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CAROLINA POWER AND LIGHT COMPANY

H. B. ROBINSON SEG PLANT

PLANT OPERATING MANUAL

VOLUME 6

PART 2

SYSTEM DESCRIPTION PROCEDURE

SD-056

DEDICATED SHUTDOWN DIESEL GENERATOR

REVISION 1

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RECOMMENDED BY: J. C. Reig 7/16/90  
Engineering Supervisor - Systems Date

APPROVED BY: M. F. Page 7/27/90  
Manager - Technical Support Date

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## 1.0 GENERAL DESCRIPTION

### 1.1 System Purpose

The Dedicated Shutdown Diesel Generator provides a source of electrical power to bring the plant safely to a hot shutdown condition in the event of a fire in the Control Room, Cable Spread Room, E-1/E-2 Room, Battery Room, or the first floor of the Auxiliary Building.

In addition, Dedicated Shutdown Diesel Generator provides an emergency source of electrical power in the event of a simultaneous loss of all on-site power and both Emergency Diesel Generators.

### 1.2 System Description

The Dedicated Shutdown Diesel Generator is a completely self-contained unit with no outside support systems required. The entire unit is skid mounted in a metal enclosure.

The Dedicated Shutdown Diesel Generator unit is directly west of the Turbine Building. The unit is started up and synchronized with 480 Bus DS from the Local Control Panel.

The Dedicated Shutdown Diesel Generator is comprised of the following components:

- a. Diesel Engine
- b. Generator
- c. Air Intake and Exhaust System
- d. Lube Oil System
- e. Cooling System
- f. Fuel System
- g. Governor
- h. Protective Devices
- i. Starting System
- j. Control Panel

## 2.0 COMPONENT DESCRIPTION

### 2.1 Diesel Engine

The engine is a 20 cylinder, turbocharged, fuel injected, "V" type engine which delivers 3600 bhp at 900 rpm. The engine operates on the two-stroke cycle; therefore, each piston undergoes a power stroke for every revolution of the crankshaft.

### 2.2 Generator

The generator is a single bearing type with the rotor directly connected to the engine flywheel through a flexible coupling. The shaft is supported at the outboard end by a single, grease lubricated, self-aligning, spherical roller bearing. The bearing is assembled in a bearing closure which is bolted to the main frame of the generator. The generator rests on a common base with the engine.

The generator output is 3-phase 60 Hz, 4160V AC and is rated at 2600 kW. The generator output voltage is stepped down from 4160V AC to 480V AC to match Bus DS voltage. Generator output voltage is controlled by an exciter-regulator which controls current to the generator field windings. The generator field flashing is supplied from the 125V DC battery bank located in the Dedicated Shutdown Diesel Generator enclosure.

### 2.3 Air Intake and Exhaust System

The Air Intake and Exhaust System provides air for combustion and the removal of combustion products. Outside air is brought in through a silencer and filter to the turbocharger compressor end. The turbocharger compresses and discharges the air through an aftercooler on each bank of the intake manifold.

The engine exhaust is piped through a common manifold, running along the engine "V". The exhaust gases pass through the turbine end of the turbocharger and discharge to the atmosphere through an exhaust silencer.

During startup and low load operation, the turbocharger is driven by the engine camshaft through an overrunning clutch. As engine load increases, engine exhaust will cause the turbocharger to turn faster than the camshaft, disengaging the clutch.

Lube Oil System

Engine bearing and piston lubrication is provided by the Dedicated Shutdown Diesel Generator Lube Oil System. The engine-driven, helical gear type, scavenging pump takes a suction on the engine sump and discharges through the full-flow lube oil filter and fintube lube oil cooler to the lube oil strainer at the suction of the main and piston cooling lube oil pumps. Both pumps are rotary gear type pumps driven from the same shaft and sharing the same housing. The pumps share a common suction and discharge to separate headers. The piston cooling pump supplies oil at 109 gpm for lubrication and cooling of the engine pistons. The main oil pump provides cooling and lubrication of the engine and turbocharger bearings. All engine oil gravity drains to the engine sump. A turbocharger soak back pump is provided to prelubricate the turbocharger bearings and provide cooling of the turbocharger bearings following engine shutdown. During engine shutdown a circulating pump circulates lube oil through the lube oil filter and lube oil cooler to the engine. Heated jacket water circulates through the cooler to warm the lube oil, facilitating rapid engine starting.

2.0 COMPONENT DESCRIPTION (Continued)

2.5 Jacket Cooling System

The Dedicated Shutdown Diesel Generator Jacket Cooling System provides cooling for the engine cylinder jackets, aftercoolers and lube oil cooler. The system also provides for lube oil heating during engine shutdown.

The two engine driven cooling pumps provide flow for the system. The 1100 gpm centrifugal pumps are gear driven by the engine cam shafts and discharge to the engine jackets and combustion air aftercoolers. The water then flows through a thermostatic bypass to the remotely mounted radiator. The radiator is equipped with an electric fan and provides the heat sink for the system. Water from the radiator flows through the lube oil cooler and back to the pump suction. An expansion tank provides a surge volume and positive suction pressure for the system. When the engine is shutdown, the jacket water is heated by an immersion heater. The system is designed for natural convection flow to provide for warming the lube oil and the engine to facilitate rapid starting.

2.6 Fuel Oil System

The Dedicated Shutdown Diesel Generator Fuel Oil System provides the correct amount of fuel at the proper time for combustion in the engine.

A 5000 gallon fuel oil storage tank is located outside the engine enclosure. The tank gravity drains the fuel through a solenoid operated valve to the 150 gallon fuel oil day tank. The day tank is equipped with level indication and vent and overflow connections. The 4.5 gpm, positive displacement, engine driven fuel oil pump takes a suction on the day tank and discharges through the fuel filter to the injectors. Excess fuel is returned to the day tank via the bypass fuel and return fuel lines.

## 2.0 COMPONENT DESCRIPTION (Continued)

A 3 gpm, DC motor-driven priming pump and a hand-operated priming pump are provided to prime the fuel oil system prior to engine operation.

### 2.7 Governor

The Dedicated Shutdown Diesel Generator Governor maintains the speed of the engine at the predetermined setpoint by controlling the fuel flow through mechanical linkage. By maintaining a constant speed, the generator provides a constant 60 Hz cycle for electrical power throughout the loading and unloading sequence during Dedicated Shutdown.

Main components of the governor are: a speed adjusting mechanism or synchronizer; a speed sensing group, consisting of the speeder spring, speed setting piston, and flyweights; fuel adjustment control group, consisting of power piston and spring; compensating mechanism, consisting of power piston pilot valve, compensating piston, and compensating linkage; a speed droop system; and an oil system for component operation and lubrication consisting of oil pump, oil sump and accumulators.

### 2.8 Starting Air System

The Dedicated Shutdown Diesel Generator starting air system provides the initial engine rotation necessary for the cylinder compression required to cause combustion in a diesel engine.



## 2.0

COMPONENT DESCRIPTION (Continued)

A reciprocating compressor driven by a 480V AC, 3 phase, 60 Hz, 5 hp motor compresses air up to a pressure of 200 psig and discharges to a 35 ft<sup>3</sup> receiver. When the engine start button is depressed, the starting air solenoid valve is opened allowing air to engage the lower air start motor pinion to the engine flywheel ring gear. Engaging the lower pinion provides a flowpath allowing air to engage the upper pinion to the ring gear. Engaging the upper pinion provides a flowpath allowing air to open the two-way air start valve. Opening the valve allows starting air to turn the air start motors which rotate the engine. This design prevents attempting to rotate the engine with only one pinion engaged.

A lubricator assembly provides lubrication to the air start motors by allowing oil to become entrained in the passing air.

## 3.0

INSTRUMENTATION AND CONTROLS

## 3.1

Engine Control Panel Indications and Controls

## 3.1.1

## Indications

1. Lube Oil pressure 0-160 psig
2. Fuel Oil pressure 0-100 psi
3. Start Air pressure 0-300 psig
4. Governor Control Lower-Raise
5. Engine elapsed time
6. 120V DC Power ON
7. Engine Speed 0-1200 RPM

## 3.1.2

## Controls

1. Immersion heater ON-OFF
2. Governor Control Low-High
3. Engine Start Button
4. Engine Stop Button
5. Alarm Test Button
6. Lamp Test Button

### 3.0 INSTRUMENTATION AND CONTROLS (Continued)

7. Alarm OFF Button
8. Alarm Reset Button
9. Fuel prime control Button
10. Control Power ON-OFF (120V DC)

### 3.2 Generator Control Panel Controls and Indications

#### 3.2.1 Indications

1. Wattmeter 0-4000
2. Varmeter 0-4500
3. Ampmeter 0-600
4. Frequency Meter 0-65
5. Voltmeter 0-5000
6. Elapsed Time Meter
7. Generator output breaker OPEN/CLOSED

#### 3.2.2 Controls

1. Voltage Control Raise-Lower
2. Governor Control Speed Control Raise-OFF-Lower
3. Voltage Regulator Manual Control AUTO-MANUAL-OFF Selector
4. Manual Voltage Adjust Increase
5. Breaker Control Pull Out - Trip - Close
6. Generator Lockout Switch (TRIP/RESET)
7. Ampmeter Switch OFF-1-2-3
8. Voltmeter Switch OFF-(1-2)-(2-3)-(3-1)

### 3.3 Engine Mounted Indications

The Dedicated Shutdown Diesel Generator engine is also equipped with engine mounted indications which are as follows:

- |    |                                      |          |
|----|--------------------------------------|----------|
| a. | Lube oil temperature to engine       | 50-300°F |
| b. | Lube oil temperature from engine     | 50-300°F |
| c. | Jacket Coolant temperature to engine | 50-300°F |

### 3.0 INSTRUMENTATION AND CONTROLS (Continued)

- d. Jacket Coolant temperature from engine 50-300°F
- e. Starting air receiver pressure 0-300 psig
- f. Lube oil circulating pump discharge pressure 0-100 psig
- g. Fuel oil day tank level Empty-1/4-1/2-3/4-Full

### 3.4 System Alarms

The Dedicated Shutdown Diesel Generator alarms are located on the Local Engine Control Panel and the Remote DS Control Panel.

Actuation of any of these alarms will sound an alarm horn in the Dedicated Shutdown Diesel Generator enclosure.

The Local Engine Control Panel alarms are as follows:

<u>Alarm</u>	<u>Function</u>	<u>Setpoint</u>
HOT ENGINE	Jacket Water Temperature High	208°F
ENGINE FAULT	Low Lube Oil Pressure/Engine Shutdown	21 psig
OVERSPEED TRIP	Engine Overspeed Alarm	1035 rpm
LOW TURBO OIL PRESSURE	Prevent Engine Start	10 psig
HIGH FUEL LEVEL	N/A	Full
AIR FILTER	Air Filter $\Delta P$ high	7" H <sub>2</sub> O
LOW FUEL LEVEL	Engine Shutdown	Empty
LOW OIL TEMPERATURE	N/A	85°F
START FAILURE	N/A	15 sec.

### 3.5 Control Functions and Interlocks

#### 3.5.1 Dedicated Shutdown Diesel Generator Starting

The Dedicated Shutdown Diesel Generator is not equipped with an Auto-Start feature and therefore must be started from the pushbuttons on the Engine Control Panel or Remote Dedicated Shutdown Control Panel.

Pushing the START button de-energizes the starting solenoid which will sequentially engage the air-start motors to the engine flywheel. Both air start motors must be engaged to actuate the 2-way air start valve and supply air to the air motors. As the engine begins to fire (about 200 rpm), the air start solenoid valve is closed, disengaging the air motors and closing the 2-way air-start valve.

### 3.5.2 Engine Starting Interlocks

The air start solenoid valve will not open unless the following conditions are met:

1. Turbocharger lube oil pump running with a discharge greater than 10 psig
2. Engine speed control is set for idle

### 3.5.3 Engine and Generator Trips

The Dedicated Shutdown Diesel Generator engine is protected from damage due to component failure by several automatic shutdown features. These engine trips and their setpoints are listed below:

<u>Trip</u>	<u>Setpoint</u>
Hot engine	Jacket water temperature 215°F
Engine fault	Lube oil pressure 21 psig
Overspeed	990-1035 rpm
Crankcase overpressure	+1" H <sub>2</sub> O
Manual	

The Dedicated Shutdown Diesel Generator is also protected from damage by three conditions which trip the generator output breaker. These conditions are reverse power, overcurrent and phase differential current.

### 3.0 INSTRUMENTATION AND CONTROLS (Continued)

#### 3.5.4 Lube Oil System

The engine is interlocked with the lube oil system such that the engine will not start unless the turbocharger lube oil pump discharge is greater than 10 psig.

When the Dedicated Shutdown Diesel Generator is tripped automatically or manually, the oil circulating pump will start. In addition, the pump will stop when the engine is started.

#### 3.5.5 Engine Jacket Cooling System

The cooling system radiator fan is controlled to maintain coolant temperature between 160 and 175°F.

The cooling system immersion heater maintains the engine warm by providing a thermal driving head for natural circulation flow through the lube oil cooler. This is provided by cycling the heater to maintain coolant temperature between 125 and 155°F when the engine is shut down. The heater is locked out when the engine is operating.

A temperature control valve is installed at the inlet to the radiator to bypass water around the radiator, maintaining engine temperature. This valve functions to assist in rapid engine warmup and prevent the jacket water from becoming too cold during cold weather engine operation.

#### 3.5.6 Starting Air System

Starting air pressure is maintained between 160 and 200 psig by a pressure switch mounted on the air receiver which controls compressor operation.

A mechanical interlock prevents air from being directed to the air start motors unless both air start motors are engaged.

3.0      INSTRUMENTATION AND CONTROLS    (Continued)

3.5.7    Engine Fuel Oil System

The fuel oil day tank is equipped with level switches which control the solenoid operated day tank inlet valve to maintain tank level.

4.0      SYSTEM AND COMPONENT DESIGN

4.1      Diesel Engine

Manufacturer	Morrison-Knudsen Co.
Model	20-645E4B
Number of Cylinders	20
Cylinder Arrangement	45° - "V"
Operating Description	Turbocharged, 2 stroke, Fuel Injection, Water cooled
Engine Rating	3600 HP @ 900 rpm

4.2      Generator

Manufacturer	Beloit
Type	TBGZJ
KW Output (.8 P.F.)	2600 KW (3250 KVA)
Frequency	60 Hz
Speed	900 rpm
Number of Poles	8
Voltage	4160V AC
Number of Phases	3
Temperature Rise	203°F
Exciter Rated Current	136 Amp DC
Exciter Normal Voltage	125 volts
Exciter Continuous Power Output	17 KW

If a fire develops in the Control Room, Cable Spread Room, E-1/E-2 Room, Battery Room, or the first floor of the Auxiliary Building or if there is a simultaneous loss of all on-site power and both Emergency Diesel Generators, the Dedicated Shutdown Diesel Generator will be manually started and electrically connected to Bus DS.

Prior to startup, an operator will check the following:

- Turbocharger Lube Oil Pump discharge greater than 10 psig
- Fuel Oil Storage Tank greater than 3000 gal.
- Lube Oil Sump level between FULL and LOW marks
- Lube Oil Temperature is greater than 50°F
- In Line Air Lubricator Oil Reservoir full
- Air Lubricator Needle Valve 1 ½ turns OPEN
- Jacket Water Expansion Tank level visible
- Governor Oil Level visible
- Lube Oil Filter level sight glass full
- Lube Oil Circulating Pump discharge pressure equal to or greater than 25 psig
- Starting Air Compressor oil level full
- F.O. Day Tank Supply Valve EV-4541 Manual Override, Fully Open
- Governor Speed Droop at 50
- Governor Load Limit Switch at 7
- Overspeed Trip Lever in the Reset position

The operator will then depress the Engine Start Button and hold until the engine speed reaches 300 rpm. The engine speed will then be increased to approximately 450 rpm and held there to warm the Lube Oil and the Cooling Water. The engine speed will be increased to 900 rpm and the generator synchronized and the feed breaker (52/32B) closed. At that time, the generator will be operated equal to or greater than 75% of rated load to prevent incomplete combustion which may cause an exhaust fire.

5.0      OPERATION    (Continued)

When the Dedicated Shutdown Diesel Generator is to be shut down, Bus DS will be unloaded and the Generator feed breaker (52/32B) tripped. Engine speed will be reduced to and maintained at approximately 450 rpm for 20 minutes to cool the engine. Then the engine will be tripped.

6.0      REFERENCES

6.1      System Description

SD-016, Electrical System

6.2      Operating Procedures

OP-602, Dedicated Shutdown Diesel Generator

6.3      FSAR

7.4.2.3.2h, Diesel Generator

6.4      Technical Manuals

Morrison-Knudson Co. - Instruction/Parts Manual

6.5      Flow Diagrams

HBR2-7707 - Three Line Diagram Dedicated Shutdown Bus DS  
5357-E-6106 - Diesel Generator Motor Control Center - Side 1  
5357-E-6001 - Dedicated Shutdown Bus

7.0      ATTACHMENTS

7.1      None Applicable