



Revitalizing the Waukesha fleet

Services Offerings

March 1st, 2017

Imagination at work

GE Information—U.S. Government approval is required prior to export from the U.S., re-export from a third country, or release to a foreign national wherever located.

CM&U introduction

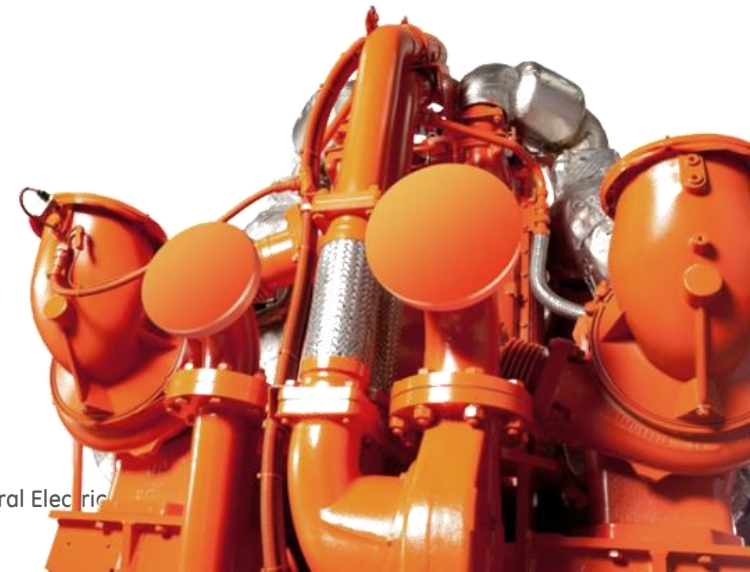
CM&U – Conversions, Modifications and Upgrades

Conversion, Modification and Upgrade (CM&U)

- Solutions to sustain or improve the economic viability of your GE equipment throughout its operating life.
- Our retrofit solutions improve reliability, availability, maintainability, performance, durability, emissions, usability and/or flexibility of existing installations.

Our Mission

- Make our customers more successful by improving the economic viability of their installations in a changing environment



Offerings overview

CM&U – Conversions, Modifications & Upgrades

GE offers a comprehensive portfolio of CM&Us for Waukesha* gas engines to increase your profitability



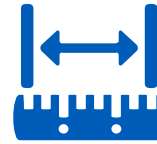
OUTPUT
INCREASE



AVAILABILITY



CONTROLS
UPGRADES



OPER.
FLEXIBILITY



EFFICIENCY
INCREASE



LIFETIME & SERVICE
INTERVAL EXTENSION



EMISSIONS
REDUCTION



LOWER OPER.
COSTS



VHP* SERIES 2 to 4 upgrade (GSI only)

Improve reliability and life with less oil consumption



LOWER OPER. COSTS



LIFETIME & SERVICE
INTERVAL EXTENSION

2 levels to choose

LEVEL

1

Series 4 Cylinder Head
More robust design



LEVEL

2

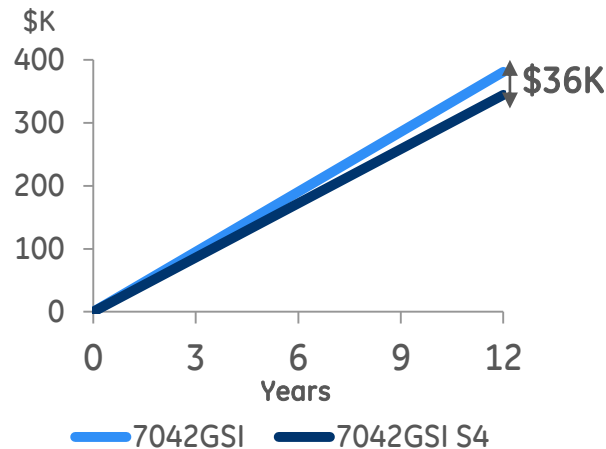
Power Cylinder
Add scuff
resistant pistons,
cylinder liners



- Further improved reliability under difficult operating conditions
- Extended service intervals
- Significantly lower oil consumption
- Improved sealing with new spark plug carrier (SPARC)

Increased lifetime by up to 60% with optimized cylinder head design

Parts, labor, and downtime costs

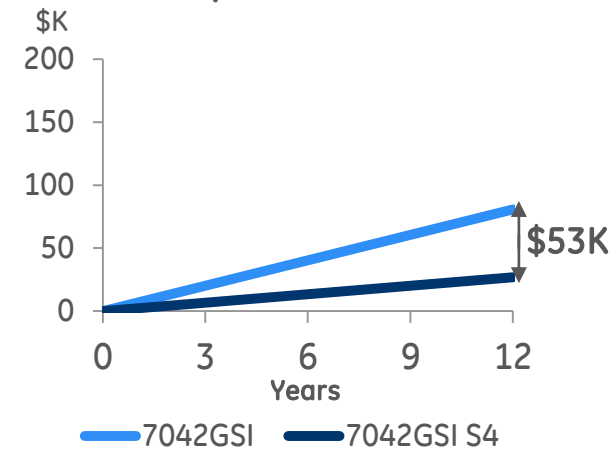


- Reduced parts cost and downtime.
- ~32,000 OPH on L7042GSI S4 vs ~20,000 OPH on existing L7042GSI

~\$36,000 parts, labor, and downtime savings over 2 Majors

~66% less oil consumed annually

Oil consumption costs



Assumptions

- Oil consumption savings w/ S4 Power Cyl.: ~0.0002 lb/bhp-hr
- Annual OPH: ~8400

Reduced oil consumption yields ~\$53,000 savings over 2 Majors

*Trademark of General Electric Company

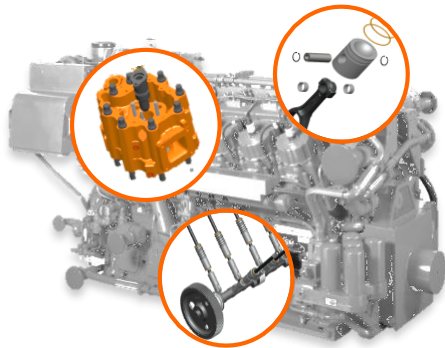


VHP model conversions

Maximize output while matching reliability of new a new unit



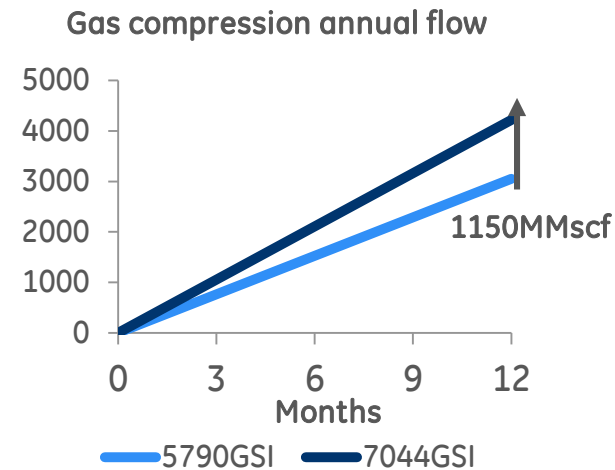
Converts engine small and large bore VHP to current model configuration rich burn



Typical scope

- Cylinder head
- Piston, ring and liner
- Turbocharger
- Carburetor modification (GL only)
- Intake manifold (GL only)
- Harness upgrade
- Breather
- ESM/AFR2 with emPact

Up to 38% higher gas flow for L5790GSI to L7044GSI

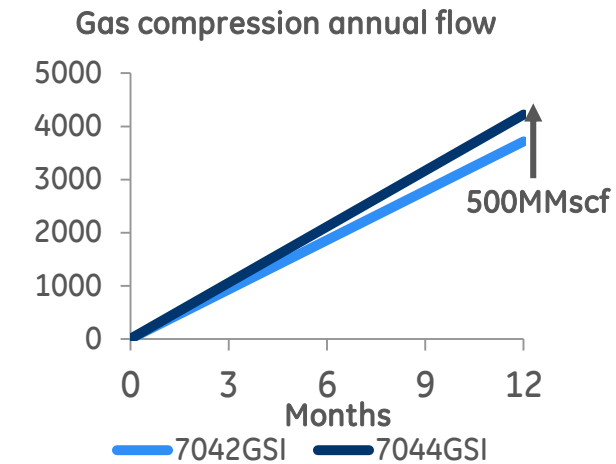


Assumptions

- Standardized compressor set (JGK 3-stage)
- Typ. Ps: 10psi, Pd: 1000 psi
- +465 BHP compared to L5790GSI
- Annual OPH: 8600

Compress & flow up to 38% more gas
~\$300,000/yr more revenue annually
(in gathering)

Up to 14% higher gas flow for L7042GL to L7044GSI



Assumptions

- Standardized compressor set (JGK 3-stage)
- Typ. Ps: 10psi, Pd: 1000 psi
- +200 BHP output compared to L7042GL
- Annual OPH: 8600

Compress & flow up to 14% more gas
~\$130,000/yr more revenue annually
(in gathering)

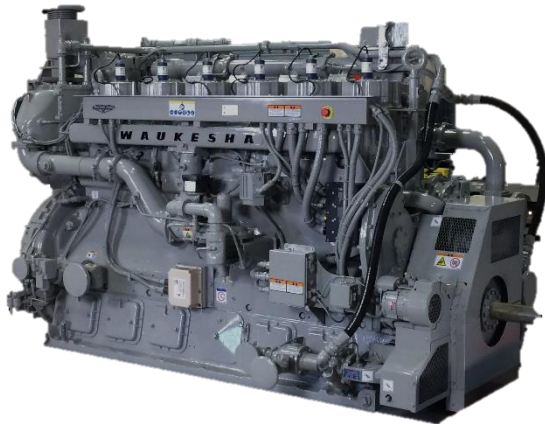


F3521 to F3524 model conversion

Maximize output while matching reliability of a new unit



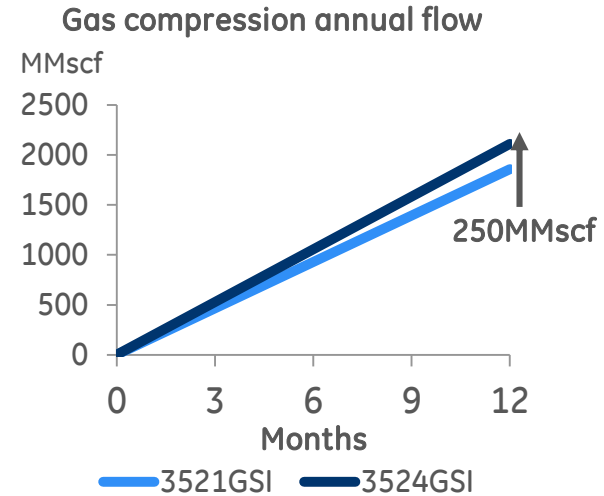
Converts engine to F3524 ESM2 with emPact



Typical scope

- Cylinder head
- Crankshaft
- Piston, ring and liner
- Turbocharger
- Harness upgrade
- ESM2

Up to 14% higher gas flow for F3521GSI to F3524GSI



Assumptions

- Standardized compressor set (JGH 3-stage)
- Typ. Ps: 10psi, Pd: 1000 psi
- +100 BHP compared to F3521GSI
- Annual OPH: 8600

Compress & flow up to 14% more gas
\$65,000/yr more revenue annually
(in gathering)

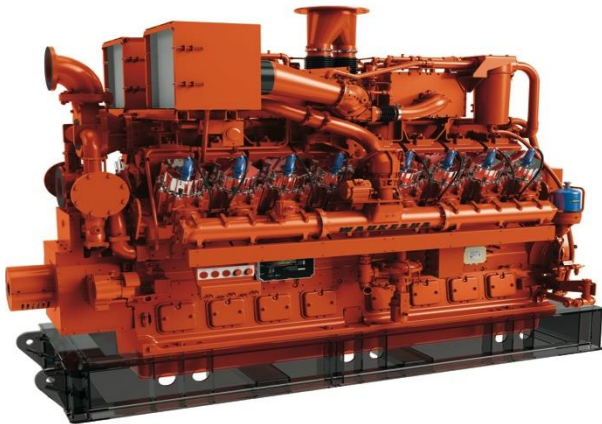


P9390 to P9394 model conversion

Maximize output while matching reliability of a new unit



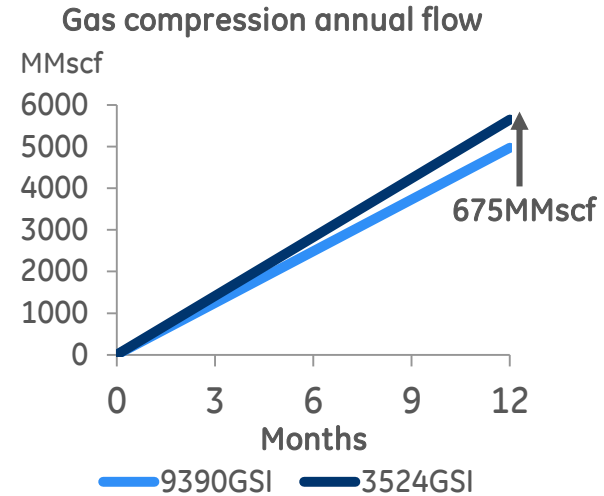
Converts engine to P9394 with ESM AFR2 miller timing ...



Typical scope

- Cylinder head
- Crankshaft
- Piston, ring and liner
- Turbocharger
- Harness upgrade
- Extender components
- Breather
- ESM/AFR2

Up to 14% higher gas flow for P9390GSI to P9394GSI



Assumptions

- Standardized compressor set (JGK 3-stage)
- Typ. Ps: 10psi, Pd: 1000 psi
- +270 BHP compared to P9390GSI
- Annual OPH: 8600

Compress & flow up to 14% more gas
\$175,000/yr more revenue annually
(in gathering)

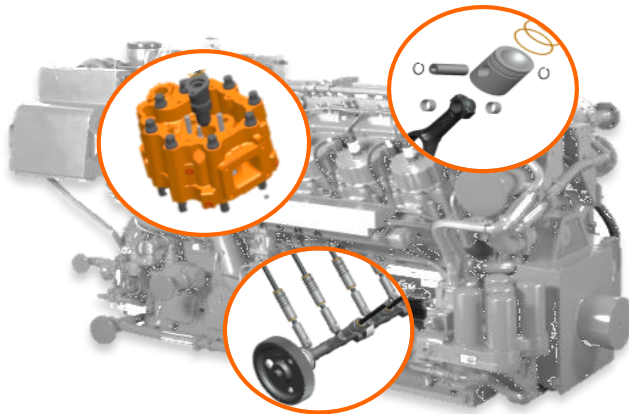


VHP & VGF rich burn conversion

Take on the toughest fuels, reduce emissions and increase output



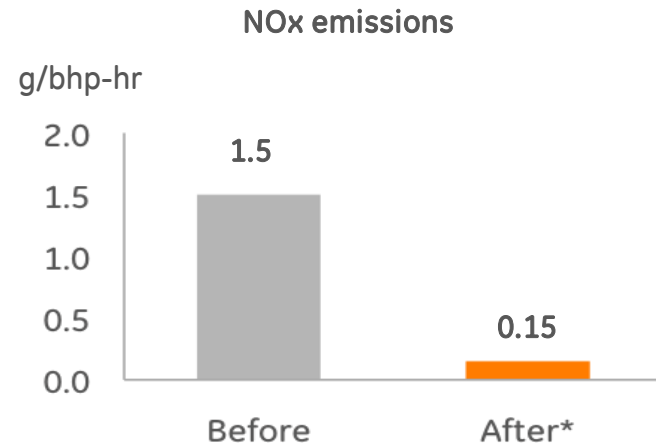
Converts engine from lean burn combustion (excess air to fuel ratio) to rich burn, especially suited for customers in gas compression or oil field power.



Typical scope

- Cylinder head
- Piston, ring and liner
- Turbocharger
- Carburetor modification
- Harness upgrade
- Intake manifold
- Wastegates

Wider fuel tolerance and reduced emissions



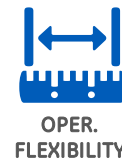
- Automatic adjustment maintains emissions at desired levels
- Increased operating limits up to 8,000 feet altitude with S4 turbocharger/wastegate
- Better ability to handle changes in ambient/fuel conditions.
- VHP conversion also includes benefits of the Series 2 to Series 4 conversion

90% lower NOx emissions*

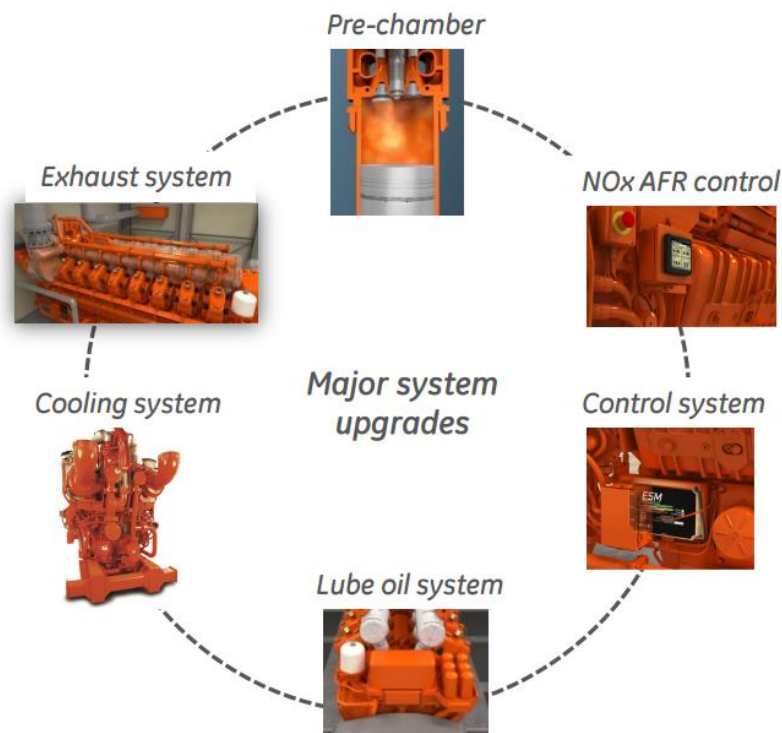


AT to 275GL+ Conversion

Increase power and reduce emissions with updated control



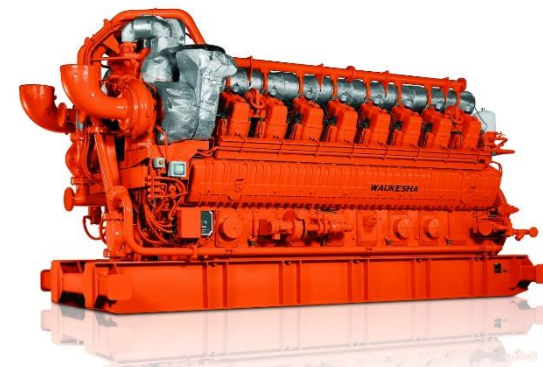
Converts an AT engine to a 275GL+ with enhanced engine control and reliability



AT / 275GL+ performance comparison

Performance	ATGL 12V/16V		275GL+ 12V/16V	
Power (hp)	3375	4500	3625	4835
BSFC (BTU/hp-hr)	6800		6539	6499
Nox (g/hp-hr)	0.7		0.5	
CO (g/hp-hr)	2.0		1.6	
NMHC (g/hp-hr)	1.0		0.8	
Fuel flex.	600-2300 BTU/scf			

Additional option to increase power to 3750(12V) or 5000(16V) hp



VHP S2 to S4 upgrade ... SPARC system

Why:

Improved sealing and ease of install

Applies to:

All Series Four engines

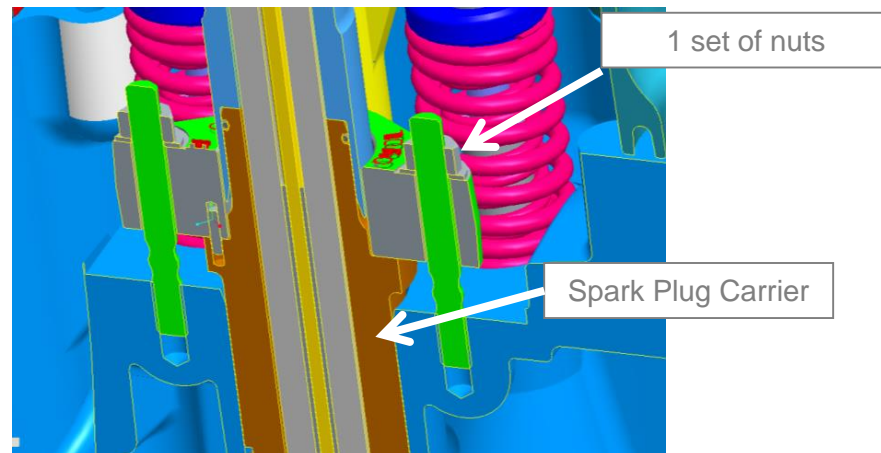
Kit #G-962-1117

Benefits:

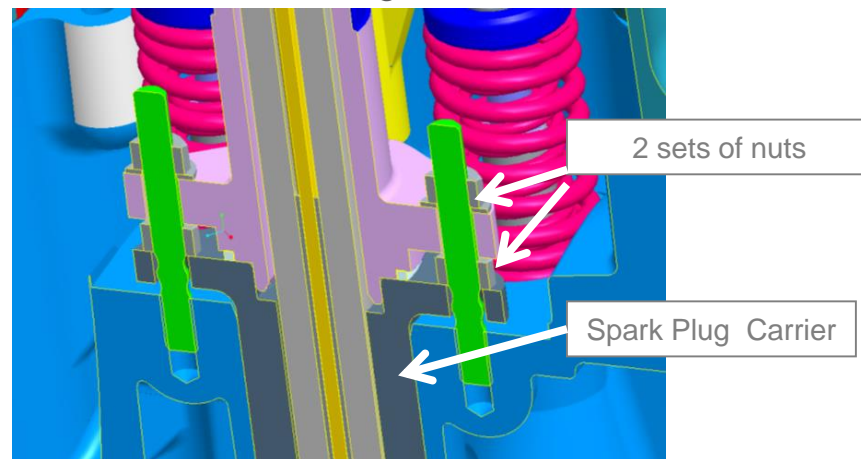
- Single nut maintains seal and simplifies install ... 50% of time
- Improved sealing mechanism minimizes coolant leakage
- Required torque marked on flange



Current Design



Previous Design



VHP GL head upgrade kit (4-valve)



LOWER OPER. COSTS



LIFETIME & SERVICE
INTERVAL EXTENSION

**Robust design improvements from S4 rich burn
VHP carried over to lean burn**

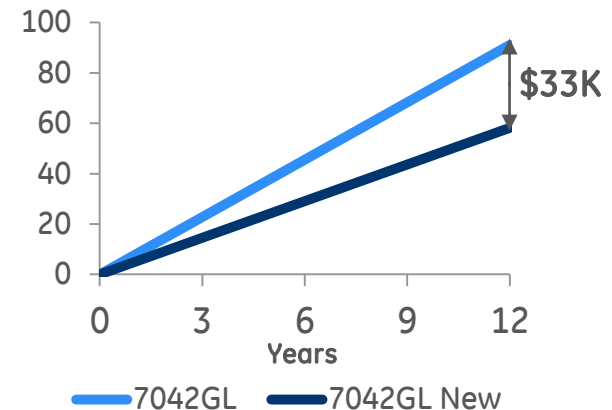
VHP GL cylinder kit components



- Design change scope: Valves, guides, rotators
- Material and dimensions optimized to reduce wear
- Further improved reliability under difficult operating conditions
- Extended service intervals

**Increased lifetime by up to 60% with optimized
cylinder head design**

Top-end parts, labor, and downtime costs (in \$K)



- Eliminates every third top end overhaul
- ~32,000 OPH on upgraded L7042GL compared 20,000 on previous overhaul kit

Eliminating a top end through 48,000 hours
~36% savings in \$/hr lifecycle



VGF* Inline GL head upgrade (4-valve)



LOWER OPER. COSTS



LIFETIME & SERVICE
INTERVAL EXTENSION

Robust design improvements from VGF SE carried over to VGF

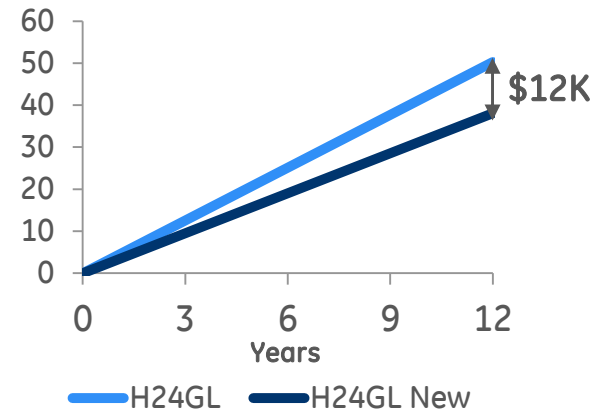
VGF GL inline cylinder head



- Design change scope: Valves, guides, rotators
- Material and dimensions optimized to reduce wear
- Further improved reliability under difficult operating conditions
- Extended service intervals

Increased lifetime by up to 50% with optimized cylinder head design

Top-end parts, labor, and downtime costs (in \$K)



- Up to 50% longer intervals between top-end overhauls
- ~24,000 OPH on F18GL and H24GL S4 vs ~16,000 OPH on existing VGF inlines

Eliminating a top end through 48,000 hours
~25% savings in \$/hr lifecycle



VHP* Advanced Breather

Reduces key component operating costs



LOWER OPER. COSTS



LIFETIME & SERVICE
INTERVAL EXTENSION

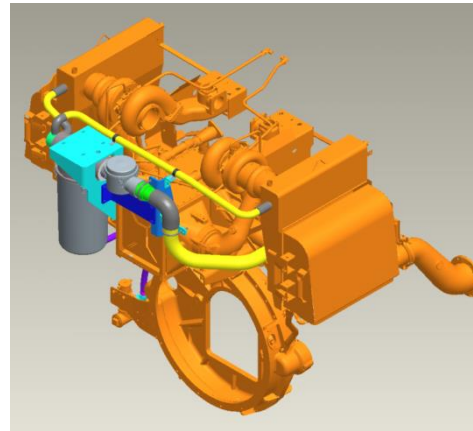
Advanced crankcase breather



- Redesigned breather system includes pre-separator, pressure regulator valve, separator, check valve, insulation, tubing, brackets
- High efficiency coalescing filter reduces oil fouling of catalyst
- Fewer oil leaks due to more consistent crankcase vacuum

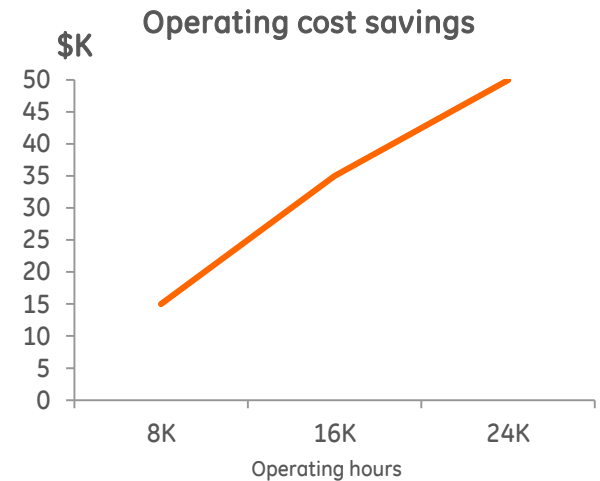
Maintains crankcase pressure through speed and load changes

Mounted on flywheel end of engine



- Engine safety improvement with efficient removal of exhaust gases
- Prevents coking of intake valve seats, turbocharger and fouling of catalyst

Oil integrity increases availability and reduces operating costs



Assumptions

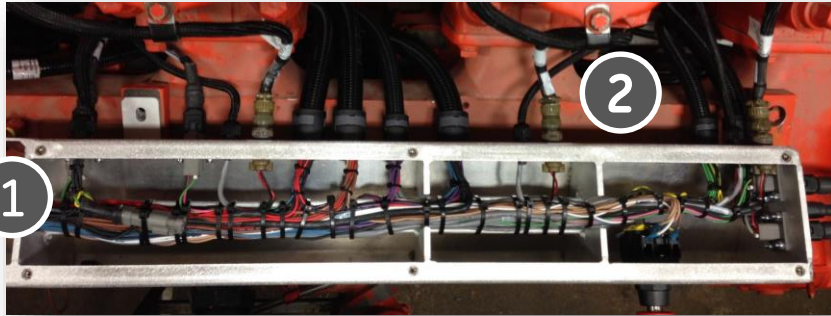
- Increase in catalyst, head and turbocharger life
- Availability increase with downtime avoidance

Up to \$50K revenue potential with availability increase

*Trademark of General Electric Company



Wiring harness improvements



Wires supported and bundled in tray to prevent wear



Shielded from engine heat

Harness improvements

- 1 Redesigned wire ways to prevent wire chafing and easier construction.
- 2 More modular design to allow sections of harnesses to be replaced
 - Reduced operating cost
 - Easy to maintain
- 3 Harness routing improvement to limit heat exposure.



Wiring Harness Upgrade Detail

Customer Issue	Resolution
Nuts on wireway ground studs are found loose	Remove the ground studs on the wireways
Wires can be pinched between metal parts or chafe inside wireway.	Fewer metal surfaces in wireway; 1 main bundle of wires allowing the bundle to be secured tightly.
Loose wireway screws get dropped and lost	Captive screw flush with the cover
Loose connectors inside wireway	Connectors inside of wireway replaced by ultrasonic splices
Customer interface jumper harness plastic bulkhead connector breaks.	Engine bulkhead connector changed to metal connector
Exhaust sensor harness reliability; become brittle and crack	Utilized heat shield with new breather; harness to sensors mounted on the cool side of the intercooler instead of the hot side
Coil connector vibrates apart and index cylinder breaks	Use mutli-conductor cable and integrated cable; connector at the wireway upgraded
Wires wear in plastic conduit due to vibration	Multi conductor cables are being used
Difficult to mate connectors	Mating connectors made of the same material.
Wireway openings allow rodents and snakes to enter and cause damage.	New wireway design reduces the openings



New Power Distribution Box

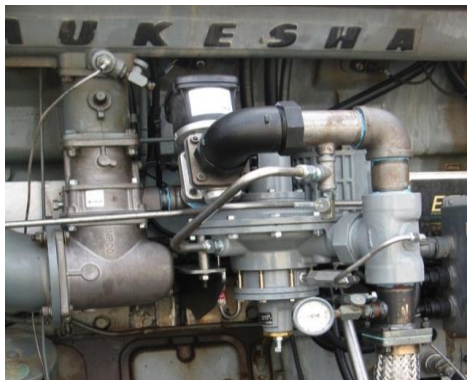
- CSA type 4 sealing
- LED circuit indicators
- Internal fault LED
- Remote PDB fault indicator
- Reset switch
- Noise suppression



AFR2 Upgrade for 5794/7042/7044GSIs

The Next Generation of Rich Burn Air-Fuel Ratio Control

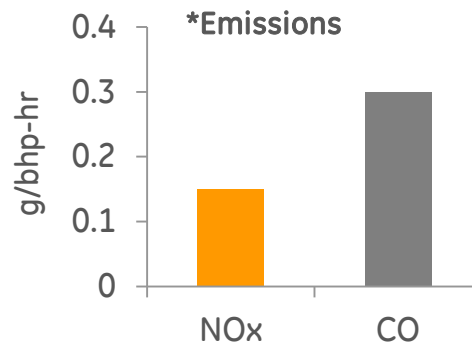
More than just improved air-fuel ratio control.



Typical scope

- Full authority fuel valve
- Operator HMI
- AFR2 engine control module
- New pre-cat O2 sensors
- Harness improvements
- Power distribution box
- Carb cone
- Differential pressure wastegates

Long term emissions performance with little-to-no tuning



- Maintains emissions levels across load, speed and fuel swings with no operator intervention
 - Speed: 900-1200 rpm
 - Load: 75 – 100%
 - Fuel: 58 – 98 WKI (900 – 1200 btu/ft3)
- Save money on reduced technician support and emissions testing time

*w/ 3-way catalyst

Package panel mounted HMI with operator inputs

Operator interface via HMI



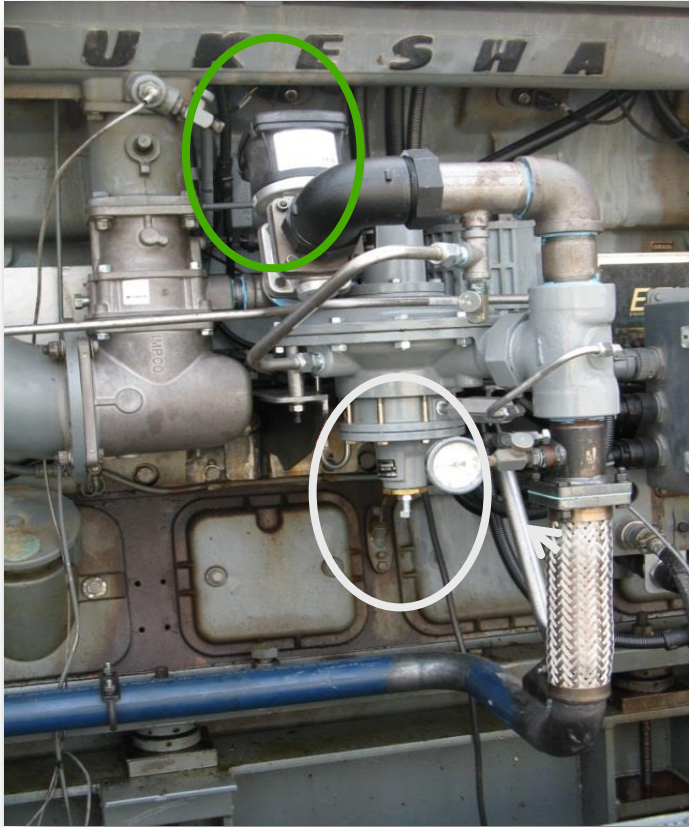
- Six step setup process for engine
- No laptop needed for AFR adjustments
- Up to 5-7 days of data logging with flash drive port
- Displays most engine parameters
- Catalyst health sensor monitoring (if equipped with **emPact)

**Trademark of General Electric Company



VHP AFRII with emPact ... fuel systems upgrade

Right & left bank



Fuel system improvements

- Provides quicker response when position change required
- Installed between regulator and carburetor
- New carb cone for wide fuel tolerance w/o adjustment
- Minimizes “travel” delays
- Replaces stepper motors, improving access to oil pan doors













ESM AFR1 to AFR2 comparison

AFR1

AFR2

Benefit

1 Piece harness	Wireway harness, modular harness leads, industrial connectors	 AVAILABILITY	 LOWER OPER. COSTS
Stepper motor	Replaced by fuel control valve	 OPER. FLEXIBILITY	 AVAILABILITY
Narrow band O2 sensors	New wideband O2 sensor	 EMISSIONS REDUCTION	 LONGER LIFE
Lambda control	Voltage Control	AFR adjustments are more intuitive	
ESM-D panel	AFR2 HMI	HMI logs data with jump drive. Setup instructions in HMI are simple and fast.	
Old-style wastegate	Differential pressure wastegate	 EMISSIONS REDUCTION	 AVAILABILITY
PDB/ IPMD	Design improvements	 AVAILABILITY	 LOWER OPER. COSTS



ESM AFR1 to AFR2 comparison

AFR1

AFR2

Benefit

1 Piece harness	Wireway harness, modular harness leads, industrial connectors	More reliable and easier to fix
Stepper motor	Replaced by fuel control valve	Wider fuel range, more reliable
Narrow band O2 sensors	New wideband O2 sensor	Better control, better life (2x longer)
Lambda control	Voltage Control	AFR adjustments (if req'd) are more intuitive
ESM-D panel	AFR2 HMI	HMI logs with jump drive. Setup instructions in HMI are simple and fast.
Boost-Limiting Wastegate	Differential pressure wastegate	Eliminates onsite adjustments, stable AFR control
PDB/ IPMD	Design improvements	More reliable / easier to troubleshoot



Upgraded sensor package



O₂ sensor improvements

- Pre-catalyst, wideband, on engine, one per bank
- Wideband allows ability to run nearly any set point stably for steadier emissions with varying fuel quality
- 4000 hour life is 2x that of previous O2 sensor
- Single post-cat sensor (emPact only) optimized for gaseous fuel

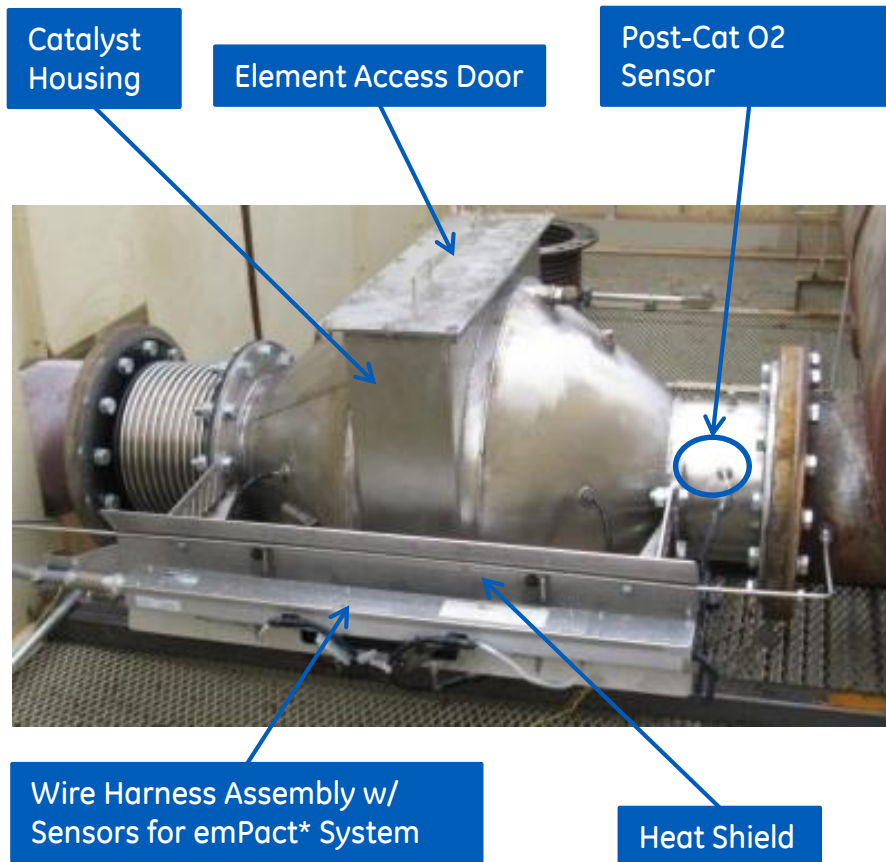
Ambient temperature, humidity and barometric pressure sensor

- Mounted in air-cleaner housing to monitor changes in ambient conditions



emPact Emissions Solution

Unmatched performance, life, and serviceability



- Sized for 0.15 g NO_x / 0.3 g CO
- Includes 2 premium catalyst elements
- Post-Cat O₂ sensor designed for natural gas, maintains optimal catalyst control with fuel and ambient swings
- Stainless steel housing provides resistance against corrosion and warping
- Separate catalyst and silencer allows for more accurate sample & faster response
- Catalyst health monitoring with pre and post temperature/pressure sensors
- Access door “overhangs” for maximum sealing, captured nuts for serviceability
- Includes inlet flex connect and emission sampling port



ESM2 Upgrade for Series Four GSI*

Waukesha's next generation controls system



What's New?

- Return to single, centralized ECU
- Integrated main bearing & exhaust temperatures + crankcase pressure
- Modular / serviceable harness package
- Integrated remote monitoring
- Optimized spark timing map for hot fuels
- HMI industrial PC interface
- New power distribution box
- Multiple user access levels



Benefits

- No laptop required
- Lower package control cost
- Better engine protection
- Reduced downtime through improved E Help + continuous data logging
- More powerful and flexible platform for future technology updates
- Smaller package design with less boxes on engine allows easier engine service

*Excludes draw thru engines and 9394GSI



GE Industrial Finance Offerings

Solutions designed to keep your business running efficiently.

Provide capital for your existing packages through:

- Loans
- Sale-leasebacks

To allow you to invest in:

- Overhauls
- Emissions/Controls upgrades
- Model Conversions
- New Units

Contact:

Bryan Nusky

IFS Waukesha Sales Leader

1-502-452-1192, ext. 6

bryan.nusky@ge.com



Equipment stays online while capital is freed up to invest in your business.



Genuine remanufactured parts

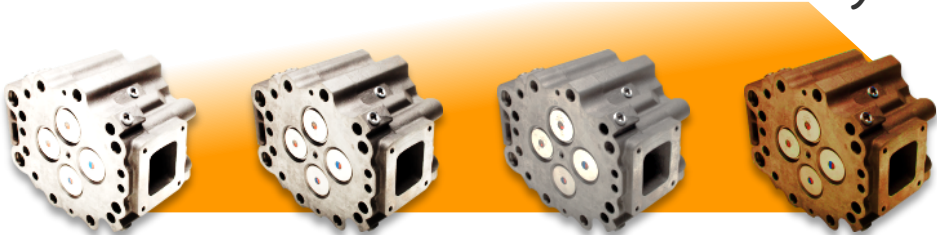
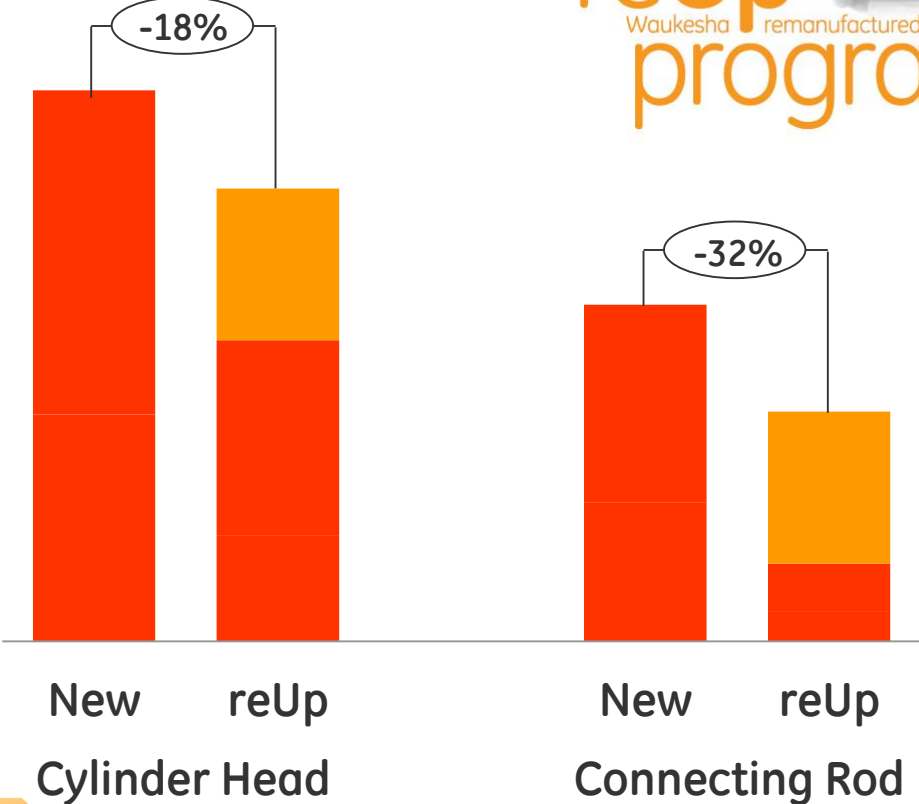
OEM remanufactured parts are...

...designed for high **reliability** and **performance**

...brought back to original and **latest specifications**

...produced by efficient salvage technologies enabling **competitive pricing**

...given the **same warranty** as new parts



■ Part Price
 ■ Core Deposit → Delayed billing





reUp remanufactured parts

Get the parts that make your engine better



Product portfolio today

	VHP			VGF		AT/275
	GSI	GL	LT	GL	GSI	GL
Cylinder heads	✓	✓	✓	✓	✓	✓
Connecting rods	✓	✓	✓	✓	✓	
Lube oil pump	✓	✓	✓			
Jacket water pump	✓	✓	✓			
Turbochargers	✓	✓				



Product portfolio tomorrow

- Crankshafts
- Camshafts
- Crankcases
- Aux Water Pumps
- Rocker Assemblies
- Wastegates
- Actuators



Core management program

Streamline recip program with consistent core returns

- 6-month consistent return policy
- Scrapping guidelines for specific countries w/ logistical challenges



Product Information sources



Contact option

WANT TO LEARN MORE? [Contact Us Now](#)

JENBACHER GAS ENGINE UPGRADES
Make sure your Jenbacher is operating at its highest level.
Output Efficiency Availability Flexibility Reliability

JENBACHER TYPE 4 B-VERSION UPGRADE
Upgrade your Jenbacher Type 4 gas engine to the latest B-version.
LEARN MORE >

JENBACHER TYPE 4 B-VERSION UPGRADE
Upgrading your 200 gas engine version technology with the latest electrical...
LEARN MORE >

WHAT CAN A TYPE 3 D-VERSION UPGRADE DO FOR YOU?

- Improve profitability. The upgrade can handle challenges such as increasing gas prices and declining electricity feed-in tariffs, and can enhance overall economic viability of your unit.
- Increase engine efficiency—percent.
- Longer intervals result in a maintenance downtime.
- Maintenance schedule allows for up to 80,000 oph and delay

applied anytime—ideally includes an engine upgrade.

modification (if applicable)

Power Generation

INDUSTRIES & APPLICATIONS PRODUCTS SERVICES SOFTWARE & ANALYTICS CUSTOMER OUTREACH RESOURCES ABOUT

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WALKESHA VHP SERIES 2-TO-4 UPGRADE

VHP S4 cylinder head upgrade packages offer the latest technology with field-tested S4 heads. Options include an upgrade to the scuff-resistant S4 piston, and a full S4 power option with an additional up to 200 bhp. Each of these product features can be combined or used separately to upgrade your already-installed VHP S2 gas engine. With these upgrades, you can expect to see increased uptime, reliability, and performance.

WHAT CAN UPGRADING DO FOR YOU?

- Larger intervals between overhauls, means more uptime: 30 to 45 percent longer intervals between top-and-overhauls up to 32,000+ hours on L7042S9 S4 vs. 22,000 hours on existing L7042S9 engines.
- Lower oil consumption. S4 pistons feature increased scuff resistance and three-ring design, which can reduce oil consumption by up to 87 percent, reducing makeup oil cost and catalyst fouling.
- Wider operating range. For options 1 and 2, full S2 power to 100% ambient temperature at 8,000 feet is up to 20% hotter, or 25 percent higher, than the current version, which achieves full power to 100% at 8,000 feet elevation.
- Intervals may vary depending on factors such as fuel quality, maintenance practices, and operating conditions. Engine configuration must be verified for upgrade opportunity.

GE Power **Waukesha gas engines CM&U Product Catalog** 10/11/2016

VHP*	VGf	275GL/ATGL	Fact Sheets/Brochures
E2895G	F18GL	12V-AT27GL	<p>You will need to be logged into the portal for the following links to work.</p> <p>Upgrade your Waukesha VHP S2 engine with S4 technology</p> <p>Advanced Crankcase Breather Upgrade for Waukesha VHP gas engines</p> <p>ESM engine system manager control upgrade for Waukesha engines</p> <p>Waukesha Series 2 VHP gas engines lean-burn upgrade</p> <p>VHP AFR2 Air-fuel ratio control for Waukesha rich-burn gas engines</p> <p>GE's Waukesha emPact Emission Control System Upgrade</p> <p>VGP Lean-Burn Cylinder Head Upgrade</p> 
E2895GL	H26GL	16V-AT27GL	
E2895GSJ			
E3521G			
E3521GL			
E3521GSJ			
E351A/3524GSJ			
L5730G			
L5730GL			
L5730GSJ			
L5730LT			
L5734GSJ			
L7042G			
L7042GL			
L7042GSJ			
L7044GSJ			
P3390GL			
P3390GSJ			

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WK- CM&U Product catalog

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NEW! [GE Power](http://www.ge.com) website incl. product info on key CM&Us



VHP* VGF 275GL/ATGL

- [F2895G](#) [F18GL](#) [12V-AT27GL](#)
- [F2895GL](#) [H24GL](#) [16V-AT27GL](#)
- [F2895GSI](#)
- [F3521G](#)
- [F3521GL](#)
- [F3521GSI](#)
- [F3514/3524GSI](#)
- [L5790G](#)
- [L5790GL](#)
- [L5790GSI](#)
- [L5794LT](#)
- [L5794GSI](#)
- [L7042G](#)
- [L7042GL](#)
- [L7042GSI](#)
- [L7044GSI](#)
- [P9390GL](#)
- [P9390GSI](#)

Fact Sheets/Brochures

You will need to be logged into the portal for the following links to work.

- [**Upgrade your Waukesha VHP S2 engine with S4 technology**](#)
- [**Advanced Crankcase Breather Upgrade for Waukesha VHP gas engines**](#)
- [**ESM engine system manager control upgrade for Waukesha engines**](#)
- [**Waukesha Series 2 VHP gas engines lean-burn upgrade**](#)
- [**VHP AFR2 Air-fuel ratio control for Waukesha rich-burn gas engines**](#)
- [**GE's Waukesha emPact Emission Control System Upgrade**](#)
- [**VGF Lean-Burn Cylinder Head Upgrade**](#)



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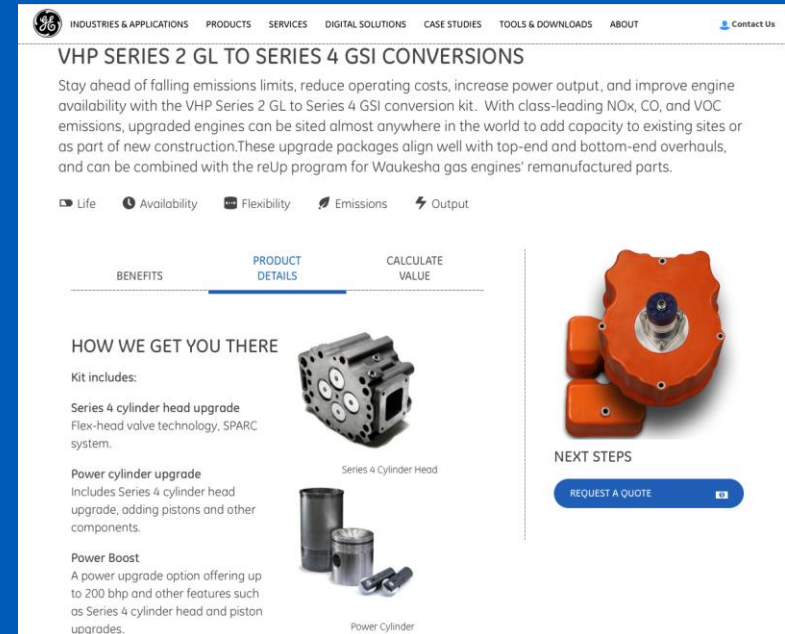
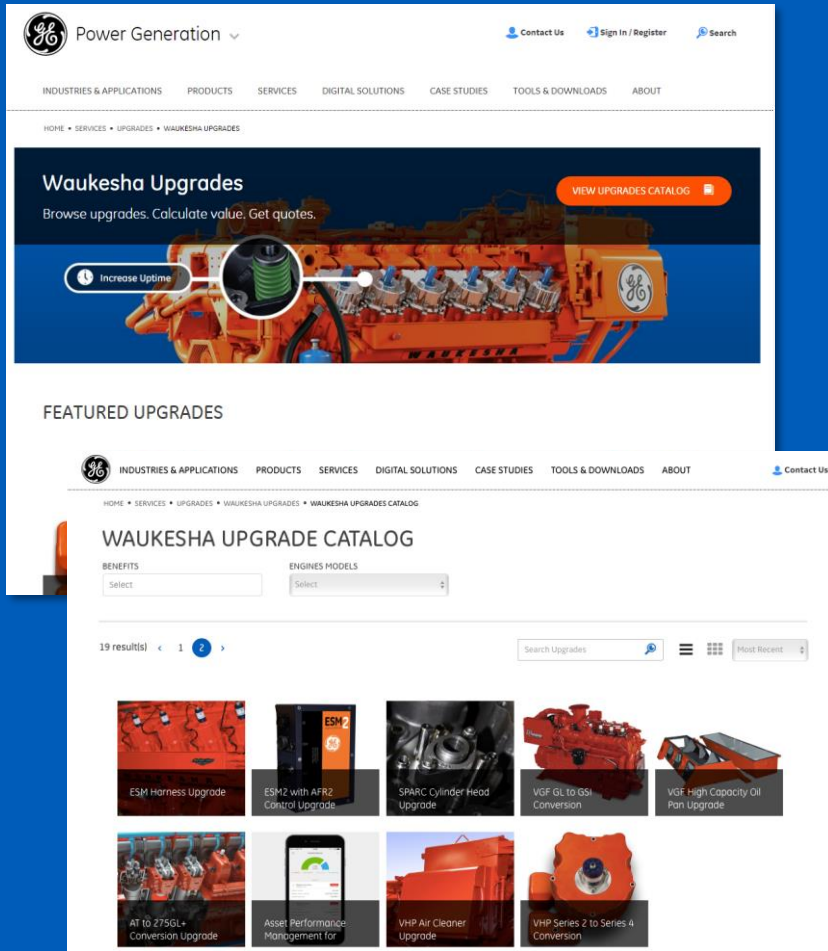
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Model ship dates and product scope are approximate. The actual CM&U scope and quotation will depend on engine serial number and current configuration of the engine being converted. Contact GE Waukesha sales manager for more information.

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Waukesha Service Upgrades Website



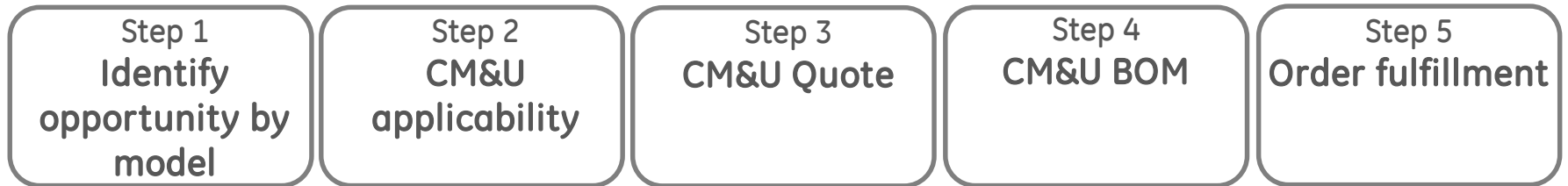
Offers quick access to:

- Information on relevant engine upgrades
- Interactive value calculators (where applic.)
- Ability to request formal quotes (through CP)

www.gepower.com/waukeshaupgrades



Waukesha CM&U opportunity progression



- 1 Obtain serial numbers to determine original BOM
- 2 Map CM&U offerings applicable to CM&U opportunities
- 3 Finalize pricing and lead time based on CM&U scope
- 4 Order entry with in iStore or direct to Oracle
- 5 Complexity of the scope will impact delivery timeline



