

Section: Repeater Shelter

1 Introduction

This section describes the functional requirement, major technical parameters and all the testing requirements for telecom shelter system, including its sub-systems, Air-conditioning system, DG Set, PIU & 48V DC Power Supply.

1.1 Repeater Shelter Requirements

1.1.1 Shelter Dimensions

The minimum internal and external dimensions of the shelters shall be as per Table 1.1 as specified below:

Table 1.1: All dimensions are in mm

SNo.	External /Internal	Length (L)	Width (W)	Height (H)
1	External	4500	2700	3160
	Internal	4340	2540	3000

1.1.2 General

The shelters shall be protected and insulated to achieve sound proof, thermal resistance and impact withstand capabilities. The shelters shall be 100% leak and water proof with IP 55 protection. The shelters shall be maintenance free having minimum life of 15 years. These shelters shall be suitable for outdoor and may be mounted at any location including ground and rooftop and in any climatic conditions. The shelters shall be easily assembled and installed at site. The shelters shall be re-locatable as and when required.

1.1.3 Shelter Panels

The shelter shall be made of “sandwich insulated panels” 80 mm thick with Poly Urethane Foam (PUF) as filler material between polyester pre-coated cold rolled aluminium sheets. The insulation characteristics of PUF material shall conform to Clause no. 1.1.19 of these specifications.

For Steel shelters, the thickness of the inner-side and outer steel sheets except floor panel sheets shall be minimum 0.8 mm and 0.6 mm respectively. For Aluminium shelters, the thickness of both inner side and outer side aluminium sheets except floor panel sheets shall be minimum 0.91 mm. The outer bottom sheet shall be hot dip galvanised steel sheets and aluminium sheets of minimum 1.0 mm and 1.2 mm thickness respectively to avoid rusting of the bottom panel. The sandwich panels shall be manufactured by high pressure injection technique. The panels to be provided with tubular element precast in panels while foaming to form an integral part through this precast element GI steel rods of required sizes shall be inserted and fastened to top and bottom structures. The steel and aluminium sheets of standard and reputed make shall only be used.

1.1.4 Floor

The floor shall consist of standard PUF sandwich panels suitably reinforced to support the minimum load capacity of 2000 kg/m² and having at least 19 mm Marine plywood covered with anti static PVC flooring. In case of floor panel, 19 mm Marine plywood shall be provided on top of the panel and no steel or aluminium sheet shall be provided inside the panel. The anti static flooring shall be provided with pacific blue anti static vinyl robust rolls of at least 2 mm thickness. The floor shall be even surfaced,

scratch proof having long life. The installation of various proposed equipment shall be possible either by direct placement on the floor or by grouting to the floor or through C rails. The Contractor shall submit the reinforcement and other details calculations in support of the meeting the load capacity.

1.1.5 Roof

Roofs shall be made of the panels same as specified for walls. A secondary slanting roof of suitable material shall be provided to protect the primary roof from direct sunlight and rainwater. A minimum down slant of 1:50 shall be maintained from front to back. The secondary roof shall have minimum projections and shall be hidden by angular profiles on the rooftop to decrease the aerodynamic effect and improve on aesthetics. The secondary roof shall be suitably clamped/ bolted to the shelter panels to withstand the specified wind load. The details of the secondary roof and its attachment arrangement shall be submitted for Employer's approval during detail engineering. The cable tray shall be attached suitably from the roof and the roof shall have sufficient strength to support the load of cable trays and the cables installed on the cable tray.

1.1.6 Door

The Shelters shall have one door for main entrance. The door dimensions shall be 1000 mm (W) X 2200 mm (H). Main door opening outwards shall be provided with external and internal handles/knobs respectively. A reputed make lock shall be provided in door handle. The make of the lock shall be got approved during detail engineering. The door can be opened from inside when locked. Door, when locked cannot be removed even if the hinges are removed. The door shall generally be hinged at right, however, other option may be also required at some sites to meet the actual site condition. The door shall have aluminium biddings extrusions in door/jamb profile, replaceable and suitable neoprene rubber gaskets around its border for proper weather proofing. The door shall also be equipped with a hydraulic auto closure and the door latch / stopper shall be provided to keep the door in open position. The door shall have a limit switch to indicate intrusion and switch on one light provided inside the shelter. A canopy of minimum size 1200 mm X 500 mm shall also be fixed up above the external light / door for protection from direct sun/rain. The canopy shall suitable slope and shall be covered from both sides.

1.1.7 Jointing

All panel to panel connections shall be made with eccentric cam locks or suitable locking system. The wall to floor and wall to roof jointing shall be made with angular frames of suitable size. The panel to panel jointing at the corners shall either be suitably angular frames of suitable size or a single corner panel may be provided. All internal corners shall be jointed suitable angles. All the joints shall be suitable sealed with PU or silicon sealant to provide 100 % leakage and water proofing. The Contractor shall submit the drawing indicating details of all joints in support of meeting the specified requirement.

1.1.8 Opening

The shelter shall have provision for openings for required air-conditioners, piping and all electrical and optical cablings on the wall panels. The details of openings required for different applications and the locations of the openings shall be decided during detail engineering. All openings shall be custom built based upon the actual application required at each site. The Contractor shall provide the required cut outs for above purpose. Any sealed cut outs required for future use may also be provided and the size of this cut out shall be finalised during detail engineering. All the openings shall be sealed for water and leak proof with suitable flexible sealing arrangement for the proposed cable connections and also for addition and deletion of cables/pipes in future. The sealing arrangement shall be fire retardant and type/make/details shall be got approved by the Employer.

1.1.9 Insulation

The PUF to be used for insulation of the panels shall be CFC free and conforming to latest IS 12436 standards or equivalent International standard. The other parameters shall be as per Table 1.2 as given below:

Table : 1.2

SNo.	Items	Required Parameter
1	Thickness	78.6 mm
2	Density	40 kg/m ³
3	Compressive Strength	1.2 kg/cm ²
4	Tensile Strength	3.6 kg/m ²
5	Bending Strength	4.0 kg/m ²
6	Adhesion Strength	2.9 kg/m ²
7	Dimensional Stability	At (-) 25 oC : 0.1%, at 38 oC : 0.1% and at 100 oC : 0.4%
8	Temperature Range	(-)15 oC to 95 oC
9	Thermal Conductivity	0.02 kcal/hr/m/oC
10	Fire Resistance	As per BS-4735 horizontal burn < 125 mm
11	Water Absorption	0.2 % @100% RH
12	Vapour Permeability	0.08/0.12 g/hr/m ²
13	Self Extinguishing	Yes
14	Biodegradable	Yes

The Contractor shall submit the earlier carried out type tests reports for PUF material. In case the contractor does not submit the reports or the submitted reports are not meeting the requirements, the contractor shall carry out the type tests on PUF material for the following:

Thickness, Density, Compressive strength, Tensile Strength, Dimensional Stability, Thermal Conductivity and Fire resistance.

1.1.10 Heat Transmission Coefficient

The installed shelter with one door shall have the heat transmission coefficient $K \leq 0.3$.

1.1.11 Colour

The colour shall be stabilised grey on all external sides and off white on all internal sides. The colour of the slanting roof shall also be stabilised grey. However, the actual colouring scheme shall be finalised during detail engineering.

1.1.12 Fire and Smoke Detection System

Suitable fire & smoke detection system shall be provided in each of the shelters. The offered fire & smoke detection system shall work on DC supply (-48V) being provided by the Contractor under this contract. In case, the smoke detector and fire alarm system requires other voltage than the above stipulated voltage (-48V DC) for operations, suitable converter & hardware shall also be provided by the Contractor. The Contractor shall provide all required cabling & accessories for full functioning of the offered system with both power supplies. At least two ionisation type smoke detectors along with fire detection panel shall be provided below the roof panel in strategic locations inside the shelter. The alarm should activate only if both fire detectors are actuated to avoid any false alarm. The details, locations and its various logistics shall be finalised during detail engineering. The operation/activation of the fire detector shall result in the following:

- a. An external visual signal and audible alarm sounded outside the shelter.

- b. A signal to be given to the telecom equipment panel through potential free dry contact as a local alarm for its remote monitoring in the control centre.
- c. Suitable pilferage proof enclosure for visual and audio alarm outside the shelter.

All the detectors installed shall be tested for actuation and its required operations during SAT. The exact method of the testing shall be detailed in SAT procedures.

1.1.13 Lighting system

Normal and emergency lighting shall be provided inside the shelters. The normal lights shall consist of two nos. (36 Watts) of reputed make fluorescent lights along with requisite fittings and shall be powered with ac supply from ACDB. Two nos. emergency light with requisite fittings shall also be provided which shall be powered with dc supply available (-48 V DC) for telecom equipment from DCDB. In the event, the emergency lighting system requires other voltage than the above stipulated voltage for operations; suitable converter & hardware shall be provided by the Contractor. The outside light shall be bulk head type, powered with ac power supply from ACDB, provided at top of the door and covered with the door canopy. The bulk head type shall be provided with metallic guard to prevent pilferage. The switch of both internal and external lights shall be inside the shelter but adjacent to the entrance for easy accessibility. Additionally, at least one of the normal lights inside the shelter shall be lit up with the opening of the shelter door. One 5 A / 15 A duplex socket with switch shall also be provided in addition to the requisite switches for the normal and emergency lights.

1.1.14 Cable Tray

The cable tray of size minimum 300 mm width made of Fibreglass Reinforced Polymer (FRP) material shall be provided inside/outside the shelter for supporting various cables and shall be attached to the roof top/wall panels. The alternate material for the cable tray, if required shall be with specific approval of the Employer. The cable trays shall have sufficient strength to take loading of various cables like fibre optic cables, various power, signal & control cables, earthing flats etc. The rungs along the cable ladder shall be separated by not more than 300 mm. The colour of the cable tray shall match with the inside colour of the shelter. The Contractor shall submit the cable tray details for Employer's approval. The cable tray shall run along the four sides just below the ceiling with smooth curvatures at the bends/corners. The actual routing including length and height of the cable tray for each site shall be finalised during detail engineering. The Contractor shall clamp the cables suitably with the trays after installation of the cables.

1.1.15 C – Rails

C-rails made of extruded aluminium alloy of suitable size along with required number of lock-nuts shall be provided inside and outside the shelter to support various items like lighting, AC Distribution Box (ACDB), DC Distribution Box (DCDB), Fire detector along with the panel, cables and all other accessories. The C-rails may also be used for supporting cable trays from the roof, mounting of equipment on the floor and on the wall. The requirement of C-rails shall be finalised during detail engineering.

1.1.16 Energy Meter Box

An IP 55 compliant weatherproof box shall be provided for housing the energy meter along with MCBs and fuse units. The energy meter box shall have two different doors and compartments, one for accessing/housing energy meter and another for accessing/housing MCBs and fuses. The energy meter box shall have glass for view of meter reading from outside. The energy meter box shall be of Fibreglass Reinforced Polymer (FRP) material. The alternate material, if required, shall be with specific approval of the Employer. The box shall be provided with pad lock arrangement and shall be installed on external shelter panels with suitable fittings. Proper sealing shall also be done to avoid any water leakage into the panel. The size and locations of meter installation shall be finalised during detail engineering.

1.1.17 Loading Capacity

Minimum roof loading capacity: 250 kg/m²

Minimum floor load capacity: 2000 kg/m²

Minimum wall load capacity: 300 kg/m²

The above load capacities have been identified as minimum requirement. However, during detail engineering, to meet the actual load requirement for cable tray, ACDB, DCDB, C-rails, Air-conditioning system, battery, batteries chargers, telecom equipment, lighting etc. to be supplied and installed inside the shelter, the actual localised loading requirement may be higher and the supplied shelter loading capacity shall meet the actual localised loading requirement at no additional cost to INDIGRID.

1.1.18 Structural Stability

- Resistant to various volumes of rain, dust & sand impinging from various directions over different durations and different speeds.
- Resistant to corrosion against water, industrial air and saline air.
- Resistant to decomposing vegetation, rodents, termites and micro-organisms.

1.1.19 Survival wind speed

The shelter shall be designed to withstand a wind load of 200 kmph.

1.1.20 Cables and Cabling

All cables and cabling of required size and capacity shall be supplied, installed and terminated with necessary and required accessories among all the equipment/systems being supplied under this Package. The cables from cable ladder to equipment cable entry height shall be installed in the wall of the shelter in PVC cable conduits and in flexible conduits from shelter wall to equipment. The cables shall be dressed properly and suitably attached with the shelter panel. No hanging cables shall be allowed.

1.1.21 Structural

All structural steel shall conform to latest IS: 2062 or equivalent International standard. The ISMBs shall conform to IS – 808 or equivalent International standard. The structural MS pipes shall conform to IS:1161 or equivalent International standard. The steel work shall be galvanised after full fabrication as per latest IS standards and the coating thickness shall be greater than 127 micron. All welding shall be as per IS – 816 or equivalent International standard. All nuts and bolts shall be galvanised and conform to IS : 6639 or equivalent International standard. All fittings and hardware used in the shelters shall be made of corrosion-resistant aluminium or galvanised steel as specified in the relevant clauses of this specification.

The requirement of steel/aluminium sections shall also be provided and no separate payment shall be made in this regard.

1.1.22 Earthing

For satisfactory operation of the equipment inside the shelter, good and proper earthing is required at each site. The earthing resistance generally varies depending on soil resistivity. The earthing system at each site shall be provided by the Contractor with earthing resistance not exceeding the five (5) ohms. The Contractor shall provide the pipe type earthing along with the necessary hardware and accessories required. Minimum two earth pits shall be made at each location. However, if required resistivity is not met, then, sufficient nos. of pipe type earthing shall be provided by the Contractor. The Contractor shall submit the earthing pit diagram for Employer's approval.

An earthing ring of copper strip of minimum size 25mmX3mm shall be made inside the shelter. Each equipment shall be connected to above earthing ring through 70sqmm copper cable. The connectivity

from earthing pit to the shelter earthing ring shall be made by the Contractor through two (2) nos. of 50 X 6 mm GI strips. The connection of GI strips with the copper strips shall be made through flexible copper cable and bi-metal washers for proper connectivity. The GI strips for earthing pit to shelter shall be buried inside the ground.

Three days after completion of the earthing pit, the earth resistance shall be measured in the presence of Employer's representative and test results for each location shall be submitted for Employer's approval.

All the equipment shall be connected properly to this earthing system for their safe operation.

1.1.23 Foundation System for Shelter

The Contractor shall design and construct complete foundation system for all finalised shelter locations depending on the type of soil, including supply and furnishing all the material & labour, tools & tackles, plant and machineries etc. as required for successful completion of the job. The foundation system shall also include the following:

- Site preparation
- Soil characteristics assessment as required for foundation design for each site including detail soil investigation, if required.
- Water level assessment
- Raising of site level above maximum flood limit level to avoid any water logging in the shelter area.
- Concrete pedestals (in situ) along with base slab for the foundations located on ground and concrete pedestals for roof top locations along with supply and fixing of necessary holding down / anchor bolts.
- PCC and finish of surface below and around shelter location with suitable slope.
- Installation of base frame and sub-frames on the pedestals through ISMB channels.
- Stair access for shelter.

1.1.24 Site Preparation at Shelter locations

For each of the shelter to be installed on the ground, the Contractor shall execute the work for site preparation, such as clearing of the site, levelling of the site, the supply and compaction of fill material (if required), excavation and compaction of backfill for foundation, trenches etc with available excavated earth. At certain locations, the finished ground level (FGL) site shall be fixed above High flood level (HFL) to avoid water logging in the shelter area. The site shall be prepared to meet the specified requirement for each site and up to satisfaction of the Employer. If fill material is required for site preparation, the fill material shall be provided with suitable protection so as to prevent the erosion by wind and water from its final compacted position or the in-situ position of undisturbed soil. Quantities of Earth filling with suitable protection have been identified in BoQ for above purpose.

Backfill material around foundation and shelter shall be suitable for the purpose for which it is used and compacted to the satisfaction of the Employer. Excavated material not suitable for use or not required for backfill shall be disposed off in area as directed by the Employer, including all leads and lifts.

Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom of the excavation level during excavation, concreting and backfilling.

For roof top shelters, the Contractor shall also prepare the site suitably for shelter installation on the pedestals. In all cases, each site shall be fully prepared before start of foundation activities up to satisfaction of the Employer.

1.1.25 Concrete Pedestals and Foundation system

Two types of foundations are envisaged for shelters viz. (i) required for shelters to be installed on ground & (ii) required for shelters to be installed on roof top of a building.

The foundation of shelters to be installed on the ground shall consist of RCC pedestals of minimum 600 mm above levelled ground. The depth of pedestals below the ground shall be minimum 1500 mm

including bottom slab. The size of bottom RCC slab of the foundation shall be minimum 600 mm X 600 mm for a minimum 250 mm depth. The reinforcement shall be as stipulated at clause 2.4.4 below. The PCC (1:4:8) of minimum depth 75 mm shall be provided below the bottom slab of minimum size 750 mm X 750 mm. The size of the pedestals shall be minimum 300 mm X 300 mm. The grade of concrete shall be M20 (1:1.5:3). The concrete cover for the reinforcement shall be minimum 50 mm.

The foundation of shelters to be installed on the roof top shall consist of RCC pedestals of size minimum 300 mm X 300 mm and 300 mm above roof surface of M20 (1:1.5:3) grade. The bottom of the pedestal shall be connected and attached with the existing roof structure/slab. The reinforcement shall be as stipulated at clause 2.4.4 below.

The exposed portion of the concrete pedestals shall be plastered with 1:4 cement plaster for smooth finish.

The above pedestal dimensions are minimum requirement and the Contractor shall provide the required size of pedestals depending upon the soil bearing capacity and other soil parameters of each site to support the installed shelter along with all equipment. The detailed design for all above type of foundations shall be submitted to the Employer and got it approved before commencement of work at site.

The shelter shall be fixed to the pedestals through ISMBs 200 mm minimum and sufficient number of sub-frames with suitable anchor bolts. The required ISMBs and sub-frames shall be provided by the Contractor as part of shelter/foundations. The required number of pedestals shall be provided for shelter installations, however, minimum one pedestal is to be provided at each corner of the shelter. The Contractor shall provide the required and necessary foundation system at each site irrespective of soil to meet the requirement and submit the civil/structural/foundation design and drawings along with the load calculation for Employer's approval. All required foundation system and related works shall be in Contractor's scope and no additional payment shall be paid to the Contractor irrespective of soil characteristics and site conditions.

The suitable staircase shall be provided at each shelter location in front of the door for easy entry into the shelter as a part of foundation/pedestal system and no separate payment shall be made in this regard.

1.1.26 Concreting

After completion of foundation work at each shelter location, PCC (1:2:4) of depth minimum 100 mm shall be provided below the shelter position and outer sides for shelter as decided during detail engineering / execution. There shall be adequate slope in the Shelter area PCC to avoid water logging.

The Contractor shall also provide the RCC platform of about 600 mm height for installation of DG set. The exact area and the height of RCC required for DG set and shelter area shall be finalised during detailed engineering. At few locations, PCC platform for DG set may be provided. Quantities of PCC have been identified in BoQ for above.

1.1.27 Properties of Concrete

The cement concrete used for foundation shall be of grade M-20 corresponding to 1:1.5:3 nominal mix ratio with 20 mm coarse aggregate. All the properties of concrete regarding its strength under compression, tension, shear, punching and bend etc. as well as workmanship will conform to latest IS standards or equivalent International standard.

The Portland cement used in concrete shall conform to 33 grade (IS:269) or 43 grade (IS:8112) or 53 grade (IS:12269) or equivalent International standards.

The Pozzolana cement used in concrete shall conform to IS : 1489 or equivalent International standard. The curing time of Pozzolana cement shall be decided at the time of execution of the work under the contract based on the certificate from a reputed laboratory which will be obtained and submitted by the Contractor. Cement of only INDIGRID approved make shall be supplied.

Concrete aggregate shall conform to IS: 383 or equivalent International standard.

The water used for mixing concrete shall be fresh, clean and free from oil, acids and alkalies, organic materials or other deleterious substances. Portable water is generally preferred.

Reinforcement shall conform to IS: 432 or equivalent International standard for MS bars up to 6 mm and hard drawn steel wires and to IS : 1139 and IS : 1786 or equivalent International standard for deformed and cold twisted bars 8 mm and above respectively. All reinforcement shall be clean and free from loose mill scales, dust, loose rust and coats of paint, oil or other coatings, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of drawings and specifications. Reinforcement of only INDIGRID approved makes shall be supplied.

1.1.28 Mixing, Placing and Compacting of Concrete

Mixing shall be continuous until there is uniform distribution of material and the mix is uniform in colour and consistency. Normal mixing shall be done close to the foundation, but exceptionally the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

Form boxes shall be used for casting all types of foundations and pedestals.

The concrete shall be laid down in 150 mm layers and consolidated well, so that the cement cream works, up to the top and no honey-combing occurs in the concrete. Preferably, a mechanical vibrator shall be employed for compacting of concrete. However, in case of difficult terrain, manual compaction may be permitted at the discretion of the Employer. Monolithic casting of foundations must be carried out. After concreting the pedestal portion to the required height, the top surface should be finished smooth.

Wet locations shall be kept completely dewatered, both during and 24 hours after placing the concrete, without disturbance of the concrete.

If the concrete surface is found to be defective after the form work has been removed, the damage shall be repaired with rich cement sand mortar to the satisfaction of the Employer before the foundation is back filled.

1.1.29 Curing

The concrete shall be cured by maintaining the concrete wet for a period of at least 10 days after placing. Once the concrete has set for 24 hours, the pit may be backfilled with selected moistened soil and well consolidated in layers not exceeding 200 mm thickness and thereafter both the backfill earth and exposed pedestal shall be kept wet for the remainder of the prescribed 10 days. The exposed concrete chimney shall also be kept wet by wrapping empty cement bags around it and wetting the bags continuously during the critical 10 days period.

1.1.30 Other associated civil works

The Contractor shall also carry out other minor civil works in the shelter area for the equipment/system being supplied under the Contract at no additional cost to the Employer.

1.1.31 Installation

The shelter shall be installed on the foundation system as specified above and to meet the actual requirement as per actual site/soil conditions. The installation of shelters shall be carried out in such a way that it shall meet all specified requirement. The installed shelters shall be suitable for both transporting in assembled condition to another location and dismantling, transporting to another site and reassembling there.

The Contractor shall make their own arrangement for AC supply / DG set during installation/testing of the system.

1.1.32 Finish

The final finish of the installed shelter system shall show good workmanship. The panels and floor shall be totally scratchproof. The floor shall not have any uneven surface. The total shelter shall be air tight, the roof and all joints shall be leak and water proof and the door shall be easily lockable & unlockable.

1.1.33 Wire Mesh Fencing System for Outside Protection

To protect the shelters along with the installed equipment, air-conditioners, DG sets etc. from vandalism, wire mesh fencing shall be constructed at each of the shelter locations installed at ground. The wire mesh size shall be of 75 mm, the nominal dia of the mesh wires shall be 3.5mm and fencing shall be at least 2.0 m height from ground level. The pipes/angles of adequate size and capacity shall be provided to support the fencing. An iron gate of minimum size of 2 m or as per site requirement with pad locking facility shall also be provided at each location to enter the protected area. The fencing system shall also be painted (one coat of primer and 2 coats of final paint) for better reliability. The paint colour shall be finalised during detailed engineering. The provisional quantities of wire mesh fencing system including the gate in running meters have been indicated in the BOQ and the actual quantity shall be finalised during detail engineering based upon the actual site conditions. All associated civil works for the fencing shall also be carried out by the Contractor. The Contractor shall submit the layout of the shelter and other equipment and the barbed wire fencing for each of the locations for Employer's approval.

1.1.34 External Alarms

The telecom equipment being provided under separate package shall have provision of taking input of external alarms from various equipment e.g. DG set, air-conditioning system, DCPS, fire & smoke detection system, PIU unit etc. The Contractor shall provide necessary dry contacts at all the equipment being provided under this package and shall wire up these up to the telecom equipment. Contractor shall integrate and extend the Potential Free Contacts minimum for the alarms indicated at Cl.6.3.5 of specification.

1.1.35 Testing of Shelter system along with all sub-systems

1.1.35.1 Type testing

The Contractor shall provide the earlier carried type test reports for the PUF material and other sub systems of the shelter.

1.1.35.2 Factory Acceptance Testing (FAT)

The following tests shall be carried out during Factory Acceptance testing (FAT):

- a. Dimensional and checks as per approved DRS/drawings
- b. BOQ verification as per approved drawings/documents
- c. Test certificates from the Original Equipment Manufacturer.
- d. Density test, Compression test and Thermal Conductivity test on the PUF material.

FAT on other items shall be carried out as specified in this specifications and relevant standards.

1.1.35.3 Site Acceptance Testing (SAT)

The site acceptance testing shall be carried out for each site. The installed system shall be powered up and all the equipment shall be tested and commissioned. The various installed system shall be tested for the specified functional requirements and shall be as per approved drawings. The SAT shall be carried in an integrated way and not individual equipment basis to demonstrate the integrated functioning of the installed system. The tests shall be carried out on following minimum items during SAT:

- i. Site preparedness, PCC and RCC.
- ii. Civil Pedestals and Steel structure for Base of Shelter System
- iii. Shelter (including water proof test)
- iv. Air-Conditioning System
- v. Cable Tray
- vi. Lighting System
- vii. Fire and Smoke Detector System
- viii. C-Rails
- ix. Earthing System
- x. Wire Mess Fencing

The detailed SAT procedure shall be submitted for Employer's approval.

1.1.36 Marking

The following information shall be provided outside the shelter and near the door engraved on a steel metal plate:

- a. INDIGRID logo and name.
- b. Project Name
- c. Shelter location name
- d. Identification no.
- e. Year of Manufacture
- f. Shelter dimension

1.2 Requirements of Air Conditioning System

1.2.1 General

The air conditioning system shall be provided in the shelters to be used for housing Telecom equipment, power interface unit, VRLA batteries, battery charger etc. throughout the country. Repeater Shelters are placed for amplification of telecom signals in between the fibre optic links. The Contractor may note that these shelters are generally located in unmanned areas; therefore, the air-conditioning system shall be rugged, reliable, maintenance free and designed for long life.

1.2.2 Technical Experience

The Air Conditioners shall be offered from a manufacturer and Air Conditioners manufactured by such manufacturer should have been in operation for at least one (1) year as on the originally scheduled date of bid opening.

Bidder shall furnish the details/document in support of above Technical experience of manufacturer along with bid.

1.2.3 Operational Requirements

The air-conditioning is required for critical applications i.e. for maintaining the temperature of the critical telecom equipment inside the shelters on 24hours, 365 days of the year operation basis. Thus, to provide redundancy for such critical applications, Contractor shall offer twin circuit air conditioning system comprising of two air conditioning units packed in a single frame working in conjunction, controlled by the single inbuilt Micro processor based controller for desired operation.

Depending upon the size and location of shelter, following type of air conditioning systems shall be supplied:

- i) 2X2TR capacity air conditioning system with free cooling unit
- ii) 2X2TR capacity air conditioning system without free cooling unit
- iii) 2X1.5TR capacity air conditioning system with free cooling unit

iv) 2X1.5TR capacity air conditioning system without free cooling unit

Both units shall be independent of each other. The units shall run one by one in pre settable time bound cyclic ON/OFF mode. However, during running of AC unit 1, if the inside temperature of the shelter reaches to a predefined value, the AC unit 2 shall also start running to maintain the inside temperature to specified 24 oC. After achieving this temperature, the other unit shall again shut off.

Problem/ fault in one of the unit shall not hamper the working of other unit and during such fault in any of the unit; the alternate unit shall take over and continue to operate till the faulty unit is operational again.

Both units shall never start at the same time. If the condition is such that both units shall start together then internal time delay of at least 10sec shall be provided in starting of each unit to avoid surge.

In free cooling mode, the refrigerant cycle of AC unit shall be switched off and outside air (after filtration) shall be circulated inside the conditioned space through the operation of dampers provided with suitable sensors. It should be possible to run the Free Cooling Unit (FCU) on both AC & -48V DC Power supplies. This mode shall come into operation in the following conditions;

- i. When the ambient temperature is below a preset value, which is to be decided during detailed engineering.
- ii. In case of failure of refrigeration system of both the units.

The failure of free-cooling feature shall not hamper the normal operation of Air Conditioning units.

1.2.4 Operational Life

The air conditioning system to be supplied shall have operational life of 10 years.

1.2.5 Design

The air-cooled self contained package AC system shall be designed as per following conditions:

- Rated Capacity : 1.5TR/2TR
- Type of Discharge : Free Flow.
- Air inlet Temp (Return Air) : 24 0C (DB) RH : 50
- Temperature Variation allowed : ☐ 1 0C
- Ambient Air Design Temp : 45 0C
(entering the Condenser)
- No. of Refrigeration Circuits : Two
- Type of load Factor : High sensible heat load (SHR>0.9)

1.2.6 Micro processor based Controller

The air conditioning system shall have a common microprocessor based controller for both AC units, packed within the same cabinet. The microprocessor based controller shall have the following features;

Controller	Common for AC1+AC2
Mode of Operation	RUN/TEST/ Standby mode
Temperature Setting	16 -30 deg. C with 1 deg C resolution
Temperature variation from set temperature:	☐ 1 0C
Cycle Time, Duty Changeover	2, 4, 6, 8, 10, 12 hours.

Unit Changeover Both the AC units shall operate in pre-settable cyclic mode. Also, if one unit is faulty the controller shall be able to detect & put the other unit in operation automatically.

Running of both units:	Start of IInd unit along with Ist unit in case sensor senses high temperature.
Memory	Non-volatile memory for various settings supported by Battery backup eg. Set temp., working hours & ON/OFF Status
Alarms Displays	Potential Free contacts for Remote monitoring at NOC a) AC unit1 fails alarm b) AC unit2 fails alarm c) High Temp inside shelter alarm d) Power Fail alarm e) Indication for free cooling In addition to the above, following minimum LED Indications shall also be available in the Controller Mimic Panel for local indication; a) Alarm. b) Power Healthy. c) Blower Working. d) Compressor Working.
Time Delay	On / Off sequence delay shall be available.
Cumulative hours run	For each compressor of Air-conditioning system
Free Cooling	Operates the blower fans & changeover damper position to circulate outside air.
Enthalpy/Temperature Sensor :	As required along with free cooling.

Further, the free cooling function may be enabled/ disabled with help of the controller.

1.2.11 Earthing

The AC equipment shall be properly earthed by connecting it to the earthing system.

1.2.12 Power Supply

The offered air-conditionings equipment shall work satisfactorily for the power supply range as mentioned at mentioned below:

Nominal Voltage: 230 V (Single phase)

Variations: $\pm 10\%$

System frequency: 50 Hz ($\pm 5\%$)

Supply and installation of all required cabling, wiring and termination and accessories including surge arrestors, motor starters, circuit breakers and switches from the power supply point/ Meter point to the various units via ACDB shall be carried out by the Contractor.

1.2.13 Testing

1.2.13.1 Type Testing

The type testing of the air-conditioning system shall conform to latest IS: 8148 standards or equivalent International standard.

1.2.13.2 Factory Acceptance Testing

The factory acceptance testing shall be carried out as per latest IS: 8148 standards or equivalent International standard.

1.2.13.3 Site Acceptance Testing (SAT)

The site acceptance testing for air-conditioning system shall be carried out by the Contractor after successful installation of the air conditioning system. The SAT shall demonstrate all its functions properly. The detailed SAT procedure shall be submitted by the Contractor for Employer's approval.

1.3 Requirements for DG Set

1.3.1 General

The DG sets shall generally be installed on ground and the required RCC/PCC floor shall be provided by the Contractor. Single Phase DG sets of rated capacity without AMF panel are required. AMF panel shall be the part of Power Interface Unit (PIU). Most of these DG sets shall be installed at unmanned sites located in rural/remote villages/towns. The DG set shall have an operational life of 10 years.

1.3.2 Technical Experience

The DG set shall be offered from a manufacturer of Diesel Generator set and Diesel Generator set manufactured by such manufacturer should have been in operation for at least one (1) year as on the originally scheduled date of bid opening.

Bidder shall furnish the details/document in support of above Technical Experience of manufacturer along with bid.

1.3.3 Generator Set Configuration

The generator set shall consist of a diesel engine directly coupled to an electric generator, together with the switchgear, controls, battery and other associated accessories required to provide continuous electric power for any duration of failure of the normal AC source. The DG sets shall be rated for continuous operation.

1.3.4 Diesel Engine

The Contractor shall provide diesel engines of standard designs of original manufacturers in their DG sets. It shall be from reputed manufacturers i.e. Kirloskar Oil Engine / Cummins / Ashok Leyland / Mahindra / Crompton Greaves / Eicher makes conforming to latest BS 5514/ ISO 3046 standards. The bidder shall submit the details of the engine along with their bid.

The diesel engine shall be direct injection, 4 stroke cycles, multi cylinder, air-cooled/ water-cooled, naturally aspirated/ turbo charged, instantly started, operating at a nominal speed of 1500 R.P.M. and capable of developing requisite Brake Horse Power i.e. the rated horsepower of the engine, at the generator synchronous speed, with all accessories attached, shall not be less than the required power as specified in the appendices. In addition, the horsepower rating shall take into account the generator efficiency, losses and maximum rated environmental conditions stipulated in Clause 1.3.19. All moving parts of the engine shall be mechanically guarded in such a manner that a human finger cannot touch a moving part. The diesel engine shall be equipped with a dry type air filter system.

1.3.5 Governor

The engine shall be equipped with class A-1 governor or better as per IS 10000 Part-VII or any other equivalent International standard. The speed regulation shall be as per the above governing class.

1.3.6 Engine Cooling

The bidder may offer air-cooled or water-cooled type DG sets. However, no preference / compensation shall be applicable for any particular type of offered DG sets. The cooling system shall provide adequate cooling to the generator set when operated on full load for prolonged periods of time at the maximum environmental conditions stated in Clause 3.3.19. In case of water-cooled engine, necessary breathing arrangement shall be provided with the radiator to take care of the expansion/ contraction of the coolant water in the radiator.

1.3.7 Fuel System

The engine shall operate on a commercial grade diesel fuel; no premium fuel shall be required. The DG set shall be provided with inbuilt fuel storage tank with capacity to last 12 hrs on 100% load. It shall be equipped with low level fuel alarm potential free contacts for connection to the Equipment NMS system.

The Contractor shall also indicate the fuel consumption of the offered DG sets at 25%, 50%, 75% and 100% of rated loads along with their bid in the DRS format.

Fuel required to carry out all kind of tests including site acceptance tests shall be supplied by the Contractor.

1.3.8 Exhaust System

The DG set shall be provided with a suitable exhaust system capable of carrying exhaust gases from the engine and dissipate them to the atmosphere as quickly and silently as possible meeting the latest noise and emission norms of CPCB. The exhaust system shall be equipped with proper heat shielding to protect personnel and facilities.

1.3.9 Starting System

The engine shall be equipped with an electric starting system with a 12/24 volt heavy duty lead acid battery of suitable AH capacity sufficient to provide a minimum of twelve (12) successive abortive starts of the engine without recharging. A suitable battery charger complete with voltage regulator, float or booster selector switch, on-off switch, digital voltmeter and ammeter shall be supplied (along with the battery) for charging the battery from mains. The battery charging system shall operate on an input of 240 V AC, 50 Hz from the ACDB. The battery shall be housed within the DG enclosure suitably.

The engine control shall provide for multiple crank start-up cycles. Each cycle shall be approximately 10-seconds of cranking followed by 10-seconds of rest. The starting circuit shall automatically be disconnected after the start up of the engine. If the engine does not start after three (user adjustable number) attempts, the starting circuit shall be disabled and an alarm indication ("over crank") shall be provided. A potential free contact shall be provided to interface these alarms with the Equipment NMS.

The starting time of the DG set in 'AUTO' mode shall be continuously and linearly adjustable from 5 minutes to 8 hours from the time of power failure sensing. The starting of DG set shall be based on the condition of the 48V DC battery voltage (being used for telecommunication equipment) and temperature inside shelter. For this purpose, the required auxiliary contacts from DC power supply system shall be available in DCPS cabinet and for sensing temperature inside shelter, the required thermostat shall be provided by the DG Contractor. The exact time setting and other settings of DG start up shall be finalised during site acceptance on site-to-site basis based on the actual site conditions.

1.3.10 Instrumentation and Controls

The Employer shall procure DG sets with the capability to extend the controls to external PIU unit equipped with AMF control panel.

The microprocessor based AMF (Automatic Mains Failure) panel shall be equipped with standard instrumentation including interlock and protection arrangement, suitable annunciation and indications etc. for proper start up, monitoring, control and safe operation of the DG set. The AMF shall start the DG set in case of AC mains failure and transfer the load from normal source to diesel generator without any human intervention. Similarly on restoration of mains supply it shall be able to transfer the load to mains supply and switch off the DG automatically.

The AMF panel shall be equipped with following minimum instrumentation:

- a). Microprocessor based relay with composite meter for digital display of;
 - i. AC mains Voltage & Generator Voltage
 - ii. Generator Current
 - iii. Power Factor
 - iv. Output KW meter

- v. Output AC frequency meter
 - vi. RPM indication
 - vii. Over speed indication
 - viii. Engine hours indication (Cumulative)
- b). Mode selector switch for setting the panel on any one position such as OFF or Auto/ Manual/ Test. The operation of the DG set shall be possible in any of the modes.
 - c). Engine ON/OFF switch (Push button type)
 - d). Emergency Stop switch (Push button type)
 - e). ON delay timer for load change over.
 - f). ON delay timer for engine shut off.
 - g). Indicating lamps to indicate 'Mains ON', 'Load on Mains', 'DG Running', 'Load on DG', 'Battery charger ON'
 - h). Audio visual alarm for
 - i. Low lubricating oil pressure
 - ii. High water temperature (for water cooled DG)
 - iii. High cylinder head temperature (for air cooled DG)
 - iv. Start failure
 - v. DG over load.
 - i) Suitable battery charger complete with voltage regulator, float or booster selector switch, on-off switch, digital voltmeter and ammeter for charging the battery from mains operating 240V/ 50 Hz
 - j). MCCB of suitable rating
 - k) Two no. contactors of suitable ratings (one for DG set and one for AC mains) with overload relay.
 - l) Under voltage relay for Mains.
 - m) Instrument and control fuses.
 - n) Any other switch, instrument, relay or contactor etc. essential for smooth and trouble free functioning of DG set with AMF panel. (To be specified by the bidder with complete detail of the item).

Standard colour codes and numbered ferrules shall be used for wiring the AMF panel. Sensing and control relays shall be of continuous duty, industrial control grade type. The transfer breaker shall be rated for continuous duty. The breaker shall be interlocked to ensure non-paralleling SEB power supply and DG supply.

Following automatic shut down protection system for DG set shall also be integrated in the control panel;

- i. Low lubricating oil pressure shut down.
- ii. High coolant (water) temperature shut down.
- iii. Engine over speed shut down.
- iv. Over load shut down.
- v. Short Circuit shut down.
- vi. Over Voltage shut down
- vii. Low Fuel Level
- viii. Earth Fault shut down.
- ix. Emergency Stop

The AC mains supply shall be of either single Phase or three Phase. The loads connected shall be single phase in nature.

1.3.11 Alternator

The Contractor shall supply alternators in their offered DG sets only from the reputed manufacturers i.e. Crompton-Greaves / Kirloskar / FG Wilson / ELGI / KEL makes as per latest BS 5000/ IS 4722 standards. Details of alternator shall be submitted by the Contractor along with the bid.

The alternator shall be self excited, self regulated, screen protected, double bearing, brushless type, drip proof, continuous duty type, synchronous and suitable for 1500 RPM. 0.8 P.F lagging, horizontal foot mounted, with class H insulation.

The alternator shall also have a solid state type Automatic Voltage Regulator (AVR) suitable for single running with control limits of 1% from no load to full load under normal load changes. It shall be of static type and complete with cross current compensation. The regulator shall be provided with voltage adjusting potentiometer and shall be complete with all alarm contacts, internal wiring etc.

The alternator shall be capable of carrying 50% overload for a duration of one minute.

The alternator shall be suitable for 20% over speed for two minutes.

The alternator shall be capable of carrying 10% overloading for one hour in any period of 12 hrs running without injury.

1.3.12 Mounting Arrangement

Engine and alternator shall be mounted on a common MS fabricated base frame with anti vibration pads.

1.3.13 DG set Enclosures

1.3.13.1 A suitable weather-proof enclosure which shall be provided for protection from rain, sun, dust etc. Further, in addition to the weather proofing, acoustic enclosures shall also be provided such that the noise level of acoustic enclosure DG set shall meet the requirement of MOEF The diesel generator sets should also conform to Environment (Protection) Rules, 1986 as amended. The enclosure shall allow sufficient ventilation to the enclosed D.G. Set so that the body temperature is limit to 50°C. The air flow of the exhaust fan shall be from inside to the outside the enclosure. The exhaust fan shall be powered from the DG set supply output so that it starts with the starting of the DG set and stops with the stopping of the DG set. The enclosure shall have suitable viewing glass to view the local parameters on the engine.

1.3.13.2 Fresh air intake for the Engine shall be available abundantly; without making the Engine to gasp for air intake. A chicken mess shall be provided for air inlet at suitable location in enclosure which shall be finalized during detailed engineering.

1.3.13.3 The Enclosure shall be designed and the layout of the equipment inside it shall be such that there is easy access to all the serviceable parts.

1.3.13.4 Engine and Alternator used inside the Enclosure shall carry their manufacturer's Warranty for their respective Models and this shall not degrade their performance.

1.3.13.5 Exhaust from the Engine shall be let off through Silencer arrangement to keep the noise level within desired limits. Interconnection between silencer and engine should be through stainless steel flexible hose/ pipe.

1.3.13.6 All the Controls for Operation of the D.G. Set shall be easily assessable. There should be provision for emergency shutdown from outside the enclosure.

1.3.13.7 Arrangement shall be made for housing the Battery set in a tray inside the Enclosure.

1.3.14 Construction Features:

1.3.14.1 The enclosure shall be fabricated from at least 14 Gauge CRCA sheet steel and of Modular construction for easy assembling and dismantling. The sheet metal components shall be pre-treated by Seven Tank Process and Powder coated (PURO Polyester based) both-in side and out side – for long life. The hard-ware and accessories shall be high tensile grade. Enclosure shall be given a lasting anti-rust treatment and finished with pleasant environment friendly paint. All the hardware and fixtures shall be rust proof and able to withstand the weather conditions.

1.3.14.2 Doors shall be large sized for easy access and provided with long lasting gasket to make the enclosure sound proof. All the door handles shall be lockable type.

1.3.14.3 The suitable material of required density and thickness shall be used with fire retardant thermo – setting resin to make the Enclosure sound proof as per CPCB standards.

1.3.14.4 Points for Neutral/Body earthing shall be available at two side of the enclosure with the help of flexible copper wires from alternator neutral, and electrical panel body respectively. The earthing point shall be isolated through insulator mounted on enclosure.

1.3.15 Main Circuit Breaker of DG

The DG set shall be connected to the Input ACDB buses through main circuit breaker (MCCB type). Separate cables from DG set to the breaker shall be laid to extend DG power supply.

1.3.16 DG Set Mode of Operation

Operation of DG set shall only be allowed when the selector switch is in the Manual/Automatic/Test positions. Moving the selector switch to the OFF position shall properly shut down the generator set, remove it from the AC loads and inhibit it from starting in any mode. The DG set shall be capable of operation in the following modes;

1.3.16.1 Start Operation

- a. Auto Mode
- b. Manual Mode
- c. Test Mode

1.3.16.1.1 Auto Mode

In the 'AUTO' mode, the DG Set shall start only after a set time delay when either the primary AC source has failed or conditions prevail as indicated below;

When the main source power fails, the DG set shall include detection and control to automatically disconnect the primary AC source, start the DG set and extend power to ACDB after the set time period of the timer. The time delay is continuously & linearly adjustable at site from 5 minutes to 8 hours as specified at **Clause 5.2.6**. The engine shall also start automatically after detecting a predefined temperature (20 oC to 55 oC continuous) inside the shelter or initiation from 48V DC under-voltage contact from DCPS. All required control like thermostat, extension of potential DC under-voltage contact from DCPS shall be provided by the Contractor to support the above controls.

All phases of primary AC sources voltage shall be monitored. The automatic start-up system shall detect failure or abnormal conditions specified and start the generator set. At the time of loss of primary voltage or an abnormal condition of low phase voltage, a start control shall be initiated. The automatic start shall try the start-up of the generator set for three successive attempts. If the primary AC returns during the start-up attempt, the start-up sequence shall be stopped.

If at any time during operation of the generator set the selector switch is set to 'OFF' position, the generator shall shut down and be disabled from starting.

1.3.16.1.2 Test Operation

A test operation of DG set shall be possible by putting the control switch in "TEST" position from where the generator shall initiate an automatic start, just as if there had been a power interruption to the primary power. Upon removal of the selector switch from "TEST" position, the generator shall initiate an automatic shutdown sequence. However, there shall be interlock such that Main circuit breaker of DG set is in 'OFF' condition while the engine is started in "TEST" position.

1.3.16.1.3 Manual Operation

When the control switch is in "MANUAL" position, the generator set can be started using the manual start push-button on the control panel. The generator set will be stopped by setting the control switch back to the "OFF" position or by pressing stop button on the AMF panel. During manual operation, all main and AC source breakers must be operated manually to transfer load to or from the generator set.

1.3.16.2 Automatic Shutdown

When the primary power is restored and remains normal continuously for a period of 5 minutes (locally user adjustable from 0 to 15 minutes), the load will be switched over from DG set to primary power and the generator shall be automatically stopped and be enabled for another future start-up request.

1.3.17 Remote and Local Monitoring

The DG set shall be capable of being monitored from remote as well as local.

1.3.17.1 Visual Annunciation

The following minimum visual annunciation shall be provided for DG set shut down due to:

- (i) Low fuel level
- (ii) Engine failed to start (failed to start in 60 sec. after receiving the first start impulse)

1.3.17.2 Remote Monitoring

The above parameters shall also be monitored remotely through telecom equipment NMS or any other independent remote monitoring arrangement. Suitable potential free dry contacts (NO) for this purpose shall be provided by the Contractor. The contractor shall do all the required wiring for such purpose.

1.3.18 General Requirements

The DG sets shall be generally installed at outdoor positions near to the shelter locations. The DG sets shall be installed either on ground near to Shelter installed at ground or on rooftop near to shelter installed at roof top. However, in some cases, the DG sets may be installed on ground and shall be connected to shelter installed on rooftop. The exact requirement shall be finalised during detail engineering based on actual site conditions.

1.3.18.1 Mounting and Installation

The generator set shall be skid mounted using anti vibration pads. At some locations, DG set may be installed on the rooftop. The required RCC floor/ PCC pedestals shall be provided by the Contractor.

1.3.18.2 Earthing

The Contractor shall suitably connect the DG sets with the integrated earthing system being provided by the Contractor under this package. The neutral of alternator shall be earthed separately.

1.3.18.3 Trenching

The Contractor shall prepare necessary cable routes for installing cables and earthing system from DG set to the shelter and earthing pits. The cables shall always be installed inside the GI pipes of suitable size embedded properly with PCC finish. In case the DG set is installed on ground and the shelter is installed at roof top, the necessary cable trenching/ GI pipe shall be provided from DG set to the building ground from where the cables shall be installed in the wall of the building. The cable trays with proper cover and supports shall be provided from bottom of the trench at the ground near the building up to the shelter installed at the roof top. The Contractor shall submit the detail drawings for the same for Employer's approval.

1.3.19 Operating Environment

The generator sets shall operate within the following ambient environmental requirements:

- (a) Operating temperature range: +2°C to +50°C
- (b) Maximum relative humidity at 23°C of 95% (non-condensing)
- (c) In non-filtered air containing a high proportion of dust
- (d) In a corrosive atmosphere (at high humidity)
- (e) At altitudes of up to 500 metres above sea level
- (f) The equipment must withstand mechanical vibrations as defined in the IEC 68-2-6 test requirements.

1.3.20 Cables and ACDBs

All cables of required size and ratings for proper functioning of the DG set including all accessories shall be supplied, installed and terminated by the Contractor.

1.3.20.1 AC Distribution Boards

The contractor shall provide AC Distribution Boards associated with each system. The AC distribution boards shall distribute power to the equipment and provide protection against failures on feeder circuits.

Generally, ACDBs shall be part of Power Interface unit (PIU), however, at few locations, Standalone ACDB shall be required where PIU is not required. ACDBs shall be wall mounted enclosure/panel as finalized during detailed engineering. They shall have indicating lamps and voltmeter to indicate three phase voltage on the bus.

The MCCB and sub-assemblies shall be easily replaceable and maintainable. The MCCBs of requisite ratings must conform to IEC-60947-2 and IS 13947-2/IEC 60947-2. All MCCBs shall provide over-current, short circuit protection and coordinate with associated breakers in upstream & downstream such that faults are cleared reliably with discrimination.

The contractor shall extend safety earth connections from Input ACDB panel & Output ACDB panel to nearest earthing system being provided under this contract.

1.3.21 Testing of DG sets

1.3.21.1 Type Test

The Contractor shall submit the earlier carried type test reports for the engines, Alternator & enclosure of the offered DG sets for the highest rating of offered DG set as per the latest relevant IS standards or equivalent International standard for Employer's approval. The type tests on Alternators shall be carried out as per Table 1.10(a) as given below.

1.3.21.2 Factory Acceptance Test

A complete DG set shall be assembled and installed at factory as being envisaged at site and shall be run to check proper installation and assembly of all items of the DG set. It shall demonstrate all specified design features and functional requirements as per specifications, for adopting the same at sites. Manufacturer's internal test reports of Alternators for each DG set shall be submitted during FAT.

Table-1.10(a)
List of Tests for DG Set

	Test	Type Test	Factory Acceptance Test	Site Acceptance Test
A. ALTERNATOR				
	Measurement of resistance	√		
	Regulation test	√	√	√
	Measurement of open circuit characteristics	√		
	Measurement of short circuit characteristics	√		
	Efficiency test	√		
	Temperature rise test	√		
	Occasional excess current test	√		
	Over speed test	√		
	Insulation resistance (both before & after high voltage test)	√		

	Test	Type Test	Factory Acceptance Test	Site Acceptance Test

High Voltage test √

Determination of deviation of voltage waveform sinusoidal √

Note : All the above tests as per IS: 4722 or equivalent International standard

B. DG Set (including Alternator)			
Noise and vibration test	For all		√
Load Test	Type tests	√	√ (Note)
Functional tests on control panel, starting provision AVR and speed governor		√	√

Note: SNo. 1 above: As per standard IS 12065/12075 or equivalent International standard.

1) During FAT, Load test shall be conducted on each rating of DG sets before dispatch to site as follows:

- No load test for 15 minutes
- 100% Load test for 8 hrs
- 110% load test for 1 hr

2) During SAT, 6 hours load test shall be carried out with existing load.

3) The Oil consumption, governing, noise and vibration shall be recorded during the testing period.

Further during above test, AMF panel associated with highest rating DG set shall be integrated to check all the functional requirements and other requirements as per technical specifications.

---End of Table---

1.3.21.3 Site Acceptance Test

After successful installation of the DG set, Site Acceptance Testing for each DG set shall be carried out at respective site. The total installed system in power up condition shall be tested for the specified functional requirements. The minimum requirements for SAT are given in Table 1.10(a) above. The timer setting for automatic DG set starting after normal power supply failure and for automatic shut off after restoration of normal supply shall be done at each site based on the actual site conditions. The detailed SAT procedure shall be submitted by the Contractor for Employer's approval.

1.3.22 Marking

The following information shall be provided on each DG sets:

- INDIGRID and its logo
- DG Set location name
- Identification no.
- Year of Manufacture
- DG set dimension
- DG set weight
- KVA rating, HP Rating
- Voltage, Per phase current

1.3.23 Tool Kit

One set of following tools of Taparia or other reputed make shall be supplied with each DG set;

SNo.	Item Description	Unit	Qty
1	Digital Multimeter	No.	1
2	Cutter	No.	1
3	Pliers	No.	1
4	Nose Pliers	No.	1
5	D Spanner set (All sizes from 6 mm to 22 mm)	Set	1
6	Ring Spanner set (All sizes from 6 mm to 22 mm)	Set	1
7	Cable Cutter	No.	1
8	Hammer – 250 gm with handle	No.	1
9	Hack Saw	No.	1
10	Wire Stripper	No.	1
11	Screw Driver Set (-) type (6 Nos. of different sizes)	Set	1
12	Screw Driver Set (x) type (6 Nos. of different sizes)	Set	1
13	Tool Box (To accommodate all the above specified tools)	No	1
--End of Table--			

1.4 Requirements for Power Interface Unit (PIU)

1.4.1 General Requirements

Power Interface Unit (PIU) shall integrate the surge protection devices, AMF panel for DG control, AC voltage stabilizer, and AC distribution panel etc. in a single unit to save the valuable floor space inside the shelter and to provide quality AC power supply to the various systems including SMPS based DC power supply system, air conditioning system etc. used in telecom applications.

The PIU unit to be supplied shall have an operational life of 15 years.

1.4.2 System Configuration

PIU unit shall consist of following subsystems integrated in a single cabinet suitable for indoor installations.

- 1) Healthy Phase Selector
- 2) Surge Protection Devices
- 3) Static Voltage Stabilizer
- 4) AMF Panel
- 5) PIU controller
- 6) AC distribution panel

1.4.3 Healthy Phase Selector

Generally the AC supply shall be taken directly from available rural/urban overhead distribution supply. Healthy phase selector shall select the healthy phase out of the available phases. PIU in one of the following three configurations shall be provided at each location;

- i) 15kVA PIU working on best two phase with input voltage 240-480 Normal L-L for Urban locations
- ii) 10kVA PIU working on best single phase with input voltage 155-280 Normal L-N for Rural locations

- iii) 10kVA PIU working on best single phase with input voltage 155-280 Normal L-N for Rural locations capable of controlling two DG sets (as per clause 6.3.7)

NOTE: NMS, Repeater shelter system, VRLA Battery bank for DCPS, SMPS and Annual maintenance contract for communication equipment shall be offered from a manufacturer(s) who is a “Local Supplier” as per latest DPIIT and DoT notification.

Suitable circuitry along with all hardware, cables, relays, sensors etc. shall be so provided that it shall be possible to select the healthy phase(s) automatically and have the output at the stabiliser and the load requirement can be met. The Contractor shall submit the scheme for Employer’s approval during detail engineering.

There should be a Manual by pass arrangement for bypassing the Healthy Phase Selector.

1.4.4 Lightning & Surge Protection

The PIU unit shall be equipped with lightning and surge protection devices to provide protection to all the equipment being connected and integrated against incoming lightning and low voltage surges. The lightning/surge protection shall be in compliance with IEC-61312, IEC-61024 and VDE-0100-534 for following surges:

A) Lightning Electromagnetic impulse and other High Surges (Class B):

Between	Requirement
R, Y, B & N	$I_{imp} \geq 50 \text{ kA}, 10/350 \mu\text{S}$ for each phase
N & PE	$I_{imp} \geq 100 \text{ kA}, 10/350 \mu\text{S}$

I_{imp} = Value of Lightning Impulse Current

B) Low Voltage Surges (Class C)

Between	Requirement
R, Y, B & N	$I_n \geq 10 \text{ kA}, 8/20 \mu\text{S}$ for each phase
N & PE	$I_n \geq 20 \text{ kA}, 8/20 \mu\text{S}$

I_n = Value of Nominal Discharge Current.

The protection system for both the above stages shall be reusable after clearance of surge. In case of fault, provision for manually bypassing the protection system should be available to ensure the operation without protection system. The manufacturer shall give complete details of the arrangement provided for the purpose during detail engineering and also ensure and demonstrate the effectiveness of the arrangement. Test Certificate from a reputed third party lab may be accepted provided the protective devices of both stages have been tested in the same lab.

1.4.5 Static Voltage Stabilizer

AC Static automatic voltage stabiliser using microprocessor based controller shall provide the stabilised quality power supply to the air-conditioners, battery charger, lighting etc. through ACDB. The capacities/ratings of voltage stabiliser shall be as per appendices. The stabiliser shall conform to the following parameters specified in Table 6.1 below:

Table 6.1

S. No.	Items	PIU for Urban locations	PIU for Rural locations
1	Input Power	3 Φ , 4 wire	3 Φ , 4 wire
2	Input Voltage (Volts)	240-480 Normal L-L on best two phase working	155-280 L-N when working on single phase
3	Output Voltage (Volts)	230 V $\pm$ 10% (Single Phase)	230 V $\pm$ 10% (Single Phase)
4	Voltage correction speed	400 V in 1 μ sec	400 V in 1 μ sec

Table 6.1

S. No.	Items	PIU for Urban locations	PIU for Rural locations
5	Efficiency (excluding IT)	> 96%	> 96%
6	Frequency	48 – 52 Hz	48 – 52 Hz

1.4.6 Automatic Mains Failure (AMF) Panel

The PIU unit shall support the microprocessor based AMF panel for various capacity DG sets as per BoQ. The AMF shall start the DG set and transfer the AC load from normal source to diesel generator automatically in case of AC mains failure with availability of other conditions as per section 1.3.16.1.1 of this specification. Similarly on restoration of mains supply it shall be able to transfer the load to mains supply and switch off the DG automatically. Provision for a suitable delay shall be kept for starting of DG and changeover of load between DG & Mains.

The AMF panel shall be equipped with suitable instrumentation, interlock and protection arrangement, suitable annunciation and indications etc. as defined in the Section 1.3.10 of this specification for proper start up, monitoring, control and safe operation of the DG set.

An option for selection of Auto / Manual Mode operation should be provided on the front panel of the PIU. Operation (Start / Stop) of the DG set in manual mode should be available on the PIU. In manual mode, AMF logic will be totally bypassed. However during manual mode, the DG protections will not be bypassed. A change over switch shall also be provided for total bypassing the AMF.

1.4.7 PIU Controller

Contractor shall integrate the Alarms of various Auxiliaries of shelter with the PIU and Alarms shall be monitored by Central Supervisory Unit. Central Supervisory Unit shall be designed to facilitate better interface of man and machine. It shall consist of High-Speed micro controller displaying true RMS for all voltage & current through LCD display. All the inputs to the measurement board shall be duly protected against surge as per IEEE-62.41. The measurement circuit shall be rated at 1.5 times the maximum input range. The unit shall be equipped to log 500 events with date and time stamping including DG start and stop logs. It shall display various site conditions like Mains ON, DG ON, Smoke/ Fire Alarm, Over Load, Charger MODULE fail, DG Fuel Low, DG fail to start, DG fail to stop, Alternator fail, LLOP, DG overload, Mains Fail, Site battery low, DG battery low, HCT/HWT, High Shelter temperature etc. Various Mains and DG related measurements viz. Mains energy measurement, DG energy measurement, DG accumulated hours, peak energy requirement of site etc. shall also be displayed.

Contractor shall integrate and extend the Potential Free Contacts for monitoring at NOC for following minimum alarms;

- i) Mains Fail
- ii) Door Open
- iii) High Room Temperature
- iv) DCPS battery Low
- v) Rectifier Fail
- vi) Fire and Smoke
- vii) DG Fail to Start
- viii) LLOP
- ix) Fuel Low
- x) DG ON LOAD
- xi) DG ON
- xii) HCT
- xiii) DG Over speed
- xiv) DG Fail to Stop
- xv) Other Common DG Faults

It must support a RS 232 port for PC interface for programming / reconfiguration of the parameters through laptop.

1.4.8 AC Distribution Panel

There shall be AC distribution panel for termination of the load. The SMPS, Air conditioners etc. shall be connected to this AC distribution panel through suitable MCBs. The ratings of the MCBs shall be selected to provide safe and continuous operation of the DCPS system, Air conditioning system etc being supplied under this contract. The Contractor shall submit the details of MCB ratings for Employer's approval.

The AC mains and DG set shall be connected to PIU unit through MCCBs of suitable ratings.

1.4.9 PIU with Dual DG logic

At few of the remote Telecom locations, two DG sets may be required. For those locations, PIU capable of controlling two DGs shall be supplied. In case of power failure, command shall always go to that DG which was in standby mode during previous cycle of Power failure. For the sites operated purely on DG supply, the logic shall be to run the DG Set for a prefixed time with in the range of 0 to 10 hrs. After every set time of DG run the load of the Repeater Shelters need to be shifted to battery bank. DC load need to be fed through battery till time either shelter temperature exceeds the set threshold or battery bank voltage falls below the set threshold. In case of crossing of any of these thresholds, the PIU to give DG start command to second DG set. DG sets supplied under earlier packages having capacity 15kVA or below may also be available at sites.

1.4.10 Constructional Features of Rack

Only a single cabinet shall accommodate all the systems that include phase selector, surge protection devices, static voltage stabilizer, AMF panel and PIU controller, digital displays and meters, wires and cables, associated sub systems etc. The dimensions of the rack shall be such that it shall occupy minimum space inside the shelter.

The enclosure (rack) shall be freestanding type of design and shall have sufficient structural strength to withstand the ultimate mechanical load capacity without any deformity. Cable entry shall be from the bottom/top of the enclosures. The design of the rack (enclosure) shall be modular allowing easy maintenance and installation such that replacement or taking out of one subsystem for repair or maintenance shall not require dismantling of whole system. The rack shall be free of sharp edges or sharp corners. Rack mounting arrangement shall provide easy access from front, rear and top for installation and maintenance.

Where cables pass through metal panels suitable arrangement including bushings shall be provided to protect cables from damage. Bus-bars shall be suitably spaced and insulated to prevent any possibility of short circuit between bus-bar and/ or rack.

With doors in position, all visual alarms and meters shall be clearly visible. In case of hinged doors, meters and alarm indicators are permitted on the door provided the fixtures on the door do not restrict the movement of door in any way.

1.4.10.1 Components

The component parts of the equipment shall be of professional grade from reputed manufacturer to ensure continuous and safe operation of the equipment including its sub systems. The component shall conform to relevant IEC/IS standards and Complete PIU unit shall ensure compliance to safety as per IEC-60950 or any other international standard.

1.4.10.2 Finish and Painting

The finish of Steel/Aluminium structure and panels shall conform to relevant IS specification (or equivalent international specifications). The colour scheme for Rack, Door and Modules shall be decided during detailed engineering.

1.4.10.3 Earthing

The PIU unit including its subsystems shall be properly earthed by connecting it to the earthing system being provided by the Contractor under this Package.

1.4.11 MTBF

The mean time between the faults of the PIU and its subsystems shall be more than 70,000 hrs.

1.4.12 Installation

The transportation of PIU unit and its complete installation at respective sites as per attached appendices shall be carried out by the Contractor. All type of cables or associated accessories shall be supplied and installed by the Contractor. Connection to SEB supplied AC mains and ACDB etc shall also be carried out by the Contractor

1.4.13 Testing

1.4.13.1 Type Testing

PIU shall conform to EMI/EMC requirements as per IEC-870-2-1 standards. It shall also conform the Environmental requirements as per the TEC Standard for Environmental testing i.e. SD: QM-333 Mar 2010 (with amendments, if any) in category B2.

Electrical and mechanical safety and Performance test shall also be carried out on PIU as per specification. The Contractor can also submit the earlier carried out type test reports on the offered system for above tests.

1.4.13.2 Factory Acceptance Testing

The Contractor shall submit the detailed format of factory acceptance testing plan for PIU unit incorporating various tests for testing of all its systems and sub systems and get it approved from the Employer. The FAT shall be conducted on the offered PIU units as per approved FAT tests and procedure.

1.4.13.3 Site Acceptance Test

After successful installation, the site acceptance testing for PIU unit including its subsystems shall be carried out by the Contractor for each site demonstrating all its functions properly. The detailed SAT procedure shall be submitted by the Contractor for Employer's approval.

1.5 DC Power Supply system

In order to provide reliable power supply to communication equipment at various locations, 48 V DC Power Supply (DCPS) system is to be provided as a part of this project. This section describes the technical requirement of DC power supply & associated Battery.

The DC Power Supply system shall be capable of meeting the load requirements for various Telecom equipments. The rating of offered SMPS modules shall meet Employer's requirements of DCPS system as stipulated in the BoQ.

The DC Power supply system shall have a single DCPS system as per conceptual configuration diagram given in Fig.3-1, shall be supplied.

Surge protection devices shall be installed in the DCPS panel to provide adequate protection against current and voltage transients introduced on input mains AC due to load switching and low energy lightning surges. These protection devices shall be in compliance with IEC 61312, IEC 61024 and VDE 0100-534 for following surges:

It shall be provided with Class 'B' & 'C' type surge protection device. The device must be provided with Class B type lightning current arrester (Switching Type) with a discharge current capacity of at least 50 kA, 10/350 μ s, and Class C type surge arrester (linear device) as per IEC 61643-1. The blind spots shall be avoided in accordance to IEC 61312. The Class 'C' surge protection device should be pluggable type, equipped with features of thermal disconnection, & health indication and potential free contacts for surge arrestors connected between phase & neutral.

The surge protection device shall comply to IEC 61643.

1.5.1 General Technical Requirements for SMPS based DC power supply units

SMPS based DC power supply system is to be used in Auto Float-cum-Boost Charge mode as a regulated DC Power source. DCPS system is to be installed indoors and shall be provided with IP21 panels. The System shall consist of the following:

SMPS modules

- a) Controller module to control and monitor all DCPS modules.

The Panel, Distribution/Switching arrangement shall be provided for the ultimate system capacity. Ultimate System capacity is defined as 150% of the present capacity specified. The ultimate capacity is over and above the requirement of redundancy wherever specified. All factory wiring for the panel shall be for the ultimate capacity so that only plugging-in of SMPS module shall enhance the DC power output.

The size of fuses, MCBs, switch, bus etc shall be suitable for the ultimate capacity.

The SMPS modules of DCPS system shall be suitable for operation from single phase A.C. mains/DG set supply. However, the input AC mains supply to DCPS system shall be 3-phase, 4 wire which shall be evenly distributed among all the offered SMPS modules.

1.5.1.1 Operational/Component Requirements

The basic modules shall operate at specified ratings and conform to requirements stipulated in this specification. The DCPS system shall meet requirement of the latest TEC specification / IEC/BS for other parameters as applicable.

1.5.1.2 Wiring

All insulated conductors except those within the confines of a printed circuit board assembly shall be of the rating enough to withstand the maximum current and voltage during fault and overload. All insulated conductors/cables used shall conform to IS 1554 or equivalent international standard.

1.5.1.3 Bus Bars

High conductivity Cu bus bar shall be provided and shall be sized to take care of the current of ultimate DCPS system capacity for which it is designed. However, it shall not be less than 25mm X 5mm.

1.5.1.4 Earthing

Two earth terminals shall be provided in the frame of the system. The Contractor shall connect these earth terminals to the earth bus. All modules and devices shall be connected to these earth terminals. The hinged door, if provided shall be connected to the panel with braided Cu at two points at least.

1.5.1.5 Marking and Labelling of Cables

The Contractor shall propose a scheme for marking and labelling the inter panel cables by Halogen & Silicon free labels of polyamide ensuring scratch proof labelling with the use of solvent free ink & latest UV Technology making it environment friendly printing with a WIPE RESISTANCE according to DIN EN 61010-1/VDE 0411-1 and get it approved from the Employer. A cabling diagram, screen printed or any other better arrangement ensuring better life expectancy shall be placed in the inside of the front door or any other convenient place for ready reference of the maintenance staff.

1.5.1.6 System and Panel Configuration

The mechanical and electrical requirements of the Panel are described as below:

1.5.1.7 System Configuration

The SMPS modules shall be accommodated in panels. The system shall employ a modular configuration to provide flexibility, keeping in view the future load requirements of DC Power. The system shall be configured for ultimate capacity as brought out in Section 3.1. The Control, Monitoring, Alarm arrangement and DC & AC distribution shall be provided suitably in the panel.

The SMPS modules shall be provided as per the load requirement stipulated in the Appendix, BOQ. The DCPS system shall comprise of N+2 Modules. In case of DCPS system having N=1, the SMPS shall comprise of N+1 modules. Here N refers to number of SMPS modules to meet the load requirements specified in the Appendix, BOQ and battery charging current. The current rating of each module shall be considered as output current of the SMPS module at nominal voltage (48V).

Total current = load current + battery charging current

Where, battery charging current is equal to the 20 % AH of the battery supplied.

$$N = \frac{\text{Total Current}}{\text{Current rating of each SMPS module at 48 V}}$$

The Distribution/switching/Alarm unit shall be provided for the ultimate system capacity. All AC, DC or control/alarm cabling/wiring shall be pre-wired for the ultimate capacity so that mere plugging-in of SMPS module shall add to the DC power output.

1.5.1.8 Constructional Features of Panel

For the enclosures/panel, the front door (if provided) shall not be wider than 80 cm and rear door may be of hinged or removable type with locking as per standard design of the manufacturer. Keyed locking is required with identical keys for all enclosures. The enclosures shall not exceed 220 cm in height. The thickness of the structural frames and load bearing members shall be minimum 2.0 mm and for others shall be minimum 1.6 mm. The panels/boards shall be equipped with necessary cable gland plates. The degree of protection of DCPS enclosures shall preferably be IP21.

Conductors in multi conductor cables shall be individually colour coded, and numbered at both ends by Halogen & Silicon free labels of polyamide ensuring scratch proof labelling with the use of solvent free ink & latest UV Technology making it environment friendly printing with a WIPE RESISTANCE according to DIN EN 61010-1/VDE 0411-1 within enclosures.

Each panel shall be supplied with 240 VAC, 50Hz single-phase sockets with switch and lighting lamp for panel illumination.

The Panel shall be designed to allow cooling preferably by natural convection. The Contractor shall submit detail design of proposed Panel/enclosure and heat dissipation calculations during detailed engineering. Forced cooling is permitted (DC Fans are permitted in the Panel or SMPS module) for equipment mounted indoors (buildings/rooms/shelters). Proper filtering shall be provided to control dust ingress. There shall be an arrangement for automatic Switching-OFF of fans during AC input failure.

1.5.1.9 Electrical Requirements:

AC input supply: The nominal input frequency is 50 Hz, which may vary from 47.5-52.5Hz. The input voltage shall be as mentioned below:

Field Site Application – Three phase/4Wire (Nominal 415/240 V): 415 + 10 % - 15%. However, at site the voltage may vary from 160V to 300V (Ph-N). An Auto-Mains Changeover unit shall be provided for each field site DC power supply system. The Auto-Mains Changeover unit shall accept input from two AC sources and extend any one of the available healthy sources to the DC Power supply system.

The suitable HVD (High Voltage Disconnecter) Protection shall be provided at input of each DCPS system.

This HVD protection shall protect the SMPS modules of DCPS system against the sustained over voltage at the input.

A tolerance of $\pm 5V$ may be acceptable for protection & alarm operation.

1.5.1.10 DC output Characteristics of Modules

The module shall be capable of operating in “Auto Float-cum-Boost Charge” mode depending on the condition of the battery sets being sensed by the Control unit.

- (a) The float voltage shall be continuously adjustable & pre-settable at any value in the range of -48 to $-56V$ or as per battery manufacturer recommendations either at the module or may be set from the common controller configuration. Further, the prescribed float voltage setting shall be based on recommendations of the battery supplier.
- (b) In Boost charge mode, DCPS shall supply battery & equipment current till terminal voltage reaches set value, as recommended by the battery supplier & shall change over to constant voltage mode
- (c) The DC output voltage variation shall not be more than 2% for load variation from 25% load to full load.

1.5.1.11 Current Limiting (Voltage Droop)

The current limiting (Voltage Droop) shall be provided in DCPS SMPS modules in float and boost charge modes of operation. The float/boost charge current limiting shall be continuously adjustable between 50 to 100% of rated output current for output voltage range of -44.4 volts to -56 Volts or as per manufacturer's specified catalogue.

The float and boost charge current limit adjustment shall be provided in the DCPS system. The SMPS modules shall be fully protected against short circuit. It shall be ensured that short circuit does not lead to any fire hazard.

1.5.1.12 Soft/Slow Start Feature

Soft/Slow start circuitry shall be employed such that SMPS module input current and output voltage shall reach their nominal value within 10 seconds.

The maximum instantaneous current during start up shall not exceed the peak value of the rectifier input current at full load at the lowest input voltage specified.

1.5.1.13 Voltage Overshoot/Undershoot

The requirements of (a) to (c) given below shall be achieved without a battery connected to the output of SMPS modules.

- (a) The SMPS modules shall be designed to minimize DC output voltage Overshoot/Undershoot such that when they are switched on the DC output voltage shall be limited to $\pm 5\%$ of the set voltage & return to their steady state within 20 ms for load variation of 25% to 100%.
- (b) The DC output voltage overshoot for a step change in AC mains as specified in clause 4.3.12 Electrical Requirements shall not cause shut down of SMPS module and the voltage overshoot shall be limited to $\pm 5\%$ of its set voltage and return to steady state within 20ms.
- (c) The modules shall be designed such that a step load change of 25 to 100% and vice versa shall not result in DC output voltage Overshoot/Undershoot of not more than 5% and return to steady state value within 10 ms without resulting the unit to trip.

1.5.1.14 Electrical Noise

The Rectifier (SMPS) Modules shall be provided with suitable filter at output with discharge arrangements on shut down of the modules. The Psophometric Noise (e.m.f weighted at 800Hz) with battery connected across

the output should be within 2 mV at full load at nominal input AC supply. For test purposes, this shall be taken as equivalent to 4mV when the battery is not connected and in accordance to ITU-T Rec. O.41.

Voltage at the output of the Rectifier (SMPS) module, without battery connected, shall not exceed 300 mV at the switching frequency measured by an Oscilloscope of 50/60 MHz bandwidth (Typical).

1.5.1.15 Parallel Operation

SMPS modules shall be suitable for operating in parallel with one or more modules of similar type, make and rating, other output conditions remaining within specified limits.

The current sharing shall be within $\pm 10\%$ of the average current per rectifier module individual capacity of each rectifier module in the system (mounted in the same or different Panels) when loaded between 50 to 100% of its rated capacity for all other working conditions.

1.5.1.16 Protection

The SMPS module, which has failed (for any reason) shall be automatically isolated from the rest of the modules and an alarm shall be initiated for the failure.

1.5.1.17 DC Over voltage protection

DCPS shall be fitted with an internal over voltage protection circuit.

In case output DC voltage exceeds $-57V$ or as per the recommendations of the manufacturer of batteries, the over voltage protection circuit shall operate & shut off the faulty module. A tolerance of $\pm 0.25V$ is permitted in this case.

Shutting off of faulty SMPS module shall not affect the operation of other SMPS modules operating in the Panel. Operation of over voltage shut down shall be suitably indicated and extended monitoring/control unit. The circuit design shall ensure protection against the discharge of the Battery through the SMPS module in any case. The over voltage protection circuit failure shall not cause any safety hazard.

1.5.1.18 Fuse/Circuit Breakers

Fuses or miniature circuit breakers (MCB) shall be provided for each SMPS module as follows:

1. Live AC input line
2. Control Circuit

All fuses/circuit breaker used shall be suitably fault rated.

1.5.1.19 AC Under/Over Voltage Protection

AC input Under/Over voltage protection shall be provided as per clause 3.1.11 for Electrical Requirements. The DC side of the SMPS should also be provided with surge protection device to protect the SMPS in case of transients being generated by the loads or due to induction in the DC line from the AC line running parallel together. The Surge protection device should be able to discharge a current of at least 10 kA of 8/20 μs (Class 'C' surge arrestor), pluggable and should have indication to show its health to facilitate the replacement on fault condition.

1.5.1.20 Over Load/Short Circuit Protection

The SMPS shall be protected for Over load/Short circuit as per clause 3.1.13 Current Limiting (Voltage Droop).

1.5.1.21 Alarms and indicating lamps

Visual indications/display such as LEDs, LCDs or a combination of both shall be provided on each SMPS module for detection of SMPS module failure.

1.5.1.22 Termination

Suitable termination arrangements shall be provided in the panel for termination of inter cubicle cables from other equipment such as Employers ACDB, Telecom and other associated equipments and alarm cables.

1.5.1.23 DC Terminations

All terminations including through MCBs shall be through lock and screw type terminations. Load and batteries shall be connected to DCPS through appropriate MCBs. The isolation of any of the battery from the load shall create an alarm. DC distribution shall be provided with adequate no. of feeders with appropriate MCBs (6 Amp thru 32 Amp) for termination of the loads. Actual rating of the MCBs shall be finalized during the detail engineering. The no. of feeders shall be minimum 10 (ten) nos.

DC distribution may be done either on wall mounted panel or on the DCPS panel. The proper rated MCB shall be provided at the combined output of the SMPS modules (if not provided at each SMPS module). All the AC, DC and Control/alarm cabling shall be supplied with the Panel. All DC +ve and -ve leads shall be clearly marked. All conductors shall be properly rated to prevent excessive heating.

1.5.1.24 Earthing Cables

Earthing cables between equipment and grounding bus bars shall be minimum size 70 mm² stranded conductors copper/copper strip, rated at 300 volts. All hinged doors shall be earthed through flexible earthing braid. Signal and Safety earthing shall be provided separately.

1.5.1.25 Alarms

Following Visual indications/display such as LEDs, LCDs or a combination of both shall be provided to indicate:

Functional Indications for local monitoring:

- a) Mains available
- b) DCPS/SMPSs in Float charge Mode
- c) DCPS/SMPSs in Boost Charge Mode

Alarm Indication for local monitoring:

- a) Load Voltage High /Low
- b) DCPS module/SMPS fail
- c) Mains out of range
- d) System Over Load
- e) Mains "ON"/Battery Discharge
- f) Battery fail/isolated

All the protections/alarms shall be within tolerance of 0.25V in case of DC voltage, 1% in case of DC current and $\pm 5V$ for AC voltage

Alarm Indication for remote monitoring:

- a) Input AC mains supply fail alarm
- b) Battery low voltage (Pre cut off) alarm
- c) DCPS module fail

Potential free Contacts in two numbers for each of the above remote monitoring alarms (one for remote alarm interfaced through communication equipments and one redundant for local monitoring at suitable location) shall

be provided. All these potential free contacts are to be wired and terminated at the suitable location for interfacing purpose.

1.5.1.26 Digital Meters/Display Unit

There shall be provision to monitor the following parameters through digital meters or digital display units:

- (a) Input AC voltage.
- (b) Out put DC voltage
- (c) Output DC current of charger
- (d) Battery current
- (e) Load current.

The Digital display of meters or LCD based display unit shall be with minimum 3 1/2 digital display of height 12mm and shall have accuracy 1.5% or better.

1.5.2 Cabling & Enclosure Requirements

The contractor shall supply, install and commission all power cables, control cables, network interface cables and associated hardware (lugs, glands, cable termination boxes etc.) as required for all equipment. The contractor shall be responsible for Cable laying and termination at both ends of the cable. The Contractor shall also be responsible for termination of feeder cables at contractor's equipment end including supply of suitable lugs, glands, terminal blocks & if necessary cable termination boxes etc. All cabling, wiring, and interconnections shall be installed in accordance with the following requirements.

1.5.2.1 Power Cables

All external power cables shall be stranded Aluminium conductor, armoured XLPE/PVC insulated and sheathed, 1100V grade as per IS-7098 Part-I/IS 1554 Part-I.

1.5.2.2 Enclosure/Panel Earthing

Each enclosure shall include suitable earth networks within the enclosure. Earth network shall be a copper bus bar, braid or cable inside enclosures.

The safety earth network shall terminate at two/more studs for connecting with the earthing grid. Safety earthing cables between equipment and enclosure grounding bus bars shall be minimum size 6 sq. mm, stranded copper conductors, rated at 300 volts. All hinged doors (if provided) shall be earthed through flexible earthing braid.

For all enclosures requiring AC input power, the green earthing wire from the AC input shall be wired to the safety earthing stud. The Contractor shall provide all required cabling between enclosures for earthing. The contractor shall connect safety and signal earths (as applicable) of each enclosure to the Employer provided nearest earth grid/earth riser through suitable 50X6 sq. mm. GI strips or suitably sized copper cable.

The signal earthing network shall terminate at a separate stud connection, isolated from safety ground. The stud connection shall be sized for an external earthing cable equipped with a suitable lug.

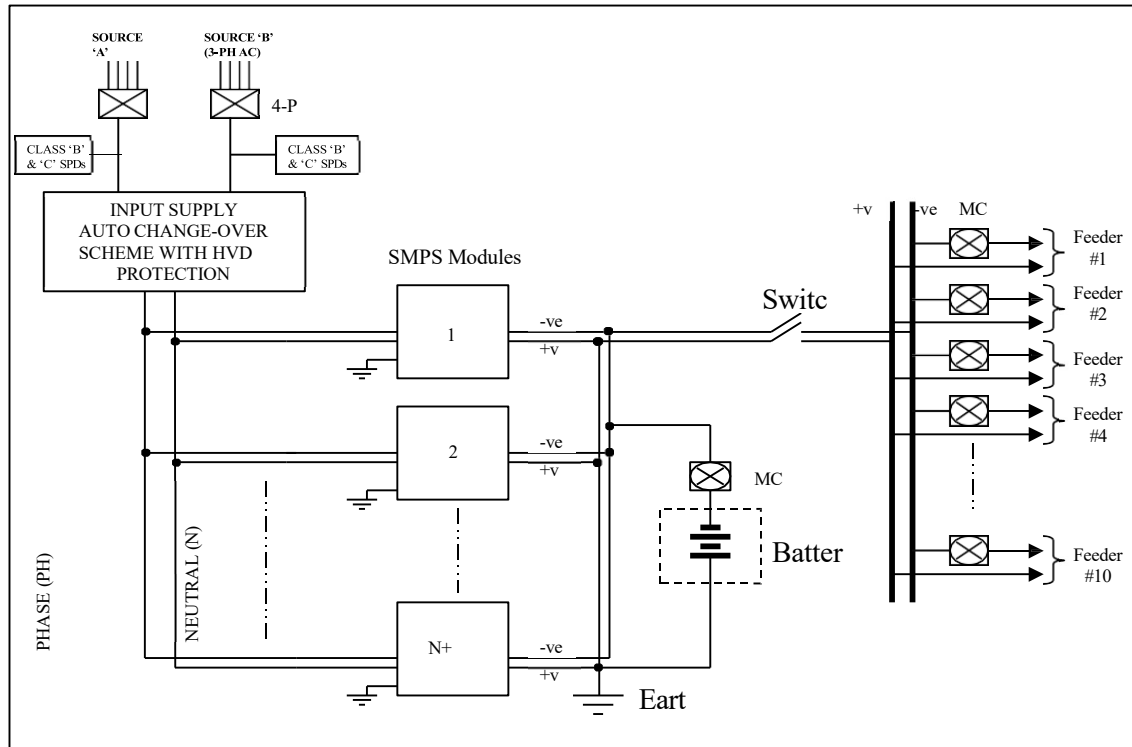
All earthing connections to equipment shall be made directly to each equipment chassis via earthing lug and star washer. Use of the enclosure frame, skins, or chassis mounting hardware for the earthing network is not acceptable.

1.5.3 Temperature Compensation for Battery

There shall be provision for monitoring the temperature of battery and consequent arrangement for Automatic temperature compensation of the SMPS output voltage to match the battery temperature dependent charge characteristics. The output voltage of the rectifier in Float/Charge operation shall decrease or increase at the rate of 72 mV (3mV/cell, 24 cell battery) per degree increase or decrease in temperature over the set voltage or as

may be recommended by the VRLA Battery supplier. A tolerance of $\pm 5\text{mV}$ may be acceptable over the specified rate of 72 mV/degree C . The output voltage shall decrease till the open circuit voltage of the battery is reached. The open circuit voltage range shall be settable between 2.1V/cell to 2.2V/cell . The increase in output voltage due to decrease in temperature has been taken care of by the tripping of the unit due to output voltage high (57V) protection. Failure of temperature compensation circuit including sensors shall create an alarm and shall not lead to abnormal change in output voltage. The nominal distance between the battery & DCPS system may be 20 metres . The Contractor shall provide the necessary sensor and cord for the purpose with DCPS system to sense the Battery temperature.

FIG.: CONCEPTUAL CONFIGURATION OF DC POWER SUPPLY (DCPS) SYSTEM (For Field Sites Locations)



1.5.4 Battery Requirements

1.5.4.1 Valve Regulated Lead Acid (VRLA) maintenance free Battery

The contractor shall supply Valve Regulated Lead Acid (VRLA) maintenance free Battery. Each battery set shall have sufficient capacity to maintain output at full rated load as indicated in BOQ in Appendix. The battery shall be capable of being recharged to 90% State of Charge (SOC) from the fully discharged condition (1.75V/cell) within 10 hrs. In all cases, the battery is normally not allowed to discharge beyond 80% of rated capacity (80% DOD) at 10 hours rate of discharge.

The supplier, supplying the cells/batteries as per this document shall be responsible to replace/repair free of charge, the battery/cell becoming faulty, owing to defective workmanship or material as per the provisions of the bid document

1.5.4.2 Containers

The container material shall have chemical and electro-chemical compatibility and shall be acid resistant. The material shall meet all the requirements of VRLA batteries and be consistent with the life of battery. The container shall be fire retardant and shall have an Oxygen Index of at least 28%. The porosity of the container shall be such as not to allow any gases to escape except from the regulation valve. The tensile strength of the material of the container shall be such as to handle the internal cell pressure of the cells in the worst working condition. Cell shall not show any deformity or bulge on the sides under all working conditions. The container shall be capable of withstanding the rigours of transport, storage and handling. The containers shall be enclosed in a steel tray.

1.5.4.3 Pressure Regulation Valve

Each cell shall be provided with a pressure regulation valve. The valve shall be self re-sealable and flame retardant. The valve unit shall be such that it cannot be opened without a proper tool. The valve shall be capable to withstand the internal cell pressure specified by the manufacturer.

1.5.4.4 Flame Arrestors

Each cell shall be equipped with a Flame Arrestor to defuse the Hydrogen gas escaped during charge and discharge. Material of the flame arrestor shall not affect the performance of the cell.

1.5.4.5 Battery Bank Stand

All batteries shall be mounted in a suitable metallic stand/frame. The frame shall be properly painted with the acid resistant paint. The suitable insulation shall be provided between stand/frame and floor to avoid the grounding of the frame/stand.

1.5.4.6 Capacity Requirements

When the battery is discharged at 10 hour rate, it shall deliver 80% of C (rated capacity, corrected at 27°Celsius) before any of the cells in the battery bank reaches 1.85V/cell.

All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life. Float voltage of each cell in the string shall be within the average float voltage/cell +0.05V band.

The capacity (corrected at 27°Celsius) shall also not be less than C and not more than 120% of C before any cell in the battery bank reaches 1.75V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at C/10 rate:

- | | |
|------------------------------------|--------------|
| (a) After Six minutes of discharge | : 1.98V/cell |
| (b) After Six hours of discharge | : 1.92V/cell |
| (c) After 8 hours of discharge | : 1.85V/cell |
| (d) After 10 hours of discharge | : 1.75V/cell |

Loss in capacity during storage at an average ambient temperature of 35° Celsius for a period of 6 months shall not be more than 60% and the cell/battery shall achieve 85% of its rated capacity within 3 charge/discharge

cycles and full rated capacity within 5 cycles, after the storage period of 6 months. Voltage of each cell in the battery set shall be within +0.05V of the average voltage throughout the storage period. Ampere hour efficiency shall be better than 90% and watt hour efficiency shall be better than 80%.

1.5.4.7 Expected Battery Life

The battery shall be capable of giving more than 1200 charge/discharge cycles at 80% Depth of discharge (DOD) at an average temperature of 27° Celsius. DOD (Depth of Discharge) is defined as the ratio of the quantity of electricity (in Ampere-hour) removed from a cell or battery on discharge to its rated capacity. The battery sets shall have a minimum expected operational life of 5 years at normal operating conditions or 1200 charge/discharge cycles (whichever is early).

1.5.4.8 Routine Maintenance of Battery system

For routine maintenance of battery system, the contractor shall supply one set of following tools:

- a. Torque wrench.
- b. Tool for opening /closing of pressure regulation valve of battery.

1.5.4.9 Testing requirements

The Contractor shall submit type test reports for the battery for the same make, model & rating as offered as per the IEC 60896 or equivalent IS/EN/BS/TEC standards. In the event, the type test reports for exact rating is not available, the Contractor shall submit type test reports for higher rating Battery.

1.5.4.10 List of Type Tests

The type testing shall be conducted on the following equipment

- (a) DCPS
- (b) Battery System

1.5.4.10.1 Type testing of DCPS

The test reports for Immunity, Emission and safety must be in accordance with relevant IEC/CISPR standards shall be submitted. The Contractor shall submit the DCPS type test reports of earlier conducted tests on the same make, model, type & rating which shall include the following tests listed in Table A.

Table A	
Type Tests on DCPS	
1	Surge immunity (Level 4- as per IEC 61000-4-5)
2	Electrical Fast Transients/Burst (Level 4 – as per IEC 61000-4-4)
3	Electrostatic Discharge (Level 4 – as per IEC 61000-4-2)
4	Radiated Electromagnetic Field (Level 3 – as per IEC 61000-4-3)
5	Conducted disturbances induced by radio-frequency field (Level 3 – as per IEC 61000-4-6)
6	Damped oscillatory magnetic field (Level 3 – as per IEC 61000-4-10)
7	Voltage dips, short interruptions and voltage variations (Level 2 – as per IEC 61000-4-11)
8	Conducted Emission (Level - Class A, Group 1 as per IEC CISPR 11)
9	Radiated Emission (Level - Class A, Group 1 as per IEC CISPR 11)
10	Safety Tests (as per IEC 60950)

1.5.4.10.2 Testing Requirements of Battery

Table B
List of tests for VRLA battery

Sl. No.	Test	Type Test As per IEC 60896	FAT	SAT
1.	Verification of marking - Visual observation - Dimensional inspection - Polarity checking	√	√	√
2.	Capacity test	√	√	√
3.	Suitability for floating battery operation	√		
4.	Endurance in discharge/charge cycles	√		
5.	Charge Retention	√		
6.	Short-circuit current and internal resistance	√		
7.	Stability against mechanical abuse of units during installation	√		
NOTE : The batteries shall meet the general requirements as per IEC 60896 or equivalent.				

1.5.4.11 Factory Acceptance Tests

1.5.4.11.1 FAT/SAT of DCPS

The factory/site tests to be carried out on DCPS system/module in the factory and site are listed respectively in Table C below.

Table C			
Lists of tests for FAT/SAT of DCPS			
S.No	Test	FAT	SAT
.			
Tests on DCPS System			

1.	Mechanical & Visual Check Tests	√	√
2.	Insulation Test.	√	
3.	High Voltage Withstand Test	√	
4.	Switch On Test	√	√

Table C			
Lists of tests for FAT/SAT of DCPS			
S.No	Test	FAT	SAT
5.	DCPS Low voltage & High voltage limits check Test	√	√
6.	Pre-alarm test for Battery Voltage Low	√	√
7.	Battery Low Voltage Disconnect Level Test	√	√
8.	AC Input Low and High voltage limits check Test	√	
9.	Rectifier Fail Alarm Test	√	√
10.	Voltage Regulation Test	√	
11.	Current Sharing Test	√	
12.	Total Output Power Test	√	√
13.	Hot Plug In Test (if applicable)	√	√
14.	Calibration & Parameter settings	√	√
15.	Automatic Float cum Boost Charge Mode Change Over Test	√	√
16.	Battery Path Current Limiting Test	√	√
17.	Battery Charging and full load Current Test	√	√
18.	Total Harmonic distortion Test	√	
19.	Burn in Test at 50 ° C (for 8 hrs duration)	√	
Tests on SMPS module			
20	Mechanical & Visual Check Test	√	
21	Module-On Test	√	
22	Input low/high voltage cut-off test	√	
23	Voltage Drop Test	√	
24	Voltage Regulation Test	√	
25	Power Output & Current Limit Test	√	
26	DC High Voltage Test	√	
27	O/P Voltage Ripple Test	√	
28	Psophometric Noise Test	√	
29	Efficiency Test	√	
30	Power Factor	√	
31.	Input Current Limit	√	
32.	Input AC Frequency Range Test	√	
33.	Rectifier Dynamic Response	√	
34.	Output Short Circuit Test	√	
35.	Hold up Time Test	√	