

# Waukesha product update

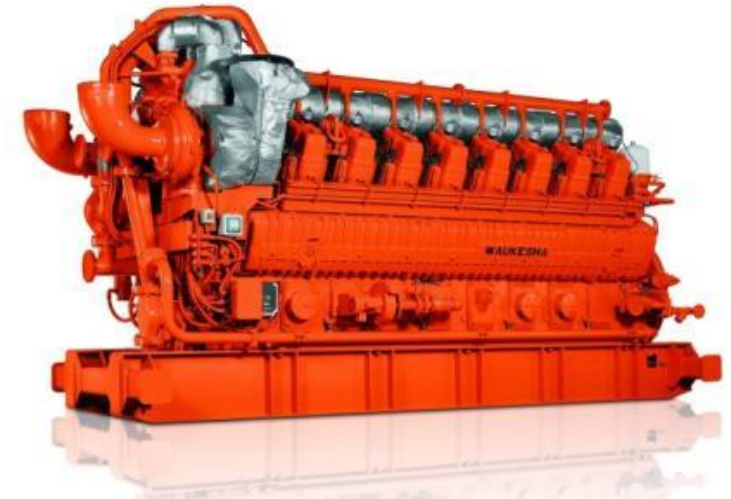
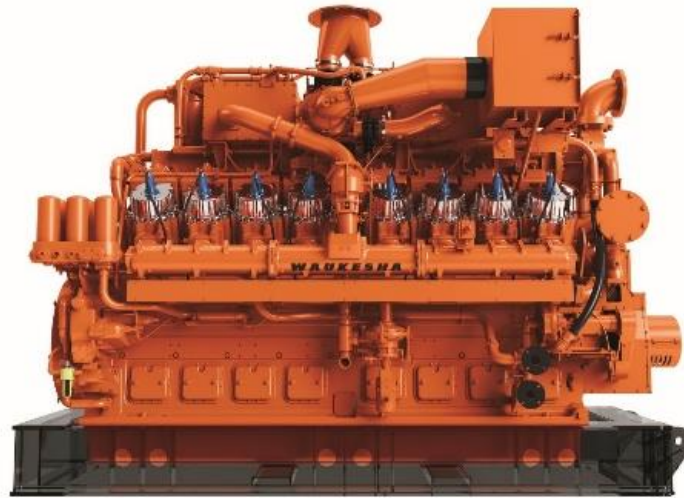
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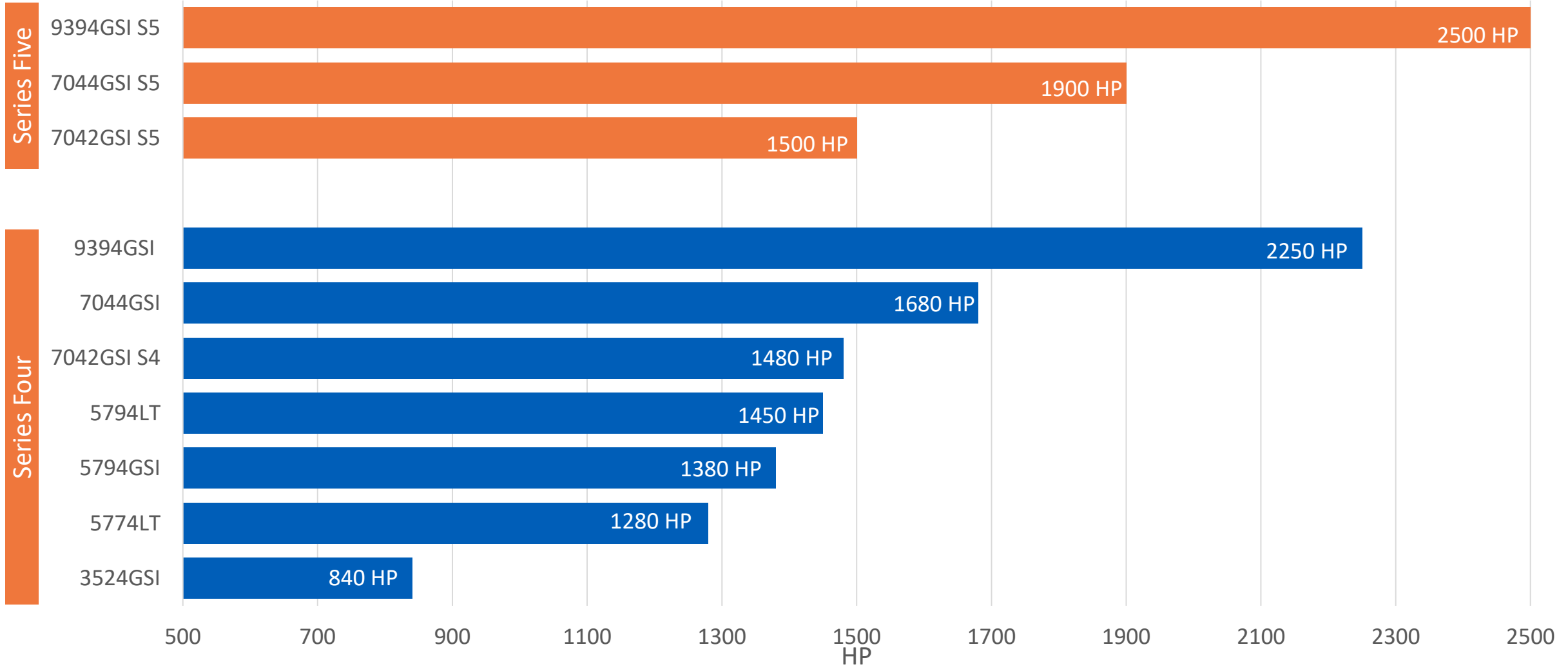
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# Agenda

1. VHP Series Five overview
2. 275GL+ overview

# VHP Lineup



# VHP Series Five... Working smarter, not harder

7042 S5:1500 HP @ 1200 rpm, 7044 S5:1900 hp @ 1200 RPM, 9394 S5: 2500 HP @ 1200 rpm

## Piston/Ring/Liner

- Reduced piston temperatures
- 4000 hour oil change (2X vs. S4)
- Improved low load oil consumption
- Improved fuel flexibility

## Cylinder head

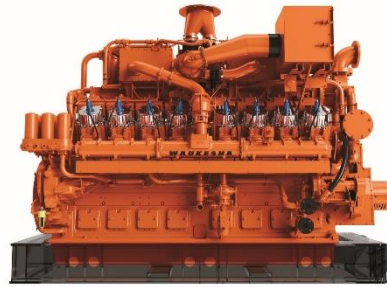
- New design with improved cooling
- Extended life and improved reliability; 24k hr @ 2500 HP, 24k hr @ 1900 hp; 30k hr @ 1680 hp; 36k hr @ 1500 hp

## Improved controls

- Next gen. ESM2/AFR2 controls
- New ignition module & spark plugs
- 4000H spark plug interval with non-precious metal plugs (2X vs. S4)

## Turbocharger

- Enhanced rich burn with lower in cylinder temp. via Miller cycle



## Dimensions... Same as Series Four

- Same centerline, mounting, connect points... drop-in replace

## Performance benefits

- Power... 8 to 13% higher vs. Series 4
- Improved ambient... Full power to
  - 7042: 120F/4000, 100F/4800 ft.
  - 9394/7044: 120F/4200, 100F/5000 ft.
- Improved fuel consumption...
  - 7042 @ 7209 BTU/hp-hr (-9%)
  - 7044 @ 7063 BTU/hp-hr (-11%)
  - 9394 @ 7150 BTU/hp-hr (-3%)
- Improved fuel flex... Full power to
  - 35 WKI (2300 BTU) on 7042
  - 55 WKI (1200 BTU) on 7044
  - 58 WKI (1250 BTU) on 9394
- 0.15 g/hp-hr NOx emissions

Series Five enabled by improved thermal management (lower temp.) and smarter controls

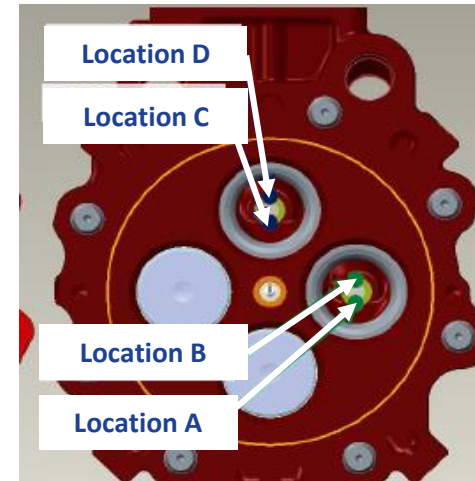
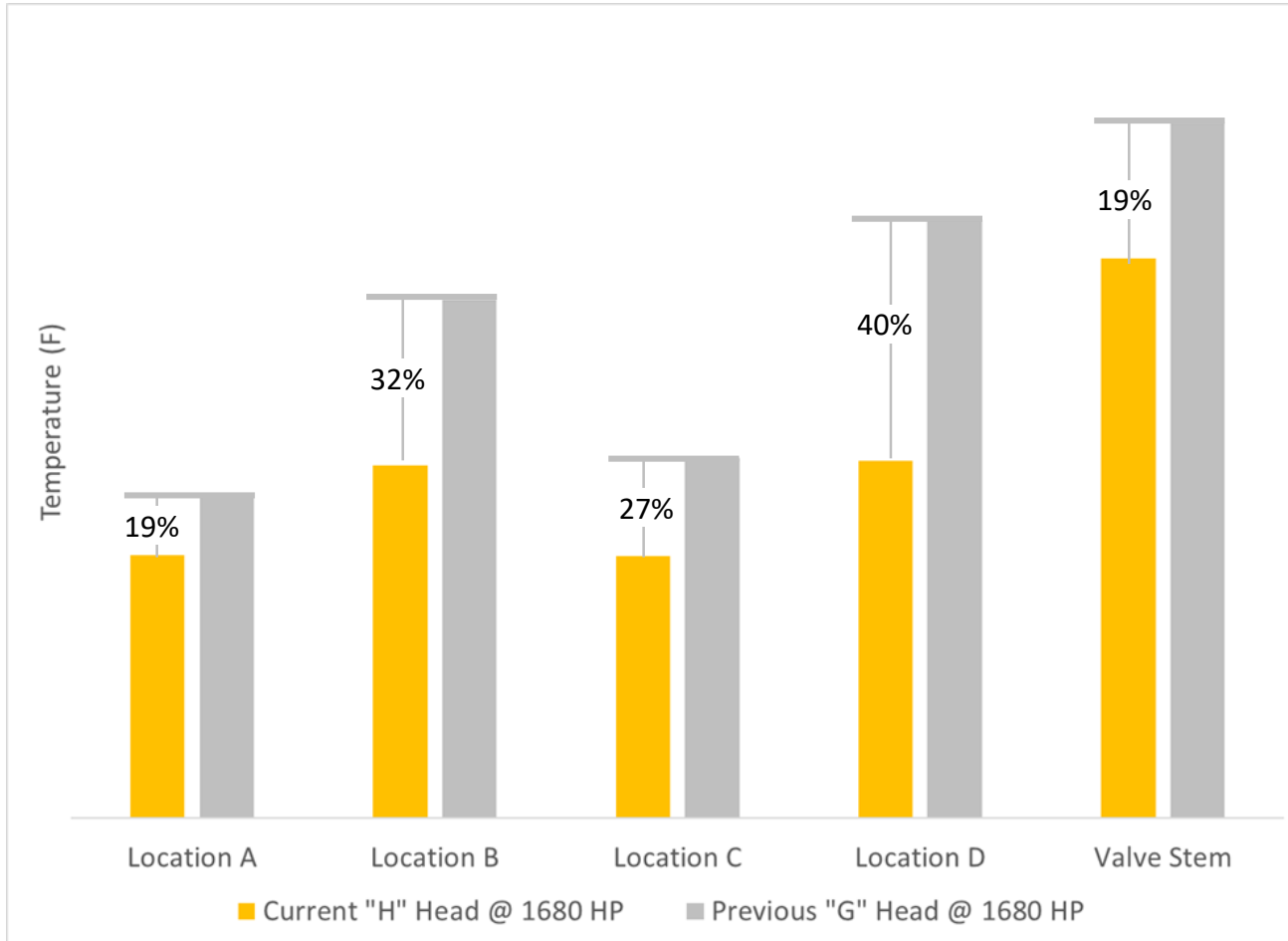
# Series 5 vs. Series 4 CTQ comparison

Parameter	5794GSI S4	7042GSI S5	7044GSI S4	7044GSI S5	9394SI S4	9394GSI S5
Combustion	RB	RB	RB	RB	RB	RB
Configuration	Vee 12	Vee 12	Vee 16	Vee 16	Vee 16	Vee 16
Height x Width x Length (in)	98 x 85 x 147	98 x 85 x 147	98 x 85 x 147	98 x 85 x 147	101 x 78 x 168	101 x 78 x 168
Weight (lbs)	24,250	24,250	24,250	24,250	34,000	34,000
Power (hp)	1380	1500	1680	1900	2250	2500
Speed Range (RPM)	1200-750	1200-900	1200-750	1200-900	1200-750	1200-900
BMEP (psi)	158	141	158	178	158	176
Fuel Cons. (Btu/bhp-hr) -0/+5%	7919	7209	7919	7063	7333	7150
Fuel flex. (WKI # to derate)	52	No Fuel Derate	58	55	70	58
Fuel flex w/o derate (Btu/ft3 LHV)	1350 (est)	2300 (est)	1250 (est)	1300 (est)	1100 (est)	1250 (est)
Fuel Range w/o Adj	+/- 150 Btu	+/- 150 Btu	+/- 150 Btu	+/- 150 Btu	+/- 150 Btu	+/- 150 Btu
NOx emis. (g/hp-hr)	0.15	0.15	0.15	0.15	0.15	0.15
Ambient T before Derate, CQNG (F)	100	130F @ 2500 ft	100	130F @ 3000 ft	100	120F @ 4000 ft
Max alt. before derate @ 100F (ft)	8000	4300 ft @ 100F	8000	4800 @ 100F	6000	5000 @ 100F
Maintenance TBO (K' hr)	24/48	36/60	24/48	24/48	24/48	24/48
Oil Change (hr)	2000	4000	2000	4000	2000	4000
Spark Plug (hr)	2000	4000	2000	4000	2000	4000

# Enhanced cylinder head

Enhanced Cylinder Head (H Series or X-cooled head)

Lower Temps → Longer Life, Higher Reliability, and More Power (~6000 heads sold with >5M OPH)



- Up to 40% cooler guide temps w/less variation increases reliability and head life to 30k hours
- Direct replacement for "G" head
- "H" std. on Series Five

## Applies To:

- F3514/24GSI
- L5794GSI
- L7042GSI S4
- L7044GSI
- P9394GSI
- L7042GSI S5
- L7044GSI S5

## Availability Date:

- In production; ~6000 heads sold to date

# Upgraded engine controls – ESM2

- 1993 – CEC Controls
- 2001 – ESM1 controls
- ...
- ...
- 2017 – ESM2 controls

16 years

## ESM1 disadvantages

- Multiple manual AFR adjustments
- Separate laptop hookup for diagnostics
- Emission drift under varying conditions
- Little ability to customize controls
- Limited fault diagnostics
- Poor operator service support help

## ESM2 benefits

- Touch-screen HMI, eliminating need for a separate laptop
- Continuous data log (10Y) with trending, reports, storage
- Advanced fault diagnostics (incl. misfire detection)
- Pre/post catalyst O2 based sensing for tighter emissions control
- Integrated E-help with latest service manuals
- Multiple user access levels with custom configurations
- Improved timing map – Speed/load/fuel type based
- Plant levels views when multiple engines on site
- New protections/readings
  - Crankcase & oil filter differential pressure
  - Exhaust port and main bearing temperatures
  - Boost pressure sensors... Throttle reserve monitored

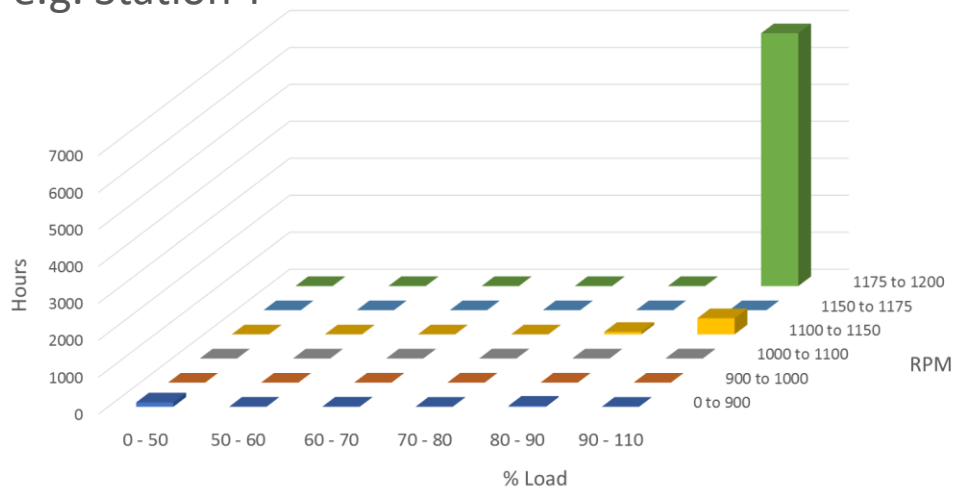


# Series 5 runtime summary... operating @ 100% load

Lead engines... Run period from July 2017 to Jan 2019

Engine Model	Site Unit Number	Monitoring start date	Commissioning date	Operating Hours	Engine-only Data
					Reliability [%]
7044GSI S5	Station W	July 29, 2017	July 30, 2017	11,575	99.89
7044GSI S5	Station T	October 11, 2017	October 11, 2017	10,846	99.81
7044GSI S5	Station M	December 6, 2017	Nov 30, 2017	9,158	99.15

e.g. Station T



- Run max speed/load 90% of time
- Hours begin accumulating once ESM2 is powered up, so includes production test, commissioning, and time when engine not running

Reliability demonstrated at full load/speed



# 275GL+ with ESM2

## What has changed?

1. Compression ratio... Lowered from 9:1 → 8:1
2. Engine controls... upgraded to ESM2 ( same as VHP Series 5)
3. Turbocharger... Larger for improved emissions/altitude

## What are the benefits?

1. Fuel flexibility... no derate until 45 WKI/1550 BTU
2. Altitude... 6000 ft. before derate
3. Emissions... 0.3 g/hp-hr NOx; Permitting ease, Title V, GP-5
4. Reliability & ease of use... via smarter ESM2 controls

Parameter*	12V275GL+			16V275GL+		
	Current	New		Current	New	
Power (HP)	3750	3750		5000	5000	
Compression ratio	9:1	8:1		9:1	8:1	
Fuel quality (BTU/ft3)	1125	1550		1160	1550	
Altitude (start of derate, feet)	3000	4000	6000	4500	4000	6000
Fuel flexibility (BTU/ft3)	550 – 2300		550 – 2350		550 – 2350	
Emissions (g/hp-hr)	NOx: 0.5	NOx: 0.3	NOx: 0.5	NOx:0.5	NOx: 0.3	NOx: 0.5
	CO: 1.7	CO: 2.15	CO: 1.45	CO: 1.6	CO: 2.15	CO: 1.45
	HC: 6	HC: 5.7	HC: 4.2	HC: 5.6	HC: 5.7	HC: 4.2

\*All data at 130°F intercooler temp.; Altitude and fuel flexibility improve further at 110°F intercooler temp.; contact factory for details; Waukesha does not recommend ratings that require intercooler water below 110°F due to risk of excessive condensing of intake air moisture.

**Availability - ATQi: 12V275/16V275 – 1H 2019**

# Summary

## VHP Series Five

1. **Full family of engines...** 7042GSI S5 @ 1500 HP, 7044GSI S5 @ 1900 HP, 9394GSI S5 @ 2500 HP
2. **Improved rich burn technology...** Focus on thermal management and smarter engine controls
3. **Major benefits...** ↑ HP, efficiency, fuel flex./ambient capability, ↓ opex. (oil, plugs)
4. **Attractive pairing...** via Ariel's new KBK compressor frame (for both 7044 and 9394 S5)
5. **Wider asset deployment...** enabled by rich burn... ↓ emissions & ↑ fuel/ambient tolerance

## 275GL+

1. **Upgraded performance...** Enabled by lower compression ratio, large turbocharger, latest ESM2 controls
2. **Key benefits include...** Improved fuel flexibility, altitude, lower NOx emissions and ease of use