Contents

10. Technology, Procedures and Processes

10.1 Introduction

This section presents the technologies, procedures and processes that will be used in the implementation of the project. The power plant is based on ten Wärtsilä model 20V32 reciprocating generating sets with a total capacity of 80MW. Wärtsilä will provide a finished plant designed for safe, reliable, efficient, long-term operation.

The primary fuel for the plant will be heavy fuel oil (HFO), also known as CIMAC E25. Secondary fuel, for maintenance and auxiliary services, will be distillate fuel oil, commonly called diesel (DFO).

Power generated by the plant will be evacuated to the KP&LC.

10.2 Equipment Scope of Supply

Wärtsilä will furnish a complete power plant including engineering, procurement, construction, start-up and testing. Once commissioned, the power plant will be operated by Operations and Maintenance Company. The major items which comprise the power plant are listed below.

Engine-Generator Sets

- Ten Wärtsilä Model 20V32 turbocharged Diesel engines
- Matching electric generators
- Radiators for engine cooling
- Intake air filters
- Exhaust silencers and stacks
- Control system

Heavy Fuel Oil (HFO) Handling Systems

- HFO Truck Unloading Station including pumps and filters
- HFO Bulk Storage Tanks
- HFO heating, purification and delivery system

Distillate Fuel Oil (DFO) Handling Systems

- DFO Truck Unloading Station including pumps and filters
- DFO Bulk Storage Tank
- DFO pumping and delivery system

Thermal Oil System

- Exhaust heat recovery units for heating thermal oil
- Thermal oil circulating system

Water Systems

- Fresh water tank and pumps
- Process and sanitary wastewater systems

Compressed Air Systems

- Dual air compressors
- Compressed air storage tanks
- Air-start system for engines
- Instrument and service air system

Fire Protection System

- Detection and alarm system
- Extinguishers

Electrical Systems

- Medium voltage generator bus and breakers
- Low voltage system and motor control centers for plant auxiliary loads
- Convenience voltage system for lighting and convenience outlets

Buildings

- Power House including control room
- Maintenance Building
- Fuel Treatment Building
- Admin building
- Guard house

Site Work

- Chain link fence with gates
- Driveways and parking area

Miscellaneous

- Plant startup and commissioning
- Operator training
- Plant testing
- Special tools for engines

10.3 Plant operating philosophy

10.3.1 Normal operations

The plant is designed for continuous operation at constant load, with all engines running at full output, except for maintenance outages. All power, net of internal loads, will be delivered to the end user at high voltage using the plant substation.

Normally the engines will burn heavy fuel oil (HFO) and the plant will be designed to operate continuously on HFO.

10.3.2 Start-up and shut-down

The engines can be started and stopped on HFO. Prior to an extended shutdown however, the engines will be switched over to distillate fuel oil (DFO) until the HFO has been flushed from the system. Upon returning to service, the engines will be started on DFO and switched over to HFO after warm-up.

10.3.3 Part-load operation

The plant can also operate at reduced output by shutting down or throttling one or more engines. In the event of complete loss of load, the plant will be designed to automatically reduce output and continue to supply its own internal power needs without tripping or interruption.

10.4 Plant layout

The plant will occupy a roughly rectangular site, bounded by chain link fence including the buildings and structures described below.

10.4.1 Power House

The largest of the buildings is the Power House, located near the center of the site. This prefabricated metal building houses the engine-generator sets, control room and certain auxiliary equipment. The engine air intake structures are mounted along one wall and the engine exhaust ducts exit through the wall on the same side as the engine intake air.

10.4.2 Maintenance Building

This is a small building located adjacent to the Power House near the main entrance gate. This building houses a maintenance area, parts storage area, offices and a reception area. A parking lot is also provided.

10.4.3 Fuel Treatment Building

This small building houses fuel heating and filtering equipment. It is located near the Power House.

10.4.4 Tank Farm

Located at one edge of the site, the tank farm includes all the major fuel, lubricant and waste oil storage tanks in a single location. All tanks are mounted in spill-containment dikes.

10.4.5 Truck Unloading Station

The Truck Unloading Station includes a driveway that allows trucks to drive in, unload fuel or lubricants, and drive out in a continuous loop. The station also includes hoses with quick-connect fittings, unloading pumps, filters and fuel meters. The driveway and unloading area are located along one edge of the site, and are paved with concrete.

10.4.6 Radiators

Radiators for cooling the engines are mounted near the Power House. The radiators are horizontally mounted on steel legs.

10.5 Design Parameters

10.5.1 General

Site conditions and general design features of the plant are listed in the sections below.

10.5.2 Plant operating range

The plant will be designed for the following ambient conditions.

AMBIENT CONDITIONS		
Reference site ambient temperature	25	^{0}C
Design ambient temperature	32	^{0}C
Minimum ambient temperature	7.5	^{0}C
Wet bulb temperature	27	^{0}C
Charge air cooling water temperature	33	^{0}C
Altitude	1525	masl
Generator voltage	11000	V

AMBIENT CONDITIONS		
Frequency	50	Hz
Power factor (lagging to leading)	0.8 – 0.9	
Service voltage	400	V
Fuel viscosity	380	cst
Lower heating value liquid fuel	41585	kJ/kg

10.5.3 Fuel Quality

Fuel (HFO) must meet one of the following CIMAC (International Council on Combustion Engines) standards:

- A10
- B10
- C10
- D15
- **E25**
- F25
- G35
- H35
- H45
- H55

Fuel (DFO) must meet one of the following standards: ISO 8217, DIN EN 590, ASTM D396 or ASTM D975.

10.5.4 Prohibited Materials

Asbestos, polychlorinated biphenyls (PCBs) and lead-based paint will not be installed anywhere in the plant.

10.5.5 Noise

The plant will include a number of noise-abatement features according to the project requirements, such as:

- Engine inlet air silencers;
- Engine exhaust silencers;
- Engines, generators and air compressors enclosed in a sound-attenuated building; and
- Engine hall ventilation silencers.

10.6 Codes and standards

The design and construction of the power plant will be in general accordance with the latest versions of the following codes and standards, as deemed applicable.

ANSI	American National Standards Institute
DIN	Deutsches Instituit fur Nomung, e.V.
NEMA	National Electrical Manufacturer's Association (USA)
IEEE	Institute of Electrical and Electronic Engineers (USA)
IEC	International Electric Code
ISO	International Standards Organization
NEC	National Electric Code (USA)
ASTM	American Society for Testing and Materials
VDE	Information Technologies (Germany)
ASME	American Society of Mechanical Engineers
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ICBO	International Conference of Building Officials
AWWA	American Water Works Association
IAPMO/UPC	International Association of Plumbing and Mechanical Officials, Uniform Plumbing Code
API	American Petroleum Institute
AWS	American Welding Society
UL	Underwriter's Laboratories (USA)
ISA	Instrument Society of America
SSPC	Steel Structures Painting Council (USA)
HEI	Heat Exchanger Institute (IEC)
CIMAC	International Council on Combustion Engines

10.7 Engine-generators

10.7.1 Engines

The engines will be Wärtsilä 20V32 diesel units designed especially to burn HFO/DFO. Engines will include the following features.

- Direct fuel injection
- Turbo charging
- Electric turning gear

- Local, free standing monitoring and control panel
- Exhaust valve rotators
- Electronic governor
- Service platforms and ladder
- Special tools

The number of cylinders and operating RPM depend on the engine model and generator frequency are indicated in the table below.

Engine Model	Number of Cylinders	Vee or Inline	RPM (50Hz)
20V32	20	**Vee**	**750**

10.7.2 Generators

The three-phase AC generator shall be designed for the application in base load, peak load and parallel operation. The generator can be used with all types of drive systems such as diesel/HFO engines, gas engines and gas turbines. The generator will be suitable for delivering performance as defined in specifications and data sheets. The generators will be air-cooled units with the following features.

- Class F insulation minimum, limited to an F rise
- Rated for power factor of 0.8
- Vacuum pressure impregnation of stator
- Direct coupling to engine
- Automatic voltage regulator
- Brushless exciter with integral pilot exciter
- Independent two-bearing design
- Two Bearing Resistance Temperature Detectors (RTD's)
- Six RTD’s in stator windings Stator
- Rotor
- Excitation system
- Bearings
- CT’s and PT’s

10.8 Fuel and lubricating unloading systems

10.8.1 Combined HFO, DFO and Lube Oil Delivery Area

Heavy fuel oil, DFO and engine lube oil will be delivered to the plant by truck. Trucks will be owned and operated by others. A truck unloading station will be furnished, consisting of a driveway with the following features:

- The driveway will allow fuel trucks to drive into the site, pull off to the side to wait their turn, unload, and exit the site;
- A rain roof will be provided over the area where the truck cabs will be parked while unloading. The rain roof will also cover the unloading pumps and equipment;
- The system will be sized to keep the plant running at full load (plus a reasonable margin) with truck deliveries limited to normal business hours;
- The width and design turning radius of the driveway will be suitable for tractor-trailer trucks with a single tank trailer;
- The unloading area will be paved with reinforced concrete suitable for heavy trucks, and will include curbs to direct spills and storm water to an oil/water separator; and
- Outdoor lighting will be provided sufficient light for safety after dark.

10.8.2 HFO Unloading and Storage System

The HFO unloading and storage system will pump fuel out of tanker trucks, meter it and pump it into one of two HFO aboveground storage tanks. The unloading pumps and tanks shall be sized according to the fuel consumption requirements of the power plant. The following equipment will be included in the HFO unloading and storage system:

- Flexible unloading hose with quick-connect fittings;
- Two 100% capacity unloading pumps (1 working, 1 standby) with suction strainers;
- Positive displacement fuel meter with totalizing feature;
- Containment dikes around pumps and all HFO handling equipment;
- Two HFO aboveground storage tanks each having a capacity of 5,500m^3. These steel tanks will be located in the tank farm which includes spill retention dikes; and
- Heating system for HFO aboveground storage tanks.

10.8.3 DFO Unloading and Storage System

The distillate fuel oil (DFO) unloading and storage system will pump fuel out of tanker trucks, meter it and pump it into a DFO above ground storage tank. The unloading pumps and tanks shall be sized according to the requirements of the power plant. The following equipment will be included:

- Flexible unloading hose with quick-connect fittings;
- Two 100% capacity unloading pumps (1 working, 1 standby) with suction strainers;
- Positive displacement fuel meter with totalizing feature;
- Containment dikes around pumps and all DFO handling equipment; and
- One DFO aboveground storage tank having a capacity of 700m^3. This steel tank will be located in the tank farm, which includes spill retention dikes.

10.8.4 Lube Oil Unloading and Storage System

The lube oil unloading and storage system will pump engine lube oil out of tank trucks and pump it into lube oil aboveground storage tank. The following equipment will be included:

- Flexible unloading hose with quick-connect fittings;
- One unloading pump with suction strainer;
- Containment dikes around the pump and all lube oil handling equipment; and
- One lube oil Bulk Storage Tank. This steel tank will be in the tank farm, which includes concrete spill retention dikes.

10.9 HFO conditioning system

10.9.1 General

The purpose of the HFO Conditioning System is to deliver clean, heated fuel to the engines at the proper temperature and pressure. This is accomplished by a series of pumps, heaters, separators, day tanks and filters.

10.9.2 Flow Path

In simplified terms, the HFO Conditioning System flow path is described below.

a) HFO is pumped from the aboveground storage tank to an HFO separator module. This module includes a heater (the separator heater), pumps and a fuel separator. The fuel separator is a standard centrifuge that uses centrifugal force and water to wash dirt and contaminants from the fuel.

b) The fuel then flows to a heated service tank. This tank holds enough fuel for 6 hours of plant operation, in case of minor upstream fuel supply interruptions.

c) From the service tank, the fuel flows to an HFO pre-pressure module. This module includes an HFO pre-pressure pump and an HFO automatic filter that back flushes and self-cleans as required.

d) Finally the fuel flows to an HFO circulating module. This module boosts the fuel pressure and precisely heats the fuel to the optimum viscosity for delivery to the engine fuel injection system. Major components of the module include:

- Mixing tank which facilitates a stable flow loop to the engine and allows for a smooth transition between HFO to DFO;
- Circulating pump which pumps fuel around the loop;
- Final preheater and viscosity control module which heats the fuel to the ideal temperature and viscosity; and
- A fuel flow meter.

10.9.3 Fuel Treatment Building

The HFO conditioning system will be housed in a fuel treatment building. All tanks in and around the building will be mounted in spill-retention dikes with drains to an oil-water separator. The fuel treatment building will include a monorail chain fall or portable A-frame for removal and handling of centrifuge bowls.

10.9.4 HFO Heating System

Thermal oil will be the heating medium for the above mentioned fuel heaters. The heating system will also include heat tracing, piping and necessary insulation and controls. The system will be capable of maintaining HFO at proper temperatures over the full range of operating conditions.

10.10 Distillate fuel oil system

10.10.1 General

The purpose of the DFO fuel system is to deliver DFO to the engines at the proper temperature and pressure. Because of the superior cleanliness and viscosity characteristics of DFO as compared to HFO, no conditioning is required for DFO.

10.10.2 Flow path

DFO is pumped directly from the aboveground storage tank to the HFO/DFO pre-pressure unit and then to HFO circulation module which functions as previously described in the HFO section above.

10.11 Lube oil system

10.11.1 General

The purpose of the lube oil system is to deliver clean, cool lubricating oil to the engines at the proper pressure and temperature. This is accomplished by a series of pumps, coolers, tanks, and filters.

10.11.2 Flow Path

A lube oil circulating tank serves as a central receiver for lube oil that is circulated to the engine and back in a continuous loop. A lube oil force pump driven by the engine shaft pumps lube oil from the lube oil circulating tank through an automatic filter and through a three-way valve. The three-way valve diverts part of the oil flow through a cooler as necessary to maintain proper temperature. The oil then flows to a duplex filter mounted on the engine and then into the engine itself. Return oil from the engine drains back to the lube oil circulating tank.

A lube oil separator module draws a side stream of lube oil from lube oil circulating tank. This module includes a preheater and a lube oil separator. The lube oil separator is a standard centrifuge that uses centrifugal force and water to wash dirt and contaminants from the oil.

10.12 Combustion air intake and exhaust system

10.12.1 Combustion Air Intake System

The Combustion Air Intake System which is not combined with the powerhouse ventilation system provides ambient clean air to the diesel engine for combustion while minimizing inlet air pressure loss to the turbocharger. Depending on the environmental conditions, the standard system utilizes dry type pocket filter units in rural, baseline temperature environments.

Components of the system include the following:

- Integral droplet separator;
- Filter section: pocket filters;
- Sound attenuator unit with transition piece;
- Transition piece with connection flange(s) (to suit engine specific air inlet connections);
- Fastening and sealing materials; and
- Pocket filter control/differential pressure transmitter.

Features of the system include the following:

- G4 Class filters;
- 12 mbar maximum pressure drop across unit; and

- 40 dB(A) noise reduction through silencer section.

10.12.2 Exhaust System

An exhaust system for each engine will convey engine exhaust gases through a thermal oil heat recovery unit, then through a silencer, and finally out to atmosphere through a stack. Expansion joints, supports and insulation will be furnished as required.

An exhaust system for each engine will convey engine exhaust gases through a silencer, and finally out to atmosphere through a stack. Expansion joints, supports and insulation will be furnished as required.

10.13 Cooling water system

As fuel burns inside the engine, various engine parts become hot. The cooling water system pumps water through the engine to a radiator where the heat is dumped to atmosphere. Cooled water from the radiator is then returned to the engine. The radiators are self-contained horizontal units mounted outdoors on structural steel legs. Multiple fans draw cooling air up through the radiators. Aboveground supply and return piping connects the radiators to the engines.

The power plant Wärtsilä model 20V32 reciprocating generating sets will be configured with two-circuit cooling systems as described below.

10.13.1 Two-Circuit cooling system

This system has two completely independent cooling circuits. A pump is provided in each circuit. Two three-way valves, one in each circuit, maintain the temperature and cooling control in each circuit. The first three-way valve regulates the flow of water from the high temperature loop into the high-temperature section of the radiator. The second three-way valve regulates the low temperature cooling water flow through the first-stage charge air cooler, with full flow into the low temperature section of the radiator. The low and high temperature sections of the radiator are combined into a single unit for each engine. An expansion tank is provided at the high point for each of the two cooling water loops to accommodate water volume changes caused by thermal expansion.

10.14 Heat recovery system

10.14.1 Thermal oil System

The thermal oil system shall be designed, utilizing the exhaust gas heat recovery system for the generation of heated thermal oil for HFO heating applications.

The main components of the exhaust gas heat recovery – thermal oil system include the thermal oil heater unit, exhaust gas bypass system, thermal oil expansion tank, thermal oil drain tank, thermal transfer oil pump, filling and drainage pump, thermal oil circulation pumps for engines and consumers, thermal oil heater control board, and thermal oil auxiliary heater unit .

Several of the main components are engine model specific, including the thermal oil heater unit with bypass damper system. The remaining components are common, sized to serve the entire system; these include the thermal oil circulation pumps, thermal oil expansion tank, thermal oil drain tank and filling & drainage pump, and the thermal oil auxiliary heater unit.

Features of the thermal oil system include the following:

Thermal Oil Heater Unit

- Automatic operation according to consumer demand; exhaust gas input adjusted based on thermal oil outlet temperature;
- Heater fitted with exhaust gas bypass damper system for control of exhaust gas input. Bypass dampers are self-regulating type, mechanically linked and automatically controlled.

Thermal Oil Circulation Pumps

- Pump capacity is based on parallel use of all exhaust gas boilers at nominal capacity and one oil-fired thermal transfer heater.
- Minimum of two (2) pumps provided for each circulation system, each rated at 100% capacity; one (1) running and one (1) standby.

Thermal Oil Expansion Tank

- Expansion tank sizing is according to the thermal oil system configuration matrix.
- Expansion tank is insulated and aluminum clad.

Thermal Oil Drain Tank

- Drain tank is sized to accommodate draining of the largest section of the thermal oil system that can be shut-off and isolated.

Filling and Drainage Pump

- Electric motor driven screw pump is provided for transfer of thermal oil to and from the drain tank.

Thermal Oil Heater Control Board

- One (1) common control system for controlling and operating the exhaust gas heat recovery system for self-demand thermal oil heating.

Thermal Oil Auxiliary Heater Unit

- 500 kW thermal oil auxiliary heater unit rating is identical for all plant configurations.
- All necessary control equipment for automatic operation and system integration to the main heat recovery system are included.
- Burner is a fully automatic pressure atomizing diesel oil (DO) burner.

Thermal Oil Pump/Header Group:

- A thermal oil pump/header group is provided with connections and valves for the following:
  - From thermal oil heater unit.
  - Return to thermal oil heater unit.
  - From thermal oil auxiliary heater unit.
  - Return to thermal oil auxiliary heater unit.
  - To consumers.

10.15 Compressed air system

The compressed air system compresses, stores and delivers medium pressure (30 bar) compressed air to start the diesel engines. Through a pressure reducing station, low pressure (8 Bar) air is delivered for various utility services and instrument requirements. Components of the system include air compressors, air receiver tanks, filters, and a pressure reducing station. The entire system is modularly designed to allow a seamless integration into the plant's infrastructure.

Features of the system include the following.

- Two separate modules – air compressor and air receiver;
- Two identical air compressors on the air compressor module;
- Two identical air receivers on the air receiver module;
- One set of pre filters to eliminate dust and other particles from entering the intake of the air compressors;
- One set of air filters (for low pressure instrument air only) to aid in removal of any water or oil carry-over;
- One pressure reducing station (consisting of redundant pressure reducing valves) on the air receiver module;
- Each module with a welded steel base sized for transport in a 20 foot ISO container;
- Compressor output through common manifold so only one mechanical connection point;
- One common control panel that handles all control and electrical-power functions of the air compressors located on the air compressor module;

- All electrical wiring will be through rigid conduit to one terminal point in the control panel;
- Air tank output through common manifold with isolation valves;
- Medium pressure air piping constructed of black and oiled carbon steel; and
- Low pressure air piping constructed of non-corrosive material to minimize debris from entering downstream instruments and equipment.

10.16 Power house ventilation system

The powerhouse ventilation system which is not combined with the combustion air intake system, has three (3) basic purposes:

- To provide an environment that permits the machinery and equipment to function properly with dependable service life.
- To provide an environment in which personnel can work comfortably and effectively.
- To provide noise attenuation.

To accomplish this, the powerhouse ventilation system is split into three (3) modules:

- Two (2) ventilation inlet modules – one (1) for the generator side and one (1) for the annex side. Each module includes a filter section, silencer section and fan section, and is directly connected to the powerhouse.
- One (1) ventilation outlet module; sized to naturally exhaust the combined generator and annex side ventilation inlet air volumes.

Features of the system include:

- Two (2) completely separate ventilation inlet modules for each generator set as described above, one (1) for the generator side and one (1) for the annex side.
- Ventilation units are furnished as pre-packaged modules, fully assembled and pre-wired.
- Ventilation air filtration, G4 class.
- Ventilation air silencing, 25 dBA noise reduction.
- Ventilation outlet is natural; no power requirements.

10.17 Water system

10.17.1 Fresh water system

The Proponent's existing treated water system will provide fresh treated water to the standards required to operate the equipment, through a connection at the power plant battery limits. The connection will include metering, backflow presenters, and isolation valves as required. Fresh water distribution will be by underground piping to buildings and equipment. Hose bibs will be provided at all buildings and near tanks and equipment as required. Fresh water will be used for the following purposes:

- Floor and equipment wash down
- Feed water for the process water treatment system

10.18 Process wastewater system

Wastewater streams that may contain oil will be directed to an oil/water separator. Such streams include floor drains, rainwater from spill containment basins, and sludge from the lube oil, HFO and DFO separators. Clear water discharge from oil/water separators will be discharged to the Proponent's existing sewer system via a connection at the power plant battery limits. The following wastewater streams will also be discharged to the owner's existing sewer:

- Regeneration brine from the process water treatment system

10.19 Sanitary wastewater system

Sanitary sewage will be collected from sinks, toilets, showers and other sources. The Proponent has two options for treatment and disposal of sanitary sewage:

- They can build a conservancy tank which will collect sanitary sewage from various parts of the power plant and contract a sewage exhauster company for disposal to the approved Mavoko Water and Sewage Company location; or
- Build a sanitary sewage pipeline to the main Mavoko Water and Sewage Company sewer line.

A cost benefit analysis will be undertaken by the Proponent to decide which option is preferable for managing sanitary sewage from the power plant.

10.20 Fire protection system

The fire detection system will define the power plant's fire alarm and detection system(s), and electrical fire pump. Components of the system will include pull stations, audible and visual alarms, smoke detection devices, fire protection water storage tank, electric fire pump and portable fire extinguishers.

10.21 Electrical system

10.21.1 General

It is absolutely necessary for the successful operation of the power plant that the entire system be monitored and controlled by a single responsible entity. The intent is to provide that equipment which meets Caterpillar's requirements to safely monitor, control and operate the essential equipment needed to make the power plant perform to peak efficiency. A complete electrical system will be provided including the major subsystems listed below. The electrical systems will operate at 50 Hz.

- High voltage 66 kV substation;
- Medium-voltage 11 kV system including generator and generator bus;
- Low-voltage 0.4 kV system for plant auxiliary loads;
- Convenience voltage 400/230 V system distribution for lighting and convenience outlets; and
- Control voltage 24 V DC and 110 or 125 V DC.

The primary purpose of the electrical systems will be to:

- Export net electrical generation;
- Distribute station power for internal loads when the plant is operational;
- Import station power during plant outages.

10.21.2 Medium Voltage System

The medium voltage system will comprise an indoor metal clad/metal enclosed AC switch gear with a voltage range of 1 kV to 36 kV used for power plants, industrial and distribution substations etc. This medium voltage switchgear shall be designed to:

- Switch on/off during normal conditions; and
- Automatically operate during abnormal conditions.

A typical metal enclosed switchgear has following components:

- A busbar;
- Switching devices such as VCB, Load break switch;
- CT's and PT's;

- Measuring instruments and relays;
- Cable termination for incoming and outgoing cables; and
- Electrical and mechanical interlocking facility.

The switchgear will be located in an electrical room in the main building.

10.21.3 Low Voltage System

The low voltage system is designed to match the required auxiliary power of various electrical consumers of the entire power plant. The AC switchgear operating within and up to 1kV is known as low voltage switchgear. The number of switching operations demanded from low voltage switchgear is very high. Low voltage switchgear is designed for long mechanical and contact life. The low voltage system will include the following:

- Motor control centers with breakers, motor starters, pushbuttons and indicating lights;
- Power wiring to various internal motors and loads;
- Busbar;
- Switching devices such as ACB, MCCB, MCB;
- CT's and PT's;
- Station Service Transformer;
- Measuring instruments and relays;
- Cable termination for incoming and outgoing cables; and
- Electrical and mechanical interlocking facility.

10.21.4 Convenience-Voltage System

The convenience voltage system distribution panels and wiring will be provided for lighting and convenience outlets in all power plant buildings. Welding outlets will be provided in the main building and fuel treatment building. Battery-operated emergency lighting and exit signs will be provided.

10.21.5 Control and Protection System

The control and protection systems are designed to provide control, protection and monitoring of the entire power plant. The control systems will be separated into two sections with communication between:

- Power Train Control; and
- Common Plant Control

Power Train Control (one per engine)

The power train control system consists of a freestanding local control panel located next to each engine. The local control panel provides control, monitoring, and protection functions for the engine, engine support modules and the generator. All of the control and monitoring functions are capable of performing locally at the panel using either a panel-door-mounted graphic user interface, or remotely at the plant SCADA system through a high-speed communication link.

Common Plant Control System (one per plant)

The common plant control system consists of a freestanding common plant control programmable logic controller (PLC) panel, a plant desktop SCADA (Supervisory Control and Data Acquisition) system, and an engine diagnostic DICARE (a Caterpillar diagnostic and condition monitoring system) system. All components of the common plant control system are located in the power control room. They are interconnected with each other, as well as with the individual power train local control panels, through a high-speed communication network.

10.21.6 Neutral Grounding Resistor

The neutral point of a star connected three phase AC generator is connected to ground through low resistor. Such a resistor is called neutral grounding resistor. The purpose of the neutral grounding resistor is to limit the earth fault current to ground to protect the windings in case of a phase to earth fault. The standard design is one neutral grounding resistor per power plant.

10.21.7 Miscellaneous Electrical

The following miscellaneous electrical items will be provided as part of the electrical system.

- Conduit, wire, cable and trays as required;
- Lightning protection throughout plant;
- Grounding grid;
- Emergency DC power system for critical switchgear and control systems; and
- Outdoor lighting for safety and security.

10.22 Monitoring and control system

10.22.1 General

A complete power plant control system will be provided, consisting of the following major subsystems:

- Engine-Generator local control panels;
- Control and monitoring unit for engine-generators, located in the control room;

- Measurement and protection unit, located in the control room; and
- SCADA system, located in the control room.

Each of these components is discussed below.

Engine-Generator Local Control Panel

Each engine will be equipped with a freestanding control panel mounted near the engine. The local control panel (LCP) is an indoor type metal enclosed cubicle with a front accessible door and is free standing on the floor or over a cable trench. The following major components are included in the LCP.

- Programmable Logic Controller (PLC);
- Multifunction Unit (MPU2);
- Automatic Voltage Regulator;
- Electronic Engine Governor System;
- RPM switch for ignition and over speed;
- Control and monitoring unit for genset (CMG2); and
- KFM Temperature Regulator.

The LCP is a solid state fully programmable PLC based unit which serves to control and monitor all the engine functions, protection system for the genset as well as providing the operator interface for starting, stopping, voltage regulation, engine and generator protection, synchronizing and governor control using a front door mounted HMI called CMG2. The LCP is fully capable of providing remote monitoring and control capability as well as data logging.

Control and Monitoring Unit for Engine-Generators

The control and monitoring unit is mounted in the control room in a freestanding console. This unit provides remote control of the engine-generators including starting, stopping, changing load, adjusting voltage, adjusting reactive power, controlling the generator breaker and acknowledging faults. Primary components of the system will include:

- Industrial Windows-based computer;
- One human-machine interface (HMI) consisting of graphic color display for each engine;
- Menu-driven display screens including electrical parameters, breaker status, engine P and I Diagram (P&ID) with operating data, data logging, alarm list, etc.;
- Password protection;
- Digital indication of key generator data including voltage, frequency, current, power, reactive power and kWh; and
- Data logging and trending.

Measurement and Protection Unit

The primary purpose of the measurement and protection unit is the control and protection of the medium voltage switchgear. The system mounted in the central control room, is housed in a pre-wired metal cubicle. The following components are included:

- Synchronization equipment;
- PLC;
- Generator protection such as over current, reverse power, over voltage, etc.;
- Mimic diagram of one-line with semaphore indicator for position of circuit breakers;
- Digital indication of key electrical data such as voltage, frequency, current and power factor; and
- Data exchange with individual engine control PLC's.

SCADA System

A complete Supervisory Control and Data Acquisition (SCADA) system will be provided to the power plant. This system located in the control room will include the following features:

- Windows-based computer;
- Display monitor;
- Menu-driven graphic displays;
- Transmission of control commands to the respective systems;
- Password protection;
- Long-term data logging and trending;
- Alarm listing and analysis;
- Monitoring and control of balance of plant systems, including:
  - Fuel oil handling and treatment systems;
  - Lube oil handling and treatment systems; and
  - Compressed air system.