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49TH TURBOMACHINERY & 36TH PUMP SYMPOSIA

SEPTEMBER 14-17, 2020 | HOUSTON, TX | GEORGE R. BROWN CONVENTION CENTER

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Resolution of Check Valve Failures in Reciprocating Compressors

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Presenter/Author Bios

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Joel Sanford is a Senior Key Expert in the Technology and Innovation group at Siemens. He is responsible for the development of new valve and unloading technologies for reciprocating compressor product lines. Mr. Sanford has 30 years of experience in the design and development of reciprocating compressors for the oil and gas industry. He holds a BS degree in mechanical engineering from Alfred University in Alfred, New York, and an associate degree in applied science and internal combustion engine technology from Alfred State College.

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Jeff Pennypacker is the Head of Valve Engineering in the Reciprocating Compressors and Gas Engine division at Siemens. He is responsible for managing the design and support of valve and unloading technologies for new equipment and upgrades for reciprocating compressors. Mr Pennypacker has 13 years of experience in the design and development of reciprocating compressors for the oil and gas industry. He holds a MS degree in Engineering Management from Clarkson University in Pottsdam, New York, and a BS degree in Mechanical Engineering from Penn State University in Erie, Pennsylvania.

Abstract

Discharge line check valves for reciprocating compressors are subjected to pressure pulsations, varying flow rates, and debris in the gas stream. Consequently, swing check, piston check, and modified plate-style compressor check valves are sometimes susceptible to failures. This case study will discuss two applications in which poppet style compressor valve technology was implemented to resolve field failures.

A natural gas feed reciprocating compressor routinely failed plate style check valves every 6-12 months. Thereafter, a valve modification was employed that resulted in doubling the runtime.   The modified check valve technology resolved the problem related to pulsating and variable flow, resulting in improved run time and efficiency.

A hydrogen reciprocating compressor, also experienced frequent check valve failures due to debris. Modified check valve technology was able to increase runtime from approximately one to over five years. A key lesson learned is that line check valves are in a harsh environment and should be customized for each application's specific operating conditions to improve reliability.

Agenda

- Non-Return (Check) Valve Technology Overview
- Case Study #1: Natural Gas Compressor with Variable Flow
  - Problem
  - Solution
- Case Study #2: Hydrogen Compressor with Heavy Debris
  - Problem
  - Solution
- Lessons Learned

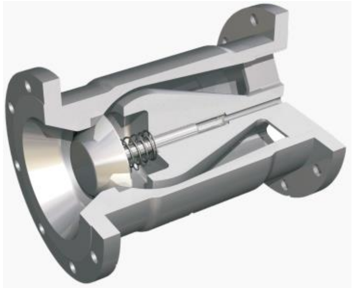
Non-Return (Check) Valves for Reciprocating Compressors

- Check Valves that are used in Gas Piping Systems
- Installed in discharge piping downstream of reciprocating compressors
- Subjected to pressure pulsations, varying flow rates and debris in gas stream
- Prevent backflow into the compressor when it is shut down. Important for restarting of unit.

Non-Return (Check) Valve Technology

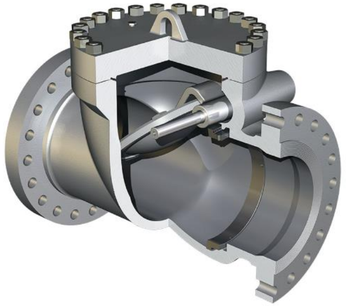
Lift Check Valves

- Nozzle check, silent check and ball check valves



Nozzle Check Valve

Swing Check Valves



Swing Check Valve

Piston Check Valves

Piston Check Valve

Compressor Style Check Valves

- Plate
- Poppet

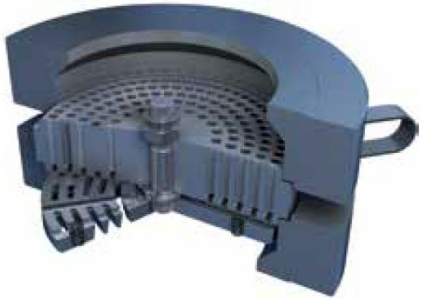
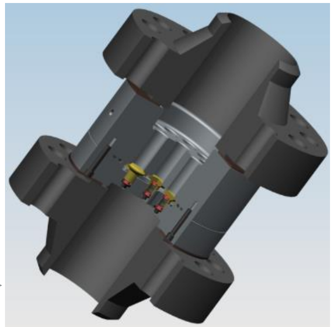


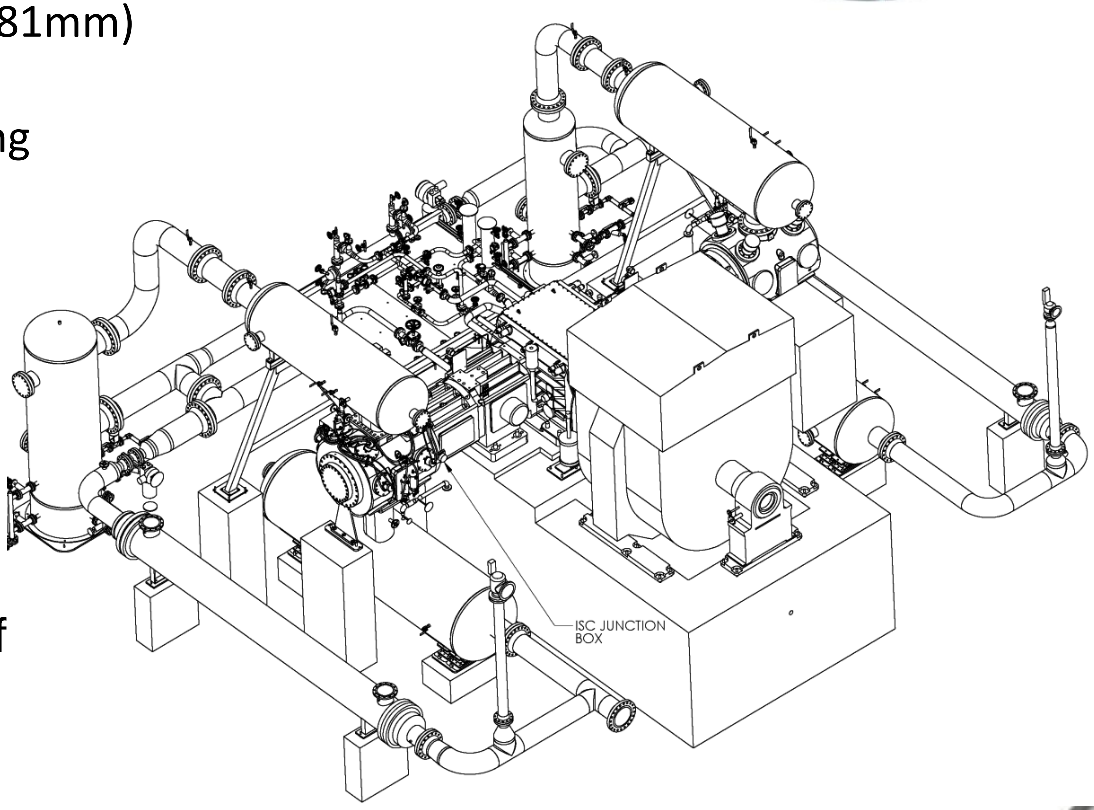
Plate Check Valve



Poppet Check Valve

Case Study #1: Overview
Natural Gas Compressor with Variable Flow

- Two Natural Gas injection two-stage compressors
- Size: 25.50” (648mm) Cylinder + 28.50” (724 mm) Cylinder X 15.00”(381mm) Stroke
  - Stepless unloading system installed on 2nd stage only due to incoming sidestream
- 6000 HP (4.5MW) electric motor driven
- Check Valve: 14” (356mm) 300 lb (136 kg)
  - Originally supplied with plate style compressor check valve



Application:

- Two compressors installed in parallel to provide reliable supply of hydrogen to a refinery
  - One compressor was primary natural gas feed
  - Second compressor was standby unit and operated in recycle flow in case 1st unit shuts down

Case Study #1: Problem
Natural Gas Compressor with Variable Flow

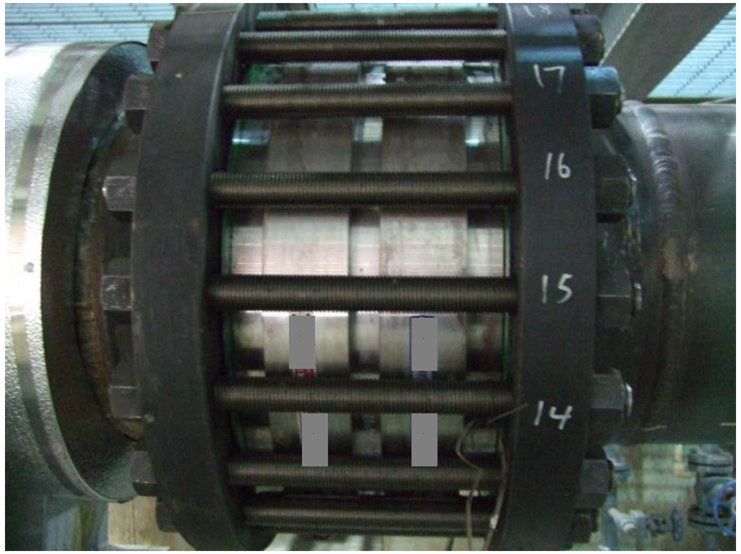
- Planned maintenance interval for compressor equipment: 3-4 years

- Original check valve on the standby unit failed prematurely every 3-4 months

- Check valve was sized for full flow of primary unit
  - Standby unit was operated at reduced flow rate which did not create enough pressure drop through the valve to keep the element(s) open

- Insufficient valve pressure drop caused excessive valve flutter.
  - The valve design was not capable of withstanding the excessive element and spring cycling which resulted in premature failure

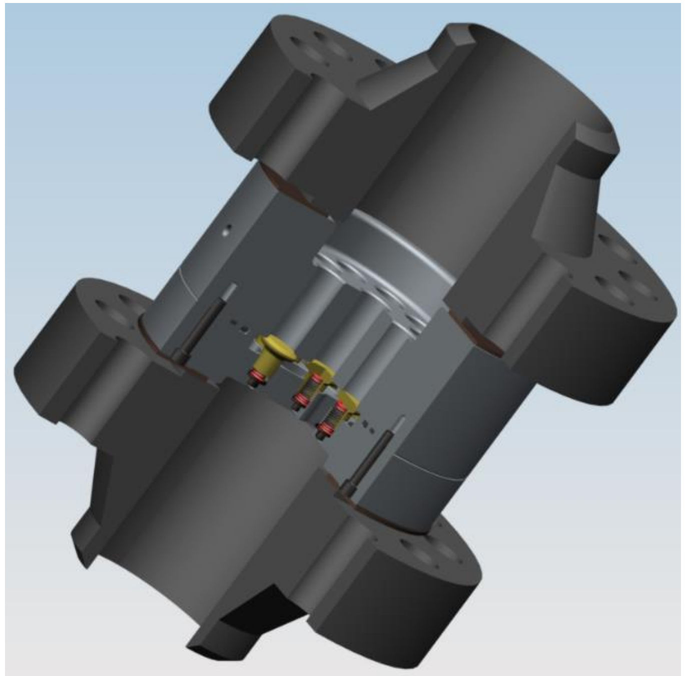
- Check valve failures can cause unplanned pressure relief conditions if the primary compressor tripped. This can prevent client from being able to meet demand since unit is not readily available.



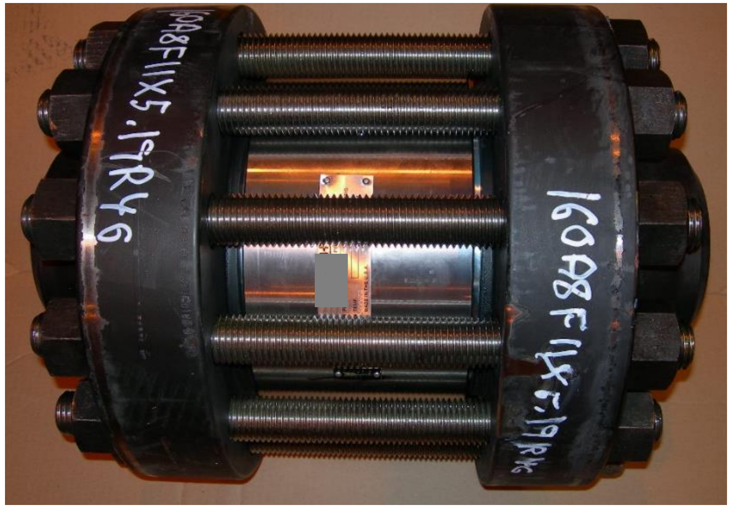
Original Check Valve

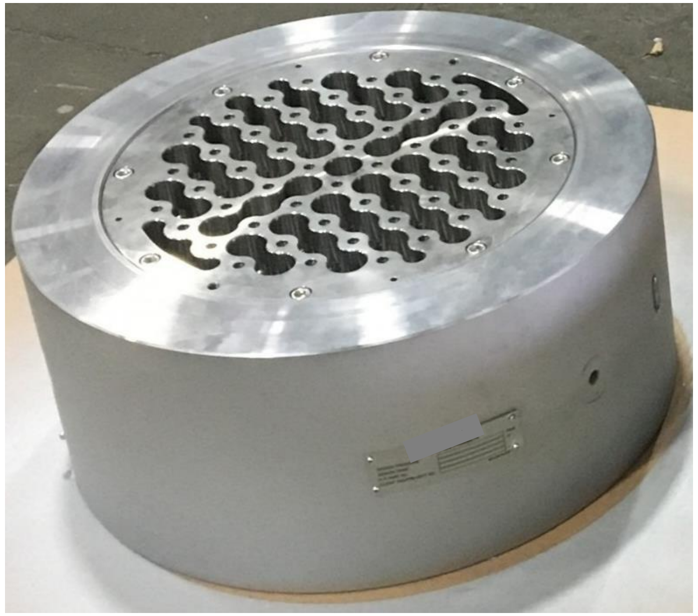
Case Study #1: Solution
Natural Gas Compressor with Variable Flow

- Poppet style compressor valve technology was used to replace plate style
- Valve design considered both primary and standby compressor flow rates
  - Valve flutter existed at standby compressor flow rates



Poppet Style Check Valve Cross Section





Poppet Style Check Valve

Case Study #1: Solution
Natural Gas Compressor with Variable Flow

- One check valve was removed from operation and inspected after 18 months of successful run-time
  - All poppet elements and springs were intact and undamaged
  - Seat sealing surfaces were clean and undamaged
  - Air leak test performed and tested better than when new due to element seating in with sealing bevel

- Check valve has been in uninterrupted operation for over 2.5 years without issues

- Client was able to supply reliable source of natural gas to the refinery satisfying their contract

Case Study #2: Problem
Check Valve in Dirty Service

- Compressor: 13.00” (330mm) Cylinder + 9.50” (241mm) Cylinder x 12.00”(305mm) Stroke Hydrogen Makeup Compressor

- Original plate style check valve clogged after 4-6 months, causing PSV to trip

- Excessive check valve fouling would cause an increase in discharge pressure until the relief valve opened resulting in unplanned compressor shutdowns.

Compressor valves after 27 months of operation

Case Study #2: Solution
Check Valve in Fouling Service

- Compressor valve poppet style technology utilized to improve reliability
    - Large flow areas on seat and stopplate

- Valves inspected after 2.5 years of successful run time

Lessons Learned

- Compressor style valve designs used for check valves are more reliable in reciprocating compressor applications since they are more resistant to pressure pulsations, varying flow rates and debris in gas stream.

- Poppet style elements and springs are designed for high cycle operation and are less prone to failure during high flutter conditions.

- Valves with large flow area like swing and piston checks have low pressure drop and are less prone to fouling. However, they are less reliable due to large masses and not designed for dynamic service that is typical in reciprocating compressors.

- Check valve designs must be customized for the site's specific operating conditions.

Questions?