PWPS MP25 Equipment Description

The MP25 Mobile Pac is a completely self-contained, gas turbine powered electric generating unit containing all the equipment necessary for local automatic operation. The unit is capable of remote operation.

The Mobile Twin Pac consists of two primary units – the power trailer and the control trailer. The power trailer contains the gas turbine and generator unit, and the control trailer the electrical/control unit. The Mobile Pac consists of an Industrial Gas Turbine directly connected through a diaphragm coupling to an electric generator. 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 weatherproof, 15 kV cables. The turbine/generator and electrical control units are housed in enclosures including lighting and electrical services. Fire suppression equipment is provided in the gas turbine enclosure.

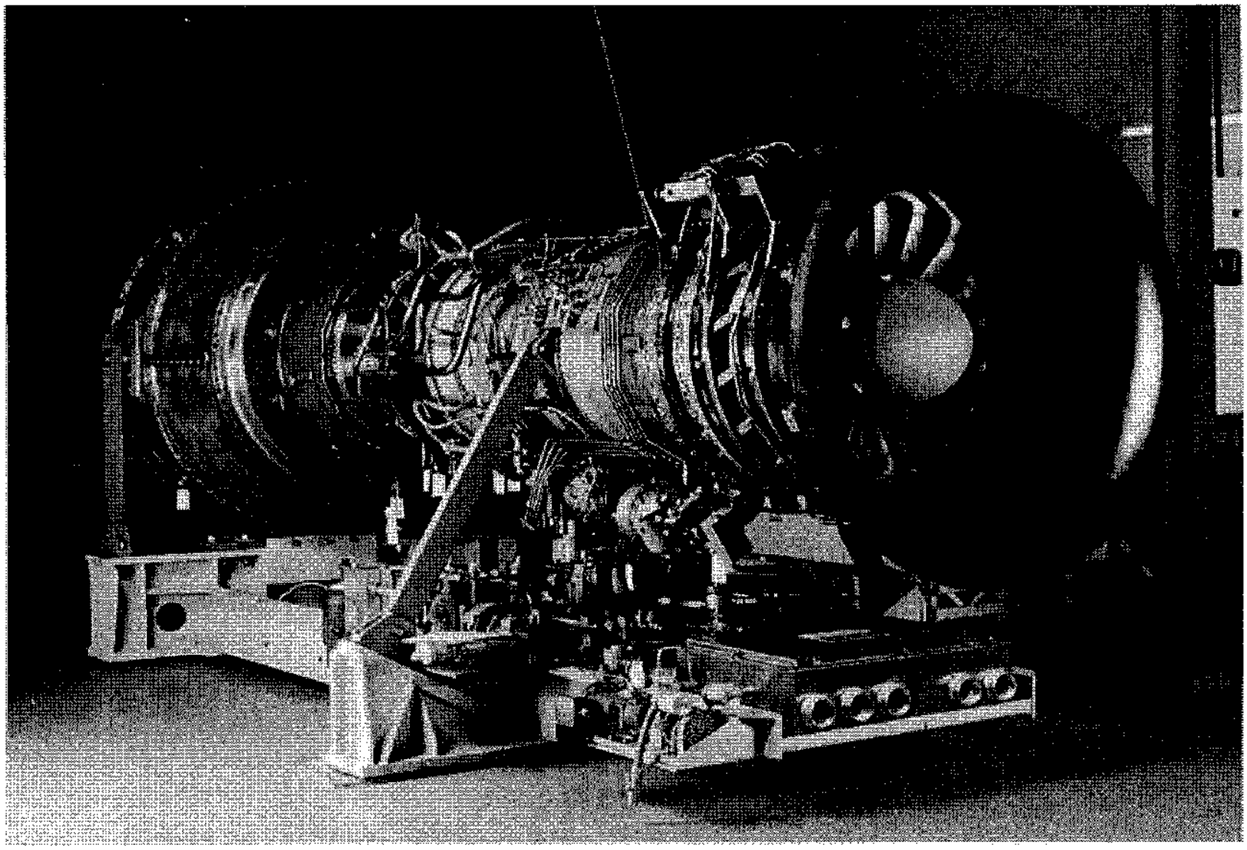
The generating plant can be erected on a site for emergency operation in 8 hours at a site with the Purchaser's distribution system and fuel supply systems. The package concept of this type of power plant, coupled with their relatively small size, allow them to be readily installed in almost any location and conveniently relocated or combined with other units to meet an area's emergency or temporary power requirements.

Whether for emergency or for semi permanent operation, modular options can be added to allow long term environmentally compatible operation. These modules are inlet silencing and filtration, exhaust silencing and water injection. All modules can be quickly mounted to the unit. This equipment would arrive at site on a separate truck.

The MP25, like the standard FT8 power plants, can operate on liquid and/or gas fuel. In addition, water injection can be added to provide low emissions.

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.



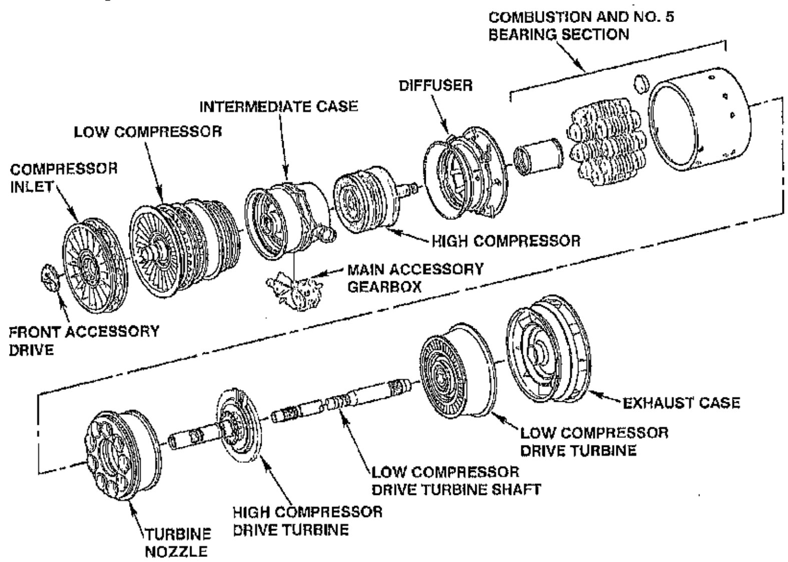
GAS GENERATOR

The GG8 gas generator is based on the latest version of Pratt & Whitney's JT8D turbo fan aero engine family, the JT8D-219. More than 14,000 JT8D engines have accumulated over 400 million operating hours in the world's commercial aircraft fleet.

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 no. where it enters a large plenum consisting of nine fuel nozzles and combustion cans. Most of the air enters the combustion can through the fuel nozzles and through the combustion can walls, which also cools the combustion chamber walls. 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 both compressor sections. The remainder of the hot gas energy is used for driving the power turbine. The output of hot gases is regulated by controlling the flow of fuel to the combustion chambers.

The GG8 gas generator uses modulated cooling air to the Low Pressure Turbine 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.



GAS GENERATOR BUILD GROUPS AND MAJOR ASSEMBLY SECTIONS

INLET CASE GROUP

This group includes the inlet case, No. 1 bearing, and the No. 1 bearing housing. The case incorporates variable inlet guide vanes for directing air into the low pressure compressor. The case also provides support for the No. 1 bearing. The front accessory drive houses the NL speed sensors.

LOW PRESSURE COMPRESSOR (LPC)

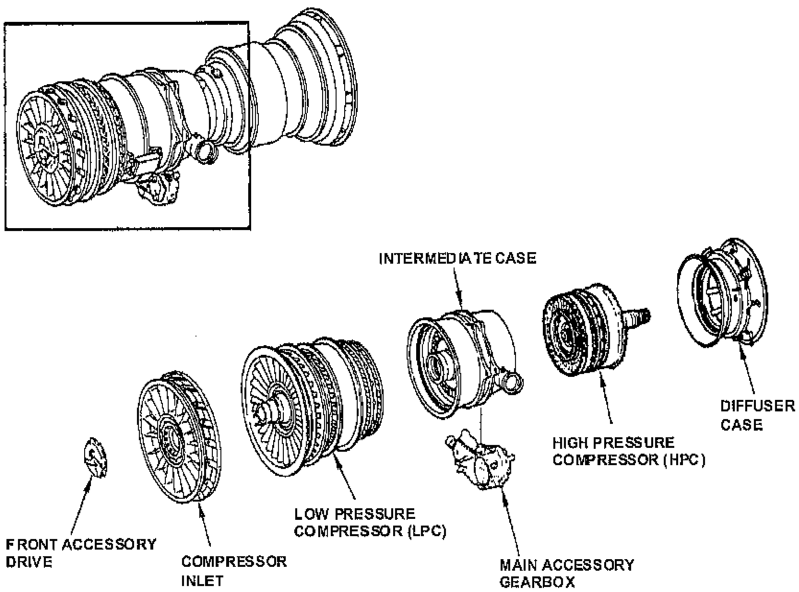
The GG8 Low Pressure Compressor is derived from the JT8D Low Pressure Compressor. The fan stage used in the JT8D is replaced with three booster compressor stages at the GG8 inlet. The inlet guide vanes plus the first two stages have been fitted with variable geometry. Variable vane movement provides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

The Low Pressure Compressor has 8 blade stages and 7 stator vane stages. The first 2 stator vane stages are variable.

The Low Pressure Compressor gas path is connected to the High Pressure Compressor by the Intermediate Case. The Intermediate Case also provides a structural connection between the two compressor sections, provides support for the No. 2 and No. 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 Low Pressure Compressor rotor is physically connected to the Low Pressure Turbine rotor by a shaft that passes through the High Pressure Compressor and Turbine.



GG8 COLD SECTION GROUPS

HIGH PRESSURE COMPRESSOR (HPC)

Except for a few changes in materials and coatings, the GG8 High Pressure Compressor is the same as the aircraft version.

The High Pressure Compressor consists of seven blade stages and seven stator vane stages. It is driven by the High Pressure Turbine through a connecting shaft. The High Pressure Compressor operates at a higher rotational speed that does the Low Pressure Compressor.

The gearbox, attached to the Intermediate Case, is driven through gearing from the front of the High Pressure Compressor section.

DIFFUSER GROUP

The Diffuser Case houses the No. 4 bearing that supports the High Pressure Compressor 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.

COMBUSTION SECTION

The combustion section has nine chambers arranged in an annulus around the turbine shafts and positioned between the High Pressure Compressor and the High Pressure Turbine. 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.

Each combustion chamber is supported radially at the front end by a fuel nozzle and support assembly and radially at the rear by a guide ring which supports the chamber at the combustion chamber outlet duct. Axial restraint is provided by a pin attachment to the diffuser case at the front end of each chamber.

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.

TURBINE NOZZLE GROUP

This group includes the turbine inlet nozzle guide vanes that direct the hot gas flow from the combustion chambers to the High Pressure Turbine blades.

Parts in this group also provide support for the outlet end of the combustion chambers.

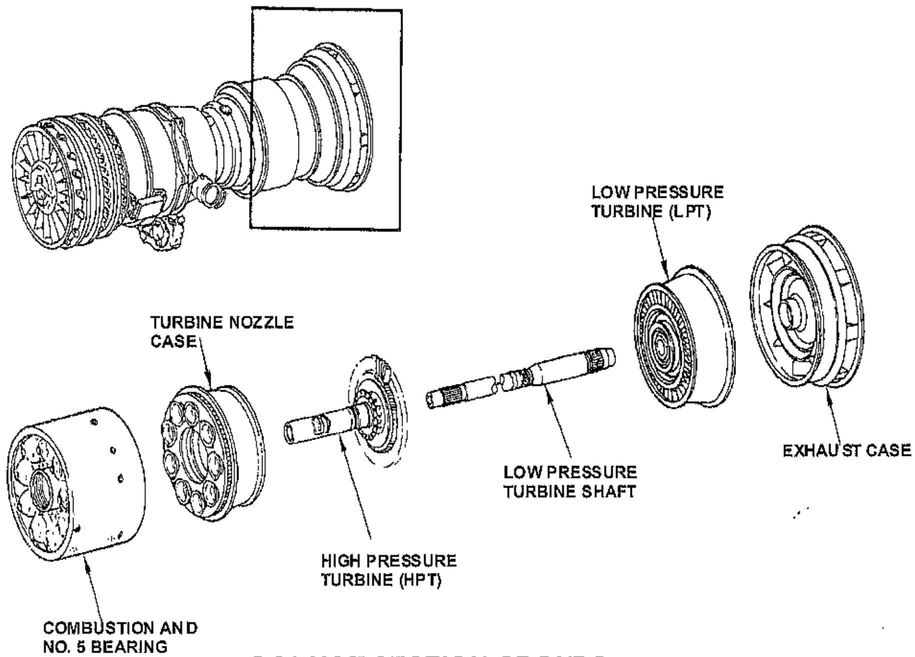
The inner support for the nozzle guide vanes includes the tangential on-board injection (TOBI) system which provides 13th stage compressor air for cooling of the High Pressure Turbine blades and attachments.

HIGH PRESSURE TURBINE (HPT)

The High Pressure Turbine is a single stage turbine with shroudless, air-cooled turbine blades. The turbine is supported by the No. 5 bearing. The turbine is physically connected to the High Pressure Compressor by the High Pressure Turbine 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 High Pressure Turbine converts thermal and kinetic energy from the gas path into shaft horsepower to drive the High Pressure Compressor.



GG8 HOT SECTION GROUPS

LOW PRESSURE TURBINE (LPT)

The Low Pressure Turbine has two turbine rotor stages and two stages of turbine vanes. The front blade and vane are air cooled, and both blade rows utilize shrouded tips. The last stage vanes are clustered. Each vane cluster consists of three vane airfoils. The Low Pressure Turbine shaft connects the Low Pressure Turbine to the Low Pressure Compressor.

The Low Pressure Turbine converts kinetic energy from the gas path into shaft horsepower to drive the Low Pressure Compressor.

TURBINE EXHAUST CASE (TEC)

The Turbine Exhaust Case 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 No. 6 bearing, which supports the rear of the Low Pressure Turbine rotor.

Pressurized oil supplied to the Exhaust Case provides lubrication for the No. 6 bearing and for the No. 4-1/2 bearing.

BEARINGS

The MP25 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.

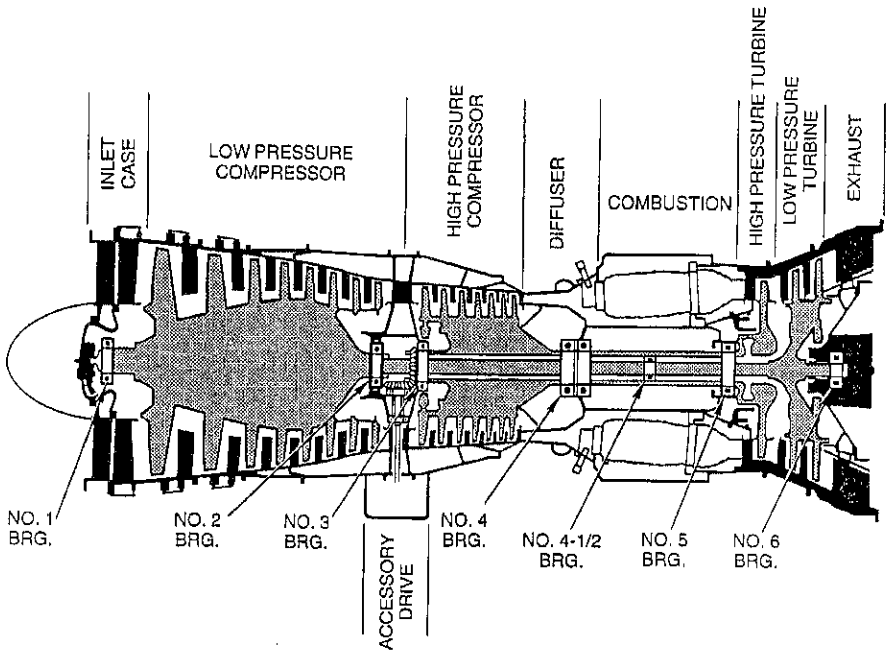
Antifriction ball and roller bearings are used throughout the gas turbine since they absorb about 50 percent less power than sleeve or hydrodynamic bearings and require a less costly and complex lubrication system. They can also withstand intermittent losses of lubricant flow for time periods that would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

The No. 1 bearing (oil damped roller bearing) provides radial support for the Low Pressure Compressor front hub. It is supported by the inlet case.

The No. 2 bearing (ball bearing) is a thrust bearing for the Low Pressure Compressor and supports the rear of the Low Pressure Compressor. It is supported by the Intermediate Case.

The Tower Shaft Bearings (roller bearing and ball bearing) are supported by the Intermediate Case.

GAS GENERATOR SECTIONS AND BEARING LOCATIONS



The No. 3 bearing (ball bearing) is a thrust bearing for the main accessory drive bevel gear. It provides radial support for the front of the High Pressure Compressor rotor. It is supported by the Intermediate Case.

The No. 4 bearing (duplex ball bearing) is the thrust bearing for the High Pressure Compressor rotor, and supports the rear hub of the High Pressure Compressor.

The No. 4-1/2 bearing (roller bearing) provides intershaft support between the Low Pressure Turbine shaft and the High Pressure Turbine shaft.

The No. 5 bearing (oil damped roller bearing) provides radial support for the High Pressure Turbine. It is supported by the Combustion Chamber inner case and the Turbine Nozzle group.

The No. 6 bearing (oil damped roller bearing) provides radial support for the rear of the Low Pressure Turbine.

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

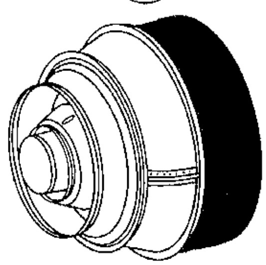
The main oil seals are fabricated from specially treated carbon, and are of the face type or ring type configuration. Ring type seals are used only where assembly procedures preclude use of face type seals.

POWER TURBINE

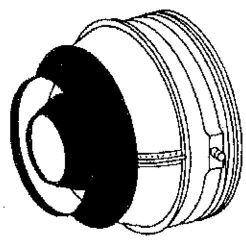
Development of the PT8 Power Turbine focused on high efficiency and extended service life. The power turbine consists of an annular, transition duct connected to the gas generator; a single four-stage, axial flow, reaction turbine; and an exhaust casing consisting of exit guide vanes and rear bearing support that connects to the diffuser section and an exhaust collector. The power turbine is supported by two anti-friction roller-type bearings and one ball-type thrust bearing. This bearing configuration is similar to the field-proven FT4.

In addition to the speed alternatives of 3,000, or 3,600 rpm, the turbines are available with either direction of rotation. This allows for a Twin Pac configuration with twice the power capacity of the Power Pac. In Twin Pac installations, the generator is driven from both sides.

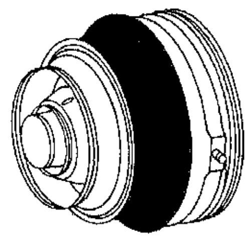
The power turbine converts the thermal and kinetic energy in the exhaust of the gas generator into a rotational force. This shaft horsepower is transmitted to the driven equipment via two flexible couplings and drive shaft.



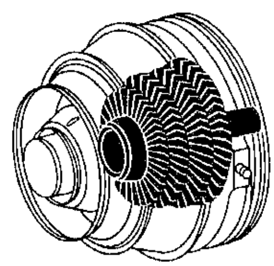
INLET SECTION



TURBINE CASE AND VANE SECTION



ROTOR ASSEMBLY



EXHAUST CASE SECTION

INLET SECTION

The inlet case and inner and outer ducts of the power turbine form an annulus, which directs the gas generator exhaust hot gases 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.

TURBINE CASE & VANE SECTION

The vanes direct the hot gases to the turbine blades at the proper angle for maximum rotor efficiency. They form an assembly with the turbine case.

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.

EXHAUST CASE SECTION

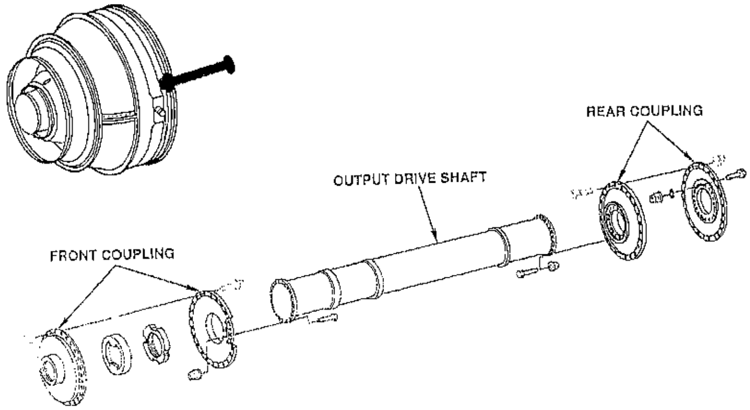
The exhaust case section turns the exhaust gases via exit guide vanes to axial flow before entering the diffuser section. The case structure supports the rear bearings and rear engine mounts.

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. The diffuser and turning vane design permits the smoothest possible movement of exhaust gas through the exhaust system, minimizing backpressure and maximizing efficiency.

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 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.



POWER TURBINE OUTPUT DRIVE ASSEMBLY

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.

MOUNTS

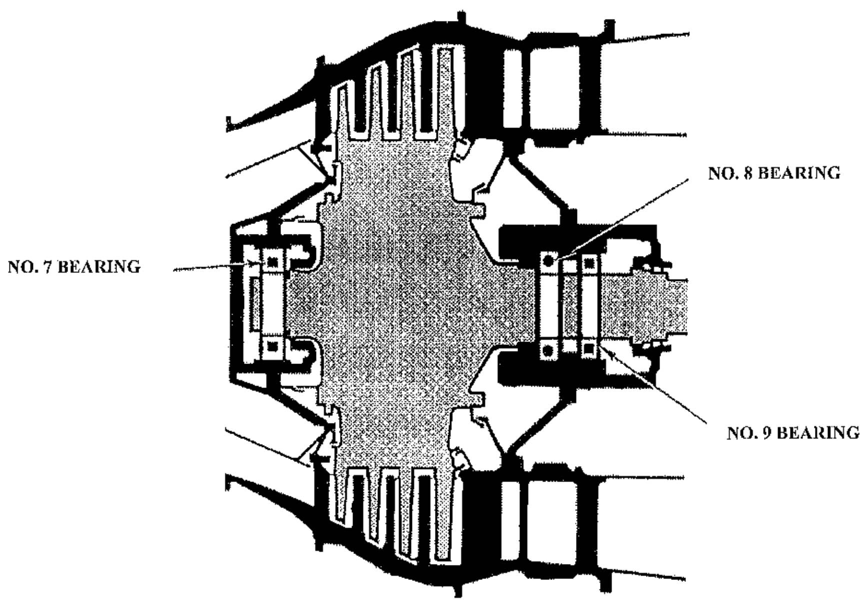
The mounts, located at the 3 and 9 o'clock positions on the power turbine exhaust case, provide the rear support for the gas generator/power turbine system. The mounts are adjustable vertically and horizontally. There is also a bottom mount pin, which positions the gas generator/power turbine system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

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 #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 #7, #8 and #9 bearing compartment seals.

BEARINGS

The No. 7 bearing (roller bearing) provides radial support for the front of the rotor assembly. The No. 8 (ball bearing) provides axial support and the No. 9 bearing (roller bearing) provides radial support for the rear of the rotor assembly.



CROSS SECTIONAL VIEW OF POWER TURBINE WITH MAIN BEARINGS

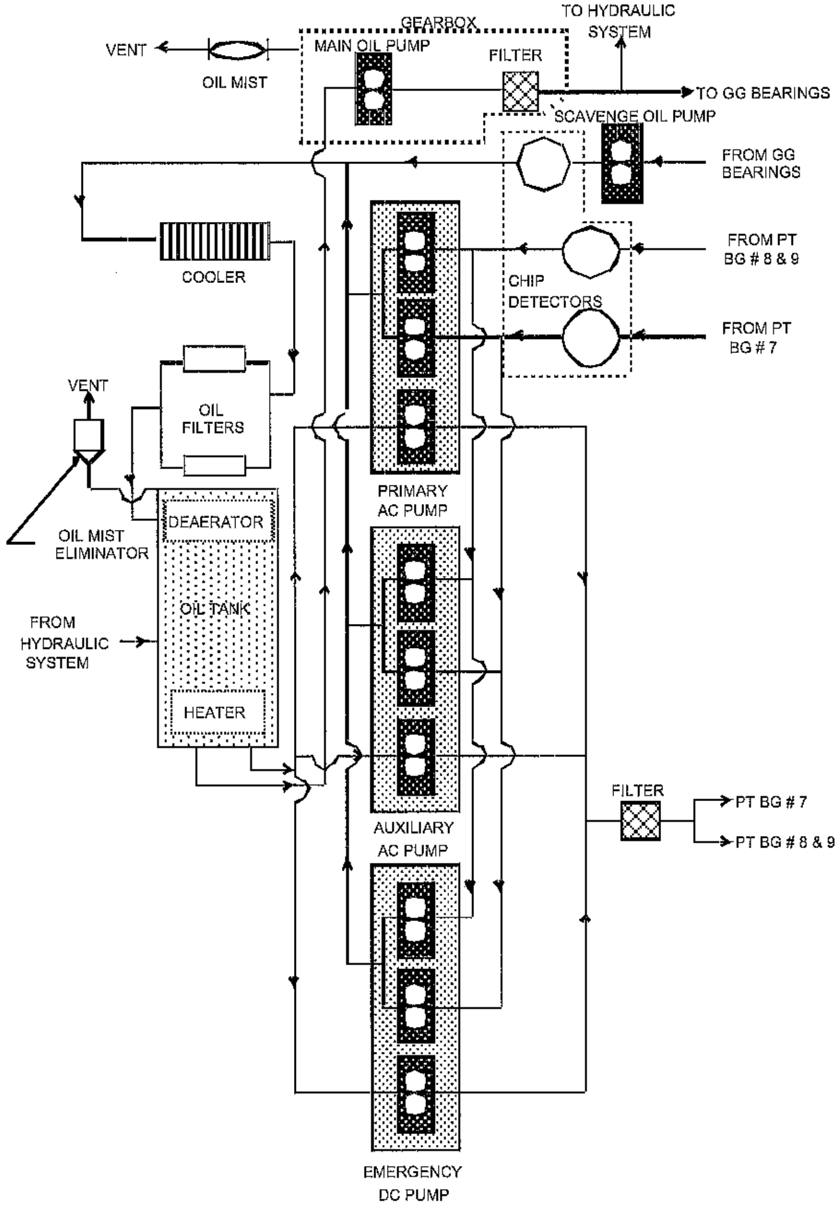
LUBRICATION

The MP25 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.

Components not integral to the gas turbine are mounted as a preengineered package in the gas turbine enclosure, contains the combined reservoir, filters, air-to-oil cooler, and the power turbine supply and scavenge pumps.

The gas generator supply and return lines terminate at the accessory drive mounted gearbox. Since both the 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 net positive suction pressure to the hydraulic system pump.

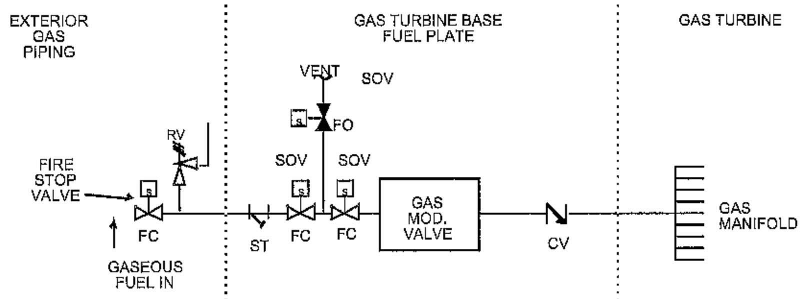
The power turbine lube oil system lubricates and cools the main bearings and bearing seal assemblies. Lubrication is provided by identical three-element pumps, which provide primary and auxiliary flow functions. The pumps are AC motor driven at 50/60 Hz while the emergency pump is a DC motor driven at 1800 rpm. 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.



Lube Oil System

GAS FUEL SYSTEM

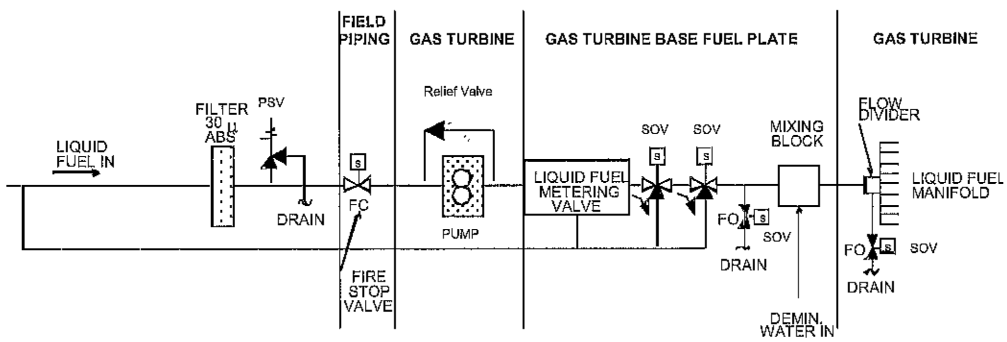
The Customer furnished fuel gas supply is provided at a minimum pressure of 445 psig (30 bar). After flowing through a fire valve, the gas flows through two shutoff valves and the modulating valve to the gas manifold, where it is injected through the nine gas fuel nozzles. The modulating valve meters fuel in response to signals from the electronic gas turbine control.



GAS FUEL SYSTEM

LIQUID FUEL SYSTEM

In the liquid system, fuel in a flooded suction line from the fuel storage tanks is pumped by the customer supplied fuel forwarding system to the filtering skid. After flowing through a fire stop valve, the fuel is boosted by the gas generator mounted fuel pump, and sent to the modulating valve. The modulating valve meters fuel in response to a signal from the electronic gas turbine control. The fuel then flows through two fuel shutoff valves and a flow divider, into the manifold and through the nine liquid fuel nozzles.



LIQUID FUEL SYSTEM

STARTING SYSTEM

The starting system consists of a hydraulic starter mounted on the gas turbine and a 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.

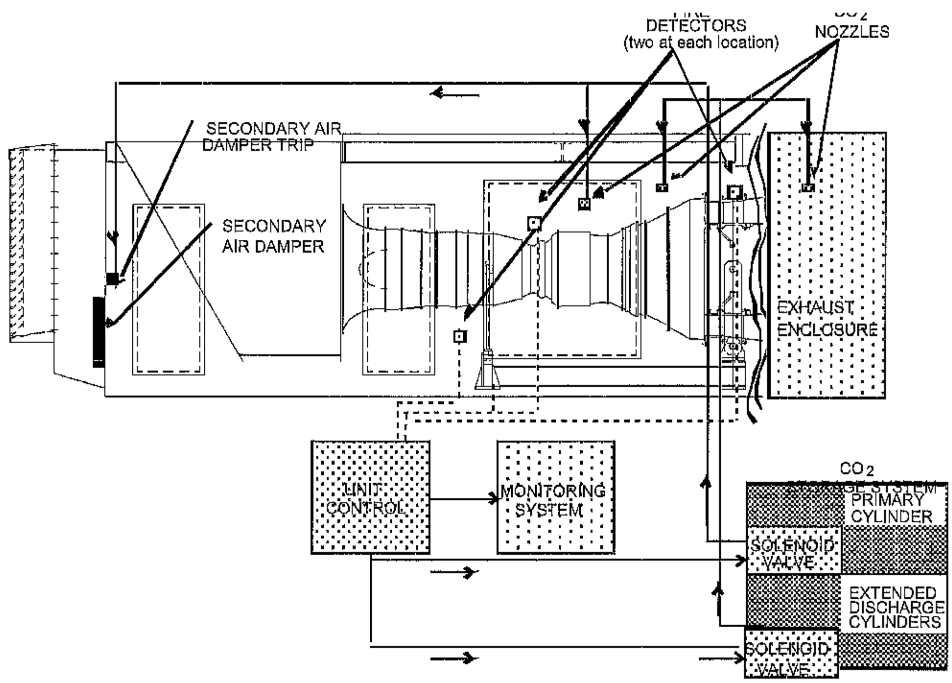
After fuel is admitted to the gas turbine combustion section and ignition is achieved, the gas turbine accelerates to its self-sustaining speed and the starter is disengaged from the shaft. If any problems are detected during the start cycle, the control shuts off fuel flow and hydraulic fluid flow,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

FIRE PROTECTION SYSTEM

The fire protection system provides independent fire detection and CO_2 total flooding fire suppression systems for the gas turbine enclosure and is available as an option for the generator and control enclosures.

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 trailer.


DETECTORS
(two at each location)
NOZZLES
SECONDARY AIR DAMPER TRIP
SECONDARY AIR DAMPER
EXHAUST ENCLOSURE
UNIT CONTROL
MONITORING SYSTEM
CO_2
PRIMARY CYLINDER
SOLENOID VALVE
EXTENDED DISCHARGE CYLINDERS
SOLENOID VALVE

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 Vdc 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 evacuation of the gas turbine and generator enclosures 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 louvers closing off the secondary air path. Simultaneously, a series of nozzles floods the enclosures to a 34 percent CO_2 concentration, sufficient for inerting the combustion process.

Pressurized tanks supply CO_2 to two manifolds. The first manifold is quick emptying, while the second extended flow manifold maintains the concentration by overcoming dilution from air leakage. This CO_2 concentration is maintained for approximately 30 minutes, sufficient time to allow combustibles to cool below their autoignition 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 keyswitch 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.

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 an option.

Electric Generator

The electric generator is an open ventilated, two-pole, air-cooled unit rated to ANSI/IEC standards with Class "F" insulation. 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.

STATOR

The stator frame is fabricated from mild-steel plate, forming a rigid structure. The stator core is built up from segmental 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.

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 155°C. (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 endwinding is securely braced to insulated brackets supported from the stator frame. The individual subconductors of all windings are fully transposed to ensure minimum circulating currents. "Nose" type or Roebel transpositions are used as appropriate.

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 endcaps are shrink fitted to spigots at each end of the rotor body. All rotors are tested at 20 percent overspeed and balanced.

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. Noncontact vibration sensors are provided for both bearings.

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 interslot ventilation ducts and discharging at the top of the frame. The exciter is self-ventilated.

LUBRICATION

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

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.

VOLTAGE REGULATOR

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

The MAVR, which controls the excitation of the generator 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 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

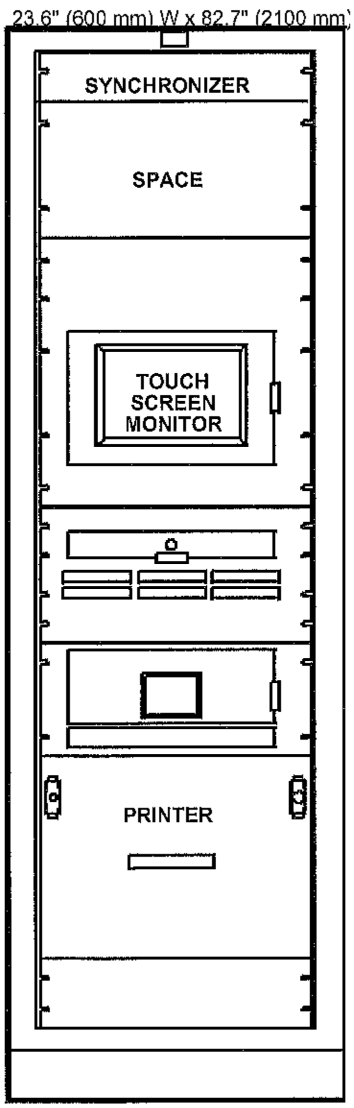
The MAVR has a voltage adjustment range of $\pm$ 10% and accuracy of regulation of no load to full load.

Electrical Control Center Enclosure

The electrical/control center enclosure contains all of the equipment necessary for local control of the MP25, together with the switchgear and generator protectives. The enclosure is air-conditioned and heated for operating personnel comfort 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, protectives relaying, and master terminal board. These controls and instruments are mounted on the following cabinets:

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



MONITORING CABINET (MAIN OPERATOR INTERFACE)

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.

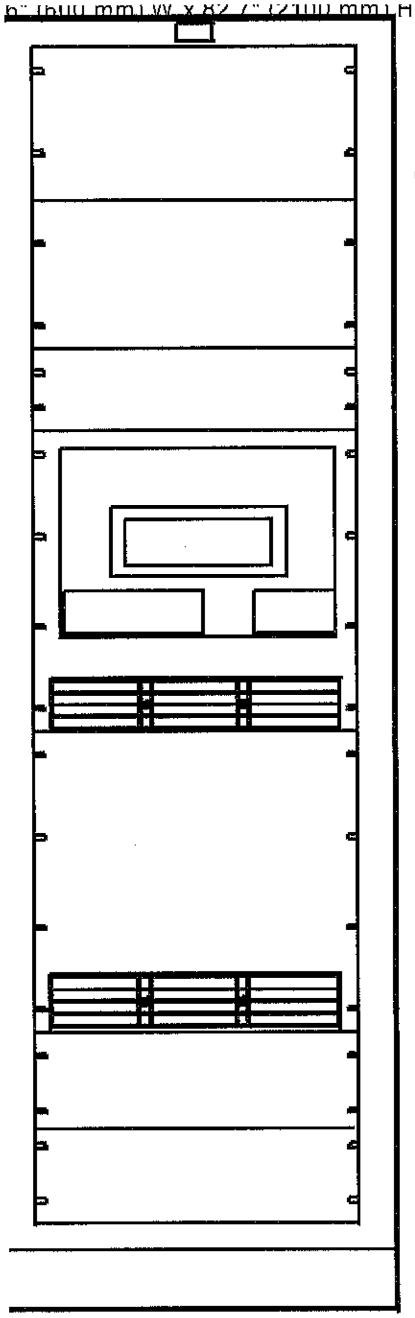
Housed in this cabinet is the Industrial Control Engine (ICE) monitoring system computer, which is utilized by the operator for gas turbine data acquisition and operating parameter adjustments. It consists of a 20" touch screen monitor, CPU, keyboard and trackball. The CPU interfaces with the controller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

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

Synchronizer - This Westinghouse XMC synchronizer is a microprocessor based unit that synchronizes the generator to the bus when running the unit in automatic operating mode. Power is turned on to the XMC by the unit control system once synchronous speed is reached and remains on for one minute after breaker closure. This time delay allows breaker closure time, shown on the front LCD display, to be recorded if desired.

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.

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 Central Processing Unit (CPU). One cabinet also houses the unit control system.

- 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.

PROTECTIVE RELAY CABINET

The equipment in this cabinet provides protection for the gas turbine, generator and bus equipment. The panel contains four (4) lockout relays that are used to trip the unit or in response to signals from the various electrical protectives 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. Functions of the lockouts are:

- 86 G-1: Opens generator circuit breaker
- 86 E: Trips gas turbine
- 86 G-2: Opens generator circuit breaker, de-energizes excitation
- 86 E: Trips gas turbine, opens generator circuit breaker and de-energizes excitation.

Also provided on the panel are the following protective relays and meter:

- Beckwith M3425A integrated protection system
- GEN WHM - Generator Watt-Hour Meter
- 25SC - Sync Check Relay
- 87G - Generator Differential Relay
- TSB-1, TSB-2 - Test Blocks
- Dead Bus relay

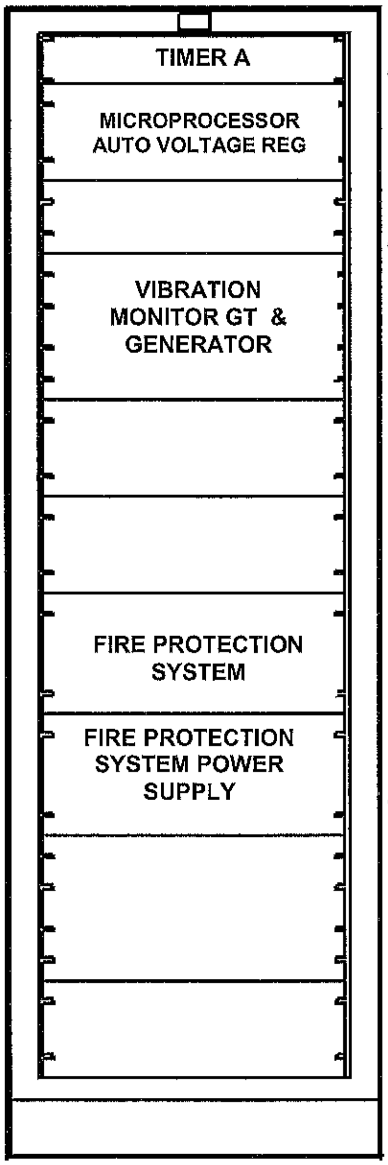
PANEL BACK WALL DEVICES (not shown)

- Real Power Sensor - Connected directly to the potential transformers (PTs) and current transformers (CTs), this device supplies the generator output watts to the unit control system.
- VAR Transducer - Calculates generator VARs for use in the unit control system.
- Speed Switch - Provides generator and power turbine overspeed protection.
- Short Circuit Blocks - When shorted, these blocks isolate the generator current transformers (CTs) circuits for troubleshooting.
- 76E - Overexcitation Relay

INSTRUMENT CABINET

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

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



- Microprocessor Auto Voltage Regulator - This unit, commonly referred to as the MAVR, is primarily designed to control the excitation of the generator. The MAVR allows both manual and automatic control of generator excitation.
- Timer Panel - Timers and counters for engine "A" include engine starts, engine cycles, engine operating hours, operating hours on liquid fuel and operating hours on gas fuel.
- Vibration Monitors - Bentley Nevada Vibration Monitoring System

  Electric Generator - The monitor interfaces with two embedded proximity probes on each generator bearing. Display of each bearing vibration level amplitude is 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.
- Fire Protection System - This unit provides the control for the unit fire protection system described earlier. The fire protection system monitors the health and status of all input devices looking for a fire, gas leak, fire suppression activation or fault. Upon detection of a problem, the unit alarms the condition and takes any appropriate action. Indication of the alarm source can be found on the front LCD display.

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, 3-phase, 3-wire Auxiliary Transformer which distributes the power to the MCC through a 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.

DC POWER SUPPLY

125 VDC and 24 VDC batteries, racked mounted in a ventilated enclosure, supply all necessary DC power for safe shutdown of the MP25 and Emergency blackout conditions. Battery chargers are furnished and properly rated to supply the MP25's DC loads and also have capacity to charge the batteries. Chargers are supplied power from the MCCs AC distribution panel that is fed from the AC, 3-phase, auxiliary transformer.

The auxiliary transformer is connected to the load side, not the generator side, of the 15 KV switchgear circuit breaker. Thus, when the MP25 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 MP25 is started and synchronized to the high side of the main-step-up transformer and the main breaker is closed, the MP25 generator supplies power to the auxiliary transformer.

15 KV CLASS, METAL-CLAD SWITCHGEAR MODULE

The 15 KV class switchgear is installed in the Control Trailer along with all other control components, and is connected to the generator by cables. The switchgear module is of the Metal-Clad construction and consists of three cubicles installed on one end of the Control Center Enclosure and described as follows:

- The first cubicle contains the dry-type, auxiliary transformer. The 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 AC power to the MP25 MCC. An AC 3-pole, 600 amp, 50/60 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 drawout-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 disconnectable control wiring connections.

The main generator circuit breaker is a 750 MVA interrupting, 2000 Ampere, 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.

CONTROL SYSTEM

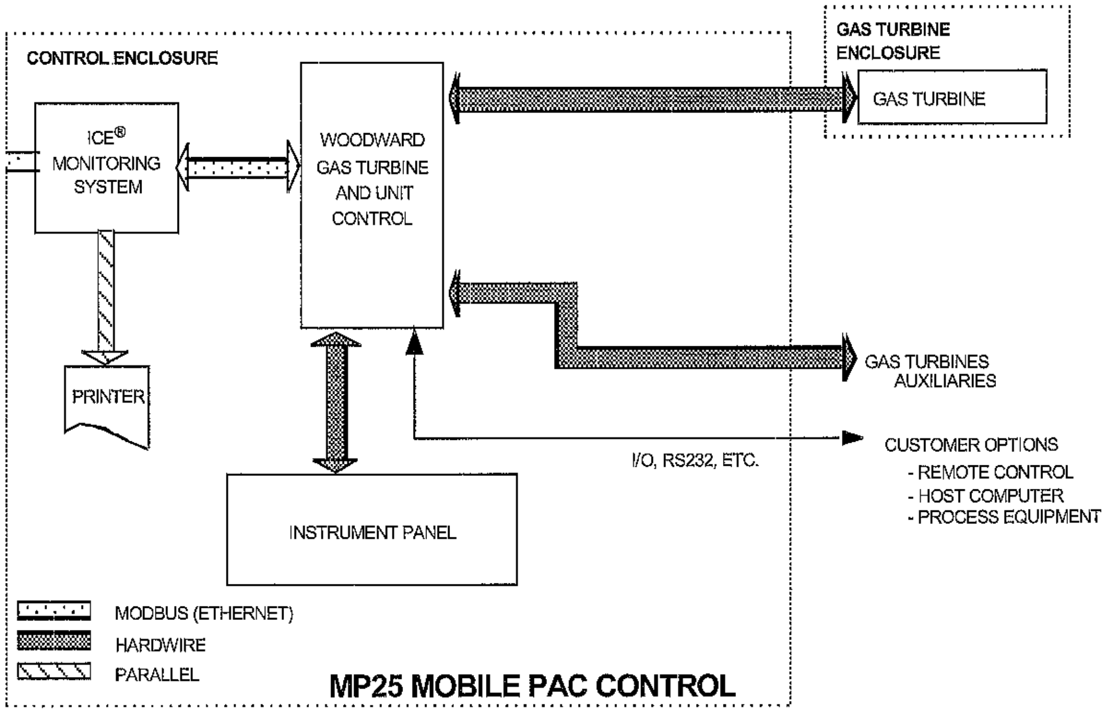
The MP25 control system contains an integrated Woodward gas turbine and unit control. This integrated controller acts as a central processing point for all I/O, serial and ethernet communications associated with the MP25. Data from this control is sent to a user-friendly ICE operator interface to display pertinent information.

UINTEGRATED GAS TURBINE AND UNIT CONTROL

The Woodward Control performs both fuel control and sequencing functions. This system incorporates a digital, programmable microprocessor, 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.

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 performance monitoring
- Start sequencing
- Unit synchronization
- Alarm and shutdown protection



MONITORING SYSTEM

The ICE¨ monitoring system package operates on a Pentium¨ based industrial PC and serves as the operator interface for the MP25. 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

GAS TURBINE ENCLOSURE

The gas turbine enclosure protects the gas turbine and other ancillaries located within it from the environment and provides noise attenuation. It provides a protected working environment and inside lighting for maintenance with the unit in a non-operating condition. It protects outside workers from the high component temperatures in an operating system

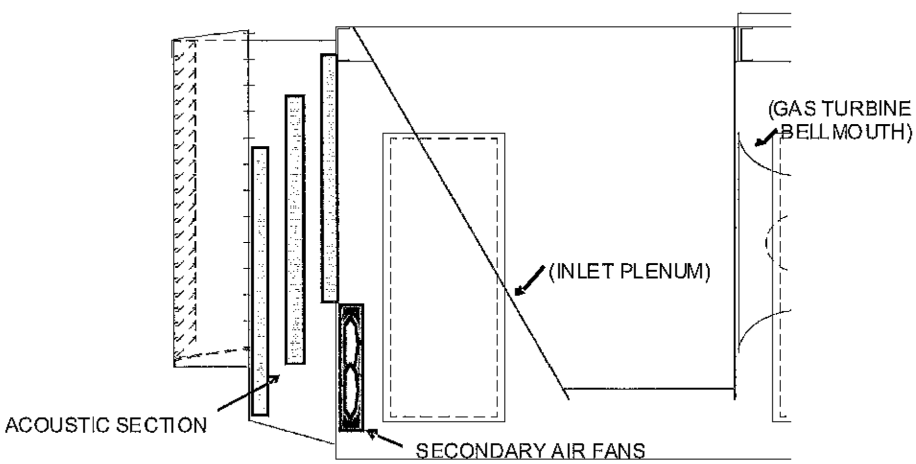
The gas turbine enclosure includes the inlet plenum and the exhaust enclosure. The inlet plenum channels the air from the inlet air silencer to the gas turbine bellmouth to minimize the inlet air pressure loss. The exhaust enclosure houses the exhaust diffuser/collector, which delivers the power turbine 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.

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) 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 deenergized and a pair of dampers are released to block the inlet air supply ports.



Gas Turbine Secondary Air System

INLET AIR FILTRATION

The primarily 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.

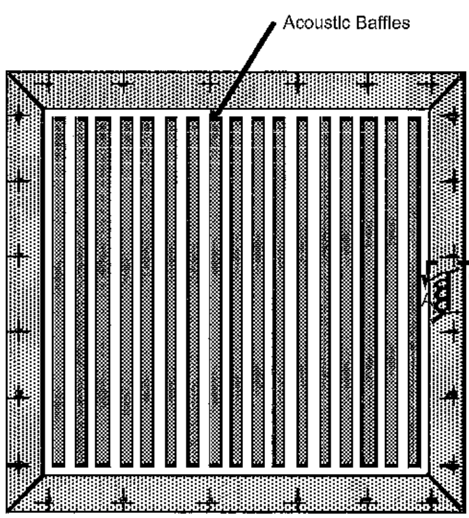
The high efficiency, replaceable fiberglass filters are preceded by a prefilter.
Filter elements can be replaced from inside the filter house.

INLET AIR SILENCER

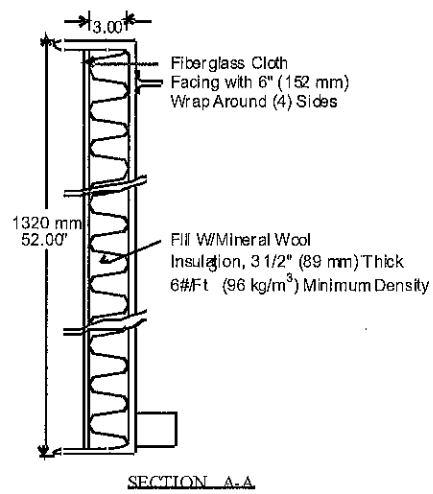
The inlet air silencer module attenuates noise over a broad band of frequencies.

Nominally 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) plate and the inner wall is 16 gauge perforated with four inches of mineral wool fill between them.

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



Top View of Inlet Silencer with Baffles Highlighted



Wall Construction

EXHAUST SILENCER

The exhaust silencer is composed of two major modules, the exhaust silencer transition module and the exhaust silencer module.

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

Construction of the exhaust silencer transition module and the exhaust silencer module is similar, both employing 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 exhaust 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.

DERWICK

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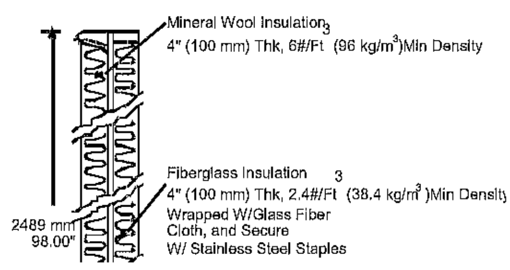
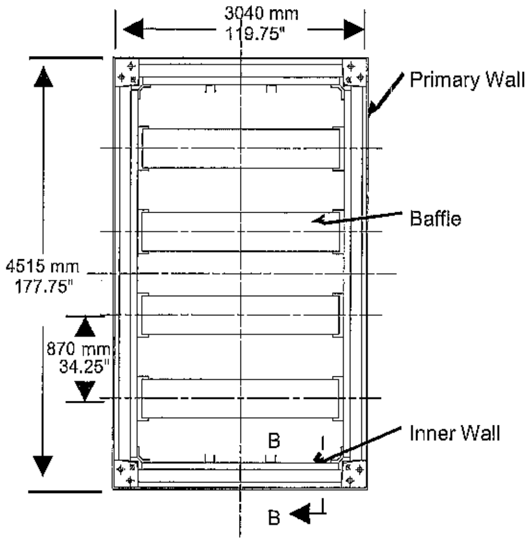


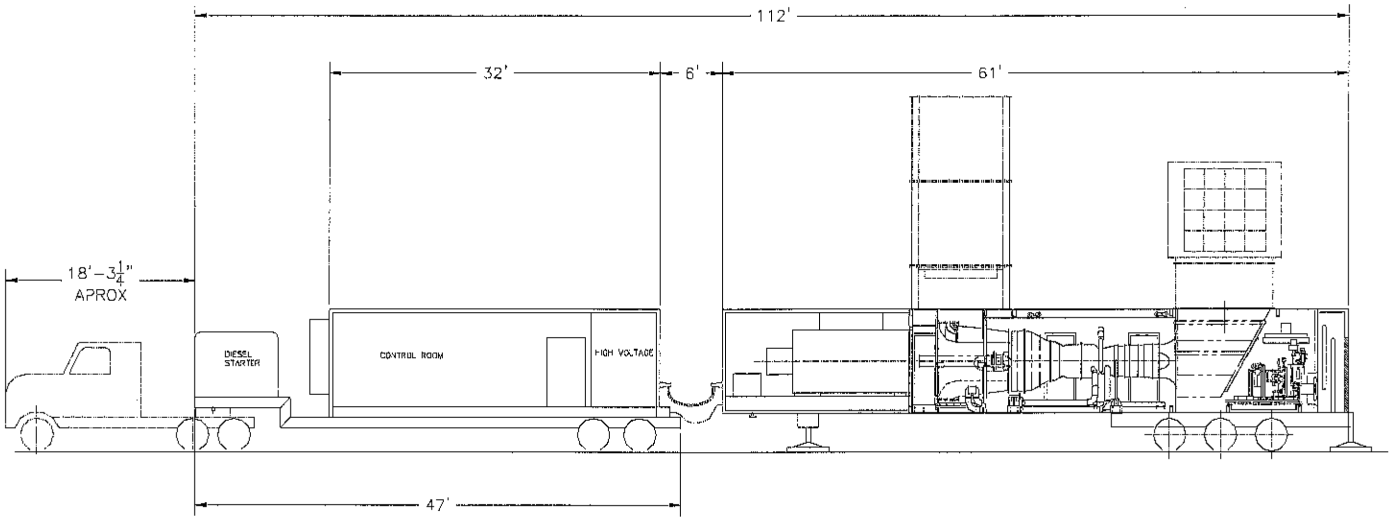


Top View of Exhaust, Showing Baffles in Place

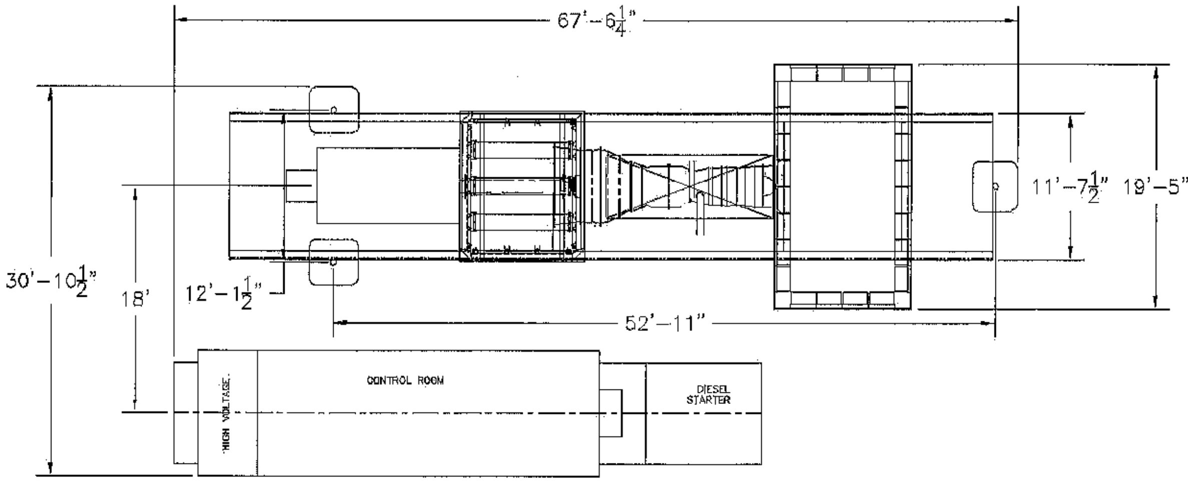
Wall Construction

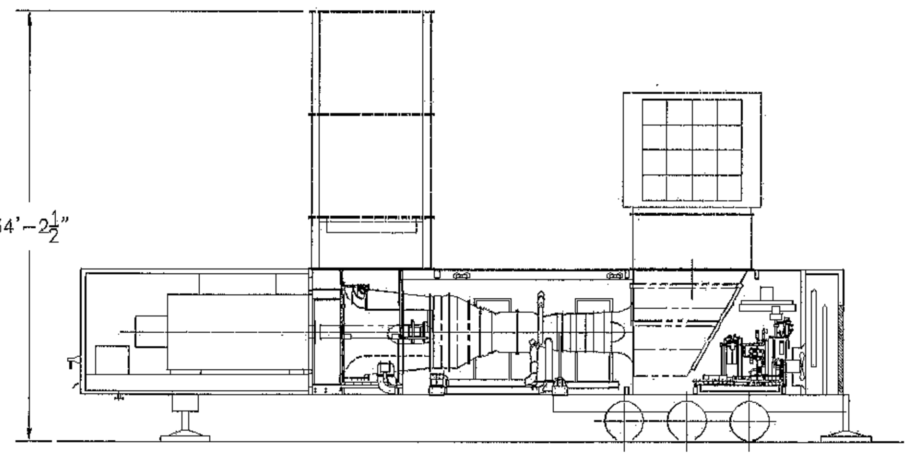
ESTIMATED SP25M MOBILE PAC WEIGHTS AND SIZES

Quantity	Description	Weight, lb/kg (ea)	Length, ft/m	Width, ft/m	Height, ft/m
1	Gas turbine Trailer	180,000/81646	61/18.5	12/3.7	13.5/4.1
	contains Enclosure				
	Secondary inlet silencer Engine				
	Diffuser inner/outer cylinder, tunnel and turning vanes				
	Engine Lube oil system Generator with lube oil module				
1	Control/switchgear trailer	80,000/36,370	49/12.8	11.5/3.5	13.5/4.1
	contains				
	Control system/monitor				
	Batteries/remote panel				
	MCC				
	Aux transformer				
1	Secondary Air silencer	5500/2500	11.5/3.5	10/3.1	7/2.1
1	Inlet air filter	14550/6600	15/5.5	12/3.6	12/3.6
1	Inlet silencer	9,900/4500	11.5/3.5	10/3.1	5/1.6
1	Exhaust transition piece	9,900/4,500	15/4.6	10/3.1	5/1.6
2	Exhaust silencer	16,000/7,300	15/4.6	10/3.1	9/2.7



Linear Arrangement





Parallel Arrangement

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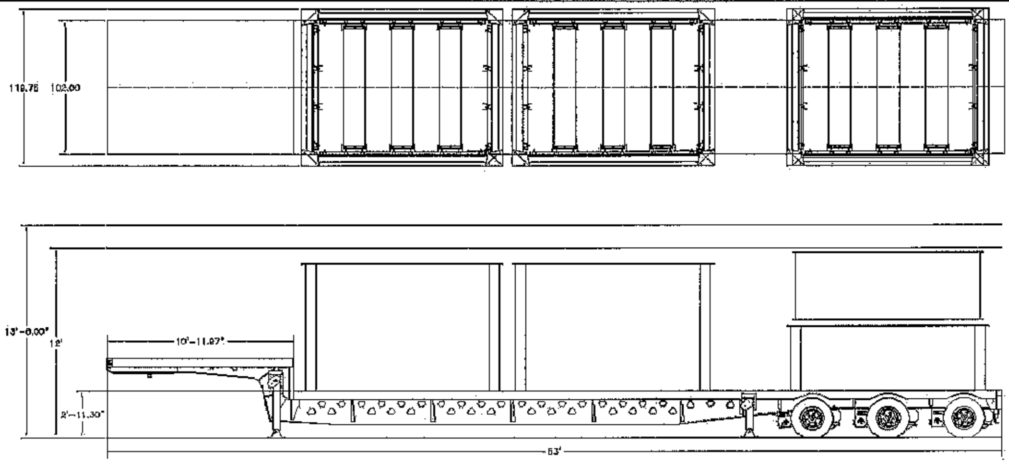

ACCESSORY TRAILERS REQUIRED