MHPS Gas Turbine

G Series

MHPS Gas Turbine
M501G / M701G

MITSUBISHI HITACHI POWER SYSTEMS, LTD.

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A Giant Step in Gas Turbine History

In February 1997, a new page was written in the history of gas turbine development. The M501G – a state-of-the-art large capacity, heavy-duty gas turbine with steam cooled combustors began commercial operation at the Takasago combined cycle power plant in Japan.

GAC with air cooled DLN combustors

The GAC incorporates the latest air cooled combustor technology into the prior G-series with steam cooled combustors. It uses compressor discharge air and does not require any external cooling air source. The advanced GAC with the air cooled combustors adds operational flexibility by eliminating any need for steam cooling from the bottoming cycle.

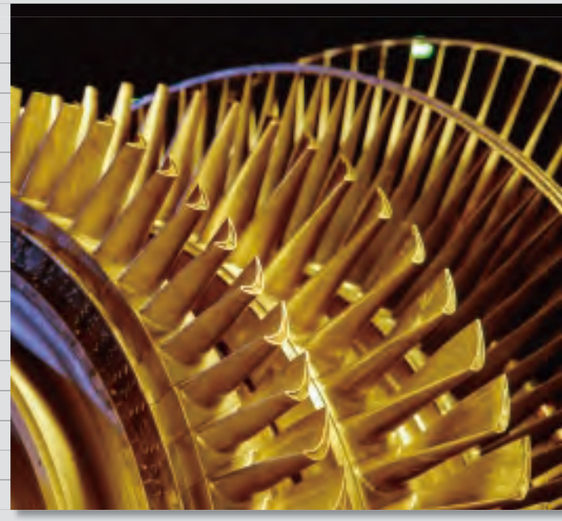
Current production models are M501GAC for 60Hz and M701G for 50Hz.

Proven design based on over 40 years of experience

The GAC incorporates basic design features and concepts developed through years of experience, such as cold-end generator drive, single shaft rotor construction and axial exhaust. These fundamental and proven features are based on our experience of more than 40 years.

Environmental protection

- Most efficient use of fossil fuel resources
- Low NO_X, CO, UHC and VOC emissions
- Reduction of CO_2 emissions is approximately 60% in combined cycle operation when compared to conventional coal plants

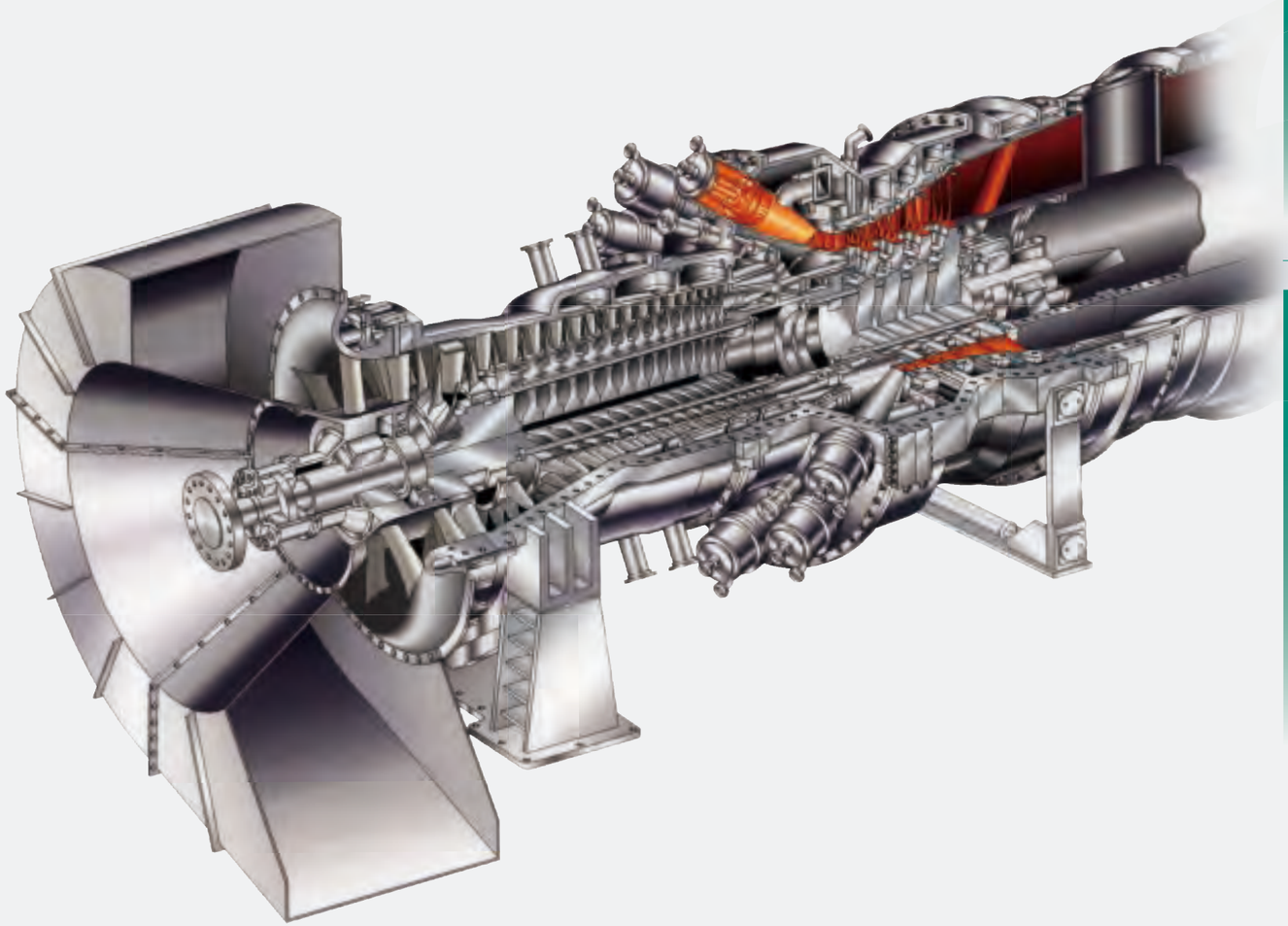


Longitudinal Section

Overall Design

The design of G-series gas turbines is based on proven F-series features.

- The compressor shaft end drive reduces the effect of thermal expansion on alignment and eliminates the need for a flexible coupling
- The rotor has a two-bearing structure to support the compressor and turbine ends
- An axial flow exhaust structure is used to optimize the combined-cycle plant layout
- The rotor structure has bolt-connected discs with the torque pins in the compressor rotor, and discs with CURVIC couplings in the turbine rotor to ensure reliable torque transmission
- Horizontally split casings that facilitate field removal of the blades with the rotor in place



Compressor

The GAC uses the existing proven G-series compressor.
The advanced airfoil designs were incorporated resulting in a large volume, high efficiency and higher pressure ratio.
Variable inlet guide vanes operate to modulate the gas turbine air flow in order to maintain relatively high exhaust temperatures (at part load) for improved bottoming cycle efficiency.

Combustor

The M501GAC have 16 annular combustor cans.
The combustor is an ultra-low NO_X design with a single pilot nozzle for diffusion firing surrounded by eight nozzles for premixing firing.
Innovations such as an air cooled, dry-low-NO_X combustor and the latest blade technology have been incorporated into the GAC following stringent finite element, and operational model tests.
Similar to the proven steam cooled G-series, the advanced GAC adds operating flexibility by eliminating any steam cooling need from the bottoming cycle.

Turbine

The G-series adopts a 3D aerodynamic design in a four-stage axial-reaction turbine.
Directionally solidified (DS) materials with thermal barrier coating (TBC) are applied to the first two stages and the first three stages are air-cooled.
Turbine rows 1 to 3 blades are cooled by the compressor bleed air, which is cooled by the external air cooler.
Turbine rows 1 to 3 vanes are also air cooled, with row 1 vane cooled from compressor discharge air, and the remaining vane rows cooled by compressor intermediate stage bleeds respectively.
The first and second stages on the turbine rotor are the free-standing type.
The third and fourth stages use integral shrouds.
Each row of vane segments is supported in a separate blade ring, which is keyed and supported to permit radial and axial thermal response independent of possible external cylinder distortions.

Combined Cycle Power Plant

**In 1971, MHPS delivered the first combined cycle plant in Japan to a Japanese utility company.
Since then, through the experience in supplying many combined cycle plants,
we have earned an excellent reputation from our customers.
In order to satisfy customers' needs, MHPS offers its expertise
not only in supplying plants systems and equipment,
but also in providing a wide range of after-market services.**

Gas Turbine Simple Cycle Performance (as of December, 2016)

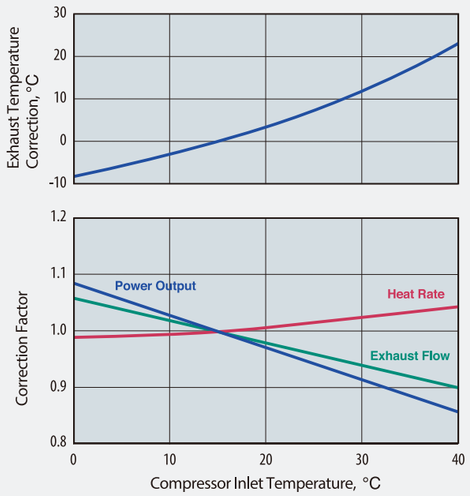
GT Model	M701G	M501G	M501GAC
	50Hz	60Hz	
ISO Base Rating, kW	334,000	267,500	283,000
LHV Heat Rate, kJ/kWh	9,110	9,211	9,000
Air Flow, kg/s	755	612	618
Exhaust Temperature, °C	587	601	617

Combined Cycle Power Plant (as of December, 2016)

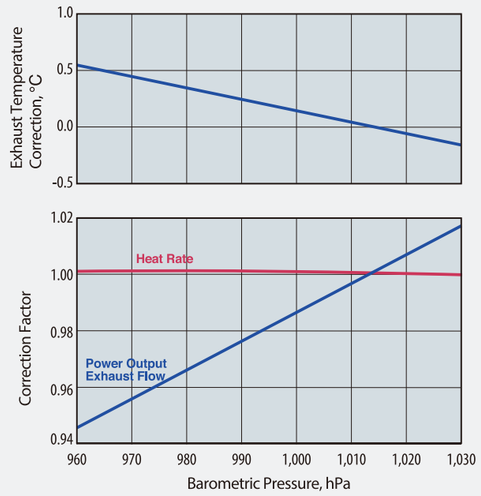
GT Model		M701G	M501G	M501GAC
		50Hz	60Hz	
1on1	Plant Output, kW	498,000	398,900	427,000
	LHV Heat Rate, kJ/kWh	6,071	6,165	5,951
	Plant Efficiency, %	59.3	58.4	60.5
2on1	Plant Output, kW	999,400	800,500	856,000
	LHV Heat Rate, kJ/kWh	6,051	6,144	5,931
	Plant Efficiency, %	59.5	58.6	60.7

• All ratings are defined at ISO standard reference conditions: 101.3kPa, 15°C and 60%RH
• All ratings are at the generator terminals and based on the use of natural gas fuel

Effects of Compressor inlet Temperature on Gas Turbine Performance (Typical)



Effects of Barometric Pressure on Gas Turbine Performance (Typical)

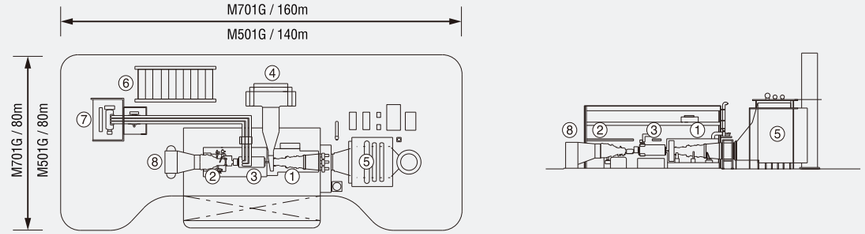


Flexible Configurations

Based on our sophisticated combined cycle plant technology and diverse product application, we can offer our customers not only the multi-shaft arrangement such as 2 on 1 configuration, but also 1 on 1 configuration having the gas turbine, steam turbine and generator connected on the same shaft.

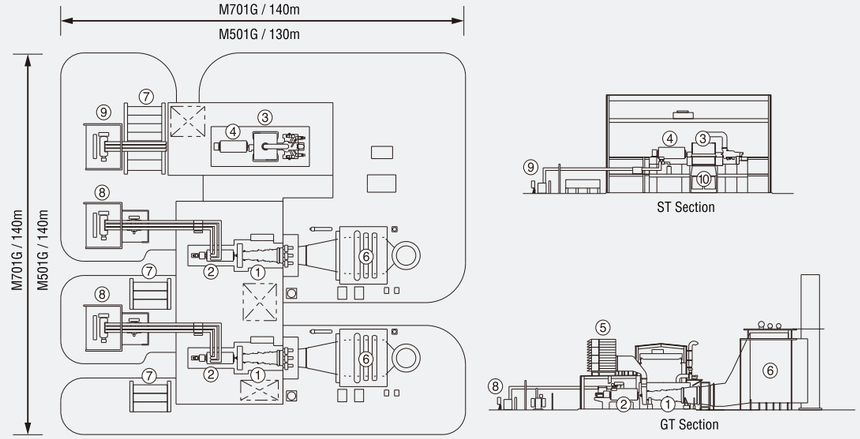
Typical Plant Layout

1 on 1 configuration, single-shaft



①Gas Turbine ④Inlet Air Filter ⑦Main Transformer
②Steam Turbine ⑤Heat Recovery Steam Generator ⑧Condenser
③Generator ⑥Electrical / Control Package

2 on 1 configuration



①Gas Turbine ⑤Inlet Air Filter ⑧GT Main Transformer
②GT Generator ⑥Heat Recovery Steam Generator ⑨ST Main Transformer
③Steam Turbine ⑦Electrical / Control Package ⑩Condenser
④ST Generator

T-point at MHPS' Takasago Works

T-point, located at Takasago Works of Mitsubishi Hitachi Power Systems (MHPS), is the MHPS gas turbine demonstration facility, operating as a commercially dispatched combined cycle power generation plant.

Objectives of T-point

- Demonstration of the technologies applied to the gas turbine allowing increased turbine inlet temperatures, improved efficiency, and reduced emissions
- Verification of the performance and reliability of the high efficiency, low-pollution combined cycle power generation plant through long-term operation

Verification of the G and J-series Gas Turbine

Performance and durability tests for G-series gas turbines have been successfully conducted since 1997. Commissioning tests of the first M501J started in February 2011 were completed in June. The M501J unit has been in commercial operation at T-point since July 2011.

① *Gas Turbine Building*
② *Heat Recovery Steam Generator*
③ *Steam Turbine Building*
④ *Air-cooled Condenser*
⑤ *Cooling Water Cooler*
⑥ *Fuel Gas Compressors*
⑦ *Main Office*

Gas Turbine Manufacturing Facilities

MHPS is proud of the M501 / M701 gas turbine production capability in Takasago, Japan and Savannah, Georgia, USA. Their capabilities include:

- Gas turbine manufacturing
- Comprehensive inspection and repair
- Complete spares inventory

MHPS Takasago Works, Japan

MHPSA Savannah Machinery Works, Georgia, USA

Key Worldwide Gas Turbine Projects

Based on our continuous research and development in the gas turbine field, all MHPS gas turbines are specially designed to meet power and environmental requirements. Long-lasting performance and high availability of our machines have won the confidence and satisfaction of customers around the world. After commissioning, MHPS offers a full range of support, including comprehensive technical assistance to complete overhaul, as well as maintenance services provided by our field service engineers.

PT.PLN, Muara Karang, Indonesia
700MW, M701F×2

NUON N.V., Nuon Magnum, Netherlands
1,300MW, M701F×3

Tohoku Electric Power, Higashi-Niigata, Japan
1,700MW, M701G×4

Tokyo Electric Power, Kawasaki, Japan
2,000MW, M701G×4

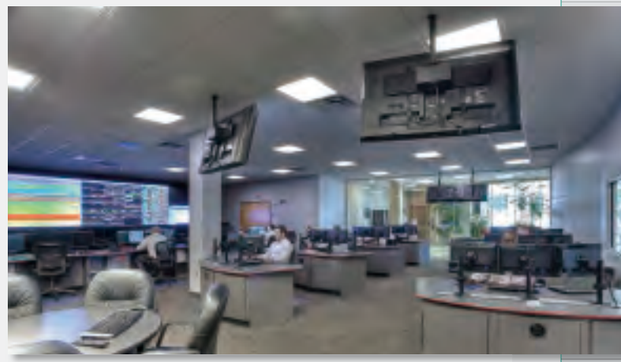
Kansai Electric Power, Sakaiko, Japan
2,000MW, M501G×5 (Courtesy of KEPCO)

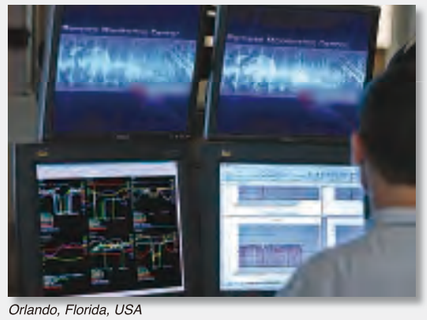
Taiwan Power, Dah-Tarn, Taiwan
4,200MW, M501G×8 and M501F×6

Remote Monitoring Center

- Technical support (24/7/365)
- Combustion dynamics tuning support
- Real-time trend and historical data analysis
- Diagnostic and root-cause evaluation

Takasago, Japan





Orlando, Florida, USA