MHPS Gas Turbine

F Series

MITSUBISHI HITACHI POWER SYSTEMS, LTD.

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MHPS Gas Turbine
M501F / M701F

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M501F/M701F

F-series Evolution

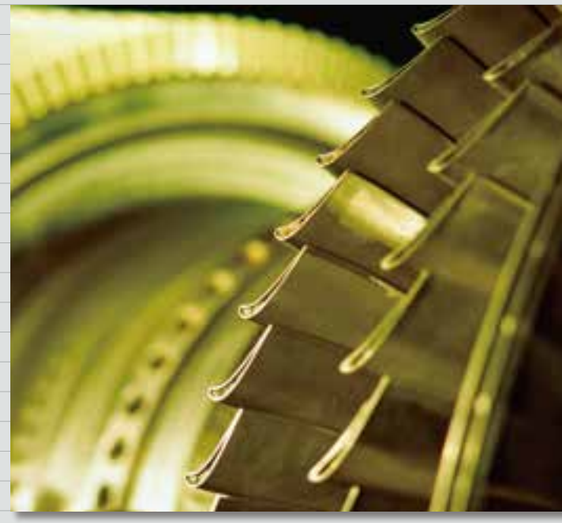
The basic M501F is a 3,600rpm heavy duty gas turbine introduced in 1991 to serve 60 Hz power generation needs for utility and industrial service.
The scaled up M701F followed in 1992 for the 50Hz market.
MHPS has continued to develop the F-series gas turbine to improve overall performance.
Each stage of the development has been achieved by introducing improved and validated components and materials from the proven F and G-series gas turbines.
The F-series gas turbine is a proven reliable design concept that will satisfy the large power generation needs for many more years.

Proven design based on over 40 years of experience

The F-series 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

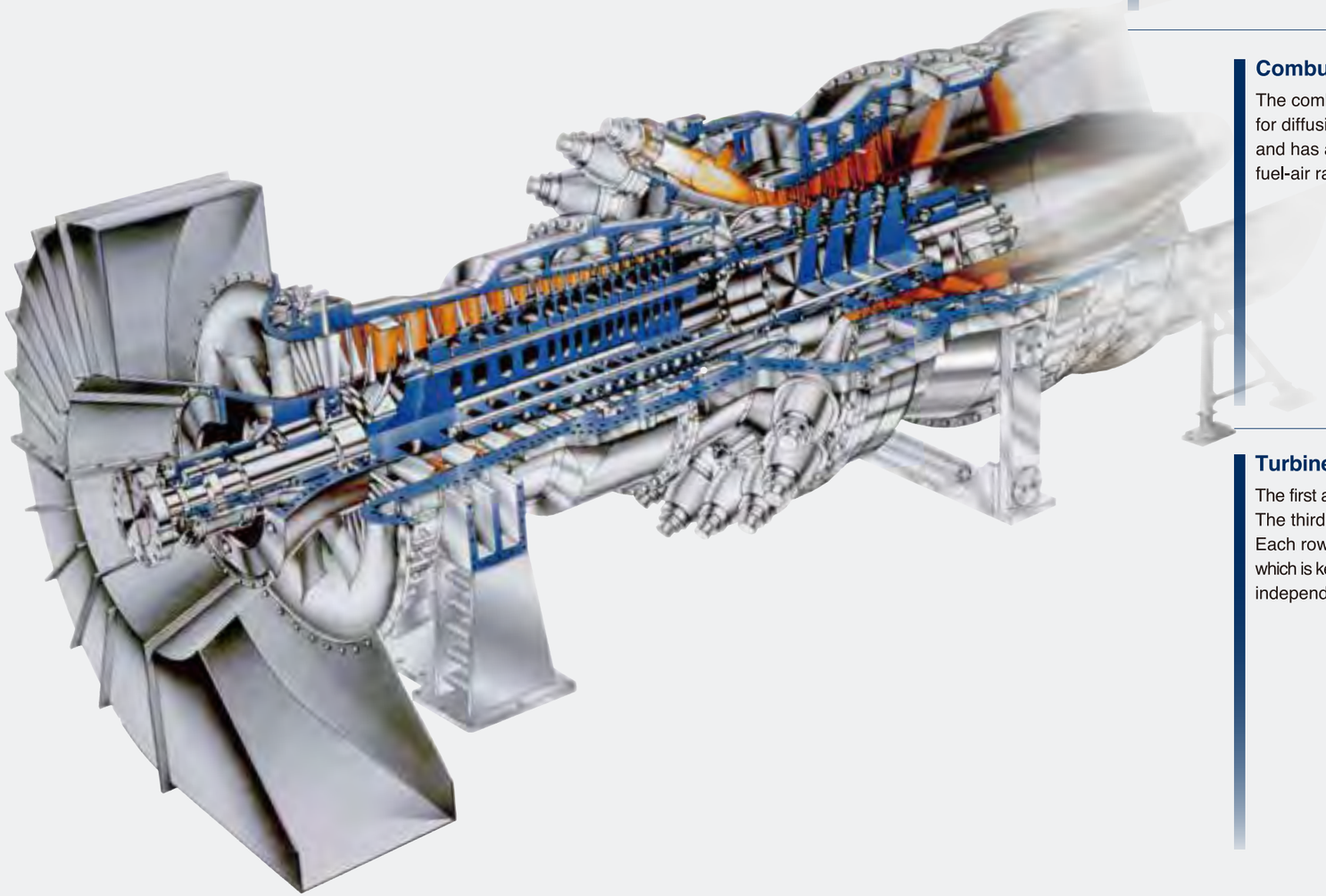


Longitudinal Section

Overall Design

Proven fundamental 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

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.

Combustion System

The combustor is a low NO_x design with a single pilot nozzle for diffusion firing surrounded by eight nozzles for premix firing and has an air bypass mechanism that enables the regulation of fuel-air ratio in the combustion region.

Turbine

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)

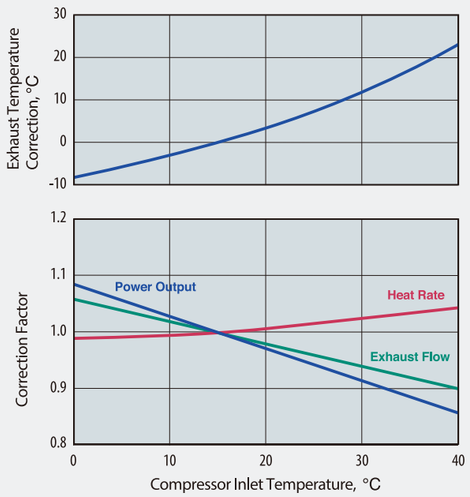
GT Model	M701F	M501F
	50Hz	60Hz
ISO Base Rating, kW	385,000	185,400
LHV Heat Rate, kJ/kWh	8,592	9,740
Exhaust Flow, kg/s	748	468
Exhaust Temperature, °C	630	613

Combined Cycle Power Plant (as of December, 2016)

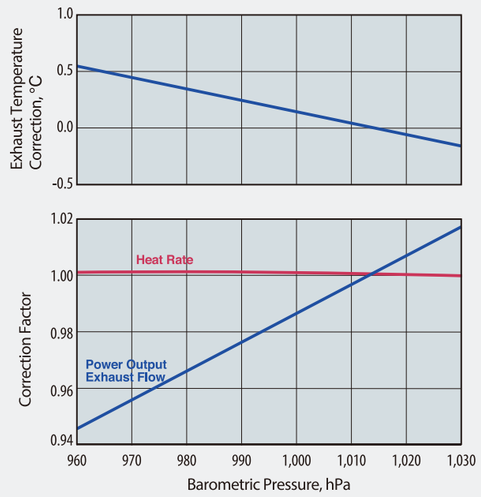
GT Model		M701F	M501F
		50Hz	60Hz
1on1	Plant Output, kW	566,000	285,100
	LHV Heat Rate, kJ/kWh	5,807	6,305
	Plant Efficiency, %	62.0	57.1
2on1	Plant Output, kW	1,135,000	572,200
	LHV Heat Rate, kJ/kWh	5,788	6,283
	Plant Efficiency, %	62.2	57.3

• 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)

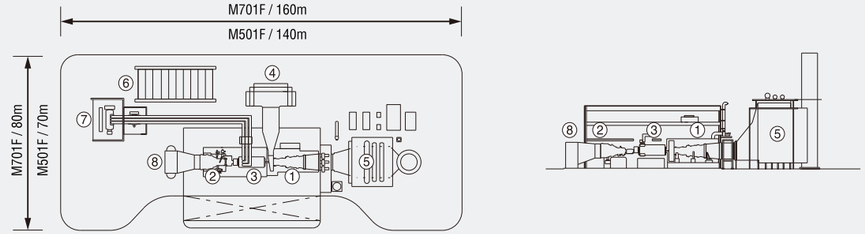


Flexible Configurations

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.

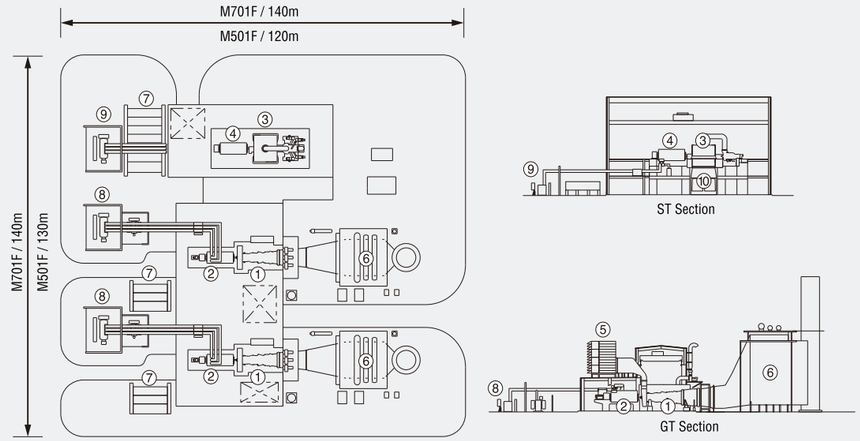
Typical Plant Layout

1 on 1 configuration, single-shaft



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

2 on 1 configuration



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

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.

Chugoku Electric Power, Mizushima, Japan
285MW, M501F×1

Shikoku Electric Power, Sakaide, Japan
296MW, M501F×1

Tohoku Electric Power, Sendai, Japan
446MW, M701F×1

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

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

Tohoku Electric Power, Higashi-Niigata, Japan
339MW, M701F×1

Azerenerji, Shimar, Azerbaijan
400MW, M701F×1

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