How and Why Compressor Valves Fail

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What causes valves to fail or operate inefficiently?

Compressor valves significantly affect operating performance, efficiency and the life of reciprocating compressors. Valves open and close with every stroke of the piston. For a 1700 rpm machine, this means about 900 million cycles a year! It's remarkable, not that we have valve problems, but that we have as few as we do. When the valve malfunctions the compressor must be brought down for repair. Whatever improves or prolongs valve life will also improve machine availability and profitability.

Compressor valves fail for a variety of reasons. Causes of failures fall into two broad categories; those caused by environmental effects or abnormal mechanical action. The environment in which a valve operates may contain:

- corrosive elements
- foreign particles
- liquid entrainment and carryover
- improper lubrication
- formation of carbon or other deposits
- temperature extremes

Valves are also subjected to destructive forces that lead to abnormal mechanical action. Tensile and compressive forces, impacts, twisting, bending, abrasion, and erosion can cause the valve to:

- flutter
- slam from delayed closings or other pulsations
- have multiple impacts from excess pulsations
- close late due to very low volumetric efficiency

To determine the root cause of valve failure, our valve service professionals conduct a valve failure analysis. They investigate the physical evidence—deposits, wear, fatigue, and fractures. They work closely with customers obtain complete operational and valve design data to determine whether the failure is due to an inherent operating or maintenance practice or if the valve was poorly selected or manufactured.

Compression efficiency is closely related to valve performance. A valve's efficiency is analyzed over its entire life cycle. Valve studies provide anticipated pressure drops across the valve, and valve losses, for a specific application. The theoretical values obtained from a valve study are used to compare actual operating conditions to determine whether the valve is delivering optimum performance.

Valve efficiency and valve lift are trade-offs. If valve lift is reduced to rectify a mechanical failure, the free lift area is also reduced, gas velocity through the valve increases, and more power is consumed. Lower lift and the resultant decrease in impact forces will extend the life cycle of a valve, but at the price of increased operating losses through lower efficiency.

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It is important to determine the root cause for mechanical or efficiency failure before a cure is sought.

Determining root cause

Solid knowledge of how a valve works is required for a proper diagnosis. Which components move or compress in the opening/closing cycles of a given design? Where must the valve seal when closed? Which surfaces are subject to friction or impact? Careful examination of a worn or broken valve will often disclose the reasons for premature breakage.

Inspect the valve

Carry out inspection in a well-lighted work area. Use an assembly vise to carefully dismantle the valve. Take care to keep the parts of each valve together and do not wipe or clean the component parts before the visual inspection or you may erase valuable clues.

Try to relate wear of the valve to its hours of operation. Compressor valves are expected to operate from one turnaround to the next which may mean as long as a year. But in highly contaminated environments, even 2000 hours of uninterrupted performance may be acceptable.

Examine maintenance records

Maintain records about the frequency and nature of valve failures. Tag the valve with the date of the failure, the compressor location and valve type and the operating hours . Then, describe what failed and any reason you suspect for the failure. Examine the maintenance history and compare it to other identical valves operating in the same gas stream. Often a pattern emerges suggesting proper corrective action.

Develop a diagnosis

The process of determining the root cause of the failure starts with eliminating poor assembly, poor machining, and manufacturing defects.

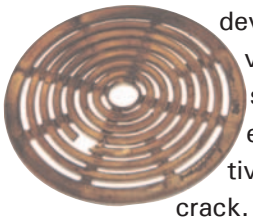
Improper assembly. Was the failure due to improper assembly?Did the components meet manufacturer specifications, assuring that the valve could function properly at an acceptable life and efficiency level?

Quality of repairs. Is the valve performing below par due to frequent repair? improper re-machining? wrong reassembly? Was reassembly performed with poor quality parts? Repairing a valve to rebuild specifications requires adherence to manufacturer's specifications and should be carried out by the manufacturer or an authorized repair facility. Improper re-machining of a seat face...failure to remove burrs after rework...installation of the wrong coil or leaf spring elements...incorrect depth of pockets in the guards, etc. can all affect valve life adversely. Coil springs are an important component of a valve. They control valve timing. Springs should not be tampered with, or replaced with inferior quality products.

Corrosion. If the gas has a substantial amount of corrosive contaminants, look for evidence of stress corrosion like damage to the sealing element (valve ring, plate and springs). Certain compounds become corrosive only if moisture is present in the system, or develops after shutdown. This moisture, in combination with gas contaminants, can corrode valves. A gas sample should reveal whether any of these factors are at work. Hydrogen can cause embrittlement due to molecular penetration of the metal.
To cope with corrosion, upgrade valve plate, ring or spring materials or in severe cases—the material of all valve components. Consult NACE specifications as a guide to material selection.

Foreign material and impurities. Despite proper scrubbing, foreign matter occasionally wedges in the valve and prevents proper operation and ultimately causes damage. Examine the seat lands and impact surfaces of the valve plate for traces of foreign material. Minor indentations and imprints of the particles may show up between the valve plate and seat, too. Make certain separators, knockout pots and drains are working properly and are sized to handle impurities from upstream.

Liquid carry-over. Liquid slugs are



devastating to valves. The plate is subjected to extremely destructive forces and will crack. Slugs occur when entrainments get carried through and are formed when saturated gas contacts the cylinder wall. To prevent liquid carry-over, raise the cooling water temperature 10 or 15 degrees above the incoming gas temperature, as the water enters the cylinder jackets. If liquids are coming from the upstream feed line, check separators to eliminate those liquids.

Improper Lubrication. Excessive

lubrication shortens valve life particularly suction valve life. When valve plates stick, closing is delayed and excessive force slams the valve shut. Excess lubrication resembles liquid carry-over and causes the same slugs as water contamination. Too much lubrication of the discharge valve results in coking, especially if the valve is exposed to higher temperatures. Mineral oils (especially with high ash content) will coke up more readily than synthetic oils.

Abnormal mechanical action. Well-designed valves, with the proper spring load for the application will open and close with no harmful pulsations. However, many valves are standardized for an average range of conditions and when applied outside this range may malfunction.

Spring load. The correct spring load for a valve depends, among other factors, on its operating pressure, the gas velocity, and the specific gravity of the gas. If substantial changes from original design parameters are made, contact the manufacturer and have the valve springs re-engineered. Analyze the surfaces where the sealing elements impact against the seat or guard. If the surfaces have a hammered finish it indicates wear related to multiple impacts.

Pressure pulsations. The fluctuating line pressure caused by pressure pulsations can result in multiple valve opening and closing during a single cycle. The flow of gas to and from the valve is channeled around cages, through cylinder openings and cavities under and above the valve. The uneven distribution of gas flow can cause plate valves to wobble during the opening and closing motion. Multi-ring valves may open unsynchronized; one ring opens first taking the most severe impact and others open later with lighter impact. One ring fractures more frequently than the others.

Taking corrective action

Computer simulation of valve opening and closing provides a rough indication of damage potential in a given application. When lab tests are insufficient, a thorough examination can be made while the valve operates in the compressor cylinder.

Performance analyzers, vibration detectors and ultrasonic leakage detectors provide an in-the-field diagnosis. Preventive maintenance programs will minimize equipment failures and unscheduled downtime. You can minimize the affects of environmental problems by using proper separators to provide pure, dry gas to the compressor. In corrosive environments, select valve material that is specially designed for the gas composition of the application. Lubrication should be applied according to manufacturers' recommendations.

- Inspect the machine regularly while it is operating.
- During shutdowns, perform detailed maintenance inspections of systems and parts.
- Schedule personnel and materials appropriately.
- Keep good maintenance records.

Bringing a compressor down is expensive—not only in downtime, but, more significantly in lost production. A good preventive maintenance program, based on realistic life cycles, will result in minimum losses in production and maximum maintenance efficiency.

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