COMBUSTION TURBINE SYSTEM (UNITS 3 AND 4)

BC1-SS-20-SD

TRAINING SYSTEM DESCRIPTION

NRG ENERGY, INC.

BIG CAJUN 1

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PREFACE

This Training System Description has been designed to assist you in meeting the requirements of Module BC1-SS-20 Big Cajun 1 Combustion Turbine System of the Plant Operator Training Program. It contains information about the Big Cajun 1 Combustion Turbine System. This includes system function, flow path, and details about the major system components and operation.

You should review each chapter objective. In doing so you will be better prepared to learn the required information. You should also walk down the system and identify the components and controls. Should you have additional questions about the system, ask your supervisors.

A separate document, Combustion Turbine System Operating Procedure BC1-SS-20 -SOP, covers detailed operation of the Big Cajun 1 Combustion Turbine Systems.

COMBUSTION TURBINE SYSTEM (UNITS 3 AND 4)

BC1-SS-20

TRAINING SYSTEM DESCRIPTION

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References

Siemens Westinghouse 501D5A Combustion Turbine Familiarization Training Manual

Big Cajun 1 System Descriptions and Procedures Book

Plant Walkdown

1.0 System Introduction

Chapter Objectives:

1. Describe the functions of the Combustion Turbine System.
2. State, from memory, the functions of the Combustion Turbine System.
3. Draw a simplified Combustion Turbine System diagram.
4. Describe the flow path and how the Combustion Turbine System performs its function.
5. List the normal Combustion Turbine System operating parameters.

1.1 System Function

The function of the Combustion Turbine System is to convert the chemical energy in natural gas to electrical energy. Combustion Turbine System Units 3 and 4 provide additional electrical power during peak demand periods. Combustion Turbines are capable of starting quickly, so are ideal for use as “Peakers” (Turbine-Generators only used when demand is at a peak).

1.2 Basic System Description

The Combustion Turbine System Units 3 and 4 are identical Westinghouse EconoPac (Economical Package) assemblies. Each Unit is designed provide a complete, self-contained generating system. Each Unit includes a Combustion Turbine, Generator, Starting Package, Electrical Package, Mechanical Package, and the necessary support systems to enable the Unit to operate independently.

Combustion Turbine Units draw in air, compress it, mix the compressed air with fuel, and ignite the mixture. The hot combustion gases expand through the Combustion Turbine blades, which turn the Generator to generate electricity. Exhaust is dispersed from a Stack attached to the Unit.

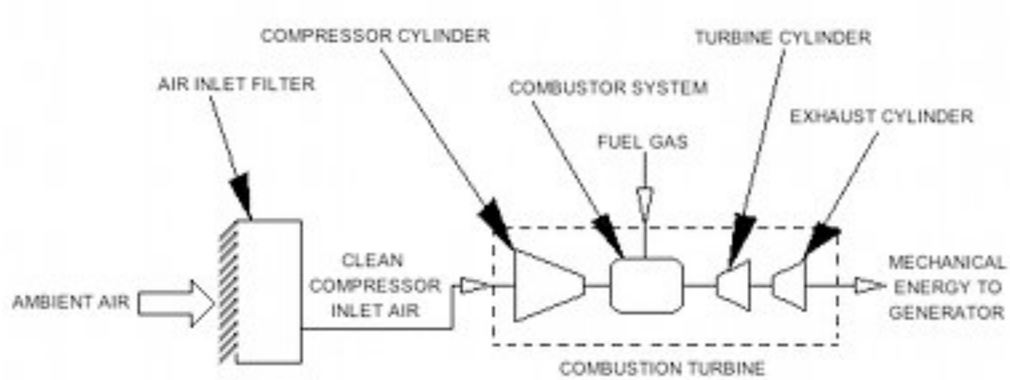
1.3 System Flowpath

Ambient air (approximately 660,000 cfm) enters the Filter House and passes through the Air Inlet Filter. The Air Inlet Filter is a single-stage pulse self-cleaning filter with pulse air supplied from a dedicated Pulse Compressor Skid. Downstream of the Air Inlet Filter, air passes through the Inlet Silencer Assembly to the Combustion Turbine's Air Inlet Manifold. The Variable Inlet Guide Vanes and Compressor Bleed Valves control the flow of air into the Combustion Turbine Compressor.

The Fuel Gas System supplies fuel gas to four manifolds on the Combustion Turbine. Each Manifold has a Throttle Valve that controls the flow through the Manifold to the Fuel Nozzles in response to the Distributed Control System (DCS).

Within the Combustion Turbine, air is drawn into the Compressor where it is pressurized and forced into the Combustion Chamber. Fuel gas is mixed with some of the compressed air and burned, converting the chemical energy of the fuel into thermal energy. The hot gas mixture expands through the Power Turbine, where the thermal energy is converted into rotational mechanical work. A portion for the power converted by the Turbine is used for driving the Compressor, and the balance is used to drive the Generator.

The Generator converts the mechanical energy produced by the Combustion Turbine and the magnetic field produced by the Brushless Exciter to electrical three-phase alternating current (AC) power for transmission and consumption.



Drawing 1 – Combustion Turbine System Flow Diagram

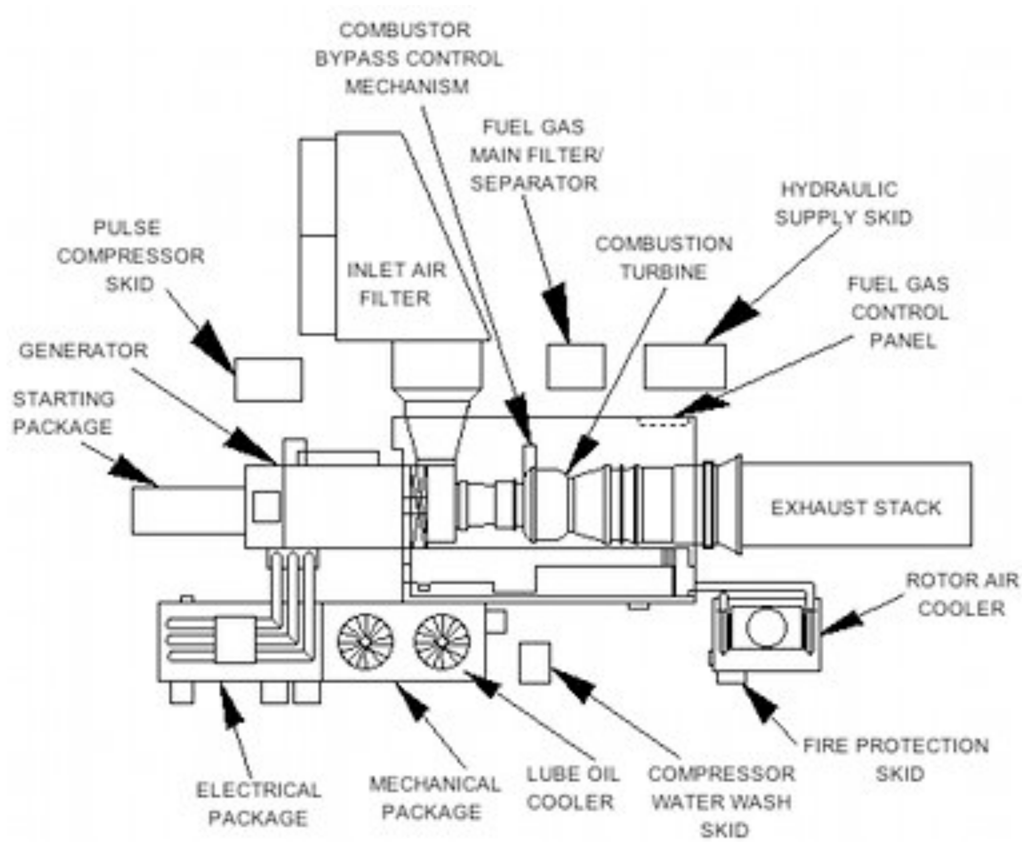
2.0 System Major Components

Chapter Objectives:

1. Describe how the Combustion Turbine System components perform their functions and how they interface with other system components.
2. Draw from memory a diagram of the Combustion Turbine System showing major components
3. State from memory, the names and functions of major Combustion Turbine System components.
4. Describe the construction of and flow paths through the major components.

The Combustion Turbine System Units 3 and 4 each consist of the following equipment:

1. Combustion Turbine
2. Generator
3. Starting Package
4. Heating, Ventilation, and Air Conditioning Systems
5. Fire Protection System
6. Lubricating Oil System
7. Turbine Air Systems
8. Control Oil System
9. Compressor Wash System
10. Fuel Gas System
11. Electrical Distribution System



Drawing 2 – Combustion Turbine Unit Layout

Figure 1 – Combustion Turbine System Unit 3

2.1 Combustion Turbine

The Combustion Turbine is the prime mover for the Generator. The Combustion Turbine is a single shaft, two-bearing, solid coupling, simple cycle unit. It contains a multi-stage (19) high efficiency axial-flow Air Compressor, a Combustion System, and a four-stage reaction type Turbine. The Compressor has Variable Inlet Guide Vanes and Interstage Bleed Ports on the sixth, eleventh, and fourteenth stages to control pressure. The Combustion System contains 14 can-type Combustors arranged in a circular array and is designed for low emissions.

The inlet to the Combustion Turbine forms a smooth passage for air flowing into the Compressor. It includes the Inlet Manifold and Inlet Casing. The Inlet Casing provides the Inlet Guide Vanes and housings for the Thrust Bearing and Forward Journal Bearing.

The Compressor Cylinder and Compressor Combustor Chamber are bolted together to form a Compression Chamber. This combined casing houses the 19 stage Compressor. It additionally incorporates the sixth and eleventh stage Bleed Air Manifolds as well as a manifold for air extracted from the fourteenth stage. The fourteenth stage manifold supplies cooling air to the second stage turbine vanes. High-pressure bleed air from the eleventh stage manifold is diverted to provide cooling air to the third stage turbine vanes. Low-pressure bleed air from the sixth stage of the Compressor is diverted in the same way to cool the fourth stage turbine vanes.

The Compressor produces a high compression ratio. Air in the Compressor flows in an axial direction through a series of rotating stages and stationary vanes (diaphragms), which are concentric with the axis of rotation. As the air passes through the various stages of compression, the pressure and temperature increase until they reach maximum levels at the last stage of the Compressor. From the Compressor exit, the air is expelled into the Combustor cavity.

The Combustor section, which includes the Combustor Baskets, is designed to burn a mixture of gas and compressed air. The Igniters, housed in the upstream end of the Combustor Baskets 5 and 6, must add sufficient heat energy to the fuel/air mixture to insure reliable ignition during startup. The Igniters are used only for starts, combustion being self-sustaining during acceleration and operation.

The four-stage Turbine Cylinder is the area in which the energy extracted from the high temperature gases discharged from the Combustion System is converted into mechanical rotation. This energy provides the force to drive the Generator for power output. Part of the force is also used to drive the common rotor assembly that consists of the Compressor Spindle and turbine Spindle.

The Exhaust Cylinder is composed of the Bearing Housing, the Inner and Outer Cones, the Exhaust Diffuser, and an Outer Case. After passing through the Turbine Cylinder, the combustion gases and cooling air enter the Exhaust Cylinder and are channeled between the Inner Cone and Outer Cone. The Outer Cone prevents excessive heating of the cylinder shell. The Inner Cone protects the Bearing Housing.

Figure 2 – Combustion Turbine

2.1.1 Combustion Turbine Data

Manufacturer	Siemens Westinghouse
Model	W501D5A Combustion Turbine Engine
Nominal rating	120 MW
Heat rating	9,900 Btu/kW in simple cycle configuration
Net plant efficiency at 3,600 rpm under ISO conditions	35 percent
Self-sustaining speed	2304 rpm

2.1.2 Combustion Turbine Controls

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2.2 Generator

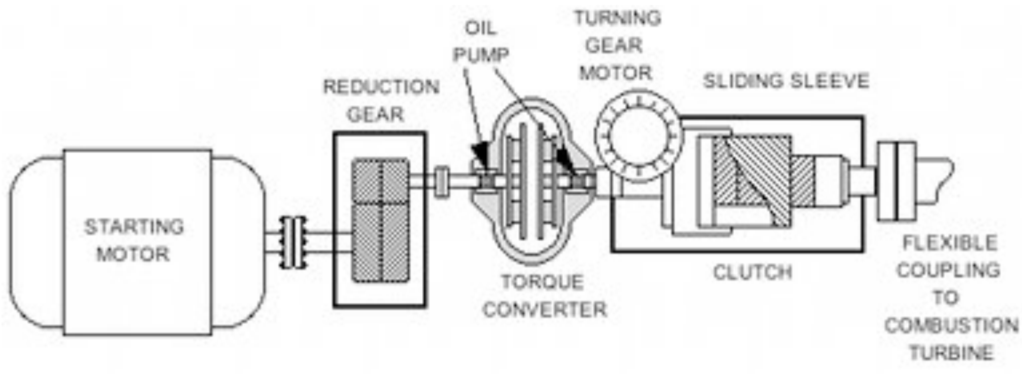
The Electrical Generation System consists of an open air-cooled Generator with an integral Inlet Air Filer Assembly and a Brushless Exciter Assembly. The Generator itself has two major components: the Stator and the Rotor.

2.2.1 Generator Data

Rated MVA / MW at 59 degrees F	147.5 MVA / 132.75 MW
Power Factor	0.90
Phases	Three (3)
Frequency	60 Hz
Line Voltage	13.8 kV
Speed	3600 rpm
Exciter	Brushless
Rotation (viewed from Exciter end)	Clockwise

2.3 Starting Package

The Starting Package provides breakaway and operating torque necessary to accelerate the Combustion Turbine Rotor from zero (0) speed to self-sustaining speed and then automatically disengages from the Combustion Turbine. A Turning Gear provides the initial breakaway torque. The Turning Gear is Driven by a 10 hp Electric Motor through a Step-Down Gearbox. The Turning Gear provides the breakaway torque necessary to initiate rotation of the Turbine Rotor from zero to 2.2 rpm. The 2050 hp Starting Motor through the Reduction Gear, Single-Stage Hydrodynamic Torque Converter, and Clutch provides the operating torque. The Turning Gear automatically disengages once the Starting Motor starts to accelerate the Turbine Rotor.



Drawing 3 – Starting Package Layout

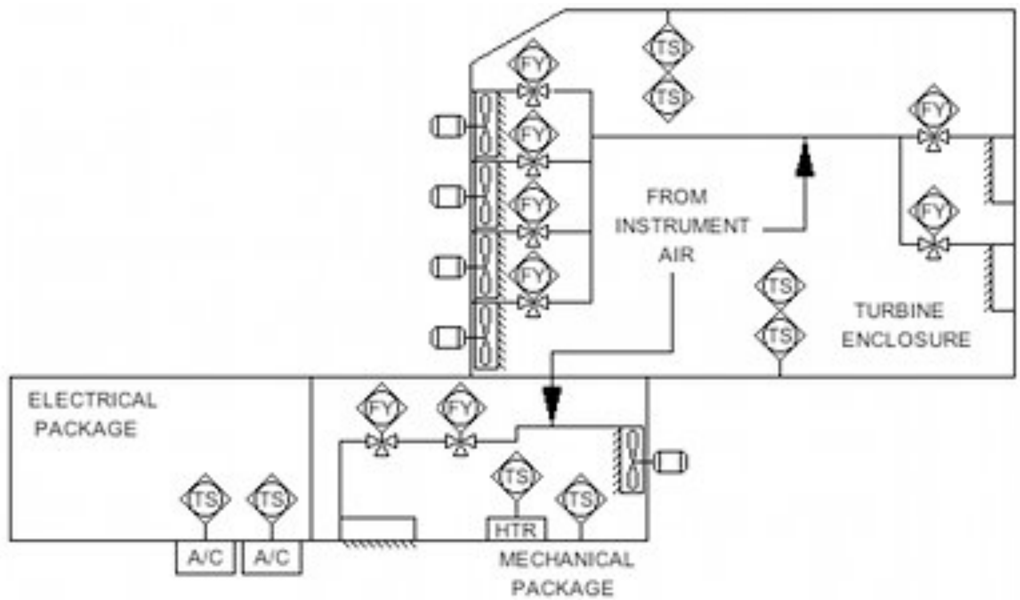
2.3.1 Starting Package Data

Turning Gear Motor	10 hp, 125 VDC electric motor with step-down gearbox
Turning Gear ratio	722:1
Starting Motor	2050 hp, 4160 VAC, 3 phase, 1786 rpm, 60 Hz electric squirrel cage type motor
Reduction Gear ratio	1:1.629
Torque Converter pressure	100 psig hydraulic

2.4 Heating, Ventilation, and Air Conditioning System

The Heating, Ventilation, and Air Conditioning (HVAC) system provides outside air for ventilation of the Mechanical Package and the Combustion Turbine Enclosure, and conditioned air (heated or cooled) for the Electrical Package. Thermostats control the temperature in each enclosure to provide a comfortable environment for the operating personnel and maintain temperature for the safe operation of equipment.

The Electrical Package Temperature Control System consists of two (2) Thermostats and two (2) Air Conditioning Units with built-in Heater Units. The Turbine Enclosure Ventilation System consists of four (4) Ventilation Fans with air-operated Louvers and Screens. The Mechanical Package Ventilation System consists of a single Ventilation Fan, Inlet and Outlet Louvers, a single Heater Unit.

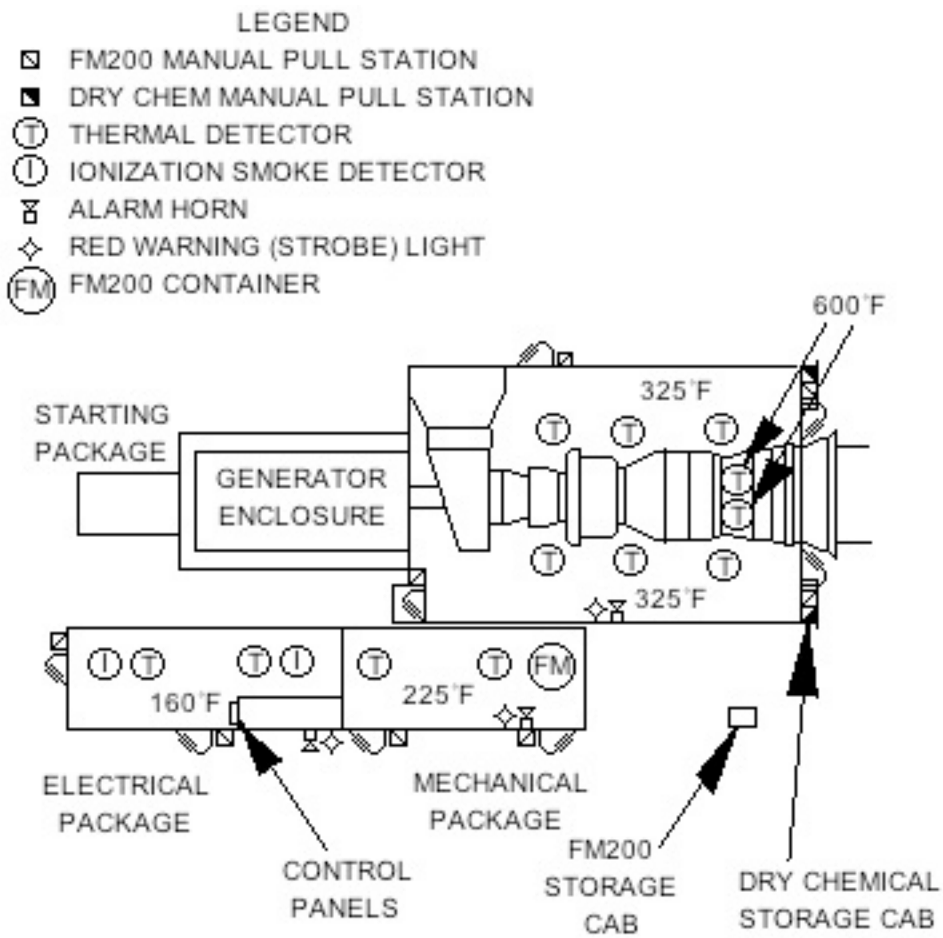


Drawing 4 – HVAC Layout

2.5 Fire Protection System

The Fire Protection System provides continuous early detection and protection of the Combustion Turbine Power Plant, auxiliary equipment, and operating personnel against the catastrophic damage that may be caused by fire.

The Fire Protection System is composed of two subsystems. The Fire Detection Subsystem consists of smoke and temperature sensing devices that are located in four protected zones, the Turbine Combustion System enclosures and Turbine Exhaust Bearing Tunnel. The Fire Suppression Subsystem consists of an automatically actuated Firemaster (FM) 200 flooding component that provides protection for the Electrical Package, Mechanical Package, and Turbine enclosures. An automatically actuated dry chemical system provides protection for the Turbine Exhaust Bearing Tunnel.



Drawing 5 – Fire Protection System Layout

2.5.1 Fire Protection Controls

The Fire Protection Control Panels are located in the Electrical Package Enclosure and provide system monitoring and control. Power is supplied from the 120 VAC panel board and converted to 24 VDC operating voltage. An automatic battery backup provides a source of DC operating power in case of loss of the 120 VAC power supply. The Fire Protection System will remain fully operational during a loss of normal power. Panel indicators indicate operational readiness of the 24 VDC backup power supply. All detectors, wiring, alarms, and solenoid release valves are constantly monitored by the Control System for electrical faults. Activation of any portion of the Fire Protection System requires the Control Panel to be reset to permit Combustion Turbine startup.

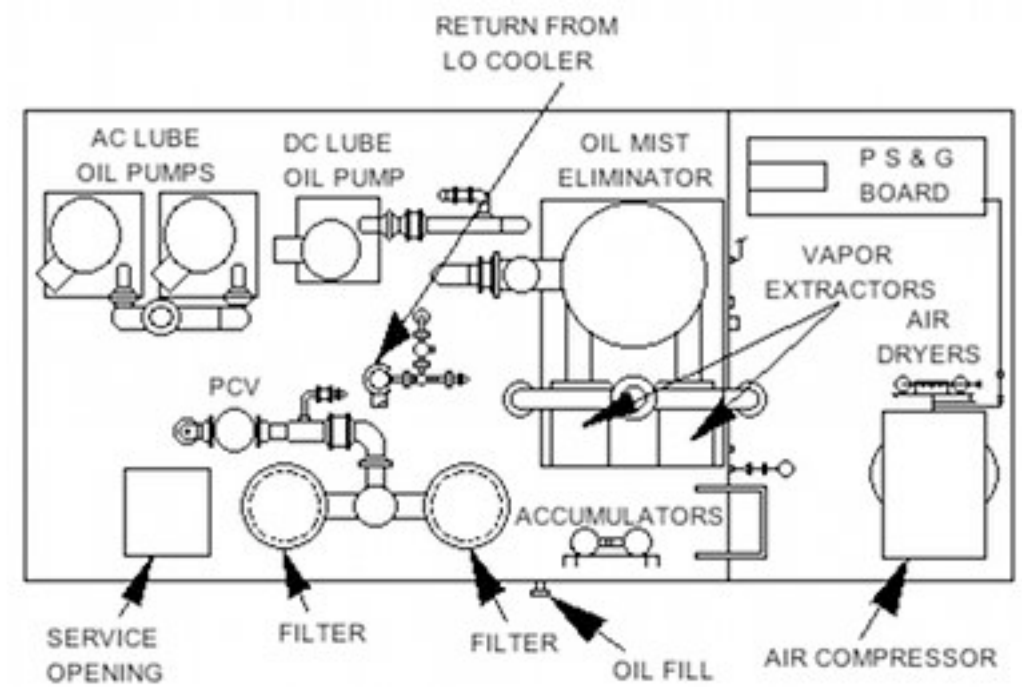
2.6 Lubricating Oil System

The Lubricating Oil System provides an uninterrupted supply of filtered oil at the required temperature and pressure to meet the lubricating requirements of the Combustion Turbine, the Generator and Exciter, and the Starting Package. Lubricating oil from the Bearing Supply Header is also utilized as the working fluid for the Starting Package, and as cooling flow to the Turbine Trunnion Supports.

The main components of the Lubricating Oil System are two (2) AC Pumps, a DC Pump, Reservoir, Duplex Oil Filter, Oil Cooler, two (2) Vapor Extractors, and temperature and pressure control valves. The Lubricating Oil System uses various pressure switches, level switches, and indicators to monitor system status.

Most of the Lubricating Oil System components are located in the Mechanical Package. The Lube Oil Cooler, Temperature Control Valve, and the Vapor Extractor Silencer/Vent are mounted on the top of the Mechanical Package.

Lubricating oil temperature must be greater than 70 degrees F before starting the Combustion Turbine. Lubricating oil temperature must be less than 145 degrees F for Turbine operation. An Electric Immersion Heater maintains the oil temperature while the Unit is idle. The Lube Oil Cooler prevents the temperature from increasing above the safe operating range during Turbine operation.



Drawing 6 – Mechanical Package Overhead View

2.6.1 Lubricating Oil System Data

Normal Reservoir capacity	3600 gallons
Maximum Reservoir capacity	4500 gallons
Nominal flow rate	650 gpm between 70 and 145 degrees F
Lube Oil Pump Head capacity	325 feet (approximately 120 psig discharge)

2.7 Turbine Air Systems

The four (4) Turbine Air Systems are the Inlet Air System, the Compressor Bleed Air System, the Turbine Cooling Air System, and the Instrument Air System.

The Inlet Air System provides clean compressor inlet air using a pulse self-cleaning filter system. Additionally, the system protects the Compressor from foreign objects, reduces turbulence, creates smooth laminar airflow, and attenuates the compressor air noise level.

The Compressor Bleed Air System provides volumetric control of the airflow in the Compressor through the use of Variable Inlet Guide Vanes and Compressor Stage Bleed Valves.

The Turbine Cooling Air System provides direct cooling to internal components and environmental control along the Turbine hot gas path through the use of compressor bleed air and cooled compressor discharge air.

The Instrument Air System provides clean, dry, pressurized air to all pneumatically controlled valves and processes.

Figure 3 – Pulse Compressor Skid

2.8 Control Oil System

The Control Oil System provides pressurized control oil for the operation of the Fuel Gas Throttle Valves, Variable Inlet Guide Vane Actuator, and Combustor Bypass Valve Actuator.

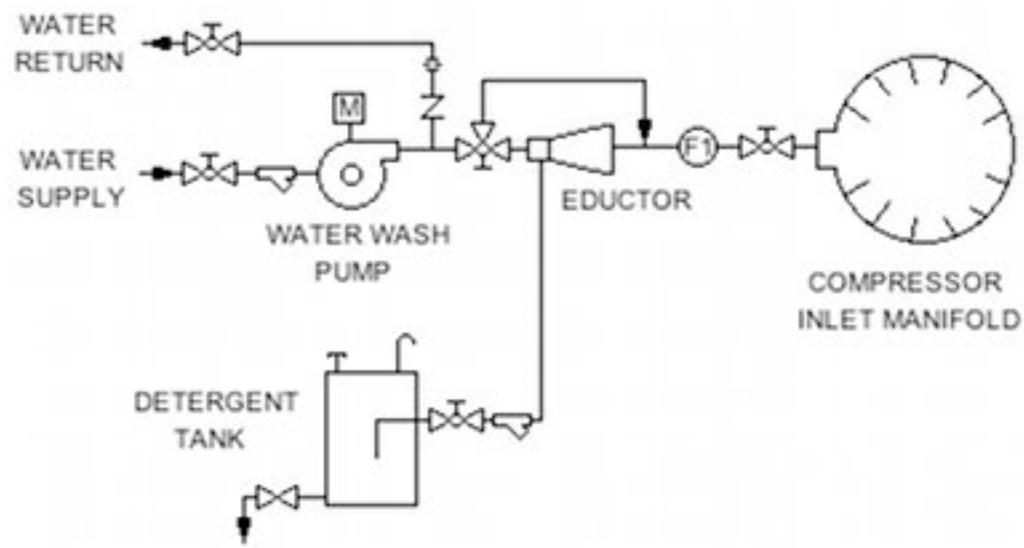
2.8.1 Control Oil System Data

Design Capacity	20 gpm of fluid
Nominal system pressure	800 psig
Oil	Mobile DTE 26

2.9 Compressor Wash System

The function of the Compressor Wash System is to remove substances, such as dust, salt, grease, hydrocarbon vapors, etc. that have deposited on both the rotating and stationary Compressor blading (predominantly the fist few rows) of the Combustion Turbine Compressor. This fowling can decrease airflow and discharge pressure, increasing the Turbine inlet and exhaust temperatures and ultimately decreasing the Turbine load capacity.

The Compressor Wash System consists of water supply piping, a Compressor Wash Pump, Compressor Wash Selector Valve, Compressor Wash Isolation Valve, Detergent Tank, Detergent Isolation Valve, Eductor, and Compressor Inlet Water Wash Manifold.



Drawing 7 – Compressor Wash System

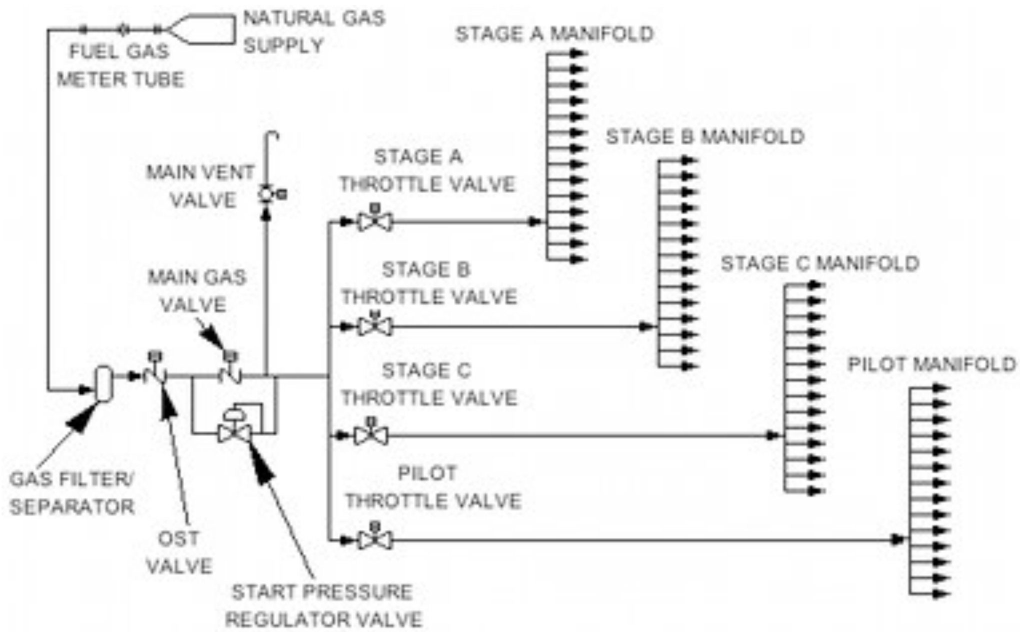
2.9.1 Compressor Wash System Data

Compressor Wash Pump	15 stage centrifugal pump
Compressor Wash Pump Motor	5 hp AC motor
Compressor Wash Pump capacity	25 gpm flow at 210 psig

2.10 Fuel Gas System

The Fuel Gas System delivers an accurately metered flow of clean natural gas under constant pressure to the Combustion Turbine. The Fuel Gas System controls the flow of fuel for all operating modes of the Combustion Turbine. Overfuel and overspeed protection are designed into the system. Block-and-bleed valve are provided to completely isolate the Combustion Turbine from the fuel gas supply when the Unit is not operating.

Fuel gas is supplied from the site's pressure regulating station to the boundary of the Fuel Gas System in the Combustion Turbine Enclosure. Prior to reaching the Fuel Gas Control System, the gas passes through a Fuel Gas Metering Section where the flow is measured and monitored by a Flow Computer.



Drawing 8 – Fuel Gas System

2.10.1 Fuel Gas System Controls

The Fuel Gas Panel is located on the inside of the Turbine Enclosure wall, adjacent to the fuel gas piping. The panel contains gauges, pressure switches, and pressure transducers that are used to monitor and indicate system conditions. The gas supply is also monitored for temperature and Throttle Valve flow and pressure elements that provide signals for control.

2.11 Electrical Distribution System

The function of the Electrical Distribution System is to safely provide power for the high (13.8 kV), medium (4160 V), and low (480 V) AC voltage requirements of the Combustion Turbine System. It also provides the capability to receive electric power for plant startup and emergency power for shutdown of the Unit's systems in the event of an AC power shortage.

The Combustion Turbine System is designed to receive electrical power from an external source at startup. When operating, the Combustion Turbine Generator is designed to provide 13.8 kV, three phase, 60 Hz AC power to a Switchyard through a Breaker and Step-Up Transformer. Power for generator excitation is provided from the Generator's 13.8 kV output through a Step-Down Transformer. Power to meet the Combustion Turbine System's 4160 VAC requirements is supplied from an existing 4160 V power source. The 480 VAC power is also supplied from an existing 480 V power source. The 125 VDC power is supplied through a Battery Charger attached to the 480 VAC Bus.

3.0 System Operation

Chapter Objectives:

Describe the Combustion Turbine System operation during:

- System Startup
- Normal Operation
- System Shutdown

NOTE: This System operation section is included for instructional purposes only, and should not be used as an operating procedure.

3.1 Combustion Turbine System Startup

1. Display the Ready-to-Start/Trips screen in the Control Room.
2. Initiate TRIPS RESET.
3. When the Ready-to-Start screen indicate that the Turbine is READY TO START, display the Startup Overview screen.
4. Make Pre-Start selections.
5. Select START to initiate the Startup Cycle.
6. If the Synchronizer is in MANUAL, close the Generator Breaker at the Electrical Package.

3.2 Combustion Turbine Normal Operation

1. At Generator Breaker closing, take temperature readings and pressure readings.
2. To increase above Minimum Load:
   a. Select BASE LOAD CONTROL.
   b. Enable the LOAD CONTROL field, and enter the desired megawatt target and load rate.
   c. Select TEMPERATURE CONTROL and monitor the MW REFERENCE as it increases to maximum.
   d. To stop load at any point prior to Base Load, select LOAD HOLD.
3. To decrease load:

a. Select MINIMUM LOAD and monitor the MW REFERENCE as it decreases to minimum. Actual output power decreases at the selected rate.
b. To stop decreasing load at any point prior to Minimum Load, select LOAD HOLD.

4. At desired load begin monitoring REACTIVE LOAD and control by the Voltage Regulator. If the Voltage Regulator is in MANUAL in the Control Room it must be reset to AUTO at the Electrical Package.

3.3 System Shutdown

1. Decrease load.
2. Close the Generator Breaker.
3. Initiate a NORMAL STOP.
4. Initiate first Spin Cooling cycle within five minutes of Turning Gear operation.
5. One hour after the first Spin Cooling cycle is completed, start the second Spin Cooling cycle.
6. Start the Turbine on SPIN HOLD.
7. Initiate the spin until stable spin speed is established. Do not exceed the five minute Starting Motor operation time to prevent overcooling.
8. Return the unit to the Turning Gear by initiating a NORMAL STOP.
9. Additional Spin Cooling cycles can be performed at one hour intervals if more cooling is required for maintenance access.