

GE Frame 9 Gas Turbine Packaged Power Plants

SCOPE, LIMITS AND EXCLUSION FROM THE SUPPLY

Scope of Supply

1. Gas turbine generator package

2. Mechanical

- Gas Turbine
- Air Compressor
- Combustors
- Turning and Reduction Gear
- Air Inlet facilities (Filters and Ducts)
- Exhaust facilities (Ducts, Silencer) (less exhaust elbow)
- Starting Motor system
- Dual Fuel Combustors
- Lube and Control Oil System
- Closed Circuit Cooling Water system
- Atomizing and Cleaning system
- Instrument Air system
- Enclosures, including HVAC, Fire-fighting, Electrical Switchboard for:
 - Gas turbine unit (external and internal)
 - Gas turbine auxiliaries
 - Electrical Switchgear
 - Control
 - Closed Circuit auxiliaries
 - Water Injection
- GT Supervision, Control and Protection Systems
- Fire Fighting (detection and protection) system
- Gas Detection system
- Thermal Insulation and Lagging
- Compressor Washing and Cleaning facilities

3. Electrical

- Electrical Generator, auxiliaries and related equipment (Circuit Breaker, Grounding Switch, Bus duct, Neutral Grounding cubicle, etc.)
 - Starting Motor system
 - Unit Transformer (11/6 kV) and auxiliary MV/LV Transformers
 - Main Switchboards (6 kV, 380 V PC, 380 MCC and emergency MCC) and MV isolated bus ducts
 - Auxiliary Switchboards (Generator Protection, HVAC, Fire-fighting, Lifting facilities, etc)
 - 110 DC Power System
 - Uninterruptible Power System (UPS)
 - AC/DC Electrical Motors (DC Motor starters included)
 - Electrical Protection system
 - Lighting and Motive Power system, Heat tracing, Grounding, etc.
 - Cables and Cable Trays
4. Instrumentation & Controls
- On board Instrumentation
 - Instrument Panels and Junction boxes
 - Control, Protection and Monitoring Panels
 - MMI (man-machine interface)

5. Miscellaneous

- Special Tools
- Anchor Bolts and Plates
- Stair and Ladders
- Steel Structures

6. Special Tools and Maintenance equipment (for the above mentioned machinery)

7. Operating and Maintenance Manuals

PERFORMANCES: SIMPLE CYCLE

The following Gas Turbine performances:

ISO Conditions

With reference to the following conditions:

Ambient Pressure: 1013 mbar

Ambient Temperature: 15 °C

Relative Humidity: 60 %

Gas Turbine Inlet/Exhaust Pressure drop: 89/127 mm H₂O

The **Plant Performances at Generator terminals** when the plant is operated at GT new and

clean conditions shall be:

Base Load

Output Power: **126 MW**

Heat Rate: **10096 BTU/KWh (10650 kJ/kWh)** (natural gas)

Gas Turbine and Auxiliaries

Gas Turbine

General description

The PG9171(E) GT package was developed by a GE/ authorized licensee with the frame 9E as basic equipment and within the license agreement with General Electric Co.

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The PG9171(E) is a single shaft, high efficiency gas turbine for power generation in 50 Hz grids, suitable for simple cycle and combined cycle application.

The engine is designed for 3000 rpm nominal speed, to be directly coupled to a two-pole synchronous electric generator. This gas turbine unit includes all features and design solution coming from the operating experience of the MS9000 family, whose evolution has brought to the PG9161(E) one of its highest reliability value. The PG9161(E) unit consists of three compartments, one housing the auxiliaries, one the gas turbine itself, and the last one housing the exhaust plenum. Each compartment is equipped with access doors for easy site inspection and maintenance. The rotor is a single shaft assembly consisting of one compressor rotor joined to one turbine rotor by a flanged joint, and lays on three journal bearings (two elliptical and one tilting pad type). Two thrust bearings; one Kingsbury type (loaded) and one tilting pad type (unloaded) are also provided.

Compressor

The compressor rotor consists of 17 stages with 12.3/1 overall compression ratio. The compressor rotor consists of 15 wheels, shrunk onto a forged shaft (rotor stages 2nd to 16th), two stub shafts (1st and 17th rotor stages), 16 tie bolts and stator/rotor blades. The stationary blades are assembled into two half rings (diaphragms) for each stage; the diaphragms are fitted into the compressor casing. The rotating blades are fitted on the discs by dove-tail roots and fixed by means of pins. The compressor external casing is totally made of grey cast iron. The compressor front portion contains the Inlet Guide Vanes (IGV) device that allows modulating the inlet flow during start up and optimize performance at part load operation. Air bleed ports provide cooling air for 1st and 2nd turbine stages (stationary and rotating buckets). The compressor end portion that discharges the air mass flow into the combustion chamber contains the compressor diffuser, devoted to eliminate flow swirl and then improve diffuser efficiency.

Combustion Section

The PG9161(E) combustion system has been designed in order to ensure reliability, durability and flexibility, even in case of using different fuels. The combustion system is contained in a

carbon steel casing which is part of the compressor-combustor shell and provides housing for combustor wrapper, combustions chamber assemblies, fuel nozzles, spark plug igniters, UV flame detectors, cross flame tubes, transition piece. The combustion takes place in 14 combustion chambers, circumferentially arranged around the machine axis. The hot gas flows from the combustion chambers toward the turbine section via 14 "S" shaped transition pieces. This special arrangement ensures a good mix between the film cooling air and the combustion gases, thereby optimizing the gas temperature pattern at the first turbine stage inlet. The combustion section consists of Hastelloy cylinders joined together with corrugated rings, which lead the cooling air film along the wall, thus improving cooling.

The combustion chambers are installed and removed without lifting the combustor casing cover, in order to facilitate inspection and to reduce the inspection time. The transition pieces connecting the combustors to the turbine inlet are manufactured with NIMONIC 263 alloy, which yields good anti-corrosion properties together with high cracking resistance, and is furthermore easily weld able for maintenance at site, without needing heat treatment. Spark plug igniters, located in the 10th and 11th combustion chambers, are used to ignite the fuel/air mixture; the remaining chambers are ignited through cross flame tubes that provide connection between every two adjacent combustors. Two ultraviolet (UV) flame scanners, located in the 4th and 5th combustion chamber are provided to detect ignition during start up. The fuel is injected into the combustion chambers through fuel injectors, one per each combustion chamber, which are provided for single fuel operation.

Turbine

The 3-stage turbine rotor is constituted by 3 discs, forged in alloy steel and coupled each other by bolted connections.

All rotating blades are precision cast, and are attached to the wheels by straight, axial-entry, multiple-tang dovetails that fit into matching cut-outs in the rims of the wheel. The turbine stationary blades (nozzles) are precision cast according to the following table:

- first stationary row 18 segments x 2 vanes Cooled
- second stationary row 16 segments x 3 vanes Cooled
- third stationary row 16 segments x 4 vanes Uncooled

The cooling flow for the cooled profiles is bled from suitable compressor stages (see compressor section). The space between 2nd and 3rd rotor wheels is also cooled by compressor bleed air. Nozzle diaphragms are attached to the inside of both 2nd and 3rd stage nozzle segments. These diaphragms prevent air leakage past the inner sidewall of the nozzles and the turbine rotor. A turbine shroud is included, whose main function is to provide a cylindrical surface for minimizing bucket tip clearance leakage (a secondary function is to provide a high thermal resistance between the hot gases and the comparatively cool shell). This reduces the shell-cooling load and allows controlling the shell diameter and roundness and turbine clearances. The shroud segments are maintained in the circumferential position by radial pins from the shell. Joints between shroud segments are sealed by interconnecting tongues and grooves.

Exhaust Frame and Exhaust Plenum

The flanged end of gas turbine shell is bolted to exhaust frame. On the structural point of view, the frame consists both of an outer and an inner cylinder, interconnected by radial struts. The GT end journal bearing is supported from the inner cylinder. The exhaust frame, fabricated in ASTM A435 carbon steel, receives gas flow from the GT diffuser, and is connected to the exhaust plenum by flexplate expansion joint.

The exhaust plenum consists of a box, open at one side and welded to its own base. It is fabricated in carbon steel, lined with 409 SS chromium steel sheet. Thermocouples for measurement of exhaust gas temperature and for transmitting the values to the GT control system are located in the final part of the exhaust plenum.

Gas Turbine Control System (SUMIVAC)

Gas Turbine Auxiliaries

The Gas Turbine includes the following auxiliaries:

- Oil Systems (Lubricating Oil system, Control Oil system)

- Inlet Air system (Filtration system, Inlet Air duct, etc.)
- Exhaust Gas facilities (silencer, vertical stack)
- Fuel system (dual fuel: natural gas, diesel oil)
- Compressor Washing system
- Enclosures including HVAC, Fire-fighting, etc.
- Lube Oil closed circuit Cooling Water system
- Instrument Air system
- Fire Fighting system (CO₂ and dry chemical type)
- Gas Detection system
- Electrical equipment (Generator Neutral Grounding Cubicles, Generator Protection)
- Board, Low Voltage Distribution Board, Power Control Centre, , DC Power system, Uninterruptable power supply, Cables, Induction Motors, Grounding system, Vibration monitoring and protection system, Indoor Lighting system).

Electrical Generator

The electrical Generator is a synchronous machine, ventilated in open air-circuit, with airexchanger shell & tube cooler provided. Characteristics of generator as follows:

NOTE: Closed Cooling Cooler not included. Special Design for climate conditions

Rated Output: 163 MVA**

Rated Terminal Voltage ($\pm 5\%$): 11.000 V

Rated Phase Current: 7400 A

Rated Power Factor: 0.85

Frequency: 50 Hz

Speed in RPM: 3000

Design Temperature: As per IEC 34

Insulation: Class F

Maximum Air Inlet Temperature: 40°C

Generator Excitation System: Static type

Response Ration: $>1.9 \text{ s}^{-1}$

Power Consumption at rated load: _290 kW

** The Generator is oversized to allow upgrade to PG-1971-E at first overhaul.

Electrical Systems

GAS TURBINE Generator

The GT generator, endowed with related auxiliary systems and devices, shall be rated to operate continuously at full load.

The excitation system shall be static type with automatic and manual Automatic Voltage Regulator (AVR) system.

The main functional generator characteristics shall be as listed below:

Rated Capacity 139 MW (ambient air at 40°C)

Power factor 0.85

Voltage 11 kV

Frequency 50 Hz

Rotation speed 3000 RPM

Phases 3

Class of insulation F

Standard IEC at 835 m.

Step-up Transformer (NOT INCLUDED)

Unit Transformers (included)