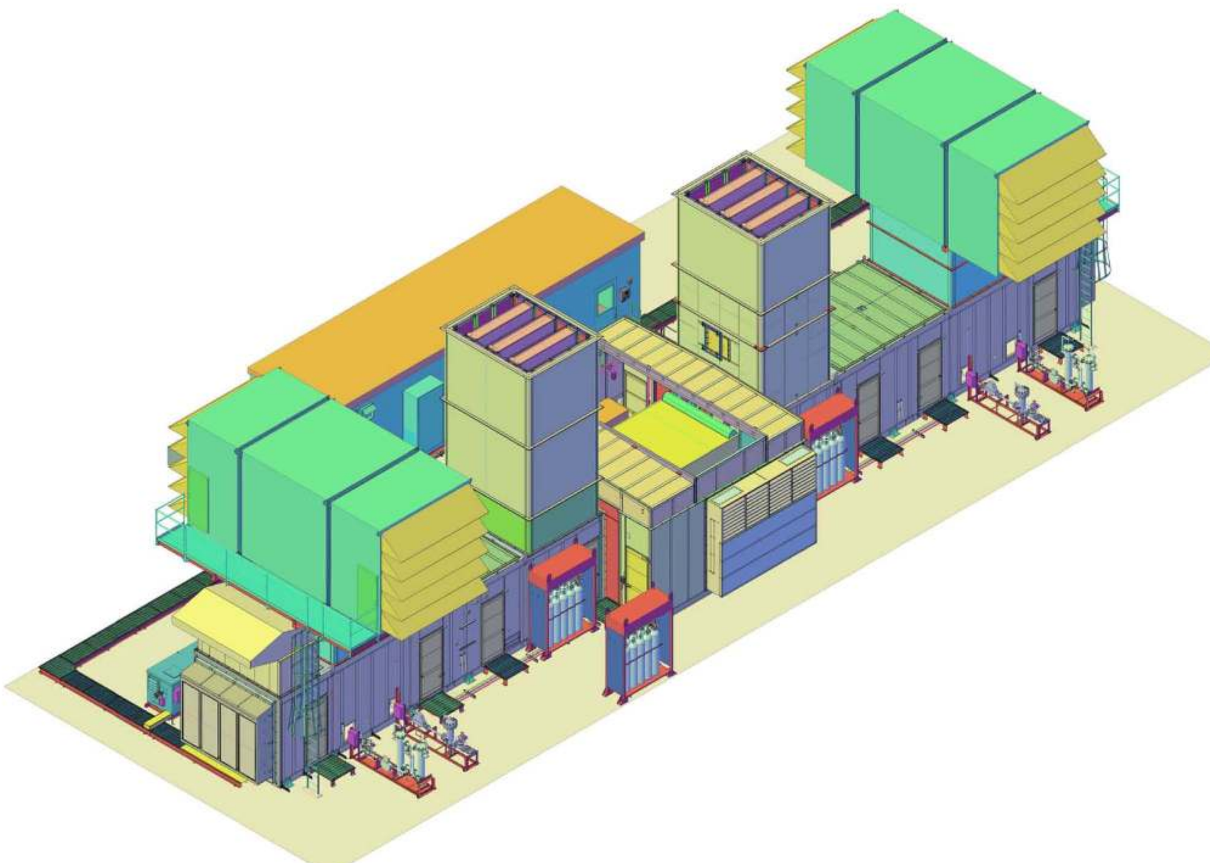
FT8® SWIFTPAC® UNIT EQUIPMENT DESCRIPTION – 60HZ



MMG TOWER Piso 16 Calle 53, Urb. Marbella Ciudad de Panana, Panama

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1. Introduction

The FT8® SWIFTPAC® Unit configurations are completely self-contained; gas turbine powered electric generating units containing all the equipment necessary for local automatic operation. The configuration consists of four (4) primary units – two (2) gas turbines units, the electric generator unit, and the electrical/control unit. The SWIFTPAC turbine and generator units consist of two opposed Industrial Gas Turbines directly connected through a diaphragm coupling to a single double-ended electric generator.

The SWIFTPAC power plants are designed to provide quick, reliable power. The plug and play packaging allows for reduced site setup time by delivering factory-assembled modules, quick disconnect cables and prefabricated field piping. Factory flushing and checkout is used where ever possible.

The electrical/control unit includes the 15 kV switchgear and all of the controls and instruments necessary for operation. The 15 kV switchgear is connected to the generator by prefabricated, totally enclosed, weatherproof, 15 kV class bus duct. The turbine/generator and electrical control units are housed in all weather, prime-painted steel enclosures including lighting and electrical services. Fire protection equipment is provided in the gas turbine enclosure.

The generating plant, as erected on a site, is ready for connection to the Customer's distribution system and water and fuel supply systems. The package concept of these type of power plants, coupled with their relatively small size, allow them to be readily installed in almost any location and conveniently relocated or combined with other units, or other equipment such as waste heat boilers, to meet changing load requirements.

2. Gas Turbine

The FT8 Industrial Gas Turbine consists of a GG8 gas generator and a PT8 power turbine (also referred to as a "free" turbine). The gas generator provides high energy gas to the power turbine, where this gas performs useful work when mechanically coupled to a driven load through a flexible coupling.

2.1. Gas Generator

The GG8 gas generator is based on the latest version of Pratt & Whitney's JT8D turbo fan aero engine, the JT8D-219. The JT8D is the most often used engine in the world's commercial aircraft fleet with more than 14,000 units accumulating over 400 million operating hours. The JT8D aero engine provides a total compression ratio of 20:1 and a thrust rating of 21,700 lbs. utilizing dual spool compressors and turbines.

The GG8 gas generator is an axial flow, gas turbine engine. The major components are two compressor modules, a combustion section, and two turbine modules. Inlet air passes through the low compressor and is then further compressed through the high compressor. The high pressure air is then diffused to a low mach number where it enters a large plenum consisting of nine fuel nozzles and combustion cans. Most of the air enters the combustion cans through the fuel nozzles and through the combustion can walls, which also cools the combustion chamber walls.

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A small portion of the air bypasses the combustion cans and is used to cool the turbine section. Two independent spark ignitors provide ignition for starting. Thereafter, combustion is self-sustaining. The hot gases pass through the single-stage high pressure turbine and the two-stage low pressure turbine, which extract energy to drive the two (2) compressor sections. The remainder of the hot gas energy is used for driving the power turbine. Controlling the flow of fuel to the combustion chambers regulates the output of hot gases.

The GG8 gas generator uses modulated cooling air to the Low Pressure Turbine (LPT) to maintain optimum clearances throughout the operating profile of the machine. This system includes cooling air valves on the gas generator that are controlled by signals from the electronic engine control.

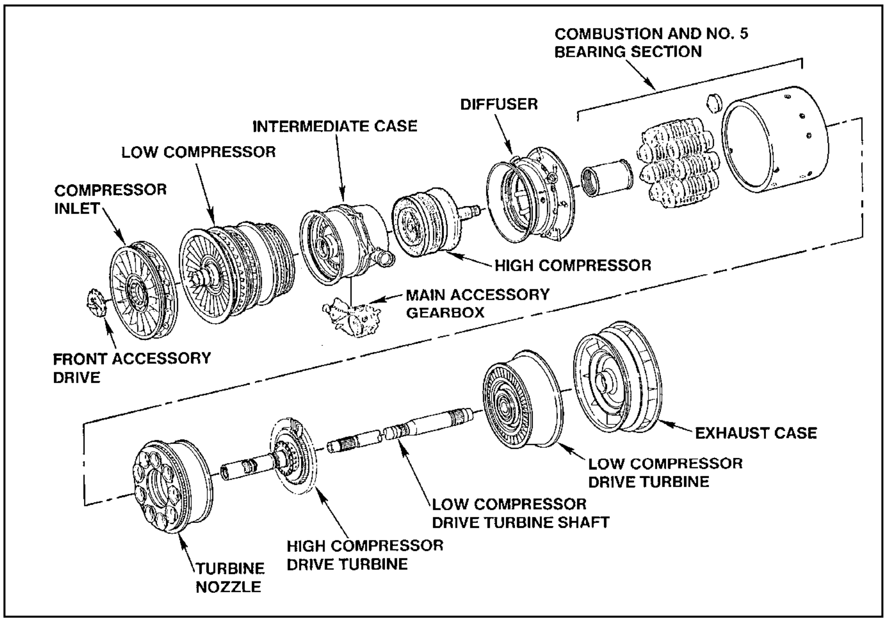


Figure 1: Major sections of the Gas Generator

2.1.1. Inlet Case Group

This group includes the inlet case, Number 1 bearing, and the Number 1 bearing housing. The case incorporates variable inlet guide vanes for directing air into the Low Pressure Compressor (LPC). The case also provides support for the Number 1 bearing. The front accessory drive houses the NL speed sensors.

2.1.2. Low Pressure Compressor

In the GG8 LPC the fan stage used in the JT8D is replaced with three booster compressor stages at the GG8 inlet. The inlet guide vanes plus the first two stages have been fitted with variable geometry. Variable vane movement provides optimum efficiency for the compressor in the complete speed range, and excellent part-load efficiency.

The LPC has 8 blade stages and 7 stator vane stages. The first two stator vane stages are variable. The LPC gas path is connected to the High Pressure Compressor (HPC) by the intermediate case. The intermediate case also provides a structural connection between the two compressor sections, provides support for the Number 2 and Number 3 bearings, is the location of the gas generator front mounts and is the stator vane stage for the last low compressor blade stage.

The LPC rotor is physically connected to the LPT rotor by a shaft that passes through the HPC and turbine.

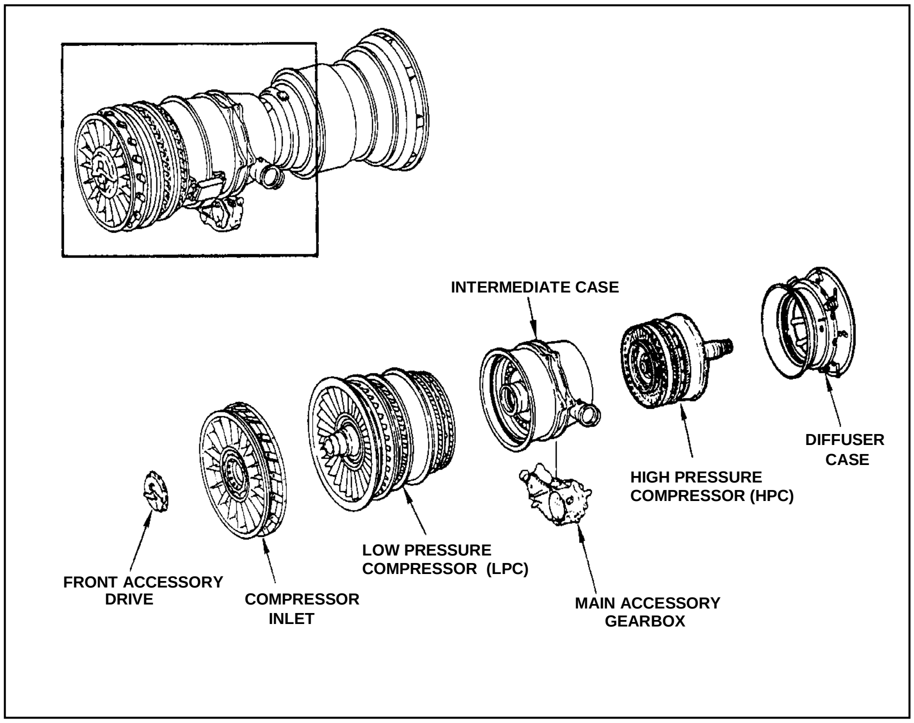


Figure 2: Gas Generator Cold Section Groups

2.1.3. High Pressure Compressor

The HPC consists of seven blade stages and seven stator vane stages, and is driven by the High Pressure Turbine (HPT) through a connecting shaft. The HPC operates at a higher rotational speed than the LPC. The gearbox, attached to the intermediate case, is driven through gearing from the front of the HPC section.

2.1.4. Diffuser Group

The diffuser case houses the Number 4 bearing that support the HPC rotor. The case also houses the nine fuel nozzle and support assemblies that provide fuel to the combustion chambers. The flow path of the diffuser case reduces the velocity and increases the static pressure of the compressed air before entering the combustion chambers.

2.1.5. Combustion Section

The combustion section has nine chambers arranged in an annulus around the turbine shafts and positioned between the HPC and the HPT. The combustion chambers are enclosed by inner and outer cases. The outer case can be unbolted and moved rearward to allow for inspection or removal of the combustion chambers and fuel nozzles.

Combustion chambers Nos. 4 and 7 each accommodate an igniter plug. During initial ignition, flame is propagated from these two chambers to the remaining chambers through integral flame crossover tubes, which interconnect all nine chambers.

The combustion chambers and nozzles were modified to allow liquid fuel, gaseous fuel, or both simultaneously. Water injection can also be utilized with these combinations. The combustion chamber outlet duct consists of inner and outer annular burner liners with a front bulkhead for support of the nine cans. This outlet duct directs the hot air to the high turbine nozzle guide vanes.

2.1.6. Turbine Nozzle Group

This group includes the turbine inlet nozzle guide vanes that direct the hot gas flow from the combustion chambers to the HPT blades. Parts in this group also provide support for the outlet end of the combustion chambers.

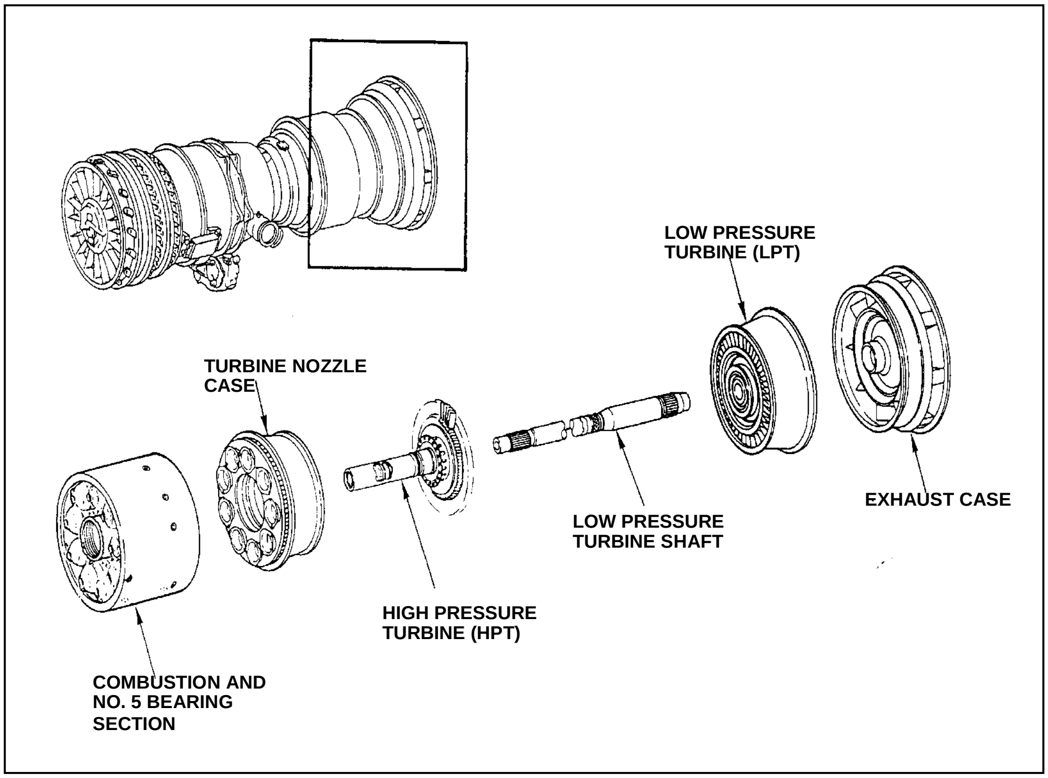
The inner support for the nozzle guide vanes includes the tangential on-board injection (TOBI) system which provides 13th stage compressor air for cooling of the HPT blades and attachments.

2.1.7. High Pressure Turbine

The HPT is a single stage turbine with shroudless, air-cooled turbine blades. The HPT is supported by the Number 5 bearing. The HPT is physically connected to the HPC by the HPT shaft. The turbine blades are cooled by 13th stage compressor air that flows through passages within each blade. Air from the TOBI duct enters the blades at the root attachment area after passing through passages at the front of the 1st stage turbine rotor.

The HPT converts thermal and kinetic energy from the gas path into shaft horsepower to drive the HPC.

Figure 3: GG8 Hot Section Groups



2.1.8. Low Pressure Turbine

The LPT has two turbine rotor stages and two stages of turbine vanes. The front blade and vane rows are air cooled, and both blade rows utilize shrouded tips. These turbine stages use tip shrouded blades. The last stage vanes are clustered. Each vane cluster consists of three vane airfoils. The LPT shaft connects to the LPC. The LPT converts kinetic energy from the gas path into shaft horsepower to drive the LPC.

2.1.9. Turbine Exhaust Case

The Turbine Exhaust Case (TEC) forms the discharge path for the exhaust gas flow into the power turbine. The case also provides physical connection to the power turbine and houses the Number 6 bearing, which supports the rear of the LPT rotor.

Pressure oil supplied to the TEC provides lubrication for the Number 6 bearing and for the Number 4½ bearing.

2.1.10. Bearings

The FT8 lube oil system is a combined system, containing the gas generator lube oil system and the power turbine lube oil system, together with necessary filters, cooler, and reservoir.

Anti-friction ball and roller bearings are used throughout the gas turbine since they absorb about 50% less power than sleeve or hydrodynamic bearings and require a less expensive and less complex lubrication system. They can also withstand intermittent losses of lubricant flow for time periods that would be catastrophic to sleeve bearings. Main bearings carry the radial and axial thrust loads of the rotors.

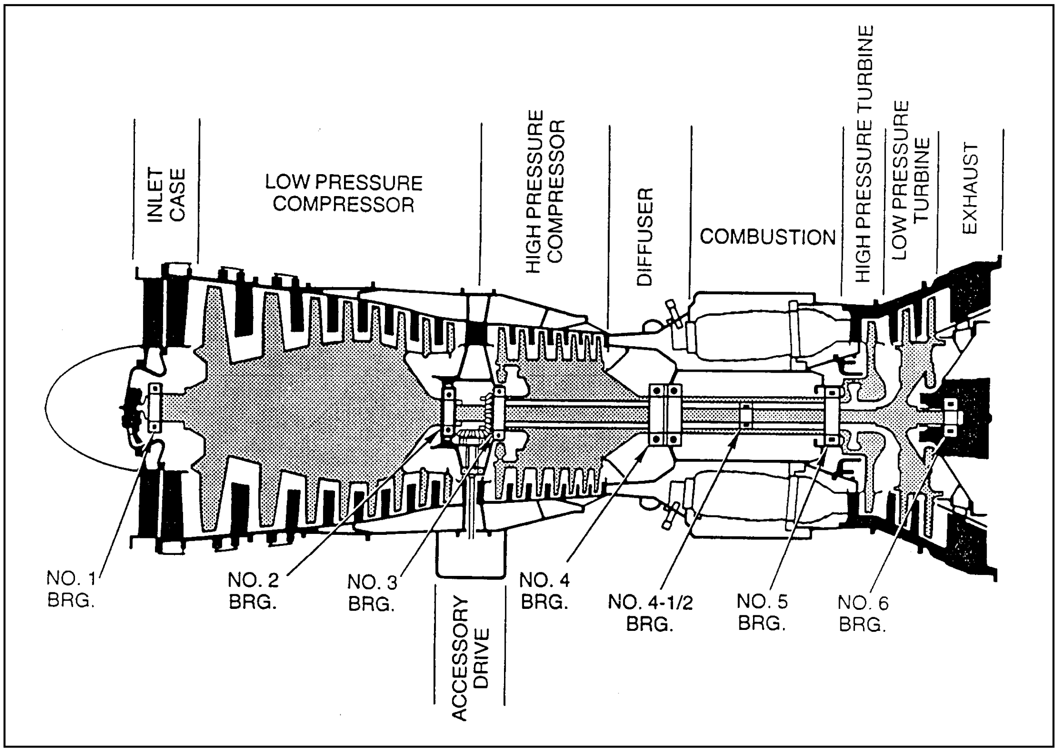


Figure 4: Gas Generator Bearing Locations

Bearing	Type	Support For
No. 1	Oil damped roller	Front of LPC
No. 2	Ball	Rear of LPC
No. 3	Ball	Front of HPC
No. 4	Duplex Ball	Rear of HPC
No. 4 ½	Roller	mid
No. 5	Oil damped roller	HPT
No. 6	Oil damped roller	LPT

The oil damped bearings have a layer of pressurized oil around the bearing outer diameter to absorb rotor-induced vibration during engine operation.

2.2. Power Turbine

The power turbine consists of an annular, transition duct connected to the gas generator; a single four-stage, axial flow, reaction turbine; and an exhaust casing consisting of exit guide vanes and rear bearing support that connects to the diffuser section and an exhaust collector. The power turbine is supported by two anti-friction roller-type journal bearings and one ball-type thrust bearing.

The turbines can rotate in either direction allowing for a SWIFTPAC configuration. As expected, the SWIFTPAC configuration has twice the power capacity of POWERPAC configuration. In SWIFTPAC configurations, the generator is driven from both sides.

The power turbine converts the thermal and kinetic energy of the gas generator exhaust into a rotational force. This force is transmitted to the driven equipment via two flexible couplings and drive shaft.

2.2.1. Inlet Section

The inlet case and inner and outer ducts of the power turbine form an annulus, which directs the gas generator hot gas exhausts to the power turbine. The inlet case, the only power turbine part physically attached to the gas generator, carries the structural load of the gas generator to the power turbine supports. The shaded section of the following figure depicts the inlet section.

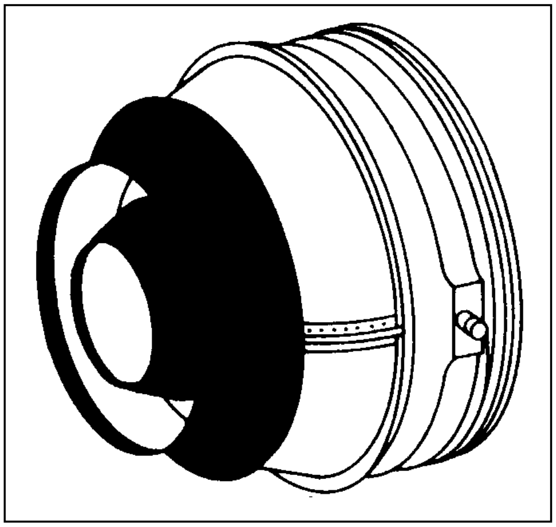


Figure 5: Inlet Section

2.2.2. Turbine Case and Vane Assembly

The vanes direct the hot gases to the turbine blades at the proper angle for maximum rotor efficiency. They form an assembly with the split turbine case. The shaded section in the following figure depicts the turbine case and vane assembly.

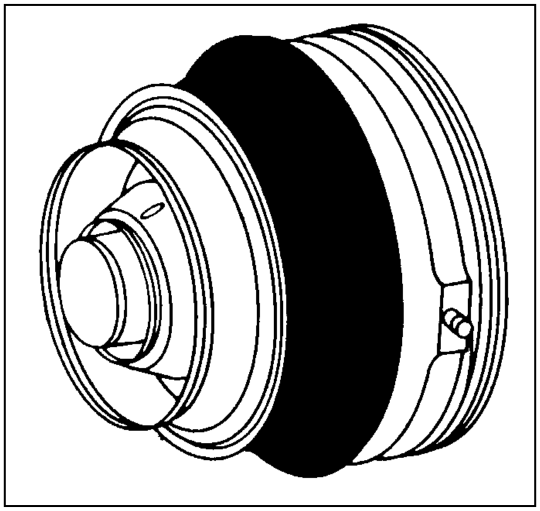


Figure 6: Turbine Case and Vane

2.2.3. Rotor Assembly

The power turbine rotor is composed of a four-stage disk and blade assembly, supported by anti-friction bearings on each end. The hot gases directed against the blades turn the rotor, creating the mechanical energy to drive the output shaft. The shaded section in the following figure depicts the rotor assembly.

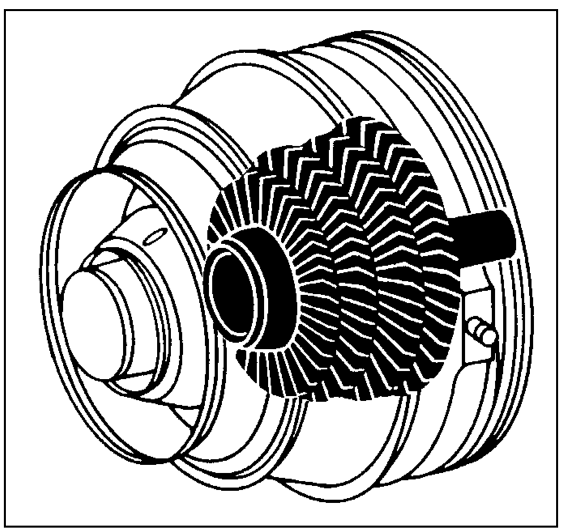


Figure 7: Rotor Assembly

2.2.4. Exhaust Case Section

The exhaust case section turns the exhaust gases via exit guide vanes to axial flow before entering the diffuser section. The case structure supports the rear bearings and rear engine mounts. The shaded area in the figure below depicts the exhaust case section.

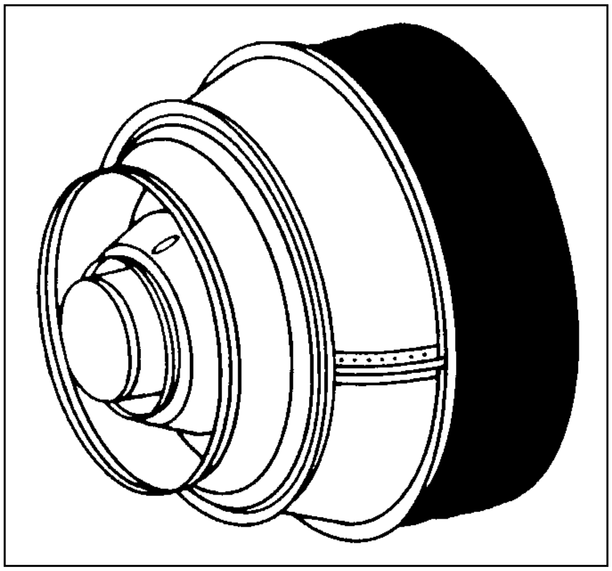


Figure 8: Exhaust Case Section

2.2.5. Diffuser and Turning Vane Assembly

The diffuser and turning vane assembly reduces the velocity and increases the static pressure of the exhaust gas flow. The diffuser directs the gas flow from the power turbine through a conical annulus surrounding the power turbine shaft. The conical annulus ends in three annular, flared exit baffles, the diffuser turning vanes. The vanes redirect the gas flow 90 degrees from all circumferential locations into the collector box for exhaust, in simple cycle configurations, to the stack acoustical system and then to the atmosphere. In combined cycle configurations, the gas flow would be exhausted to the heat recovery steam generator inlet ducting rather than the stack acoustical system. The diffuser and turning vane design permits the smoothest possible movement of exhaust gas through the exhaust system, minimizing backpressure and maximizing efficiency.

2.2.6. Output Drive Shaft

The output drive shaft extends through a cavity in the exhaust diffuser, and exits through the rear of the collector box. It transmits mechanical energy to the driven equipment (such as an electrical generator). The front of the shaft is connected to the rotor with a flexible coupling. The rear of the shaft is connected to the driven equipment with a flexible coupling. The output drive shaft is shaded in the figure below.

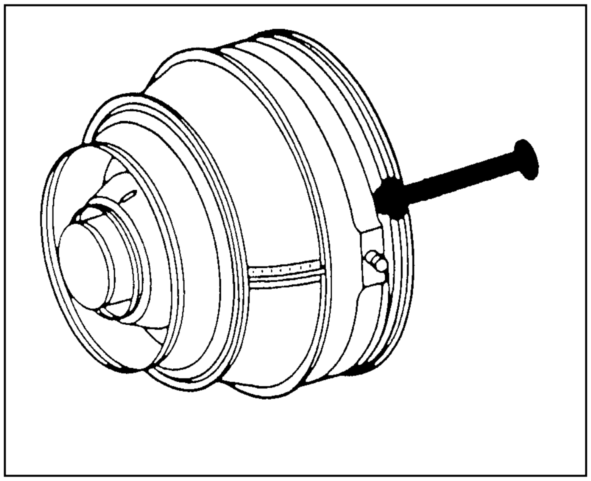


Figure 9: Output Drive Shaft

2.3. Collector Box

The collector is suspended from the exhaust enclosure. It receives exhaust gases from the diffuser and turning vanes. The gases are then exhausted through the silencer sections to the atmosphere, or through an optional heat recovery system.

2.4. Mounts

The mounts, located at the 3 and 9 o'clock positions on the power turbine exhaust case, provide the rear support for the gas generator/power turbine system. The mounts are adjustable vertically and horizontally. There is also a bottom mount pin, which positions the gas generator/power turbine system in the axial and lateral directions. This allows radial thermal growth.

2.5. Cooling Air and Thrust Balance System

One cooling air tube from the gas generator HPC case and two tubes from the LPT exhaust case provide thrust balance and cooling air to the power turbine. The two tubes from the LPT provide cooling air to the first stage disk and blade attachment as well as providing cooling air to the No. 7 bearing support and first vane attachment. The air tube from the HPC provides thrust balancing air to the backside of the rotor to offset the gas path air loads and also provides cooling air to the rotor bore and stages 2-4 disk and blade attachments. This air is also providing cool buffer air to the Nos. 7, 8 and 9 bearing compartment seals.

2.6. Bearings

Bearing	Type	Support For
No. 7	Roller	Front of rotor
No. 8	Ball	Rotor (axially)
No. 9	Roller	Rear of rotor

3. Ancillary Systems

3.1. Lubrication/Hydraulic Control

The FT8 lube oil system is a combined system, containing the gas generator lube oil system and the power turbine lube oil system. Components not integral to the gas turbine are mounted as a pre-engineered package inside the GT enclosure. This package contains the combined reservoir, duplex filters, chip detectors, air-to-oil cooler, and the power turbine supply and scavenger pumps.

The gas generator (GG)supply and return lines terminate at the accessory drive engine mounted gearbox. Since both the GG supply and scavenge pumps are hard coupled to the low-pressure and high-pressure compressor shafts, positive pressures are generated by shaft rotation. This system also supplies oil to the hydraulic control system pump suction port . The gearbox driven hydraulic high pressure pump and servo valve supply control oil to the IGV/VSV compressor actuators.

The power turbine lube oil system lubricates and cools the main bearings and bearing seal assemblies. Lubrication is provided by identical three-element pumps, which provide primary and auxiliary flow functions. The primary and auxiliary pumps are AC motor driven while the emergency pump is a DC motor driven.. The auxiliary pump automatically starts in case of trouble with the primary pump. The DC pump is used for emergency shutdown when AC power is lost.

3.2. Gas Fuel System (when specified)

Customer supplied fuel per PWPS FR-2 Gas Fuel Specification is delivered at a minimum of 475 psig (32.8 bars). First, the gas flows through a fire valve. Next, the gas flows through a simplex particulate filter, coriolis flowmeter , pressure safety valve to the fuel plate located on the GT base assembly. Gas flows through two shutoff valves and the modulating valve to the gas manifold, where it is injected through the nine gas fuel nozzles. The modulating valve meters fuel in response to signals from the electronic gas turbine control. See specific P&ID for all system components.

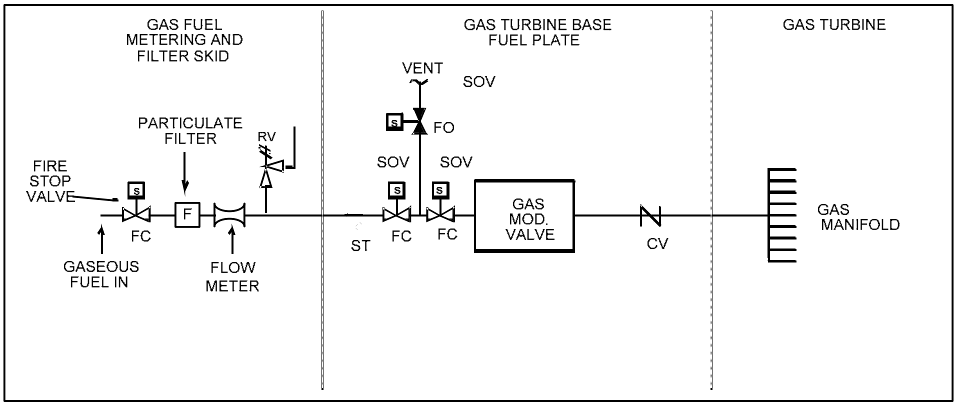


Figure 10: Gas Fuel System

3.3. Liquid Fuel System (when specified)

In the liquid system, fuel per PWPS FR-1, Liquid Fuel Specification in a flooded suction line from the fuel storage tanks is pumped by the Customer supplied fuel forwarding system to the PWPS filtering and metering skid which contains a duplex particulate filter and a coriolis meter to a downstream fire stop valve. Next, the fuel is boosted by the gas generator gearbox mounted fuel pump, and sent to the metering valve with an integral shutoff valve. The metering valve meters fuel in response to a signal from the electronic gas turbine control. The fuel then flows through another fuel shutoff valves and an engine mounted flow divider valve, into the manifold and through the nine liquid fuel nozzles. See specific P&ID for all system components.

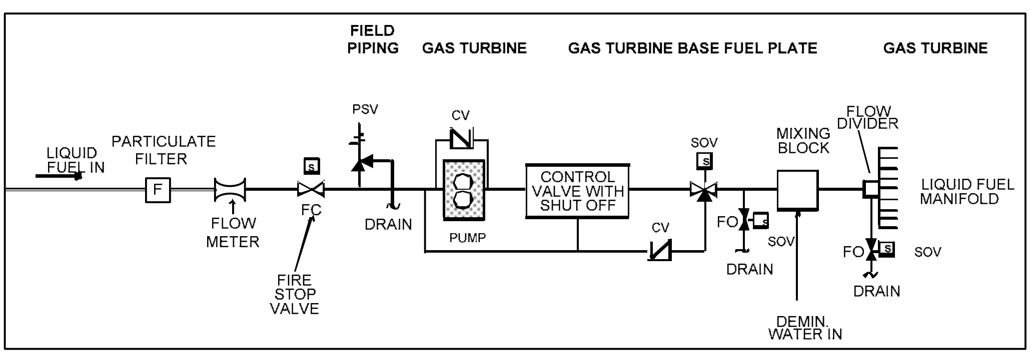


Figure 11: Liquid Fuel System

3.4. Dual Fuel System (when specified)

The dual fuel system utilizes the same components as the gas and liquid fuel systems plus a liquid fuel pump clutch and additional valves to allow switching from one fuel to the other. At startup with liquid fuel selected, the fuel pump is engaged and liquid fuel flows through the liquid modulating valve and liquid shutoff valve into the liquid fuel manifold to the nozzles. At shutdown, the pump is disengaged, the liquid modulating valve and liquid shutoff valves are closed, the liquid drain valves are opened to prevent pressure buildup downstream of the shutoff, and the manifold drain valve is opened to drain the manifold.

When gas fuel operation is selected, gas flows from the supply through two shutoff valves, through the modulating valve to the gas manifold. A small amount is sent through the liquid system purge valve to the liquid fuel manifold for continuous purging of all liquid fuel from the manifold and nozzles cool and prevent choking of the liquid fuel section of the nozzles. At shutdown, the shutoff valves are closed and the vent line between shutoff valves is opened to relieve pressure.

The gas turbine has the capability to transfer from one fuel to the other during operation.

3.5. Water Injection System (when specified)

The water injection system introduces demineralized water with the fuel into the nozzles of the gas turbine to assist in achieving required exhaust gas emission levels. The system operation is automatically controlled by the electronic gas turbine control.

The demineralized water is Customer supplied to the water injection skid located just outside the gas turbine enclosure. The skid contains a particulate filter, VFD motor driven pump to boost the water to the required pressure, coriolis flow meter and necessary valving.

When operating on liquid fuel, the water is mixed with the fuel and sent through the liquid fuel nozzles. When running on gas fuel, the water is sent through the liquid fuel nozzles and the gas through the gas fuel nozzles. During fuel transfer, the water is mixed with the liquid fuel and injected through the nozzles via the liquid fuel manifold, while the gas flows through the gas fuel nozzles.

3.6. Starting System

The starting system consists of a hydraulic starter mounted on the gas turbine and a skid-mounted hydraulic start pac. When the operator initiates a start, the hydraulic start pac provides high-pressure fluid to the starter motor geared to the high compressor rotor shaft of the gas generator. The starter converts the fluid pressure to shaft torque and rotates the high-speed rotor to ignition speed in approximately 17 seconds.

After fuel is admitted to the gas turbine combustion section and ignition is achieved, the gas turbine accelerates to its self-sustaining speed and the starter is disengaged from the shaft. If any problems are detected during the start cycle, the control shuts off fuel flow and hydraulic fluid flow, causing the starter to disengage and the gas turbine to coast down.

The starting system is also used to rotate the gas turbine rotors for water wash and/or gas path purge. When water wash is selected, the hydraulic start system is used to motor the gas generator while water, with or without detergent, is sprayed into the bellmouth. During a purge operation, gases accumulated in the gas turbine are purged by motoring the gas generator with the starting system to above 1500 rpm with the ignition and fuel systems off per requirements.

3.7. Fire Protection System

The fire protection system provides independent fire detection for the entire plant and CO_2 total flooding fire suppression for the gas turbine enclosure, CO2 suppression is strongly recommended as an option for the generator as well as FM200 suppression for the control enclosure.

Automatic fire detection is provided by rate compensated thermal detectors. Facilities for manual (electric and mechanical) initiation of the fire systems are also provided. The CO_2 tanks, solenoids, and manifold are located outside the enclosures, with the system's control module located in the control room.

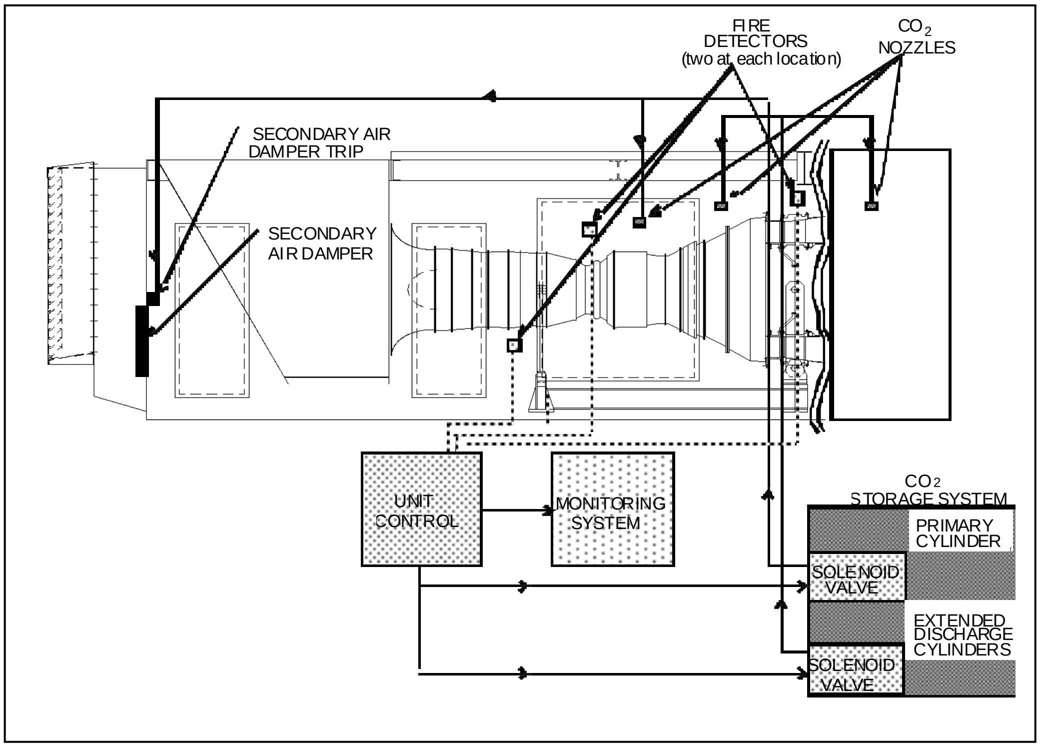


Figure 12: Fire Protection System

The control system monitors and displays the status of all fire system inputs and provides outputs to activate audible and visual alarms, discharge CO_2, close fuel fire safety valves, and signal turbine and unit control systems for required responses. The system operates on 24 volts DC and contains its own internal power supply and battery backup.

Immediately upon actuation of the system, the turbine enclosure secondary air supply fans are deenergized and the fuel supply is shut off. A 20-second time delay permits rundown of the gas turbine and generator before a solenoid valve releases the pressurized CO_2 into its distribution manifold. A pneumatic cylinder, actuated by the pressurized CO_2, releases a pair of guillotine type dampers (just forward of the fan blades) closing off the secondary air path.

Simultaneously, a series of nozzles floods the enclosures to a 34% CO_2 concentration, sufficient for inerting the combustion process.

The CO_2 supply to the manifold is fed from pressurized tanks. The first tank is quick emptying, while the second slow-emptying tank maintains the 5% level required to overcome dilution from air leakage. This CO_2 concentration is maintained for approximately 30 minutes, sufficient time to allow combustibles to cool below their auto ignition temperatures. A CO_2 status display board is provided near each protected enclosure entry to visually indicate the status of the fire protection system (i.e. CO_2 armed or disarmed).

Disarming may be accomplished by disabling the CO_2 discharge system, either electronically by means of a key switch and/or blocking the flow of CO_2 by a manually activated safety block valve in the CO_2 piping discharge system. When disarmed the detection alarm system will remain active while the CO_2 discharge capability will be disabled. Continuous alarm signals are sent to the monitoring system notifying the operator while the system is disarmed.

Additional safety features include a suppressant release delay and audible and visual alarms inside and outside the enclosure.

3.8. Gas Detection System

A resistance type combustible gas sensor provides gas detection in the gas turbine enclosure. When the gas concentration reaches 20% lower flammable level (LFL), the gas hazard alarm will be displayed in the fire control panel and warning alarms will be activated at the enclosure. When a 60% LFL level is reached an automatic trip of the fuel and gas turbine will be initiated. The enclosures ventilation system will remain operational to reduce the gas hazard.

3.9. Engine Heating (Dehumidification) System

The engine heating system maintains the internal parts of the gas turbine at a temperature above the dew point of the ambient air during non-operation periods. Hot air forced into the compressor section and out through the exhaust and inlet ducts prevents condensation, which can cause corrosion. The system is fully automatic.

3.10. Offline Water Wash System

The gas turbine requires periodic washing of its aerodynamic components that have accumulated deposits which could affect performance.

A water wash circuit, when activated by the operator, energizes a solenoid valve in the water wash line. The water flows through a nozzle located inside the inlet air plenum, directed toward the gas turbine's inlet. While the gas turbine is rotated on the starter, the sprayed water is pulled through the compressor section of the gas turbine and is drained through drain valves. After washing, the gas turbine is started to dry out any remaining water.

The water wash skid is optional.

4. Electric Generator

The electric generator is an open ventilated, two-pole, air-cooled unit rated to BS/IEC standards with Class “F” insulation but limited to Class “B” temperature rises on a total temperature basis. It includes shaft mounted overhung main and pilot brushless exciters complete with rotating fused diodes, and all required support auxiliaries, instrumentation, protective devices, and controls.

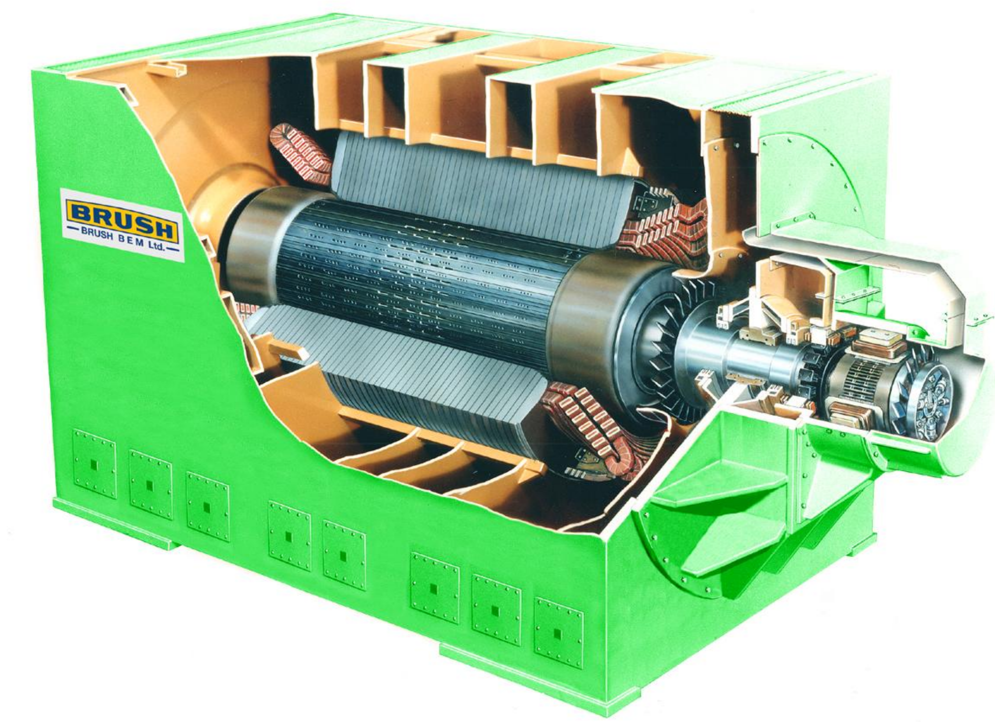


Figure 13: Electric Generator

4.1. Stator

The stator frame is fabricated from mild-steel plate, forming a rigid structure. The stator core is built up from laminations of low loss, high permeability, and high silicon content electrical steel. Radial ventilating ducts are formed at intervals along the core by “H” section steel spacers. The core is hydraulically pressed at several stages during the building operation to ensure uniform compaction. When finished it is clamped between heavy ribbed steel end plates split on the bearing lines. The stator winding is of the two-layer diamond type half coils being used for ease of handling during manufacture and winding.

The insulation system is based on a resin rich thermosetting mica glass tape which, when processed results in a dimensionally stable high performance insulation capable of continuous operation at temperatures up to 155ºC (Class F).

The half coils are placed in the stator slots in two layers, wedged securely in position by synthetic resin bonded wedges, and joined by brazing the copper laminations. The end winding is securely braced to insulated brackets supported from the stator frame. The individual sub-conductors of all windings are fully transposed to ensure minimum circulating currents. "Nose" type or Roebel transpositions are used as appropriate.

4.2. Rotor

The rotor is an integral forging of nickel chromium molybdenum alloy steel. Axial slots are milled on the periphery of the body of the rotor to carry the winding and for ventilation. The rotor winding conductor material is conventional silver bearing copper. The conductor is in the form of a strip and each rotor coil is preformed to the shape required. All insulation materials are suitable for Class "F" operation.

The preformed coils are inserted into the slots, each turn being insulated from the next. After the completion of the winding, the conductors are heated electrically and pressed to the correct depth using pressing rings. A fully interconnected damper winding is then fitted into the tops of the slots and the retaining wedges are inserted. The rotor end winding is braced with packing blocks between the conductors, after which the non-magnetic manganese chromium steel end caps are shrink fitted to spigots at each end of the rotor body. All rotors are tested at 20% overspeed and balanced.

4.3. Bearings

The main bearings are conventional circular profile, white metal lined, hydrodynamic cylindrical bearings. Pressurized oil seals are fitted at each end of the bearings. Temperature detectors are provided for the bearing metal and oil drains. Non-contact vibration sensors are provided for both bearings.

4.4. Ventilation

The generator features integral axial flow fans which supply a large volume of filtered cool air flowing through the frame and over the stator and rotor coil ends and windings via inter slot ventilation ducts and discharging at the top of the frame. The exciter is self-ventilated.

4.5. Lubrication

A separate air cooled lubrication system is provided, including a storage tank with radiator and cooling fan, two AC motor driven lube oil pumps, and a DC motor driven emergency backup pump for emergency coastdown or black start.

4.6. Excitation Systems

The generators are fitted with a brushless excitation system, where the excitation power is derived from a small AC generator driven by the generator shaft. The AC power produced by this exciter is rectified to DC by a shaft mounted rotating rectifier assembly, which is connected to the main field via conductors inside the shaft, thus eliminating the need for slip rings.

4.7. Voltage Regulator

The generator has a Automatic Voltage Regulator (AVR) system with manual control, auto follower, and null balance indication. In the event of a fault in the excitation and voltage monitors automatically transfer to manual control.

The AVR, which controls the excitation of the generator, is housed in a 19-inch rack assembly that has the advantages of compact modular construction, enabling a wide range of optional features to be readily incorporated into the excitation system. Power to operate the unit is supplied from a permanent magnet pilot exciter mounted on the generator shaft.

The unit includes the following solid state plug-in modules and facilities:

- Hand control bridge
- Auto control bridge
- Voltage control card including over flux limiter
- Diode failure detector and fast acting current limiter
- Excitation limiter card including over and underexcitation limiters with ambient temperature compensation
- Falling frequency protection
- "Soft start" circuit to minimize voltage buildup overshoot
- Power factor card for constant power factor or constant reactive power control

The AVR has a voltage adjustment range of ± 10% and accuracy of regulation of no load to full load.

4.8. Generator Data

4.8.1. Manufacturer

Brush Electrical Machines, Ltd. ***or equivalent***

4.8.2. Type

Synchronous, direct air-cooled, cylindrical rotor, and two-bracket bearing AC generator with brushless exciter and permanent magnet pilot exciter. Class F insulated rotor stator.

Note: Rating details and performance curves are found in the attached Manufacturer's Data Sheets.

5. Electrical Control Center Enclosure

The electrical/control center enclosure contains all of the equipment necessary for local control of the FT8, together with the switchgear and generator protective devices. The enclosure is temperature controlled per equipment requirements and is designed for global installation.

The enclosure contains the gas turbine and generator controls, motor control center, low voltage AC and DC distribution, station batteries, metal-clad switchgear, station auxiliary transformer, protective relaying, and master terminal board. These controls and instruments are mounted on the following cabinets:

- Monitoring Cabinet
- Operator Cabinet
- Master Terminal Cabinet
- Protective Relay Cabinet
- Instrument Cabinet
- Motor Control Center

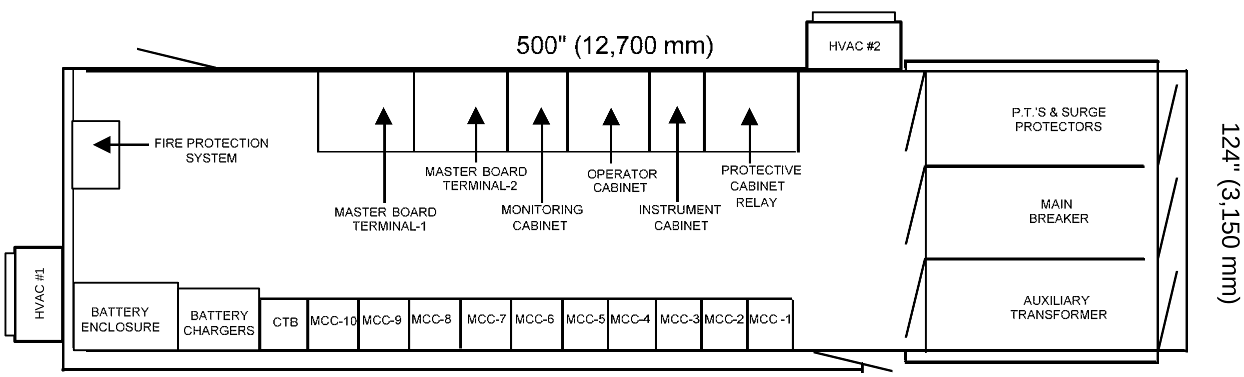


Figure 14: Typical Electrical/Control Unit Layout

5.1. Monitoring Cabinet (Main Operator Interface)

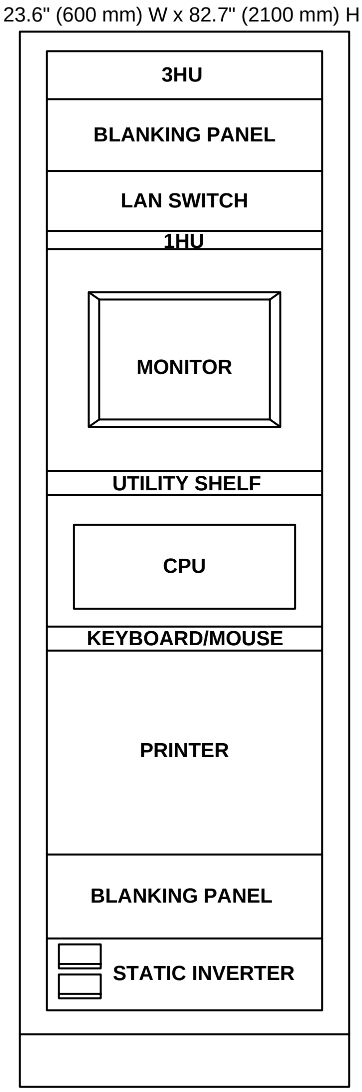


Figure 15: Monitoring Cabinet

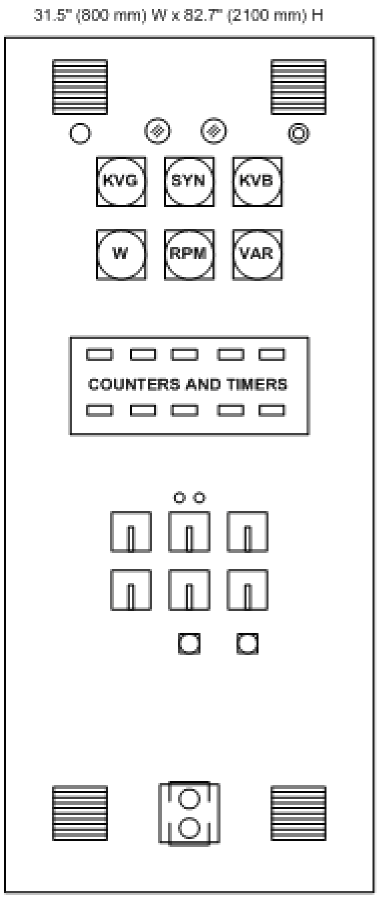
This cabinet houses equipment used by the operator to interface with the control system for data monitoring, trending and event history. It is located next to the operator cabinet for ease of access to the manual controls.

Housed in this cabinet is the Industrial Control Engine (ICE) monitoring system computer, which is utilized by the operator for gas turbine data acquisition and operating parameter adjustments. It consists of a 20" monitor, CPU, keyboard and trackball. The CPU interfaces with the controller via an Ethernet link.

A printer is also provided to print current screen information, event log, plots, and trends.

Static Inverter - The inverter converts DC power from the batteries into AC power to be used by the auxiliary AC instruments and equipment. It contains inputs from both the AC and DC buses and can provide 120 VAC output power from either source. The inverter monitors the AC bus at all times. If power supplied from the AC bus, the inverter will automatically transfer to the DC source upon loss of AC power.

5.2. Operator Cabinet



This cabinet contains panel-mounted switches and instruments used to manually control and monitor the generator performance. Manual voltage/VAR control, speed/load control, synchronization, and generating mode selection are all performed from this panel. Following is a list of components installed on the panel.

- Alarm Horn
- Synchronizing Lights
- Synchroscope and Syncroscope Switch
- Bus and Generator Voltmeters
- Generator Wattmeter
- Generator Var Meter
- Power Turbine/Generator Tachometer
- Generator Circuit Breaker Control Switch
- Speed/Load Control Switch
- Volts/Var Switch
- Lockout/Operate Switch Engine A&B
- Emergency Stop.
- 64F Test Switch

Figure 16: Operator Cabinet

- Timer – Running Hours, Liquid Hours, and Gas Hours
- Counters – Total Starts and Cycles
- Speed Relay Reset Button

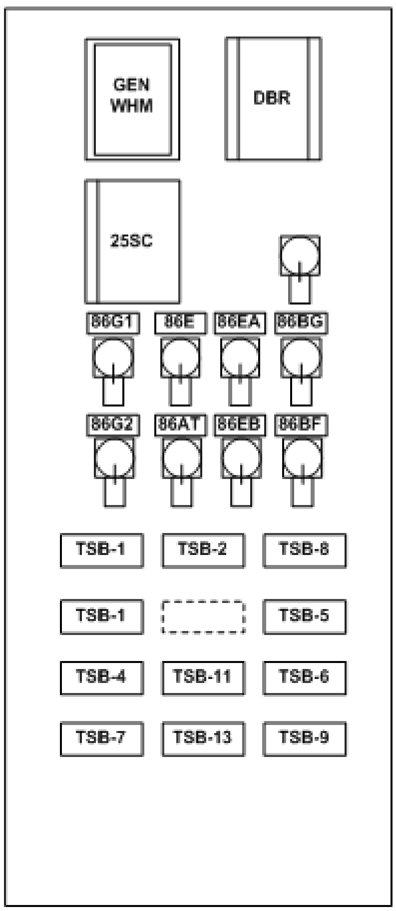
5.3. Panel Back Wall Devices (Not Shown)

- Overspeed Switch
- SEL 2401 – Satellite Clock

5.4. Protective Relay Cabinet

The equipment in this cabinet provides hardwired protection for the gas turbine, generator and bus equipment. The panel contains nine (9) lockout relays that are used to trip the unit or a single gas turbine in response to signals from the various electrical protective devices and the unit control system. Each lockout is a high speed, multi-contact, hand-reset relay provided with a mechanical target. Health monitoring relays are also provided for each lockout and are mounted on the panel back wall.

31.5" (800 mm) W x 82.7" (2100 mm) H



- GEN WHM - Generator Watt-Hour Meter
- DBR – Dead Bus Relay
- 25SC - Sync Check Relay
- TSB-1, TSB-9 - Test Blocks
- 86BF – Breaker Failure Lockout Relay
- 86BF-R – Redundant Breaker Failure Lockout Relay
- 86G1 – Generator 52G Trip Lockout Relay
- 86G2 - Generator 52G Trip + Controlled Shutdown Lockout Relay
- 86E – Engine Lockout Relay
- 86AT – Auxiliary Transformer Lockout Relay
- 86EA – Engine A Trip Lockout Relay
- 86EB – Engine B Trip Lockout Relay
- 86BG – Generator Breaker Lockout Relay

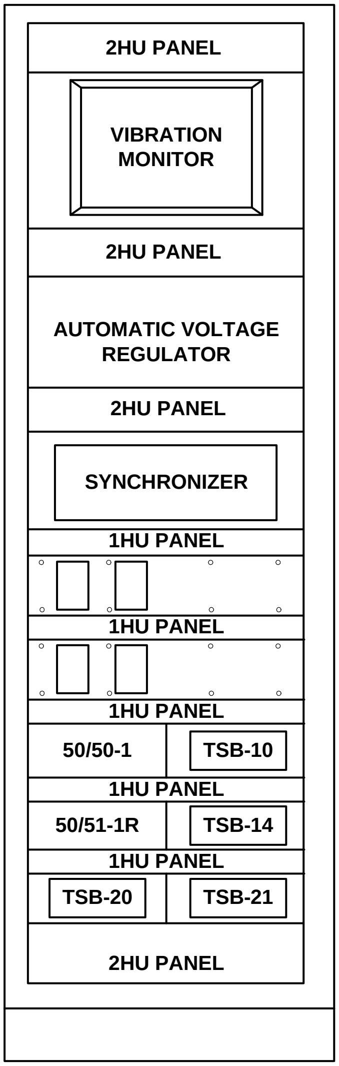
5.5. Panel Back Wall Devices (Not Shown)

- WT3801, 3802 – Watt Transducers
- Speed Switch - Provides generator and power turbine overspeed protection.
- SCB1,SCB10 – Short Circuit Blocks

5.6. Instrument Cabinet

This cabinet holds the accessory controls such as voltage regulator, synchronizer, vibration monitors, and generator protection relay. Each piece of equipment operates independently to control a specific aspect of plant operation. The unit control system coordinates the activity of these controllers through both hardwired and communication signals.

23.6" (600 mm) W x 82.7" (2100 mm) H



- Auto Voltage Regulator (AVR) -Primarily designed to control the excitation of the generator. The AVR allows both manual and automatic control of generator excitation.
- Synchronizer – Consists of three rack mounted modules that determine the proper time to initiate closing of the breaker to parallel the generator to the bus.
- Generator Protective Relay – Beckwith M-3425A is a microprocessor based unit that uses digital signal processing technology to provide up to thirty four protective relaying functions for generator protection.
- Vibration Monitors - Bentley Nevada Vibration Monitoring System.
    - Electric Generator - The monitor interfaces with two embedded proximity probes on each generator bearing. Displays of each bearing vibration level amplitude are shown on the front of the monitor along with lamp indication of system malfunction, alarm and shutdown vibration levels.
    - Gas Turbine - The monitor interfaces with velocity transducers mounted on the GG8 inlet case (flange A) mid-engine case (flange K) and the PT8 exhaust case (flange S). Vibration amplitudes are displayed on the front of the monitor for each of the three channels. Lamps on the front of the monitor indicate a faulty transducer or monitor malfunction and vibration level alarm and vibration level shutdown. A reset button must be depressed to re-arm visual alarms after alarm indication.

5.7. Master Terminal Boards

These cabinets terminate the majority of field control wiring at one central location. They contain terminal strips that connect the instruments to monitor and control the gas turbine and support systems to the CPU. One cabinet also houses the unit control system.

The unit control is a Woodward Governor Company digital microprocessor. It uses data from instruments throughout the plant to control unit operation. This data is also passed on to the monitoring system where it is accessible to the operator. The system is composed of a main chassis and one expansion chassis. The cabinet holds the main chassis, which contains the CPU, communication hardware, and input/output cards for the generator and control house equipment.

5.8. Motor Control Center (MCC)

The Motor Control Center contains all the 3-phase motor starters and contactors and required 480V - 3-phase feeder circuit breakers for the plant. Additionally, the MCC contains the AC and DC distribution panels and the transfer switch. The front panel of each motor starter bucket has a red and green indicating light to identify motor ON/OFF operation.

Power to the MCC is supplied by the 300 kVA, 13.8 kV / 480 V, 3-phase, 3-wire auxiliary transformer that distributes the power to the MCC through a 480 V, 3-pole, 600 amp circuit breaker. The auxiliary transformer and circuit breaker are housed in a cubicle next to the main circuit breaker. The 125 VDC and 24 VDC distribution panels in the MCC are supplied power from the 125 VDC and 24 VDC batteries and associated 125 VDC and 24 VDC battery chargers that are located close to the MCC.

5.9. DC Power Supply

One hundred twenty five (125) VDC and 24 VDC batteries are rack mounted in a ventilated enclosure. They supply all necessary DC power for safe shutdown of the FT8 and Emergency blackout conditions. Battery chargers are furnished and properly rated to supply the FT8's DC loads and also have capacity to charge the batteries. Chargers are supplied power from the MCCs 480 VAC distribution panel that is fed from the 13.8 kV / 480 VAC, 3-phase, auxiliary transformer.

The auxiliary transformer is connected to the load side, not the generator side, of the 13.8 kV switchgear circuit breaker. Thus, when the FT8 is in the standby mode and not generating power, the auxiliary transformer derives its power via the back-energized main step-up transformer. Unless there is a blackout, this is a very reliable source of power. However, when the FT8 is started and synchronized to the 13.8 kV side of the main-step-up transformer and the main breaker is closed, the FT8 generator supplies power to the 13.8 kV / 480 VAC auxiliary transformer.

5.10. 15 kV Class, Metal-Clad Switchgear Module

The 15 kV class switchgear is installed in the control center enclosure, and is connected to the generator by a totally enclosed, non-segregated phase, 3-phase bus duct system rated at 3000 amp. The switchgear module is of the metal-clad construction and consists of three cubicles installed on one end of the electrical control center enclosure and described as follows:

- The first cubicle contains the dry-type, auxiliary transformer that is rated at 300 KVA,
  13.8 kV / 480 VAC, 3-phase, 3-wire, 60 Hz. The 13.8 kV primary side of the transformer is connected to the load side of the main circuit breaker located in the adjacent second cubicle. The auxiliary transformer supplies the necessary 480 VAC power to the FT8 MCC. A 480 VAC, 3-pole, 600 amp, 60 Hz, circuit breaker connected to the secondary side of the auxiliary transformer is also contained in this cubicle.
- The second cubicle contains the main circuit breaker and necessary current transformers for metering and relaying. The main switching and interrupting device (vacuum circuit breaker) is of the removable draw-out type arranged with a mechanism for moving it physically between connected and disconnected positions and equipped with self-aligning and self-coupling primary disconnecting devices and control wiring connections.
- The main generator circuit breaker is a 750 MVA interrupting, 3000 amp, 15 kV air circuit breaker featuring 125 VDC close and trip.
- The third cubicle contains the potential transformers, lightning arrestors, and the surge capacitors as required for metering and equipment protection.

6. Control System

The FT8 control system contains an integrated Woodward gas turbine and unit control. This integrated controller acts as a central processing point for all I/O, serial and Ethernet communications associated with the FT8. Data from this control is sent to a user-friendly operator interface to display pertinent information.

6.1. Integrated Gas Turbine and Unit Control

The Woodward MicroNet Control System performs both fuel control and sequencing functions. This system incorporates 32-bit microprocessor based digital controllers, which optimizes turbine safety and efficiency. The programmable features of this control enhance the ability of the end user to incorporate the latest features in gas turbine technology. The MicroNet provides a flexible system to control associated processes such as high speed control functions, system sequencing, auxiliary system control, surge control, monitoring and alarming, and station control. Communications with the MicroNet platform are available to program and service the control as well as to interface with other systems (Plant DCS, HMI, etc.). A service interface allows the user to view and tune system variables.

This integrated control performs all of the gas turbine control functions including:

- Speed Control
- Temperature Protection and Control
- Acceleration and Deceleration Limiting
- Fuel Valve Control
- Inlet Guide Vane Control
- Variable Stator Vane Control
- Water Injection
- Gas Turbine Operational Monitoring
- Start Sequencing
- Unit Synchronization
- Alarm and Shutdown Protection

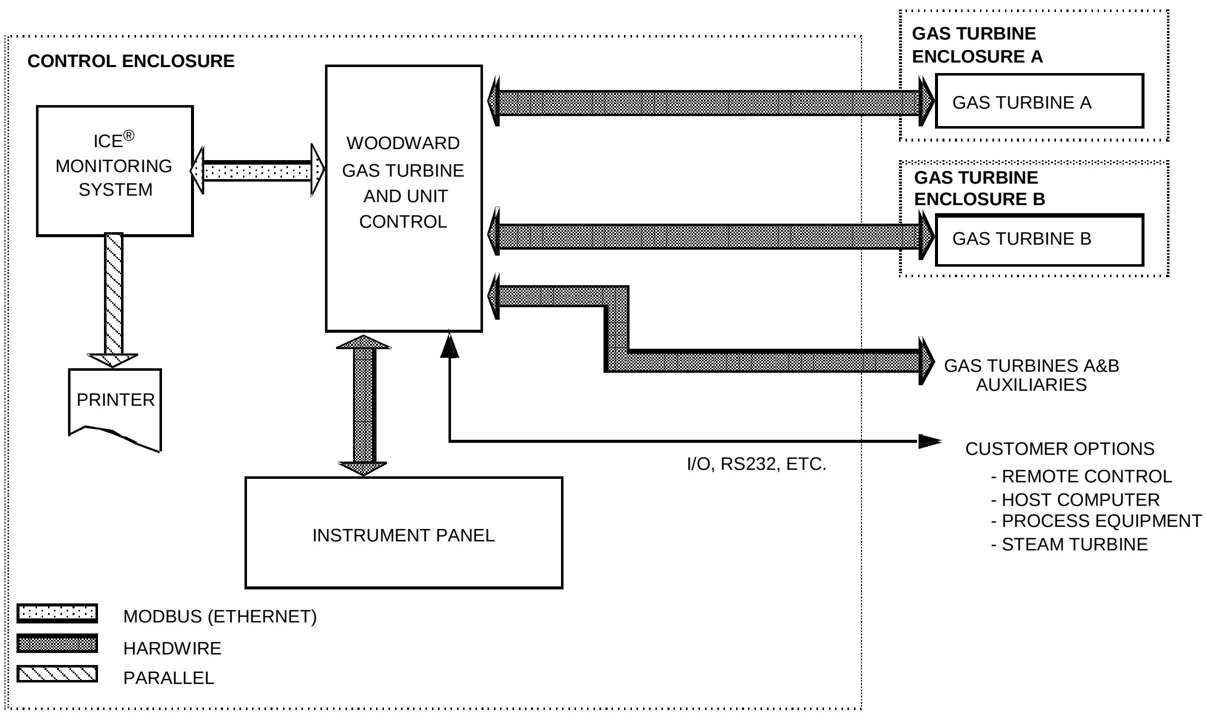


Figure 16: FT8 SWIFTPAC Control

6.2. Monitoring System

The monitoring system package operates on an industrial PC and serves as the operator interface for the FT8. This system interfaces to the gas turbine and unit control via an Ethernet local area network (LAN). The monitoring system performs such functions as:

- Data Logging and Trending
- Alarm Monitoring
- Alarm and Event Logging
- Sequence-of-Events Recording
- First-Out Alarm Indication
- X-Y Plotting
- Calculation Functions
- Event Storage, Archiving, and Redisplay
- Operator Control Functions
- Process Animation
- Control System Diagnostics

7. Gas Turbine Enclosure

The gas turbine enclosure protects the gas turbine and other ancillaries from the environment and provides noise attenuation. When the unit is operating the enclosure protects outside workers from the high component temperatures. When the unit is not operating it provides a protected working environment and inside lighting for maintenance.

The gas turbine enclosure includes the inlet plenum and the exhaust enclosure. The inlet plenum channels the air from the inlet air silencer to the gas turbine bellmouth to minimize the inlet air pressure loss. The exhaust enclosure houses the exhaust diffuser/collector, which delivers the power turbine exhaust gases to the exhaust transition duct and silencer. The enclosure serves as a mounting structure for the inlet and exhaust air systems, and as a duct for passing secondary air over the gas turbine for cooling. The enclosure also provides a limited containment volume for the fire protection system.

7.1. Gas Turbine Enclosure Secondary Air System

The gas turbine enclosure secondary air system provides cooling air flow throughout the length of the enclosure. Air is drawn into the intake assembly, through the silencer chamber, and blown into the gas turbine enclosure. It passes along the length of the gas generator and power turbine, around the exhaust collector and up into the exhaust air silencer, where it joins with the gas turbine exhaust.

A pair of AC motor driven fans, rated at 22,000 scfm (10.3 m^3/sec), are mounted low on the front bulkhead of the enclosure to take in atmospheric air through a louvered opening with a 2 x 2-inch (5 x 5 cm) mesh screen and a silencer module.

If a gas turbine enclosure fire is detected, the fans are de-energized and a pair of guillotine-type gates are released to block the inlet air supply ports.

7.2. Inlet Air Filtration

The primary inlet filtration system has a filtration efficiency of 99.7% for particles down to 5 microns, and 95% for particles down to 2 microns. Clean elements flow about 190 pounds (86 kg) of air per second with a maximum pressure drop of approximately one inch (2.54 cm) of water.

The filter house weighs approximately 32,500 lbs (14,800 Kg) and is 20 feet (6.1 m) long, 12 feet (3.6 m) wide and 13 feet (4.0 m) high. It is constructed of mild steel and rests atop (with its flange bolted to) the inlet air silencer module. Air enters both end walls of the filter house. Each end wall is configured to have 30 two ft^2 filter elements and 6000 half-sized elements in individual galvanized frames.

The high efficiency, replaceable fiberglass filters are preceded by a pre-filter. The two filters are held together by a pair of extended spring clips. Filter elements can be replaced from inside the filter house. The doors can be accessed from a full-length external catwalk with safety railing and fixed-end ladder.

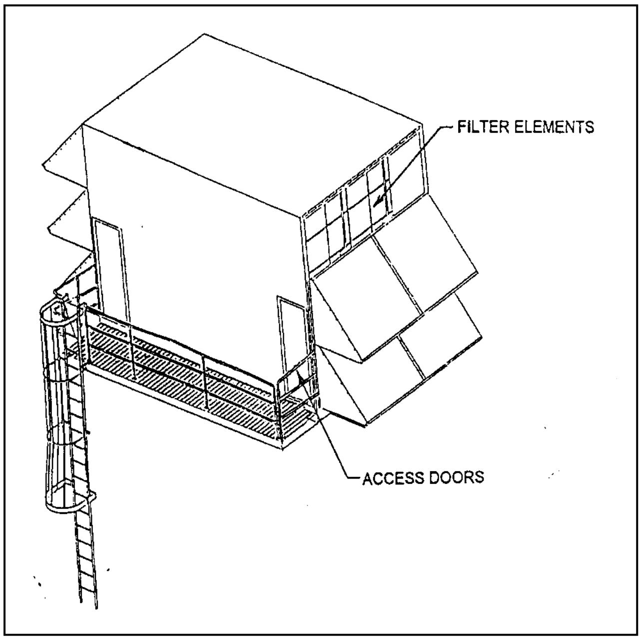


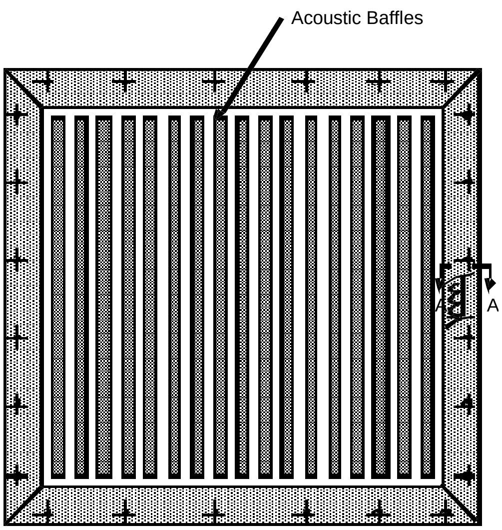
Figure 17: Filter House

7.3. Inlet Air Silencer (when specified)

The inlet air silencer module attenuates noise over a broad band of frequencies. It is 10 feet (3 m) wide by 11.5 feet (3.5 m) long. The box configuration housing is four feet high and flange-bolted on top of the forward end of the gas turbine enclosure. Air flows through this module directly into the contoured inlet plenum.

A similar flange ringing the top of the housing is bolted to a mating flange in the floor of the inlet air filter house. The silencer outer wall is 3/16-inch (4.75 mm) steel plate and the inner wall is 16 gauge perforated galvanized steel, with four inches of mineral wool fill between them.

Module walls, configured for sound attenuation, consist of 17 equally spaced, transversely mounted vertical acoustic baffles. The baffles, which have a 16-gauge perforated galvanized steel shell and are filled with three inches of mineral wool, may be removed for servicing.



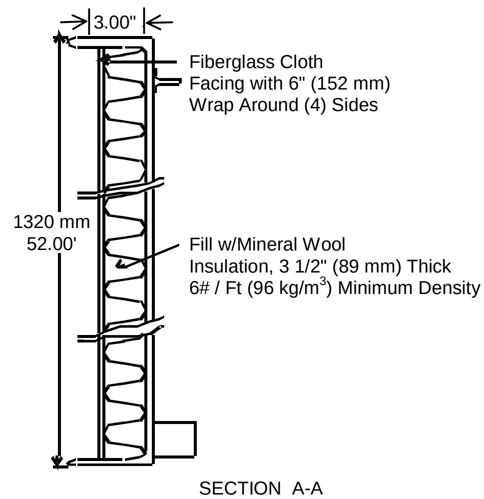


Figure 18: Top View of Inlet Silencer **Figure 19: Wall Construction of Inlet Silencer**

7.4. Exhaust Silencer (when specified)

The exhaust silencer is composed of two major modules, the transition module and the silencer module. The transition module provides a transition for the gas turbine exhaust gases and surrounding secondary cooling air. The silencer module is flange-mounted to the exhaust silencer transition-housing module. The number of the exhaust silencer modules is shown on the general arrangement drawings, and is also indicated in the Scope of Supply.

Construction of the transition module and the silencer module is similar; both employ double wall construction. Mineral wool is used in the outer wall for sound absorption and fiberglass wool is used in the inner wall for heat insulation and sound absorption. Four sound attenuating baffles are contained in the silencer module.

Each consists of perforated stainless steel channel shapes filled with fiberglass wrapped by stainless steel wire mesh. The baffles slide into module sidewall channels. The exhaust silencer modules are stacked for maximum sound attenuation. Surfaces exposed to hot exhaust gas are made from 409 stainless steel.

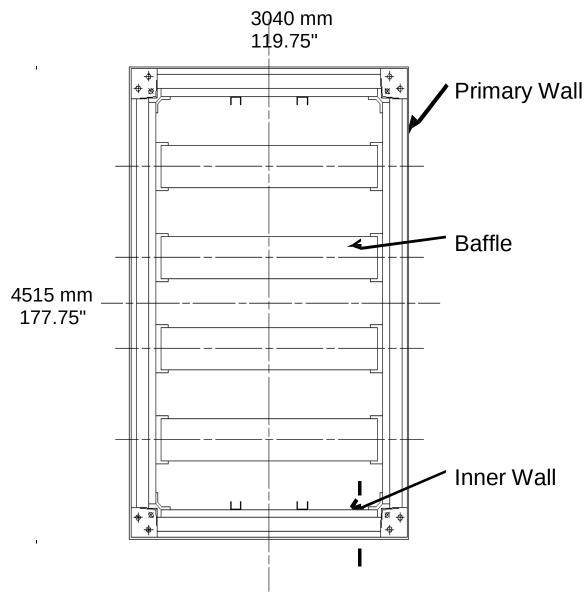


Figure 20: Top View of Exhaust

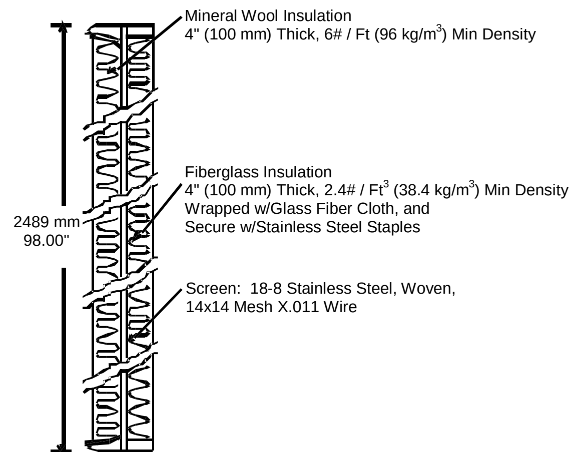


Figure 21: Top View of Exhaust

MMG TOWER Piso 16 Calle 53, Urb. Marbella Ciudad de Panana, Panama

8. Estimated SWIFTPAC Weights and Sizes

Quantity	Description	Weight, lb/kg (ea)	Length, ft/m	Width, ft/m	Height, ft/m
2	Gas turbine assembly on base inside enclosure	53,500/24,300	27.5/8.4	12/3.7	11/3.3
2	Engine heater950/430	5/1.5	4/1.2	3.5/1.1	
2	Exhaust enclosure	8,700/3,950	15/4.6	10.5/3.2	11/3.3
2	Collector box *4,400/2,000	14/4.3	6/1.8	10/3.2	
2	Secondary inlet silencer with inlet louver	6,200/2,800	11.5/3.5	10/3.2	5/1.5
2	Inlet air filter assembly, ladders and walkways	32,500/14,800	20/6.0	13/4.1	14/4.2
2	Diffuser inner/outer cylinder, tunnel and turning vanes	6,200/2,800	8/2.5	8/2.5	5/1.6
2	Inlet silencer	9,900/4,500	11.5/3.5	10/3.1	5/1.6
2	Exhaust transition piece	9,900/4,500	15/4.6	10/3.1	5/1.6
4	Exhaust silencer	16,000/7,300	15/4.6	10/3.1	9/2.7
2	Lube oil system inside enclosure	19,800/9,900	20/6.0	11.5/3.5	10.5/3.2
2	Water injection skid	2,500/1,100	8/2.4	5.5/1.7	6/1.8
1	Hydraulic start pac	9,900/4,500	7.5/2.3	7/2.2	8/2.4
1	Electric generator * with lube oil module	180,600/82,100	23/7.1	13/3.9	11/3.3
1	Recirculation damper	2,500/1,100	9/2.8	10/3.2	4/1.2
1	Generator enclosure *	14,500/6,600	22/6.7	12/3.6	6/1.8
		14,500/6,600	22/6.7	12/3.6	6/1.8
		11,000/5,000	24.5/7.5	6.5/2.0	7/2.2
1	Generator silencer	15,000/6,800	24.5/7.5	10.5/3.2	6/1.9
1	Control/switchgear unit	71,000/32,300	42/12.8	11.5/3.5	12/3.7
1	Batteries/remote panel	1,900/850	3/1	3/1	8/2.5
1	Bus duct	5,100/2,300	18/5.5	4/1.3	6.5/2

9. List of Typical Suppliers

Standard Design

Structural

Enclosures	BECON, Sound, SMT,
Inlet Silencer	VAW, Sound
Inlet Plenum	Sound
Exhaust Silencer	Sound, SMT
Exhaust Stacks	Braden, Sound, SMT, VAW
Gas Turbine Base and Mounts	Industrial Technologies, Edward King, American Design
Collector Box	Northern Manufacturing
Inlet Air Filter House	VAW, Farr,
Inlet Air Filter Elements	VAW, Farr,
Secondary Air Fans	Hartzell
Coupling	Goodrich, Ameri-Drive

Mechanical

Pump, Water Injection	HS Sundyne
Pump, Miscellaneous	Hayes, Gould, Hamilton Sundstrand, Cascon
Lube Oil Cooler	Hayden
GG Starter	Eaton Aerospace
Valves, Miscellaneous	Jordan, Woodward, Atkomatic, Hamilton Sundstrand,
Fire Valve	Lawrence (Leslie)
Heat Exchanger	HS Marstson,
Clutch, Fuel Pump	Carlyle Johnson, ARGO Tech
Gas Turbine Heater	American Design
Fuel Heater	Wattlow
Gauges, Pressure	Ashcroft, Omega, Orange Research
Gauges, Temperature	Ashcroft, Omega, Orange Research
Fire Protection	Associated Fire Protection
Filters, Fuel	FCS/Nelson, , Pall Trinicor
Filters, Lube Oil	Pall Trinicor
Hoses	Faxon, Industrial Technologies, Titeflex, Aeroquip, Tube Bends
Hydraulic Start System	Berendsen
SCR's	Peerless, Deltak, Hitachi, Mitsubishi, EnviroKinetics

Electrical

Electric Generator	Brush Electrical Machines, Electrical Machinery
Auxiliary Transformer	Westinghouse, National, Hevi-Duty, Hawker-Siddley, ABB, Hitachi, Hammond Power Solutions
Synchronizer	Woodward, Westinghouse, Basler
Bus Duct	Powell, UNIBUS
Vibration Monitor	Bentley Nevada
Turbine Control	Woodward
Batteries	Powell, Alcad
Battery Charger	CPI

Motor Control Center	Cutler Hammer
Motors	Baldor, U.S., Westinghouse, G.E.
Protectives	G.E., ABB, Beckwith, Schweitzer
Switchgear	Powell,
CRT Monitor	Adek
Gas Detectors	General Monitors
Pressure Transducers	Barksdale, Statham, Sensotec
Pressure Switches	Custom Components
Level Switches	Gems
Differential Pressure Switches	Custom Components
Resistive Temperature Detectors	Pro-Temp
Flowmeter, Fuel	Yokogawa, IMT Corp, Flow Technology

Pratt & Whitney Power Systems, Inc. (PWPS) provides the Typical Suppliers list as a service to potential Customers interested in knowing generally the typical suppliers of PWPS products. The Typical Suppliers list is not intended to limit or restrict the supplier(s) that PWPS may use for any part or parts. PWPS retains the right to use other suppliers for the parts described. Upon request, PWPS can provide specific supplier information to any Customer wishing to know the exact supplier for any or all parts.

Pratt & Whitney
A United Technologies Company

FT8/GG8 GAS TURBINE REFERENCE LIST

Customer and Site	No.	Application	Gas Turbine Commissioning Date
United Technologies Corporation P&W Manufacturing Division East Hartford, CT	1	Cogeneration	01-93
Futian Power Company Shenzhen, China	1	Combined Cycle	03-92
Public Service Electric and Gas Co. Burlington, NJ	4 4	Combined Cycle Combined Cycle	03-92 06-93
Ebara Corporation Sodegaura, Japan	1	Peaking	07-92
Newfoundland and Labrador Hydro Happy Valley, Labrador, Canada	1	Peaking Synch Condensing	03-92
Mitsubishi Heavy Industries Car & Passenger Ferry, Japan	2	Marine Propulsion	1994
MAN TURBO Oberhausen, Germany	1	Compressor Drive	09-92
Hainan Electric Power Company Sanya, Hainan Province, China	2 2	Combined Cycle	4-94 6-95
Jamaica Public Service Company Montego Bay, Jamaica	2	Base Load Generation	12-94
Industriekraftwerk Baienfurt Baienfurt, Germany	1	Cogeneration	01-95
Massachusetts Water Resources Authority (Formerly Boston Edison Company) Deer Island, Boston, MA	2	Emergency	06-95
Rhodia Energy (Formerly Rhone Poulenc) Melle, France	1	Cogeneration	09-95

Pratt & Whitney
A United Technologies Company

FT8/GG8 GAS TURBINE REFERENCE LIST

Customer and Site	No.	Application	Gas Turbine Commissioning Date
E.ON Ruhrgas Werne 7, Germany	1	Compressor Drive	10-95
Energieversorgung Oberhausen (EVO) Oberhausen, Germany	1	Base Load Cogeneration	01-96
Wuxi Suyuan Gas Turbine Electric Company Wuxi County, China	2	Combined Cycle	07-96
Cogeneration Management Steiermark Graz, Austria	1	Cogeneration	10-96
Solvay Deutschland Rheinberg, Germany	2	Cogeneration	11-96
Chloralp Pont de Claix, France	3	Cogeneration	11-96
EPCOR (originally TransCanada Pipelines)			
Kapuskasing, Canada	1	Combined Cycle	12-96
North Bay, Canada	1	Combined Cycle	12-96
ESYS-Montenay Clermont-Ferrand, France	1	Cogeneration	12-96
Asahi Chemical Industry Co., Ltd. Kanagawa, Japan	1	Combined Cycle	04-97
Chengdu AES-Kaihua Gas Turbine Power Co., Ltd. Chengdu City, China	2	Base Load	06-97
I.C. Industrias, S.A. La Dorada, Colombia	2	Base Load Generation	09-97
Communaute Electrique du Benin			
Contonou, Benin	1	Base Load	07-98
Lome, Togo	1	Base Load	06-98

Pratt & Whitney
A United Technologies Company

FT8/GG8 GAS TURBINE REFERENCE LIST

Customer and Site	No.	Application	Gas Turbine Commissioning Date
Endesa			
Charrua, Chile	2	Base Load	02-99
Valdivia, Chile	4	Base Load	03-99
Tomen Power Samukawa			
Samukawa, Kanagawa, Japan	2	Combined Cycle	06-99
Ebara Corporation			
Fujisawa, Kanagawa, Japan	2	Combined Cycle	06-99
WINGAS			
Mallnow Station, Germany	2	Compressor Drive	09-99
Rueckersdorf Station, Germany	1	Compressor Drive	06-99
E.ON Ruhrgas (GG8-2)			
Werne 8, Germany	1	Compressor Drive	06-99
Adisseo France S.A.S			
(Formerly Rhone Poulenc)			
Commentry, France	1	Cogeneration	09-99
CURCHAL			
Chalon sur Saone, France	1	Cogeneration	12-99
Tokyo Metropolitan Government			
Kanto Chisei, Japan	2	Pump Drive	01-00
Omaha Public Power District			
Omaha, Nebraska	4	Peaking	05-00
DPL Energy, Inc.			
Montpelier, Indiana	8	Peaking	05-01
Buckeye Power			
Greenville, Ohio	8	Peaking	05-00
Virgin Islands Water & Power Auth.			
St. Thomas, U.S. Virgin Islands	1	Base Load	09-01

FT8/GG8 GAS TURBINE REFERENCE LIST

Customer and Site	No.	Application	Gas Turbine Commissioning Date
WINGAS			
Mallnow Station, Germany	1	Compressor Drive	01-01
Rueckersdorf Station, Germany	1	Compressor Drive	03-01
Tokyo Metropolitan Government			
Higashi Kojiya Pump Station Tokyo, Japan	1	Emergency	01-01
Boremer			
San Martin de la Vega, Spain	1	Cogeneration	03-01
Constellation			
Handsome Lake, Pennsylvania	10	Peaking	07-01
Tenaska			
University Park, Illinois	12	Peaking	07-01
Bristol, Virginia	10	Peaking	07-01
Big Sandy, West Virginia	12	Peaking	07-01
Puget Sound			
Fredonia, Washington	4	Peaking	07-01
PacifiCorp			
Klamath Falls, Oregon	4	Peaking	04-02
Benton PUD			
Benton County, Washington	1	Peaking	10-01
Rochester Public Utility			
Rochester, Minnesota	2	Peaking	05-02
EBARA Corporation			
Sodegaura, Japan	3	Combined Cycle	12-02
Ameren UE			
Venice, Meremac, Illinois	2	Peaking	05-02
Peno Creek, Bowling Green, Missouri	8	Peaking	04-02

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FT8/GG8 GAS TURBINE REFERENCE LIST

Customer and Site	No.	Application	Gas Turbine Commissioning Date
City Utilities of Springfield			
Springfield, Missouri	4	Peaking	02-02
Michigan Public Power	2	Peaking	12-02
Kalkaska, Michigan			
Petrobras Termoceara	8	Peaking	06-02
Fortaleza, Brazil			
FPL Energy	2	Peaking	06-02
Bayswater, New York			
Jamaica Public Service	1	Peaking	01-02
Montego Bay, Jamaica			
Empire Electric			
Sarcoxie, Missouri	2	Peaking	02-03
Sarcoxie, Missouri	2	Peaking	02-03
CalPeak			
Escondido, California	2	Peaking	09-01
Border, California	2	Peaking	09-01
Panoche, California	2	Peaking	11-01
Vaca Dixon, California	2	Peaking	06-02
El Cajon, California	2	Peaking	06-02
Wisconsin Public Power	2	Peaking	05-04
Kaukaua, Wisconsin			
FPL Energy	2	Peaking	06-03
Jamaica Bay, New York			
Global Commons Greenport LLC	2	Peaking	07-03
Greenport, NY			
Seminole Electric Cooperative	10	Peaking	12-06
Hardee County, Florida			

FT8/GG8 GAS TURBINE REFERENCE LIST

Customer and Site	No.	Application	Gas Turbine Commissioning Date
Endesa	2	Peaking	6-03
Arona, Tenerife, Canary Islands			
Endesa	2	Peaking	6-03
Mahon, Menorca, Spain			
Tokyo Metropolitan Government			
Kanto Chisei, Japan	2	Pump Drive	1-05
Contact Energy			
Whirinaki, New Zealand	6	Peaking	4-04
Electricity Supply Board			
Asahi, County Mayo, Ireland	2	Peaking	12-03
Aghada, County Cork, Ireland	2	Peaking	12-03
Ministry of Oil			
Al-Bashrah, Iraq	2	Base Load	TBD
Ministry of Electricity			
Al-Hilla, Iraq	1	Base Load	3-04
Kraftnät Åland Ab			
Tingsbacka, Åland, Finland	1	Emergency	3-05
Electricity Supply Board			
Rhode, County Offaly, Ireland	4	Peaking	9-04
North Carolina Electric Membership Corp.			
Wake County, NC	12	Peaking	6-07
Person County, NC	10	Peaking	12-07
Endesa	2	Peaking	4-06
Guio de Isora, Tenerife, Canary Islands			
WINGAS			
Reckrod Station, Germany	1	Compressor Drive	06-05

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FT8/GG8 GAS TURBINE REFERENCE LIST

Customer and Site	No.	Application	Gas Turbine Commissioning Date
Endesa **Las Palmas, Canary Islands**	1	MOBILEPAC	11-04
Beijing Blue Sky Gas-fired Cogeneration Co. Beijing, China	4	Combined Cycle Cogeneration	06-06
WINGAS Rueckersdorf Station, Germany	1	Compressor Drive	12-05
WINGAS Eischleben Station, Germany	1	Compressor Drive	5-06
Amber Investment Changxing County, Zhejiang, China	2	Combined Cycle	06-06
JSC Energy Invest Gardabani Power Station Republic of Georgia	4	Intermediate	04-06
Fingrid Olkiluoto, Finland	4	Emergency	12-06
Bell Bay Power Tasmania, Australia	6	Peaking	3-06
Guangzhou University City Guangzhou, China	4	Combined Cycle Cogen	3-09
EADC/EAS Charrua, Chile	4	Base load	11-06
EDF #1 **Various Islands**	1	MOBILEPAC	2-07
RAO UES **Moscow, Russia**	10	MOBILEPAC	1-07
EDF #2 **Various Islands**	1	MOBILEPAC	10-07

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FT8/GG8 GAS TURBINE REFERENCE LIST

Customer and Site	No.	Application	Gas Turbine Commissioning Date
ZAO UK "DKM-Engineering" Moscow, Russia	2	Cogeneration	12-07
Campanario Generacion II Charrua, Chile	2	Base load	12-07
Nevada Power Company Las Vegas, Nevada	24	Peaking	04-08
STATNETT SF **Tjeldbergodden, Norway**	7	MOBILEPAC	12-07
STATNETT SF Nyhamna, Norway	6	Intermediate	12-07
Endesa Mahon, Menorca, Spain	2	Peaking	6-08
Puerto Rico Electric Power Authority Mayaguez, Puerto Rico	8	Intermediate	6-08
MEGAL			
Waidhaus, Germany,	1	Compressor Drive	11-08
Endesa			
Ibiza, Spain	1	Peaking	5-08
Ibiza, Spain	1	Peaking	12-08
Endesa Mahon, Menorca, Spain	2	Peaking	12-08
Tokyo Metropolitan Government			
Higashi Kojiya Pump Station Unit 2 Tokyo, Japan	1	Emergency	12-09
Generacion Mediterranea S.A. Central Modesto Maranzana Rio Cuarto, Argentina	4	Base load	7-08

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FT8/GG8 GAS TURBINE REFERENCE LIST

Customer and Site	No.	Application	Gas Turbine Commissioning Date
Sharjah Electricity & Water Authority Khorfakkan Power Station, Sharjah	2	Intermediate	5-09
Starwood-CalPeak Midway, California	4	Peaking	5-09
Tampa Electric Company Bayside, Florida	8	Peaking	6-09
Tampa Electric Company Big Bend, Florida	2	Peaking	9-09
CODELCO Calama, Chile	3	Intermediate	3-09
Infratel & Perth Energy Kwinana, Australia	4	Intermediate	6-10
Solalban Energia, S.A. Bahia Blanca, Argentina	4	Base load	2009
RAO UES **Vladivostok, Russia**	2	MOBILEPAC	11-08
RAO UES **Moscow, Russia**	5	MOBILEPAC	8-09
Paducah Power Systems Paducah, Kentucky	4	Peaking	05-10
ALTEK ALARKO Kirklareli, Turkey	2	Combined Cycle	2009
C.A. La Electricidad de Caracas Planta Termoeléctrica "La Raisa" Santa Lucía, Miranda, Venezuela	6	Base Load	2009
Marshfield Utilities Marshfield, Wisconsin	2	Peaking	06-10

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FT8/GG8 GAS TURBINE REFERENCE LIST

Customer and Site	No.	Application	Gas Turbine Commissioning Date
Northwestern Energy Anaconda, Montana Mill Creek Generating Station	6	Peaking	2010
C.A. La Electricidad de Caracas Planta Termoeléctrica "Luisa Caceres" Margarita Island, Venezuela	2	MOBILEPAC	12-09
Bord na Mona Cushaling Power Ltd Edenderry, Ireland	4	Peaking	2010
MGETS Siberia, Russia	2	MOBILEPAC	Dec '09 delivery

Total Reference Units	418
Units Delivered & On Order	403

12/22/09