

**VOLUME-2**

**PART- I**

**Section-13**

**DG Sets**

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## 13. DG Sets

### 13.1 Scope of Work

The intent of these specifications is to define and cover the scope of work under this section which includes the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Purchaser's personnel, handing over to Purchaser and guarantee for two years of DG sets for Keyi Hydro Electric Project, Arunachal Pradesh as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation.

It is not the intention to specify the minute details/smallest items to deliver a functional system or to define the standard manufacturing practice but to outline the performance, constructional, operational and guaranteed requirements. It is the responsibility of the contractor to ensure these requirements.

### 13.2 Scope of Supply

#### 13.2.1 DG Set for Powerhouse

- One (1) no. silent type diesel engine suitable to give an alternator output of 375 kVA or nearest higher standard rating for powerhouse, complete with fuel system, lubrication system, cooling system, air intake and exhaust system, battery and battery charger, instruments and protection system, annunciators etc.
- One (1) no. 375 KVA, 50 Hz alternator with exciter, automatic voltage regulator etc
- One (1) no. engine starting system (Automatic Mains Failure Starting System Panel).
- Coordination and provision of necessary contacts and/or ports for integration with plant SCADA system
- Spare parts.
- Special Tools and instruments, if applicable

#### 13.2.2 DG Set for Intake Site

- One (1) no. Silent type diesel engine suitable to give an alternator output of 100 kVA or nearest higher standard rating for weir site, complete with fuel system, lubrication system, cooling system, air intake and exhaust system, battery and battery charger, instruments and protection system, annunciators etc.
- One (1) no. 100 KVA, 50 Hz alternator with exciter, automatic voltage regulator etc
- One (1) no. engine starting system (Automatic Mains Failure Starting System Panel).
- Coordination and provision of necessary contacts and/or ports for integration with plant SCADA system

- Spare parts.
- Special tools and instruments, if applicable.

### 13.2.3 Services

- Transportation and delivery to site including all logistics and proper site storage and preservation as per manufacturer's recommendation.
- Site installation and commissioning
- Field / touch-up painting including all painting materials
- Performance and field acceptance testing as per the relevant clause of this section and submission of report
- Training of Purchaser's personnel including operation and maintenance staff
- All the technical documentation including preparation and submission of O & M manuals

## 13.3 Specific Parameters and Layout Conditions

### 13.3.1 Layout and General Arrangement

The silent type diesel generator set for powerhouse shall be suitable to supply emergency supply for essential unit and station auxiliaries in case of complete failure of main AC supply. DG set shall also be suitable to meet load requirement of essential unit auxiliaries to enable starting of the unit under black start conditions. DG set for powerhouse along with its control board shall essentially be outdoor type although it may be installed in a sheltered structure adjoining to powerhouse end wall on unit 3 sides. The details of the layout of the diesel generator set shall be provided by contractor.

Like-wise silent type diesel generator set for Weir shall be suitable to supply emergency supply for essential Weir and intake gate auxiliaries in case of complete failure of main supply. DG set for weir along with its control board shall essentially be outdoor type although it may be installed at weir site in a semi-permanent structure. The details of the layout of the diesel generator set shall be provided by contractor.

## 13.4 Rating and Functional Characteristics

### 13.4.1 Rating

#### 13.4.1.1 Engine

|               | DG set for Powerhouse                     | DG set for Intake Area                    |
|---------------|---|---|
| Engine output | Corresponding to 375 kVA generator output | Corresponding to 100 kVA generator output |

|  |  |  |
|--|--|--|
| Type   | Diesel, Four stroke, Sound proof   |  |
| Power output, continuous rating                | To match rated capacity of generator at rated power factor (0.8 lagging)         | To match rated capacity of generator at rated power factor (0.8 lagging)         |
| Overload rating                                | In accordance with DIN 6270 (Internal Combustion Engines, Definitions of Output) | In accordance with DIN 6270 (Internal Combustion Engines, Definitions of Output) |
| Speed  | 1500 rpm   | 1500 rpm   |
| Cooling system                                 | Radiator type  | Radiator type  |
| Max Ambient temperature                        | 40°C   | 40°C   |
| Lubrication system                             | Forced feed  | Forced feed  |
| Fuel supply system                             | Fuel supply pump   | Fuel supply pump   |
| Starting                                       | Electric starter, 24 V DC supplied by own batteries of suitable AH               | Electric starter, 24 V DC supplied by own batteries of suitable AH               |
| Provision for parallel operation of generators | Yes, Another DG set may be installed at future date                              | Yes, Another DG set may be installed at future date                              |

**13.4.1.2 Generator**

|                        |                       |                       |
|------------------------|-----------------------|-----------------------|
| Nominal voltage        | 415 V $\pm$ 5 %       | 415 V $\pm$ 5 %       |
| No. of phases          | 3                     | 3                     |
| Frequency              | 50 Hz $\pm$ 3 %       | 50 Hz $\pm$ 3 %       |
| Rotational speed       | 1500 rpm              | 1500 rpm              |
| Rated output           | Not less than 375 kVA | Not less than 100 kVA |
| Power factor (lagging) | 0.8                   | 0.8                   |
| Excitation system      | Brushless / self      | Brushless / self      |
| Duty                   | Continuous            | Continuous            |

|                              |  |  |
|------------------------------|--|--|
| Class of insulation          | F  | F  |
| Temperature rise of windings | According to IEC 60034-1 (resistance method) | According to IEC 60034-1 (resistance method) |
| Ambient temperature          | 0° C to 40°C                                 | 0° C to 40°C                                 |
| Stator winding               | Y-connection                                 | Y-connection connection                      |

The generator shall be capable of delivering continuously at full load, rated frequency and power factor and at any voltage between 105% and 95% of rated voltage without any part exceeding the maximum allowable temperature rise. It shall also be capable of operating continuously with 20% unbalanced load. The generator shall be capable of withstanding for not less than 15 seconds a current 50% excess of its rated current after having attained the thermal equilibrium corresponding to the rated load, the voltage being maintained as near the rated values as possible consistent with the maximum capacity of the prime mover i.e. engine. The engine shall be capable of delivering an output of 10% in excess of its rated output at its rated speed for a period of one hour in any period of 12 hours consecutive running, without undue heating of the engine or any other mechanical part.

#### **13.4.1.3 Governor**

Each engine shall be provided with appropriate governor to maintain the speed within the value stipulated for class A-1 (precise standard) governing in BS: 5514. The governor shall have drooping characteristics to ensure proper load sharing. It should be possible to control the speed to facilitate the parallel operation and for this purpose speed raise/lower control switch shall be provided on the generator control panel. The governing system shall be complete with devices and shall be compatible with auto synchronizer for parallel operation. A mechanical over speed trip mechanism shall be provided to automatically shut off the supply of fuel in case the engine speed reaches 110 % of rated speed.

#### **13.4.1.4 Excitation system**

Each alternator shall be provided with brushless excitation system. The capacity of the exciter shall be adequate to meet the full load and overload ratings of the alternator particularly under short circuit conditions. The exciter shall have an automatic demagnetizing arrangement for the field circuit and insertion of field circuit in the event of an internal fault. Such an arrangement shall be capable of reducing the induced voltage to a safe limit.

#### **13.4.1.5 Automatic voltage regulator**

Each alternator shall have necessary inherent regulation and for close regulation there shall be an automatic voltage regulation having regulation of 0.5 % at all loads between no load to full load and power factor 0.8 lagging to unity. The AVR for each generator shall be panel mounted where a control knob will be provided for control of voltage for synchronization and voltage raise/lower feature should be compatible with auto synchronizer for parallel operation.

### 13.5 Performance Guarantee

The DG sets along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

### 13.6 Design and Construction

#### 13.6.1 Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

| Standard    | Description  |
|-------------|--|
| IEC 60034   | Rotating electrical machines   |
| IEC 60364-3 | Electrical installation of buildings - Assessment of general characteristics |
| BS 5514     | Reciprocating internal combustion engines                                    |
| IS 8183     | Bonded mineral wool  |
| DIN 6270    | Internal Combustion Engines, Definitions of Output                           |

#### 13.6.2 Diesel Generator

Unless otherwise agreed upon the general arrangement shall be as follows:

The combined diesel engine and generator with all required accessories shall be mounted on a structural steel base frame and plate. All base plate mounted components shall be completely piped and wired in the shop. Vibration isolation shall be provided for the base plate mounted units and all outgoing pipes and tubes. The diesel engine with the generator shall be engineered and designed to be free from all harmful critical speed within the normal operating range. The DG sets shall be soundproof to the maximum extent possible.

The generator shall be brush-less alternator, directly flanged to the engine, with closed damper cage and a reactive current compensator.

The voltage regulator shall be electronic type having regulation of 0.5% at all loads between no load to full load and power factor 0.8 lagging to unity, with means for unattended parallel operation.

The governor shall be electronic with adjustable speed droop 0-10%, suitable for unattended parallel operation.

Suitable lifting lugs shall be provided on each diesel generator assembly.

### **13.6.3 Engine Starting / Shutdown**

#### **13.6.3.1 Automatic Starting**

The diesel generator will be connected to the 415 V switchgear system as shown in the single line diagram.

Automatic starting of the diesel generator shall be through a starting signal from the auxiliary control system after ensuring necessary interlocks as explained later in the chapter in the case of:

- Mains power outage
- Low mains voltage
- Loss of one phase in mains

The DG shall start and build up voltage automatically within 20 seconds from getting command to closing of AC supply CB associated with DG set.

#### **13.6.3.2 Alarms/Automatic shut-down**

Following alarm signals shall be provided:

- Breaker trip
- Low Fuel Level alarm
- Over frequency alarm
- Over current alarm
- High engine Temperature -pre-alarm
- Low oil pressure -pre-alarm
- Generator over voltage alarm
- Generator under voltage alarm
- Generator under frequency alarm
- Ground fault alarm
- High alternator Temperature alarm

Automatic shut down shall be under following conditions:

- Low voltage,
- Low frequency,
- Very High engine temperature
- Very High water temperature
- Very Low radiator water level
- Very Low oil pressure
- High oil temperature



- Very Low Fuel Level
- Over Crank (fail to start)
- Reverse Power
- High Voltage
- Loss of Phase
- Instantaneous and IDMT over current and Earth fault

The shutdown of the diesel engines shall be by means of fuel shut-off solenoid.

#### ***13.6.3.3 Dehumidification arrangement***

The alternator and exciter shall be provided with suitable space heating arrangement, so that the excessive humidity does not reduce the insulation level of the equipment to an undesirable value. Such an arrangement shall entail space heating of the alternator and the exciter to 15 deg. above ambient temperature with arrangement to measure space temperature. The space heaters shall be suitable for single-phase 50 Hz AC supply from an independent source, which should automatically switch off before starting of unit. However, once the dehumidification unit is switched ON, it shall be controlled automatically with a thermostat. The dehumidification unit shall be designed to avoid hot spot.

#### ***13.6.3.4 Instrument panel***

The diesel generator shall have a separate engine instrument panel. The panel shall be mounted on the framework of the generating set and shall contain:

- Oil pressure gauge,
- Water temperature gauge,
- Oil temperature gauge.

#### ***13.6.3.5 Auxiliary equipment***

The following auxiliary equipment shall be included in the supply for each DG set:

- The generating sets shall be housed inside a high quality acoustic enclosure which shall have features like modular construction along with surface treatment like degreasing, pickling, phosphating, passivation, etc,
- A high quality insulation material in accordance with relevant IS: 8183 or equivalent IEC code shall be used for maximum sound absorption,
- The lubricating oil system shall include a full flow oil filter and lubricating oil cooler. The lubricating oil cooler shall be water cooled with the main engine cooling system,
- The cooling system shall be air / water cooling system,
- A high efficiency residential silencer along with associated piping and flexible bellows, which shall be roof mounted and completely concealed in the roof of the acoustic enclosure, shall be provided,

- Louvers and outside air grilles for the inlet and outlet air shall be provided and when the engine starts and stays open during the running time of the engine,
- 24 V DC starting system through axial type starter motor, complete with high capacity lead
- acid starting batteries, battery racks mounted on the floor, and heavy duty interconnecting cables with terminations,
- Heavy duty dry type air filters with replaceable elements suitable for use in dust or sand laden conditions,
- Fuel and lubricating oil filters with replaceable elements,
- Starting batteries shall be suitable for three consecutive starting cycles at the most
- unfavourable conditions, larger batteries have to be installed,
- A static battery charging system, constant voltage current limiting type. The charging system shall be operated from the AC single-phase supply to maintain charge of the batteries while plant is stationary. The system shall be able to cope with at least  $\pm 10\%$  voltage variations in the supply voltage. In all cases, the batteries shall be kept fully charged but protected against overcharging,

#### **13.6.4 Control, Protection and alarm-annunciation panel**

A separate freestanding panel containing diesel engine and auxiliary controls shall be provided. The panel shall be complete with all necessary internal wiring, control circuit relays and terminations. All circuit components, control switches, indicator lamps and push buttons shall be clearly identified by nameplates. The following equipment shall be accommodated in the panel:

- Ammeter for the battery charger current,
- Voltmeter for the DC system,
- All necessary additional control equipment for the test mode operation of the set,
- The built in provision for auto/ manual synchronising,
- All necessary control and supervisory equipment for the automatic operation of the set,
- All protection equipment i.e., reverse power relay, under voltage relay, frequency relay, instantaneous and IDMT over current relay, earth fault relay etc. and other relays to satisfy the requirement of the clause "Automatic shutdown" of this section,
- Voltmeter with selector switch,
- Ammeter one each per phase,
- Frequency meter,
- kW meter,
- kWh meter,
- Running hour meter
- Measuring instruments for current and voltage

A common audible alarm system shall be incorporated in the control panel to operate in event of fault protection shut down. Alarm shall remain in operation until manual reset after fault condition has been corrected. Each alarm shall be identified by its own flag or light.

The common alarm shall be connected to the remote control system. For this purpose, a potential free contact shall be provided.

The following alarms shall be included in the common alarm:

- All alarms included in the shutdown of the generator,
- Low starting battery voltage,
- Fail to start in automatic mode,
- In case of any engine safety device (trip alarms) operating, the engine will be shut down automatically and simultaneously associated circuit breaker will trip by a direct tripping

command, without depending upon the operation of reverse power relay. In addition, provision should be made to shut down the engine in case of electrical fault.

#### **13.6.4.1 Control**

The diesel generator shall have four different control modes, off, test, manual and automatic.

- Off mode

In off mode the diesel generator set shall, if running, stop without time delay and remain stopped.

- Test mode

In test mode, it shall be possible to manually start the diesel generator directly. Then the automatic starting sequence is energized and the generator synchronized to the energized main bus. The generator runs parallel to the electrical system and automatically loaded up to an adjustable value. On a manually stop command the generator shall be disconnected from the main bus and stopped after a cooling period.

- Manual mode

In the manual mode, the engine shall be started manually by the operator by pressing the 'start' push button on the generator panel,

The closing of C.Bs. shall be done manually with the help of manual synchronizer and check synchronizing relay,

The DG set shall be synchronized manually through synchronizing panel,

The DG set shall be shut down manually by pressing the 'stop' push button.

- Automatic mode

When switching over to automatic mode after a test run the voltage adjuster shall return automatically to the basic setting for emergency operation.

In automatic mode the diesel generator shall be automatically started in case of starting signal (power failure) and shall be maintained running until auxiliary control circuit detects mains supply. The diesel generator shall be running for adjustable time for cooling purposes after the generator has been disconnected from the network. In automatic mode the diesel generator shall, if necessary, make three automatic attempts to start with a rest period duration recommended by the manufacturer. Start and stop periods shall be time adjustable. If the engine fails to start, the control shall lock the starting procedure, and light an indicating light.

A red stop push button shall be provided on the generator terminal cubicle for emergency stopping of the diesel generator set. All necessary provisions shall be provided for manual adjustments of the speed and voltage of the diesel generator set on the generator terminal cubicle.

In automatic mode, the operating procedure in case of power failure shall be as follows: - (However, the Contractor shall coordinate his design of control and supervision of the diesel generator set and circuit breaker connecting DG sets to the 415 V mains bus with the design of the control system as described in "Section -10,415 V switchgear).

- The diesel engine shall start automatically if mains power outage is detected on the 415V switchgear bus and starting signal has been given by the auxiliaries control system,
- The diesel generator shall supply voltage to the 415 V station supply bus. To facilitate this connection, all breakers shall automatically operate to connect this part of the system, and disconnect parts of the system, which may not be supplied with the diesel generator set. To prohibit wrong connection an electrical interlock shall be provided. The closing of the breaker in the 415 V switchgear connecting the DG sets to the electrical network shall be automatic,
- At recovery of mains power, upon receiving a stop signal from the auxiliaries control system, the DG sets shall automatically disconnect from the main bus. After adjustable cooling period the engine shall stop,
- The disconnection from the main bus shall not occur, until voltage has recovered for about 5 minutes on mains 415 V bus. When the generator is disconnected from the main bus, all breakers shall automatically restore the system in the normal way. The time it takes to change over from the diesel generator to the mains power shall be as short as possible,
- The Contractor may optionally offer another procedure of automatic mode of operation justifying the same/more reliable/better for approval of the Purchaser.

#### **13.6.4.2 Finish**

The generator shall be thoroughly cleaned and primed with two coats industrial primer and finished in two coats industrial high gloss paint.

### **13.7 Drawings, Documents and Design Calculations**

#### **13.7.1 Design memorandum**

The Contractor shall submit to Purchaser a design memorandum prepared in accordance with clause 1.2 of "Section 1- General Technical Specification (GTS)" of the proposed equipment /system fulfilling the contract specification/requirement for approval prior to submission of drawings and documents. The design memorandum shall include the design philosophy, methodology, system description, input

parameters for design, standards and codes, design & selection criteria, equipment data, material specification, major technical features, basic arrangement / layout etc.

### **13.7.2 Drawings and documents**

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in "Section 1 - Technical Documents" of "General Technical Specification (GTS)".

These drawings and documents shall include at least the following:

- Layout drawing of Diesel Engine Generator sets for PH, Intake site & Surge Shaft Area
- Electrical schematic for start / stop of DG set in automatic mode.
- Dimensional details of DG sets
- Space requirements for DG set
- Foundation Plan
- Overall plan of DG set room/enclosure showing DG set, oil tank, control panel, cable trenches etc.
- Illustrative details of DG sets
- Efficiency characteristics of DG sets

### **13.7.3 Design calculation**

The Contractor shall submit the design calculation in accordance with Clause 2.6 of "General Technical Specification (GTS)" covering at least the following, for review / acceptance.

- Calculations for selecting the engine capacity based on the black start of the generating unit,
- Automatic mode starting/stopping logics.

### **13.7.4 Delivery, Installation and Commissioning**

The Contractor shall follow the requirements of Delivery, Installation and commissioning elaborated in clause 1.8 "packing and transportation", clause 1.9 "site installation and erection" & clause 1.10 "site inspection & tests" of "Section 1 - General Technical specification"

### **13.8 Spare Parts**

The spare parts shall include all the standard spare parts normally supplied by the OEM.

### **13.9 Special Tools**

The Contractor shall propose the list of recommended special tools (other than those included under "Tools and Appliances" above) including their make and detailed specification as recommended by manufacturer(s) and to be accepted by the Purchaser.

**13.10 Quality Assurance and Testing**

The bidder shall submit the quality assurance plan along with bid for approval of the purchaser. The Contractor shall follow the quality assurance and testing requirements as per quality assurance plan approved by the purchaser.

**13.11 Guaranteed and Technical Particulars**

Guaranteed and Technical Particulars as called for in Vol. VI shall be furnished along with the bid. Bids lacking in this may be considered unresponsive. Particulars subject to guarantees shall be clearly marked

**13.12 Completeness of Equipment**

All fittings and accessories of the DG sets and associated auxiliary & ancillary equipment which may not have been specifically mentioned in these specifications, but are usually necessary for completion of the above equipment, shall be deemed to be covered by the specification; and shall be indicated and furnished by the supplier without any charges to the purchaser.

**13.13 Deviation from Specifications**

While the purchaser does not bind himself to accept any deviation, due consideration will be given to any special devices or equipment put forward by the supplier with a view to increase the efficiency of the equipment and minimize the maintenance cost of the equipment as a whole.

Should the supplier wish to depart from these specifications, he shall submit a complete and itemized list of such deviations, together with full particulars of the reasons for the deviations in a separate schedule with special reference to clause and paragraph nos. of this specification. Unless this is done and also the purchaser's concurrence in respect of such deviations is obtained in writing, the equipment offered shall be deemed to comply in every respect with these specifications.