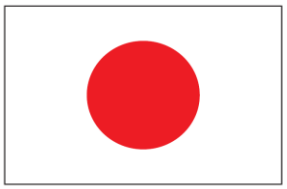

من الشعب الياباني
From the People of Japan

Empowered lives.
Resilient nations.

Jericho Agro-Industrial Park (JAIP)

Electrical Works

Technical Specifications

March, 2015

TECHNICAL SPECIFICATIONS

CONTENTS

ELECTRICAL WORKS – LIST OF MANUFACTURERS

Name of Item	*Manufacturer*	*Country of Origin*
Conduits & Accessories (PVC)	Viseman Kasimplast	Local Local
Cable Tray & Cable Ladder	Swift NIEDAX Davis	UK Germany UK
Outlets & Switches	Gewiss Schneider Petchino	Italy France Italy
Panel Boards	MELEMCO EMCO ALAKHRAS	Local Local Local
Earthing	Furse Helita	UK France
Switchboards	Moeller Schneider	Germany France
Wires & Cables	Superior Pamukeli	Local Turkey

Name of Item	*Manufacturer*	*Country of Origin*
Circuit Breakers	Moeller Schneider ABB	Germany France Germany
Starters	Telemechanique Schneider	Belgium Germany
PLC	Moeller Schneider ABB	Germany France Germany
Lightning System	Helita Furse	France UK
UPS	Liebert Merlin Gerin	USA France

Generator	Caterpiller Chokorova Perkins	USA Turkey UK

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies general grounding and bonding requirements of electrical equipment operations and to provide a low impedance path for possible ground fault currents.

B. “Grounding electrode system” refers to all electrodes required by IEC, as well as including made, supplementary, lightning protection system grounding electrodes.

C. The terms “connect” and “bond” are used interchangeably in this specification and have the same meaning.

1.2 SUBMITTALS

Submit in accordance with, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:

A. Shop Drawings:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
2. Include the location of system grounding electrode connections and the routing of aboveground and underground grounding electrode conductors.

B. Test Reports: Provide certified test reports of ground resistance.

C. Certifications: Two weeks prior to final inspection, submit four copies of the following to the Resident Engineer:

1. Certification that the materials and installation is in accordance with the drawings and specifications.
2. Certification, by the Contractor, that the complete installation has been properly installed and tested.

1.3 APPLICABLE PUBLICATIONS

Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

A. International Electro-technical Commission (IEC):

IEC 60364 (all parts)……Low-voltage electrical installations 1)

IEC 60364-4-41...……..Low-voltage electrical installations – Part 4- 41: Protection for safety –Protection against electric shock

IEC 60364-4-42...…….. Electrical installations of buildings – Part 4-42: Protection for safety –Protection against thermal effects

IEC 60364-4-43..... Electrical installations of buildings – Part 4-43: Protection for safety –Protection against over current

IEC 60364-5-51..... Electrical installation of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules

IEC 60364-5-52..... Electrical installations of buildings – Part 5-52: Selection and erection of electrical equipment – Wiring systems

IEC 60364-5-53..... Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control

IEC 60364-5-54..... Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors

B. American Society for Testing and Materials (ASTM):
   - B1-2001 ..... Standard Specification for Hard-Drawn Copper Wire
   - B8-2004 ..... Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   - 81-1983 ..... IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

D. National Fire Protection Association (NFPA):
   - 70-2005 ..... National Electrical Code (NEC)
   - 99-2005 ..... Health Care Facilities

E. Underwriters Laboratories, Inc. (UL):
   - 44-2005 ..... Thermo set- Insulated Wires and Cables
   - 83-2003 ..... Thermoplastic- Insulated Wires and Cables
   - 467-2004 ..... Grounding and Bonding Equipment
   - 486A-486B-2003 ..... Wire Connectors

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment grounding conductors shall be insulated stranded copper, except that sizes 6 mm² (10 AWG) and smaller shall be solid copper. Insulation color shall be continuous yellow green for all equipment grounding conductors.

B. Bonding conductors shall be bare stranded copper, except that sizes 6 mm² (10 AWG) and smaller shall be solid bare copper wire.

C. Isolated Power System: Type XLPE insulation with a dielectric constant of 3.5 or less.
D. Electrical System Grounding: Conductor sizes shall not be less than what is shown on the drawings and not less than required by the IEC, whichever is greater.

2.2 GROUND RODS

A. Copper clad steel, 19 mm (3/4-inch) diameter by 3000 mm (10 feet) long, conforming to IEC.
B. Quantity of rods shall be as required to obtain the specified ground resistance.

2.3 SPLICES AND TERMINATION COMPONENTS

Components shall meet or exceed IEC requirements and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).

2.4 GROUND CONNECTIONS

A. Below Grade: Exothermic-welded type connectors.
B. Above Grade:
    1. Bonding Jumpers: compression type connectors, using zinc-plated fasteners and external tooth lockwashers.
    2. Ground Busbars: Two-hole compression type lugs using tin-plated copper or copper alloy bolts and nuts.
    3. Rack and Cabinet Ground Bars: one-hole compression-type lugs using zinc-plated or copper alloy fasteners.

2.5 EQUIPMENT RACK AND CABINET GROUND BARS

Provide solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks with minimum dimensions of 4 mm thick by 19 mm wide (3/8 inch x ¾ inch).

2.6 GROUND TERMINAL BLOCKS

At any equipment mounting location (e.g. backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide screw lug-type terminal blocks.

2.7 SPLICE CASE GROUND ACCESSORIES

Splice case grounding and bonding accessories shall be supplied by the splice case manufacturer when available. Otherwise, use 16 mm² (6 AWG) insulated ground wire with shield bonding connectors.

PART 3 - EXECUTION

3.1 GENERAL

A. Ground in accordance with the IEC, as shown on drawings, and as hereinafter specified.

B. System Grounding:

1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformers.
2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.

C. Equipment Grounding: Metallic structures (including ductwork and building steel), enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be bonded and grounded.

3.2 INACCESSIBLE GROUNDING CONNECTIONS

Make grounding connections, which are buried or otherwise normally inaccessible (except connections for which periodic testing access is required) by exothermic weld.

3.3 SECONDARY EQUIPMENT AND CIRCUITS

A. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.

B. Metallic Piping, Building Steel, and Supplemental Electrode(s):

1. Provide a grounding electrode conductor sized per IEC between the service equipment ground bus and all metallic water and gas pipe systems, building steel, and supplemental or made electrodes. Jumper insulating joints in the metallic piping. All connections to electrodes shall be made with fittings that conform to IEC requirements.
2. Provide a supplemental ground electrode and bond to the grounding electrode system.

C. Service Disconnect (Separate Individual Enclosure): Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors.

D. Switchgear, Switchboards, Unit Substations, and Motor Control Centers:

1. Connect the various feeder equipment grounding conductors to the ground bus in the enclosure with suitable pressure connectors.
2. For service entrance equipment, connect the grounding electrode conductor to the ground bus.

3. Connect metallic conduits, which terminate without mechanical connection to the housing, by grounding bushings and grounding conductor to the equipment ground bus.

G. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders and power and lighting branch circuits.

H. Boxes, Cabinets, Enclosures, and Panel boards:
   1. Bond the equipment grounding conductor to each pull box, junction box, outlet box, device box, cabinets, and other enclosures through earth conductor.
   2. Provide lugs in each box and enclosure for equipment grounding conductor termination.
   3. Provide ground bars in panel boards, bolted to the housing, with sufficient lugs to terminate the equipment grounding conductors.

I. Motors and Starters: Provide lugs in motor terminal box and starter housing or motor control center compartment to terminate equipment grounding conductors.

K. Ground lighting fixtures to the equipment grounding conductor of the wiring system when the green ground is provided; otherwise, ground the fixtures through the conduit systems. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.

L. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.

M. Raised Floors: Provide bonding of all raised floor components

3.4 CORROSION INHIBITORS

When making ground and ground bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.5 CONDUCTIVE PIPING

A. Bond all conductive piping systems, interior and exterior, to the building grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.

3.6 LIGHTNING PROTECTION SYSTEM

Bond the lightning protection system to the electrical grounding electrode system.

3.7 ELECTRICAL ROOM GROUNDING

Building Earth Ground Busbars: Provide ground busbar hardware at each electrical room and connect to pigtail extensions of the building grounding ring.

3.8 WIREWAY GROUNDING

A. Ground and Bond Metallic Wire way Systems as follows:
   1. Bond the metallic structures of wire way to provide 100 percent electrical continuity throughout the wireway system by connecting a 16 mm² bonding jumper at all intermediate metallic enclosures and across all section junctions.
   2. Install insulated 16 mm² bonding jumpers between the wire way system bonded as required in paragraph 1 above, and the closest building ground at each end and approximately every 16 meters (50 feet).
   3. Use insulated 16 mm² bonding jumpers to ground or bond metallic wire way at each end at all intermediate metallic enclosures and cross all section junctions.

3.9 GROUND RESISTANCE

A. Grounding system resistance to ground shall not exceed 5 ohms. Make necessary modifications or additions to the grounding electrode system for compliance without additional cost to owner. Final tests shall assure that this requirement is met.

B. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

C. Services at power company interface points shall comply with the power company ground resistance requirements.

D. Below-grade connections shall be visually inspected by the Resident Engineer prior to backfilling. The Contractor shall notify the Resident Engineer 24 hours before the connections are ready for inspection.

3.10 GROUND ROD INSTALLATION

A. Drive each rod vertically in the earth, not less than 3000 mm (10 feet) in depth.

B. Where permanently concealed ground connections are required, make the connections by the exothermic process to form solid metal joints. Make accessible ground connections with mechanical pressure type ground connectors.

C. Where rock prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified resistance.

- - - E N D - - -

MOTOR-CONTROL PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation and connection of the motor control panel boards.

1.2 SUBMITTALS

Submit in accordance with, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

A. Shop Drawings:
   1. Sufficient information, clearly presented, including descriptive cuts, shall be included to determine compliance with drawings and specifications.
   2. Include electrical ratings, dimensions, weights, mounting details and materials, running over current protection, branch circuit over current protection, wiring diagrams, and accessories.
   3. Complete nameplate data including manufacturer's name and catalog number.

B. Manuals:
   1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.

C. Factory Tests: Submit within fourteen (14) days prior to the proposed test six (6) copies of manufacturer's routine factory test procedures and production line tests for all motor control panel boards to the Resident Engineer.

D. Test Reports:

1. Submit six (6) complete copies of the factory inspection and test results in booklet form including all plotted data curves, all test conditions, a listing of test equipment complete with calibration certifications and all measurement taken.

E. Certifications: Two weeks prior to the final inspection, submit four (4) copies of the following to the Resident Engineer.

1. Certification by the manufacturer that the panel boards conform to the requirements of the drawings and specifications.
2. Certification that the equipment has been properly installed, adjusted, and tested.

1.3 APPLICABLE PUBLICATIONS

Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

A. International Elctrotechnical Commission (IEC):

IEC 61439-1.....Partially Type-Tested low-voltage switchgear and control gear Assembly (TTA)

IEC 60529.....Degree of Protection provided by the enclosure

IEC 60947-1.....Low-voltage switchgear and control gear, Part 1: General Rules

IEC 60947-2.....Low-voltage switchgear and control gear, Part 2: Circuit-breakers

IEC 60947-3-1.....Low-voltage switchgear and control gear, Part 3: Switches, disconnectors, disconnection switches and fuse combination units

IEC 60947-4-1.....Low-voltage switchgear and control gear, Part 4-1: Electromechanical contactors and motor-starters

IEC 60269-1 and -2.....Low Voltage Fuses

B. American National Standards Institute (ANSI)

PB-1 2006 ..... Installation Operation and maintenance of Panel boards 600Volts or less

C. American Society of Testing Materials (ASTM)

B187/B187M-2003..... Copper Bus Bar, Rod and Shapes and General Purpose Rod Bar Shapes

B317/B 317M-2004..... Aluminum Alloy Extended Bar, Rod, tube, Pipe and Structural Profiles for Electrical Purposes (Bus Conductor).

D. National Electrical Contracting Association (NECA)

NEIS 407-2002..... Recommended Practice for Installing and Monitoring Panelboards

E. National Electrical Manufacturers Association (NEMA):

250-2003 ..... Enclosure for Electrical equipment (1000 Volts Maximum)

ICS l-2005 ..... Industrial Control and Systems General Requirements

ICS 2-2005 ..... Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts

ICS 4-2005 ..... Industrial Control and Systems: Terminal Blocks

ICS 6-2001 ..... Industrial Control and Systems: Enclosures

F. National Fire Protection Association (NFPA):

70-2005 ..... National Electrical Code (NEC)

70E-2004..... Standard for Electrical Safety in the Workplace

G. Underwriters Laboratories, Inc. (UL):

44-2005 ..... Thermo set – Insulated Wires and Cable

50-2003 ..... Enclosures for Electrical Equipment

67-2006 ..... Panel boards

508-2005 ..... Industrial Control Equipment Safety Standard

PART 2 - PRODUCTS

2.1 MOTOR CONTROL PANELBOARD

A. General

1. Motor control panel boards shall be Type Tested Assembly (TTA) in accordance with IEC and NEMA, Standards and as shown on the drawings.
2. Motor control panel boards shall be complete, metal-enclosed, grounded type, panel board and cabinet assemblies.
3. Interrupting ratings shall be not less than the maximum short circuit currents available where the panel boards are being installed, as shown on the drawings.
4. Coordinate components of the panel boards and their arrangements electrically and mechanically. The components and the control wiring shall conform to IEC, the approved shop drawings as furnished for the various applicable electrical and mechanical sections of the specifications.

B. Enclosures:

1. Panel box shall be Code Gage sheet steel with removable end walls.
2. Enclosures shall be designed for surface mounting/ selfstanding
3. Enclosures and trim shall be thoroughly cleaned, phosphate treated and primed with rust-inhibiting paint. Final finish coat shall be manufacturer's standard gray.
4. Enclosure shall be in accordance with IEC 61439-1.

C. Panel boards Features:
1. Each motor controller individually enclosed in steel with an individual door.
2. Tubs and trims fronts shall meet the strength and rigidity requirements of IEC.
3. Tubs:
   a. Wiring gutters completely around the panel boards with adequate cross sections to accommodate both the present and future wires.
   b. Cover unused openings with snap-in metal covers.
4. Trims with concealed, self-retaining fasteners for attaching them to the tubs.
5. Fronts for surface mounted panels shall be same dimensions as box.
6. Doors mechanically interlocked to prevent their opening unless the disconnect is open. Incorporate "defeater" mechanism for inspection by qualified personnel.
7. External operating handles with lock-open padlocking provisions and ON and OFF position indicators.
8. Bus Bars:
   a. Bus bars shall be copper as per IEC 61439-1.
   B. Bus bar joints shall be plated, constant-high-pressure type.
   c. Bus bars shall be panel-sequenced and rigidly supported by high impact resistant insulated bus supporting assemblies to prevent vibration or short circuit mechanical damage.
   d. Ground bar with terminals as required in each panel board for all of the grounding wires.
9. Spring cage terminal Blocks shall comply with IEC 60947-7-1,2.
10. Completely equipped spaces for future motor controllers.
11. Provide cylindrical tumbler type locks. Provide sliding vault locks with 3-point latching for enclosures more than 1.2 mm (48 inches) high. Key all lock assemblies a like provide two (2) keys with each lock plus four (4) spares.

D. Motor Controllers:
1. Shall conform to the applicable requirements in LOW-VOLTAGE MOTOR STARTERS.
2. Shall be the products of a single manufacturer.
3. Shall be interchangeable for the same ratings in all of the motor control panel boards being installed under this contract.

E. Identification: Identify each motor controller, circuit breaker and switch with a separate nameplate of laminated black phenolic resin with white core and engraved lettering not less than 6 mm (1/4 inch) high. Identify each motor by its number or other designation and indicate the function fulfilled by the motor.

F. Factory Testing: Test the motor control panel boards at the factory to assure that the panel boards do not have any defects.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the panel boards in accordance with IEC 60439-1, as shown on the drawings and as recommended by the manufacturer.

B. Mount the panel boards so the top circuit breaker will not exceed 1950 mm (78 inches) above the finished floor, except where otherwise shown on the drawings or required to avoid conflicts. For panel boards that are too high, mount them so the bottoms of the cabinets will not be less than 150 mm (6 inches) above the finished floor.

C. Locate the cabinets so the present and future conduits can be conveniently connected.

D. Ground and bond panel boards as required.

3.2 IDENTIFICATION

A. Provide one hard copy and an electronic copy of the panel board schedule to the Resident Engineer at project closeout.

B. Install a plastic-laminated copy of the circuit directory on the inner side of the panel board door.

C. Identify panel boards and install warning signs and arc-flash warning labels as required by NFPA 70E.

3.3 FIELD QUALITY CONTROL

A. Inspect complete installation for physical damage, provide alignment, anchorage and grounding.

B. Clean, inspect, test, and energize installed panel boards in accordance with IEC related code.

C. After completing installation, cleaning, and testing, touch up scratches and marks on finish to match original finish.

- - - E N D - - -

PROGRAMMABLE LOGIC CONTROLLER

Technical Specifications:

Each PLC system shall contain the following main components:

Sl. No.	Description	
1	TCX Premium CPU with built-in Ethernet Port	
2	6 slot back plane for CPU modules	
3	Back plane power supply	
4	Ethernet module	
5	RIO Drop Processor	
6	12 slot back plane for IO modules	
7	32 Ch 24 V (Sink) Dig. input module	
8	32 Ch 24 V (Source) Transistorized Dig. Output module	
9	8 Ch Voltage / Current Analog input module	
10	4 Ch RTD/TC/Voltage/Current Analog input module	
11	4 Ch Voltage / Current Analog output module	
12	Memory expansion Card SRAM for PCMCIA Slot	
13	PLC programming package PL-7	
14	CPU Fan	
15	HMI, 1000 IO tags, for 2 development and 4 runtime license	
16	Unitel Way Cable	

- TCX CDP cable should be used for connecting all I/O devices to PLC.
- System shall be based on advanced high end 'TSX Premium Automation Platform'. CPU shall handle up to 14000 Discrete IO, 1400 Analog IO on R I/O Topology, 4 networks, with built-in 176kword integrated RAM memory, typically program execution time per 1K instruction (65% Boolean and 35% Numerical) shall be 0.11mS.
- CPU System and I/O Subsystem shall be from same series.
- All the modules shall be rack mounted.
- All I/O modules shall be HOT Swappable i.e. on power on condition: Modules can be plugged into or out of the rack without any damage to or electrical noise. No output shall be affected while replacing these modules.
- All I/O modules shall have channel level diagnostics.
- Programming language shall be based on: Ladder, Instruction List, Structure Text, SFC or Block diagram.

- Lithium battery shall be provided for RAM backup. (Application program shall remain for a period of 3 years without power supply to the PLC rack.
- Programming package support Windows XP.
- USB Programming cable of 1.5 meter length shall be provided for PLC programming. Programming over Ethernet network shall be possible.
- All trends in History and Real Time shall be available at the Operator Station.
- Soft button with passwords shall be provided at operator station for manual operation of various equipments.
- Engineering station shall be loaded with licensed version of programming software and licensed version of HMI developed software. Engineering station shall be used as operator station also.
- Each I/O shall be protected against the reversal of polarity of the power voltage to I/O.
- Each I/O module shall have a LED per channel to indicate the status of each input/output**.**
- Each input shall be provided with filters to filter out any noise in the input line or noise because of input contract bouncing. The I/O cards pertinent to Electrical Inputs shall of fast scan time conforming to Sequence Of Event (SOE) type. The time stamping has to be done in CPU level and not in MMI Level.
- Dual redundant power supplies shall be provided for each I/O rack. Analog Input cards should be able to accept Powered & Non powered Input.
- Output contacts from the PLC shall be potential free / Dry contacts with contact ratings 220 V AC, 5 Amps.
- It is recommended that all I/O shall be fused. Each output shall be short circuit proof and protected by fuse. Visual indication of fuse blown indication must be provided for each output.
- The communication of I/O system with central processor shall be Redundant with complete error checking.
- For Analog I/O's there shall be Optical Isolation. For Digital I/O Free Wheel Diode is recommended
- Dual redundant processor shall perform the logic simultaneously.
- Watchdog timer shall be a software device. Watchdog timer shall continuously monitor the healthiness of processor. Any hardware or software problem in the processor sub-system, which shall include CPU, memory, power supply, communication interface etc. shall cause the watchdog timer to report processor failure.
- PLC processor shall always monitor the status of PLC input and output modules for their healthy condition and annunciate the same through operator console and configuration and maintenance printer.

- It shall be possible to generate the first out alarm output by the PLC in case where a group of parameters are likely to trip a system.
- It shall be possible to modify, add or delete the application program on line without affecting the outputs.
- It shall be possible to printout the ladder / logic diagram on the PLC printer. In addition printer shall also be able to print the following.
    a) Diagnostic messages, as and when they appear.
    b) Diagnostic report when called for.
    c) Processor alarms connected to PLC as and when they appear and alarm report whenever initiated.
    d) Shut down report as and when initiated.
    e) I/o map showing status of all inputs and Corresponding outputs in a user defined format.
    - The PLC console shall be provided with self-diagnostics feature, which shall display error messages and initiate an audible alarm if the fault is detected.
    - The diagnostic shall include but not limited to the following:
        - Failure of main or I/O processor
        - Memory faults, both PROM and EPROM
        - Microprocessor faults
        - Communication faults
        - I/O interface or address faults
        - Voltage signal discrepancy on input and output
        - Power supply faults
        - Output loop check

SYSTEM SOFTWARE

Tenderer must supply the off-line software package to enable the owner to modify/add/delete any part of program.

System software for I/O map showing status on inputs and the corresponding outputs giving Tag numbers as per logic diagrams in the user defined formats to be provided.

System software for the report generation for reports like hourly on demand, shiftily, daily and weekly report shall be provided whenever specified in job specifications, in the user defined format.

SPECIAL FEATURES

a)	Purpose	:	To provide Process with continuous control to analog input, sequencing, timing, integration, logical operations, digital inputs, pulse inputs, digital outputs, self-tuning, limitation, rationing etc.
b)	Processor Capacity	:	32 bit or better
c)	Power Supply	:	220 V 50 Hz $\pm$ 10% voltage
d)	Redundancy is available through	:	2 system on standby mode to each other 1 backup system taking over any of failed primary system automatically within 1 cycle.
e)	Functions	:	Filtering, liberalization including extraction for orifice type flow meter trending alarm, limits checking switch, integrating from average flow transmitter, inputs, ratio system, special systems, PID action and values settable by key board auto-manual bump less transfer manual to auto bump less transfer output reversal block self tuning. Calibration of Field mounted Smart Transmitter shall be done from PLC terminal.
f)	Processor Intelligence	:	Confirm if controller can act independently with its own processor fully when console fails (Display may not be possible) or controller is dependent on console with intelligence and process at console.

Panel Internals (Wiring)

1 Wiring standard **:** NEC and NEMA

2 Wiring material **:** i) Cross link polyethylene/PVC insulated timed copper, stranded conductor or switch board wire for all high level signal wiring

ii) Wiring to door mounted devices provided with 49 strands (minimum) and adequate loop lengths of hinge wire to be maintained to prevent exc4essive fatigue due to multiple door openings

3 Wire sizes **:** i) Control switch wiring – 1.5 mm^2

ii) Annunciation – 1.5 mm^2

iii) Power supplies – 1.5 mm^2

			iv) Transmitted signals – 1.5 mm²
			v) All others – 2.5 mm²
4	Dressing	:	i) Internal wiring shall be grouped so that all outgoing wiring to each particular remote location is terminated on adjacent terminal blocks
			ii) All low level signal cables shall be separately bundled from control cable and maintained at 300mm minimum spacing from control bundles
			iii) Wiring shall be arranged to ensure free access to all instruments or devices necessary for adequate maintenance services
			iv) No wiring shall be routed across the face or rear of any device, which will restrict the opening of covers or obstruct access to leads, terminals or devices
			v) Tapping or splicing between terminal points is not permissible
			vi) Interior wiring and jumperings shall be arranged so that external corrections can be made from internal side of terminal blocks
			vii) Common connections limited to 2 (two) wires per terminal
			viii) Groups of wires shall be bunched with cable straps(lockable unlock able type) provided at frequent intervals
5	Running of Wire	:	Suitably grouped wires placed in polyethylene wiring tray with clam on type covers
6	Terminal Lug	:	Compression, Insulated Sleeve, ring tongue type.
7	Identification	:	Wire number of each termination shall be by means of split sleeve ferrules
8	Internal Lighting	:	Switch fuse unit for lighting supply separated from instrument power supply isolator are mounted inside the cabinet in each access door
9	Maximum Allowable Supply Voltage	:	230 Volt
10	Power Supply Isolation	:	MCB for individual instruments

Panel Internals Terminal Block

1	Wiring material	:	i) Moulded, Heavy Duty, Barrier type and single depth.
			ii) Having 6 or 12 points and equipped with corrosion resistant washer head binding screw
2	Rating	:	600 Volts 30 Ampere AC
3	Applicability	:	i) For incoming & outgoing wires except where prefabricated cable are used for direct connection to electronic cubical
			ii) Interconnecting wiring between all electrical device terminals shall be terminated in terminal blocks and jumpered across
4	Spare Capacity		20% after final wiring.

Auto Manual Station (Digital)

1. Supply: 220 V ac, 50 Hz
2. Input: 4 to 20 mA
3. Output : 4 to 20 mA

4. Type: Microprocessor based
5. Range: 0 – 100 %
6. Display: 4 digit, 0.5” LED, seven segment
7. Accuracy: (+/-) 0.25 %
8. Mounting: Flush on panel
9. Cut out : 45 mm X 92 mm
10. Bezel : 48 mm X 96 mm

Digital Panel Meter (Digital)

1. Supply: 220 V ac, 50 Hz
2. Input: Universal
3. Range: 0 – 100 %
4. Display: 4 digit, 0.5” LED, seven segment
5. Accuracy: (+/-) 0.25 %
6. Output (Isolated) : 4 to 20 mA
7. Type: Microprocessor based
8. Mounting: Flush on panel
9. Cut out : 45 mm X 92 mm
10. Bezel : 48 mm X 96 mm

U P S

1. Type: Online
2. Input supply: 180 to 250 V AC, 50 Hz
3. Rating : 2 KVA
4. Output: 230 V AC, 50 Hz
5. Output waveform: Sine wave
6. Should come with computer connectivity for display of alarms
7. Battery Backup time : 30 Min. (with supplied Battery)

Annunciator

1. Microprocessor based
2. No. of Annunciating windows : 14
3. Supply Voltage : 230 V AC
4. Should come with sounder
5. Membrane type TEST, Mute, Acknowledge and Reset Switches, should be mounted on Annunciator body.
6. In addition to Sl. No. 5 There should be provision for mounting these switches externally.
7. Input Signal : Potential free contact NO type
8. Input Interogation voltage +12 V DC
9. LED Colour in Window : Amber (Yellow)

ENGINE GENERATORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, complete installation, connection and testing of the engine generator system. This includes: air filtration, starting system, generator controls, instrumentation, lubrication, fuel system, cooling system and exhaust system.

B. The engine generator system shall be fully automatic and shall constitute a unified and coordinated system ready for operation.

C. The engine generator system shall include, but not be limited to the following:

1. Diesel Engine.
2. Lubrication Oil System.
3. Fuel Oil System.
4. Cooling System.
5. Intake and Exhaust Air Systems.
6. Starting System.
7. Generator.
8. Controls, Supervision and Distribution.
9. Outdoor Generator Enclosure.(not included in this contract)
10. Spare Parts.

1.2 QUALITY ASSURANCE

A. The supplier of the diesel-engine generator set shall be responsible for satisfactory total operation of the system and its certification. This supplier shall have had experience with three or more installations of systems of comparable size and complexity in regards to coordinating, engineering, testing and supervising. Each of these installations shall have been in successful operation for three or more years. Prior to review of submittals, the client reserves the right to:

1. Have the manufacturer submit a list of locations of similar installations.
2. Inspect any of these installations and operations of engine-generator set, and question the user concerning the installations without the presence of the supplier.

B. Factory authorized representative shall be capable of providing emergency maintenance and repairs at the project site within 12 hours maximum of notification.

C. Engine generator and auxiliary components shall be supplied from a single manufacturer.

D. Noise level developed by the generator set shall be as herein specified.

E. Factory Test: The client shall have the option of witnessing the following tests at the factory. The client will pay all expenses for his representative's trip to witness these tests. Contractor shall notify the Resident Engineer 15 days prior to date of testing.

1. Load Test: Shall include **six hours** of continuous operation; **four hours** while the set is delivering 100 percent of the specified KW and **two hours** while delivering 110 percent of the specified KW. During this test record the following data at 20-minute intervals:

Time	Engine RPM 1500	Oil Temperature Out
KW	Water Temperature In	Fuel Pressure
Voltage 400V	Water Temperature Out	Oil Pressure
Amperes	Oil Temperature In	Ambient Temperature 30C°

2. Quick Start Test: Record time required for the engine generator set to develop specified voltage, frequency and KW load from a standstill condition.

1.3 SUBMITTALS

A. Submit in accordance with specifications, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. Shop Drawings:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
2. Data shall be submitted in the following form:
   a. Technical data sheets (TDS): These include published performance, rating and derating curves, published ratings, catalog cuts, pictures, manufacturer's specifications, material composition, and gauge thickness.
   b. Description of operation (DO): Manufacturer's literatures and, if suitable, diagrams.

c. Calculations (CALC): Detailed engineering calculations with all equations, graphs, assumptions, and approximations shown, and data sources referenced.
d. Certification (CERT): Written confirmation as to the document's accuracy, and genuineness.
e. Shop Drawings (SD): Scaled drawings showing plan views, side views, elevations and cross sections.
f. Diagrams (DGM): These include control system diagrams, elementary diagrams, control sequence diagrams or table, wiring diagrams, interconnections diagrams (between local control cubicles, remote enunciator panels, remote derangement panels, remote monitoring panels, remote exercising panel and underground fuel storage tanks), wireless connection diagrams, illustrative diagrams, flow diagrams, and other like items.

3. Prior to fabrication, submit for approval the following data for each engine-generator set, transfer device and control and supervisory equipment:
   a. Engine generator set: TDS, SD including subtransient reactance and short-circuit current capacity.
   b. Engine jacket water heaters: TDS
   c. Muffler assembly: TDS, SD
   d. Motor-operated damper assembly: TDS
   e. Day tank and pumps or integral sub-base fuel tank: TDS, CALC
   f. Batteries, racks and charger: TDS, CALC
   g. Torsional Vibration: CERT
   h. Control and Supervisory Equipment: TDS, DGM, DO, SD
   i. Performance:
      1) Voltage regulating equipment: TDS
      2) Frequency regulating equipment: TDS
      3) Voltage and frequency dips and recovery times due to specified motor loading: CALC
      4) Antifreeze derating: TDS
      5) Ambient derating: TDS
   j. Fuel oil system: DGM
   k. Cooling system: DGM
   l. Vibration isolators: TDS, CALC
   m. Sound power level data for the packaged outdoor generator.

n. Vibration isolation system performance data from no-load to full-load. This must include seismic qualification of the engine-generator mounting, base and vibration isolation.

C. Manuals:

1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals of the engine generator set and auxiliaries including technical data sheets, wiring diagrams, and information, such as telephone number, fax number, and web sites, for ordering replacement parts.
2. Two weeks prior to the final inspection, submit four copies of the updated maintenance and operating manual to the Resident Engineer:
   a. Include complete "As installed" diagrams, which indicate all items of equipment and their interconnecting wiring.
   b. Include complete diagrams of the internal wiring for each of the items of equipment, including "As installed" revisions of the diagrams.
   c. The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation and testing.
   d. Complete lists of spare parts and special tools recommended for two years of normal operation of the complete system.

D. Certifications:

1. Prior to fabrication of the engine-generator set, submit the following for approval, to the Resident Engineer:
   a. A certification in writing that a diesel engine of the same model and configuration, with the same bore, stroke, number of cylinders, and equal or higher BMEP and RPM ratings as the proposed diesel engine has been operating satisfactorily, with connected loads of not less than 75 percent of the specified KW/KVA rating, for not less than 2,000 hours without any failure of a crankshaft, camshaft, piston, valve, injector or governor system.
   b. A certification in writing that devices and circuits will be incorporated to protect the voltage regulator and other components of the auxiliary electrical power system during operation of the diesel engine-generator set at speeds other than the rated RPM while performing maintenance. Include thorough descriptions with submittal of any precautions, which will be necessary to protect the voltage regulator and other components of the system during operation of the diesel engine-generator set at speeds other than the rated RPM.

2. Prior to installation of the engine-generator set at the job site, submit four copies of the following to the Resident Engineer:
    a. Certified test data, alternator temperature rise test and strip chart recordings, and photographs showing test setup and equipment.
3. Two weeks prior to the final inspection, submit four copies of the following, to the Resident Engineer:
    a. Certified test report by the manufacturer of the engine-generator set that the auxiliary electrical power system conforms to the requirements of the drawings and specifications.
    b. Certified report of field tests from the contractor that the engine-generator set and major auxiliaries have been properly installed, adjusted and tested.

1.4 STORAGE AND HANDLING

A. Equipment shall withstand the mechanical stresses caused by rough handling during shipment in addition to the electrical and mechanical stresses, which occur during operation of the system. Protect radiator core with wood sheet.
B. Store the equipment in a location approved by the Resident Engineer.

1.5 JOB CONDITIONS

A. Shall conform to the arrangements and details shown on the drawings. The dimensions, enclosures and arrangements of the engine-generator set shall permit the operating personnel to safely and conveniently operate and maintain the system in the space designated for installation.
B. Unless specified otherwise, each component of the engine-generator system shall be capable of operating as specified herein at 800 meters above sea level in a ventilated room which will have average ambient air temperatures ranging from a minimum of 4 degrees C in winter to maximum of 49 degrees C in summer.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
   British Standards (BS):

B. 5000 Part 3 -……. Generators to be driven by Reciprocating Internal Combustion Engines
5514 (ISO3046) - ……..Specification for Reciprocating Internal Combustion Engines Part 1-6
5486 (IEC 439) - ……Factory Built assemblies of Low Voltage Switchgear and Control Gear
BS 4999(IEC34-1) - ……General requirements for Rotating Electrical Machines

C. American National Standards Institute (ANSI):

C37.50-00 ..... Low-Voltage AC Power Circuit Breakers used In Enclosures-Test Procedures

D. American Society of Testing Materials (ASTM):

A53/A53M-04 ..... Standard Specification for Pipe, Steel, Black, and Hot–Dipped, Zinc Coated Welded and Seamless.

B88-03..... Specification for Seamless Copper Water Tube

B88M-03..... Specification for Seamless Copper water Tube (Metric)

E. Institute of Electrical and Electronic Engineers (IEEE):

C37.13-95 ..... Low Voltage AC Power Circuit Breakers Used In Enclosures

C37.90.1-02 ..... Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

F. National Electrical Manufacturers Association (NEMA):

AB 1-02 ..... Molded Case Circuit Breakers and Molded Case Switches and Circuit Breaker Enclosures

ICS 6-01..... Industrial Control and Systems: Enclosures

ICS 4-05..... Terminal Blocks,

MG 1-04 ..... Motor and Generators

MG 2-01 .....Safety Standard and Guide for Selection, Installation and use of Electric Motors and Generators

PB 2-01 ..... Dead-Front Distribution Switchboards

SG 3-95..... Low Voltage Power Circuit Breakers-Power Switching Equipment

SG 5-95..... Power Switchgear Assemblies

250-03..... Enclosures for Electrical Equipment (1000 Volts Maximum)

G. National Electrical Testing Association (NETA):

ATS-95..... Electrical Power Distribution Equipment and Systems

H. National Fire Protection Association (NFPA):

30-03 ..... Flammable and Combustible Liquids Code.

37-02 ..... Installations and Use of Stationary Combustion Engine and Gas Turbines

70-05 ..... National Electrical Code (NEC)

99-05 ..... Health Care Facilities

110-05 ..... Standard for Emergency and Standby Power Systems.

I. Underwriters Laboratories, Inc. (UL):

50-03 ..... Enclosures for Electrical Equipment

142-02 ..... Steel Aboveground Tanks for Flammable and Combustible liquids

2085-95 ..... Insulated Aboveground Tanks for Flammable and Combustible Liquids

2200-04 ..... Stationery Engine Generator Assemblies

1236-02 ..... Battery Charges for Charging Engine-Starter Batteries

467-04 ..... Grounding and Bonding Equipment.

489-04 ..... Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

508-05 ..... Industrial Control Equipment

891-03 ..... Dead-Front Switchboards

PART 2 - PRODUCTS

2.1 DIESEL ENGINE-GENERATOR SET

A. The engine generator system shall be in accordance with NFPA, UL, NEMA and ANSI, and as specified and as shown on the drawings.

B. Provide a factory-assembled, wired, (except for the field connections), complete, fully automatic diesel engine-generator system.

C. Published Rating:

1. Shall be 1450RPM, not less than 150 KVA for water well site and 50 KVA for waste water site, Standby at 400 volts, 3-phase, 4-wire, 50 Hz and 0.80 power factor.

2. Shall be capable of operating continuously for two consecutive hours within any 24-hour period of operation at 110 percent of its specified rating without damage.

D. Assemble, connect and wire the equipment at the factory so that only the external connections need to be made at the construction site.
E. Unit shall be factory painted with manufacturer's primer and standard finishes.
F. Coordinate the components of the system and their arrangements, electrically and mechanically.
G. Connections between components of the system shall conform to the recommendations of the manufacturer of the diesel engine-generator set.
H. Couplings, shafts, and other moving parts shall be enclosed and guarded. Guards shall be metal, ruggedly constructed, rigidly fastened and readily removable for convenient servicing of the equipment without disassembling any pipes and fittings.
I. Generator set and cooling system shall be furnished with extended life antifreeze solution to protect the system from freezing at all times.
J. Generator set shall have the following features:
    1. Factory-mounted on a common, rigid, welded, structural steel base.
    2. The maximum engine-generator set vibration in the horizontal, vertical, and axial directions shall be limited to 0.15mm with an overall velocity limit of 24 mm/sec RMS, for all speeds.
    3. The isolators shall be constrained with restraints capable of withstanding static forces in any direction equal to twice the weight of the supported equipment.
    4. Automatic start, accelerate to the specified RPM and deliver the specified KW/KVA output at 50 Hz within 10 seconds after a single pole contact closes in a remote device.
    5. Recover rapidly from instantaneous changes between no load and the specified KW/KVA rating, and the reverse changes of load, without damage.
    6. Shall be capable of operating satisfactorily as specified for not less than 10,000 hours between major overhauls.
    7. Engine-generator set shall be statically and dynamically balanced at the factory in order to comply with the maximum vibration velocity specified in paragraph 3.1.D.

2.2 DIESEL ENGINE

A. Coupled directly to a generator.
B. Minimum 4-cylinders.
C. Operating speed shall be 1500 RPM.

D. Brake Main Effective Pressure (BMEP) for the diesel engine, while the engine-generator set is delivering 100 percent of its specified output, shall not exceed the following maximum limits:

E. The minimum cubic inch displacement of the engine shall not be less than the value calculated from the following equation:

$$\text{Displacement} = \frac{\text{BHP} \times K}{\text{BMEP} \times \text{RPM}}$$

$$\text{Where BHP} = \frac{\text{Specified KW}}{0.746 \times G} + R$$

K = 396,000 for 2-cycle engines

K = 792,000 for 4-cycle engines

BMEP = Values specified above

RPM = 1800

G = generator efficiency expressed as a decimal

R = horsepower of radiator fan

R = O, when electric motor driven radiator fan is herein specified

F. The engine shall be able to start in a 4.5 degrees C ambient temperature while using No. 2 diesel fuel oil without the use of starting aids such as glow plugs and ether injections.

G. Fuel oil consumption of the engine rate shall not exceed 0.44 pounds of fuel oil per BHP per hour when it delivers 100 percent of its specified KW/KVA rating.

H. Equipped with electric heaters for maintaining the engine's coolant temperature in the range of 32-38 degrees as recommended by the manufacturer.

1. Install thermostatic controls, contactors, and circuit breaker protected circuits for the heaters.
2. The heaters shall operate continuously except while the engine is operating or the water temperature is at the predetermined level.

2.3 GOVERNOR

A. Isochronous; electronic type.

B. Steady-state speed band at 50 Hz shall not exceed plus or minus 1/3 of one percent.

C. At 50 Hz, when load changes equal to 25 percent of the specified KW/KVA rating, frequency change shall not exceed two percent and it shall recover to 50 Hz within three seconds.

D. At 50 Hz, when load changes equal to 100 percent of the specified KW/KVA rating, frequency change shall not exceed eight percent and it shall recover to 50 Hz within five seconds.
E. While the engine is running, manual speed adjustments may be made.

2.4 LUBRICATION OIL SYSTEM

A. Pressurized type.
B. Positive-displacement pump driven by engine crankshaft.
C. Full-flow strainer and full-flow or by-pass filters.
D. Filters shall be cleanable or replaceable type and shall remove particles as small as 3 microns without removing the additives in the oil. For by-pass filters, flow shall be diverted without flow interruption.
E. Extend lube oil sump drain line passing out through the skid base and terminate it with a drain valve and plug.
F. Provide a 230-volt oil heater for exterior generator set.

2.5 FUEL OIL SYSTEM

A. Shall comply with NFPA 37 and NFPA 30, and have the following features:
    1. Injection pump(s) and nozzles.
    2. Plungers shall be carefully lapped for precision fit and shall not require any packing.
    3. Filters or screens, which require cleaning or replacement, will not be permitted in the injection system assemblies.
    4. Return surplus oil from the injectors to the main storage tank by gravity or a pump.
    5. Filter System:
        a. Dual primary filters shall be located between the main fuel oil storage and day tank.
        b. Secondary filters (engine mounted) shall be located so the oil will be thoroughly filtered before it reaches the injection system assemblies.
        c. Filters shall be cleanable or replaceable type and shall entrap and remove water from oil as recommended by the engine manufacturer.
B. Day Tank:
    1. Capacity of the day tank shall be not less than:
        a. 75 gallons for generator sets specified from 201 KW to 300 KW.
    2. Shall be welded steel, UL approved.

3. Secure, pipe and connect the tank adequately for maximum protection from fire hazards, including oil leaks.
4. Incorporate a vent, drain cock, shutoff cocks and gauge glass. Terminate the vent piping outdoors with mushroom vent cap.
5. Incorporate a float switch on the day tank to control the fuel oil transfer pump and to actuate an alarm in the engine generator control cubicle when the oil level in the tank drops below the level at which the transfer pump should start to refill the tank.
    a. The float switch contacts, which control the fuel oil transfer pump, shall be set to energize the pump when the liquid level in the tank reaches 1/3 of the total volume of the tank.
    b. The float switch contacts, which actuate the low fuel oil day tank alarm device, shall be set to alarm and energize the second fuel transfer pump when the liquid level in the tank reaches 1/4 of the total volume of the tank.
6. Day tank and engine supply line elevations shall be below the elevation of the injector return outlet on the engine.

C. Fuel Oil Transfer Pump-Main Storage Tank to Day Tank(s).
1. Electric motor- driven, duplex arrangement, close- coupled, single- stage, positive-displacement type with built- in pressure relief valves. When the fuel is used for cooling components of the fuel injection system, the engine's fuel return line shall be returned to the main storage tank, rather than the day tank.
2. Include a heavy-duty automatic alternator and H-0-A switch to alternate sequence of pumps and allow maintenance. Pumps shall be controlled with the float switch on the day tank and H-O-A selector switch so the day tank will be refilled automatically when the oil level lowers to the low limit for the float switch. The H-0-A selector switches shall enable the pumps to be operated manually at any time.
3. For all engines, each transfer pump and its electrical and plumbing connections shall be sized to provide a flow rate of at least four times the engines' fuel pumping rate.
4. Provide a manually operated, rotary-type, transfer pump connected in parallel with the electric motor-driven transfer pumps so that oil can be pumped to the day tank while the electric motor-driven pumps are inoperative.

D. Piping System: Black steel, standard weight, ASTM A-53 pipe and necessary valves and pressure gages between:
1. The engine and the day tank as shown on the drawings.

2. The day tank and the supply and return connections at the underground storage tank as shown on the drawings. Connections at the engine shall be made with flexible piping suitable for the fuel furnished.
3. See fuel oil piping diagram on the drawings.

2.6 ENGINE COOLING SYSTEM

A. Liquid-cooled, closed loop, with radiator mounted on the engine generator set as shown on the drawings.

B. Cooling capacity shall not be less than the cooling requirements of the engine-generator set and its lubricating oil while operating continuously at 110 percent of its specified rating.

C. Water circulating pumps shall be the centrifugal type driven by engine. Incorporate pressure relief devices, where required, to prevent excessive pressure increase after the engine stops.

D. Coolant shall be extended life antifreeze solution, 50 percent ethylene and 50 percent soft water, with corrosion inhibitor additive as recommended by the manufacturer

E. Radiator core tubes material shall be as recommended by the engine manufacturer.

F. Fan shall be driven by multiple belts from engine shaft.

G. Coolant hoses shall be flexible per manufacturer's recommendation.

H. Self-contained thermostatic-control valve shall modulate coolant flow to maintain optimum constant coolant temperature as recommended by the engine manufacturer.

I. Motor-Operated Dampers:
   1. Dampers, shall be two-position, electric motor-operated.
   2. Dampers shall open simultaneously with the starting of the diesel engine and shall close simultaneously with the stopping of the engine.

2.7 AIR INTAKE AND EXHAUST SYSTEMS

A. Air Intake:

   Provide an engine-mounted air cleaner with replaceable dry filter and dirty filter indicator.

B. Exhaust System:
   1. Exhaust Muffler:
      a. Shall be Critical grade type and capable of the following noise attenuation:

Octave Band Hertz (Mid Frequency)	Minimum db Attenuation (.0002 Microbar Reference)
31	5
63	10
125	27
500	37
1000	31
2000	26
4000	25
8000	26

2. Pressure drop in the complete exhaust system shall be small enough for satisfactory operation of the engine-generator set while it is delivering 110 percent of its specified rating.
3. Exhaust pipe size, from the engine to the muffler, shall be as recommended by the engine manufacturer. Pipe size from muffler to air discharge shall be two-pipe sizes larger than engine exhaust pipe.
4. Connections at the engine exhaust outlet shall be made with a flexible exhaust pipe. Provide bolted type pipe flanges welded to each end of the flexible section.

C. Condensate drain at muffler shall be made with schedule 40 black steel pipe through a petcock.

D. Exhaust Piping and Supports: Black steel pipe, ASTM A-53 standard weight with welded fittings. Spring type hangers, as specified in NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, shall support the pipe.

E. Insulation for Exhaust Pipe and Muffler:
1. Calcium silicate minimum 75 mm (3 inches) thick.
2. The installed insulation shall be covered with aluminum jacket 0.4 mm (0.016 inch) thick. The jacket is to be held in place by bands of (0.38 mm) (0.015 inch) thick by 15 mm (0.5 inch) wide aluminum.
3. Insulation and jacket are not required on flexible exhaust sections.

F. Roof, Wall Sleeves: Pipe sleeves (thimble) shall be schedule 40 standard weight steel pipe. Flash exhaust pipe thimble through roof with 16 ounce soft sheet copper, flanged and made watertight under built-up roofing and extended up around pipe thimble. The

exhaust pipe shall be positioned within the thimble by four 150 mm (6 inch) wide spiders welded to the exhaust pipe.

2.8 ENGINE STARTING SYSTEM

A. Shall start the engine at any position of the flywheel.

B. Electric cranking motor:
   1. Shall be engine- mounted.
   2. Shall crank the engine via a gear drive.
   3. Rating shall be adequate for cranking the cold engine at the voltage provided by the battery system, and at the required RPM during five consecutive starting attempts of 10 seconds cranking each at 10 second intervals, for a total of 50 seconds of actual cranking without damage.

C. Batteries: 24 volt electric with the following features:
   1. Batteries shall be nickel-cadmium high discharge rate type.
   2. Each battery cell shall have minimum and maximum electrolyte level indicators, and flip top flame arrestor vent cap.
   3. Batteries shall have connector covers for protection against external short circuits.
   4. With the charger disconnected, the batteries shall have sufficient capacity so that the total system voltage does not fall below 85 percent of the nominal system voltage with the following demands:
      a. Five consecutive starting attempts of 10 seconds cranking at 10 second intervals for a total of 50 seconds of actual cranking (the fifth starting attempt will be manually initiated upon failure of a complete engine cranking cycle).
   5. Battery racks shall be metal with an alkali resistant finish and thermal insulation, and secured to the floor.
   6. Battery shall operate continuously for 12 hours and be able to provide the cranking power described in 2.8.B.3 without charging.

D. Battery Charger:
   1. The charger shall maintain one percent voltage regulation from no load to full load for line voltage variation of 10 percent and frequency variation of $\pm$ 3 Hz from 50 Hz.
   2. The charger shall maintain a nominal float voltage of 1.4 VDC and a nominal equalizing voltage of 1.6 VDC.
   3. The charger shall be capable of continuous operation in an ambient temperature of –20 to 60 degrees C without derating. The charger shall be convection cooled and

housed in a NEMA 250, Type 1 enclosure. The charger shall have a hinged front door and all components shall be accessible from the front.

4. Provide both AC and DC transient protection. Charger shall be able to recharge a fully discharged battery without tripping AC protective devices. AC circuit breaker shall not trip under any DC load condition including short circuit on output terminals.
5. The charger shall be capable of recharging the fully discharged battery in 12 hours and simultaneously power the Supervisory and Control panel.
6. The charger shall have fused AC input and DC output protection, and shall not discharge the batteries when AC power fails.
7. The charger shall have the following accessories:
    a. On-Off control switch with pilot light.
    b. Hand adjustable 0 to 24 hour equalize charge timer.
    c. AC power failure alarm light.
    d. High DC voltage alarm light.
    e. DC voltmeter – 5 percent accuracy.
    f. DC Ammeter – 5 percent accuracy.

2.9 GENERATOR

A. Synchronous, amortisseur windings, bracket-bearing, self-venting, rotating-field type connected directly to the engine.
B. Lifting lugs designed for convenient connection to and removal from the engine at the construction site.
C. Integral poles and spider, or individual poles dove-tailed to the spider.
D. Insulation shall be as required for the ambient temperature and other requirements designated in the paragraph, DIESEL ENGINE-GENERATOR SET, in this section.
E. Designed for sustained short circuit currents in conformance with NEMA Standards.
F. Designed for sustained operation at 125 percent of the RPM specified for the generator set without damage.
G. Telephone influence factor shall conform to NEMA Standards.
H. Furnished with brushless excitation system or static-exciter-regulator assembly.
I. Nameplates attached to the generator and exciter shall show the manufacturer's name, equipment identification, serial number, voltage ratings, field current ratings, KW/KVA output ratings, power factor rating, time rating, temperature rise ratings, RPM ratings, full load current rating, number of phases and frequency, and date of manufacture.

J. At full load, the efficiency shall be not less than: 92 percent.

K. The neutral shall be electrically isolated from equipment ground and terminated in same junction box as the phase conductors.

2.10 EQUIPMENT FOR CONTROLS, SUPERVISION AND DISTRIBUTION

A. Shall include Engine Generator Control Cubicle, Master Control Cubicle.

1. Control Equipment shall be in accordance with UL 508, NEMA ICS-4, ICS-6 and ANSI C37.90.1.
2. Panels shall be in accordance with UL 50.
3. Cubicles shall be in accordance with UL 891.
4. Incorporate all of the items required to fulfill the requirements in the specifications and on the drawings.
5. Components:
   a. Shall be heavy duty, industrial type.
   b. Electrical contacts shall be precious metal surfaced.
   c. Only heavy duty solid-state components will be accepted.
6. Coordinate controls with the automatic transfer devices shown on the drawings, so that the systems will operate as specified.
7. Cubicles and Panels:
   a. Code gauge steel; manufacturer's recommended heavy gauge steel with factory primer and light gray finish.
   b. Doors shall be gasketed and be attached with concealed or semi-concealed hinges, and shall have a permanent means of latching in closed position.
   c. Panels shall be wall mounted or incorporated in other equipment as indicated on the drawings or as specified.
   d. Cubicle design shall be of frame construction free standing sheet metal cabinet, floor supported with front and rear access openings for air circulation.
   e. Door locks for panels and cubicles shall have identical keying to operate from a single key.
   f. Panel installation shall be suitable for convenient maintenance and operation. Overall heights of the cubicles shall not exceed 2.2 meters.
8. Wiring: Insulated, rated at 600 volts, UL approved.
   a. Install the wiring in vertical and horizontal runs, neatly harnessed.
   b. Terminate all external wiring at heavy duty, pressure type, terminal blocks.

9. Clearly and permanently label the equipment, wiring terminals and wires.
10. Laminate or mount under plexiglas appropriate wiring diagrams and mount them within the frame on the inside of the cubicles and panels.

11. The system shall be designed and manufactured employing the most modern technology to insure maximum reliability and longevity. It shall be arranged for automatic and manual starting, and stopping.
12. The cubicles shall be arranged into a switchboard lineup:
    a. Bus shall be copper with maximum current density of 1000 amps per square inch. All joints shall be plated.
    b. Bus shall be adequately braced to withstand the maximum short circuit current available. Minimum bracing level shall be not less than 100,000 amps RMS symmetrical.
13. All indicating lamps and switches shall be accessible and mounted on the cubicle doors.
14. Electronic governor control panel, voltage regulator, control panel, motorized voltage adjusting potentiometer, and associated components shall be shipped to the generator control switchboard manufacturer for assembly, mounting and/or interwiring in the switchboard. Detailed drawings outlining proper interconnection and physical mounting data shall also be furnished to the generator switchboard manufacturer to facilitate proper design and interfacing. The engine generator set supplier shall furnish these items as soon as possible.
15. All meters shall be solid-state switchboard type, 112 mm (4-1/2 inches), 1 percent accuracy transformer rated for 600 volt service. Ammeters and voltmeters shall be furnished with phase selector switches. Metering shall include necessary current and potential transformers and instrument fuses.
16. The repetitive accuracy of the monitors shall be as stated over an environmental temperature range of 0 to 45 degrees C and voltage range of 70 to 110 percent of nominal. The accuracy shall not exceed the following limits:

Voltage Monitors	+ 2 percent of set point
Current Monitors	+ 3 percent of set point
Frequency Monitors	+ 0.2 Hz.
Power Monitors	+ 3 percent of set point

17. The manufacturer shall coordinate the interfacing of the control systems with all related equipment supplied in accordance with other sections of the project specification.

B. Engine Generator Control Cubicle

1. Starting and Stopping Controls:
    a. A three-position, maintained- contact type selector switch with positions marked "AUTOMATIC", "OFF" and "MANUAL". Provide flashing amber light for "OFF" and "MANUAL" positions.
    b. A momentary contact pushbutton switch with positions marked "MANUAL START" and "MANUAL STOP".
    c. Selector switch in "AUTOMATIC" position shall cause the engine to start automatically when a single pole contact in a remote device closes. When the generator's output voltage increases to not less than 90 percent of its rated voltage, and its frequency increases to not less than 48 Hz, the remote devices shall transfer the load to the generator. An adjustable time delay relay, 0 to 15 minute range, shall cause the engine generator set to continue operating without any load after completion of the period of operation with load. Upon completion of the additional 0 to 15 minute (adjustable) period, the engine generator set shall stop.
    d. Selector switch in "OFF" position shall prevent the engine from starting either automatically or manually. Selector switch in "MANUAL" position shall cause the engine to start when the manual start pushbutton is also depressed momentarily.
    e. With selector switch in "MANUAL" position, depressing the "MANUAL STOP" pushbutton momentarily shall stop the engine after a cool down period.
    f. A maintained contact, red mushroom head pushbutton switch marked "EMERGENCY STOP" will cause the engine to stop without a cool down period independent of the position of the selector switch.
2. Engine Cranking Controls:
    a. The cranking cycles shall be controlled by timer that will be independent of the battery voltage fluctuations.
    b. Shall crank the engine through one complete cranking cycle, consisting of four starting attempts of 10 seconds each and 10 seconds between each attempt.

c. Total actual cranking time for the complete cranking cycle shall be 40 seconds during a 70 second interval.
d. Cranking shall terminate when the engine starts so the starting system will not be damaged. Termination of the cranking shall be controlled by self-contained, speed-sensitive switch. The switch shall prevent re-cranking of the engine until after the engine stops.
e. After the engine has stopped the cranking control shall reset.

3. Supervisory Controls:
   a. Overcrank:
      1) When the cranking control system completes one cranking cycle, four starting attempts, without starting the engine, the "OVERCRANK" signal light and the audible alarm shall be energized.
      2) The cranking control system shall lock-out, and shall require a manual reset.
   b. Coolant Temperature:
      1) When the temperature rises to the predetermined first stage level, the "HIGH COOLANT TEMPERATURE - FIRST STAGE" signal light and the audible alarm shall be energized.
      2) When the temperature rises to the predetermined second stage level, which shall be low enough to prevent any damage to the engine and high enough to avoid unnecessary engine shutdowns, the "HIGH COOLANT TEMPERATURE - SECOND STAGE" signal light and the audible alarm shall be energized and the engine shall stop.
      3) Difference between the first and second stage temperature settings shall be approximately -12 degrees C.
      4) Permanently indicate the temperature settings near the associated signal light.
      5) When the coolant temperature drops to below 21 degrees C, the "LOW COOLANT TEMPERATURE" signal light and the audible alarm shall be energized.
   c. Low Coolant Level: When the coolant level falls below the minimum level recommended by the manufacturer, the "LOW COOLANT LEVEL" signal light and audible alarm shall be energized.

d. Lubricating Oil Pressure:
    1) When the pressure falls to the predetermined first stage level, the "OIL PRESSURE - FIRST STAGE" signal light and the audible alarm shall be energized.
    2) When the pressure falls to the predetermined second stage level, which shall be high enough to prevent damage to the engine and low enough to avoid unnecessary engine shutdowns, the "OIL PRESSURE - SECOND STAGE" signal light and the audible alarm shall be energized and the engine shall stop.
    3) Difference between the first and second stage pressure settings shall be approximately 15 percent of the oil pressure.
    4) Permanently indicate the pressure settings near the associated signal light.
e. Over speed:
    1) When the engine RPM exceeds the maximum RPM recommended by the manufacturer of the engine, the engine shall stop.
    2) Simultaneously, the "OVERSPEED" signal light and the audible alarm shall be energized.
f. Low Fuel - Day Tank:
    1) When the fuel oil level in the day tank decreases to less than the level at which the fuel oil transfer pump should start to refill the tank, the "LOW FUEL DAY TANK" light and the audible alarm shall be energized.
g. Low Fuel - Main Storage Tank:
    1) When the fuel oil level in the storage tank decreases to less than 1/3 of total tank capacity, the "LOW FUEL-MAIN STORAGE TANK" signal light and audible alarm shall be energized.
h. Reset Alarms and Signals: Overcrank, Coolant Temperature, Coolant Level, Oil Pressure, Overspeed, and Low Fuel signal lights and the associated audible alarms shall require manual reset. A momentary- contact silencing switch and pushbutton shall silence the audible alarm by using relays of solid state devices to seal-in the audible alarm in the de-energized condition Elimination of the alarm condition shall automatically release the sealed-in circuit for the audible so that it will be automatically energized again when the next alarm condition occurs. The signal lights shall require manual reset after elimination of the condition, which caused them to be energized. Install the audible alarm just outside the generator

room in a location as directed by the Resident Engineer. The audible alarm shall be rated for 85 dB at 3 meter.

i. Generator Breaker Signal Light:
   1) Molded case circuit breaker and contactor: A flashing green light shall be energized when the generator circuit breaker is in either the "OPEN" or "TRIPPED" position.
   2) Power circuit breaker: A flashing green light shall be energized when the generator circuit breaker is in the "OPEN" or "TRIPPED" position.
   3) Simultaneously, the audible alarm shall be energized.

4. Monitoring Devices:
   a. Electric type gauges for the cooling water temperatures and lubricating oil pressures. These gauges may be engine mounted with proper vibration isolation.
   b. A running time indicator, totalizing not less than a 9,999 hour, heavy duty and an electric type tachometer.
   c. Voltmeter, ammeter, and their selector switches, frequency meter, kilowatt meter, manual adjusting knob for the output voltage and the other items shown on the drawings shall be mounted on the front of the generator control panels.
   d. Install potential and current transformers as required.
   e. Individual signal lights:
      1) OVER-CRANK
      2) HIGH COOLANT TEMPERATURE - FIRST STAGE
      3) HIGH COOLANT TEMPERATURE - SECOND STAGE
      4) LOW COOLANT TEMPERATURE
      5) OIL PRESSURE - FIRST STAGE
      6) OIL PRESSURE - SECOND STAGE
      7) LOW COOLANT LEVEL
      8) GENERATOR BREAKER
      9) OVERSPEED
      10) LOW FUEL - DAY TANK
      11) LOW FUEL – MAIN STORAGE TANK
   f. Lamp Test: "Lamp Test" momentary contact switch shall momentarily actuate the alarm buzzer and all the indicating lamps.

5. Power switching and over current protection shall be accomplished with molded case circuit breakers.

    a. Molded Case Circuit Breakers shall have the following features:
        1) Solid state adjustable trip type circuit breakers.
        2) Shall be in accordance with IEC 60947-4 and NEMA AB-1.
        3) Trip units shall have field adjustable tripping characteristics as follows:
            a) Ampere setting (continuous).
            b) Long time band.
            c) Short time trip point.
            d) Short time delay.
            e) Instantaneous trip point.
            f) Ground fault system for circuit breakers rated 400 volt, equal to or greater than 1000 amperes. The system shall alarm but not trip the circuit breaker.
        4) Trip setting shall be as indicated on the drawings.
        5) Shall be 100 percent rated.
        6) Electrically and mechanically trip free.
        7) Manual operating handle with lock-open padlocking provisions, and position indicators on the front of the breaker.
        8) Rear stud connection for both line and load sides.
        9) Shall include type "a" and "b" auxiliary contacts for interfacing with controls.
6. Automatic Voltage Regulator:
    a. Shall maintain the generator's output voltage within plus or minus one percent for load variations between no load and full load.
    b. Shall correct voltage fluctuations rapidly and restore the output voltage to the predetermined level with a minimum amount of hunting.
    c. Shall include voltage level rheostat located inside the control cubicle.
7. Governor: Specified herein before in Article 2.3 "GOVERNOR".
8. The voltage regulator and other components of the auxiliary electrical power system shall be protected during operation of the diesel engine-generator set at speeds other than the rated RPM while performing maintenance by a power monitoring system which monitors single phase and three phase faults. A time-delay relay shall shut down the engine when the alternator thermal capacity is exceeded.

2.11 MASTER CONTROL CUBICLE

A. Shall contain all system-totalizing controls for the integrated system operation as specified below:
   1. Bus Metering:
      a. AC ammeter.
      b. AC voltmeter.
      c. Frequency meter 45-55 Hz Scale.
      d. Watt/Var meter.
      e. Ammeter/Voltmeter phase selector switches with current and potential transformers and proper fuses.
   2. A load demand monitor shall sense the load connected to the bus, and establish the proper number of generator sets to operate and maintain the connected load with a minimum on-line reserve generating capacity of 10 percent of the rating of a single generator set. The load monitor shall also disconnect a generator from the bus whenever the on-line reserve capacity exceeds 110 percent of a single generator set. The load demand monitor shall be adjustable to initiate the addition and removal of a generator set from the main bus. The monitor shall be unit chassis construction utilizing state-of-the-art solid-state circuitry and shall include built-in time delays. The load monitor shall sense the bus kilowatts (kW), real load without the use of thermal transducers, meter relays, and like items. The load monitor shall be designed to maximize fuel economy while maintaining sufficient capacity to sustain the load.
   3. The emergency bus shall have a frequency monitor with integral time delay to initiate load dumping upon a reduction of the bus frequency to 48 Hz or less for a period of two seconds or more. Upon sensing a bus under frequency, the system shall automatically shed the lowest priority load connected at the time of the occurrence. This shed circuit shall override any manual load add activity and lock out the manual load add circuitry. Visual and audible alarms shall be energized upon sensing of bus under frequency load dump.
   4. Control power for the system logic shall be derived from the engine starting batteries. The control logic shall be powered through a suitable means, which shall permit continuity of power until the last battery is no longer available. The controls shall be powered from any battery or combination of batteries as is necessary with positive isolation of batteries to prevent feedback to a failing battery. The transition of control

logic power from any battery combination to any other battery combination shall be without discontinuities in the power flow.

5. Individual visual signals plus common audible alarm and silencing circuitry shall be provided to monitor the following conditions:
    a. Low Fuel Level Main Underground Storage Tank shall be energized when the fuel oil level decreases to less than 1/3 of total capacity.
    b. Under frequency failure.
    c. Controls not in automatic mode.
    d. Load shed circuit activation.
6. A "Lamp Test" momentary contact switch shall momentarily actuate the alarm buzzer and all the indicating lamps.
7. Manual/Automatic Mode Control Switch.

2.13 REMOTE ANNUNCIATOR PANEL

A. Remote annunciator panel shall be installed at the Engineering Control Center.

B. The annunciator shall indicate alarm conditions of the emergency or auxiliary power source as follows:
    1. Individual visual signals shall indicate:
        a. When generator is operating to supply power to load?
        b. When battery charger is malfunctioning?
        c. When main storage tank is low.
    2. Individual visual signals plus a common audible alarm shall warn of the following:
        a. "LOW LUBRICATING OIL PRESSURE - FIRST STAGE."
        b. "LOW COOLANT."
        c. "EXCESSIVE COOLANT TEMPERATURE - FIRST STAGE."
        d. LOW FUEL - DAY TANK."
        e. "OVERCRANK" (failure to start).
        f. "OVERSPEED."

C. The annunciator shall also have the following features:
    1. One pushbutton momentary contact switch. Label switch "LAMP - TEST". Initiating this switch shall momentarily actuate the alarm buzzer and all the indicating lamps.
    2. Audible Alarm: There shall be an audible alarm, rated for 85 dB at 10 feet, which shall become actuated whenever an alarm condition occurs. A momentary-contact acknowledge pushbutton shall silence the audible alarm, but not clear the alarm

lamp. Elimination of the alarm condition shall automatically release the seal-in circuit for the audible alarm and extinguish the alarm lamp.

2.18 SPARE PARTS

A. For each engine-generator set:
   1. Six lubricating oil filters.
   2. Six primary fuel oil filters.
   3. Six secondary fuel oil filters.
   4. Six intake air filters.

B. For each battery charger:
   1. Three complete sets of fuses.
   2. One complete set of indicating lamps.

C. For each control and supervisory panel:
   1. Three complete sets of fuses.
   2. One complete set of indicating lamps.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install concrete bases of dimensions shown on the drawings for packaged engine-generator sets.

B. Installation of the engine generator set shall comply with manufacturer's written instructions and with NFPA 110.

C. Mounting
   1. Support the base of engine- generator set on vibration isolators, each isolator bolted to the floor (pad), generator base bolted to isolator.
   2. Install sufficient number of isolators so that the floor (pad) bearing pressure under each isolator is within the floor (pad) loading specification.
   3. Install equal number of isolators on each side of the engine- generator set's base.
   4. Locate isolators for approximately equal load distribution and deflection per isolator. Base of the engine- generator set shall be drilled at the factory for the isolator bolts.
   5. Isolators shall be shipped loose with the engine- generator set.
   6. All connections between the engine- generator set and exterior systems, such as fuel lines, electrical connections, and engine exhaust system and air exhaust shroud, shall be flexible.

D. Balance:
    1. The vibration velocity in the horizontal, vertical, and axial directions shall not exceed 16.25 mm per second peak at any specific frequency. These limits apply to main structural components such as the engine block and the generator frame at the bearings.
    2. Balance the engine-generator set statically and dynamically at the factory in order to comply with the maximum specified vibration velocity.

E. Connect all components of the essential electrical power system so that they will continue to be energized by the auxiliary electrical power system during failures of the normal electrical power supply system.

F. Install piping between diesel engine and remote components of cooling, fuel and exhaust systems.

G. Flexible connection between radiator and exhaust shroud at the wall

damper:

    1. Install noncombustible flexible connections made of 20-ounce neoprene-coated fiberglass fabric approximately 150 mm wide.
    2. Crimp and fasten the fabric to the sheet metal with screws 50 mm (two inch) on center. The fabric shall not be stressed, except by the air pressure.

H. Exhaust System Insulation:
    1. Adhesive and insulation materials shall be applied on clean, dry surfaces from which loose scale, and construction debris has been removed by wire brushing.
    2. Fill all cracks, voids and joints of applied insulation material with high temperature 1093 degrees C insulating cement before applying the outer covering.
    3. The installation shall be neat, thermally and structurally tight without sag, neatly finished at all hangers or other penetrations and shall provide a smooth finish surface.
    4. Insulation and jacket shall terminate hard and tight at all anchor points.
    5. Insulate completely from engine exhaust flexible connection through roof or wall construction, including muffler.

3.2 START UP AND TESTING

A. Provide the services of a factory-authorized, factory-trained representative of the diesel engine-generator set manufacturer to inspect field-assembled components, and equipment installation and supervise the field tests

B. When the complete auxiliary electrical power system has been installed and prior to the final inspection, tests all components of the system in the presence of the Resident Engineer for proper operation of the individual components and the complete system and to eliminate electrical and mechanical defects.

C. Furnish fuel oil, lubricating oil, anti-freeze liquid, water treatment and rust inhibitor and load bank for testing of the diesel engine-generator set.

D. Field Tests for the Diesel Engine-Generator Set:

1. Test the engine generator set for eight hours of continuous operation as follows:
    a. First six hours while the set is delivering 100 percent of its specified KW rating.
    b. Last two hours while the set is delivering 110 percent of its specified KW rating.
    c. If during the 8-hour continuous test a failure occurs, either the diesel engine shuts down or the full KW rating of the load bank is not achieved, the test is null and void. The test(s) shall be repeated until the satisfactory results are attained at no additional cost to the government.
2. Record the following test data at 30-minute intervals:
    a. Time of day, also reading of running time indicator.
    b. KW.
    c. Voltage on each phase.
    d. Amperes on each phase.
    e. Engine RPM.
    f. Frequency.
    g. Engine water temperature.
    h. Fuel pressure
    i. Oil pressure.
    j. Outdoor temperature
    k. Average ambient temperature in the vicinity of the diesel engine.
    l. Average ambient temperature in the vicinity of the starting batteries.
3. Demonstrate that the generator set will attain proper voltage, frequency and will accept 100 percent block load within 10 seconds from a cold start after the closing of a single contact.
4. Furnish a resistance type load for the testing of the generator:
    a. When approved in writing by the Resident Engineer prior to the testing, the Contractor may use connected loads in the building (resistant plus other types) as part of the test load provided the Contractor assumes complete responsibility

for the use of the connected loads, including personnel injuries and property damage.

b. Test loads shall always include adequate resistance to assure stability of the loads and equipment during all of the testing operations. The test load KW rating:
   1) Shall not be less than 110 percent of the specified KW rating of the largest generator set.

E. Battery and Starting System Test:
   1. Demonstrate that the batteries and cranking motor are capable of 5 starting attempts of 10 second cranking each at 10 second intervals with the battery charger turned off.

F. At the completion of the field tests, fill the underground storage tank with fuel of grade and quality as recommended by the manufacturer of the engine.

G. When any defects are detected during the tests, correct all the deficiencies and repeat all or part of the 8-hour continuous test as requested by the Resident Engineer, at no additional cost to the Government.

H. Provide test and inspection results in writing to the Resident Engineer.

3.3 INSTRUCTIONS AND FINAL INSPECTIONS

A. Laminate or mount under Plexiglas a set of operating instructions for the system and install instructions within a frame mounted on the wall near the diesel engine-generator set as requested by the Resident Engineer.

B. At the final inspection in the presence of client representative, demonstrate that the complete auxiliary electrical power system operates properly in every respect.

C. Furnish the services of a competent, factory-trained engineer or technician for five, 4-hour periods for instructions to client personnel in operation and maintenance of the equipment, on the dates requested by the Resident Engineer.

- - - E N D - - -