

Diesel Generators

Technical Specification

March 2017



List of Acronyms

°C	degree Celcius
A	Ampere
AC	Alternating Current
AVR	Automatic Voltage Regulation
BMEP	Brake Mean Effective Pressure
BTU	British Thermal Unit
CD	Compact Disc
CFM	Cubic Feet per Minute
dBA	Decibel A-weighting
DC	Direct Current
DOD	Depth of Discharge
ECM	Electronic Control
FAT	Factory Acceptance Test
FPM	Feet per Minute
g	Gram
HEUI	Hydraulic activated Electronic Controlled and Unit controlled Injector System
HP	Horse power
hr	Hour
HSNO	Hazardous Substances & New Organism
Hz	Hertz
ISO	International Organization for Standardization
ITP	Installation Test Plan
kVA	Kilo Volt Ampere
kVA _r	Kilo Volt Ampere reactive
kW	Kilowatt
kWe	Kilo Watt electric
kWh	Kilowatt hour
LED	Light-emitting diode
m	Meter
mA	milli-Ampere
masl	Meter Above Sea Level
MEUI	Mechanic activated Electronic Controlled and Unit controlled Injector System
mm	Millimeter
mm ²	square millimeter
PCC	Provisional Completion Certificate
PDF	Portable Document Format
pf	power factor
PLC	Progammable Logic Control
PO	Purchase Order
ppm	parts per million
PV	Photo Voltaic
RMS	Root Mean Square
rpm	Revolutions per minute
SAT	Site Acceptance Test

UN	United Nations
UNHCR	United Nations High Commissioner for Refugees
V	Volt
VA	Volt Ampere
VAr	Volt Ampere reactive
W	Watt
Ω	Ohm

I Introduction

UNHCR is seeking a commercial company which has the capability to provide power generator sets, synchronization control systems and accessories, as well as technical advice, assistance and training through confirmed worldwide service to the UNHCR operations. The successful bidder should be able to integrate in the UNHCR supply chain in a value added manner beyond simple sale of generator sets and accessories, enabling UNHCR to reduce the response time for emergency required generator sets deliveries on one hand, while maintaining a defined maximum lead time for delivery of standard orders and providing comprehensive after sales services.

II General Requirements

The scope of works includes the supply of complete enclosed diesel generators of various capacities (See Below) including spare parts, tools, controls and all accessories as outlined in this specification. The diesel generator sets are foreseen to operate on isolated mini grids either alone, in modular combination with other diesel gen sets or in hybrid set-up with gen sets using renewable energy sources (e.g. PV & battery modules). They could also be used as back up supply for grid-connected systems.

Each Generator shall be supplied complete with the following items:

- Supply of all installation drawings and documentation, Operation and Maintenance manuals.
- Design, supply and warranty of:
 - a. Enclosed diesel generator sets with the given minimum kVA rating Prime rated at 240/415V, 1500/1800 rpm, comprising a diesel fueled, reciprocating, inter-cooled, prime power rated engine which is direct coupled to a three phase 400 V synchronous generator;
 - b. The gen set shall be able to provide prime power on variable loads for an unlimited number of hours per year, in island operation mode, providing 110% of prime power during minimum of 1 hour per 12 hours cycle;
 - c. Completely enclosed diesel generators fully suitable for the given environment complete with sufficient space for all engine fluids, base fuel tank, noise abatement, water-air radiator, exhaust systems and all necessary controls, remote monitoring and ancillary components;
 - d. General access and protection structures;
 - e. Diesel generator earthing system;
 - f. Synchronization unit for load sharing across multiple interconnected generators (kW, kVA),
 - g. Diesel generator control system and enhanced power management;
 - h. Fuels transfer system inclusive manual fuel transfer system from external tanks;
- Factory Acceptance Testing (FAT) complete with all documentation, certificates, test reports;
- Remedy all defects.
- Provision of training for Operations and Maintenance staff.
- Provision of Operation and Maintenance manuals
- Provision of spare parts, and special tools.
- Provision of all signed certification (HSNO, Electrical Certification etc.) for the plant supplied.

- Warranty during the warranty period.

The supplier shall provide separate prices for generator sets with the following prime-rated output capacities below:

- A. 5kVA (single phase)
- B. 10kVA (Single phase)
- C. 16kVA (single phase and three phase options)
- D. 25kVA
- E. 40kVA
- F. 60kVA
- G. 80kVA
- H. 100kVA
- I. 150kVA
- J. 200kVA

The supplier shall also provide separate prices for each of these generators to operate at altitude above 2,000meters (or an adaptation kit for enabling generator set to operate at high altitudes).

The supplier shall also provide separate prices for the synchronization control system which could be provided with each generator.

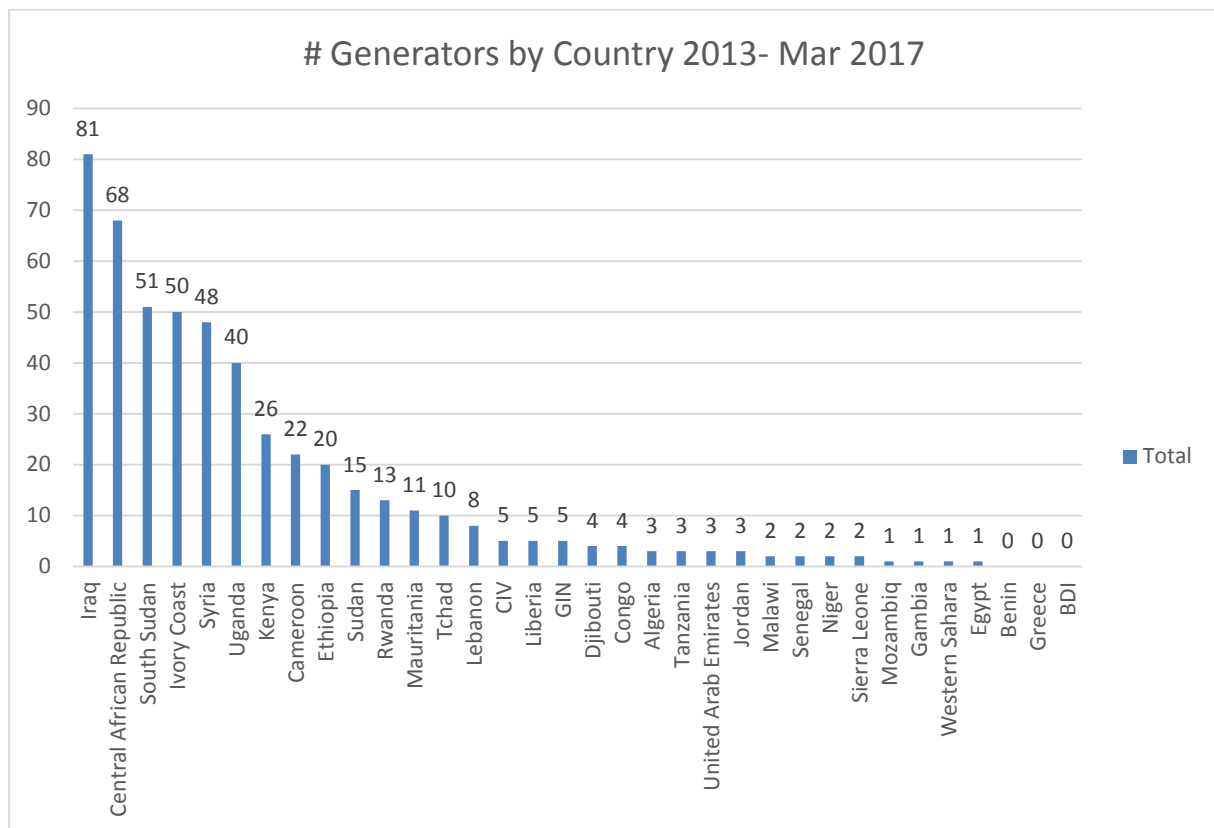
The supplier shall also price for variable speed generator sets, including all necessary converters etc., where these are available for given kVA ratings.

The supplier shall provide details of the manufacturing process and all materials used, including quality assurance standards and any environmental certifications. Full technical specifications for each item shall be included. It is also preferred that the supplier details the recyclability of product components and packaging.

The supplier shall also indicate the locations in which they can provide direct supply of generators and associated equipment.

The supplier shall provide a list of their authorized maintenance services providers, indicating the locations in which such services could be provided (not to be priced within this offer).

1. Locations for which generators were purchased during the last 5 years:



2. Climatological Conditions

The generators, and associated panels shall be able to operate under various climatic (i.e. tropical, semi tropical and arid) conditions and must therefore be constructed to work in difficult conditions i.e. in ambient temperatures varying between minus -15°C to plus 60°C, in altitudes from sea level up to 2,500 meters above sea level, in relative humidity conditions of up to 100%, and in sandy, dusty and/or heavy windy environment.

3. Operating Concept

To provide optimal fuel efficiency and maximum machine life, the supplier shall provide several generators in series to match the load profile provided in each order, (instead of one large generator which would run at high inefficiency). Additionally, should load grow beyond the capacity of the installed diesel generator(s), it shall be possible increase load capacity following a modular concept, adding multiple units to form a single combined source of electricity or mini grid. The operation concept also considers the future connection of PV modules or other RE sources (supplied by others; either with or without batteries) to the generation units. Each diesel generator unit shall be able to operate as stand-alone within the mini grid.

The supplier shall price separately for manual switchover control panel, automatic switchover control panel for single machine control, and also, panels for full synchronization control. The synchronization control in each case shall be designed for the following modes of operation:

- **Diesel only:**

The first diesel unit takes over all loads. In case load is approaching a certain threshold (preset on site, e.g. 70% of nominal capacity) the second unit will be automatically switched on and synchronized. Switching off and disconnecting second unit from grid will take place when load is below a certain threshold (e.g. 60% of unit capacity). The diesel gen sets are running in isochronous or base load control mode and are adjusted to an internal speed droop.

- **PV-diesel Hybrid: (Controls to manage PV system supplied by others)**

In case of PV-diesel hybrid generation the diesel units operate as stand-by systems on the main AC bus together with the PV modules. Diesel gen sets are operated if load exceeds a certain threshold (e.g. 70% of module or battery capacity) or DOD of battery is below a preset threshold (e.g. 50%).

- **Off**

The diesel generators will not start from local or remote control.

- **Automatic**

In this mode the diesel generator control will respond only to a single start/stop command from the control system.

Once an automatic start is initiated, the diesel generator will start, run up to speed, synchronise (if required), run to pre-set warm up load output until a pre-set time period has expired or the engine is up to normal operating temperature then ramp to load levels for automatic load sharing with other diesel generators online.

On automatic shutdown, the diesel generator will ramp unload, open the main breaker at pre-set load, go into cooldown for pre-set time and then shutdown.

- **Semi-Automatic**

In this mode the diesel generator control will respond only to an operator initiated single start/stop command.

Once a semi-automatic start is initiated, the diesel generator will start, run up to speed, synchronise, run to pre-set warm up load output until a pre-set time period has expired or the engine is up to normal operating temperature then ramp to load levels for automatic load sharing with other diesel generators online.

On semi-automatic shutdown, the diesel generator will ramp unload, open the main breaker at pre-set load, go into cooldown for pre-set time and then shutdown.

- **Manual**

In this mode the diesel generator control will respond only to an operator initiated single start/stop and synchronize command.

Once a manual start is initiated, the diesel generator will start, run up to speed, and then wait for the operator initiated synchronize command. Once synchronized run to pre-set warm up load output until a pre-set time period has expired or the engine is up to normal operating temperature then ramp to load levels for automatic load sharing with other diesel generators online.

On manual shutdown, the diesel generator will ramp unload to a pre-set load, and then open the main breaker on an operator command, go into cool down for pre-set time and then shutdown.

- **Base Load / Isochronous Load Control**

In all operation modes (automatic, semi-automatic and manual) it shall be possible to select between Base Load / Isochronous Load Control.

- Base load control is by operator set point for fixed kW and power factor output.
- Isochronous Load Control is by automatic load sharing control.

- **Local Test**

In Local Test mode only (initiated only at the diesel generator control panel), the diesel generator and ancillaries will run to speed for mechanical and electrical excitation checking. They will not synchronize to the load.

The bidder shall submit with its bid detailed operational instructions for the intended operating concept.

4. Design Life

The supplier shall indicate with their offer the life of the mechanical and electrical equipment at rated efficiencies under preset operating conditions. The Bidder shall submit with its bid charts of life expectancy in hours and assumed efficiencies.

The supplier shall also submit with their offer a generator sizing guide and respective maintenance recommendations. (See below for additional details)

5. Manuals, Catalogues and Electrical Drawings

Manuals, catalogues and drawings and any other documentation supplied shall be available in English, French and Arabic. The following manuals and catalogues shall be supplied with each generating set, as well as with the bid:

- a) Engine and alternator Manuals.
- b) Generating set operation Manual.
- c) Control and synchronization installation and operation manual
- d) Maintenance Manual.
- e) Troubleshooting Manual.
- f) Workshop and Spare Parts Manuals and catalogues.
- g) Electric diagram.

In particular, the appended manuals should contain the following information:

- **Generator Sizing Guide:**

The bidder shall submit with its bid a sizing guide for single generators and for multiple synchronized generators. The guide shall allow for optimal sizing of a generator to match a specific load, and also to compare using single generators against multiple synchronized generators. The sizing shall include but not limited to:

- a) Entering of:
 - i. loads, operating hours and power factor
 - ii. altitude in meters above sea level
 - iii. max. ambient temperature in °C
 - iv. Calculation of
 - v. Base, peak load and current in kW kVA and A for start and full load.

b) The following main results shall be calculated and shown:

- i. Starting kVA, kW, A at base and peak load
- ii. Running kVA, kW, A at base and peak load
- iii. Voltage P-P
- iv. Voltage P-N
- v. Efficiency
- vi. Engine overload capacity
- vii. Max. running hours per day and per year on max. overload capacity
- viii. Final power factor
- ix. diesel consumption in l/hr
- x. Required generator (or multiples of generators) rating in kVA for base- and peak load
- xi. Required engine ratings in kW for base- and peak load
- xii. Cost comparison of using single generator against multiple generators in series for load profile entered
- xiii. A standard list of usual power factors for various consumers.

- **Operating Instructions:**

The Instruction Manual shall include detailed Operating Instructions and, as a minimum, should cover starting, synchronizing, stopping, protection of circuits, automatic controls, battery charging, safety considerations, method of adjustment of speed, output voltage, control timers, etc.

Performance parameters of the generator set shall be detailed for the operator's guidance and as a minimum should cover output voltage, frequency, load, engine temperature and oil pressure nominal values and acceptable limits. Circuit drawings with component identifications shall be included for reference purposes.

- **Maintenance Recommendations:**

The supplier shall provide complete maintenance procedures for all the equipment supplied. Schedules for maintenance to be effected on a daily, weekly, monthly, etc. or on hourly run basis should be included.

Guidelines for the selection of fuel oil, lubricating oil, use of water treatment additives and anti-freeze if applicable.

- **Troubleshooting:**

Troubleshooting procedures shall be available to enable the timely diagnosis of a defect considered likely to occur in service. Reference outputs and conditions shall be quoted to facilitate diagnosis.

- **End of life recycling/disposal**

The bidder shall explain its concept on end of life recycling and/or disposal for the supplied equipment.

Note: It is mandatory that one set of above manuals, catalogues, and electrical drawing/diagram for each category of the offered generating sets is supplied with the bid (electronic versions). Bids shall not be acceptable unless the offer includes these items.

Factory Acceptance Tests (FAT)

The Supplier shall provide the respective reports including test results and certifications of factory tests on all systems and sub-systems of the complete supply. This shall include but not limited to:

- Operation of all alarms, trips safety protection devices and confirmation of operation, and their indication on the diesel generator controllers (local / remote).
- Operation of all status indications and their indication on the diesel generator controllers (local / remote).
- Operation of the diesel generator in all operating modes where possible.
- Load tests at one quarter/one half/three quarters and full load, for a minimum of 4 hours per test.
- Drop and recovery load tests to an agreed regime.
- Over speed tests.
- Acoustic level measurements provided to the appropriate standard at each of the load test ratings.

6. Packing, Documentation

6.1 Packing

All Generator sets including spare parts in special weatherproof materials shall be packed and securely clamped against movement in either ISO Sea container or in wooden secured crates suitable for export shipment, such that the crates can be stack on top of each other and stable for export shipment by surface, sea and rough handling during transportation.

Similarly, spare parts shall be packed separately in weatherproof and rainproof packing in wooden crates suitable for export shipment by surface, sea & rough handling.

All electronic parts shall be carefully protected from damage by dust, moisture, heat or humid atmospheric conditions. Where parts may be affected by vibration, they shall be carefully protected and packed to ensure, that no damage will occur while they are being transported and handled.

All wood and other materials used in packing cases shall be insect free. Adequate protection and precaution are to be taken to exclude termites and other vermin, noxious insects, larvae or fungus from the packing materials. The Supplier shall protect all steelworks before shipment, to prevent corrosion and/or damage. Bundles of steel sections shall be properly tied together by an approved method and care shall be taken to ensure that they are robust and that they can be handled easily during shipment. Packing cases where used shall be strongly constructed and in no case shall timber less than 25 mm in thickness be used. Cross battens supporting weight in any direction shall not rely for their support on nails or screw driven lengthwise into grain of the wood, but shall be supported by cleats secured from the inside. Waterproof papers and felt linings shall overlap at seams and the seams secured together in an adequate manner, but the enclose shall be provided with screened openings to obtain ventilation. All cases, packages, bundles, etc., shall bear at least the identification mark relating to the appropriate shipping documents, the contents and total weight. The identification marks on the outside manufacturer's name, type of equipment shall be waterproof and permanent.

UNHCR reserves the right to inspect and approve the packing, before the items are dispatched, but such inspection will not exonerate the Supplier from any loss or damage due to faulty packing. The Supplier shall be entirely responsible for ensuring that the packing is suitable for transit and the Supplier shall bear in mind that it will be shipped, stored in harsh environment during a long period.

The markings shall be of non-removable and permanent material, fixed on each individual item clearly identifying the production batch and the supplier. The markings on the packing

are fixed outside of the to be as per the purchase order, minimum height of letters 200 mm including dimensions/weight/capacity clearly marked on crate.

The marks are printed in white color with “UNHCR” logo in blue letters and underneath the logo the words: **The UN Refugee Agency**. In addition the weight of the entire unit shall be marked on the canopy together with PO number. Inside the canopy door, a label should be affixed giving generator power (KVA), weight, dimensions, engine number, serial number, year of manufacture and manufacturer’s name, address and contact numbers.

Typical standard markings are as follows:

UNHCR LOGO

THE UN REFUGEE AGENCY

CONSIGNEE NAME

PURCHASE ORDER NUMBER

PROJECT NUMBER

Special notations such as “fragile”, “this side up”, “centre of gravity”, “weight”, etc. shall be clearly marked on each packing together with tag number, purchase order number and a brief description of the content. A packing list shall be provided for each package.

6.2 Shipping Documents

The goods are to be delivered ex-factory. Documents required by UNHCR are compiled in Table 2.

Table 1: Shipping Documents

nos	Item	Quantity
1	Signed commercial Supplier’s invoice showing Goods’ description, quantity, unit price, and total amount;	Two (2) originals and two (3) copies
2	Detailed packing list	One (1) original and two (3) copies
3	Manufacturer’s or Supplier’s warranty certificate;	One (1) original and two (3) copies
4	Certificate of origin issued by the Chamber of Commerce or any other responsible institution of country of origin	One (1) original and two (3) copies
5	Inspection certificate, issued by the manufacturer and the manufacturer’s factory inspection/test report;	One (1) original and two (3) copies

The above documents shall be received by UNHCR at least three weeks before handing over of the goods. If not received or found to be incorrect, the supplier will be responsible for any consequent expenses.

7. Fuel & Lubricants

7.1 Fuel

The fuel used is of low sulphur content of either 50 or 10 ppm in general. However, at certain locations there might be only fuel of high sulphur content (about 500 ppm) available. The engines must be able to run on both, the higher sulphur content fuel and then lower sulphur content fuel.

The fuel (diesel) level emission permissible shall be in accordance to Euro Stage II G & D standards for non-road diesel constant speed engines measured under ISO 8178-4 C1 or IAPP (International Air Pollution Prevention) Certification/regulation.

7.2 Lubricants / Coolants

The engine manufacturer shall provide not only the recommended lubricants / coolants but the equivalents to these, including the manufacturer and supplier details (Castrol, Mobil, BP, Shell).

8. 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.

Metallic paints, comprising inorganic zinc primer and silicone aluminium topcoats, shall be used on all systems with surface temperatures greater than 150°C.

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 isocyanates and shall comply with the paint manufacturer's instructions for the specified environmental conditions. Paint systems shall be of the self-levelling type.

9. Safety Guards

Where required, the diesel generator set shall be provided with safety guards to protect personnel from moving or rotating parts.

10. Technical support

10.1 Training

The supplier shall detail their capacity for delivering training courses in installation, commissioning, operation and maintenance of all equipment across their regional service centers and/or requested locations. (the provision of these training courses is not to be included in this offer)

The supplier shall also outline the content, and various levels, of their training courses.

10.2 Technical Support

The Supplier shall detail the technical support available, both globally and regionally, for troubleshooting, spare parts, installation, operation and maintenance queries.

Please note that all cost related to the Supplier's technical visit(s) necessitated under warranty claim, within twenty four (24) months from the date of delivery to the site with exception of control panel containing microprocessor Chip(s) if applicable, which carry a minimum warranty of three years for its smooth & trouble free operation, have to be borne by the Supplier.

The Supplier is required to maintain updated contacts with spare parts suppliers or the equipment manufacturer for ease of access to spare parts and/or accessories that may be necessary for repairs and/or maintenance. The Supplier is required to maintain close contact with the on-site's technicians upon receipt of the Purchase Order requesting such service(s) in order to assess the requirement of parts or other accessories. When remotely diagnosing the fault and assessment of the requirement of parts and/or accessories (those not available in the mission) is ascertained, the Supplier's technician shall immediately deploy to the respective site with the necessary part(s) and or accessories for accomplishing the task. The requirement of special tools if any shall also be carried along with the technician. When ascertaining the required parts or accessories is not possible prior to actual troubleshooting of the equipment at site, the Supplier's contacts shall be such that the technician can be provided with the necessary parts and/or accessories within two days of arrival of the technician at the project site. If the parts in question are not readily available and requires prolonged delivery periods, the Supplier's technician shall fully brief the on-site technical personnel for carrying out the repairs upon arrival of the ordered parts.

10.3 Regional Service Centres

The Supplier shall provide a detailed list of Regional/country Service Centres, highlighting in particular centres across Africa and the middle east. The Service Centres shall have the capacity to respond to emergency queries, providing immediate technical support on a 24/7 basis. Each Regional Service and Call Centre must have technical experts that are fully familiar with equipment provided to UNHCR.

The Supplier shall provide detailed information on the capabilities of the individual Regional Service Centres. It should be clearly indicated in the proposal, which Regional Service Centres have the capacity to enter into contracts to provide full maintenance and repair services and for which equipment falling under the scope of this RFP. The supplier shall also indicate from which regional/country centres, if any stocks are kept at those locations, generator sets and controls can be delivered. It is preferred that the supplier has one central operation through which orders would be placed, and that this central operation would coordinate delivery of generators from the regional centre. (UNHCR would have one point of contact under a frame agreement through which all regional orders would be directed)

10.4 Spare parts

It is imperative that the Supplier has a robust arrangement for the provision of spare parts across global locations. All spare parts must be readily available at any time for emergency requirements and the supply of spare parts for scheduled maintenance must be timely and accurate in order to avoid any service delays, equipment failure and prolonged power supply interruption.

The Supplier shall demonstrate that a well-organized network and supply chain structure for any given spare parts is in place. It shall be illustrated by the Supplier on how Regional Service Centres are facilitated with spare parts and how spare parts can be ordered and subsequently supplied in the shortest possible time.

It is important that proposed spare parts ordering and management system is safe against mixing-up of similar parts for different generator models. Parts must be clearly marked and can be easily identified during visual inspection by non-technical personnel upon arrival at destination. This can be either achieved by clearly visible engraved part number; packing/wrapping with clearly visible part number; tagged-on part number or similar.

Spare parts shall be packed suitable for long term storage, with suitable preservative coatings. Clear marking on the outside of packaging materials shall identify each part so that the parts need not be unpacked for identification.

With the Technical Proposal the Supplier shall supply the following:

- Complete list of spare parts for all generator parts and equipment for each model
- Itemized price schedule for a spare parts kit recommended for 2,000 hours of continuous generator operation and maintenance, to be supplied with each generator. This shall include all tools and associated items necessary to carry out maintenance and install these spare parts.
- List of required spare parts for each scheduled maintenance service for each model
- List of available spare parts and stock levels at each Regional Service Centre for each model.

The list shall also include standardized part numbers as per manufacturer's database for ease during ordering. All spare parts shall be numbered to ease identification and stock keeping.

The spare parts proposed should carry a warranty of twelve (12) months from the date of installation.

The Supplier shall guarantee the availability of spare parts for the engines for 10 years.

10.4.1 First Fills

The Supplier shall supply the first fills for all oil and coolant and all fuel and oil filters for the diesel generators. This shall include start-up filters and the like for the initial commissioning of the diesel generators. The Supplier is to confirm as part of the tender submission if the start-up filters are different to normal operation filters to account for possible construction debris.

10.4.2 Special Software

All diesel generator controllers, governor, and AVR software and programs, communication leads and software dongles required for general maintenance and overhauling of offered generators shall be supplied as part of the diesel generator supply. All software shall be licensed to UNHCR, unless specifically agreed otherwise.

10.5 Warranty

The generator sets and associated equipment proposed should carry a warranty of twenty four (24) months from the date of delivery to the site, with the exception of control panel containing microprocessor Chip(s) which shall carry a minimum warranty of three years for its smooth & trouble free operation. The warranty shall cover faulty parts due to manufacturer poor workmanship during and after the assembly, and the warranty shall remain in full force

from the date of delivery to the site and entities as per Incoterms 2010. The Supplier agrees to carry all costs related to fulfil warranty obligations.

The Supplier shall extend third party manufacturer warranties to UNHCR in full with the minimum warranty as stated. The Supplier shall provide certification attesting covering the above warranties in the bid.

All costs for travel and upkeep of supplier's personnel to undertake repairs and replacement of Generator sets and associated equipment supplied and found to be defective or not to conform to technical specifications contained in this document during the warranty period shall be borne in full by the supplier. Repairs or replacements of equipment made during the warranty period or thereafter shall be warranted for the remainder of the original warranty. The Supplier shall begin the remedial work within 24 hours of being notified of the failure.

10.5.1 Guarantee

The Supplier shall state and guarantee:

- Fuel usage rates at 110%, 100%, 75% and 50% prime rated output (g/kWe) and corrected values as noted.
- Maximum net output (kWe) of each diesel generator.
- Continuous net output (kWe) of each diesel generator.

11. Standards

The diesel engine, alternator, generator control panel, fuel delivery system and fuel storage system shall comply with the current versions of the following applicable standards or equivalent standards. The Supplier shall list any deviation from these standards in its bid.

Table 2: Standards

IEEE 762:1987	Standard Definitions for Reporting Electric Generating Unit
IEC 60034	Rotating electrical machines
BS 2757	Method for Determining the Thermal Classification of Electrical Insulation
BS 4999	General requirements for rotating machines.
BS 5000	Rotating electrical machines of particular types
AS1359	Rotating Electrical Machines
AS 4680:2006	Hot dipper galvanised (zinc) coatings on fabricated ferrous
AS 61000.3.6	Electromagnetic compatibility (EMC) Limits – Assessment of limits for distorting loads
IEC 60204-1	Safety of machinery, Electrical equipment and machines.
ISO 8528-1: 2005	Reciprocating internal combustion engine driven alternating current generating sets.
ISO 8528-1: 2005: Part 1	Application rating and performance
ISO 8528-1: 2005: Part 2	Engines
ISO 8528-1: 2005: Part 3	AC generator for generating sets
ISO 8528-1: 2005: Part 4	Control gear and switch gear
ISO 8528-1: 2005: Part 5	Generating sets
ISO 8528-1: 2005: Part 6	Test methods
ISO 8528-1: 2005: Part 7	Technical declaration for specification and design
ISO 8528-1: 2005: Part 8	Low power general purpose generating sets
ISO 8528-1: 2005: Part 9	Measurement and evaluation of mechanical vibration
AS 1170	Steel structures standard
AS 1692: 2006	Steel tanks for flammable and combustible liquids
ISO 8178-4 C1 or equivalent	Permissible fuel (Diesel) emissions shall be limited to Euro Stage II G & D standards for non-road diesel constant speed engines

BS 5514-I-2002	Declaration of powers fuel and lubrication oil consumption and test methods
BS 5514-III	Test measurement
BS 5514-IV	Speed governing
BS 5514-VI	Over speed protection
BS 649	Reciprocating internal combustion engines performance, torsional vibrations
BS 269	For declaring efficiency of electrical machines
IEC 34-1-1983	Rotating electrical machines-rating, performance
IS 4661	Alternator
ISO 8528	Measurement of air borne noise by enveloping surface method
ISO 9614- Part I and II	Requirement of grade II accuracy for insulation
ISO 3046-1: 2014	Reciprocating internal combustion engines performance
ISO 3046-1: 2014: Part 1	Declarations of power, fuel and lubricating oil consumptions, and test methods -Additional requirements for engines for general use,
ISO 3046-3: 2006: Part 3	Test measurements
ISO 15550: 2002	Internal combustion engines --Determination and method for the measurement of engine power --General requirements.

12. Drawings and Documentation

12.1 General

12.1.1 Documentation Formats

All documentation shall be supplied by the Supplier as PDF and native formats as detailed below:

- Documents – MS Word.
- Specifications – MS Word.
- Schedules – MS Excel.
- Program – MS Project.
- Drawings – AutoCAD.

12.1.2 Units of Measurement

Metric units of measurement (System International) shall be used on all contract documentation. Angular measurement shall be in degrees with 90° degrees comprising one right angle.

12.1.3 Language

All manuals and drawings shall be available in **English, French and Arabic**. (only the English versions should be submitted with the offer). These languages shall be used on all drawings and in all documents and wherever anything is required by the Contract, to be written, marked, printed or engraved.

12.2 Manuals

The Supplier shall provide the following manuals

- a) Quality Assurance Manual.
- b) Safety Manual.
- c) Operation and Maintenance Manuals.

12.2.1 Quality Assurance Manual

The Supplier shall operate and maintain a quality management system conforming to ISO 9001 or approved equivalent. The Supplier shall take and keep records of quality inspections and tests as evidence that the requirements of the Contract have been met. The Quality Assurance Manual shall include but not be limited to the following:

- a) Project management and organization chart
- b) Design plan
- c) Quality plan
- d) Qualification and experience of key personnel
- e) Sub-supplier quality assurance plan
- f) Inspection and test plans
- g) Field installation check lists
- h) Instrument test certificates
- i) Statutory certificates
- j) Reports on non-conforming work and corrective action
- k) Results of all inspections and tests undertaken prior to delivery.

During the course of the Contract the Supplier shall register and maintain all quality documentation in an up-to-date centralized file and make this available for inspection by the Engineer or his representative at all reasonable times.

12.2.2 Operating and Maintenance Manuals

The Supplier shall provide Operating and Maintenance Manuals for all equipment supplied under this Contract (i.e. Governors, AVR's, PLC's, Diesel Generator Controllers, etc.). The information required from the Supplier shall conform to the standard requirements detailed below:

12.2.2.1 General

The format of the Operating and Maintenance Manuals or information contained therein, shall be provided in electronic and paper format and comprise instructions, diagrams and drawings which shall be sufficiently comprehensive to facilitate the training of the staff and to enable the operation and maintenance of the equipment to be performed in a safe and efficient manner. Six (6) hard copies and two (2) compiled PDF copies on CD/DVD shall be supplied. They shall contain full documentation of the goods and shall be in a form agreed prior to binding. If not readily identifiable from the drawings the necessary ordering details shall be listed in the manual.

The Operation and Maintenance manuals shall be produced in good quality A4 size paper and placed in a suitable A4, D Type, 3 hole ring-binder. No ring-binder shall have rings greater than 50mm.

All drawings shall be of A3 size paper and placed in a suitable A3 (landscape), D Type, 3 hole ring-binder. No ring-binder shall have rings greater than 50 mm.

The sections of manuals shall contain the following as a minimum requirement:

12.2.2.2 Section 1 - Index:

An index which conveniently and logically sets out the format of the Operating and Maintenance Manuals. Part of this index shall be a contents tick sheet. All items shall be listed regardless of actual document contents. Items already included shall have a tick in the appropriate box.

12.2.2.3 Section 2 - Design:

A design and technical section which shall include;

- a) Detailed descriptions of equipment components and systems including detailed drawings.
- b) Technical data for all plant as installed.
- c) Design and material limits for loadings such as pressure, temperatures, voltage, current, operating limits, settings, etc.
- d) Grades of lubricant and recommended frequency of lubrication.
- e) Test and performance data.
- f) Details of electrical circuits, accompanied by schematic and logic diagrams, indicating the physical location of the equipment parts.
- g) A list of alarms detailing alarm initiator location and setting for alarm operation and re-set.
- h) A comprehensive list of parts for each item of installed plant.

12.2.2.4 Section 3 - Installation:

A general description of the installation in regard to location and function. The description should include all process parameters associated with the installation and should be supported by general arrangement drawings.

12.2.2.5 Section 4 - Procedures:

The operating procedures shall be set out in step-by-step instructions with each step numbered in correct logical sequence and include;

- a) Pre-start check lists covering all the individual plant systems.
- b) Starting procedures.
- c) In service checks and limits including routine test procedures.
- d) Shutting down procedures.

12.2.2.6 Section 5 - Operation:

Operating instructions are required for all items of equipment for start-up, normal operation, shutdown, standby, emergency action, and on load and off load testing procedures, and shall contain the operating procedures of the systems, in addition to the emergency and abnormal conditions procedures.

- a) Operating limits, normal, abnormal and hazards.
- b) Procedures detailed under the heading of "Emergency Action" shall include:

- i) Actions upon receipt of alarm/alarm condition/appropriate action.
- ii) Emergency procedures for each major fault situation.
- iii) Fault conditions.
- iv) Diagnostic procedures.
- v) Initial actions.
- vi) Follow up action and operation.
- vii) Loss of electrical supplies associated with important auxiliaries, controls and instrumentation.

12.2.2.7 Section 6 - Maintenance:

Maintenance instructions prepared with the objective of providing sufficient detailed technical information and step-by-step instructions to

- a) enable the efficient overhaul and replacement of all parts of the plant to be carried out by plant maintenance personnel,
- b) provide guidance in the tracing of faults and their rectification, and
- c) permit the ordering of replacement parts. Separate maintenance instructions shall be prepared for each item of plant and shall be set out in step-by-step instructions with each step numbered in correct logical sequence and including;
 - a) Maintenance programs for regular inspections, preventative maintenance and overhauls, described on the basis of frequency (viz., daily, weekly, monthly, three monthly, annual, and the like, or on hours of operation).
 - b) Special diagrams and illustrations.
 - c) Parts lists presented in a logical sequence (i.e. main assembly, sub-assembly and components) with the components listed under their respective sub-assemblies.
 - d) Lubrication schedule showing requirements and specifications for lubricants for the diesel generator.
 - e) Cleaning and conservation procedures.
 - f) List of special tools and equipment required.
 - g) Check list of operations prior to dismantling.
 - h) Dismantling sequence, with particulars of methods used.
 - i) Inspection of components and checking of permissible tolerances.
 - j) Reconditioning, replacement and adjustment procedures.
 - k) Reassembly sequence, with particulars of methods to be adopted.
 - l) Recommended spares list

12.2.2.8 Section 7 - Trouble Shooting:

A trouble shooting programme based on symptoms and including suggested frequency of inspection of components and frequency of routine maintenance. The programme shall include details of the points at which measurements should be taken, details of the normal readings at those points and the possible reasons for abnormal readings.

12.2.2.9 Section 8 - (Re-) Commissioning:

(Re-) commissioning procedures set out in step-by-step instructions and including:

- a) Controller settings and readings for normal operations.
- b) Actuator settings and readings for normal operations.
- c) AVR settings and readings for normal operations.

- d) List for checking of settings prior to re-commissioning.
- e) Procedures for preparing for service, equipment which requires tuning or other adjustment at re-commissioning after a major overhaul.

12.2.2.10 Section 9 -Test Documentation:

Manuals shall include an Appendix for insertion of;

- a) Factory Acceptance Testing (FAT).
- b) All commissioning reports, site calibration documents, data recorder logs / scope traces and test sheets to be included in this section.

12.2.2.11 Section 10 – Certificates and Warrantees:

- a) Manufacturers' written warranties and guarantees.
- b) Product type test certificates.
- c) Electrical Certificates of Compliance.

12.3 Drawing Submissions

The following drawings and documentation shall be submitted:

- **With Tender:**
 - a) Outline drawing of each diesel generator container showing major dimensions and weights, hold down arrangements of the diesel generator container, and cable access for all 400 V power cables, control and communications cabling.
 - b) Internal layout drawing of each diesel generator showing major components.
 - c) External layout drawing of each diesel generator showing major components, components removed for shipping.
 - d) Control system overview drawing showing details of all main components and monitoring, control and communication interfaces.
 - e) Technical data, information on the diesel generators, all main components and ancillaries and the like and their operating mechanisms.
 - f) Technical data on the alternator including capability curves and all reactance and rating information.
 - g) Technical data on all control system components, protection relays, etc.
 - h) Information on previous supply of like types.
- **With Orders:**
 - a) Supplier Quality Assurance Manual as detailed above.
 - b) Primary civil drawings showing dimensioned outlines and dimensioned hold down arrangements for the containers and peripherals.
 - c) Load bearing information including all static and dynamic loads under fault conditions for civil design considerations.
 - d) Factory certified dimensional drawings, complete with parts list, full dimensions, weights, and details of holding down arrangements, and cable entry points.
 - e) Calculations for silencers, radiators, exhausts for noise levels.
 - f) Detail of connection arrangements to allow removal of the engine and alternator skid from the container, complete with details of any blanking-off mechanisms when the engine and diesel generator skid is removed for major servicing.
 - g) General arrangement drawings of all equipment, including control panels
 - a) Control System logic diagrams, functional description for the diesel generator control

systems detailing local and remote monitoring and control and interfacing with other sub-systems.

- b) Control System data maps and set point methods in order to monitor and operate the generation system
- c) Complete Control System schematics and drawings.
- d) Connection drawings, showing terminations and labelling.

III Particular Specifications

1. General Arrangements

The generating set shall be powered by a water-cooled, heavy-duty, industrial type diesel engine that is directly coupled via a SAE flexible disk/flange coupling to a brush-less, synchronous, self-regulated alternator. The fuel system shall be capable of governing to ISO 8528-2 G2 specifications.

The engine/alternator/radiator shall be mounted on skid-type steel base frame with rounded and slanted rail ends. The engines/alternators shall be insulated from the frame by suitably rated and oil resistant anti-vibration mounts. A "tropical" class radiator, and belt-driven fan, capable of cooling the engine on full load, at site conditions, shall be included. A diesel day-fuel tank shall be incorporated between base-frame rails, with a minimum capacity of eight (8) hours continuous running for air cooled and 12 hours continuous running for water cooled units at 75% load. Generating set shall be mounted inside a purpose built and sound attenuated weatherproof enclosure fitted on high-speed trailer for easy towing on rough terrain. A safety shutdown system for low oil pressure, high temperature, over-speed and low fuel level shall be provided with LED, re-settable indicators. The generator sets should be in serviceable and full operational condition on delivery.

All Generator sets should be manufactured fitted with "Common Rail" or "HEUI or MEUI System operated by ECM (valid for Generator capacities above 20 kVA). It is crucial to the to make Generators fuel efficient and reduce to permissible fuel (Diesel) emissions to Euro Stage II G & D standards for non-road diesel constant speed engines measured under ISO 8178-4 C1. In absence of electronic controlled engines for the generators with capacities 10 kVA, 15 kVA and 20 kVA, mechanical governors will apply provided that they meet the desired fuel efficiencies and emission levels. Generators with capacity 25 kVA and above shall be fitted with ECM (Electronic Control Management).

The engine shall be capable of operating at light loads for extended periods of time and shall provide a means to reduce carbonisation. (With good design, periodic cleaning of exhaust parts should not be required).

An oil evacuation hand pump shall be mounted and connected for draining/filling the engine oil sump.

Battery cables, vibration-free battery racks/trays and charge alternator are also included. The engine shall be supplied with vertically mounted spin-on oil and fuel filter(s), a fill of suitable lubricating oil, and anti-freeze for cooling system [separately packed] for protection down to minus 20°C. The radiator drain shall be piped to the edge of the /skid base frame/enclosure.

During each initial start of the engine, a system shall be provided to pre-lube at low idle speed. When the internal oil pressure reaches a predetermined safe value, the engine speed will then increase to alternator set operating speed.

The engine shall be equipped with fuel filter, tube oil filters, heavy-duty tube oil cooler and the temperature controlled by a thermostat valve, fuel transfer pump, fuel priming pump and duplex filters (*primary and secondary filters*), charge-cooler and heavy duty type air filters made to withstand dusty tropical conditions, service meter, engine driven water pump, and unit mounted instruments. Supply and spill fuel-lines, fittings shall be included and fitted to the day-tank.

Unit mounted instruments shall include water temperature gauge, and lubrication oil pressure gauge. The engine shall be provided with low oil pressure, high water temperature, and low

coolant level and over speed safety shutdowns of the manual reset type. Additional instruments and safety shutdowns shall be provided as noted herein.

Injection pumps and injection valves shall be a type not requiring adjustment in service and shall be of a design allowing quick replacement by mechanics without special diesel engine experience. The engines shall have an individual electronically controlled injection pump and injection valve for each cylinder, any one of which may be removed and replaced from parts stock. Fuel injection pumps shall be positive action, constant-stroke pumps, activated by a cam driven by gears from the engine crankshaft. Fuel lines between injection pumps and valves shall be of heavy seamless tubing.

Where applicable, air filters including pre-filters and dust traps shall be mounted behind the engine, over the alternator as not to restrict the access to rocker covers and fuel injection pump.

2. Guaranteed Output and Conditions

The Generator sets shall have the Voltage, Phase, Frequency and Speed rated at 240/415 V AC, 1- phase & 3-phase, 50 Hz, and 1500/1800 rpm on load respectively.

Calculation of net power output based on prime rated variable load operation, with makes, models, kW(e), kW(m), radiator fan power requirement, efficiencies, derating factors, etc., as per original technical brochures must be furnished along with the bid.

All Generator sets must be manufactured and rated according to continuous power output as outlined in ISO-8528-1, overload power in accordance with ISO-3046/1, BS 5514, AS 2789 and DIN 6271. The net power outputs of the desired generator capacities will have been derived not only of the mechanical, electrical losses and efficiency, but also taking into account the derating factors caused by high altitude operation.

2.1 Rating

The diesel generators shall be prime rated with an electrical output from each diesel generator as given below :

- A. 5kVA (single phase)
- B. 10kVA (Single phase)
- C. 16kVA (single phase and three phase options)
- D. 25kVA
- E. 40kVA
- F. 60kVA
- G. 80kVA
- H. 100kVA
- I. 150kVA
- J. 200kVA

The diesel generator set shall achieve the rated values and performance under the following specified conditions and the above environmental conditions and shall deliver power within the following requirements.

- Nominal Voltage: 415/240 V at alternator terminals.
- Nominal Frequency: 50 Hz.
- Power Factor: Maximum 0.8 lagging.
- Overload greater than 2.0 p.u. for 10 seconds, with less than 30% voltage dip.
- Fuel specified fuel values.

2.2 Governing

The governor shall provide stable control between the limits of 48 to 52 Hz in isochronous and base load operation and a maximum speed variation of 4%.

The governing capability of the gensets shall generally comply with the given standards. Each of its generation units has a speed governor that:

- a) provides stable performance with adequate damping;
- b) has an adjustable droop over the range 0% to 7%; and

2.3 Excitation

In island mode the diesel generator, AVR and exciter systems shall be capable of supplying rated kW at 0.8 pF overexcited.

2.4 Maximum Voltage and Frequency Excursions

The set shall also be capable of operating under the following situations:

- a) The full capacity loading of the set shall be possible within 20 seconds.
- b) At 30% load steps the speed shall not change by more than 1% of nominal (depression) after not more than 5 seconds from load changes.
- c) At 30% load steps the voltage shall not change by more than 20% of nominal (depression) after not more than 5 seconds from load changes.
- d) Removal of 30% of rated load shall not result in transient speed change exceeding 10%, and voltage change exceeding 15%, recovering to 1% within 10 seconds.

2.5 Technical Schedule Guarantees

The Specific fuel consumption (g/kWe) and power output (kWe) must be quoted at standard (ISO) ambient conditions and at 45°C (although it's not the highest possible ambient this temperature will be used for assessment of the equipment performance in hot conditions). The Supplier shall advise the de-rating curves or correction curves or formulae or calculations applicable to the particular diesel generator for the power deration or fuel consumption for the contract ambient conditions, this must be advised with the bid submission.

2.6 Noise

Noise levels shall be within the specified range. The weatherproof and sound attenuated enclosure construction will limit the noise level to 70 dbA at 7 meter or 80 dbA at 1 m distance at full continuous load.

3. Diesel Engine

3.1 General

The diesel generator shall, as a minimum include;

- Diesel engine at 1500/1800 rpm, direct coupled to a 415 Volt synchronous electrical alternator.
- Tropicalised, single/dual bearing (depending on size) alternator.
- Air-water heat exchanger cooling for jacket, lube oil and intercooler cooling.
- Fabricated structural steel base skid for mounting inclusive of all protection systems, control systems to be mounted inside tropicalised container for permanent mounting on a concrete foundation.
- Diesel generator tropicalised container.
- Dual electric starting system (battery and starter motors).
- Dual fuel filters (fuel and fuel / water).
- Fuel meters to measure the net consumption of fuel by the engine in grams and litres. The meters shall have temperature correcting capability with analogue output (4-20 mA), and pulse output.
- Diesel fuel engine supply system.
- Lubrication system with engine lube oil pumps, oil filter.
- Exhaust system (stainless steel outlet, with rain cap).
- Local diesel generator control panel controlling a common rail or unit injection system type and ECM operated The ECM system shall be able to record hourly and total fuel consumption through the ECM data history for future download. In absence of electronic controlled engines for the generators with capacities below 25 kVA, mechanical governors will apply provided that they meet the desired fuel efficiencies and emission levels. Generators with capacity 25 kVA and above shall be fitted with ECM (Electronic Control Management).
- Synchronization unit for manual, semi-automatic and automatic synchronization.
- Local service 415 V / 240 V diesel generator auxiliary switchboard.
- The diesel engine shall be an intercooled, turbocharged (if applicable), water-cooled, four-stroke cycle design which is capable of accepting load immediately after starting.
- The engine unit shall be capable of driving an alternator mounted on a common base skid, at the specified output.

3.2 Starting System

Each engine shall be provided with an on-skid dual 12/24 V DC electric starting system. The Supplier shall provide the electric starting motors, low maintenance starting batteries together with ventilated battery housing, interconnection cables and 240 V AC battery charger(s).

The independent battery charger(s) must be fully automatic and allow boost, charge and float charging conditions with monitoring by the diesel generator control system.

The batteries and starters shall be capable of ten (10) starts per hour. The battery charger(s) shall be capable of re-charging the batteries to full potential within one hour after a cranking cycle and shall be adjustable to compensate for the battery self-discharge rate during standby periods. All battery system components shall be monitored and alarmed by the control system.

The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and number of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods.

The control system shall include time delay start (adjustable 0~300 seconds) and time delay stop (adjustable 0~600 seconds) functions.

3.3 Lubrication

The lubrication system shall comprise an engine driven pump to circulate lubricating oil under pressure. Full flow filters shall be provided together with replaceable elements. Lube oil make-up shall be automatic monitored and alarmed by the control system. The lubrication system shall be provided with alarms and trip sensors for high/low oil levels and temperatures and fitted with a crankcase heater if required.

3.4 Engine Cooling

The engine cooling system shall be capable of adequately cooling the diesel generator engine when the diesel generator is delivering full load at the specified maximum outdoor ambient air temperature. The on-skid radiator cooling system shall be provided with the following:

- Water pumps for jacket water and turbocharger intercooler cooling complete with thermostatic bypasses.
- Water-air heat exchanger(s) for jacket water and turbocharger intercooler cooling complete with all necessary interconnection(s) to the on-board radiator.
- Automatic control of radiator fans, including automatic cycling for even running hours
- Alarms and trip sensors for high/low coolant levels and temperatures.
- The diesel generators sets are to be installed in a complex climatological environment. The cooling and aspiration air system shall be fully suitable for this arrangement.
- All cooling system components to be monitored and alarmed by the control system.

The cooling system shall include a heavy-duty, tropical-type radiator, constructed for high ambient/engine temperatures, and prevailing conditions in tropical and arid dusty climates. The radiator shall be capable of cooling the engine when the diesel generator set is delivering full rated load in an ambient temperature not to exceed 55°C.

The engine shall be provided with a thermostatic valve placed in the jacket water outlet between the engine and the cooling source. This valve shall maintain the proper jacket water temperature under all load conditions. A flexible connecting section shall be provided between the radiator and discharge lower frame. The radiator shall be mounted in front of the engine, onto the skid base with oil resistant anti vibration mountings.

3.5 Exhaust System

The diesel engine exhaust system shall comprise the exhaust silencer, discharge pipe work and stack, and support structures. The engine exhaust system includes but is not limited to the following;

- Flanged flexible stainless steel thermal expansion bellows at the diesel engine exhaust outlet
- Exhaust silencer of a non-spark type capable of the following:
 - Low-pressure drop;
 - Damping engine pulsations, backfiring and preventing any engine resonance;

- Sound attenuation as required to meet the noise levels specified;
- Drainage facilities.
- The exhaust shall be stainless steel insulated as required and fitted with a rain flap. The discharge stack, and exhaust systems shall be supplied complete with roof, wall and ground mounts as required complete with anti-vibration supports as required. The exhaust shall discharge from the top of the diesel generator enclosure.
- All 316 stainless steel bolts mated with 304 stainless nuts together with an anti-seize compound.
- Other noise control measures including splitter attenuators and acoustic linings shall be considered with regard to reducing the noise levels. The Supplier shall state any additional options for noise reduction and associated costs.

3.6 Insulation

The Supplier shall provide and install thermal insulation on the diesel generator and supplied auxiliaries where required for the efficiency of the works, to meet statutory and local regulatory requirements and safety of personnel.

No part of the works that can be touched during normal operation shall have a surface temperature in excess of 50°C. All insulation materials shall not contain any asbestos or asbestos based products.

All insulation applied to pipe work, machinery, works, and ducting shall be clad with aluminium or stainless steel cladding of appropriate thickness not less than that conforming with BS 5970. Cladding design, application and fixing shall be in accordance with BS 5970 or as otherwise approved by UNHCR.

All insulation exposed to the weather shall be sufficiently clad to be completely weatherproof. Insulation and cladding shall be designed and applied with proper allowance for expansion and contraction.

3.7 Diesel Engine Heaters

The engine shall be equipped with a thermostat controlled coolant immersion heater, (powered from the auxiliary power distribution) to aid engine starting, in cold weather. The heater shall be automatically switched off, when is running. The fuel injection pump shall be fitted with a mechanical governor/electronic controller capable of governing to ISO 8528-2 G2; mechanical governor/electronic control shall include adjustments of gain, damping, and a ramping function to control engine speed and limit smoke while the unit is starting, standard protection devices, 12/24 Volt starting batteries, capable of starting the diesel engine at ambient temperatures down to minus 20°C, based on a minimum of six (6) consecutive start attempts.

3.8 Governor

An electronic governor system shall be provided to maintain automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The fuel rate shall be regulated as a function of starting, accelerating to start, disconnects speed, accelerating to rated speed, and operating in various isochronous or parallel states. The control system shall interface directly with the governor. All software, programming leads, software dongles and the like shall be included if a PC programmable system is offered.

4. Alternator

4.1 General

The alternator shall be a synchronous, 0.415 kV, 4 pole, 2/3 pitch, air-cooled, single or dual bearing (depending on size), drip proof industrial type. It shall be of a rotating field brushless design, and have an integral rotating exciter with an excitation supply from a permanent magnet alternator or other approved method of supply. The synchronous alternator shall be rated for a nominal continuous output and overload capacity at the specified environmental and operating conditions and shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 per cent above or below rated voltage. The sub-transient reactance of the alternator shall not exceed 15% and the alternator shall be able to operate up to 15% reverse kVAr.

The instantaneous voltage dip shall not exceed 20% of rated voltage when full load, at rated power factor, is suddenly applied. Recovery of stable operation shall occur within 5 seconds. Steady state modulation shall not exceed +0.5%.

The deviation of the waveform of voltage output from a pure sine wave shall not exceed the limits specified in BS 5000 Part 99: 1981 within a range of $\pm 2.5\%$. Telephone, Radio/Television radiated interference should be suppressed to the limits in accordance with BS: 800 1983 Part 99, BS 833: 1985 & BS EN: 6100-6 (1, 2, 3, 4).

4.2 Design

The stator core shall be built up of high-grade silicon steel laminations precision punched, and individually insulated. Armature lamination followers and frame ribs shall be welded integral with the frames for support of stator core. A directional blower shall be mounted on the unit to draw cooling air from the exciter and over the rotor poles and through louvered openings on the opposite end.

The rotor poles shall be built up of individually insulated silicon steel punching. Poles shall be wound and bonded with high strength epoxy resin. Cage connections to the amortisseur rings shall be brazed for strong construction and permanent electrical characteristics. Each pole shall be securely bolted to the rotor shaft with bolts sized for the centrifugal forces on the rotor. Alternator windings shall be braced for full line ground fault currents, with solidly grounded neutral system.

The alternator housing shall be weatherproof and rated to minimum IP23. The alternator output is wired to heavy-duty terminations, via an appropriately rated, moulded case circuit breaker, with overload and short circuit protection.

The alternator stator and exciter winding shall conform to BS 2757: 1984 excluding Classes Y and A standard, with 100% rated load temperature rise, protection against aggressive atmosphere, severe environment. This should be acceptable to RH >95% not less than Class H limitation.

The insulation to windings shall have an oil, moisture, slat air, fungus proof finish and epoxy coated with surface which will not retain dust or condensation, it shall be possible to put the set in service after long periods in unheated storage without the necessity for drying up insulation.

4.3 Temperature Rises

The winding insulation shall be Class 'H' to BS 2757 or equivalent. At rated output under the specified operating conditions the temperature rises for Class 'H' insulated windings shall not exceed those specified in BS 4999 Part 32 for Class 'H' insulation.

4.4 Excitation System

The exciter shall be a fast response type, with a rotating 3-phase full-wave bridge. The exciter shall have a low time constant and large capacity to minimize voltage transients under severe load changes. The voltage regulation class of accuracy and performance shall be in accordance with regulation grade VR 1 of Clause 40.3.4 of BS 4999 Part 40.

The alternator shall be AVR (Automatic Voltage Regulator) controlled (digital type). The alternator manufacturer/Supplier shall furnish a hermetically sealed, silicon controlled rectifier type voltage regulator employing a zener diode reference with $\pm 1\%$ regulation for the generator. The regulator shall include 1-phase/3-phase voltage sensing, automatic short circuit protection and shall include automatic under frequency protection to allow the generator to operate at no load at less than synchronous speed for engine start-up and shutdown procedures.

For sustaining short circuit current of up to 300% for 3 seconds when under control of the automatic voltage regulator, a permanent magnetic exciter shall be provided to the units with capacities which can meet the 300% short circuit current for 3 seconds condition, permitting the breaker to trip on overload. To prevent possible overheating of the armature windings, appropriate relaying shall be supplied to limit the fault to ten seconds.

The excitation system shall incorporate the following features and facilities;

- Voltage setting control.
- Reactive power (VAr) or power factor control.
- Protection against AVR failures (e.g. over/under excitation combined with over/under voltage).
- Supervised fault detection.
- Capability to operate with automatic synchronising equipment.
- Start excitation under black start conditions.
- An excitation system which will withstand short circuits and synchronising of the machine up to 90° out of phase without failure of the components.
- Fault current boosting as required for discrimination of the system electrical protection with the alternator running isolated.
- A brushless excitation system.

4.5 Automatic Voltage regulation (AVR)

The AVR shall be capable of maintaining voltage at $\pm 1.0\%$ of any value within 10% of the nominal voltage throughout the full range of rated load and power factor conditions. Droop, stability and voltage set point adjustments shall be by operator interface or programmable via laptop.

The AVR shall be capable of preventing sustained over voltage during over speed conditions following the loss of load. After a sudden load rejection at rated power factor, rated voltage shall be restored within 2 seconds.

Torque matching characteristic shall be adjustable for roll-off frequency and rate, and be capable of being curve-matched to the engine torque curve with adjustable in the field. The

voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via rheostat, with LED readout to indicate setting level. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceed 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown).

Controls shall be provided to individually monitor all three phases of the output for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown).

Controls shall be provided to monitor the kW load on the generator set, and initiate an alarm condition (overload) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load-shed control; to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.

All software, programming leads and software dongles and the like shall be included if a PC programmable system is offered.

4.6 Synchronizer

Synchronization will not be required on all generator sets but will be subject to separate order. However, each generator set supplied under this contract shall be capable for synchronization with other diesel gen sets or RE sources.

A fully featured synchroniser shall be included either as part of the AVR or as a separate unit. The synchroniser shall be controlled by the alternator start-up system and interface directly to the governor and AVR. Clean contacts for close/open of the main breaker shall be included as well as interface to any other indications required.

The supplier shall provide a separate price for a synchroniser.

5. Diesel Generator Control System

5.1 Diesel Generator Control

The main diesel generator control panel shall be a sturdy, self-supporting, of suitably treated and painted sheet steel (conforming to IP 54 protection and in accordance with industry standards. It shall comprise all equipment necessary to support the function, controls and modes of operation described in this specification, including but not limited to (the equipment may be adjusted for units with smaller capacities):

- Automatic controls including operator interface capable of communications for transmission of status and alarms.
- Isochronous load control and base load control modes.
- Dedicated 12/24 V DC supply system.
- Comprehensive indication including but not limited to:
 - Diesel generator voltage (LL&LN)/current per phase.
 - Battery voltage.
 - Power meters for diesel generator kW, kWh, kVAr
 - Power factor.
 - Frequency.

- Lube oil pressure/temperature
- Fuel system monitoring.
- Engine/Alternator speed.
- Coolant temperatures.
- Start fail.
- Panel controls for circuit breaker.
- Panel controls and status of diesel generator test, manual and automatic operations.
- Emergency stop – lock down / twist to release mushroom style.

5.1.1 Control Switches

5.1.1.1 Mode Select Switch

The mode select switch shall initiate the following control modes. When in the RUN or Manual position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage. In the LOAD TEST mode position the generator set shall be ready to be tested under varying-load conditions.

5.1.1.2 Emergency Stop Switch

The emergency stop switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.

5.1.1.3 Reset Switch

The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.

5.1.1.4 Panel Lamp switch

Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.

5.1.2 Generator Set AC Output Metering

The generator set shall be provided with a metering set including the following features and functions:

- a) Digital Controller working in parallel with analog metering set with 0.5% accuracy, to indicate generator RMS voltage and frequency, output current (3 ammeters), output kW, kWhr, and power factor (pf). Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three-phase voltages (line to line! and line to neutral) simultaneously.
- b) The control system shall log total number of operating hours and total kWhrs.
- c) The control system shall log total fuel consumed given certain number of operating hours and or total kWhrs.

5.1.3 Engine Status Monitoring

The following information shall be available from an analogy display status panel on the generator set control:

- a) Engine oil pressure (psi or kPA)
- b) Engine coolant temperature (degrees C)
- c) Engine oil temperature (degrees C)
- d) Engine speed (rpm)
- e) Number of hours of operation (hours)
- f) Number of start attempts
- g) Battery voltage (DC volts).

5.1.4 Control Interfaces for Remote Monitoring

The control system shall provide four programmable output relays. These relay outputs shall be configured for any alarm, shutdown, or status condition monitored by the control. The relays shall be configured to indicate:

- a) generator set operating at rated voltage and frequency,
- b) common warning,
- c) common shutdown,
- d) load shed command.

A fused 10 amp switched 12/24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.

A fused 10 amp 12/24V DC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.

The electronic and electrical controls and wiring shall be able to withstand the ambient temperature and vibrations inside the enclosure. The panel itself shall also be vibration insulated. Line diagram of the integrated control panel clearly showing all components shall be submitted with the bid.

5.2 Battery Monitoring System

A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 13.5 V DC or more that 15 V DC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and DC voltage shall be monitored as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.

5.3 Diesel Generator and Engine Protection System

The diesel generator shall be equipped with a dedicated engine protection system that acts to minimize damage in the event that the unit malfunctions, or is exposed to an external fault. This shall include:

- An engine protection system including coolant temperature, oil pressure etc.
- An emergency stop operator push button system, with emergency stops.

The electrical protection system shall operate on the main breaker. The diesel generator protection shall include warnings and trips including but not limited to:

- Over voltage.
- Under voltage.
- Over speed/frequency.
- Under speed/frequency.
- Over current and earth fault.
- Differential.
- Reverse power
- Turbo charger over speed (if applicable).
- High oil temperature.
- High jacket water temperature.
- Low oil pressure.
- Low fuel tank level and alarms.
- AVR alarms.
- Exciter alarms.
- Temperature alarms.

The Supplier shall provide any additional recommendations for protection elements, recommended settings for the diesel generators provided, and provide all base data including capability curves, negative sequence withstand curves and the like to assist with the settings of the above protection elements.

5.3.1 Voltage Monitoring System

An AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdowns of the generator set when alternator output voltage exceeds 100% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

5.4 Main line Circuit Breaker

Main line, moulded case circuit breaker mounted upon and sized to the output of the generator at 50 Hz shall be installed as a load circuit interrupting and protection device. 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 circuit breakers on the Generator power supply outlet shall be covered by flex glass internally/externally for protection against electrical hazards. Each circuit breaker shall be equipped with auxiliary contacts for connecting the required number of indicators and protection devices as stated above and to connect remote annunciation of breaker position.

The circuit breaker enclosure, together with all specified circuit breakers, shall be designed for the specified and be equipped with an isolated neutral conductor bus, rear copper stabs, or load cable lugs and be finish painted to match the generator set.

The rating of each circuit breaker shall allow the starting of full generator kVA.

The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short circuit protection. The circuit breaker shall meet standards according to IEC 947-2 and/or BS EN 60947-2.

5.5 Starting Battery and Charger

The stationary maintenance free storage battery set shall be of heavy-duty diesel starting type. It shall be of maintenance free, sealed type e.g. AGM, VRLA, OPzV or OPsV. The battery voltage shall be rated 12/24 V DC, and the battery set shall be of sufficient capacity for six starts in succession once in an eight-hour period at a minimum. Requisite quantity for initial fill of batteries will be supplied with generating sets.

An automatic 12/24 V DC battery Charger with current limiting capabilities shall be furnished to automatically charge the batteries. The Charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, DC ammeter, DC voltmeter and fused AC input.

6. Earthing

The alternator star point is solidly earthed. The earthing system may comprise of copper plates and minimum 35 mm² copper stranded wire. Maximum permissible resistivity will be 10 Ω. The supply includes:

- a) 1 piece of 600x600x6mm copper plate
- b) 1 piece of 600x600x6mm GI plate
- c) 10 m of 32mmx10mm copper strip
- d) 10 m of 32mmx10mm GI strip
- e) 10 m of PVC sleeve suitable for 32mmx10 mm copper strip
- f) 10 m of PVC sleeve suitable for 32mmx10 mm GI strip.

All metal parts including doors windows, rails, metal boxes, engines and alternators bodies, etc. shall be connected via insulated stranded copper cable of minimum 10 mm², marked yellow-green through suitable cable lugs and ready to be connected to the earthing system

7. Weatherproof and Sound Attenuated Enclosure

The generator set shall be manufactured and housed completely into a weatherproof and sound attenuated enclosure, with standard forklift slots and two standard load locking /lifting fittings. The arrangement inside the enclosure shall allow for the generating set to be pulled out in either direction after unbolting sound attenuation enclosure, anti-vibration mounts, day-tank etc.

The engine and alternator (including integrated fuel tank) shall be mounted and aligned on a rigid skid, fabricated from cross-braced structural steel members. The skid shall be complete with all necessary fixings and floor strengthening as required and be provided with vibration mounts and seismic restraint holding down bolts.

All sheet metal shall be primed for corrosion protection and finish painted with the manufacturer's standard colour using a two-step electro-coating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted. The painting process shall result in a coating that meets the following minimum requirements and shall be suitable for a minimum of 20 years life in a tropical atmosphere:

- a) Primer thickness, 0.5-2.0 mm
- b) Top coat thickness, 0.8-1.2 mm
- c) Gloss, per ASTM D523-89, 80% plus or minus 5%. Gloss retention after one year shall exceed 50%.

The canopy shall be supplied with lockable doors and window to view control panel. The canopy should be in white color clearly marked with "UNHCR" logo in blue letters and underneath the logo the words: The UN Refugee Agency. Minimum height of the letters shall be 200 mm. The letters shall be proportional to the actual size of the canopy to ensure maximum visibility. Weight of the entire unit shall be marked on the canopy together with PO (purchase order) number. Inside canopy door, a label should be affixed giving generator power (kVA), weight, dimensions, fuel tank capacity, engine number, serial number, year of manufacture and manufacturer's name, address and contact numbers.

The enclosure shall be outfitted with all necessary louvered openings to provide sufficient ventilation, and allowing the generating set to operate as per site conditions. The enclosure shall be outfitted with:

- a) Ceiling mounted Light bulb (12/24 V DC), providing sufficient light on both sides of the generator.
- b) Outside, flush –mounted, easily accessible (for re-fuelling), lockable fuel-tank filler. The Enclosure fitted with day fuel-tank shall also be supplied along with a manual hand-priming pump to fill the day fuel-tank (in case of AC power outage) from the external main storage tank.
- c) Suitable outlet for distribution cable, that when not in use is covered by a bolt-on cover accessible from inside only.
- d) The generating set is earth-connected to the enclosure, and two (2) heavy-duty earth connections are provided (one on each side).

Minor differences in the construction of the weatherproof enclosure are acceptable, provided that the main requirements are met i.e.

- a) Generating set can operate continuously at site conditions
- b) Generating set can be pulled out of the enclosure from either end.
- c) Outside mounted exhaust silencer
- d) Provision of internal day-tank
- e) Mounting of main circuit breaker.

Sound proofing materials shall be highly fire protective (material manufacturer's certificate should be provided)

8. Data sheets

The Supplier shall provide a complete set of data sheets as described below with his bid. Missing data sheets and/or information may lead to the rejection of the bid.

8.1 Installation Drawings

Installation drawings showing plan and elevations of the complete generator unit:

- a) foundation plan;
- b) exhaust silencer;
- c) starting battery;
- d) battery charger;
- e) weatherproof enclosure and trailer and
- f) base mounted fuel tank.

8.2 Engine Data:

- a) Manufacturer
- b) Model
- c) Number of Cylinders
- d) RPM
- e) Bore x stroke
- f) BMEP at full rated load
- g) Piston speed, FPM
- h) Make and model and descriptive literature of electric governor (where required)
- i) Fuel consumption rate curves at various loads
- j) Engine continuous pump drive duty rating (without fan) HP
- k) Gross engine horsepower to produce generator continuous rating (including fan and all parasitic loads) HP

8.3 Alternator Data

- a) Manufacturer
- b) Model
- c) Rated kVA
- d) Rated kW
- e) Voltage
- f) Temperature rise above 40°C ambient:
 - i) Stator by thermometer
 - ii) Field by resistance
 - iii) Class of insulation
- g) Generator efficiency including excitation losses and at 0.8 power factor:
 - i) Full load
 - ii) $\frac{3}{4}$ load
 - iii) $\frac{1}{2}$ load

8.4 Generator Unit Control Data:

- a) Actual electrical diagrams including schematic diagrams, and interconnection wiring diagrams for all equipment to be provided. Standard pre-printed sheets are not acceptable.
- b) Legends for all devices on all diagrams.
- c) Sequence of operation explanations for all portions of all schematic wiring diagrams.

8.5 Engine/Alternator Unit and weatherproof enclosure

Dimensional data shall be given for the Engine/Alternator set and for the weatherproof enclosure:

- a) Weight of skid mounted unit
- b) Overall length
- c) Overall width
- d) Overall height
- a) Exhaust pipe size
- b) CFM of air required for combustion and ventilation
- c) Heat rejected to jacket water and lubricating oil BTU/hr.
- d) Heat rejected to room by engine and alternator set BTU/hr.
- e) Weatherproof enclosure and trailer details and certification of manufacturing method per specification.
- f) Base fuel tank (capacity to be stated for each size), venting, and fuel connection points and fill cap location.
- g) Data on all miscellaneous items supplied.

8.6 Test Reports

Furnish a number of copies of certified shop test record of the complete engine driven generator unit.

8.7 Warranty information

Submit to UNHCR the operating and maintenance data.

Submit to UNHCR the equipment manufacturer's certificate of installation, testing, and instruction.