SYSTEM DESCRIPTION MBT GAS GENERATOR SYSTEM	Respons. dept GRPD	Date 2004-02-10	Reg. M DB 101
	Prepared B. Wassberg		YAMAMA CEMENT

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Purpose of the system

The gas generator generates a flow of pressurized hot gas, driving the power turbine.

General description of the system

Refer to P&ID 2046 019

The GT 10B gas turbine operates in a simple open cycle with straight air and gas flow through the turbine. It can be divided into two main sections, the gas generator and the power turbine. The two main sections are not mechanically interconnected, so the gas generator speed is determined by the output of the unit as well as ambient conditions, which allows a wider control range at sustained efficiency.

The gas generator comprises the compressor, the combustion chamber and the compressor turbine.

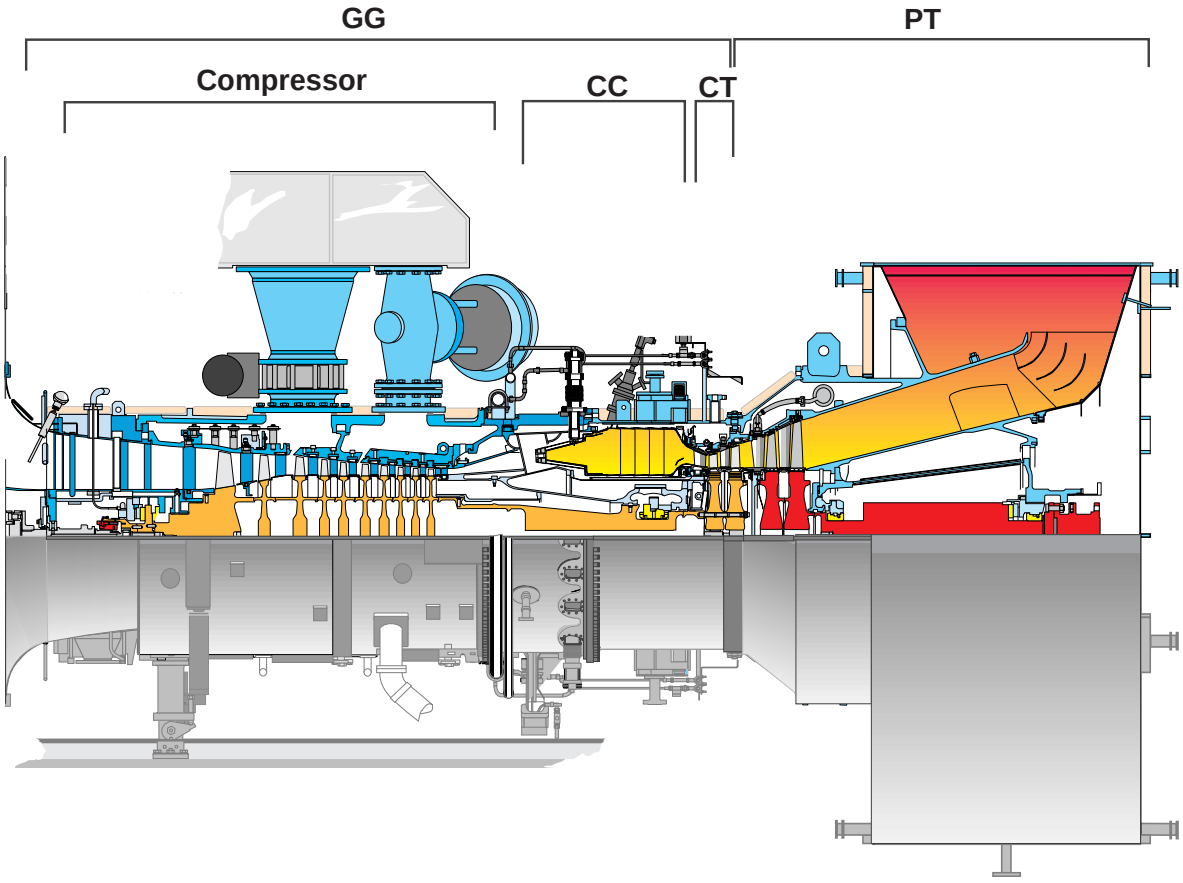

Fig.1 GT10B Gas Turbine

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Compressor

The inlet casing consists of an outer and an inner casing, which directs the incoming air to the compressor first stage. The inner casing contains bearing housing no.1 and the SSS-clutch, connecting/disconnecting the starting motor to the gas generator rotor. The SSS-clutch is described in the starting system, MBJ.

The inner casing is connected to the outer casing via four hollowed profile rods. The rods contain lube oil and seal air pipes as well as instrumentation cables (speed, vibration, axial position, bearing temperature, phase angle).
The inlet casing is bolted to the compressor casing.

The compressor casing, covering the whole compressor section, is horizontally split to facilitate maintenance. The casing contains the three stator subassemblies - front, central and rear stator casings. These casings carry the guide vanes and the stator rings.
The stator casings form slots for bleeding air downstream the second (low pressure bleed) and the fifth stage (high pressure bleed).

Two bleed valve are located on the upper compressor casing half, one for the low-pressure cavity (BV1) and one for the high pressure cavity (BV2). The bleed valves open at low load to prevent the compressor from surging. Bleed air is directed into the air intake. The BV2 is also used for emission control when required. BV2 is then used over a wider load range.

The axial flow compressor has ten stages. The guide vanes of the first two stages are of the variable geometry type, actuated by a spindle control mechanism and an AC-servo.
The compressor rotor is solid, built up from a number of fully electron beam welded discs and an intermediate shaft. The compressor blades are fitted in the discs by dove tail attachment. The blades and vanes are coated for corrosion protection.

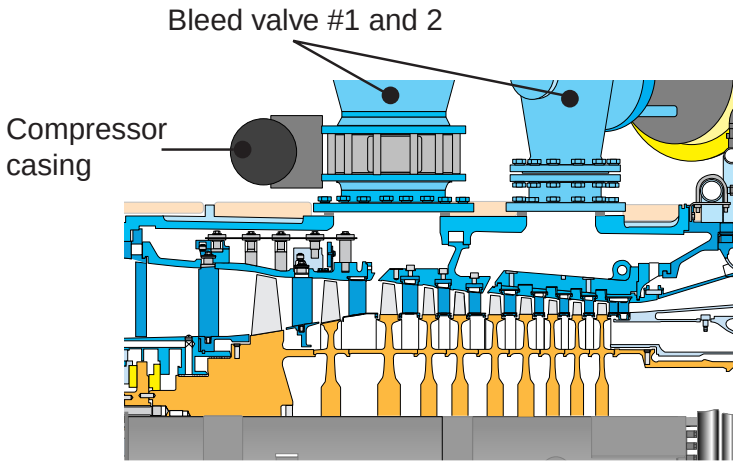

Fig.2 Compressor section

Central casing

The central casing consists of an inner and an outer casing. The fuel rods are mounted on the outer casing. A diffusor section, located between the outer and the inner casing, slows down the air speed and directs the air flow into the combustion chamber. The inner casing contains bearing no.2. The inner casing has nine profile rods. Some of these rods contain oil and sealing air pipes as well as instrumentation cables (vibration and temperature).

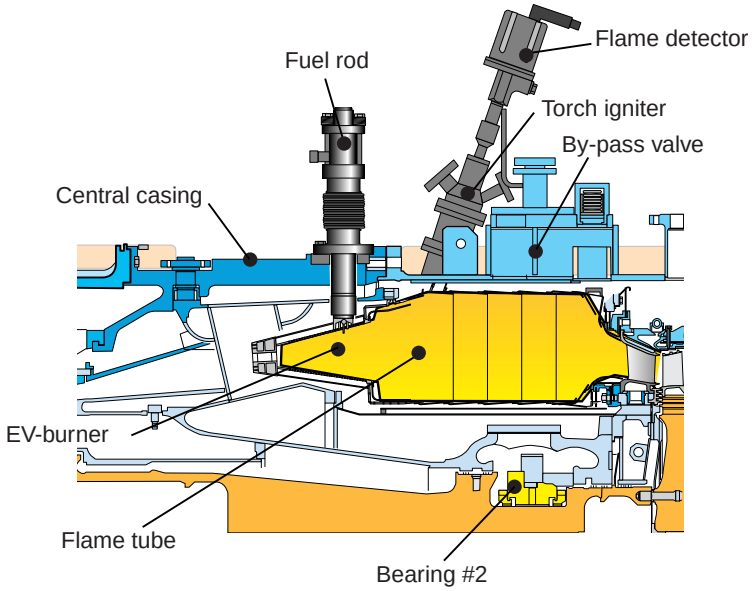

Fig.3 Combustor chamber section

Combustion chamber

The GT10 low emission combustion system is using the ABB EV-burners, which are working according to the lean premixed combustion principle when operating on gaseous fuels.

The EV-burner has the form of a cone with two slots where the compressor air is flowing in. Main gas is introduced into the air along the slots through a number of small holes.
Each burner is equipped with a fuel injector, for primary gas and oil, in the tip of the cone. Primary gas fuel is used during start up and is supporting the main gas up to approximately 95% load.

In the annular combustion chamber fuel is injected by the 18 EV-burners. Ignition takes place by means of a torch ignitor. The torch ignitor is supplied with instrument air and ignition fuel from a separate ignition fuel system. The torch igniter is ignited by a spark plug.

There are two flame detectors in the combustion chamber, one indicating the ignition torch, the other the main flame.

The fuel rods, each consisting of three concentric pipes, connects the burners to external fuel manifolds.
When operating on liquid fuel, the burners form a conventional diffusion flame.

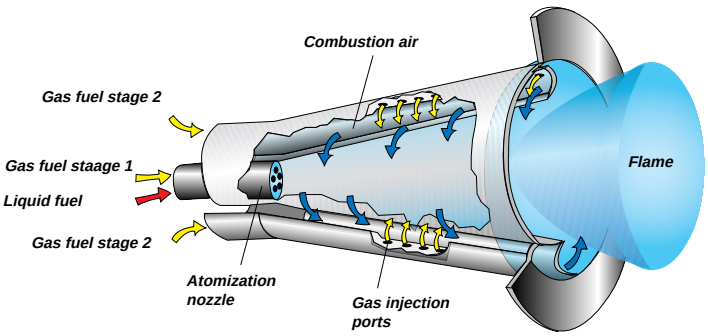

Fig.4 ABB EV-burner

Turbine casing

The combustor and the turbines are covered by the turbine casing. The ignition burner and the flame detectors are mounted on the turbine casing.

Compressor turbine

The 2-stage compressor turbine comprises the stator and the turbine discs. The turbine discs are bolted to the compressor rotor.

The stator surfaces are provided with honeycomb seals. Honeycomb is an abradable seal which can withstand a blade tip rubbing. The turbine blades are fitted in fir tree grooves and have shrouds to minimize the interstage gas leakage.

The rotor blades as well as the guide vanes are precision cast and internally cooled. All surfaces exposed by hot gas are coated with a vapor-deposited aluminum/platinum coating used for oxidation and corrosion protection.

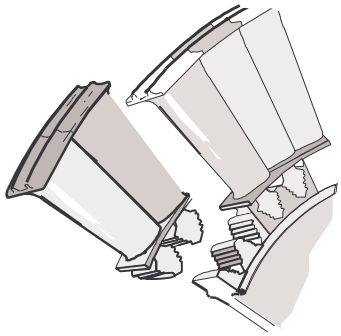

Fig.5 Fir-tree roots

Bearings

The bearings are of tilting pad design with a directed lubrication system.

The bearings are equipped with temperature sensors and vibration transducers.

Two journal bearings, no. 1 and 2, numbered from the inlet to the exhaust and one thrust bearing located next to journal bearing no.1 carry the gas generator rotor.

While the bearing housing of the bearing no 1 is kept subatmospheric, the housing of bearing no 2 is pressurized as it is located next to the compressor discharge. This permits size reduction and reduces the use of intricate labyrinth seals.

During operation, oil is continuously supplied to the bearings. Return oil from the bearing casings is led back to the lube oil tank by gravity. See also the lubrication oil system, MBV.

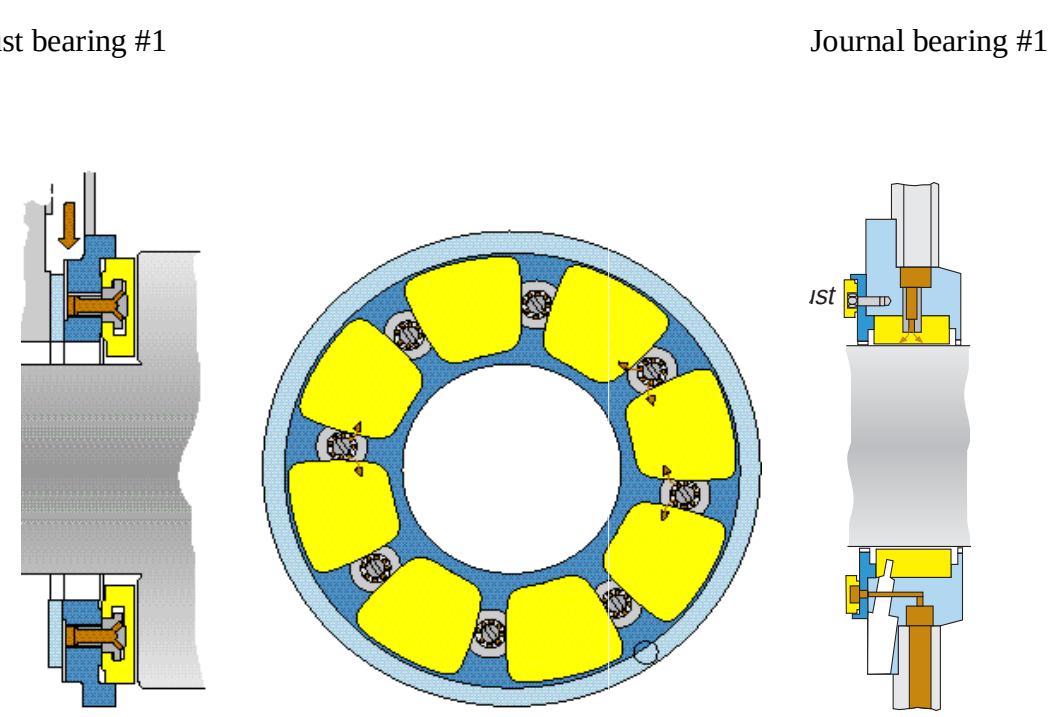

Fig.6 Bearings

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Cooling and sealing air

The cooling and sealing air are taken from the different bleed cavities and from the compressor discharge.

Cooling air is used for cooling the compressor turbine vanes, blades and discs. Sealing air is used to prevent hot gases from entering the bearing housing or oil leakage.

See also cooling and sealing air system, MBH.

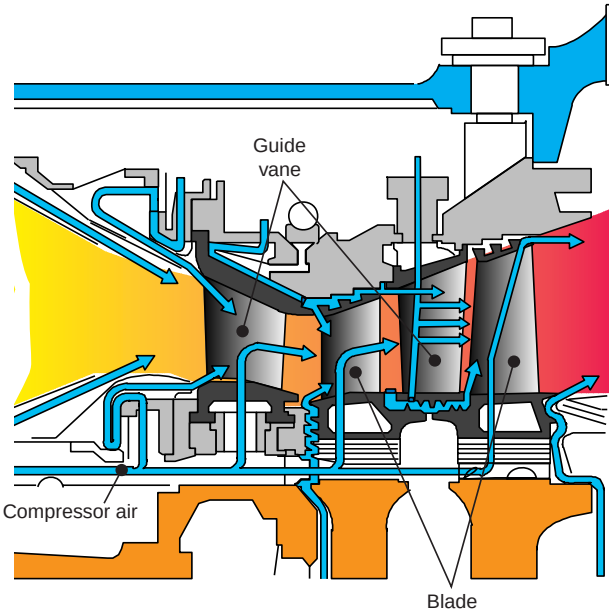

Fig.7 Cooling air - compressor turbine

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Main components

- Pressure transmitter, compressor inlet pressure
  MBT10CP005
  The transmitter is continuously monitoring the absolute pressure before the inlet plenum.

- Pressure transmitter, compressor inlet flow
  MBT10CP010
  The transmitter is continuously monitoring the differential pressure between before the inlet plenum and before the compressor inlet.

- Pressure transmitter, compressor discharge pressure
  MBT10CP015
  The transmitter is continuously monitoring the absolute pressure after the compressor.

- Pressure transmitter, compressor discharge pressure
  MBT10CP020
  The transmitter is continuously monitoring the absolute pressure after the compressor.

- Pressure transmitter, compressor discharge pressure
  MBT10CP025
  The transmitter is continuously monitoring the absolute pressure after the compressor.

- Speed transducer, GG speed
  MBT10CS005
  The transducer is continuously monitoring the speed of the GG rotor. It is used to protect the rotor from overspeed. It is also used for governing.
  High speed (H1) initiates a turbine trip.

- Speed transducer, GG speed
  MBT10CS010
  The transducer is continuously monitoring the speed of the GG rotor. It is used to protect the rotor from overspeed. It is also used for governing.
  High speed (H1) initiates a turbine trip.

- Axial position transducer, Axial displacement GG rotor
  MBT10CG005
  The transducer is continuously monitoring the axial position of the GG rotor.
  Axial displacement (L1) initiates an alarm.
  Axial displacement (H1) initiates an alarm.
  Big axial displacement (L2) initiates a turbine trip.

- Key phasor, GG rotor angle
  MBT10CG010
  The key phasor detects rotor angle at balancing of the GG rotor.

- Temperature transmitter, compressor inlet temperature
  MBT10CT005
  The PT100 is continuously monitoring the air temperature before the compressor inlet.

- Temperature transmitter, thrust bearing (no.1) temperature
  MBT10CT010
  The PT100 is continuously monitoring the bearing temperature. The transmitter is measuring the temperature of the escaping oil from the pads.
  High temperature (H1) initiates an alarm.
  High temperature (H2) initiates an alarm.

- Temperature transmitter, thrust bearing (no.1) temperature
  MBT10CT015
  The PT100 is spare for MBT10CT010.

- Temperature transmitter, journal bearing (no.1) temperature
  MBT10CT020
  The PT100 is continuously monitoring the bearing temperature. The transmitter is measuring the temperature in one of the bearing pads.
  High temperature (H1) initiates an alarm.
  High temperature (H2) initiates an alarm.

- Temperature transmitter, journal bearing (no.1) temperature
  MBT10CT025
  The PT100 is spare for MBT10CT020.

- Temperature transmitter, compressor discharge temperature
  MBT10CT030
  The TC is used for performance evaluation.

- Temperature transmitter, compressor discharge temperature
  MBT10CT035
  The TC is used for performance evaluation.

- Temperature transmitter, compressor discharge temperature
  MBT10CT040
  The TC is used for performance evaluation.

- Temperature transmitter, journal bearing (no.2) temperature
  MBT10CT045
  The PT100 is continuously monitoring the bearing temperature. The transmitter is measuring the temperature of the escaping oil from the pads.
  High temperature (H1) initiates an alarm.
  High temperature (H2) initiates an alarm.

- Temperature transmitter, journal bearing (no.2) temperature
  MBT10CT050
  The PT100 is spare for MBT10CT045

- Temperature transmitter, compressor inlet temperature
  MBT10CT055
  The PT100 is continuously monitoring the air temperature before the compressor inlet.

- Temperature transmitter, compressor inlet temperature
  MBT10CT060
  The PT100 is continuously monitoring the air temperature before the compressor inlet.

- Vibration transducer, bearing (no.1) vibration
  MBT10CY005
  The accelerometer is continuously monitoring the vibrations.
  High vibrations (H1) initiates an alarm.
  High vibrations (H2) initiates a turbine trip.

- Vibration transducer, bearing (no.2) vibration
  MBT10CY010
  The accelerometer is continuously monitoring the vibrations.
  High vibrations (H1) initiates an alarm.
  High vibrations (H2) initiates a turbine trip.

- Flame detector, main flame detection
  MBT10CQ005
  The flame detector indicates flame during start up and detects flame out during operation.
  Flame out will trip the turbine.

- Flame detector, torch and main flame detection
  MBT10CQ010
  The flame detector indicates flame during start up and detects flame out during operation.
  Flame out will trip the turbine.

- Guide vane control
  MBT10AE005
  The rotary actuator is driven by an AC-servo motor. A position transducer (RVDT) gives position feed-back.

- Bleed valve 1 (spring opening type)
  MBT10AA005
  The bleed valve no.1 is an on/off valve of butterfly type, pneumatically actuated. The valve is open during start and low load.
  The limit positions are mechanical limit switches.
  Turbine trip is activated if not open during start-up.

- Bleed valve 2 (spring opening type)
  MBT10AA010
  The bleed valve no.2 is a regulating, pneumatically actuated, butterfly valve. The valve is open during start and regulating at part load.
  A position transducer (analogous) gives position feed-back.
  Turbine trip is activated if not open during start-up.

- Ignition system
  MBT10AV005
  The spark plug (E01) is powered by the ignition exciter (T01).

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Function

Start up

The starting procedure is generally described in the Starting system description, MBJ.

The electrical starting motor accelerates the gas generator rotor to purging speed. The purging continuous for a time sufficient to ventilate the gas turbine and the complete exhaust system. When the purging time has elapsed fuel is injected and the gas turbine is ignited. The GG rotor accelerates, with help from the starting motor, until self-sustaining speed.

Continuous operation

The gas generator speed varies dependant of load and ambient air conditions. The gas generator output is limited by the maximum rotor speed or the exhaust gas temperature.

Shut down

When shutting down the combustor, the gas generator speed slowly decreases until reaching the barring speed of the electrical starting motor. Barring is then continued until the gas generator is cooled down. After this, the starting motor is stopped and the gas generator brought to stand still.

Stand still

The gas generator is kept at stand still.

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Disturbances

Gas turbine trip and Generator breaker trip

A gas turbine trip interrupts the fuel flow to the gas generator. The gas generator speed decreases until the barring speed is reached. The barring continues until the cooling down period is finalized. After this, the gas generator is brought to a stand still.

A generator breaker trip decreases the fuel flow to the gas generator to prevent over-speeding of the power turbine. The gas generator is brought down to nominal speed, no load until the generator breaker is synchronized again.

Loss of power supply

Loss of main AC power supply trips the gas turbine.

System faults

If there are any damages on turbine, compressor, bearings or combustion chamber the system may not be started or has to be shut down.

If bleed valve MBT10AA005 or MBT10AA010 not is opened during start, the gas turbine will be tripped out.

Other faults

The gas generator is dependent of its auxiliary systems for proper function. Faults in any of these systems may restrict or interrupt continued start up or operation.

Technical specification

Design criteria and standards

Direction of shaft rotation — Anti-clockwise looking in the reverse direction of flow.

Dimensioning data

- Pressure ratio — 14:1 at ISO-conditions
- Nominal speed — 9770 rpm at ISO-conditions

Engineering data

Figures given below might differ somewhat from project to project
Nominal flow — 80 kg/s

Installation

The gas generator is bolted by a flange connection to the power turbine. The complete unit, gas generator and power turbine, is mounted on the main base frame by a fix point and pendulum supports at the power turbine end and a flexible support in the front of the gas generator.
As the different sections of the gas generator is built up as removable modules, this also permits easy access and fast maintenance.

Materials

Compressor

- Discs
  - Stages 1 – 5 — ASTM SA 508 CL4
  - Stages 6 – 10 — NIM 901-AMS 5661
- Blades
  - Stage 1 — Titanium alloy (Ti 6 Al 4V)
  - Stages 2 – 10 — X12 Cr Ni Mo 12 (ASTM A 565)
  - Surface coating — SSA12
- Vanes
  - Stage 0 – 1 — X20Cr13 (AISI 420)
  - Stage 2 – 10 — X20 CR MO V12.1 (ASTM A437 B4B)

Combustion chamber

Combustion chamber	Hastelloy X
Surface coating	Thermal barrier coating

Compressor turbine

- Discs — NIM 901-AMS 5661
- Blades
  - Stages 1 – 2 — IN 792
  - Surface coating — Vapor deposited Al-coating with Platinum
- Vanes
  - Stage 1 — IN 792
  - Stage 2 — IN 939
  - Surface coating — Vapor deposited Al-coating with Platinum

Component data

- Number of compressor stages — 10
- Number of turbine stages — 2
- Thrust bearing type — Tilting pad
- Journal bearing type — Tilting pad
- Rotor design — Electron-beam welded
- Rotor weight (incl. blades) — 1620 kg
- Type of combustion chamber — Single, annular
- Burner type — DLE, Dual fuel
- Number of burners — 18
- Ignition system — 1 pilot (torch) burner

See the system lists.

Weight

Total weight of the gas generator is 9500 kg.

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Testing and service

Testing during normal operation

N/A

Accessibility during normal operation

N/A

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