iii. Dial Size

4. INSULATION

a. Manufacturer

b. Duct Acoustic lining material/density

5. VIBRATION ISOLATION SYSTEM

a. Manufacturer

b. Type

c. Deflection

SITE ACCEPTANCE TEST FORMAT

(SHALL BE PROVIDED BY CONTRACTOR)