Kawasaki Heavy Industries, Ltd.

www.khi.co.jp/gasturbine/index_e.html

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Kawasaki Gas Turbine Division is located in Akashi Works. It designs and manufactures the Gas Turbine Co-generation System, and is certified for ISO 9001, the international standard of quality assurance, and ISO 14001, the international standard for environmental management.

ISO 9001 / ISO 14001 Certified

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KAWASAKI HEAVY INDUSTRIES, LTD.
An Integrated Engineering Manufacturer Spreading It’s Interests by Land, Sea and Air.

Kawasaki Heavy Industries, established in 1878, has a history of more than 130 years of manufacturing integrated engineered products. Its business has expanded to include the manufacturing of ships, railway rolling stock, aircraft, gas turbines, many types of industrial plants, steel structures, general machinery and motorcycles. Its products are found on the land, in the sea and in the air.

By constant attention to production efficiency and through exclusive technologies developed internally, we are continuing to develop additional technologies related to transportation innovations, national land and marine resources development, space exploration development, environmental controls, new energy development and biotechnology development. The range of our technologies is greatly expanding to encompass large, diverse projects.
1. High Startup Reliability
Continuous combustion systems with single can type combustors, provide very high startup reliability and prevent potential ignition failures sometimes experienced during startup on diesel engines.

2. Clean Exhaust Gas
With more efficient and complete combustion, low exhaust gas emissions can be realized, providing more eco-friendly power generation, compared to diesel engines.

3. Ease of Maintenance
Kawasaki gas turbine consists of a smaller number of parts compared with diesel engines and are not designed with any rubbing components such as reciprocating pistons in cylinders. Therefore, mechanical failures are fewer. These features enable operators to perform the simple maintenance tasks required, and a single monthly startup is sufficient as a periodic readiness check.

4. Excellent Frequency Stability & Instant Overload Tolerance
Due to the rotating design, Kawasaki gas turbine provides power generation with very stable frequency. Also, the high rotating shaft speed of between 18,000 to 53,000 rpm provides superior, instant overload tolerance required for standby generator sets, compared with diesel engines.

5. Ease of Installation
The weight of Kawasaki gas turbine generator is approximately one fourth of an equivalent diesel generator, whilst the volume and required space is about one seventh. Kawasaki’s lightweight and compact design make the gas turbine much more suitable for installation in small and confined spaces, such as rooftops or basements.

6. Low Vibration, Excellent Earthquake-Proof
The in-house design of Kawasaki gas turbine provides for extremely low vibration characteristics of the rotating elements, and therefore, vibration mounting dampers, such as those used for diesel engines, are not required. This aspect eliminates the potential risk of resonance phenomenon with flexible mountings during catastrophic events such as an earthquake and provides continued high performance throughout the event.

7. Low-Noise Enclosure Design
Kawasaki’s long experience in projects with strict site conditions provides the capability for excellent package noise-reduction designs, resulting in customized low-noise generator packages for use in hospital and urban applications.

8. No Requirement for Cooling Water
The self-cooling (air cooling) system eliminates the need for a separate cooling water system and realizes much higher reliability, without the potential risk of typical failures in water cooling systems such as freezing or loss of water.

Unique Features of Kawasaki GPS Standby Gas Turbine Generator
Kawasaki GPS standby gas turbine generator has served as backup power solutions since 1976, with over 7000 packages delivered worldwide, and has proven itself with continued high reliability through all phases of operation.

Unique features of Kawasaki GPS standby gas turbine generator include:

1. High Startup Reliability
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Kawasaki Gas Turbine

**High-performance, single-shaft Kawasaki Gas Turbine provides high reliability**

Kawasaki GPS standby gas turbine generators achieve 99.96% of startup reliability. Compared to typical diesel engine’s startup reliability of about 95%, Kawasaki GPS reliability is significantly higher. This high reliability is achievable due to the Kawasaki’s superior technology and combustion system in the gas turbine. A gas turbine is a rotating machine utilizing continuous combustion process. Continuous combustion prevents potential ignition failure sometimes experienced on diesel engine that is a reciprocating machine with intermittent combustion process, and all parts of the process taking place in one area, i.e., the cylinder. This difference is a major key of gas turbine’s high reliability.

**Differences in the combustion process between Gas Turbine and Diesel Engine**

<table>
<thead>
<tr>
<th>Type</th>
<th>Gas Turbine</th>
<th>Diesel Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting Reliability</td>
<td>Over 99%</td>
<td>Around 95%</td>
</tr>
<tr>
<td>Steady State Speed Fluctuation</td>
<td>± 0.3%</td>
<td>± 5%</td>
</tr>
<tr>
<td>Starting Time</td>
<td>Approx. 3–40 sec.</td>
<td>Approx. 10–20 sec.</td>
</tr>
<tr>
<td>Installation Space</td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td>Emissions (Diesel Oil)</td>
<td>NOx 120ppm (O2 ≈ 15%) CO 15ppm</td>
<td>NOx 700ppm (O2 ≈ 15%) CO 500ppm</td>
</tr>
<tr>
<td>Noise Level</td>
<td>85dB(A) at 1m (option: 75dB(A) at 1m)</td>
<td>105~115dB(A) at 1m</td>
</tr>
<tr>
<td>Vibration Level</td>
<td>10~15 μm</td>
<td>50~60 μm</td>
</tr>
<tr>
<td>Cooling Water</td>
<td>Not necessary</td>
<td>Approx. 200 ton/h</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>Large</td>
<td>Small</td>
</tr>
</tbody>
</table>

**Comparison of Gas Turbine & Diesel Engine**

**Kawasaki Standby Gas Turbine Generator (GPS Series)**

- **Typical Layout of Gas Turbine Generator**

  - Generator Set
  - Room Air Ventilation Equipment (for Indoor Installation)
  - Enclosure Ventilation Equipment (for Indoor Installation)

- **Referential Layout of GPS2000**

  - Exhaust Silencer
  - Gas Turbine Control Panel
  - Package Ventilation Unit
  - Gas Turbine Generator
  - Coupling
  - Alternator

- **Compact, Kawasaki Gas Turbine Generator Package**

  - Gas Turbine Package
  - Gear Box
  - Battery & Charger Panel
**Unique Features for Reliable Power Generation**

### High Startup Reliability

Startup reliability is one of the most important factors for backup power supply system. Kawasaki GPS has proved its high startup reliability with actual performance in the disastrous situations.

**Case:1 Great Hanshin Earthquake (Jan. 17, 1995)**

Early morning on January 17, 1995, a magnitude 7.2 earthquake hit the Hanshin area, causing a blackout that hit about 3 million households in the area.

- **Units at Standby**: 147
- **Blackout**: 87
- **Successful startup**: 93
- **Startup failures**: 4

(※) By external factor out of Kawasaki’s responsibility.

**Case:2 Tokyo Area Blackout (Aug. 14, 2006)**

On August 14, 2006, a crane barge crashed into one of the main power lines in Tokyo, causing a blackout that affected 139,000 households.

- **Units at Standby**: 278
- **Blackout**: 87
- **Successful startup**: 87
- **Startup failures**: 0

**Case:3 The Great East Japan Earthquake (Mar. 11, 2011)**

On March 11, 2011, a magnitude 7.9 earthquake hit the East Japan area, causing a blackout that hit about 3 million households in the area.

- **Units at Standby**: 3,092
- **Blackout**: 1,035
- **Successful startup**: 1,034
- **Startup failures**: 1

(※) By external factor out of Kawasaki’s responsibility.

### Fuel Flexibility

Kawasaki gas turbine enables the choice of diesel fuel and gas fuel. This dual fuel capability realizes high reliable power supply and long term operation compared with diesel engine generator.

**On September 2, 2008, hurricane “Ike” hit Houston, TX, USA. Total financial damage caused by Ike was the 3rd largest damage caused by hurricanes in the north Atlantic area. Blackout lasted for 2 weeks, but gas supply line was available under the situation.**

### Benefits of Dual Fuel System

- **Long time operation without large fuel storage tank.**
- **Higher reliable operation than single fuel system.**
- **Clean exhaust gas with gas fuel.**

### System Diagram

- **Electricity**
- **Power Company**
- **Owner’s Facility**
- **Gas Turbine Power Plant**
- **Fuel Tank**
- **City Gas Tank**
- **Gas Compressor**
- **Long time operation is possible.**
- **Gas Turbine Generator Set**
- **Dividing Valve**
- **ESV**
- **Accumulator**
- **Gas Compressor**
- **Gas Fuel Supply**
- **Atmospheric Discharge**
- **EOV**
- **SSV1**
- **SSV2**
- **Electricity**
- **Liquid Fuel Cooler**
- **Fuel Tank**
## Kawasaki GPS Product Lineup

### Basic Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>GPS750</th>
<th>GPS1250</th>
<th>GPS1500</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Generator Set</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Output (kW)</td>
<td>600</td>
<td>1,000</td>
<td>1,200</td>
</tr>
<tr>
<td>Starting Time</td>
<td>Within 40-sec.</td>
<td></td>
<td></td>
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<tr>
<td>Load Application Capacity</td>
<td>100% (Resistive load)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freq. Deviation Transient</td>
<td>Within ±4.5% (with 100% block load on and off)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steady State</td>
<td>Within ±0.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Type</td>
<td>Kerosene, Diesel oil</td>
<td>Kerosene, Diesel oil, Gas (option)</td>
<td></td>
</tr>
<tr>
<td>Fuel Consumption (l/hr)</td>
<td>905</td>
<td>525</td>
<td>620</td>
</tr>
</tbody>
</table>

| Gas Turbine               |        |         |         |
| Turbine Model             | S2A-01 | M1A-01  | M1A-03  |
| Type                      | Heavy-duty, simple open cycle, single-shaft |         |         |
| Turbine Speed (rpm)       | 31,500 | 22,000  |         |
| Output Speed (rpm)        | 1,500 (50 Hz), 1,800 (60 Hz) |         |         |
| Dry Weight (ton)          | 1.48   | 3.0     |         |
| Lube Oil Type / Brand     | Synthetic oil / Shell ASTO-500, Mobil jet II, Castrol AERO 5000, DP BPTD 2380 |         |         |
| Lube Oil Tank Capacity (approx.) | 66   | 100     |         |
| Lube Oil Consumption (l/ hr) | 0.08 |         |         |

| Alternator                |        |         |         |
| Type                      | 3-phase, open screen-protected, brushless, self-ventilated, synchronous |         |         |
| Output (kW)               | 750    | 1,250   | 1,500   |
| Voltage Regulation        | Within ±5.5% (steady state from no-load to full-load, at pf = 0.8) | Brushless by A.C. exciter and rotating diodes |         |
| Excitation System         | 6,6kV  |         |         |
| Standard Voltage          |        |         |         |

| Starting System           |        |         |         |
| Type                      | Electrical start with D.C. motors (Option: Pneumatic start with air turbinés) | Valve Regulated Lead-Acid (VRLA) Battery |         |
| GT Package (Indoor Type)  |        |         |         |
| Noise Level at 1m         | Approx. 85dBA (optional: 80 – 70dBA) | Approx. 90dBA (optional: 85 – 65dBA at 1 m with a secondary silencer) |         |
| From Package              |        |         |         |
| From Exhaust Silencer Outlet |        |         |         |

(Notes: 
1) Output: Up to 40°C of ambient temp., 150m above sea level. 
2) Fuel Consumption: At full load, 15°C, using diesel fuel oil, allowance is 5%. 
3) Diesel Oil: Density 0.83g/cm³, LHV 42,700kJ/kg. 
4) Other voltage is available as option.)
General Arrangement of GPS Generator Set

GPS750

- **Outdoor Type**
  - Dimensions: 820x460x460
  - Weight (Unit kg):
    - Generator Set: 8,100
    - Exhaust Silencer: 1,350

- **Indoor Type**
  - Dimensions: 820x460x460
  - Weight (Unit kg):
    - Generator Set: 8,000
    - Exhaust Silencer: 900

GPS2000

- **Outdoor Type**
  - Dimensions: 1,000x460x460
  - Weight (Unit kg):
    - Generator Set: 16,000
    - Exhaust Silencer: 2,300

- **Indoor Type**
  - Dimensions: 1,000x460x460
  - Weight (Unit kg):
    - Generator Set: 16,000
    - Exhaust Silencer: 1,800

GPS1250/1500

- **Outdoor Type**
  - Dimensions: 1,250x460x460
  - Weight (Unit kg):
    - Generator Set: 10,200
    - Exhaust Silencer: 2,400

- **Indoor Type**
  - Dimensions: 1,250x460x460
  - Weight (Unit kg):
    - Generator Set: 14,200
    - Exhaust Silencer: 2,400

GPS2500/3000/4000

- **Outdoor Type**
  - Dimensions: 1,750x460x460
  - Weight (Unit kg):
    - Generator Set: 22,000
    - Exhaust Silencer: 3,100

- **Indoor Type**
  - Dimensions: 1,750x460x460
  - Weight (Unit kg):
    - Generator Set: 26,000
    - Exhaust Silencer: 3,900

---

*dB values in (   ) are standard noise level. ( Noise on equipment side / Noise on exhaust outlet )

Lower noise package is available as option.

Overall length and weight of equipment may change depending on specification of alternator.

Weight of generator set includes weight of exhaust silencer.

Dimensional unit is mm unless otherwise specified.
Control / Electrical System

Gas turbine control panel furnishes engine control, generator voltage control, metering, protection, and other control functions required for operating gas turbine generator.

Control Panel

- **Outdoor Type**
  - Front View
  - Side View

- **Indoor Type**
  - Front View
  - Side View
  - Rear Space: 600 mm.

---

**Single Line Diagram**

(Note): This diagram is typical and may change depending on project requirement basis.

---

**General Arrangement of GPS Generator Set**

**GPS5000/6000**

- **Outdoor Type** (46dB / 49dB)
  - Dimensional unit is mm unless otherwise specified.
  - Overall length and weight of equipment may change depending on specification of alternator.
  - Weight of generator set includes weight of exhaust silencer.

- **Indoor Type** (46dB / 49dB)

(Noise): dB values in ( ) are standard noise level. (Noise on equipment side / Noise on exhaust outlet).

Lower noise package is available as option.

Weight (Unit: kg)

| GPS5000 | 65.470 | 8.270 |
| GP56000 | 55.570 | 8.270 |

---

**General Arrangement of GPS Generator Set**

Fuel Piping Connection Port (Front): JS10K40A

---

**Control Panel**

- **Outdoor Type**
  - Front View
  - Side View

- **Indoor Type**
  - Front View
  - Side View
  - Rear Space: 600 mm.

---

**Gas turbine control panel**

- Furnishes engine control, generator voltage control, metering, protection, and other control functions.

- **Starting Motor**
  - Rated Speed: 1,500 rpm
  - Rated Voltage: 55 V (Optional: 110 V)

- **Starting Motor**
  - Rated Speed: 1,100 rpm
  - Rated Voltage: 110 V (Optional: 220 V)

---

**Dimensional Unit**

- Dimensional unit is mm unless otherwise specified.

---

**GPS5000/6000 Dimensions**

- Weight: (Unit: kg)
  - Generator Set: 65.470
  - Exhaust Silencer: 8.270

---

**General Arrangement**

- Fuel Piping Connection Port (Front): JS10K40A

---

**Gas Turbine Control Panel**

- Furnishes engine control, generator voltage control, metering, protection, and other control functions.

---

**Single Line Diagram**

(Note): This diagram is typical and may change depending on project requirement basis.
Kawasaki MGP/TGP Series are gas turbine generators mounted on trucks or on trailers for mobile application. MGP/TGP integrate all necessary equipment and enable fully automatic operation without the need for external power supply. High durability against vibration and shock, and reliable operation are important for this application. Kawasaki MGP/TGP is designed to fully meet such demands.

**Advantages**

1. Developed with Vast Field Experience
   Gas Turbines on trucks or on trailers are susceptible to large vibration and shock when they run on roads. Kawasaki meets mobile installation condition, with gas turbines experience and technology from Kawasaki aircraft jet engines operating under similar severe environmental conditions.

2. Low Center of Gravity and Large Tumble-down Angle
   Due to light weight of gas turbines, the center of gravity of MGP/TGP is low, and this makes it possible to have stable maneuverability.

3. Compact Integration
   MGP/TGP incorporate all necessary equipment, including fuel tank, batteries, exhaust silencer, cable reel, etc., inside a compact aluminum enclosure. This feature enables easy maintenance.

4. Blackout Start Capability
   MGP/TGP can start up and supply electricity without any external utility supply, such as electric power and fuel.

**System Specifications (Typical)**

<table>
<thead>
<tr>
<th>Item</th>
<th>MGP 750</th>
<th>MGP 1000</th>
<th>MGP 1250</th>
<th>MGP 1500</th>
<th>MGP 2000</th>
<th>MGP 2500</th>
<th>TGP 2000</th>
<th>TGP 2500</th>
<th>TGP 3000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Fuel (kW)</td>
<td>750</td>
<td>1000</td>
<td>1250</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>2000</td>
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<td>Fuel</td>
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<td>Generator Set Load</td>
<td>100%</td>
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<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
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<td>Application Allureance</td>
<td>(Resistance Load)</td>
<td>(Resistive Load)</td>
<td>(Resistive Load)</td>
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<td>Freq. Deviation Transient</td>
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<td>±9.6%</td>
<td>±9.6%</td>
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<td>D.C. Consumption (kW)</td>
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<tr>
<td>Trucks / Trailer</td>
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<tr>
<td>Total Weight</td>
<td>(t)</td>
<td>(t)</td>
<td>(t)</td>
<td>(t)</td>
<td>(t)</td>
<td>(t)</td>
<td>(t)</td>
<td>(t)</td>
<td>(t)</td>
</tr>
</tbody>
</table>
| Noise Level at 1 m (dBA)    | 85       | **Installation Example**

- **MGP Series Generator Set**

- **TGP Series Generator Set**

(Notes)
1. Output : Up to 40°C of ambient temp., 150 m above sea level.
Maintenance and Customer Support

**Easy Maintenance**
Kawasaki GPS requires very little maintenance due to its small number of components. Monthly start-stop test is sufficient as periodic check. Extended service agreement is available for all other required maintenance.

**High Skill Engineers**
Kawasaki’s service group is highly skilled. Our engineers and technicians train at our assembly and overhaul facility to ensure that they have the latest technique and knowledge to perform all the required field maintenance.

**Support from Worldwide Branches**
Kawasaki has five branches and three spare parts centers around the world to respond to the customer’s needs immediately. Each branch has capability to review and solve any issues that may arise. We fully support customers worldwide.

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**Kawasaki Gas Turbine Worldwide Installation**

<table>
<thead>
<tr>
<th>Region</th>
<th>Standby+Cogen</th>
<th>Standby</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>International</td>
<td>681</td>
<td>385</td>
<td>8,015</td>
</tr>
<tr>
<td>Japan</td>
<td>7,334</td>
<td>6,982</td>
<td>7,367</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8,015</strong></td>
<td><strong>7,387</strong></td>
<td><strong>8,015</strong></td>
</tr>
</tbody>
</table>

**Typical Reference**

- **Data Center**: 3,600kW x 2units
- **Office Building**: 1,000kW x 1unit
- **Chemical Plant**: 1,000kW x 1unit
- **Telecommunication**: 4,800kW x 3units