Waukesha 7042GSI S5 Overview

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VERSION 01

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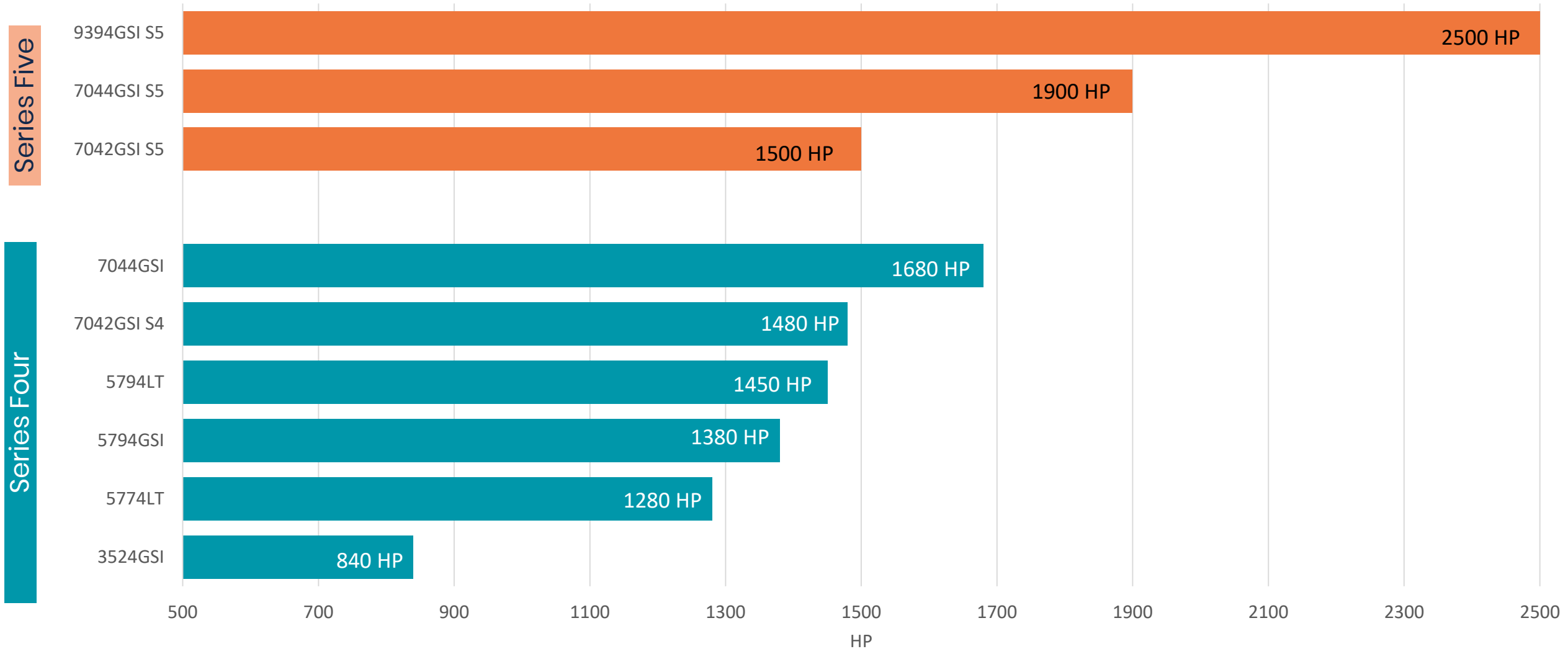
VHP Series Five Family Overview

VHP Series Five—What is it?

Series Five makes more power by working smarter, not harder, than Series Four

- Enhanced versions of 12-cylinder 7042/7044GSI and 16-cylinder 9394GSI engine
- 7042GSI S5 = 1500 hp @ 1200 rpm; 7044GSI S5 = 1900 hp @ 1200 rpm; 9394GSI S5 = 2500 hp @ 1200 rpm
- 7042 and 7044 use same BOM; power calibration different
- Engine works smarter, not harder, to make more power
- Higher HP & reduced temps
  - Enhanced rich-burn combustion for reduced exhaust temps
  - Cylinder head updated to reduce temps in valve guide/stem region
  - Optimized piston/ring design reduces piston temps
- More fuel flexibility & increased efficiency
- Up to 22% lower OpEx w/ 4k oil & spark plug intervals at higher power

VHP Lineup



Why invest in VHP Series Five?

1. Full family… 7042GSI @ 1500 HP, 7044GSI @ 1900 HP, 9394GSI @ 2500 HP (common parts, service, training)
2. Improved rich burn technology… Focus on thermal management and smarter engine controls
3. Major benefits… ↑ HP, efficiency, fuel flex./ambient capability, ↓ operating expenses (oil, plugs)
4. Wide fuel flexibility… No fuel treatment; use high BTU gas (up to propane w/o derate depending on model)
5. Deploy/Move assets anywhere… enabled by rich burn… ↓ emissions & ↑ fuel/ambient tolerance
6. More HP/site with faster permitting… enabled by ultra low rich burn engine emissions + GP/permit by rule
7. Strong market interest… ~375 units sold since launch in Q1 18' (including US rental fleets)
8. Equal or more flow @ lower $/mcf… via Ariel's new KBE, KBK compressor frame (for 7042, 7044 & 9394 S5)
9. Lower capex… Up to 40% lower engine and 15% lower package capex. vs. competition
10. Lower opex… Up to 22% lower OpEx w/ 4k oil & spark plug intervals at higher power
11. Product support package… training, ext. warranty, emergency spares etc. from Waukesha to ease adoption

Improve overall fleet asset economics vs. equivalent competitor packages

L7042GSI S5

The 7042GSI S5—The Ultimate in Flexibility

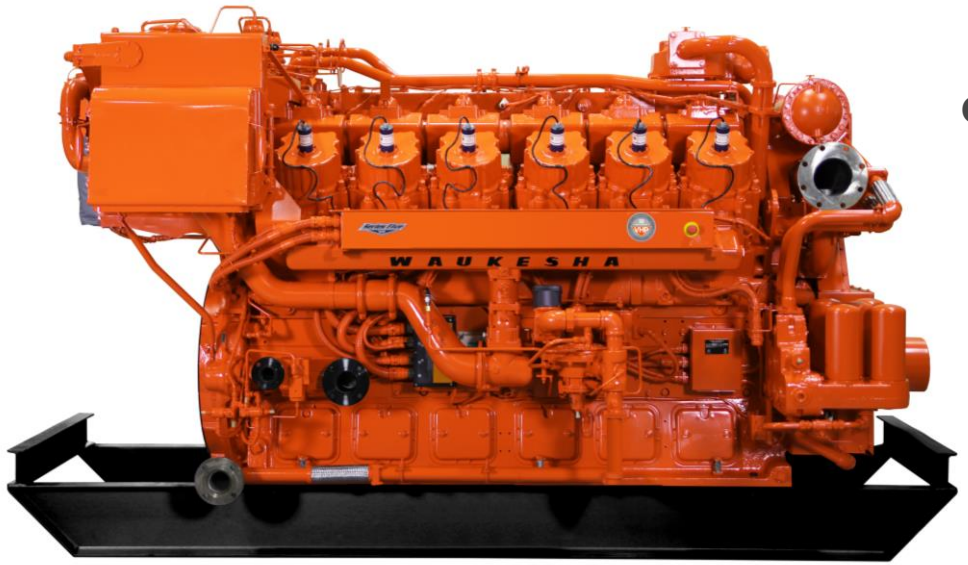
1500 hp @ 1200 rpm

Piston/Rings

- Reduced piston temps
- 4k hour oil change interval
- Improved low-load oil consumption
- Improved fuel flexibility

Controls

- Next generation ESM2/AFR2 controls
- New ignition module & spark plugs
- 4k hour spark plug interval with non-precious metal plugs



Unchanged from Series Four

- Centerline, mounting/connection points; allows for drop-in replacement

Cylinder Heads

- Enhanced design/improved cooling
- Extended life and improved reliability; 36k hr @ 1500 hp

Performance Benefits

- Modified rating approach—1500 hp w/no overload
- Full power to 120F @ 3500ft; 100F @ 4300 ft
- +10% fuel consumption reduction = 7209 BTU/BHP-HR
- No fuel derate—full power to 2300 Btu/ft3
- 0.15 g/hp-hr NOx

Using displacement to make power provides more flexibility, wider operating range, and higher reliability

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Other Engines vs 7042GSI S5

Parameter	5794GSI	OTHER ENGINES	7042GSI S5
Combustion	RB	RB/LB	RB
Configuration	Vee 12	Vee 16	Vee 12
B x S (in)	8.5 x 8.5	6.7 x 7.5	9.375 x 8.5
Disp (L)	95	69	115
Height x Width x Length (in)	98 x 85 x 147	90 x 78 x 144	98 x 85 x 147
Weight (lbs)	24,250	20,350	24,250
Power (hp)	1380	1380	1500
Speed Range (RPM)	1200-750	1400-1000	1200-900
BMEP (psi)	158	180	141
Fuel Consumption (Btu/bhp-hr) -0/+5%	7919	7329 (LB) 7309 (RB)	7209
Fuel flex. (WKI # to derate)	52	45 Cat MN ≈ 58 WKI (LB) 57 Cat MN ≈ 67 WKI (RB)	No Fuel Derate
Fuel flex without derate (Btu/ft3 LHV)	1350 (est)	1250 (est)	2300 (est)
Fuel Range w/o Adj	+/- 150 Btu	??	+/- 150 Btu
NOx emis. (g/hp-hr)	0.15	0.3 (LB) 0.15 (RB)	0.15
Ambient Temp before Derate, CQNG (F)	100	100	120F @ 2500 ft
Max altitude before derate @ 100F (ft)	8000	6800 (LB)	4300 ft @ 100F
Maintenance TBO (K' hr)	24/48	25/50	36/60
Oil Change (hr)	2000	2000	4000
Spark Plug (hr)	2000	3000	4000

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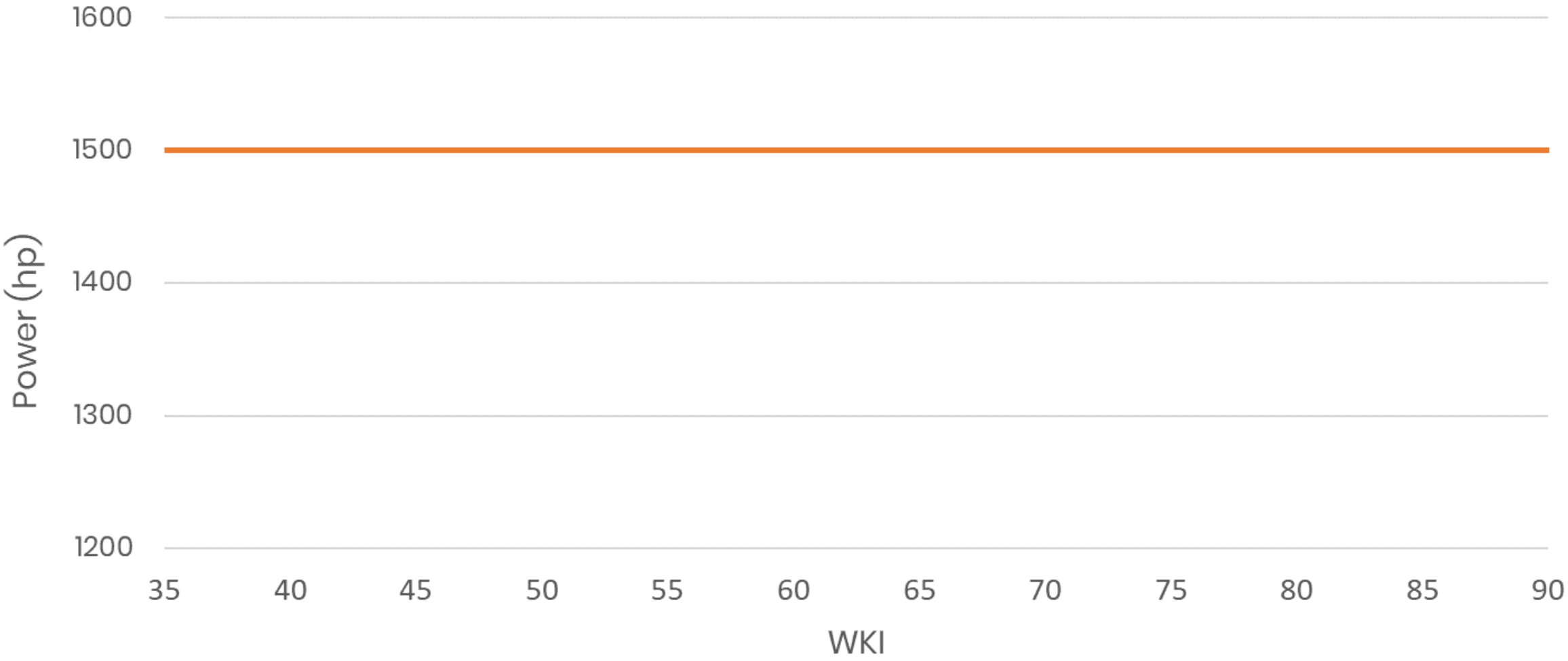
7042GSI S5 Fuel Derate Curve—Full Power to 2350 Btu



Btu/ft³ LHV	2350	1800	1500	1250	1100	1000	900

The 7042GSI S5—Ultimate Flexibility

1500 hp @ 1200 RPM

L7042GSI S5		OTHER ENGINES
1500	HP	1380
115	Displacement (L)	69
1200	Engine Speed (rpm)	1400
141	BMEP (psi) Brake Mean Effective Pressure	180

Same components/dimensions as 1900 hp 7044GSI S5

- Power limited by ESM2 calibration
- Pricing adjusted on $/hp basis

L7042GSI S5 creates power w/ displacement instead of speed and BMEP—engine doesn't work as hard

- More power (1500 hp vs 1380 hp) than competitor
- Lower BMEP (141 vs 180 psi) increases operating window and reliability:
  - No fuel derate – full 1500 hp to 2300 BTU/ft^3 LHV (35 WKI)
  - Full power at 130F ambient w/ 140F ICWT to 2500' or 100F ambient and 4300'
  - Lowest emissions w/ 3-way catalyst

No derate—full 1500 hp—on almost any site

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7042GSI S5 with KBE/T Compressor Match

- KBE/T released 4Q19—pairs with 1500 hp 7042GSI S5
- 5” stroke falls between JGT (4.5”) and JGK (5.5”) w/ 74k lb rod load
- Long-term replacement for JGT; KBK replaces JGK
- Cylinders optimized for rental applications (6, 6 3/8, 9¼, 11, 13½, 15¾)
- Price on par with JGT with ET cylinders; 120 add’l hp

7042GSI S5 compressor match (KBE) no longer at price disadvantage vs JGT w/ET cylinders

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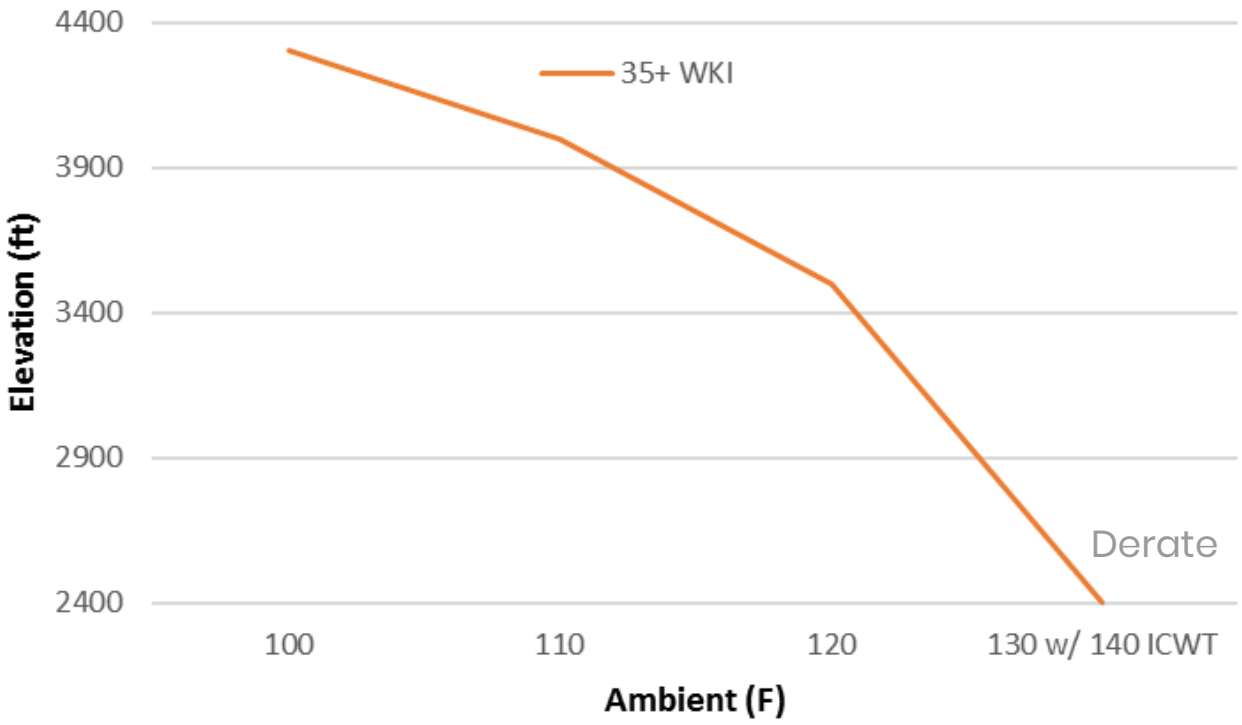
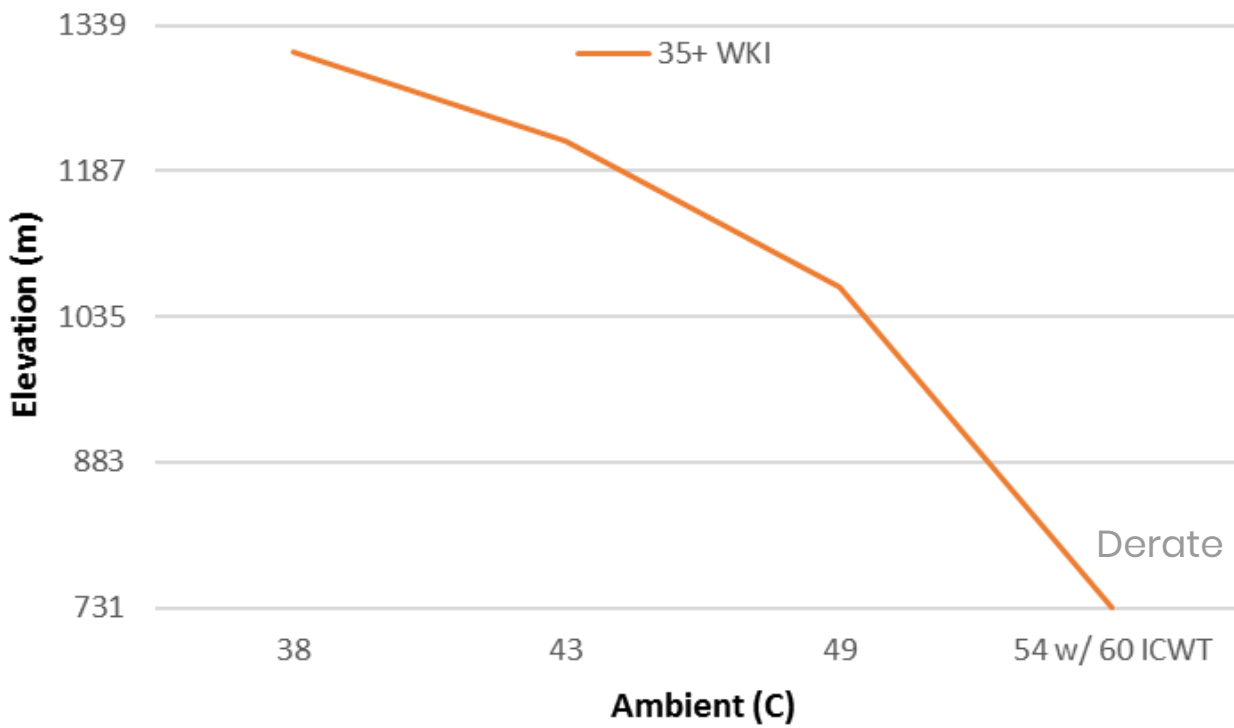
7042GSI S5 Full Power Capabilities (Ambient/Altitude/Fuel)

English Units



Metric Units



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Reliability/Experience

S5 Reliability/Runtime Summary

Engine Model	Unit Serial Number	Owner	Site Unit Number	Monitoring start date	Commissioning date	Operating Hours (measurement time)	Reliability [%]	MTBFO [h]
7044GSI S5	528705351	Crestwood	West Union	July 29, 2017	July 30, 2017	20,163 hours (2/25/2020 07:18)	99.93	2482.9
7044GSI S5	5283705472	Antero	Tamela	October 11, 2017	October 11, 2017	17,129 hours (2/25/2020 07:22)	99.76	1418.1
7044GSI S5	528705350	Antero	Mountain	December 6, 2017	Nov 30, 2017	18,748 hours (2/25/2020 07:22)	99.70	3074.6
P9394GSI S5	3706053	Antero	Ferrell Compressor Station - Unit 5	October 26, 2019	October 3, 2019	3,158 hours (2/25/2020 07:22)	99.8	160.0
P9394GSI S5	3706052	Antero	Ferrell Compressor Station - Unit 6	October 26, 2019	October 2, 2019	2,583 hours (2/25/2020 7:20)	99.8	851.7
P9394GSI S5	3706051	Antero	Ferrell Compressor Station - Unit 4	October 26, 2019	October 2, 2019	3,036 hours (2/25/2020 7:22)	99.96	2612.3

- Units operating on 58-62 WKI (1200-1250 Btu/ft3 LHV) fuel
- >375 Series Five units sold
- References:
  - Derek Hughes, Antero Midstream -Maintenance Manager 740-472-4246; dhughes@anteroresources.com
  - Mike Roy, Crestwood Midstream - Marcellus Midstream Manager 304-641-3929; mike.roy@crestwoodlp.com

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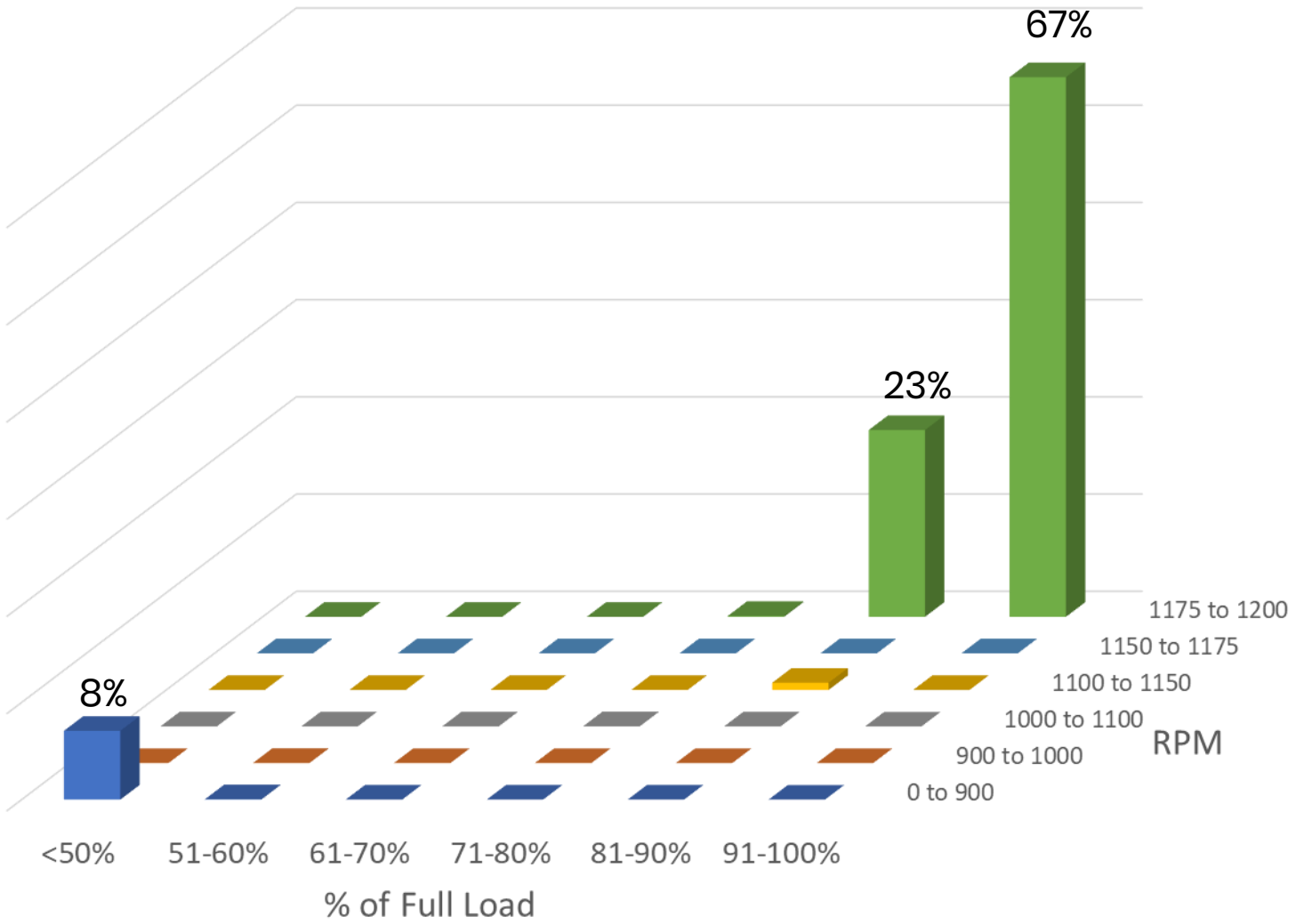
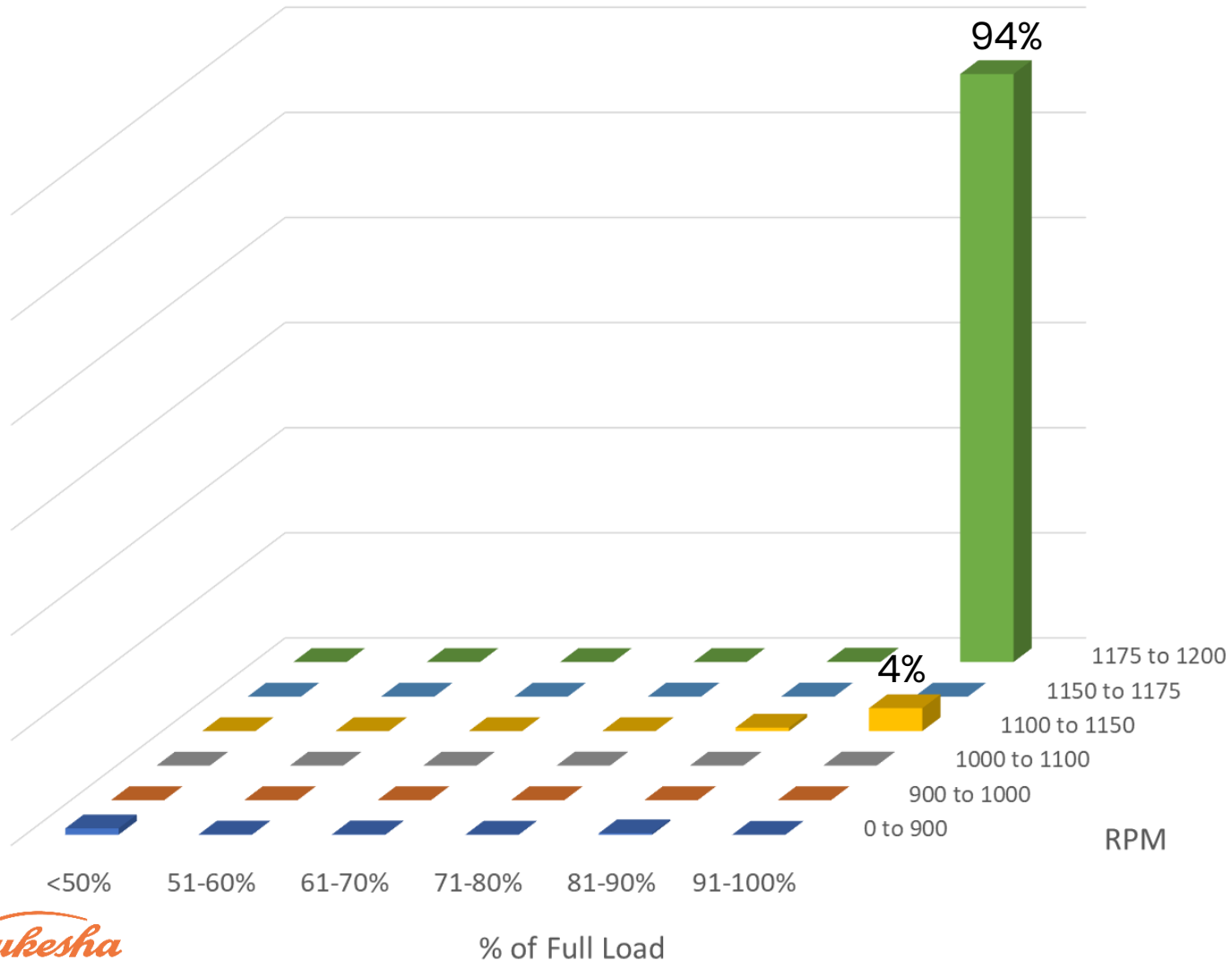
Crestwood West Union Station—20,183 Operating Hours



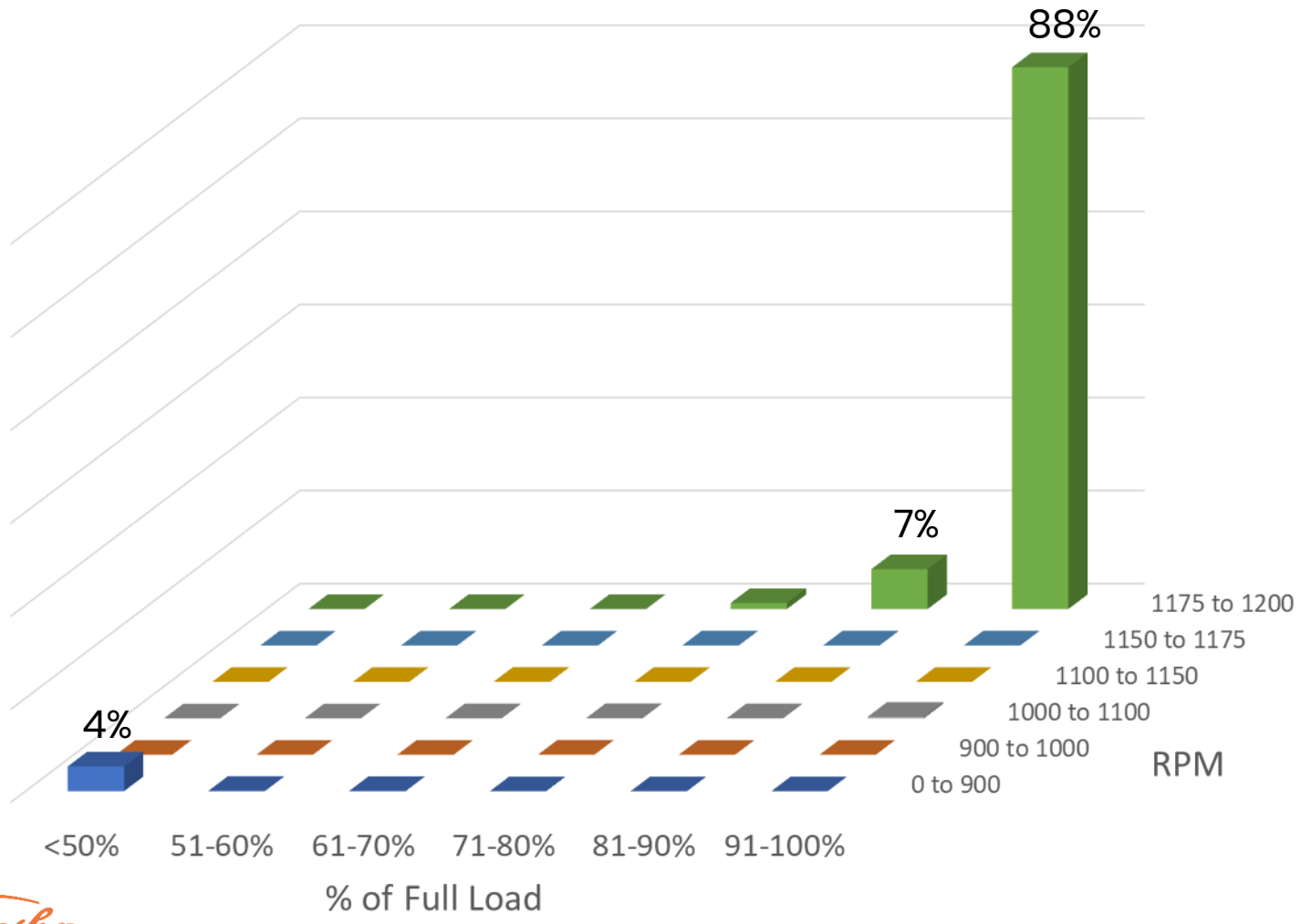
- >99.9% reliability
- Run max speed/load 67% of time; another 23% at max speed & 80-90% load
- Includes 8% engine shutdown for station maintenance
- Always run at 1200 rpm

Antero Tamela Station—17,129 Operating Hours



- 99.7% reliability
- Run max speed/load 94% of time
- Hours begin accumulating once ESM2 is powered up, so includes production test, commissioning, and time when engine not running

Antero Mountain Station—18,748 Operating Hours



- 99.7% reliability
- Run max speed/load 88% of time; another 7% at max speed & 80-90% load
- Always run at 1200 rpm
- Shutdown while building constructed around engine

7042GSI S5 Configuration Commonality

	9394GSI S5	7044GSI S5	7042GSI S5
Power @ Speed	2500 hp @ 1200 rpm	1900 hp @ 1200 rpm	1500 hp @ 1200 rpm
Combustion	Rich-Burn Miller Cycle		
Piston	Series Five—reduced piston temps and blow-by; improved fuel flex		
Cylinder Head	“H” Type for S4 & S5 – Reduced Temps		
Oil Cooler	On-Engine Mounted—Closed System		
Oil Filters	On-Engine Mounted—Closed System		
Ignition Power Module	IPMD2—Drives 4k hours spark plug life		
Control System	ESM2		
Instrument Panel	12/15/19" full color industrial PC-type HMI display panel; data logging & trending; eliminates need for laptop		
Emissions (g/bhp-hr)	0.15 NOx / 0.30 CO / 0.1* VOCs / 0.001 Formaldehyde w/emPact		

*Assumes fuel composition of 15% propane+

Common engine design and performance across Series Five family

7042GSI S5 Service Part Commonality

	7042 / 7044GSI S4	9394GSI S4	**7042** / 7044GSI S5	9394GSI S5
O2 Sensor	A740132			
Oil Filter	199395B			
Breather Filter	495671			
Gas Regulator	209167T			
Rocker Arms	E211790A			
Connecting Rod	A205707A			
Spark plug extension	A211797R			
Throttle Actuator	214046B			
Thermocouple Unit	741219			
Air/Gas Starter	214148M			
ESM ECU	740825		A741156	
IPMD	740822B		741336A	
Spark Plug	60999Z		69919H	
Piston, Ring, Liner kit	G-932-282		G-932-300	
Carburetor	59022Z		59030	
Cylinder Head	AF205002G	CF205002G	DA205002H	
Centrifugal oil filter	214656	214105	325186A	

7042GSI S5 uses same key service components as other VHPs, simplifying service parts stocking;
Cat requires two sets of stocked parts across 1500-2500 hp range

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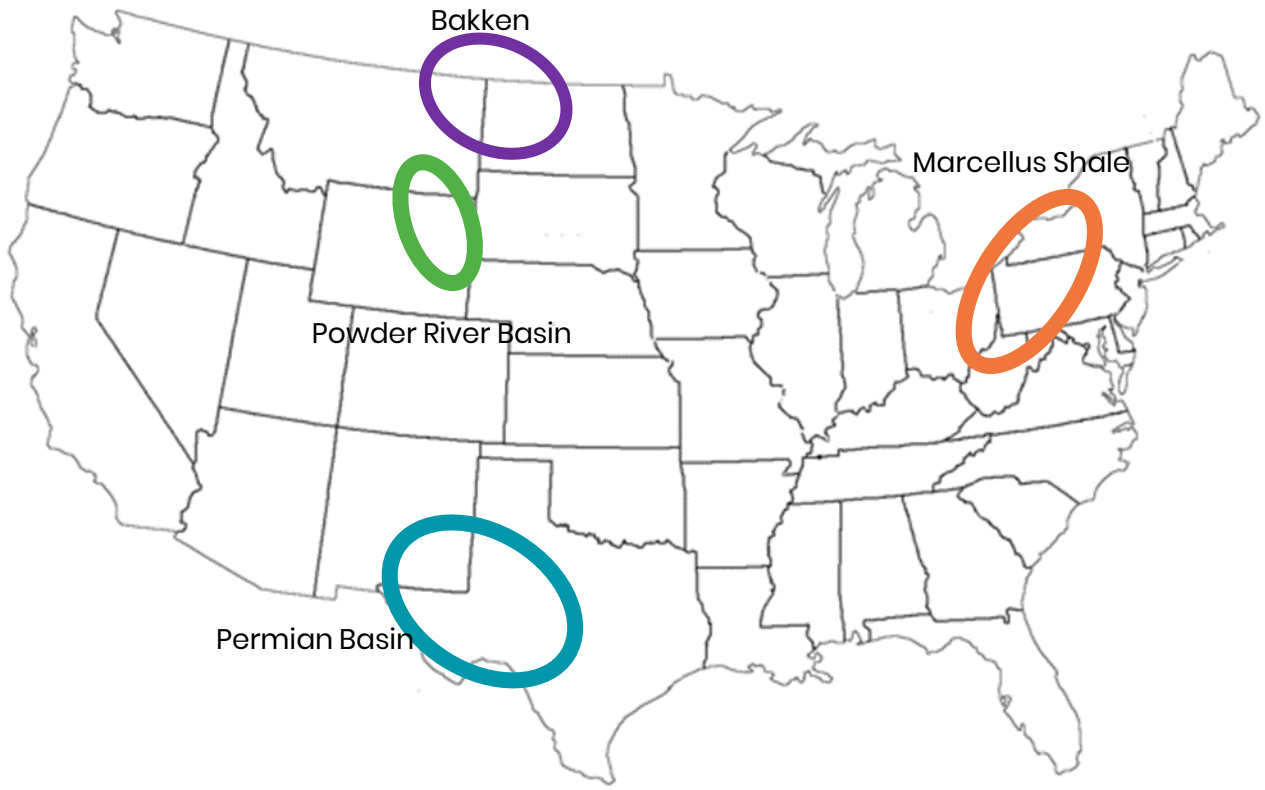
Performance and Emission Benefits

7042GSI S5 Performance Advantage



Note: 7042GSI S5 assumed to use emPact Emission Control System and "other engines" to use oxidation catalyst with 90% CO reduction, 50% VOC reduction, and 98% formaldehyde reduction

	Marcellus	Permian	Bakken	Powder River
Fuel BTU/FT3	1121	1203	1261	1546
Fuel WKI	64	56	53	43
Elevation (ft)	105	120	100	100
Ambient (F)	2000	3500	1903	4500
7042GS S5 HP	1500	1500	1500	1500
OTHER ENGINE HP	1380	1380	1325	Not Applicable
	Emissions (g/bhp-hr)			
NOx – 7042	0.15	0.15	0.15	0.15
NOx—Alternative engine	0.50	0.50	0.50	NA
CO—7042	0.30	0.30	0.30	0.30
CO—Alternative engine	0.24	0.26	0.26	NA
VOC—7042	0.05	0.07	0.11	0.14
VOC—Alternative engine	0.36	0.57	0.72	NA
Formaldehyde—7042	0.001	0.001	0.001	0.001
Formaldehyde—	0.008	0.007	0.007	NA

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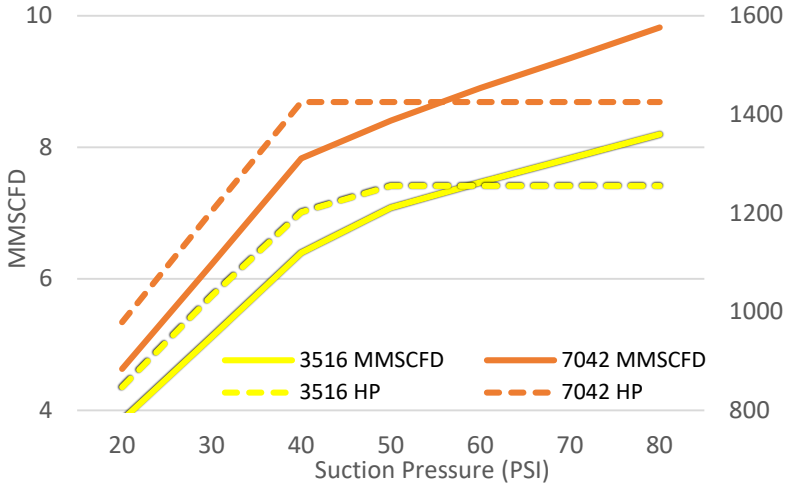
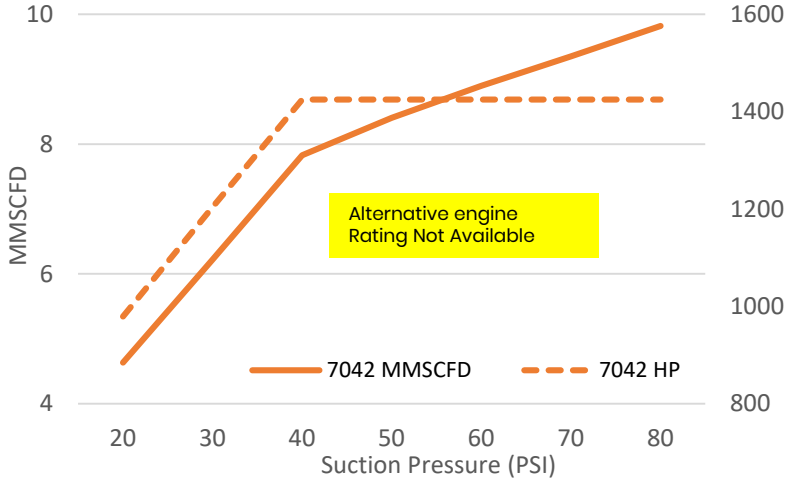
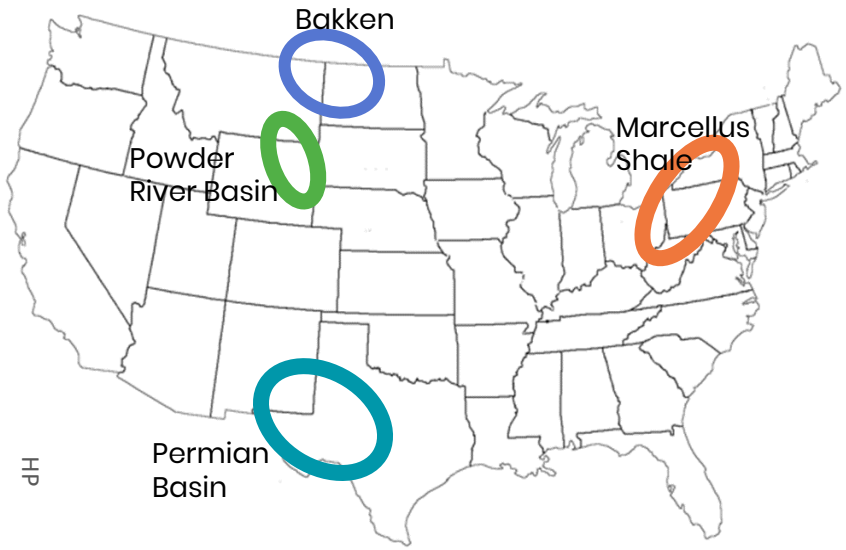
7042GSI S5 Throughput Advantage

Bakken



Power River Basin

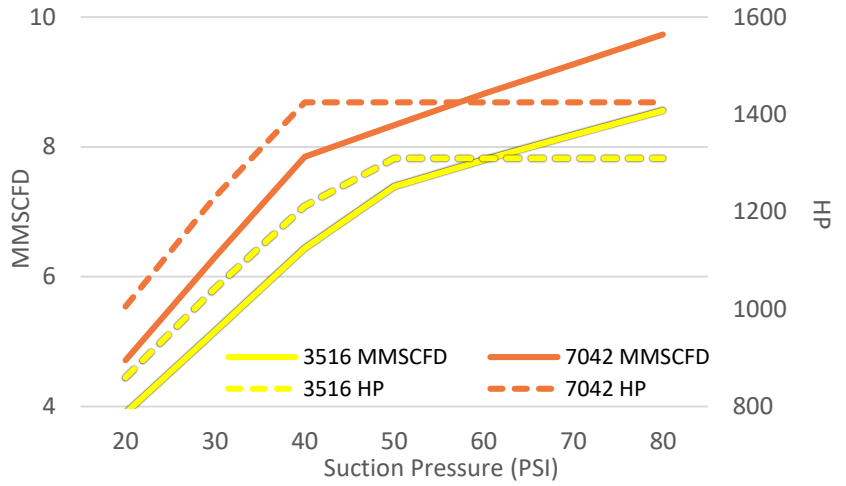




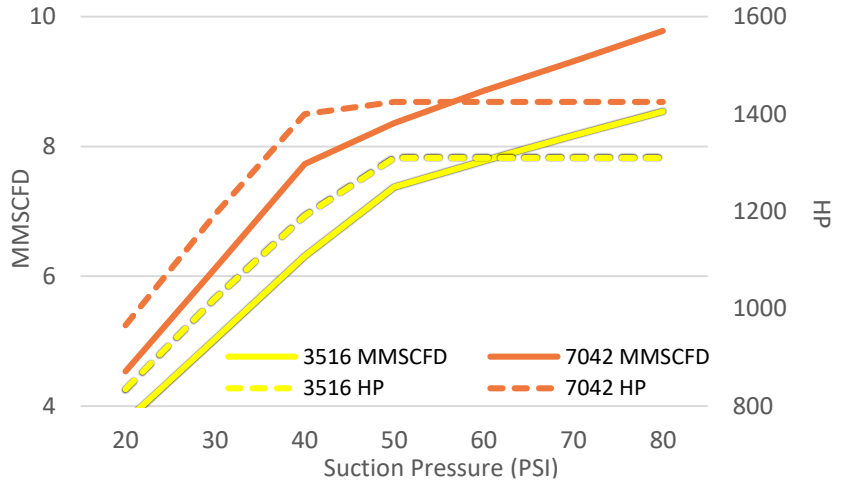
Assumptions:

- Single cylinder configuration required for entire suction pressure range
- 7042: KBT 15.875T, 15.875T, 11T, 7.25T
- Alternative engine: 13.5ET, 13.5ET, 9.25ET, 6 ET
- 1000 PSI discharge pressure
- 5% hp required for cooler fan

Marcellus



Permian Basin



Implications of 7042GSI S5 Emissions Advantage

Engine-View Only: Assumes no other balance-of-plant emissions

Marcellus

- Pennsylvania GP-05
- Both engine out & site tonnage limits
- Strict limit for VOC emissions limits alternative engines; CO limits 7042 S5
- More than 2x allowable hp with 7042
- Typically 130 day timeline to construct
- Assuming 50% of emissions from BOP, drops to 17k hp for 7042 and 7k hp for

Pollutant	GP Limit (tpy)	7042 S5 (tpy)	ALT. ENGINE (tpy)
NOx	100	2.17	6.66
CO	100	4.35 (34,500 hp)	3.20
VOC	50	0.72	4.80 (14,383 hp)
Formaldehyde	25	0.01	0.11

Bakken

Powder River

- No Permit by Rule (PBR) or General Permit (GP) in Wyoming or North Dakota

Permian Basin

- Texas Permit by Rule (PBR); NM General Permit (GP) and No Permit Required (NPR)
- Low VOC limit typically limits HP capacity
- Higher percentage of propane+ in fuel increases VOCs in exhaust
- Lean burn: Lower NOx increases VOCs
- Rich-burn: Complete combustion reduces VOCs
- Typically 30 day timeline to construct

TX PBR

Pollutant	PBR Limit (tpy)	7042 S5 (tpy)	ALT. ENG. (tpy)
NOx	250	2.17	6.66
CO	250	4.35	3.40
VOC	25	1.01 (36,986 hp)	7.60 (4,542 hp)
Formaldehyde	10	0.01	0.10

NM GP

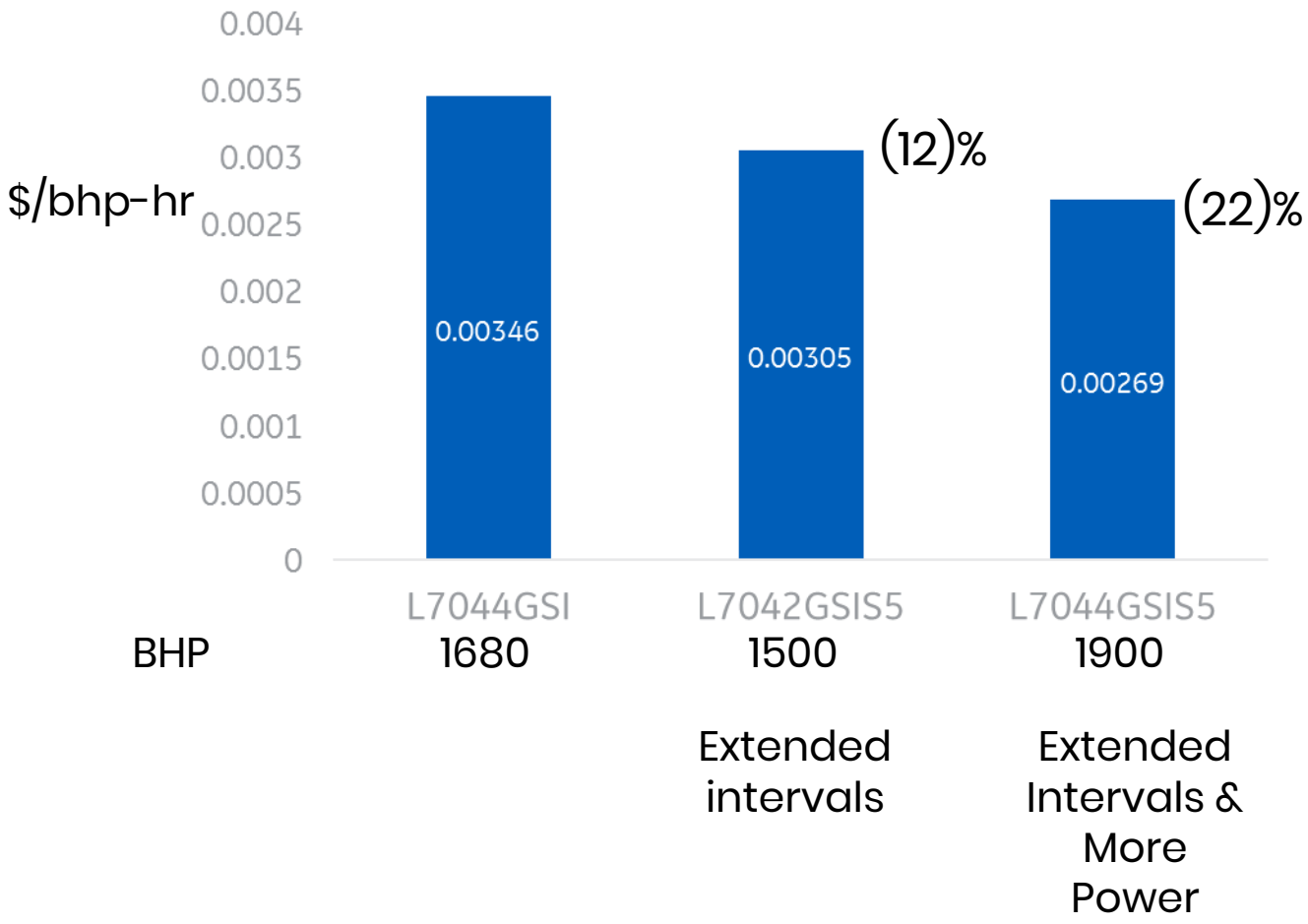
Pollutant	GP Limit (tpy)	7042 S5 (tpy)	ALT. ENG. (tpy)
NOx	95	2.17	6.66
CO	95	4.35 (32,794 hp)	3.40
VOC	95	1.01	7.60 (17,260 hp)
Formaldehyde	10	0.01	0.10

NM NPR

Pollutant	NPR Limit (tpy)	7042 S5 (tpy)	ALT. ENG. (tpy)
NOx	10	2.17	6.66
CO	10	4.35 (3,452 hp)	3.40
VOC	10	1.01	7.60 (1,817 hp)
Formaldehyde	10	0.01	0.10

Series Five OPEX Analysis

7042/7044 S5 Lifecycle Comparison



Lifecycle improvements

- **Parts & oil interval extension** … spark plugs and oil extension, lower cost spark plugs, top & bottom end intervals (L7042GSI S5)
- **Power increase** … Increasing the power while maintaining top and bottom end intervals reduces $/bhp-hr (L7044GSI S5)

Assumptions

- **Parts** … Includes planned maintenance and current reUp parts … non-reUp program parts not included
- **Oil** … no oil consumption degradation over time
- **Power & speed** … Units operating at rated load and speed
- **Labor** … will vary depending on service provider capability

Series Five Lifecycle Comparison--Details

Baseline

Planned maintenance activity (hours)	L7044GSI 1680 BHP	L7042GSI S5 1500 BHP	L7044GSI S5 1900 BHP
Lube oil change, spark plugs	2,000	4,000	4,000
O2 sensors, air & centrifugal filter elements	4,000	4,000	4,000
Breather filters, belts, carb, fuel system, turbo inspection	8,000	8,000	8,000
Spark plug extensions, air starter rebuild, gas regulator rebuild	16,000	16,000	16,000
Turbocharger	16,000	30,000	30,000
Top End	24,000	36,000	24,000
Bottom End	48,000	60,000	48,000
Average $/year (% variance to 7044GSI baseline)	$50,920	$40,077 (-21%)	$44,772 (-12%)
$/hr (% variance to 7044GSI baseline)	$5.81	$4.58 (-21%)	$5.11 (-12%)
$/bhp-hr (% variance to 7044GSI baseline)	$0.0035	$0.0031 (-12%)	$0.0027 (-22%)

VHP Series Five Review

1. **Full family of engines…** 7042 @ 1500 HP, 7044 @ 1900 HP, 9394 @ 2500 HP
2. **Improved rich burn tech…** Focus on thermal management & smarter controls
3. **Major benefits…** ↑ HP, efficiency, fuel flex./ambient capability, ↓ opex. (4k hr oil, plugs)
4. **Strong market interest…** 375+ units sold since launch in Q1 18' (including rentals)
5. **Attractive pairings…** via Ariel's new KBE/T and KBK frames (for 7042, 7044 and 9394 S5)
6. **Emissions advantage…** more hp per site and faster permitting with lower NOx, CO, VOCs

Contact us

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