

OPERATION AND MAINTENANCE MANUAL  
DESCRIPTION

**GAS TURBINE**

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## 1. GAS TURBINE

## 1.1. INTRODUCTION

## 1.1.1. GENERAL

A heavy duty gas turbine unit is a mechanical power engine installed in a plant to drive a generator to supply an electrical network.

The gas turbine power engine includes an axial airflow compressor, a multi chamber combustion system and a three stages turbine. Main components of the gas turbine are listed here below.

The axial airflow compressor is a 17 stages compressor with:

- Adjustable inlet guide vanes (IGV) to control the airflow during starting and loading sequences.
- Bleed valves to bypass part of the air flow for starting and shut down to escape from surging

The combustion system comprises :

- Fuel nozzles fitted on the combustion chamber's cover
- Six combustion chambers where the fuel burns permanently from firing speed to full load
- Six cross fire tubes connecting the combustion chamber
- Six transition pieces downstream the combustion chamber connected to the first turbine stage nozzle
- Two spark plugs for the fuel ignition
- A set of flame detectors

The three stages turbine include first, second and third stage nozzle and first, second and third wheel.

The turbine and the axial flow compressor belong to the same shaft connected to the generator at the front end.

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While the gas turbine is running, filtered ambient air is drawn through the inlet plenum assembly, then compressed in the 17th-stage axial flow compressor. Compressed air from the compressor flows into the annular space surrounding the six combustion chambers, from which it flows into the spaces between the outer combustion casings and the combustion liners, and enters the combustion zone through metering holes in each of the combustion liners.

The fuel nozzles introduce the fuel into each of the six combustion chambers where it mixes with the combustion air and burns.

The hot gases from the combustion chambers expand into the six separate transition pieces attached to the downstream end of the combustion chamber liners and flows from there to the three-stage turbine section of the machine. Each stage consists of a row of fixed nozzles followed by a row of turbine buckets. In each nozzle row, the kinetic energy of the jet is increased, with an associated pressure drop, and in each following row of moving buckets, a portion of the kinetic energy of the jet is absorbed as useful work on the turbine rotor.

After passing through the 3rd-stage buckets, the exhaust gases are directed into the exhaust casing and diffuser. Then, the gases pass into the exhaust plenum and are introduced to atmosphere through the exhaust stack or used in a heat recovery steam generator.

Resultant shaft rotation turns the generator rotor to generate electrical power.

**Starting sequence :**

The gas turbine cannot run itself from zero speed. A starting means bring the shaft line up to the self-sustaining speed. The starting means is usually the generator itself piloted through a Static Frequency Converter (SFC)

When the starting means is actuated, the IGV are in the closed shut down position and the compressor bleed valves are open. The cranking torque from the starting means system breaks away the turbine shaft and brings the gas turbine to firing speed. Fuel is injected in the combustion chamber, spark plug provide ignition in two combustion chambers and the flame spreads to the other combustion chambers through the crossfire tubes. Flame detectors confirm full ignition to the control panel.

Starting means remain actuated to accelerate the unit to self-sustaining speed. A gas turbine speed threshold stops the starting means sequence. The gas turbine reaches nominal speed, the IGV move to full speed no load (FSNL) operating position and the bleed valve closes.

Main electrically driven lube oil pump provides lubricating oil for the shaft line bearings from zero speed to full load.

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Due to the high temperature of the gas path, the gas turbine must follow a 24 hours turning gear sequence at low speed, after shut down, to provide a homogeneous cool down to the shaft line.

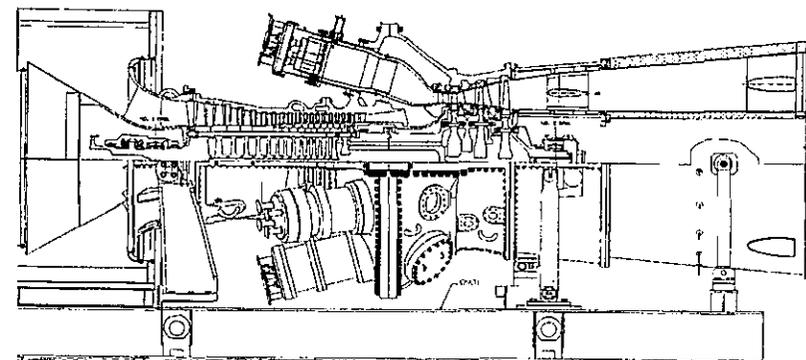
Therefore the turning gear motor starts automatically during the run down.

The various assemblies, systems and components that comprise the compressor, combustion and turbine sections of the gas turbine are described in the text, which follows. Refer to the illustrations in this section and elsewhere in this volume, the inspection and maintenance instructions volume and the parts lists and drawings volume for gas turbine component detailed information.

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## 1.1.2. DETAIL ORIENTATION

Throughout this manual, reference is made to the forward / front and aft / rear ends, and to the right and left sides of the gas turbine and its components. By definition, the air inlet of the gas turbine is the forward / front end, while the exhaust is the aft / rear end. The forward / front and aft / rear ends of each component are determined in like manner with respect to its orientation within the complete unit. Standing forward and looking aft determine the right and left sides of the turbine or of a particular component. On a drawing or picture, the forward end is usually on the left side and the aft end is on the right side.



GAS TURBINE ARRANGEMENT (TYPICAL)

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## 1.2. TURBINE BASE AND SUPPORTS

## 1.2.1. TURBINE BASE

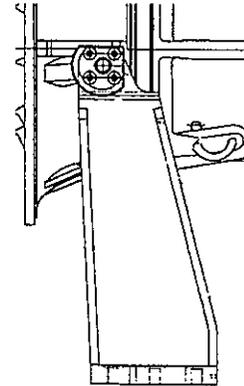
The base that supports the gas turbine is a structural steel fabrication of welded steel beams and plate. Its prime function is to provide a support upon which to mount the gas turbine.

Lifting trunnions and supports are provided, two on each side of the base in line with the two structural cross members of the base frame. Machined pads on each side on the bottom of the base facilitate its mounting to the site foundation. Two machined pads, atop the base frame are provided for mounting the aft turbine supports.

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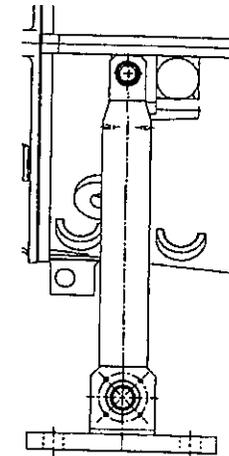
## 1.2.2. TURBINE SUPPORTS

The MS 6001 FA has rigid leg-type supports at the compressor end and supports with top and bottom pivots at the turbine end.



The support legs maintain the axial and vertical positions of the turbine, while two gib keys coupled with the turbine support legs maintain its lateral position. One gib key is machined on the lower half of the exhaust frame. The other gib key is machined on the lower half of the forward compressor casing. The keys fit into guide blocks which are welded to the cross beams of the turbine base. The keys are held securely in place in the guide blocks with bolts that bear against the keys on each side. This key-and-block arrangement prevents lateral or rotational movement of the turbine while permitting axial and radial movement resulting from thermal expansion.

To maintain of the exhaust diffuser, there are also two supports fixed on the turbine base. They are equipped with top and bottom pivots.



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## 1.3. COMPRESSOR SECTION

## 1.3.1. GENERAL

The axial-flow compressor section consists of the compressor rotor and the compressor casing. Within the compressor casing are the variable inlet guide vanes, the various stages of rotor and stator blades, and the exit guide vanes.

In the compressor, air is confined to the space between the rotor and stator where it is compressed in stages by a series of alternate rotating (rotor) and stationary (stator) airfoil-shaped blades. The rotor blades supply the force needed to compress the air in each stage and the stator blades guide the air so that it enters the following rotor stage at the proper angle. The compressed air exits through the compressor discharge casing to the combustion chambers. Air is extracted from the compressor for turbine cooling and for pulsation control during startup.

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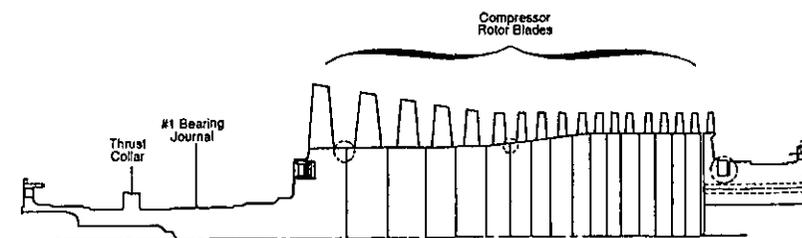
## 1.3.2. COMPRESSOR ROTOR

The compressor portion of the gas turbine rotor is an assembly of wheels, a speed ring, tie bolts, the compressor rotor blades, and a forward stub shaft.

Each wheel has slots broached around its periphery. The rotor blades and spacers are inserted into these slots and held in axial position by staking at each end of the slot. The wheels are assembled to each other with mating rabbets for concentricity control and are held together with tie bolts. Selective positioning of the wheels is made during assembly to reduce balance correction. After assembly, the rotor is dynamically balanced.

The forward stubshaft is machined to provide the thrust collar, which carries the forward and aft thrust loads. The stubshaft also provides the journal for the N° 1 bearing, the sealing surface for the N° 1 bearing oil seals and the compressor low-pressure air seal.

The stage 17 wheel carries the rotor blades and also provides the sealing surface for the high-pressure air seal and the compressor-to-turbine marriage flange.



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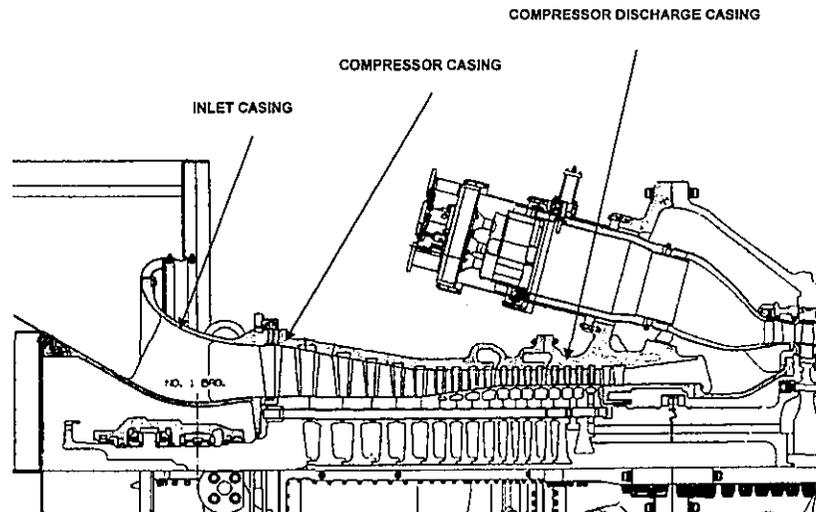
1.3.3. COMPRESSOR STATOR

1.3.3.1. GENERAL

The casing area of the compressor section is composed of three major sections. These are the :

1. inlet casing
2. Compressor casing
3. Compressor discharge casing

Those casings, in conjunction with the turbine casing, form the primary structure of the gas turbine. They support the rotor at the bearing points and constitute the outer wall of the gas-path annulus. All of these casings are split horizontally to facilitate servicing.

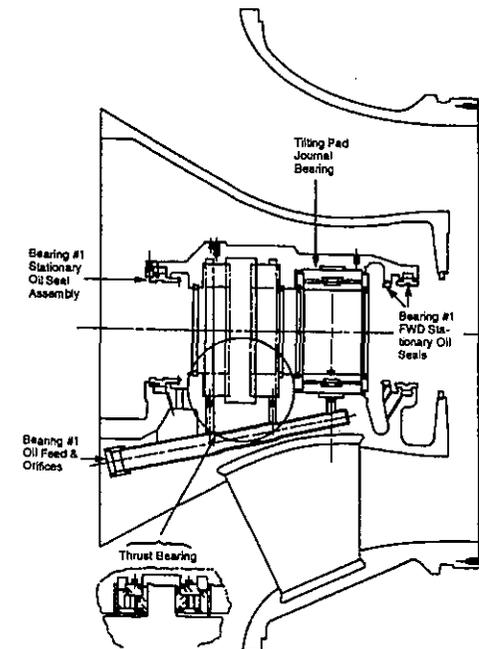


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1.3.3.2. INLET CASING

The inlet casing is located at the forward end of the gas turbine. Its prime function is to uniformly direct air into the compressor. The inlet casing also supports the #1 bearing assembly. The #1 bearing lower half housing is integrally cast with the inner bellmouth. The upper half bearing housing is a separate casting, flanged and bolted to the lower half. The inner bellmouth is positioned to the outer bellmouth by nine airfoil-shaped radial struts. The struts are cast into the bellmouth walls. They also transfer the structural loads from the adjoining casing to the forward support, which is bolted and doweled to this inlet casing.

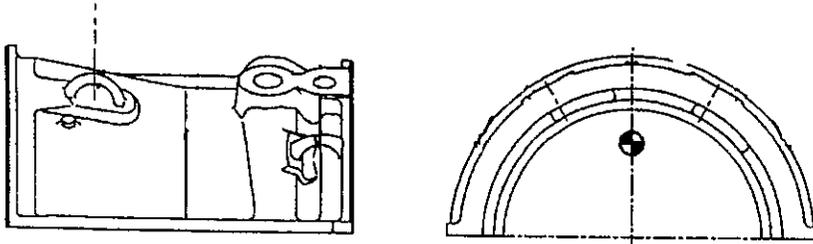
Variable inlet guide vanes are located at the aft end of the inlet casing and are mechanically positioned, by a control ring and pinion gear arrangement connected to a hydraulic actuator drive and linkage arm assembly. The position of these vanes has an effect on the quantity of compressor inlet airflow.



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## 1.3.3.3. COMPRESSOR CASING

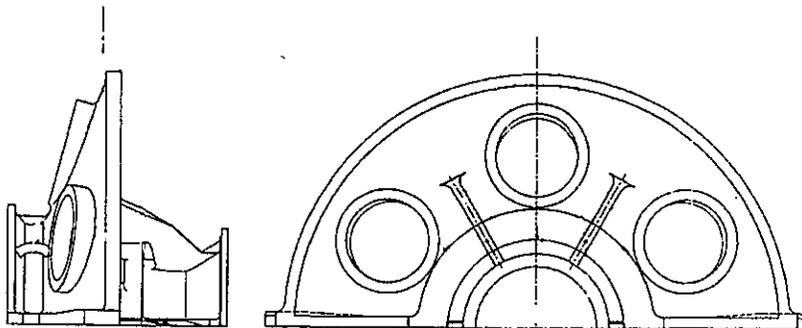
The forward compressor casing contains the stage 0 through stage 4 compressor stator stages. The compressor casing lower half is equipped with two large integrally cast trunnions, which are used to lift the gas turbine when it is separated from its base.



The aft compressor casing contains stage 5 through stage 12 compressor stator stages. Extraction ports in aft casing permit removal of 13th-stage compressor air. This air is used for cooling functions and is also used for pulsation control during startup and shutdown.

## 1.3.3.4. COMPRESSOR DISCHARGE CASING

The compressor discharge casing is the final portion of the compressor section. It is the longest single casting, is situated at midpoint - between the forward and aft supports - and is, in effect, the keystone of the gas turbine structure. The compressor discharge casing contains the final compressor stages, forms both the inner and outer walls of the compressor diffuser, and joins the compressor and turbine casings. The discharge casing also provides support for the combustion outer casings and the inner support of the first-stage turbine nozzle.

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The compressor discharge casing consists of two cylinders, one being a continuation of the compressor casing and the other being an inner cylinder that surrounds the compressor rotor. The two cylinders are concentrically positioned by fourteen radial struts.

A diffuser is formed by the tapered annulus between the outer cylinder and inner cylinder of the discharge casing. The diffuser converts some of the compressor exit velocity into added static pressure for the combustion air supply.

## 1.3.3.5. BLADING

The compressor rotor and stator blades are airfoil shaped and designed to compress air efficiently at high blade tip velocities. The blades are attached to the compressor wheels by dovetail arrangements. The dovetail is very precise in size and position to maintain each blade in the desired position and location on the wheel.

The compressor stator blades are airfoil shaped and are mounted by similar dovetails into ring segments in the first five stages. The ring segments are inserted into circumferential grooves in the casing and are held in place with locking keys. The stator blades of the remaining stages have a square base dovetail and are inserted directly into circumferential grooves in the casing. Locking keys hold them in place.

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## 1.4. COMBUSTION SYSTEM

## 1.4.1. GENERAL

The dry low NOx 2.6 (DLN 2.6) control system regulates the distribution of fuel delivered to a multi-nozzle, total premix combustor arrangement. The fuel flow distribution to each combustion chamber fuel nozzle assembly is calculated to maintain unit load and fuel split for optimal turbine emissions.

The combustion system is of the reverse-flow type with the 6 combustion chambers arranged around the periphery of the compressor discharge casing. Combustion chambers are numbered counterclockwise when viewed looking downstream and starting from the top of the machine. This system also includes the fuel nozzles, a spark plug ignition system, flame detectors, and crossfire tubes. Hot gases, generated from burning fuel in the combustion chambers, flow through the impingement cooled transition pieces to the turbine.

High pressure air from the compressor discharge is directed around the transition pieces. Some of the air enters the holes in the impingement sleeve to cool the transition pieces and flows into the flow sleeve. The rest enters the annulus between the flow sleeve and the combustion liner through holes in the downstream end of the flow sleeve. This air enters the combustion zone through metering holes for proper fuel combustion and through slots to cool the combustion liner. Fuel is supplied to each combustion chamber through six nozzles designed to disperse and mix the fuel with the proper amount of combustion air.

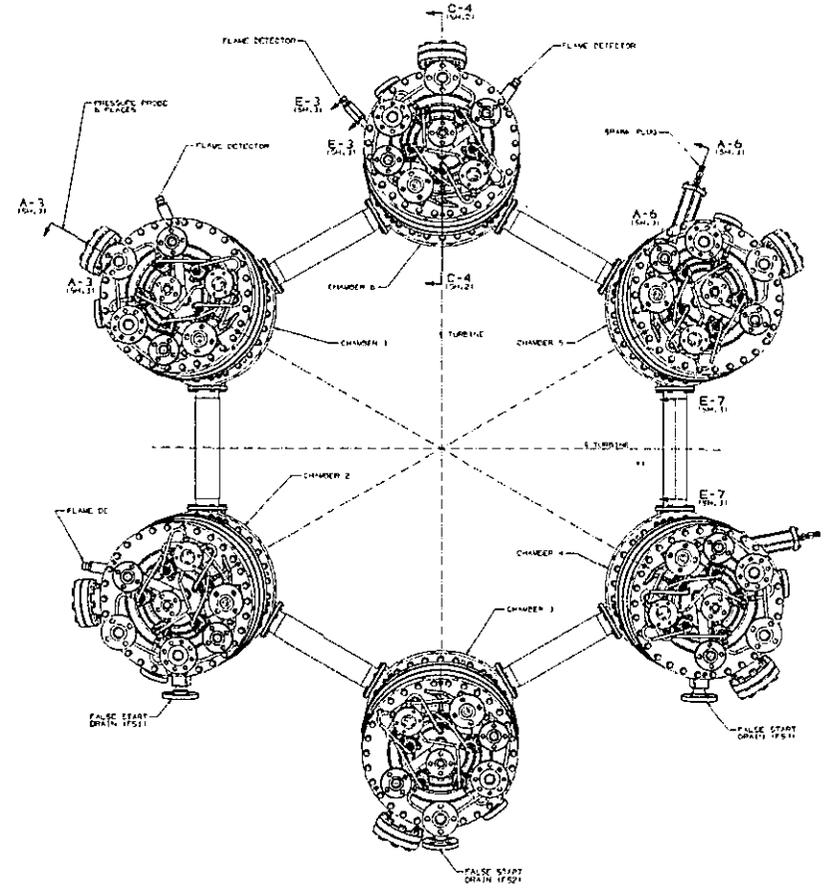
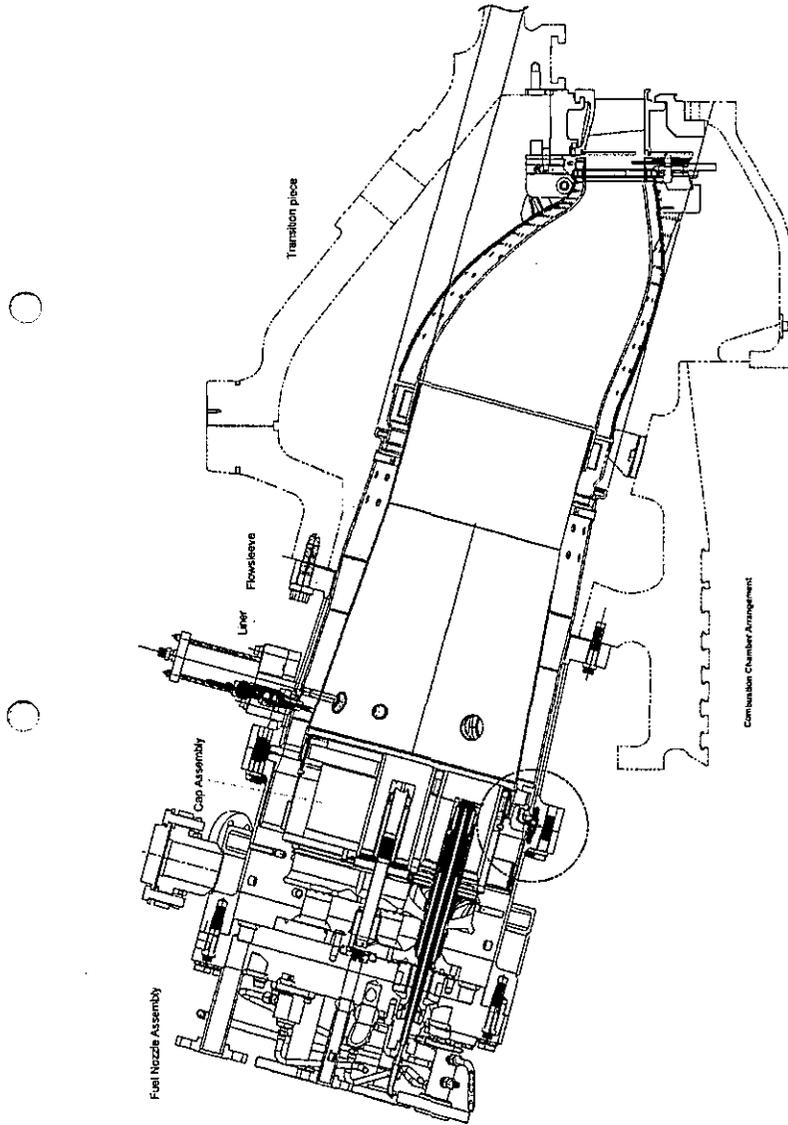
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## 1.4.2. OUTER COMBUSTION CHAMBERS AND FLOW SLEEVES

The outer combustion chambers act as the pressure shells for the combustors. They also provide flanges for the fuel nozzle-end cover assemblies, crossfire tube flanges, and, where called for, spark plugs, flame detectors and false start drains. The flow sleeves form an annular space around the cap and liner assemblies that directs the combustion and cooling air flows into the reaction region. To maintain the impingement sleeve pressure drop, the openings for crossfire tubes, spark plugs, and flame detectors are sealed with sliding grommets.

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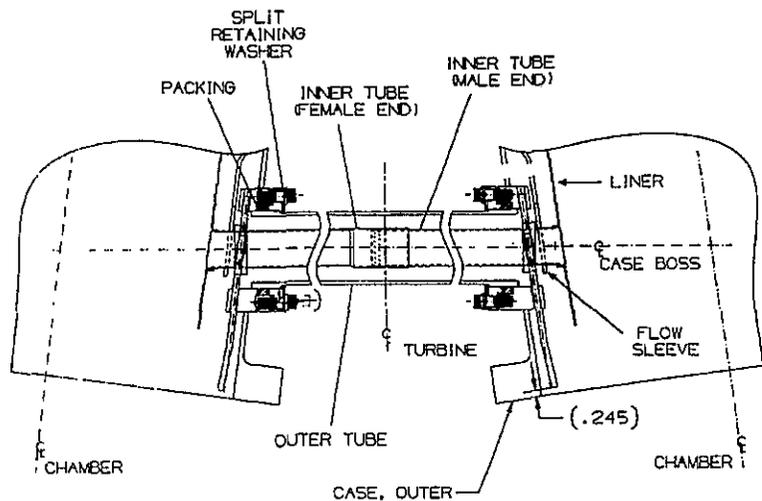


COMBUSTION CHAMBER ARRANGEMENT

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1.4.3. CROSSFIRE TUBES

All combustion chambers are interconnected by means of crossfire tubes. The outer chambers are connected with an outer crossfire tube and the combustion liner primary zones are connected by the inner crossfire tubes.



CROSSFIRE TUBE ASSEMBLY (TYPICAL)

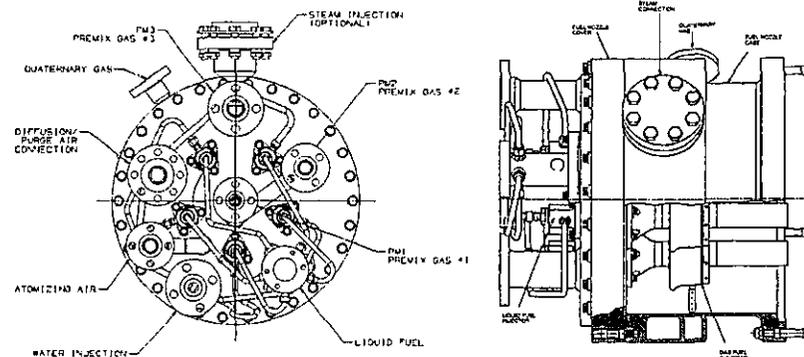
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1.4.4. FUEL NOZZLES END COVER

The MS 6001 FA multi-nozzle combustor utilizes six fuel nozzles in each combustion end cover in conjunction with provisions for water injection.

On the multi-nozzle combustor, the fuel nozzle is functionally integrated with the combustor end cover. Internal manifolds within the cover supply gas and atomizing air to the six fuel nozzles. Water (required for NOx abatement) is injected through the center of the cover. The function of the fuel oil distribution valve is to equally distribute fuel oil between the six fuel nozzles. This function is especially important during start-up when oil supply pressures are relatively low.

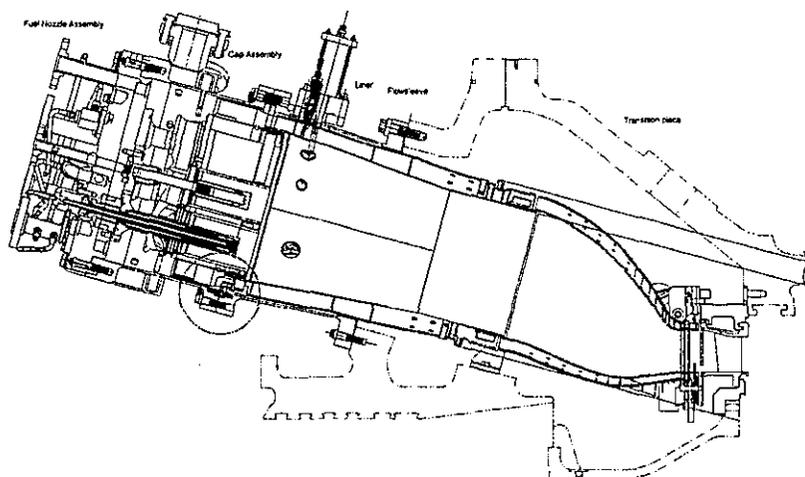
The water injector is mounted through the center of the cover. Heavy-walled tubing supplies water to each gas swirl tip. The water is directed into the swirl vanes through small holes in the tubing where it then enters the combustor for NOx reduction. The tubing is attached to the body of the distributor with special tubing fittings and supported in a groove cut around the gas tip. The assembly is locked in place using a special lockplate.



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1.4.5. CAP AND LINER ASSEMBLIES

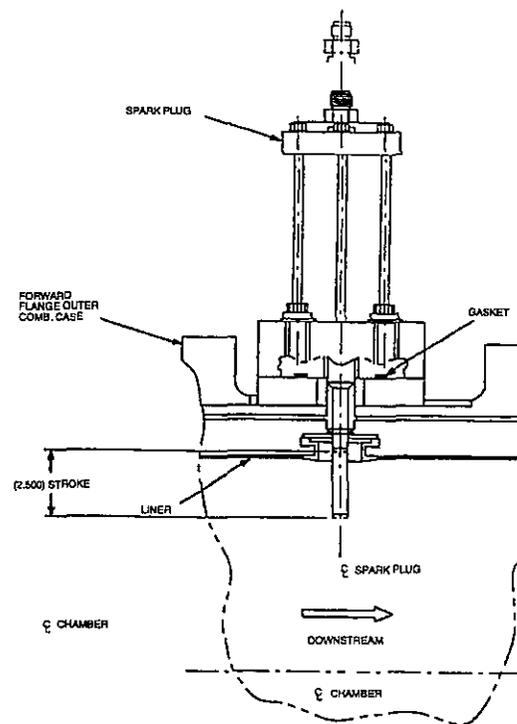
The combustion liners use conventional cooling slots but are fabricated from a heavier material. All but the seal (in contact with the transition pieces) of the liner is made from Hastelloy-X. Inconel is used for the seal of the liner. Interior surfaces of the liner and the cap are thermal barrier coated to reduce metal temperatures and thermal gradients. The cap has five floating collars to engage each of the five fuel nozzle tips. It is cooled by a combination of film cooling and impingement cooling and has thermal barrier coating on the inner surfaces.



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1.4.6. SPARK PLUGS

Combustion is initiated by means of the discharge from two spark plugs, which are bolted to flanges on the combustion cans and centered within the liner and flowsleeve in adjacent combustion chambers. A typical spark plug arrangement is shown in the following. These plugs receive their energy from high energy-capacitor discharge power supplies. At the time of firing, a spark at one or both of these plugs ignites the gases in a chamber, the remaining chambers are ignited by crossfire through the tubes that interconnect the reaction zone of the remaining chambers.



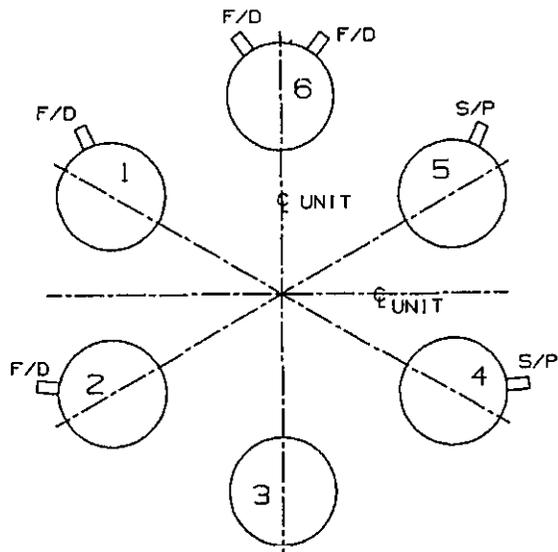
SPARK PLUG ASSEMBLY (TYPICAL)

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1.4.7. ULTRAVIOLET FLAME DETECTORS

During the starting sequence, it is essential that an indication of the presence or absence of flame be transmitted to the control system. For this reason, a flame monitoring system is used consisting of multiple flame detectors located as shown of the following figure. The flame detectors have water cooled jackets to maintain acceptable temperatures.

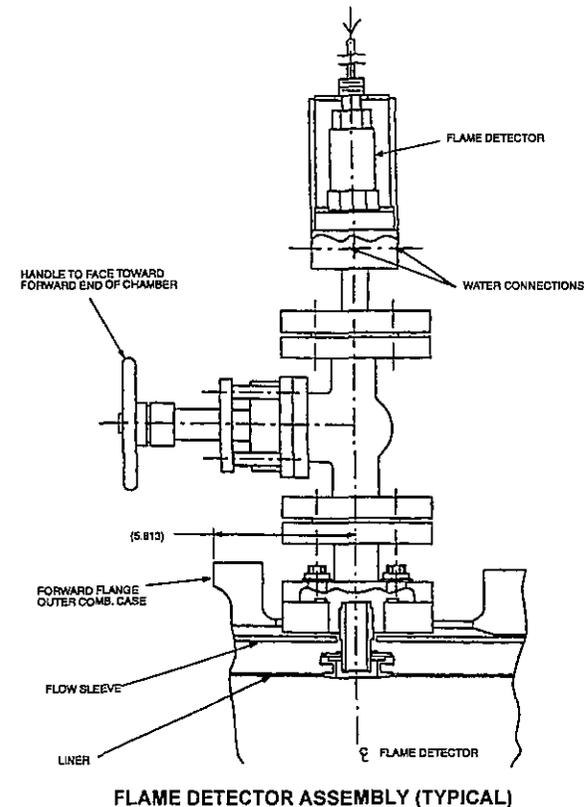
The ultraviolet flame sensor contains a gas filled detector. The gas within this detector is sensitive to the presence of ultraviolet radiation, which is emitted by a hydrocarbon flame. A DC voltage, supplied by the amplifier, is impressed across the detector terminals. If flame is present, the ionization of the gas in the detector allows conduction in the circuit, which activates the electronics to give an output indicating flame. Conversely, the absence of flame will generate an output indicating no flame.



The signals from the four flame detectors are sent to the control system, which uses an internal logic system to determine whether a flame or loss of flame condition exists.

For detailed operating and maintenance information covering this equipment, refer to the vendor publications.

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## 1.5. TURBINE SECTION

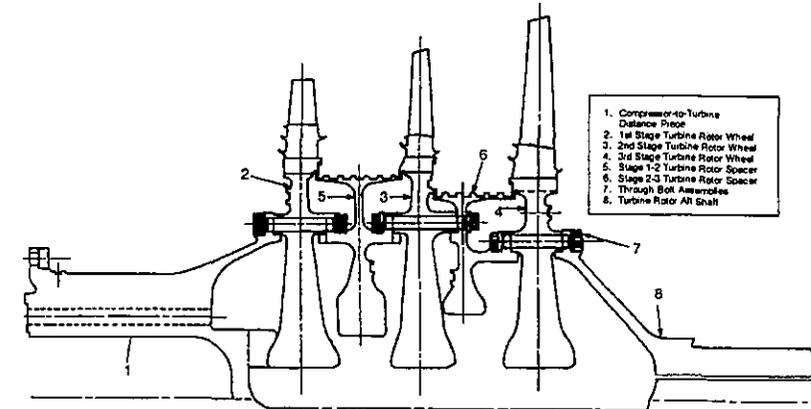
## 1.5.1. GENERAL

The three-stage turbine section is the area in which energy in the form of high temperature pressurized gas, produced by the compressor and combustion sections, is converted to mechanical energy.

MS 6001 FA gas turbine hardware includes the turbine rotor, turbine casing, exhaust frame, exhaust diffuser, nozzles, and shrouds.

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## 1.5.2. TURBINE ROTOR



## 1.5.2.1. STRUCTURE

The turbine rotor assembly consists of the forward and aft turbine wheel shafts and the first-, second- and third-stage turbine wheel assemblies with spacers and turbine buckets. Concentricity control is achieved with mating rabbets on the turbine wheels, wheel shafts, and spacers. The wheels are held together with through bolts mating up with bolting flanges on the wheel shafts and spacers. Selective positioning of rotor members is performed to minimize balance corrections.

## 1.5.2.2. WHEEL SHAFTS

The turbine rotor distance piece extends from the first-stage turbine wheel to the aft flange of the compressor rotor assembly.

The turbine rotor aft shaft includes the #2 bearing journal.

## 1.5.2.3. WHEEL ASSEMBLIES

Spacers between the first and second, and between the second and third-stage turbine wheels determine the axial position of the individual wheels. These spacers carry the diaphragm sealing lands. The 1-2 spacer forward and aft faces include radial slots for cooling air passages.

Turbine buckets are assembled in the wheels with fir-tree-shaped dovetails that fit into matching cutouts in the turbine wheel rims. All three turbine stages have precision investment-cast, long-shank buckets. The long-shank bucket design effectively shields the wheel rims and bucket root fastenings from the high temperatures in the hot gas path while

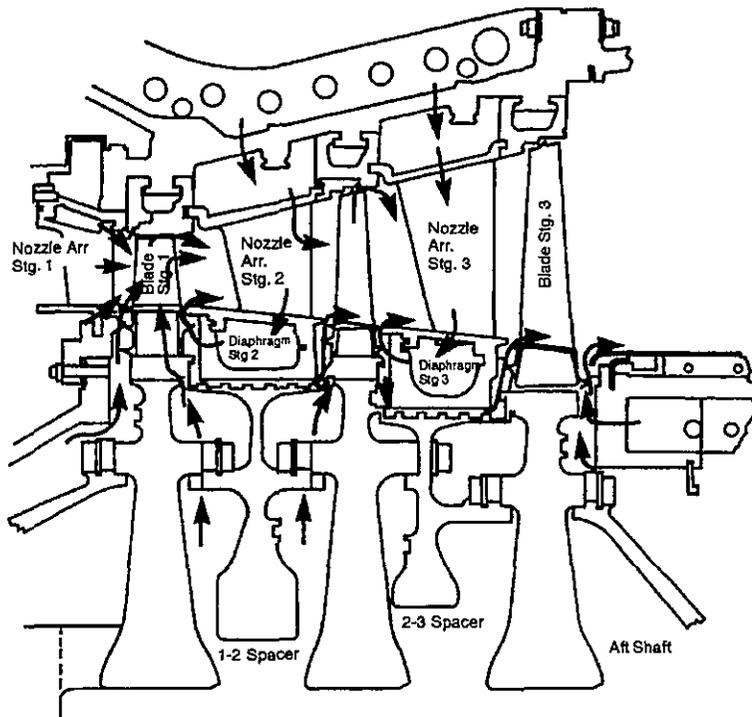
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providing mechanical damping of bucket vibrations. As a further aid in vibration damping, the stage-two and stage-three buckets have interlocking shrouds at the bucket tips. These shrouds also increase the turbine efficiency by minimizing tip leakage. Radial teeth on the bucket shrouds combine with stepped surfaces on the stator to provide a labyrinth seal against gas leakage past the bucket tips.

The increase in the size of the buckets from the first to the third stage is necessitated by the pressure reduction resulting from energy conversion in each stage, requiring an increased annulus area to accommodate the gas flow.

## 1.5.2.4. COOLING

The turbine rotor is cooled to maintain reasonable operating temperatures and, therefore, assure a longer turbine service life. Cooling is accomplished by means of a positive flow of cool air extracted from the compressor and discharged radially outward through a space between the turbine wheel and the stator, into the main gas stream. This area is called the wheel-space.

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## 1.5.2.5. FIRST-STAGE WHEELSPACES

The first-stage forward wheel-space is cooled by compressor discharge air. A honeycomb labyrinth seal is installed at the aft end of the compressor rotor between the rotor and inner barrel of the compressor discharge casing. The leakage through this labyrinth furnishes the air flow through the first-stage forward wheel-space. This cooling air flow discharges into the main gas stream aft of the first-stage nozzle.

The first-stage aft wheel-space is cooled by 9th stage extraction air ported through the 2nd stage nozzle. This air returns to the gas path forward of the 2nd stage nozzle.

## 1.5.2.6. SECOND-STAGE WHEELSPACES

The second-stage forward wheel-space is cooled by leakage from the first-stage aft wheel-space through the interstage labyrinth. This air returns to the gas path at the entrance of the second-stage buckets.

The second-stage aft wheel-space is cooled by 13th stage extraction air ported through the 3rd stage nozzle. Air from this wheel-space returns to the gas path at the third-stage nozzle entrance.

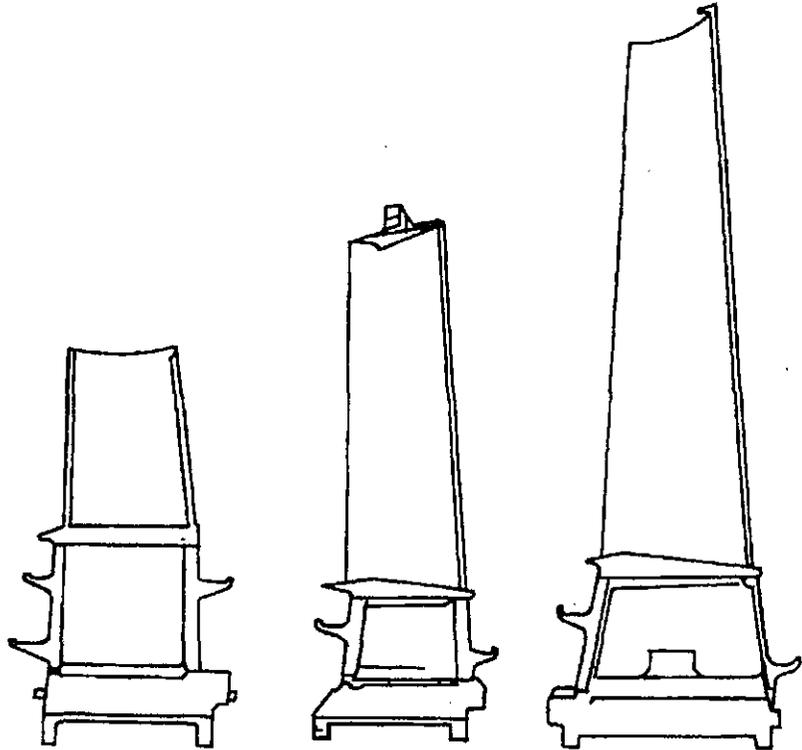
## 1.5.2.7. THIRD-STAGE WHEELSPACES

The third-stage forward wheel-space is cooled by leakage from the second-stage aft wheel-space through the interstage labyrinth. This air reenters the gas path at the third-stage bucket entrance.

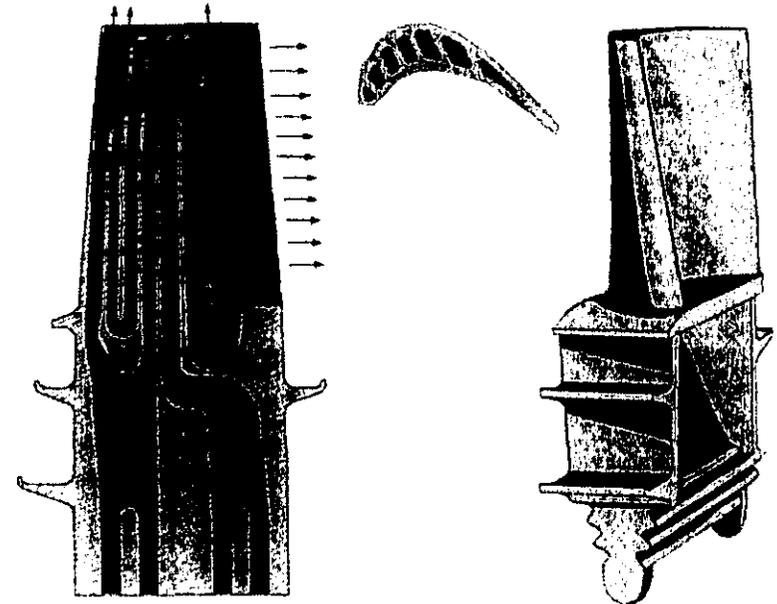
The third-stage aft wheel-space obtains its cooling air from the discharge of the exhaust frame cooling air annulus. This air flows through the third-stage aft wheel-space, and into the gas path at the entrance to the exhaust diffuser.

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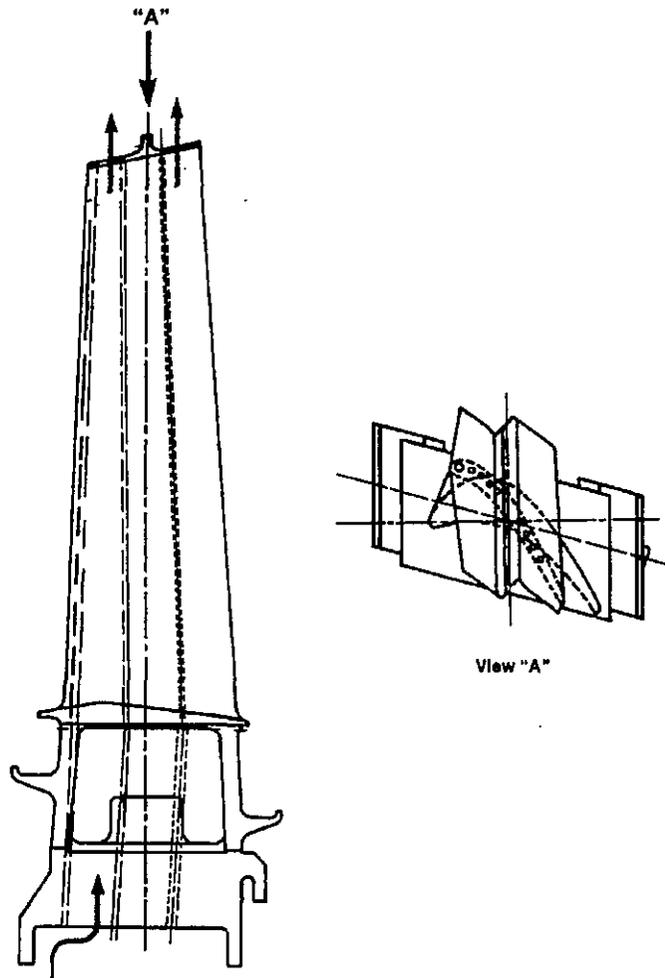
## 1.5.2.8. BUCKETS



Air is introduced into each first-stage bucket through a plenum at the base of the bucket dovetail. It flows through serpentine cooling holes extending the length of the bucket and exits at the trailing edge and the bucket tip. The holes are spaced and sized to obtain optimum cooling of the airfoil with minimum compressor extraction air.

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Unlike the first-stage buckets, the second-stage buckets are cooled by spanwise air passages the length of the airfoil. Air is introduced like the first-stage, with a plenum at the base of the bucket dovetail. Again airfoil cooling is accomplished with minimum penalty to the thermodynamic cycle.



The third-stage buckets are not internally air cooled ; the tips of these buckets, like the second-stage buckets, are enclosed by a shroud, which is a part of the tip seal. These shrouds interlock from bucket to bucket to provide vibration damping.

### 1.5.3. TURBINE STATOR

#### 1.5.3.1. STRUCTURE

The turbine casing and the exhaust frame constitute the major portion of the MS 6001 FA gas turbine stator structure. The turbine nozzles, shrouds, and turbine exhaust diffuser are internally supported from these components.

#### 1.5.3.2. TURBINE CASING

The turbine casing controls the axial and radial positions of the shrouds and nozzles. It determines turbine clearances and the relative positions of the nozzles to the turbine buckets. This positioning is critical to gas turbine performance.

Hot gases contained by the turbine casing are a source of heat flow into the casing. Heat flow limitations incorporate insulation, cooling, and multi-layered structures. 13th and 9th stage extraction air is piped into the turbine casing annular spaces around the 2nd and 3rd stage nozzles. From there the air is ported through the nozzle partitions and into the wheel spaces.

Structurally, the turbine casing forward flange is bolted to the bulkhead flange at the aft end of the compressor discharge casing. The turbine casing aft flange is bolted to the forward flange of the exhaust frame.

#### 1.5.3.3. NOZZLES

In the turbine section there are three stages of stationary nozzles, which direct the high-velocity flow of the expanded hot combustion gas against the turbine buckets causing the turbine rotor to rotate. Because of the high pressure drop across these nozzles, there are seals at both the inside and the outside diameters to prevent loss of system energy by leakage. Since these nozzles operate in the hot combustion gas flow, they are subjected to thermal stresses in addition to gas pressure loadings.

#### 1.5.3.4. FIRST-STAGE NOZZLE

The first-stage nozzle receives the hot combustion gases from the combustion system via the transition pieces. The transition pieces are sealed to both the outer and inner sidewalls on the entrance side of the nozzle ; this minimize leakage of compressor discharge air into the nozzles.

The Model 6001 FA gas turbine first-stage nozzle contains a forward and aft cavity in the vane and is cooled by a combination of film, impingement and convection techniques in both the vane and sidewall regions.

The nozzle segments, each with two partitions or airfoils, are contained by a horizontally split retaining ring which is centerline supported to the turbine casing on lugs at the sides and guided by keys at the top and bottom vertical centerlines. This permits radial growth of the retaining ring, resulting from changes in temperature, while the ring remains centered in the casing.

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The aft outer sidewall of the nozzle is loaded against the forward face of the first-stage turbine shroud and acts as the air seal to prevent leakage of compressor discharge air between the nozzle and turbine casing.

On the inner sidewall, the nozzle is sealed by a flange cast on the inner diameter of the sidewall that rests against a mating face on the first-stage nozzle support ring, a locating dowel that engages a lug on the inner sidewall.

The nozzle is prevented from moving forward by the lugs on the aft outside diameter of the retaining ring at 60 degrees from vertical and horizontal centerlines. By moving the horizontal joint support block and the bottom centerline key and the 60° blocks, the lower half of the nozzle can be rolled out with the turbine rotor in place.

## 1.5.3.5. SECOND-STAGE NOZZLE

Combustion air exiting from the first stage buckets is again expanded and redirected against the second-stage turbine buckets by the second-stage nozzle. This nozzle is made of cast segments, each with two partitions or airfoils. The male hooks on the entrance and exit sides of the outer sidewall fit into female grooves on the aft side of the first-stage shrouds and on the forward side of the second-stage shrouds to maintain the nozzle concentric with the turbine shell and rotor. This close fitting tongue-and-groove fit between nozzle and shrouds acts as an outside diameter air seal. The nozzle segments are held in a circumferential position by radial pins from the shell into axial slots in the nozzle outer sidewall.

The second-stage nozzle is cooled with 13th stage extraction air.

## 1.5.3.6. THIRD-STAGE NOZZLE

The third-stage nozzle receives the hot gas as it leaves the second-stage buckets, increases its velocity by pressure drop, and directs this flow against the third-stage buckets. The nozzle consists of cast segments, each with three partitions or airfoils. It is held at the outer sidewall forward and aft sides in grooves in the turbine shrouds in a manner similar to that used on the second-stage nozzle. The third-stage nozzle is circumferentially positioned by radial pins from the shell. 9th stage extraction air flows through the nozzle partitions for nozzle convection cooling and for augmenting wheelspace cooling air flow.

## 1.5.3.7. DIAPHRAGM

Bolted to the inside diameters of both the second and third-stage nozzle segments are the nozzle diaphragms. These diaphragms prevent air leakage past the inner sidewall of the nozzles and the turbine rotor. A honeycomb labyrinth seal is brazed into the inside diameter of the diaphragm. They mate with opposing sealing teeth on the turbine rotor. Minimal radial clearance between stationary parts (diaphragm and nozzles) and the moving rotor are essential for maintaining low interstage leakage; this results in higher turbine efficiency.

## 1.5.3.8. SHROUDS

Unlike the compressor blades, the turbine buckets tips do not run directly against an integral machined surface of the casing but against annular curved segments called turbine shrouds. The shrouds' primary function is to provide a cylindrical surface for minimizing bucket tip clearance leakage.

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The turbine shrouds' secondary function is to provide a high thermal resistance between the hot gases and the comparatively cool turbine casing. By accomplishing this function, the turbine casing cooling load is drastically reduced, the turbine casing diameter is controlled, the turbine casing roundness is maintained, and important turbine clearances are assured.

The first stage stationary shroud segments are in two pieces; the gas-side inner shroud is separated from the supporting outer shroud to allow for expansion and contraction, and thereby improve low-cycle fatigue life. The first-stage shroud is cooled by impingement, film, and convection. The second and third stage stationary shroud segments are a single piece configuration with a honeycomb seal brazed into the inside diameter to form the seal surface to the bucket seal tooth.

The shroud segments are maintained in the circumferential position by radial pins from the turbine casing. Joints between shroud segments are sealed by spline seals.

## 1.5.3.9. EXHAUST FRAME

The exhaust frame is bolted to the aft flange of the turbine casing. Structurally, the frame consists of an outer cylinder and an inner cylinder interconnected by the radial struts. The #2 bearing is supported from the inner cylinder.

The exhaust diffuser located at the aft end of the turbine is bolted to the exhaust frame. Gases exhausted from the third turbine stage enter the diffuser where velocity is reduced by diffusion and pressure is recovered. At the exit of the diffuser, the gases are directed into the exhaust plenum.

Exhaust frame radial struts cross the exhaust gas stream. These struts position the inner cylinder and #2 bearing in relation to the outer casing of the gas turbine. The struts must be maintained at a constant temperature in order to control the center position of the rotor in relation to the stator. This temperature stabilization is accomplished by protecting the struts from exhaust gases with a metal fairing that forms an air space around each strut and provides a rotated, combined airfoil shape.

Off-base blowers provide cooling air flow through the space between the struts and the wrapper to maintain uniform temperature of the struts. This air is then directed to the third-stage aft wheelspace.

Trunnions on the sides of the exhaust frame are used with similar trunnions on the forward compressor casing to lift the gas turbine when it is separated from its base.

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## 1.6. BEARINGS

## 1.6.1. GENERAL

The MS 6001 FA gas turbine unit has two four-element, tilting pad journal bearings, which support the gas turbine rotor. The unit also includes a thrust bearing to maintain the rotor-to-stator axial position. Thrust is absorbed by a tilting pad thrust bearing with eight shoes on both sides of the thrust bearing runner. These bearings and seals are incorporated in two housings, one at the inlet casing, one in the exhaust frame. These main bearings are pressure-lubricated by oil supplied from the main lubricating oil system. The oil flows through branch lines to an inlet in each bearing housing.

## 1.6.2. LUBRICATION

The main turbine bearings are pressure-lubricated with oil supplied, from the oil reservoir. Oil feed piping, where practical, is run within the lube oil drain lines, or drain channels, as a protective measure. In the event of a supply line leak, oil will not be sprayed on nearby equipment, thus eliminating a potential safety hazard.

When the oil enters the housing inlet, it flows into an annulus around the bearing. From the annulus, the oil flows through machined holes or slots to the bearing rotor interface.

## 1.6.2.1: LUBRICANT SEALING

Oil on the surface of the turbine shaft is prevented from being spun along the shaft by oil seals in each of the bearing housings. These labyrinth seals are assembled at the extremities of the bearing assemblies where oil control is required. A smooth surface is machined on the shaft and the seals are assembled so that only a small clearance exists between the oil seal and the shaft. The oil seals are designed with tandem rows of teeth and an annular space between them. Pressurized sealing air is admitted into this space to prevent lubricating oil vapor from exiting the bearing housing. The air that returns with the oil to the main lubricating oil reservoir is vented to atmosphere after passing through an oil vapor extractor.

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## 1.7. ENCLOSURE

## 1.7.1. GENERAL

Gas turbine enclosures, referred to in this manual as compartments, are those partitioned areas in which specific components of the overall power plant are contained. These compartments are built for all-weather conditions and designed for accessibility when performing maintenance. They are provided with thermal and acoustical insulation and lighted for convenience. The aim of those enclosures is :

- To provide weather protection for the equipment.
- To detect and extinguish the fire and to contain fire fighting medium
- To provide proper cooling and ventilation for the equipment including during gas turbine cooling down sequence.
- To dilute gas leak to avoid hazardous area
- To provide attenuation of the noise generated by the equipment
- To protect personnel from high temperature and fire risks.
- To heat the enclosure during cold period

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1.8. COUPLING

1.8.1. GENERAL

The load coupling links the gas turbine shaft to the load gear high speed shaft.

It is flexible type coupling which is capable of accommodating shortening and lengthening of its normal flange to flange dimension by  $\pm 25$  mm and 0,25 degrees of misalignment while operating at normal torque maximum continuous speed and maximum axial excursion.

The coupling length is approximately of 1250 mm and the flange diameter is approximately of 573 mm.

For more details refer to subcontractor literature.