### Diesel Generator Technical Specifications

#### Generator Unit (Set):

##### Diesel Engine

###### **General**

* The diesel engine shall be of the turbocharger, after cooled type with the following characteristics:
* The engine shall be of the vertical, four strokes, cold starting.
* The engine shall be capable of running satisfactorily with fuel oil and lubricating oil of grades and standards used in **Sana’a City – Yemen**.
* The engine speed regulation shall not exceed ± 10% for the momentary and ± 6% for the permanent change when the full load on the engine is suddenly thrown off or put on, respectively.
* Provision shall be made for varying the engine speed within 6% above or below the normal speed at all loads.
* The engine shall be provided with a control panel as mentioned hereafter.

###### **Engine Rating**

* The engine when running at 90% of its continuous rated output at site shall be capable of driving the alternator when delivering its full load output, i.e., the power of the engine shall be nearly 10% in excess of the power of the alternator.
* The engine shall be capable of supporting 10% overload for a period of two hrs. Running without sustaining any mechanical trouble or under heating, after 24 hours continuously running.

###### **Rated Speed of the Engine and Piston Speed**

* The speed of the engine shall not exceed 1500 RPM and the mean piston speed shall not exceed 10 m/sec.

###### **Mean Effective Pressure**

* The mean effective pressure inside the engine cylinder should not exceed 14 kg/cm2.

###### **Stroke-Bore Ratio**

* The average value of the stroke bore ratio will vary between 1.2 to 1.5.

###### **Supercharging**

* The supercharging of the diesel engine shall be achieved by means of charging blowers utilizing the energy of exhaust gases. An after cooler must be fitted in the air manifold for cooling air before entering the engine cylinders.

###### **Piston Cooling**

* The pistons may be oil cooled by means of an independent system using lubricating oil as coolant

###### **Cylinders, Liners and Cylinder Cover**

* The engine shall be multi-cylinder type provided with removable cylinder covers and renewable liners, furnished with water jacket of ample size, avoiding any pockets, which may cause accumulation of deposits from the cooling water.
* Each cylinder cover shall be fitted with a safety valve and a test cook for measuring the compression pressures inside the cylinder

###### **Duplex Fuel Oil Strainer and Filter**

* Fuel-flow strainers shall be provided ahead of the engine fuel pump. The fuel-flow filters shall be provided after the engine fuel pump. Strainers shall be of the metal edge or screen type as recommended by the engine manufacturer. The filter case shall have inlet and outlet connections plainly marked. The case shall be mounted in an accessible location, which will permit changing strainers and filter elements without disconnecting the piping or other engine-mounted equipment.

###### **Engine Fuel Pumps**

* Engine fuel pumps shall be of the positive-displacement, engine-driven type and capable of sullying the necessary quantity of fuel under all conditions of operation. Relief valves shall be provided to prevent equipment damage due to buildup of excessive pressures, which might result from restrictions in the discharge lines. In addition, a hand-operated fuel oil priming pump shall be provided.

###### **Fuel Oil Drip**

* Nozzle drip lines, overflow, … etc., shall not drain on the floor. Means shall be provided for collecting these lines and return of excess fuel to the day tank automatically.

###### **Fuel Oil Lines**

* Fuel oil lines shall be provided with solid connections between fuel piping and engine.

###### **Lubricating System**

* The engine lubricating system shall operate and be maintained at a predetermined constant pressure by means of an engine-driven positive-displacement lubricating oil pump. Relief valves, a pressure gauge, and automatic safety feature, to sound an alarm and shut down the engine at a predetermined lubrication oil pressure by closing contact, shall be supplied. To maintain proper oil temperature, if deemed necessary, lubrication system shall be provided with water cooler.

###### **Oil Cooler**

* One shell type or plate type cooler arranged to utilize engine-cooling water as the oil-cooling medium, shall be furnished with the engine. The capacity and construction of the unit shall be as recommended by the engine manufacturer. Suitable connections shall be furnished for connections between the engine, radiator, and oil cooler as required.

###### **Lubrication Oil Strainers and Filters**

* Duplex full-flow filters shall be provided in the lubrication. Oil line. The filters shall be of the cartridge type.

###### **Lubrication Oil Priming Pump**

* An electrically operated priming pump shall be provided for priming the engine lubricating system prior to starting. The pump shall be of suitable capacity. The pump shall be mounted on the engine and shall be factory completed. A manual pump shall also be provided as stand-by. Starting of engine without priming can be accept if the engines' manufacturer recommends it.

###### **Exhaust System**

* The exhaust system shall include a flexible section, condensate drain, muffler-silencer, weather cap and all necessary accessories.
* Exhaust piping shall be of the diameter recommended by the diesel manufacturer. The flexible exhaust connection shall be stainless steel. The exhaust silencer shall be of heavy duty, side inlet and end outlet, designed for vertical installation. It shall be of size and design that will ensure durability, prevent backpressure, and provide medium degree silencing. Flanged connections shall be provided at each end of the silencer. All companion flanges shall be furnished, installed, and securely attached to the housing. Exhaust system components shall be painted with high temperature aluminized paint. Each flanged joint shall be provided with 1/16" asbestos, full-face gaskets.

###### **Air Intake System**

* The engine shall be equipped with heavy-duty oil bath or dry type air cleaner (S) of sufficient capacity to protect working parts of the engine from dirt or grit. The air-cleaner shall be equipped with a pre-cleaner and a restriction indication. A crankcase breather shall be included. In-line air inlet silencer shall be provided between the turbocharger and air inlet.

###### **Speed Control Governor**

* The engine shall be equipped with a full hydraulic isochroous governor, which shall be mechanically driven by the engine, and which shall hold engine speed to within ± 5% of any selected speed at any constant load form no-load to full load.
* The governor shall control speed smoothly but positively and shall be fitted with stabilizing or compensating device to preclude hunting or over travel. The governor shall prevent variation in speed of the sustained periodic type (Hunting) and shall limit variation in speed of

###### **Flywheel**

* The flywheel shall be adequately protected by means of removable guards. An appropriate means shall be provided for barring.

###### **Emissions standers**

* The engine shall be meet Tire 4 final emission standers.

#### Alternator

##### Design Data

* The alternator shall be directly connected to the engine flywheel through a coupling designed and supplied in accordance with alternator manufacturer requirements.
* The alternator shall be of three phase, synchronous, drip proof, self-excited with built in exciter machine and voltage setting rheostat, provided with special windings for reduced harmonics and arranged for parallel operation with similar unit.
* Insulation shall be of tropical and moisture proof type, class (H).
* The alternator shall be of the following technical data:

| Power | As mentioned in B.O.Q |
| --- | --- |
| Power factor | 0.8 – 0.85 |
| Efficiency | Minimum 92% |
| Voltage | 400 V |
| Frequency | 50 Hz |
| Speed does not exceed | 1500 RPM |
| Voltage dip at starting not to exceed | 15 % |
| Overload rating | 10 % for one hour each 12 hours |
| Short circuit rating | 300% of alternator capacity symmetrical for 10 seconds |
| Temperature rises over ambient temperature | 65 °C |
| Maximum harmonic content | 1.10 |
| Ambient temperature | 45 °C |

##### Exciter

* The exciter shall be brush less and its armature shall be directly connected to the alternator shaft. It shall be of the alternator type and have a solid-state, hermetically sealed rectifiers mounted directly on its armature. The rectified exciter output shall be directly connected to the revolving alternator field windings without brushes, slip ring or communicators. The excitation system shall be equipped with a series of boots transformers or permanent magnet generator for field forcing capabilities.

##### Automatic Voltage Regulator

* Alternator and regulator manufacturers must use solid electronic state technology with no electron tubes or electrolytic capacitors and must use the voltage regulator's recommended type and size.
* It shall be designed to provide an overall alternator performance as follows:
  + Steady State
    - With any constant load between no load and full load and at any power factor from 0.8 to 1.0, and ambient temperature, specified voltage regulation shall be 1%.
    - With constant load and ambient temperature, voltage dip shall not exceed 1% during any one-hour period.
  + Transient
    - 12% maximum voltage drop when applying of 50% rated load, with two second maximum recovery time to steady state, when operating at 50% load.
    - 12% maximum voltage rise when removing of 50% rated load, with two second maximum recovery time to steady state, when operating at 100% load.
  + Voltage Adjusting Rheostat
    - The voltage regulator shall be designed for adjusting alternator output within ± 10%. A manual voltage-adjusting rheostat with operating knob shall be supplied and mounted on the switchboard.
    - The voltage regulator shall contain a limiting circuit to prevent output voltage surges in excess of 110% of rated voltage during generator set operation. On a loss of the sensing signal, the voltage regulator shall shutdown to prevent an overvoltage condition from occurring. A voltage regulator that can go into a full field condition is unacceptable. LED indication will be provided on the regulator to monitor the sensing (yellow), excitation (green), and output circuit (red). A rheostat shall provide a minimum of plus or minus 10% voltage adjustment from the rated value.

#### Main Line Circuit Breaker, Control and Instrument Panel:

* **The main line circuit breaker shall be mounted and connected in a guarded drip-proof enclosure meeting IP 23 and IEC 144.**
* For generating unit, a main line circuit breaker with shunt trip to protect generator set from accidental faults and to disconnect it from its load shall be supplied. **(It shall be with min. rating Amps** **and sized to the output of the generator at 50 Hz as specified at BOQs).**
* The control and instrument panel shall be provided. This panel shall be mounted on to the alternator and shall be provided with vibration isolators of adequate size to protect the instruments and control from vibrations.
* It shall operate both manually for normal switching functions and automatically during the above-mentioned failure events. The breaker shall also include ground fault sensing that will trip the breaker on ground fault conditions.
* The following minimum instruments and control shall be provided.
  + - * Cooling water to engine.
      * Cooling water from engine.
      * Lubrication Oil from engine.
      * Cylinder and combined exhaust (using thermo-couples).
      * Cooling water after turbocharger.
      * Alternator bearing temperature, high.
      * Charging air to cylinders.
      * Lubrication Oil to filter.
      * Engine water temperature, high-shut down of the engine.
      * Engine, over speed and visual alarm.
      * Engine control, on.
      * Radiator fan, on.
      * Low fuel level in the daily fuel tank

#### Starting of the Generating Units

##### Electric Starting System

* The engine shall be equipped with a 12/24 VDC solenoid shift electric starter capable of withstanding four, 30 second consecutive cranking periods.
* The starting battery shall be **Nickel-Cadmium, Alkaline,** especially designed for diesel engine cranking service and of a capacity as recommended by the battery manufacturer for cranking the engine being furnished, for the necessary break-away current as required and spinning current for four consecutive starts of thirty seconds of cranking on each start, or for 60 seconds of continuous cranking without being recharged and with the ambient temperature of both the engine and battery of 45°C. Steel battery rack shall be secured to the mounting skid and the battery shall be secured to this rack.
* A complete automatic battery charger shall be furnished for charging the Nickel-Cadmium, Alkaline battery being supplied. The charger shall be the static type, magnetic amplifier control with direct current voltmeter, direct current ammeter and potentiometer for voltage adjustment and shall have float and high charge rate, with a 0-to-24-hour high-rate charge timer. Charge rate shall be automatically determined by the state of the battery and reducing to milliamp. Current to fully charged battery. Charger shall be for 220-volt, single phase, and 50 Hz alternating current input, with an output of not less than 6 percent of the nominal ampere-hour rating of the battery. A time delay under voltage relay shall be provided within the charger for remote alarms. The charger shall be for the correct voltage for the battery. The charger shall be mounted inside the pump housing.
* Required battery cables shall be installed for connecting the battery to electric starter.

#### Fuel System:

##### 1.5.1. Fuel Transfer Pumps

* Fuel oil shall be transferred to and from the main fuel tanks by electrically driven pumping units.
* The electrically driven pumps shall be of the self-primed, rotary type, having a discharge of 1 Ltr/sec. directly driven and mounted on a common bedplate with its A.C., single phase, 50 cycles/sec, 220 volt, electric motor.
* The pump shall be provided with dry running protection in conjunction with the fuel level in the main storage tanks.
* The pump shall be complete with all piping and valves which shall be arranged to transfer the fuel oil from tankers to the main storage tanks and from main tanks to the daily fuel service tanks inside generating building.
* The fuel piping shall be of black steel. Piping outside the generating units buildings shall be laid down in trenches. Piping indoor shall be laid inside concrete ducts with Chaucer plate covers. Pipes shall be properly protected against corrosion. The joints shall be of the flanged and/or of the sleeve type with union couplings wherever necessary for easy dismantling.

##### 1.5.2. Daily Fuel Tank

An integral skid type fuel tank shall be provided with the generator set , a daily fuel tank made of welded black steel sheets of heavy construction according to manufacturer, specification and with capacity to cover 10-12 hours consumption of the engine when running at full load, Including all required accessories (interconnecting fuel piping, heavy duty filter incorporating a water trap shall be fitted between the day tank and the engine mounted fuel feed pump). Isolating valves shall be provided on both sides of the filter.

##### 1.5.3. Fuel Storage Tanks

Fuel oil storage tanks, outdoor type, over ground, CYLINDRICAL, the fuel tank capacity as per drawing and B.O.Q and should be suitable liters powered by electric driven pump (s), fuel flow meter complete with bypass pipe work, valves and fittings to connect to engine, The unit rate include materials, workmanship, foundations and all civil works, epoxy painting, finishing, and any others required to complete the work as per drawing and engineer instruction

The tank shall be complete with steel platform and stand and shall be equipped with the following:

* Level indicator.
* Fuel filter.
* Air vent, overflow pipe and drain pipe with cock.
* Strainer on outlet.
* Inspection opening with cover.
* Turbine type flow meter on the outlet pipeline.
* The tanks shall be painted externally with aluminum paint.
* The contractor should submit shop drawings for the tank and fuel pipe distribution, location of fittings and accessories with specific dimensions, for approval by UNOPS engineer.

##### 1.5.4. Hand Pump

A hand operated pump with the delivery permanently connected to the day tank and with a flexible suction pipe to facilitate the filling of the day tank from drums of diesel shall be provided will used for emergency situations.

##### 1.5.5. Surface Preparation and Painting

The entire works shall be painted or treated with protective coatings such as galvanizing.

For outdoor environments, paint and protective coatings shall provide for long-term protection suitable for severe atmospheric classification.

All carbon steel pipe work, equipment and fittings to be insulated shall be as a minimum painted with a primer prior to cladding. Non stainless-steel engine exhaust pipe work shall be painted with inorganic zinc primer.

Paints shall be free of any isocyanides and shall comply with the paint manufacturer’s instructions for the specified environmental conditions. Paint systems shall be of the self- leveling type.

#### Cooling System

* The engine shall be water-cooled of a closed type of system, with liquid to air radiator supplied with blower fan(s) to maintain desired operation conditions. The radiator unit shall be of the indoor or outdoor type designed for operating 10% continuous overload at 50 °C ambient temperature.
* All connections to the engine and its mounted accessories shall be solid. The radiator shall have an engine driven fan of adequate size.
* The system shall not be susceptible to the formation of deposit of rust and scale within the engine and shall circulate the coolant through the engine at a regulated temperature and flow rate as recommended by the manufacturer.
* A jacket water temperature control valve shall be provided. It shall be of thermostatic type with 3-way body and flanged connections. The thermostatic element shall be designed to maintain the jacket water temperature within the requirements at stated by the engine manufacturer.
* The system shall also include a separate path of lubrication Oil cooling.
* Similar approved type can be taken into consideration.
* Gen sets shall be equipped with a cooling system having sufficient capacity to effectively cool the engine when delivering full rated horsepower at the conditions stated above. A radiator and engine-driven fan of a type and capacity recommended by the engine manufacturer shall be included.
* The radiator shall be sized in accordance with the engine manufacturer’s recommendation for use with 50 percent aqueous ethylene glycol. Air flow shall be controlled by a power inlet damper and a gravity discharge damper, Design ambient air temperature shall be 50 degrees C at sea level.
* Gen sets shall have an engine-driven, gear driven centrifugal type water circulating pump for circulating water through the cooling system.

#### Control panel

* The following minimum instruments and control shall be providing for the generating unit power supply and one for transformer power supply:
* AC automatic transfer switch suitable for Existing DG & New DG will be install.
* AC voltage 3 phase (L – L & L – N).
* AC amps 3 PH & total.
* KW total & per phase.
* KVA total.
* K VAR total.
* KWh total.
* KVARh total.
* Power factor average & total.
* Percentage of rated (total).
* Frequency.
* DC voltage.
* Coolant temperature.
* Oil pressure.
* RPM.
* Hours run.
* System diagnostic.
* **CONTROLS**
  + Automatic transfer switch.
  + Auto start / stop and Emergency stop.
  + Lamp test.
  + Cycle crank.
  + Voltage control.
  + Cool down timer.
  + Phase selector switch.
  + Load demand relay.
* **INDICATING LIGHTS**
  + Low oil pressure.
  + High coolant temperature.
  + Over speed.
  + Emergency stop.
  + Fault shutdown and Fault alarms.
  + 3 spare lights / 4 spare inputs, customer programmable (shutdown or alarm) to spare alarm or fault Leeds and Over crank.
* **PROTECTIVE RELAYING**
  + Programmable relays.
  + Over / under voltage.
  + Reverse power relay.
  + Over / under frequency and over current.
* **LOW VOLTAGE CIRCUIT BREAKERS**
  + Low voltage circuit breakers shall be metal clad and shall be of the air break, horizontal draw out pattern 400 volts and rupturing capacity as mentioned in the drawing. Circuit breakers shall comply with VDE or BS 4752 & IEC 60439 and shall be complete with the auxiliary equipment described for high voltage circuit breakers. The circuit breakers closing mechanism shall be of the trip-free type and shall incorporate a mechanical "ON/OFF" indicator and mechanical interlock in order to prevent withdrawal, plugging or access to the breaker in the closed position.
  + Contactors shall be robust in design and shall be capable of carrying full load for an indefinite period, and shall be provide with an arc-quenching device. Contacts shall have readily renewable tips. The live fixed contacts shall be fully shroud.
* **LOW VOLTAGE FUSED SWITCHES / ISOLATORS**
  + Fused switches shall be of the heavy duty type complying with VDE No.0670 part 1/1.64 and shall be equipped with detachable neutral links and class Q1HRC fuses to VDE No.0670 part 4/3.67.
  + Fused switches shall be of the triple pole and neutral type or heavy-duty composites unit of the air break switch type and have not more than one fuse in any one pole, the fuse being contained in or mounted on the moving member or the switch. The neutral shall be either switch or taken through a removable link. A separate brass earth terminal shall be providing.
  + Isolators shall be identical to fuse switches but the fuse links shall be replace by high conductivity copper link.

#### Earthing System:

* The Contractor shall Supply and deliver an earthing system in accordance design of the system and all items shall be according to BS 7430, with the IEE Wiring regulations BS 7671. The system of PVC conduits and trunking, metallic sheaths of cables, cases and enclosures of switchgear and electrical apparatus shall be connect to the earth point, according to the current rules and regulations. The Contractor is reminded that the resistance of the earth conductor from the earth-electrode to any point in the earthing system shall not exceed one ohm as per ANSI IEEE Standard 80.
* Codes of practice and highest prevailing engineering standards for the following main system component:
  + - * 1. Extendible copper electrodes, (suggested length: 1.6~2.4 m),
        2. Main earthling cable: copper bared as per BOQ, and the length as required. And earthling cables for Gen. sets, hanger frame, fuel tank and any other equipment: insulated copper as per BOQ, Cupper earthling bar, Earth pit with manhole cast iron cover plate complete as per standard, the cover of the manhole is preferred to be clearly stamped with grounding sign.
        3. Ground Enhancement Material (Bentonite / (Salt & Coal).
        4. Earthing busbar shall be protected fixed inside sealed box.

#### Cables

* Cables shall be supplied by an approved manufacturer and where possible the same manufacturer shall be used for all cables and according to IEC 60228, IEC 61537, ISO, IEC 60227/IS 694, IEC 60502/151554 standards. In addition, the Calculations of the current rating of the cables should be according to IEC 60287.

1. Rating:
   * + The Contractor shall ensure that each cable is adequately rate for its duty under normal and possible fault conditions.
     + The rated voltage of the cable shall not less than the operating voltage and when assessing the rating and cross section of each cable the following factors shall be taken into account:
       - Maximum voltage drops permissible.
       - Type and magnitude of load.
       - Fault level and duration related to circuit protection relays and fuse gear.
       - Over current setting of relays and circuit breakers.
       - Route length and disposition of cables.
       - Ambient temperature.
       - Method of laying.
2. **Type:**
   * Cables complying with VDE or approve equivalent standards will be accepted provided all cables, which are supplied for a specified operating voltage, are to the same national standard. Standards specified in the following clauses indicated the type of cables used in the design: if the contractor wishes to use cables to alternative standard, then details of current carrying capacity, de-rating factors etc., shall be submitted to the Engineer for approval.
     1. **XLPE/SWA/PVC:**
   * Power cables specified as cross-linked polyethylene insulated steel wire armored and PVC sheathed are hereafter refer to as XLPE/SWA/PVC.
   * All such cables shall be terminated with mechanical glands, which shall be of a type as to provide adequate mechanical support by positively locking on the armor and shall at the same time give a high level of earth continuity.
     1. **PVC/SWA/PVC:**
   * Power and control cables specified as PVC insulated and sheathed, galvanized single wire armored cable with an overall PVC sheath are hereinafter referred to as PVC/SWA/PVC.
     1. **MICC/PVC:**
   * Certain control and miscellaneous circuits shall be carried out in mineral insulated copper clad cable with an overall extruded PVC sheath, hereinafter referred to as MICC/PVC cable.
   * For the purposes of core phase identification colored PVC core sleeves or colored PVC extension sleeves shall be use. Core sleeves and extension sleeves to be use on the core sizes for which they are intend.