



Superior™

825 Engines

12SGTD, 16SGTD

February 27, 2018



We invent smarter ways
to bring energy to the world.

Fullstream

Rely on cutting-edge technology, digital solutions, and expert service across every segment

Upstream

Evaluation

Drilling

Completion

Production & optimization

Midstream

Pipeline & storage

LNG

Downstream

Refinery

Petrochemical & fertilizer

Industrial power & processing

Digital

Reciprocating Compression

BHGE's Reciprocating Compression business is a leading provider of engines, compression equipment and services, focused on gas compression at or near the point of use. Reciprocating Compression's product portfolio includes highly efficient industrial reciprocating engines generating up to 12,500 bhp of power each for numerous energy producers globally.



**Our heritage and our people provide
a strong foundation for future
success**



Reciprocating Compression Products

New Equipment Offerings

Ajax™ Integral Engine-Compressors

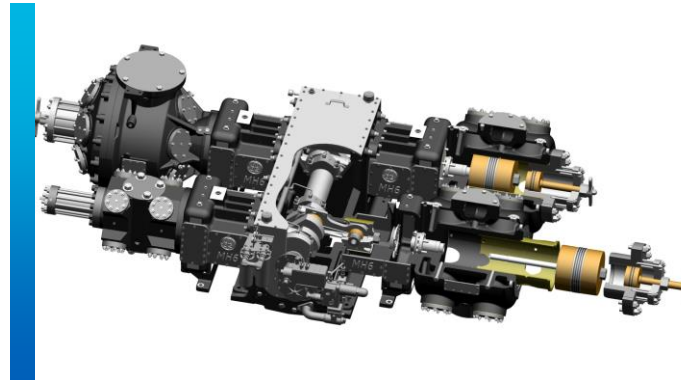
Horsepower output: up to 800 bhp
Natural gas, horizontal configuration, two stroke, integral design, slow speed



DPC-2804

High Speed Reciprocating (HSR) Compressors

Compressor horsepower: up to 9,000 hp
Horizontal configuration, separable design, high speed



MH64

Superior™ Engines

Horsepower output: up to 2,650 bhp
Natural gas, vee configuration, four stroke, separable design, medium speed



16SGTD

Reciprocating Compression Brands

Ajax™



Integral compressors up to 800 bhp

- Gas Gathering
- Gas Lift
- Fuel Gas Boosting

Reliability, availability, efficiency,
low total cost of ownership

Cooper-Bessemer™ HSR



Integral compressors up to 12,500 bhp

- Gas Storage
- Gas Transmission

Reliability, availability, efficiency,
low total cost of ownership

HSR



Separable compressors up to 9,000 hp

- Gas Lift/ Gathering
- Fuel Gas Boosting
- Gas Storage/ Transmission
- NGVs

Experience, flexibility support

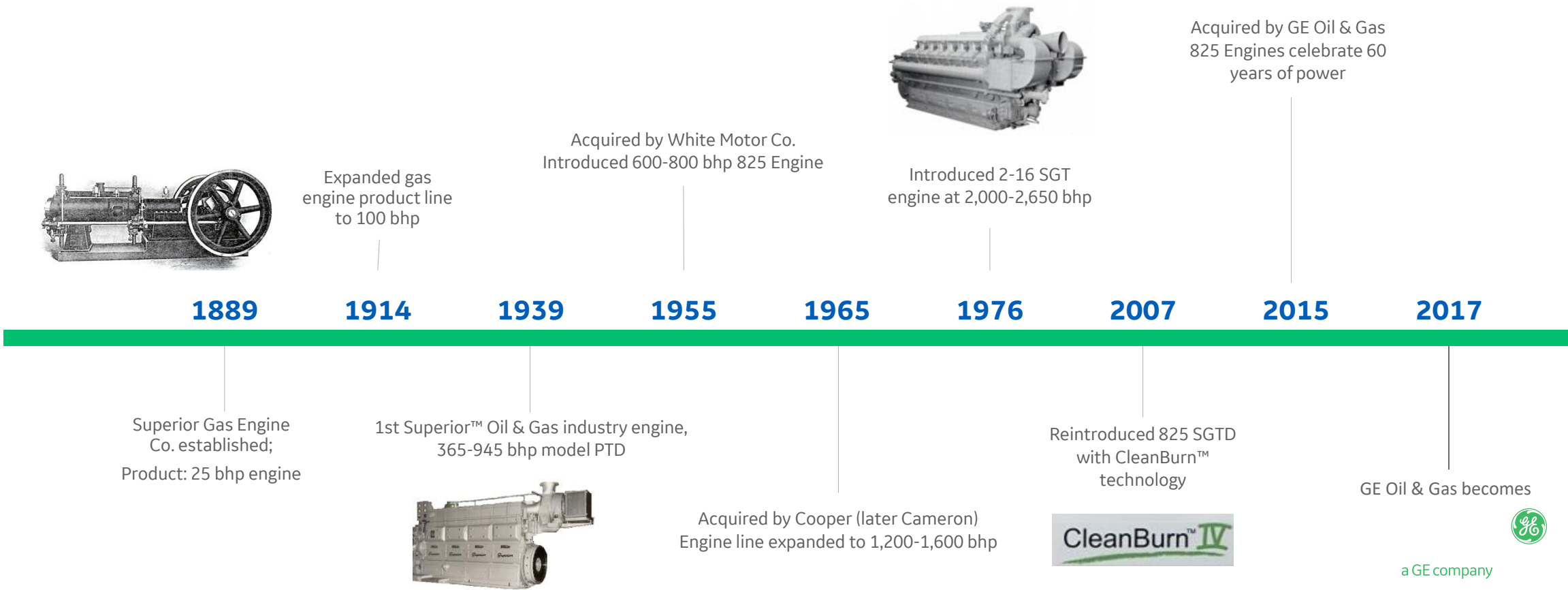
Superior™



Separable engines up to 2,650 bhp

- Gas Lift
- Gas Gathering
- Gas Storage
- Gas Transmission
- Rugged, proven, fuel flexibly

Long standing reputation for high quality engine products

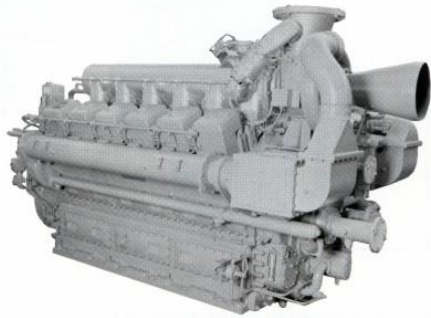


SGTD product description

1,500 bhp

2,000 bhp

2,500 bhp

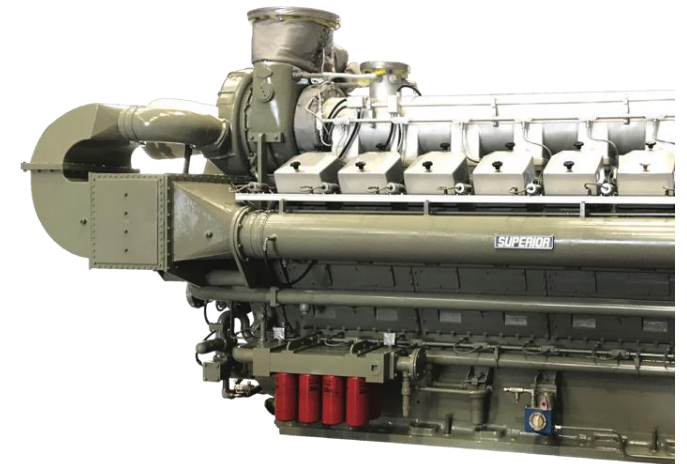


1,333 – 2,000 bhp (994 – 1,491 kWb)

V12*

1,766 – 2,650 bhp (1,317 – 1,976 kWb)

V16*



- 12, 16 cylinder configuration spanning 1,333 – 2,650 bhp
- Gas compression, processing, pumping and oilfield applications

*Capable of continuous operation down to 600 rpm and 50% load

SGTD engines



Features

- Four Stroke-Cycle Gas Engine
- Spark Ignited
- Power Cylinder Displacement: 825 cubic inches (13.5 liter) per cylinder
- V12 and V16 Configuration (600-900 rpm)
- Known as the "Work Horse" of the compressor drive industry, 30+ years history
- Low BMEP rating of 177 at 900 rpm
- ATEX compliant to Group II, Category 3, Zone 2 (G)

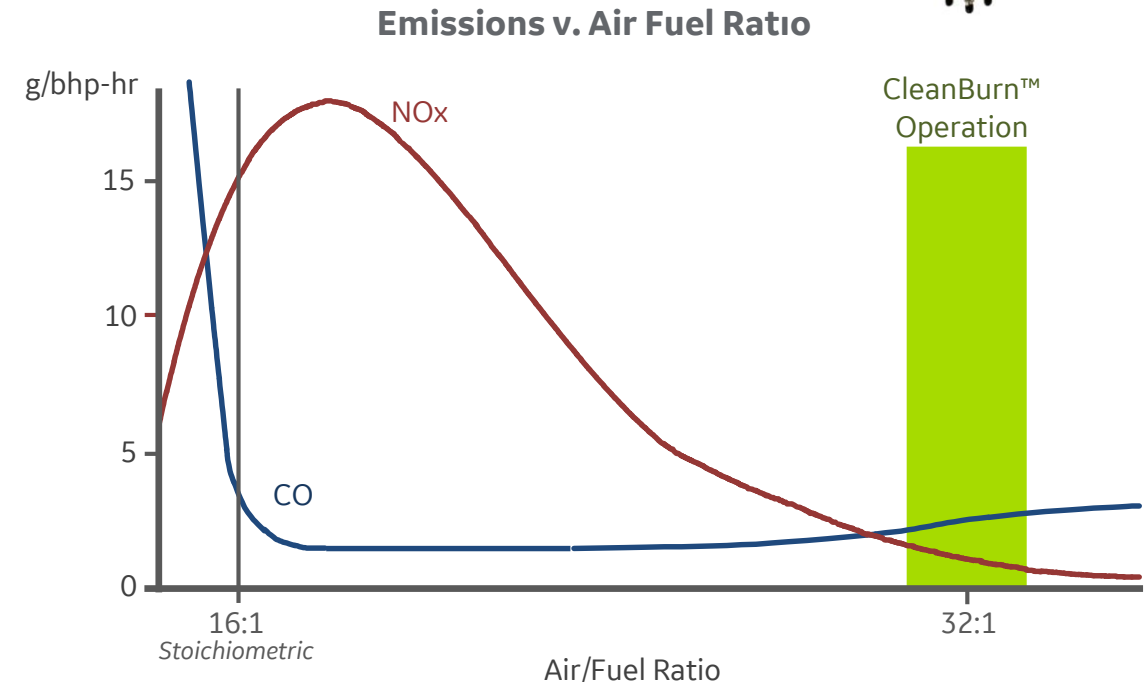
Product Specifications

Model	12SGTD	16SGTD
Cylinders	12	16
Bore, in (cm)	10 (25.4)	10 (25.4)
Stroke, in (cm)	10.5 (26.7)	10.5 (26.7)
Compression Ratio	8.2 to 1	8.2 to 1
Power, bhp (kWb)	2,000 (1,491)	2,650 (1,976)
Speed, rpm	900	900
BMEP, psi (bar)	177.8 (12.4)	177.8 (12.4)
Fuel Consumption @ 100% load, Btu/bhp-hr (kcal/kW-hr)	7,100 (2,400)	7,100 (2,400)
Dry Weight, lb (kg)	42,500 (19,280)	54,000 (24,494)
Length ft-in (cm)	15'4" (467)	18'5" (560)

Technology Upgrade – Cleanburn™ IV Controls

Air fuel controller maintains stable lean-burn operation resulting in lowest emissions and fuel consumption

- Real-time air and fuel flow measurements enabling precise combustion control
- Independent main and pilot fuel controls
- System adjusts for changes in fuel quality and protects against over-torque
- CleanBurn™ operating window limits emission increases



Engine Controls and HMI

Integrated, PLC-based engine management

- Single-source control, integrating other engine system monitors
- Allen Bradley hardware with tailored and field-proven BHGE developed algorithms
- Touch screen interface allows operator access to engine parameters, even remotely
- Real-time engine status display with extensive analog data availability
- Monitors temperature and pressure throughout the system; pre-set alarms and shutdowns protect the engine and ensure safe operation
- Electronic and automatic ignition, timing, load monitoring and speed control
- Also adaptable to customer's preferred control system

CleanBurn™ IV Engine Control System



Solid foundation

Built for reliability

- Bedded, forged steel crankshaft; durable, cast iron cylinder heads, pistons, bed, block
Results in low number of needed replacement parts compared to competitors' steel components
- Outboard camshafts with split-shell bearings, individual, slip-on cams, and top-access piston and rod assembly
Easily accessible components for reduced downtime during service
- Lower engine speed - 900 rpm ... conservative piston speed - 1,575 fpm

Designed and built for continuous, heavy-duty service

Crankshaft installed



Technology Upgrade – Pre-combustion chamber

Optimized bolt-in prechamber

- Replaced older screw-in pre-combustion chamber (PCC) with an enhanced geometry bolt-in PCC design
~75% of the NO_x is created in the PCC
Enhanced geometry allows for larger operating window
- PCC fuel gas pilot valve redesigned from a ball to a poppet style check valve
Improves check valve life.

Enhanced PCC with better operating window and maintenance

Pre-combustion chamber used on SGTD engines



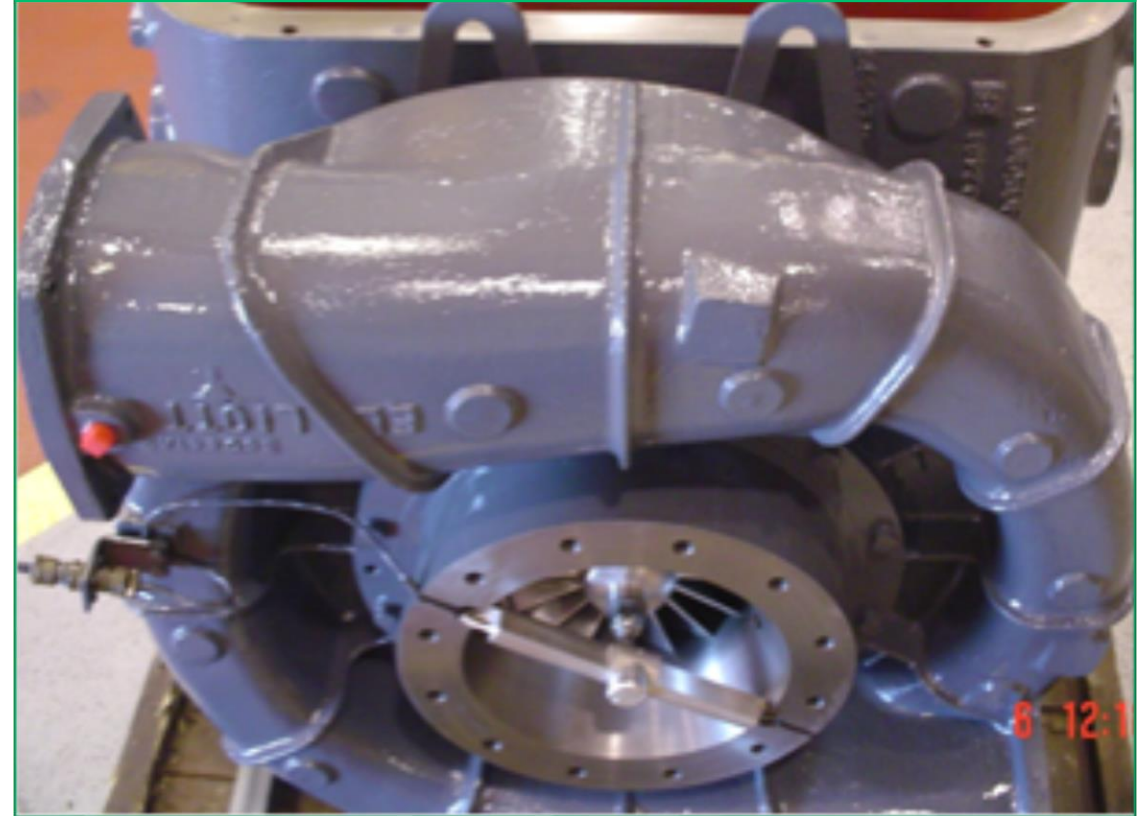
Technology Upgrade – Air-handling system

Upgraded Elliott™ BC370H turbo

- Redesigned high efficiency turbocharger with long life inboard bearing system
- New compressor & turbine stage
- Improved fuel efficiency and lower emissions
- Improved range of operation

Improved overall efficiency up to 10 percentage points

Elliott™ BC370H turbocharger used on Superior™ SGTD engines



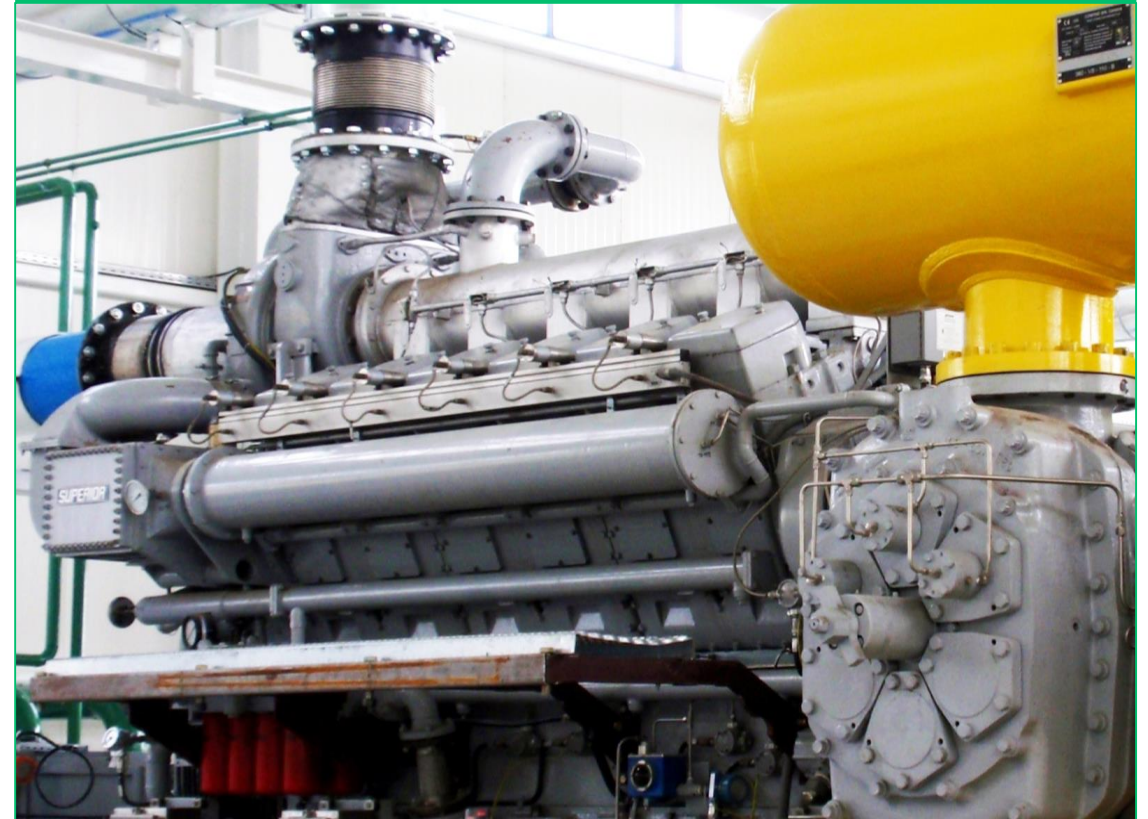
Front-mounted turbochargers

Front-end turbocharger benefits:

- Front-mounted turbos allow straight forward and uncluttered installation
- Simplify packaging
- Shorter piping runs
- No support structure required for intake/exhaust pipes
- No crane/pipe interference
- No need to remove piping when removing heads
- Less down time, more production

Front-mounted turbocharger for an uncluttered installation

Front mounted turbocharger on 12SGTD

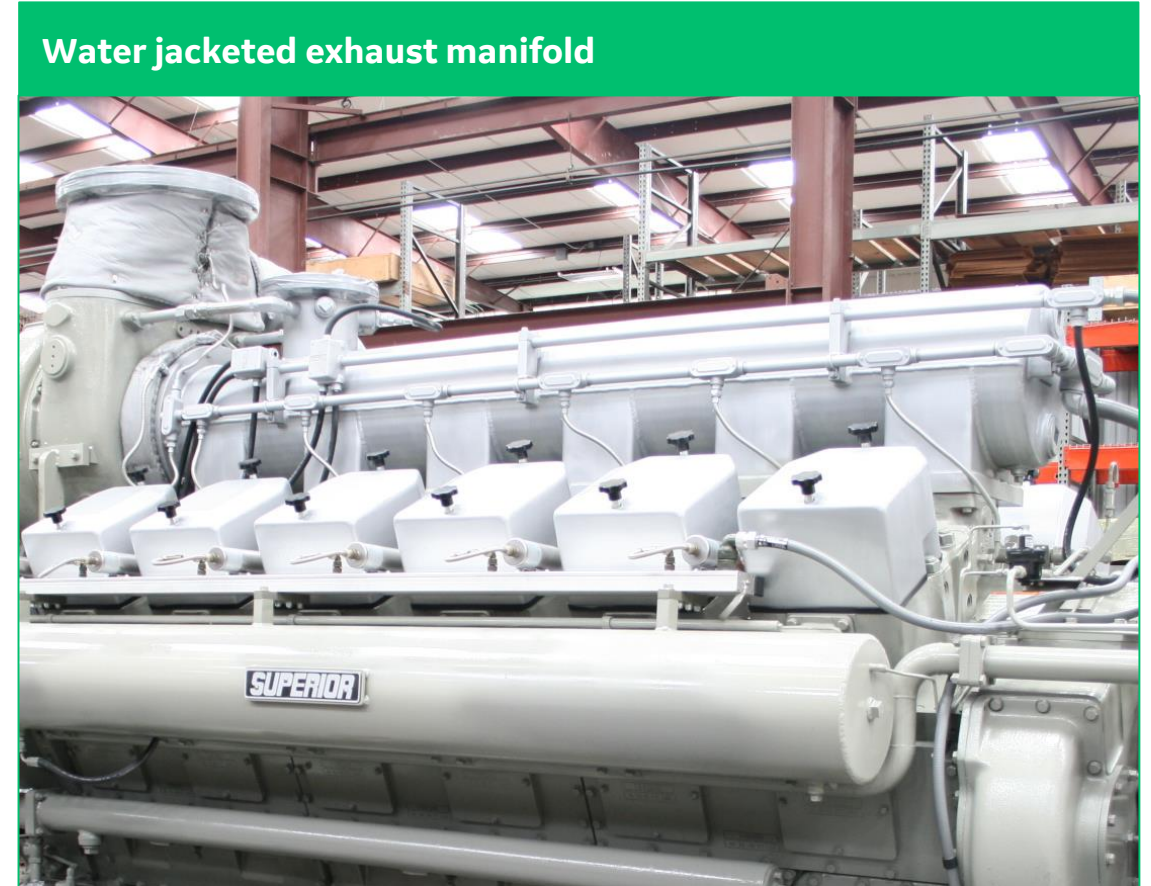


Exhaust system

Simple robust design

- Water cooled exhaust manifold without expansion joints
Water cooling mitigates thermal cycle failures, minimizes insulation requirements
No potential flexible failure points
- Improved turbocharger performance optimized to SGTD exhaust profile

Water cooling eliminates flexible bellows and associated failures



Technology Upgrade - Lube oil system

Upgraded lube oil system elements

- Upgraded from cartridge type oil filter element to factory mounted spin on disposable lube oil filter element
Easily changed filters, over the counter filter elements, extending bearing and bushing lifecycle due to better filtration of the lube oil, multiple ports on the filter body to monitor change in pressure across the filters
- Factory mounted pre-lube pump integral to engine assembly
Reduces piping, connections, and cost associated with off engine mounting

Reduced labor cost, downtime and oil spills

Mounted spin on lube oil filters on SGTD



Technology Upgrade – Fuel Gas Valves

Upgraded fuel gas valve accessibility

- Replaced two-piece cast iron transition piece and aluminum lid assembly to an aluminum one-piece fuel gas valve cover
Longer life, reduced oil leaks, ten nuts have been replaced by two hand knobs
- Replaced cast iron side cover doors with fiberglass fuel gas valve access doors with two access ports large enough to perform fuel gas valve adjustments
Reduced oil leakage, eases effort required to conduct fuel gas valve adjustments

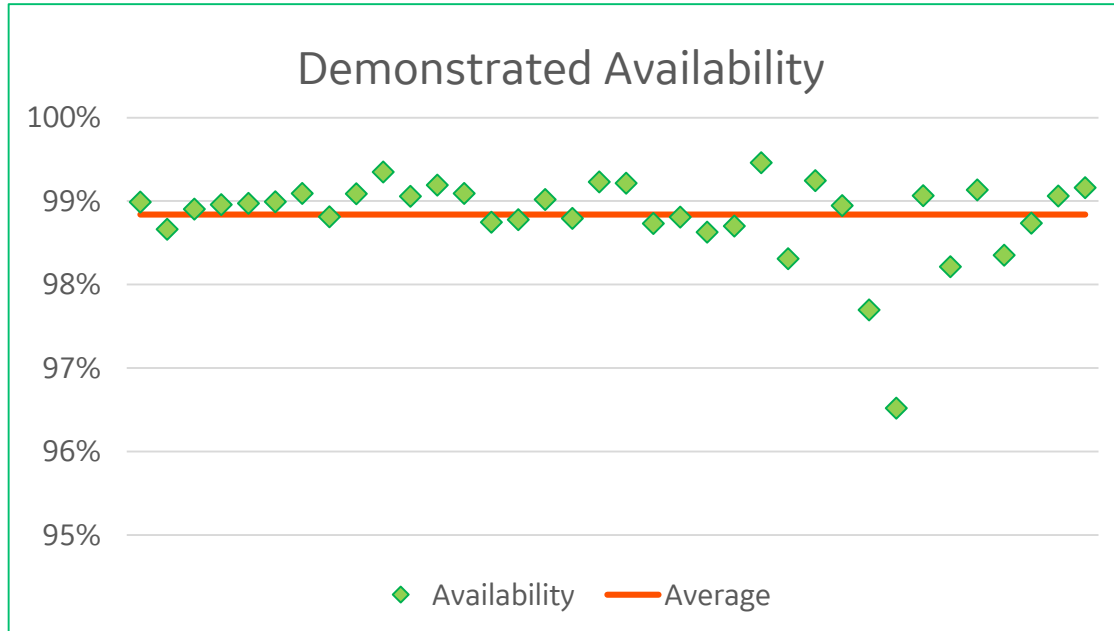
Valve adjustments are now a one-person job

Aluminum one-piece valve cover on SGTD



Demonstrated 98% availability (SGTB/C engines)

SGTB/C engine % availability



98.8% average availability for 20 years under real world conditions

Tracking performance

- Twenty years O&M data from 36 SGTB/C engines under BHGE MSA
- Exceeded expectations under most stringent hot day conditions in the San Juan basin at 5,600 FASL or higher
- Fuel gas CO₂ content differed by site from as little as 12% to over 20%.
- Comprehensive engine, lube oil analysis tools, in addition to standard engine/ compressor asset performance management

SGTD vs other brand engines

Key advantages

- SGTD has lower engine speed meaning conservative piston speeds, less wear on engine components extends time between service and overhaul intervals, leading to O&M cost savings
- SGTD has lower brake mean effective pressure (BMEP) means less stress on running parts
- SGTD has lower brake specific fuel consumption (BSFC) meaning less fuel consumed resulting in lower fuel costs

Rated performances of similar engines

Rated power

G3612 A4	3,750 bhp	G3616 A4	5,000 bhp
12SGTD	2,000 bhp	16SGTD	2,650 bhp
L7044GSI	1,680 bhp	P9394GSI	2,250 bhp

Engine speed

12SGTD	900 rpm	16SGTD	900 rpm
G3612 A4	1,000 rpm	G3616 A4	1,000 rpm
L7044GSI	1,200 rpm	P9394GSI	1,200 rpm

BMEP

L7044GSI	157.5 psi	P9394GSI	158.2 psi
12SGTD	177.8 psi	16SGTD	177.8 psi
G3612 A4	191.3 psi	G3616 A4	191.3 psi

BSFC

G3612 A4	6,638 Btu/bhp-hr	G3616 A4	6,617 Btu/bhp-hr
12SGTD	7,100 Btu/bhp-hr	P9394GSI	7,063 Btu/bhp-hr
L7044GSI	7,881 Btu/bhp-hr	16SGTD	7,100 Btu/bhp-hr

SGTD engines and HSR compressors

A Superior pairing

- Competitive pricing and lead times geared towards your project requirements
- FlexFlow lined cylinders ... adjust to changing field conditions
- Water or air-cooled cylinders
- Active engine/compressor controls ... Optimize engine horsepower, compressor flow, fuel efficiency, and/or emissions

Match with HSR compressors

Compressor		Prime Mover	
	Rating at 900 rpm	12SGTD 2,000 bhp	16SGTD 2,650 bhp
WH76	4,590 hp	•	•
WG74	4,500 hp	•	•
WG64	4,500 hp	•	•
WH66	4,050 hp	•	•
MH66	4,050 hp	•	•
WH74	3,060 hp	•	•
WH64	2,700 hp	•	
MH64	2,700 hp	•	

Product Support



SGTD product support package

Available offerings

- Training for operator personnel @ site
- Technical Services support
- Biweekly meetings available for first 8,000 hours of operation
- Commissioning support by BHGE personnel
- Technical issue resolution support
- Extended warranty

BHGE upgrade programs

4 Upgrade Programs

- Improvements in
 - Efficiency
 - Stability
 - Maintenance
 - Emissions
 - Safety

3 Genuine OEM parts

- Reduce lifecycle cost and improve reliability with genuine BHGE OEM parts solutions



1 Multiyear service agreements

- From BHGE's network of approved service providers

2 Asset Performance Management

- Digital product connectivity
- Pivotal development point
- Reduce costs and improve availability with analytics

Superior Upgrades offering overview



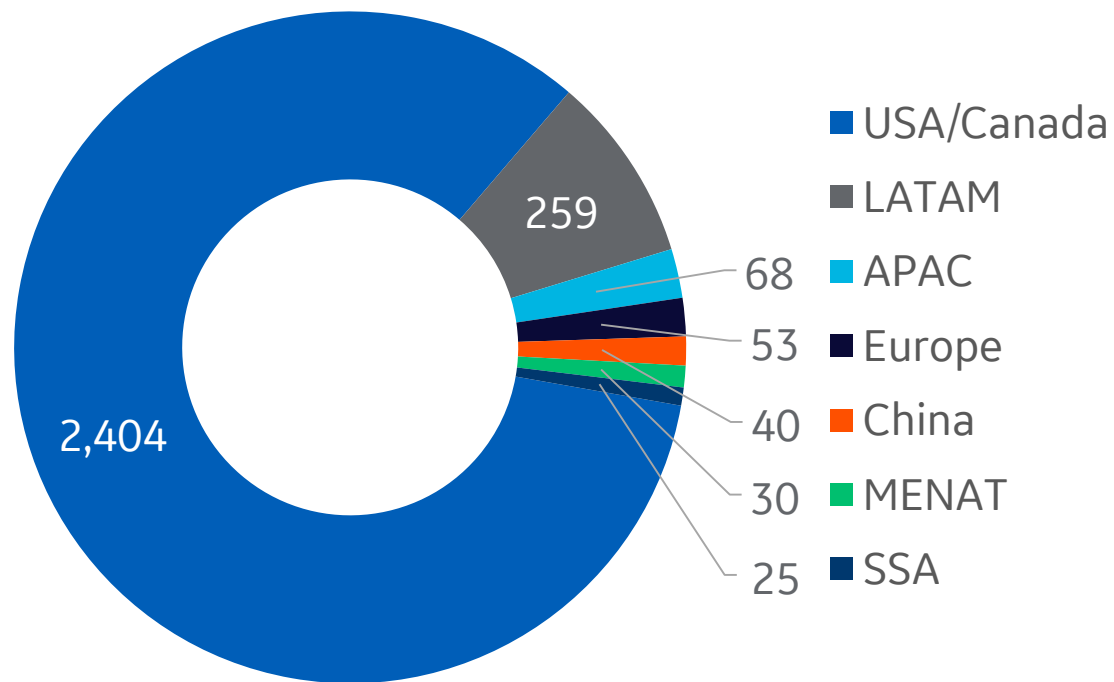
Superior upgrade portfolio focused on maximizing your profitability

Δ Efficiency	G	GT	GTL	GTLA	GTLB	SGT	SGTA	SGTB	SGTD
Clean Burn IV (CB IV) Emissions Control Upgrade	•	•	•	•	•	•	•	•	
Higher Efficiency Turbochargers		•	•	•	•	•	•	•	
Δ Stability	G	GT	GTL	GTLA	GTLB	SGT	SGTA	SGTB	SGTD
Clean Burn IV (CB IV) Emissions Control Upgrade	•	•	•	•	•	•	•	•	
Magnetic Pick-Up Mounting Brackets	•	•	•	•	•	•	•		
CleanBurn Conversion Kit		•	•						
Δ Maintenance	G	GT	GTL	GTLA	GTLB	SGT	SGTA	SGTB	SGTD
Bolt-in Pre-Combustion Chamber	•	•	•	•	•	•	•	•	
Aluminum One-Piece Valve Cover	•	•	•	•	•	•	•	•	
Fiberglass Fuel Gas Valve Adjustment Doors		•	•	•	•	•	•	•	
Oil Pump Drive Upgrade	•	•	•	•	•	•	•	•	
Wastegate Actuator Conversion				•	•				
Barring and Starter Motor Mounting Brackets	•	•	•	•	•	•	•	•	•
Δ Emissions	G	GT	GTL	GTLA	GTLB	SGT	SGTA	SGTB	SGTD
Bolt-in Pre-Combustion Chamber	•	•	•	•	•	•	•	•	
Clean Burn IV (CB IV) Emissions Control Upgrade	•	•	•	•	•	•	•	•	
Higher Efficiency Turbochargers		•	•	•	•	•	•	•	
Aluminum One-Piece Valve Cover	•	•	•	•	•	•	•	•	
Fiberglass Fuel Gas Valve Adjustment Doors		•	•	•	•	•	•	•	
CleanBurn Conversion Kit		•	•						
Δ Safety	G	GT	GTL	GTLA	GTLB	SGT	SGTA	SGTB	SGTD
Barring and Starter Motor Mounting Brackets	•	•	•	•	•	•	•	•	•

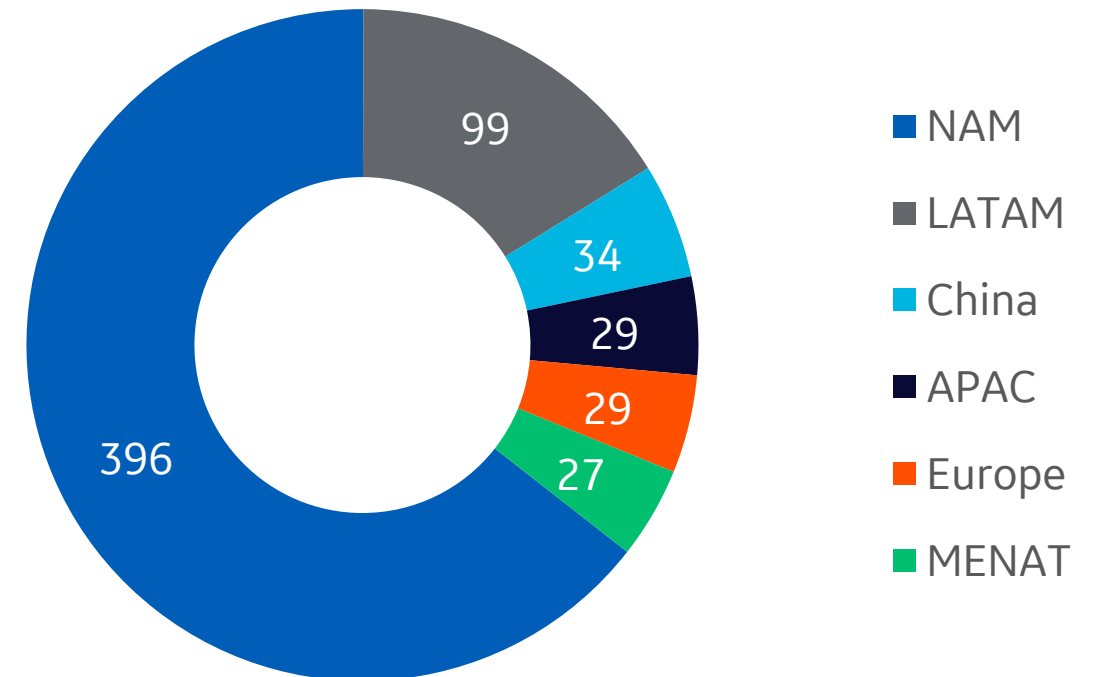
Reference Projects

Global 825 engine installed base

Number of 825 engines



Number of SGT, SGTA/B/C/D engines



6 natural gas fueled 16SGTD engines

- Used to drive MH-66 compressors for gas gathering and boosting
- Packaged in Oklahoma City (USA)
- Location: Anaco, Venezuela
- Commissioned: 2010

Blah blah blah

Planta Compresora Guere



2 natural gas fueled 12SGTD engines

- Used to drive WH-74 compressors at a gas transmission station
- Packaged by Industrial Trading
- Location: Cristuru, Romania
- Commissioned: 2007

SGT engines remanufactured to SGTD standard

Cristuru, Romania



8 natural gas fueled 16SGTD engines

- Used to drive WH-74 compressors for gas gathering and boosting
- Packaged in Oklahoma City (USA) and by Rotating Offshore Solutions
- Location: SPG Musi Barat, South Sumatra
- Commissioned: 2013

Blah blah blah

SPG Musi Barat, South Sumatra



We invent smarter ways
to bring energy to the world.



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a GE company



Backup



Superior engines

Upgrades for all 825 engines

Maximize productivity
and safety with proven
technologies and
advanced solutions



CleanBurn™ IV (CB IV) Emissions Control

Designed for all turbocharged Superior gas engines that use wastegate valves for AFR control.

- Independent main and pilot fuel control
- Real-time air and fuel flow measurements
- Fuel quality adjustments
- Engine protection and monitoring
- Integrated engine management approach
- Eliminated black-box controls approach
- Operator access to operating parameters
- Extensive data availability through integrated display



CB IV Controller

Customer Benefit				
Efficiency	Stability	Maintenance	Emissions	Safety
✓	✓		✓	

Outage Applicability		
Major Overhaul	Top End Overhaul	Annual
✓	✓	✓

Higher Efficiency Turbochargers

Previous versions of 825 engines can be upgraded to the BC370H turbocharger used in 12/16SGTD engines independently, or in conjunction with the CleanBurn IV upgrade.

- New compressor stage
- Standardized components
- New turbine
- Improved overall efficiency
- Direct bolt-in replacement
- Turbo speed measurement (tachometer)



Elliott™ BC370H Turbocharger

Customer Benefit				
Efficiency	Stability	Maintenance	Emissions	Safety
✓			✓	

Outage Applicability		
Major Overhaul	Top End Overhaul	Annual
✓	✓	✓

Magnetic Pick-Up Mounting Brackets

Mounting brackets enable magnetic pick-ups to be added to all Superior 825 engines. Magnetic pick-ups are added for precise engine controls including ignition timing, fuel management, start-up sequence, motor control centers and other run status indicators.

- Fabricated bracket
- Installation hardware (bolts, studs, washers)



Inline Magnetic Pick-Up Mounting Bracket

Customer Benefit				
Efficiency	Stability	Maintenance	Emissions	Safety
	✓			

Outage Applicability		
Major Overhaul	Top End Overhaul	Annual
✓	✓	✓

CleanBurn Conversion Kit

For the 8GT and 8GTL model engines. Converted engines will be designated as 8GTLE models. The kit has been designed and thoroughly tested to achieve 2g/bhp-hr NOx @ 900 rpm and full load.

- Pre-chambered CleanBurn
- Pilot fuel system
- Modified ignition system Electronic air/fuel controls
- Turbo modifications plus clean and balance at Salina turbocharger COE
- Electronic timing control Complete instruction/parts manual



Customer Benefit				
Efficiency	Stability	Maintenance	Emissions	Safety
	✓		✓	

Outage Applicability		
Major Overhaul	Top End Overhaul	Annual
✓	✓	

Bolt-in Pre-Combustion Chamber

The prechamber assembly method was changed from screw-in to bolt-in type. This minimizes risk for component damage during assembly/disassembly operations by reducing tooling size and required torque.

The improved pilot fuel parting reduces carbon buildup. Smaller nozzle volume reduces thermal loading and NOx formation and extends sparkplug life. Advanced materials eliminate high temperature nozzle erosion.



Bolt-in Pre-Combustion Chamber

Customer Benefit				
Efficiency	Stability	Maintenance	Emissions	Safety
		✓	✓	

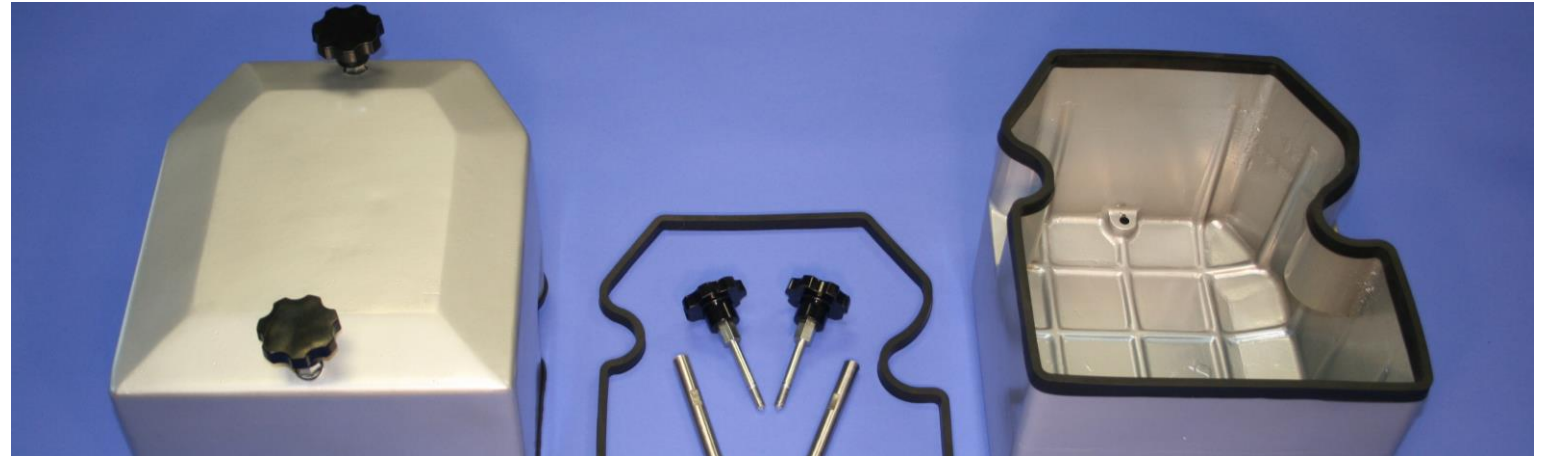
Outage Applicability		
Major Overhaul	Top End Overhaul	Annual
✓	✓	

Aluminum One-Piece Valve Cover

Aluminum one-piece valve covers are a direct replacement of the original two-piece cast iron transition piece and aluminum lid assembly

Benefits

- Lightweight
- Direct fit
- Easier maintenance
- Convenience
- Reduced oil leaks
- Available for all 825 engines
- Longer life
- Cost effective



Aluminum One-Piece Valve Cover

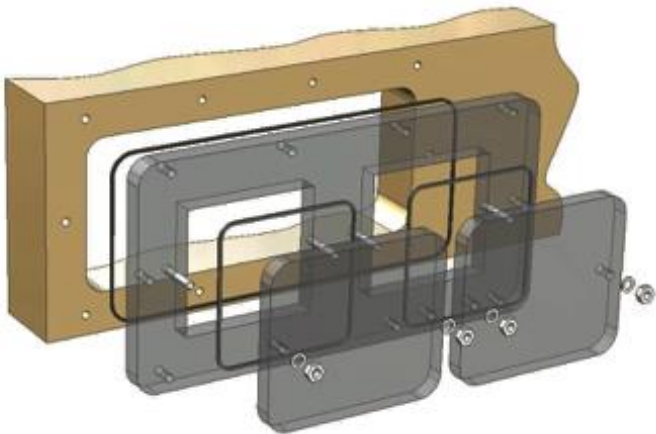
Customer Benefit				
Efficiency	Stability	Maintenance	Emissions	Safety
		✓	✓	

Outage Applicability		
Major Overhaul	Top End Overhaul	Annual
✓	✓	✓

Fiberglass Fuel Gas Valve Adjustment Doors

Engines originally were supplied with cast iron side cover doors. The numerous fasteners and weight of the doors made fuel valve adjustment a difficult and time-consuming task.

New doors are fitted with two access ports large enough to perform the 1,500-hour fuel gas valve adjustment without removing the entire side cover. The ports are covered by smaller, lightweight fiberglass doors that significantly reduce their weight.



Fiberglass Fuel Gas Valve Adjustment Doors

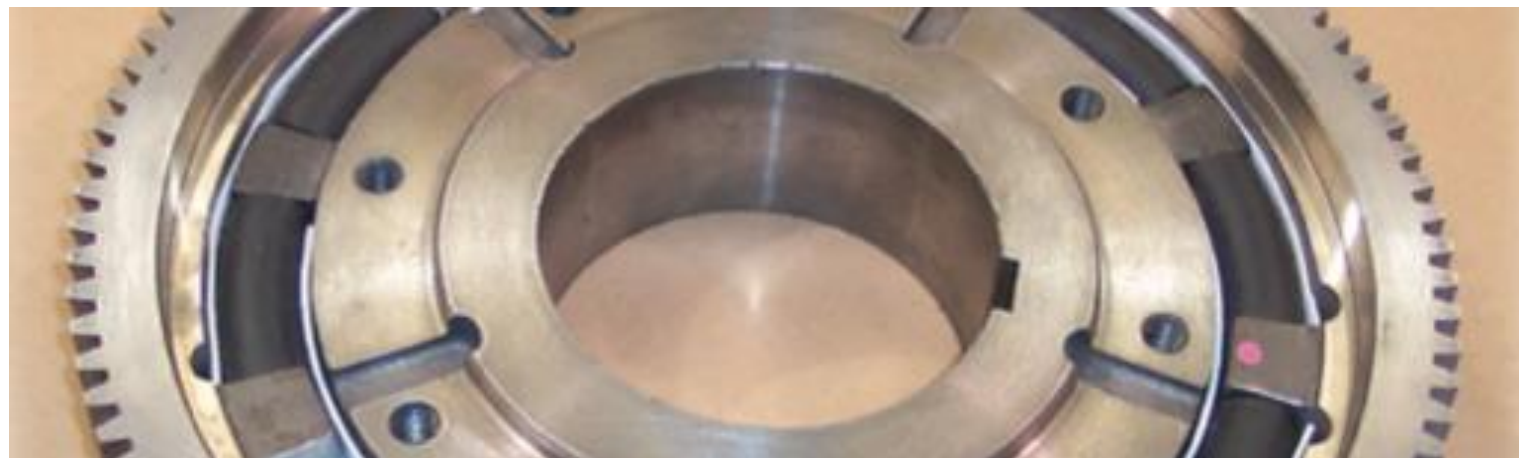
Customer Benefit				
Efficiency	Stability	Maintenance	Emissions	Safety
		✓	✓	

Outage Applicability		
Major Overhaul	Top End Overhaul	Annual
✓	✓	✓

Oil Pump Drive Upgrade

Upgrades the spring-loaded oil pump drive assembly on all 6 and 8 cylinder Superior engines with Viton cord strips.

Provides equal or better dampening for the assembly and also provides longer life and less war and tear on the gear and hub.



Oil pump drive ear and hub with Viton cord strips

Customer Benefit				
Efficiency	Stability	Maintenance	Emissions	Safety
		✓		

Outage Applicability		
Major Overhaul	Top End Overhaul	Annual
✓	✓	

Wastegate Actuator Conversion

For GTLA/B and 2400 engines.
Moves the wastegate valve actuator on an inline engine to the side of the block and onto the intercooler on a vee engine. Actuator is currently directly mounted to the wastegate valve. Potential heat at this location may shorten the actuator life.

- Kinnetrol actuator
- Brackets, linkages, fasteners
- Modified wastegate valve with brass bushing pressed into packing nut



Intercooler mounted wastegate valve actuator

Customer Benefit				
Efficiency	Stability	Maintenance	Emissions	Safety
		✓		

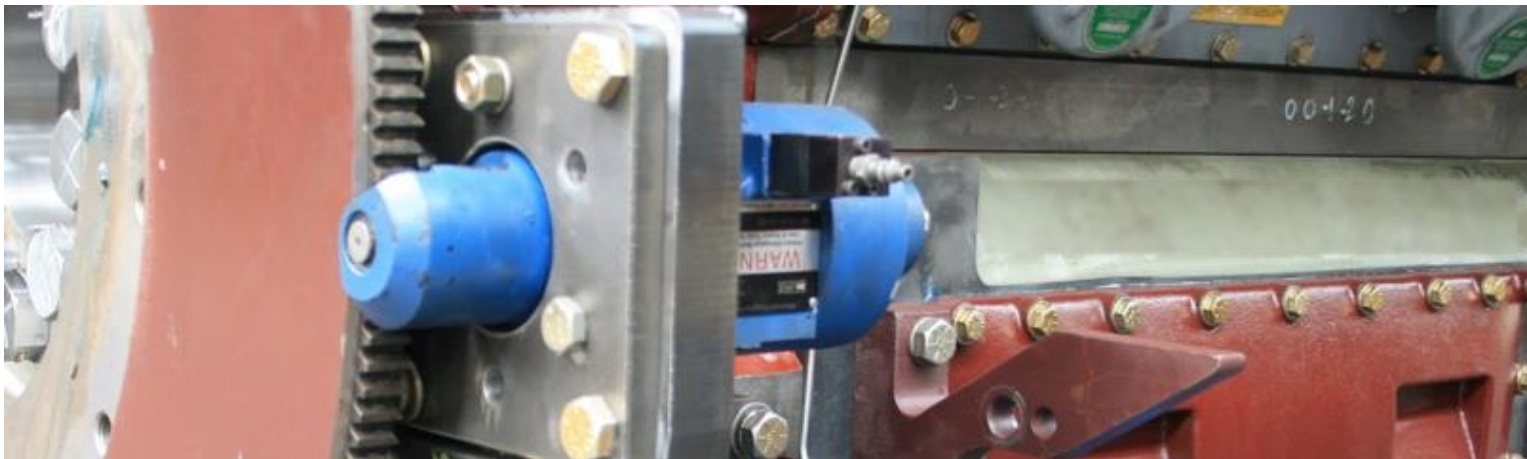
Outage Applicability		
Major Overhaul	Top End Overhaul	Annual
✓	✓	✓

Barring and Starter Motor Mounting Brackets

Enable barring and starter motors to be added to all Superior 825 Vee engines. Pneumatic barring motors deliver highly reliable, precision-controlled slow engine turning and stopping that makes it easier and safer to service gas engines.

Pneumatic starter motors provide high power-to-weight ratio and reliable starting for gas engines.

- Fabricated bracket
- Installation hardware (bolts & washers)



Barring motor on mounting bracket

Customer Benefit				
Efficiency	Stability	Maintenance	Emissions	Safety
		✓		✓

Outage Applicability		
Major Overhaul	Top End Overhaul	Annual
✓	✓	✓

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