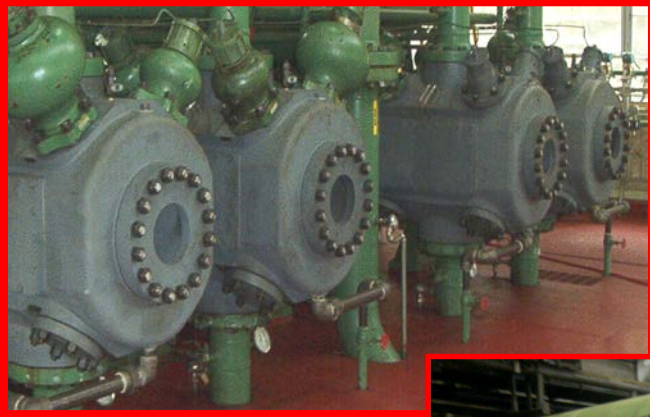


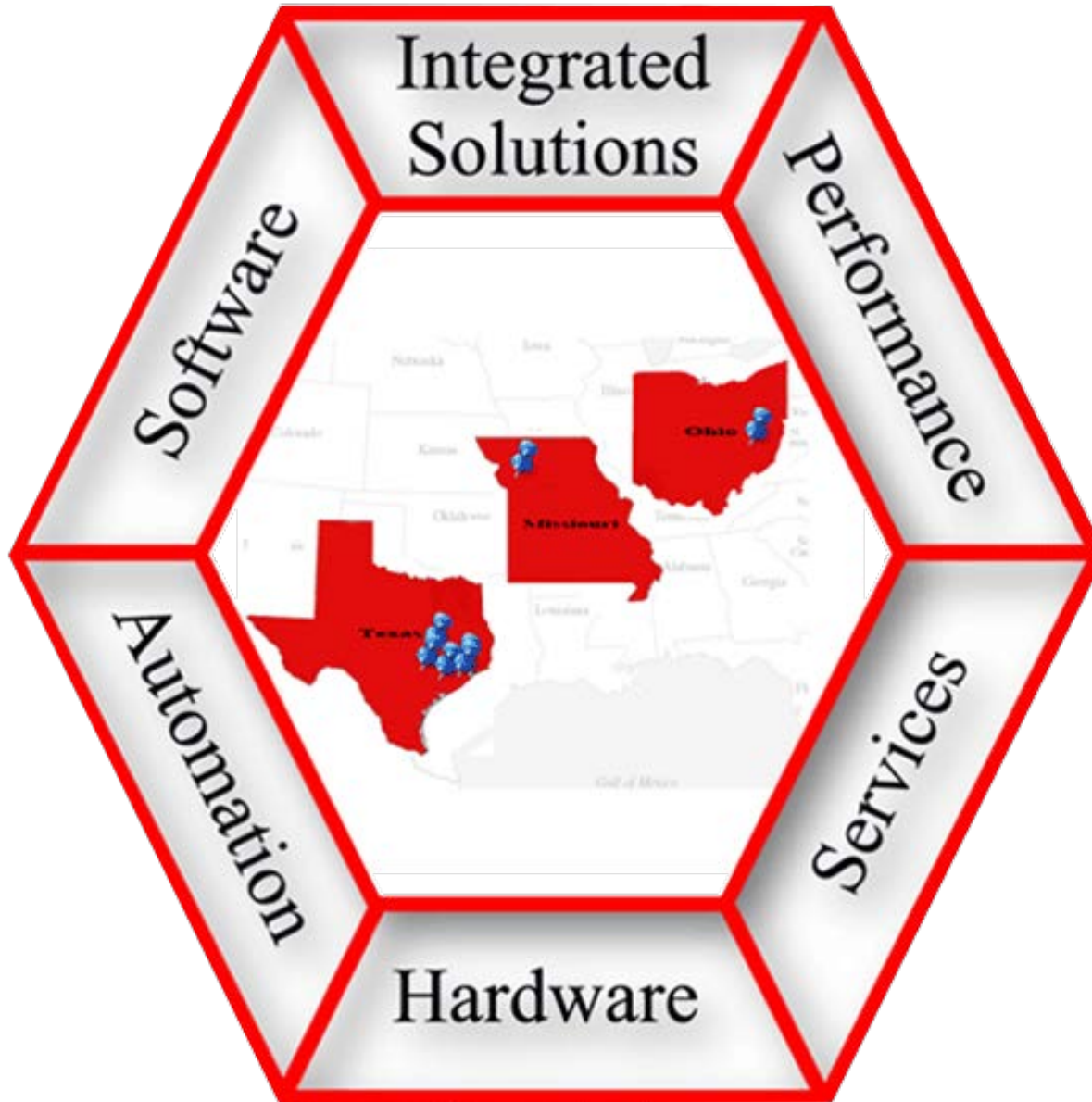
Improved Reliability, Safety and Maintenance through Valve - in - Head Cylinder Body Replacements



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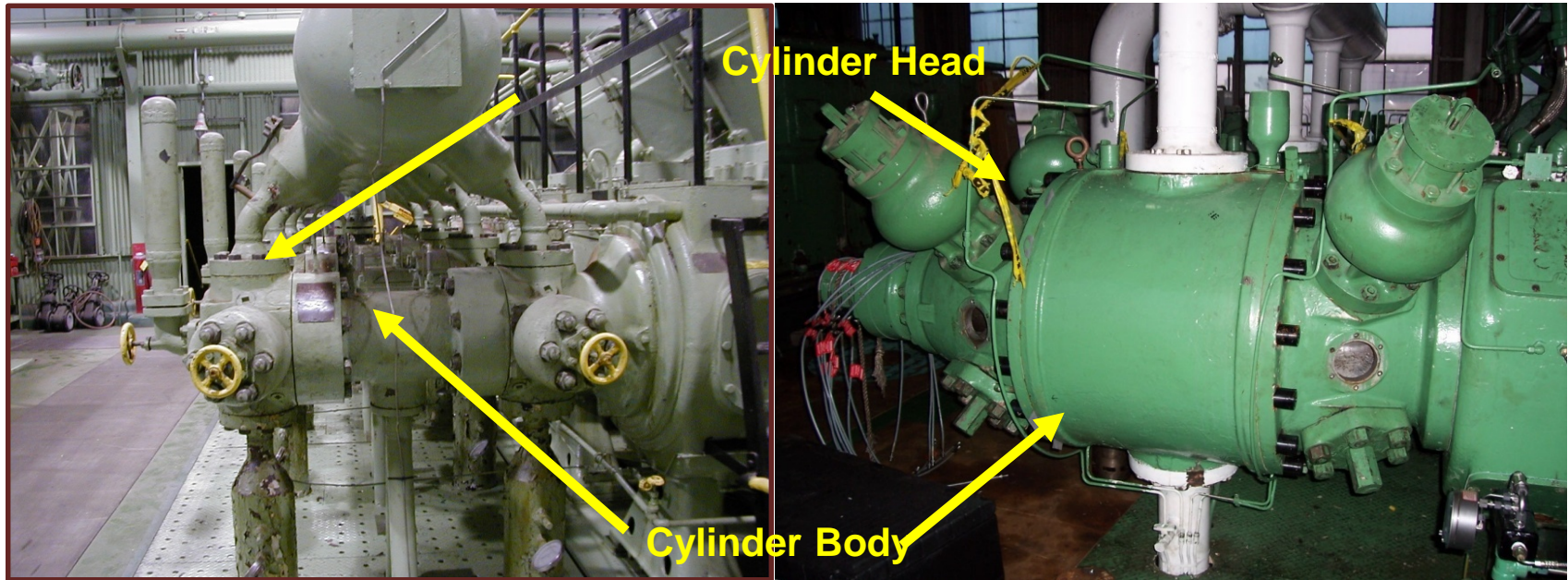


Characteristics of Existing Valve – in – Head Compressor Cylinders

- **Many have been in service for decades**
 - 30 to 50 years is not unusual – some are over 70 years old
- **Efficiency may be far from optimal**
 - design was not intended for efficiency but for production
 - age leading to condition degradation
 - wrong conditions specified, conditions changed, performance missed
- **May be plagued by reliability and safety problems**
 - maintainability may be problematic due to the large number of threaded fasteners
 - intricate gasket design may lead to leakage of compressor medium into water
- **May not be well supported by OEMs**
 - OEMs no longer in business, companies moved/acquired, experts retired
 - No longer production cylinders

Many have been in services for decades....

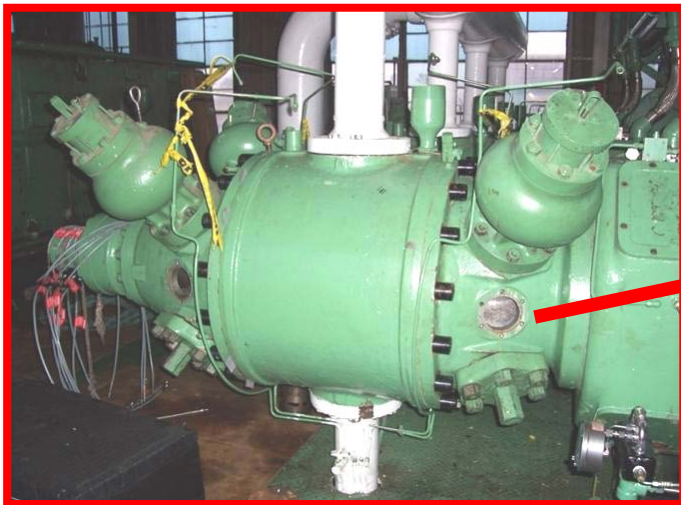
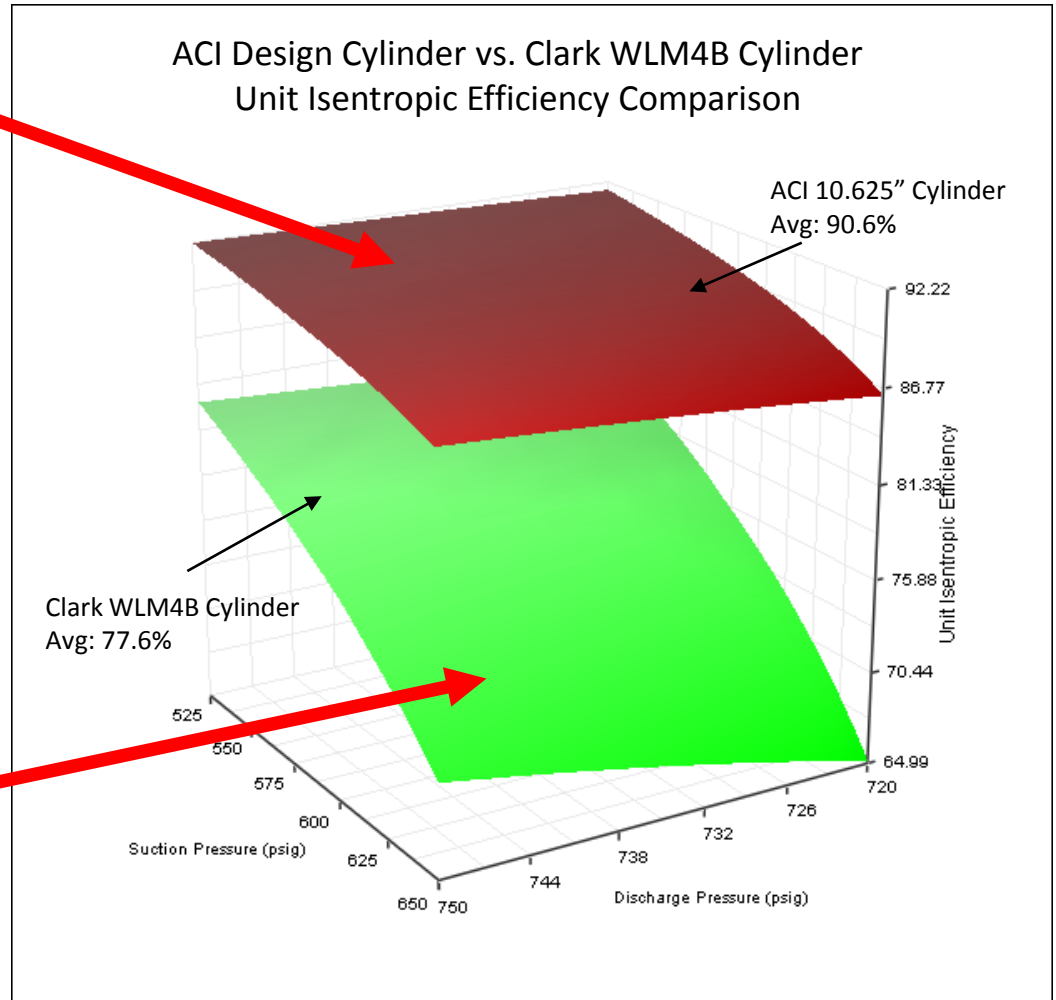
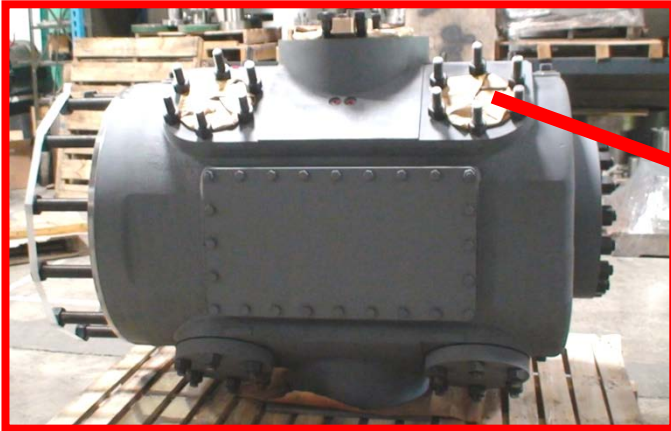
A typical valve in head design is shown. Essentially it is a three piece cylinder with a head end head that contains all of the head end valves, a cylinder body for the running bore, and a crank end head that contains the crank end valves.



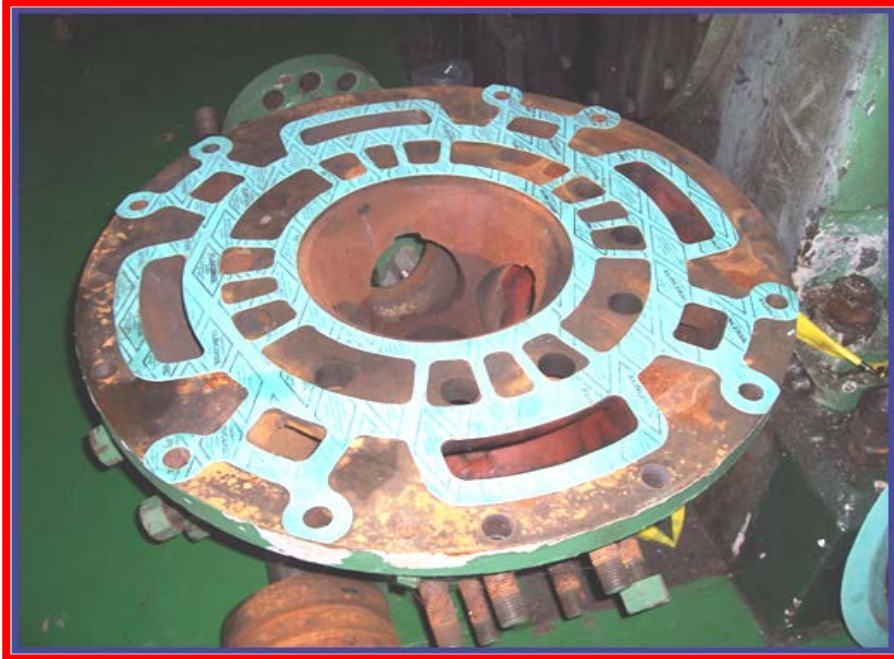
Cooper Bessemer Cylinders installed in the 1930's

Clark Cylinders installed in the 1950's

Efficiency may be far from optimal...



Many are plagued with Safety and Reliability problems....



Size of gasket and bolt loading makes it difficult to obtain proper gasket crush

Gasket material discontinuation has made it difficult to design a reliable, leak free gasket that prevents leakage 100% of the time.



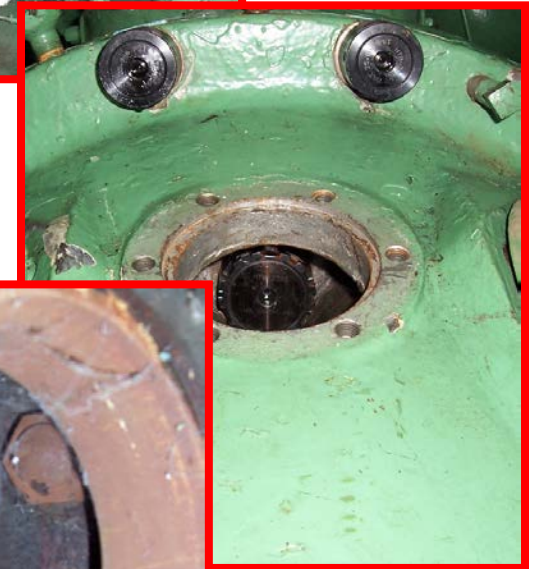
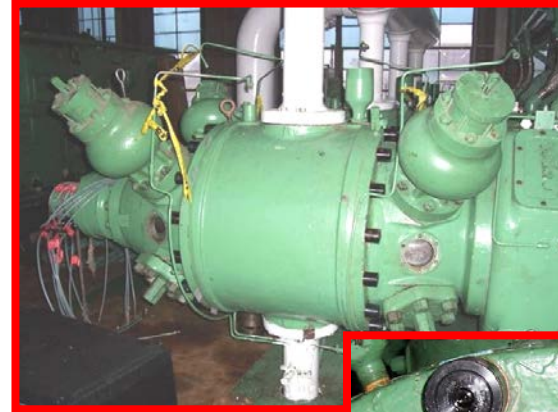
Many are plagued with Safety and Reliability problems....

Maintenance nightmare

- The cylinder heads are secured to the body via numerous threaded fasteners that are not easily accessible.
- Have to access the threaded fasteners through the valve pockets.

Potential for fugitive emissions or worse a fire

- Threaded fasteners are not able to be torqued properly
- Often once pressurized, the cylinder leaks resulting in additional blow down.
- The leak could lead to a fire if ignition source present



The Solution: Valve-in-Barrel™ Cylinder Body Design

Improves reliability and safety

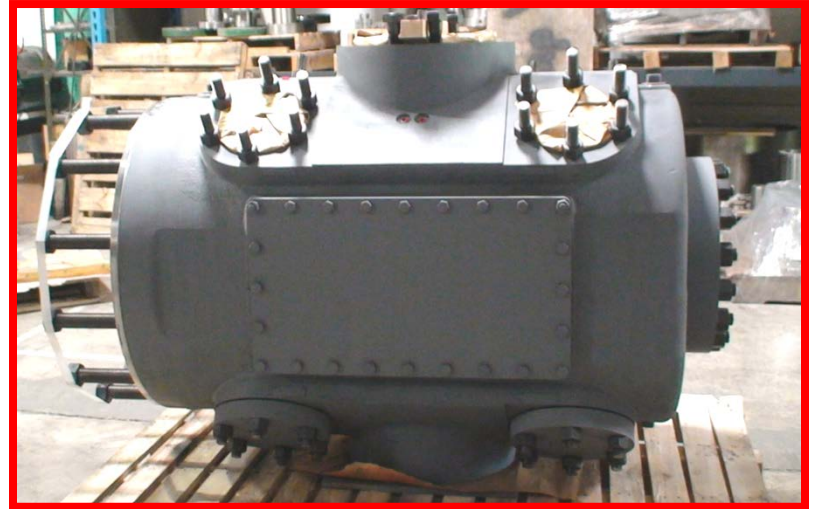
- Gasket elimination reduces possible gas and coolant leaks thus increasing safety
- Fewer and more accessible fasteners reduce maintenance, labor, downtime, and frustration

Utilize existing components

- Reduces the overall cylinder cost by reusing most existing cylinder components
- Preserves value of existing spares inventory

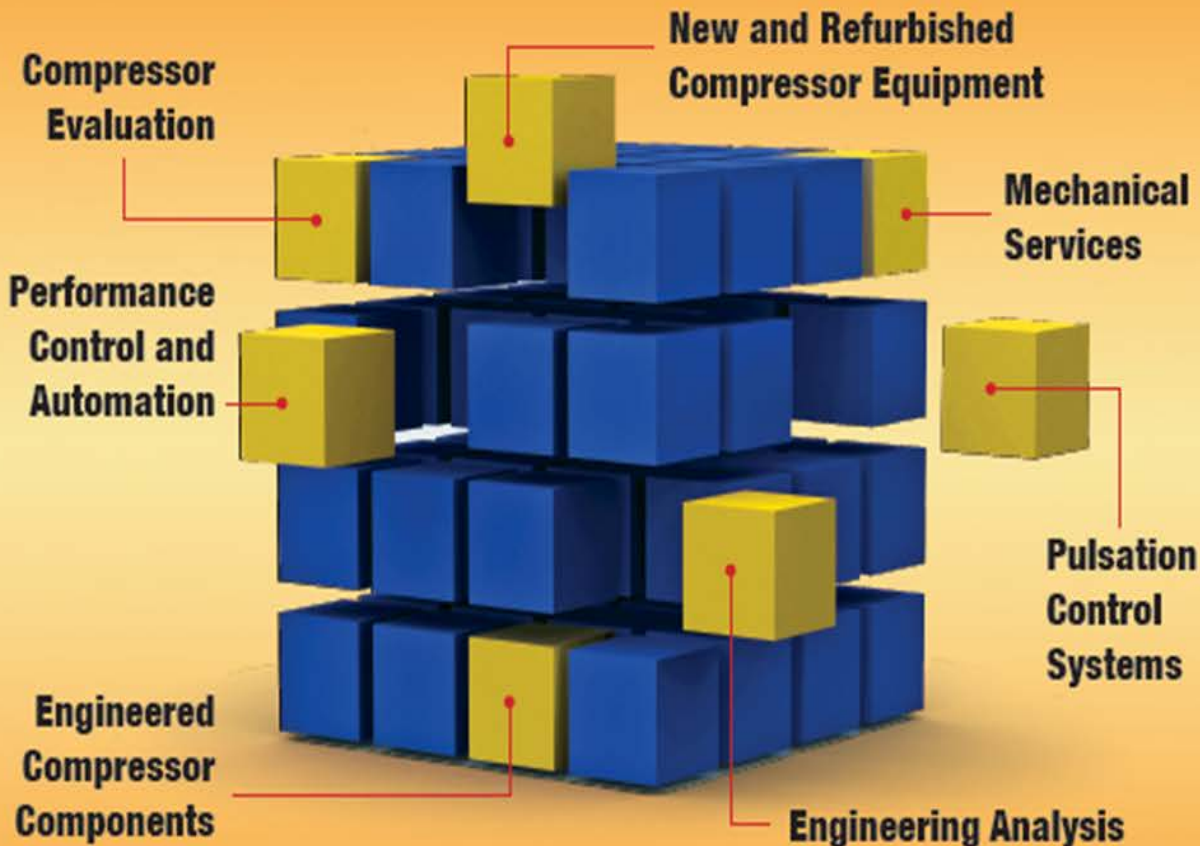
Bolt-in replacement

- Minimizes replacement cost by using existing bottles, pipe connections and mounting locations
- Minimizes installation downtime



We Manage Change

Compression requirements change. The ACI team has the expertise to develop and implement the best solutions to manage your compression projects and optimize your compression assets.



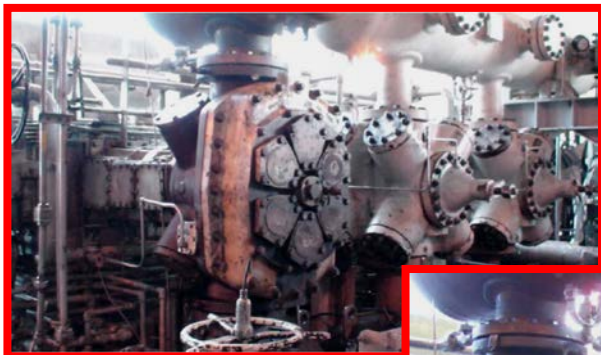
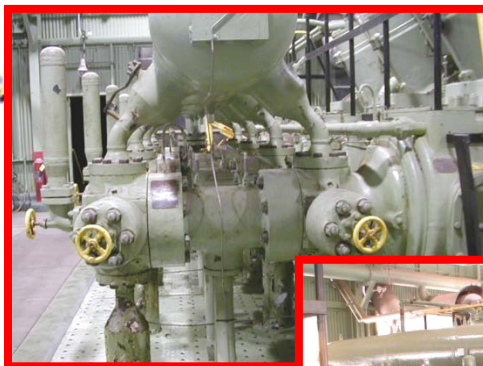
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Change Management Valve-in-Head Cylinder Body Case Studies

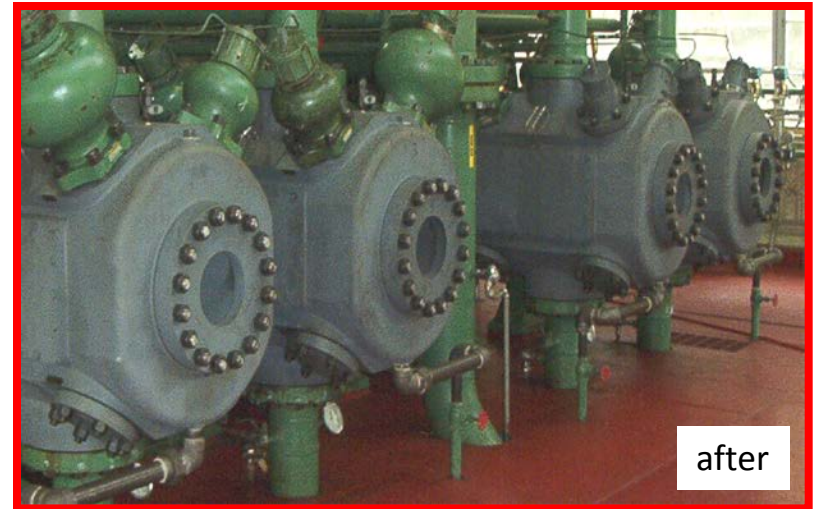
Increasing Cylinder Working Pressure

- **USA Pipeline Operator**

- Cooper Bessemer GMVA-10 integral compressor
- natural gas storage/withdrawal
- required higher MWP (1100 -> 1200 psig)
- problematic OEM valve-in-head design
- required bolt-in replacement (same connections)

- **Solution**

- cast ASTM A395 ductile iron cylinder
- valve-in-barrel design – eliminated large gaskets
- “bolt-in” replacement
- utilized/refurbished existing valves and packing
- rerated/refurbished existing clearance pockets
- air cooled / non-jacketed
- 12.0 in. (304.8 mm) bore diameter
- 14.0 in. (355.8 mm) stroke
- 1200 psig (82.7 bar) MWP
- (16) cylinders replaced on (4) compressors



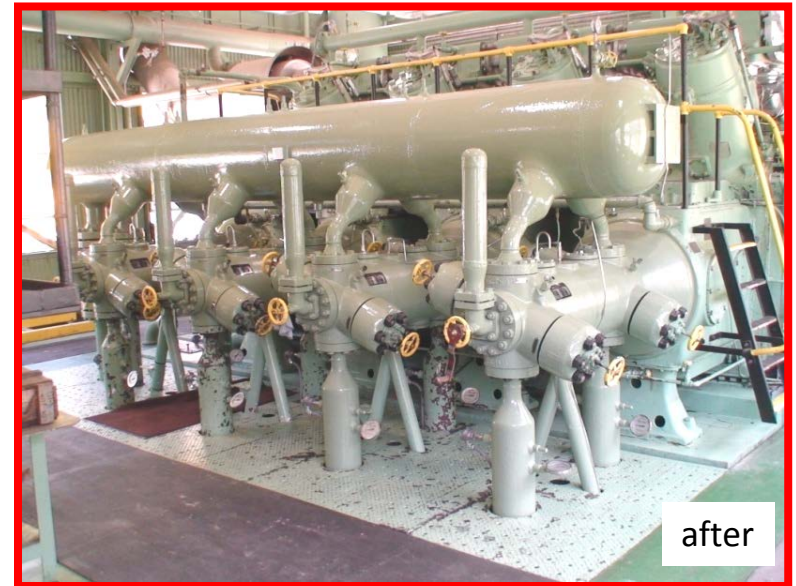
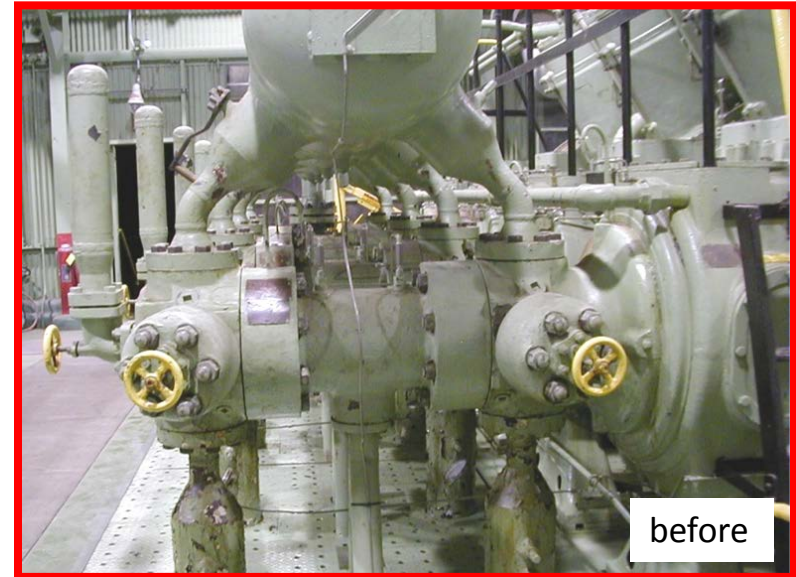
Increasing Cylinder Working Pressure

• USA Gas Storage Facility

- Cooper Bessemer GMVA-10 integral compressor
- natural gas storage/withdrawal
- required higher MWP (1800 -> 2000 psig)
- problematic OEM valve-in-head 1940's design
- required bolt-in replacement (same connections)

• Solution

- cast ASTM A395 ductile iron cylinder
- valve-in-barrel design – eliminated large gaskets
- “bolt-in” replacement
- utilized/refurbished existing valves and packing
- rerated/refurbished existing clearance pockets
- air cooled / non-jacketed
- 7.0 in. (177.8 mm) bore diameter
- 14.0 in. (355.8 mm) stroke
- 2000 psig (137.9 bar) MWP
- (20) cylinders replaced on (5) compressors



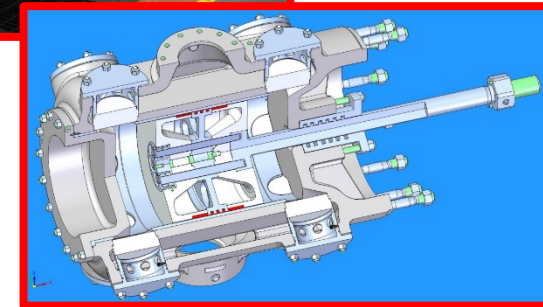
Improved Safety Margin

• UK Gas Processing Plant

- C-B GMVA-8 Compressors
- closed loop propane refrigeration process
- problematic design
 - metal seals leaked
 - over-tightening cap bolts
 - cracks in multiple valve pockets
- no more used cylinders available
- required bolt-in replacement (same connections)
- OEM had no solution

• Solution

- cast ASTM A874M ductile iron cylinder
- valve-in-barrel design – eliminated large gaskets
- o-ring valve cap seals – no metal seals
- “bolt-in” replacement
- complete assembly
- air cooled / non-jacketed
- 20.13 in. (511.3 mm) bore diameter
- 14.0 in. (355.8 mm) stroke
- 300 psig (20.7 bar) MWP
- (4) cylinders replaced on (1) compressors
- End user specified ACI cylinders through OEM



Emergency Replacement of Obsolete Cylinders

- **Canadian Oil Sands Producer**

- 2 x C-B KM5 compressors – 4 cylinders
- Hydrogen rich process application
- existing 3-piece cylinder design assemblies were found to be leaking gas – cracks in valve stud holes
- existing cylinders no longer OEM production
- no like cylinders available in used market
- entire facility dependent on compressor operating and therefore down losing \$Millions per day.

- **Solution**

- Supplied solution through compressor OEM
- Used an existing ACI design that was in production
- Made urgent design modifications to fit application
- Delivered (4) complete cylinder assemblies within 4 weeks ARO including hydrostatic and helium test.
- Only site modification was lengthening bottle nozzles about 1 in. Otherwise “bolt-in” replacements.
- cast ASTM A385 ductile iron cylinder
- liquid cooled / jacketed
- 14.0 in. (355.8 mm) bore diameter
- 14.0 in. (355.8 mm) stroke
- 1500 psig (103 bar) MWP



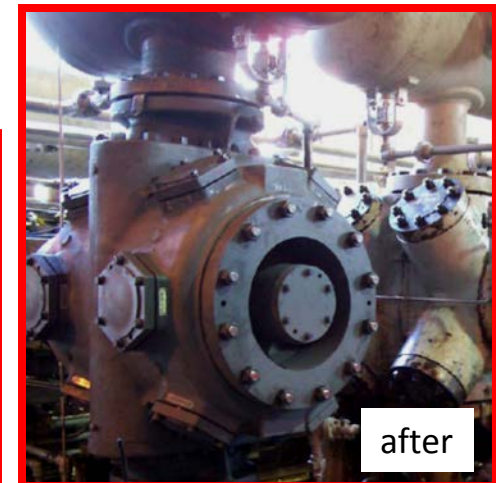
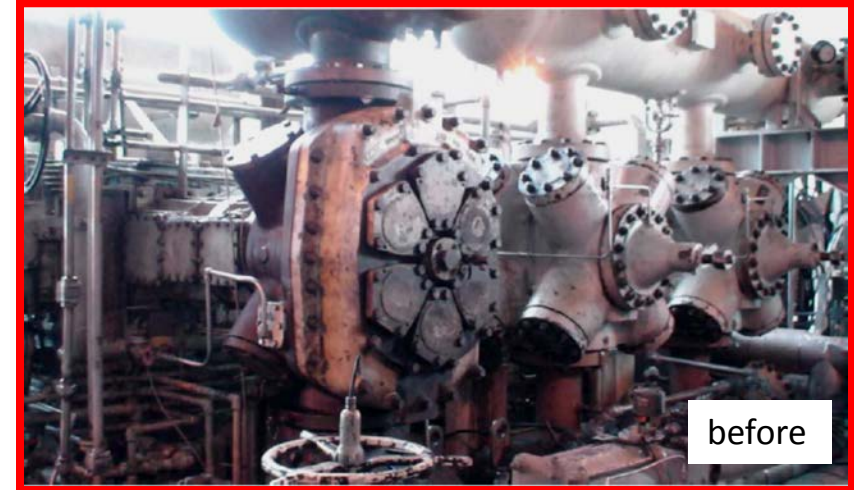
Eliminating Extremely Serious Piston Failures

• Major International Oil Producer

- Superior W76 compressor – 4000 hp (2983 kw)
- offshore sour gas lift
- multiple failed OEM 2nd stage pistons – 8 days!
- operating close to rod load limit
- high operating temperature
- severe safety & production loss issues
- wanted bolt-in replacement (same connections)
- OEM had no solution

• Solution

- detailed redesign with multiple FEA studies
- temporary aluminum piston solution
- cast ASTM A395 ductile iron cylinder & piston
- better matched 1st & 2nd stages
- “bolt-in” replacement
- special offset adapters
- liquid cooled / jacketed
- 18.13 in. (460.4 mm) bore diameter
- 7.0 in. (177.8 mm) stroke
- 550 psig (37.9 bar) MWP
- also replaced (2) 1st stage cylinders





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