

Waukesha

The VHP Series Five Family Just Got More Powerful

Now including the 2,500 HP P9394GSI S5



- More Power Across the Series Five Family:
 - P9394GSI S5: 2,500 HP @ 1,200 rpm
 - L7044GSI S5: 1,900 HP @ 1,200 rpm
 - L7042GSI S5: 1,500 HP @ 1,200 rpm
- Better Fuel Flexibility
- Improved Performance at Higher Ambient Temperatures
- Reduced Fuel Consumption
- Lower Lifecycle Costs & Extended Service Intervals

INNIO

Working Smarter, Not Harder

Waukesha Series Five rich-burn engines combine advanced technology from INNIO with the history and experience of the VHP platform.

The Series Five family of engines now includes the 2,500 hp P9394GSI S5 in addition to the 1,900 hp 7044GSI S5 and 1,500 hp 7042GSI S5. All three engines provide more power, better fuel flexibility, improved performance at higher ambient temperatures, lower fuel consumption and lifecycle costs, and longer service intervals than previous models. A common ESM2 control system and service parts across Series Five simplifies operation, maintenance, and troubleshooting.

The 1,500 hp L7042GSI S5 provides the same benefits as the L7044GSI S5 and P9394GSI S5, with even better flexibility. There is no fuel derate with the L7042GSI S5. When paired with a three-way catalyst, the L7042GSI S5 can operate at nearly any site and provide the full 1,500 hp rating while meeting strict emissions standards.

These power increases and performance improvements come without raising temperatures or pressures beyond other VHP models, illustrating why Series Five engines are working smarter, not harder.

Series Five Performance Data

	L7042GSI S5	L7044GSI S5	P9394GSI S5
Power @ RPM	1,500 hp @ 1,200 rpm	1,900 hp @ 1,200 rpm	2,500 hp @ 1,200 rpm
BSFC (Btu/bhp-hr; -0/+5% LHV)	7209	7063	6972
Altitude Capability Before Derate	4,800 ft @ 100° F 4,000 ft @ 120° F	5,000 ft @ 100° F 4,200 ft @ 120° F	4,000 ft @ 120° F
Ambient Capability Before Derate	120° F	120° F	120° F
Fuel Derate Begins	No Fuel Derate	55 WKI (~1,250 Btu/ft ³ LHV)	58 WKI (~1,225 Btu/ft ³ LHV)
Power @ 35 WKI (2,350 Btu/ft³ LHV)	1,500 hp	1,600 hp	2,135 hp
Spark Plug Interval	4,000 hours	4,000 hours	4,000 hours
Oil Change Interval	4,000 hours	4,000 hours	4,000 hours
% Change in Operating Cost vs Previous Model (\$/hp-hr)	-12%	-22%	-15%

The Series Five Story

Although Series Five engines are capable of higher power levels than previous versions, the stresses on the components have not increased. This is made possible by enhanced rich-burn combustion through the Miller Cycle, a modified cylinder head design that reduces temperatures in key regions, and an optimized piston design.

Used previously on VHP engines, the Miller Cycle moves work from the piston to the turbocharger, reducing combustion and exhaust temperatures and making the Series Five the most fuel efficient VHP ever, even though it's a rich-burn engine.

The improved cylinder head design reduces key internal temperatures by up to 40%, improving reliability and extending the life of the head.

The Series Five piston design has been optimized to reduce unburned hydrocarbons, which improves emissions and fuel consumption while lowering the temperature of the piston itself, providing better fuel flexibility even at a higher power rating.

Improvements to the ignition system allow for 4,000-hour spark plug intervals with low-cost, non-precious metal plugs. Matching 4,000 oil change intervals reduce operating costs and trips to site.

Series Five engines come standard with ESM2, INNIO's next-generation engine controller. ESM2 uses a 12" full color customer interface panel, allowing users to see all engine parameters, trend data, view manuals, and walk through troubleshooting steps, eliminating the need for a laptop computer.

INNIO's emPact Emission Control System is the option of choice for reducing emissions below 0.15 g/bhp-hr of NOx and 0.30 g/bhp-hr of CO. emPact optimizes the interaction between the Series Five engine, AFR2 air/fuel ratio control, and the INNIO-supplied 3-way (NSCR) catalyst to maintain emissions compliance even as engine speed, load, fuel, and environmental conditions change.

Series Five Benefits

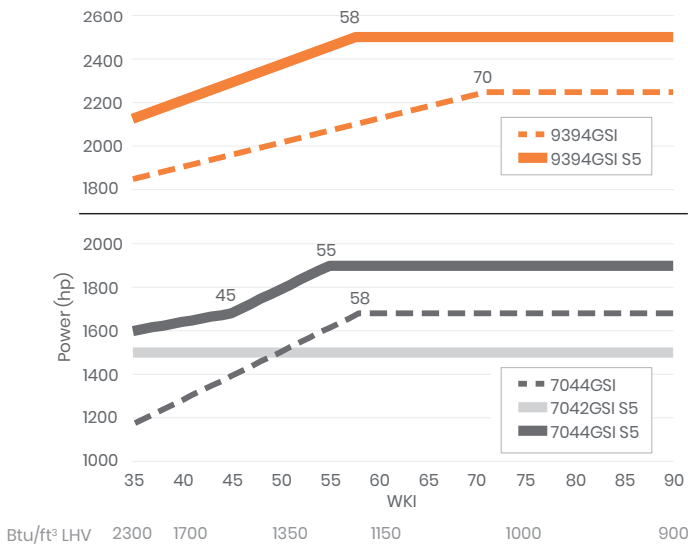
Improved Fuel Flexibility

Although the Series Five starts at a higher power rating than previous models, improved fuel flexibility helps ensure more power on more fuels thanks to Miller Cycle combustion, an improved piston design, and ESM2.

- 2,500 hp to 58 WKI (~1,225 Btu/ft³ LHV) on P9394GSI S5; 2135 hp on 35 WKI (2,300 Btu/ft³ LHV) fuel
- 1,900 hp to 55 WKI (~1,250 Btu/ft³ LHV) on L7044GSI S5; 1,600 hp on 35 WKI (2,300 Btu/ft³ LHV) fuel
- No fuel derate on L7042GSI S5; 1,500 hp on 35 WKI (2,300 Btu/ft³ LHV) fuel

The chart below illustrates the fuel flexibility improvement with Series Five compared to the previous version.

Series Five Fuel Flexibility Improvements

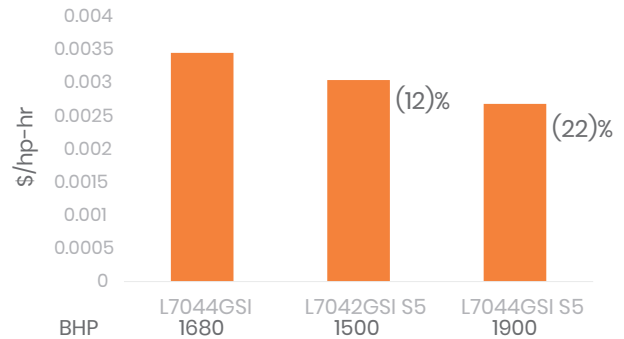


Up to 22% Lower Operating Cost

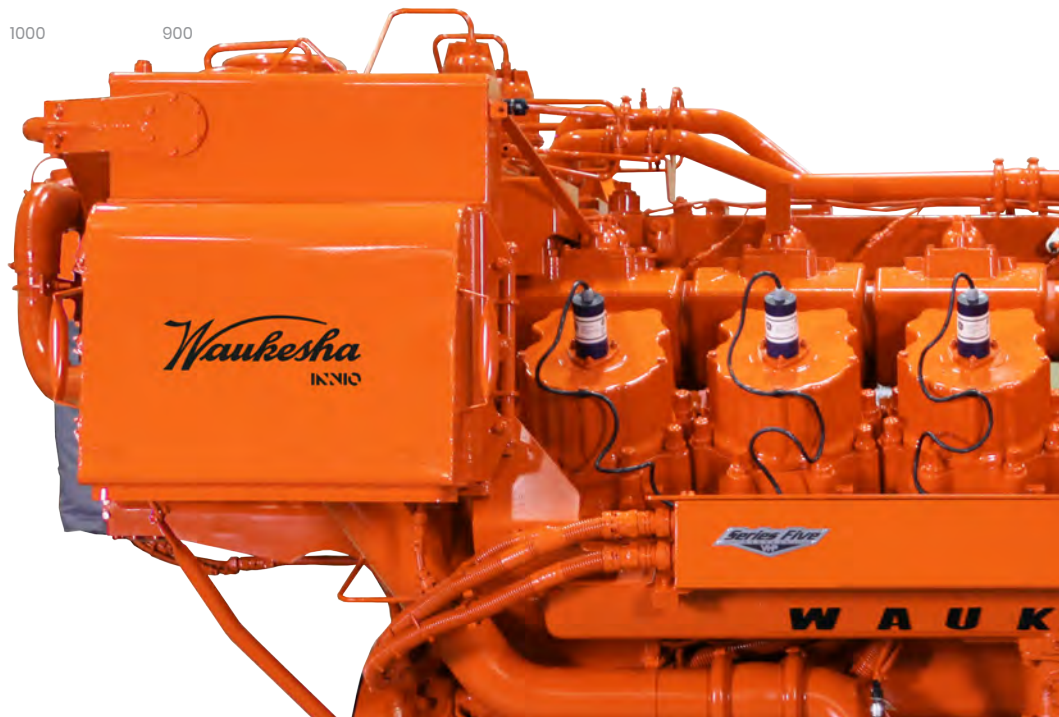
- Reduced \$/hr operating costs, even with increased power
- Non-precious metal spark plugs and next-generation Ignition Power Module (IPMD2) extend spark plug intervals to 4,000 hours
- Improved piston design extends oil change intervals to 4,000 hours
- Fewer visits to engine reduces operating costs

The chart below shows the reduced lifecycle costs with Series Five.

Series Five Lifecycle Comparison



Note: Chart data is representative only and may vary based on application, scope, etc.



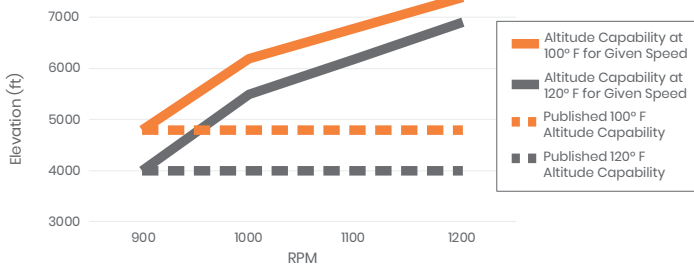
Increased Altitude and Ambient Capability

Series Five achieves full power at up to 120° F ambient temperature, providing more throughput in hot regions such as West Texas and the Middle East. The altitude limits without derate for Series Five are:

- P9394GSI S5: full power to 120° F and 4,000 ft.
- L7044GSI S5: full power to 120° F and 4,200 ft. or 100° F and 5,000 ft.
- L7042GSI S5: full power to 120° F and 4,000 ft. or 100° F and 4,800 ft.

These published ambient and altitude limits apply from 1,200 rpm down to 900 rpm; however, the L7042GSI S5 can operate at full power at higher elevations when less speed turndown is required, as shown in the chart below:

L7042GSI S5 Altitude Capability without Derate



7042GSI S5 Ultimate Flexibility

The L7042GSI S5 provides the ultimate in application flexibility. Because it uses the same components and has the same displacement as the 1,900 hp L7044GSI S5, the L7042GSI S5 operates at a lower BMEP, meaning it does not work as hard to achieve its 1,500 hp rating. This increases the operating range, flexibility and reliability of the L7042GSI S5.

The L7042GSI S5 does not have a fuel derate, it makes the same 1,500 hp on 35 WKI (2,350 BTU/FT³ LHV) as it can on sweet, commercial-quality natural gas. It also can make full power with ambient temperatures up to 120° F.

The L7042GSI S5 can operate at 1,500 hp at virtually any site while meeting emissions requirements when paired with a simple three-way (NSCR) catalyst, making this the ultimate lease fleet engine.

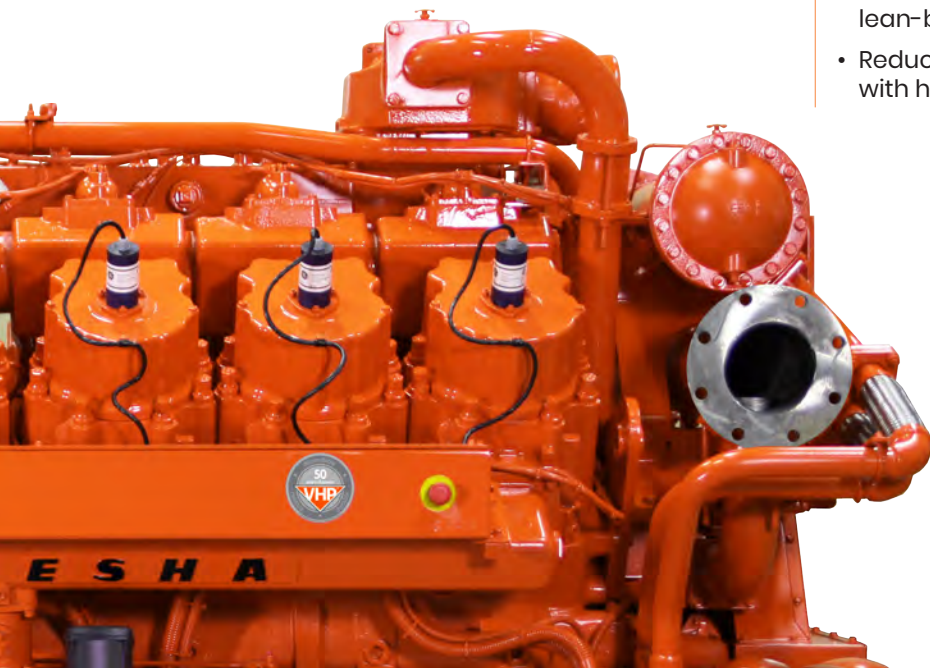
Service Kits

Upgrade existing engines to Series Five to get the following benefits:

- Reduced operating cost
- Improved efficiency and reliability
- Ability to increase power from 1,500 hp to 1,900 hp without changing engine hardware

Most Fuel-Efficient VHP Ever

- 10% lower fuel consumption reduces carbon footprint and emissions
- Rich-burn engines can be more fuel efficient than lean-burn engines
- Reduced heat rejection allows for similar-size cooler with higher power engine



Series Five Technology

Miller Cycle

Miller Cycle combustion modifies valve timing to shift work from the piston to the turbocharger. It also reduces temperatures at the end of the compression stroke. Miller Cycle combines the benefits of higher compression ratio pistons—improved power and reduced fuel consumption—with the improved fuel flexibility typically seen with lower compression ratio pistons.

The Miller Cycle requires more boost than a traditional rich-burn engine.

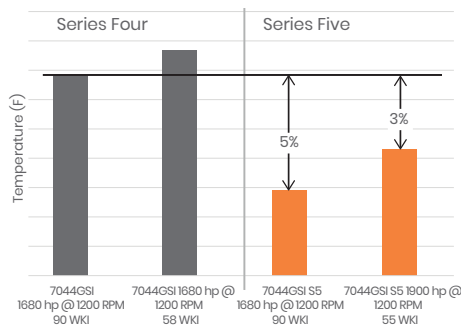
A new turbocharger match was used on the Series Five to provide that boost. Series Five turbochargers have a 30,000 hour lifetime and are built with higher material specifications than previous models for better reliability.



Modified Cylinder Heads

Series Five engines use a Miller Cycle variant of the newest VHP rich-burn cylinder head design. Also released on higher temperature Series Four applications, these heads look identical to previous versions from the outside, but have modified internal passages to improve heat transfer and reduce temperatures within the head.

Series Five vs. Series Four Comparison - Exhaust Valve Temperature



Hotter, lower WVKI fuels require the engine to retard timing to prevent knock. This timing change increases temperatures within the head.

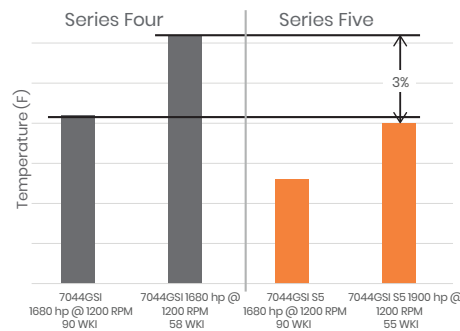
The worst-case, highest temperature of the exhaust valve is 3% lower on a Series Five engine than the best-case temperature on a Series Four engine, even though Series Five operates at 1,900 hp vs 1,680 hp on a Series Four.

The charts below show that worst-case exhaust valve and guide temperatures at 1,900 hp on a Series Five engine are lower than nominal operating temperature on a 1,680 hp Series Four engine.

Again, this illustrates how the Series Five engine makes more power without increasing temperature.

Series Five engines are working smarter, not harder.

Series Five vs. Series Four Comparison - Exhaust Valve Guide Temperature



Similar to the exhaust valve, the worst-case exhaust valve guide temperatures are lower on the 1,900 hp Series Five engine than the best-case temperatures on the 1,680 hp Series Four.

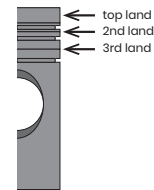
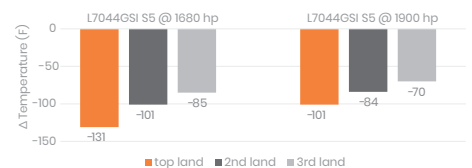
Enhanced Piston Design

Series Five uses a piston design that decreases crevice volume. The result is:

- 100° F temperature reduction in the critical area
- Reduced carbon deposits for increased robustness, durability, and oil life
- Reduced fuel slip for improved efficiency and lower hydrocarbon emissions
- Improved fuel flexibility

The chart below shows the relative temperature comparison between a Series Five piston and Series Four. At the same 1,680 hp rating, the Series Five piston temperature is 131° F lower. At 1,900 hp, the Series Five piston is 101° F lower than the Series Four piston operating at 1,680 hp.

Piston Temperature Comparison Relative to L7044GSI @ 1,680 hp



A VHP Series Five piston after field validation illustrates reduced carbon deposits

ESM2

ESM2 is Distributed Power's next-generation engine controller. Previously released on Series Four engines, it brings the following features and benefits to the Series Five:

- Provides a touch-screen HMI panel with all operating parameters, fault monitoring, and data logging displayed in full color
- Integrates a step-by-step troubleshooting tool into the HMI panel
- Optimizes ignition timing based on fuel quality to increase power, fuel flexibility and efficiency, while lowering temperatures
- Does not require a laptop for commissioning or parameter changes
- Allows for proper engine lubrication with oil pressure differential and oil pressure permissive
- Reads exhaust and main bearing temperatures for each cylinder; provides ability to display alarms and shutdown engine when values are out of range
- Incorporates Asset Performance Management (APM) solution through myPlant* software and mobile app, specially designed for reciprocating engine operators and service providers, to:
 - Monitor equipment health and diagnose faults
 - Proactively manage asset performance with analytics



ESM2 HMI display panel operating on a L7044GSI S5 gas compression package



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Our diverse portfolio of reliable, economical and sustainable industrial gas engines generates 200 kW to 10 MW of power for numerous industries globally. We can provide life cycle support to the more than 48,000 delivered gas engines worldwide. And, backed by our service network in more than 100 countries, INNIO connects with you locally for rapid response to your service needs. Headquartered in Jenbach, Austria, the business also has primary operations in Welland, Ontario, Canada, and Waukesha, Wisconsin, US.

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