SEVERN
Superior Valve Engineering

60 YEARS
Engineering Excellence

FROM 44 DAYS TO 15+ YEARS

CASE STUDY

How Severn's intelligent OEM retrofit extended control valve life at Berri Junction

Topline overview

In 2005, Saudi Aramco was facing significant challenges associated with black powder contamination of sales gas transmission pipelines. Some control valves were **failing after just 44 days in service** due to the rapid erosion of internal components. This resulted in excessive downtime and a fundamental lack of process control. In a bid to turn the situation around, Saudi Aramco collaborated with Severn to devise a new specification for pressure control valves (PCVs) deployed in contaminated applications.

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Engineering control valves to handle black powder duty

INDUSTRY
Gas transmission pipelines

LOCATION
Berri junction (Jubail)
Saudi Arabia

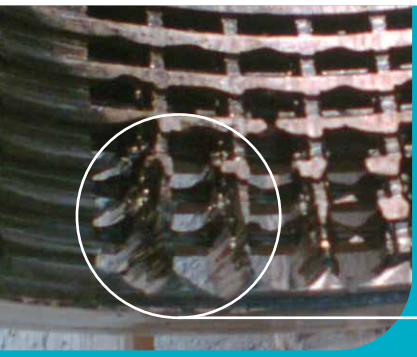
PROJECT
How Severn's intelligent OEM retrofit extended control valve life at Berri Junction

Severn's advanced valve services division was commissioned to develop a highly engineered control valve retrofit solution to meet this specification. The resultant valves were required to handle the rigorous demands of black powder duty under a five-year operational warranty.

Two PCVs were initially selected for retrofit. The combination of the pressure drops they needed to handle and the black powder contamination put them at the extreme end of 'severe service'.

Following the retrofit, the valves delivered immediate performance improvements and remained in **continuous service without incident beyond the five-year warranty period.** When the valves were made available for an inspection after five and a half years, only mild internal erosion was observed and the valves were still functioning within the required performance and safety parameters.

This paper explores the scale of the black powder challenge, the retrofit solution devised by Severn and outcomes achieved. The full report from the routine inspection of the PCVs is also available on request.



Previously, OEM control valves were failing in as little as 44 days.

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What is black powder?

Black powder (the common term for various forms of iron sulfide mixed with contaminants) is the least understood but most prominent contaminant in natural-gas pipelines and compression equipment in pipeline, refinery, gathering, and storage applications. It collects in gas pipelines, creates wear and reduced efficiency in compressors, clogs instrumentation and valves and leads to flow losses.

Its sources have been understood by corrosion engineers, but the problem is not broadly understood in other parts of gas companies where decisions are made that affect the formation of black powder. The material may be wet and have a tar-like appearance, or it can occur as a dry, very fine powder that is almost like smoke.

Black powder can be any of several forms of iron sulfide or iron oxide. It may be mechanically mixed or chemically combined with such other contaminants as water, liquid hydrocarbons, salts, chlorides, sand, and dirt.

Black powder has occurred in both dry and wet lines. Even in parallel lines, one line may show evidence of the problem while the other does not. No known pipeline has been able to eliminate the black powder problem once it has begun.

Iron sulfide is not easily filtered out of the flow stream, and it is pyrophoric (can catch fire) under some conditions.

No clear or universal solutions to eliminate the iron sulfide problem have been determined, but several approaches should aid in controlling it.

Source: Oil & Gas Journal

Olympus Park,
Quedgeley,
Gloucester, GL2 4NF.

T: +44 (0)845 223 2040
E: sales@severnvalve.com

www.severnvalve.com

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The challenge

Saudi Aramco was experiencing rapid control valve failure at some metering and pressure reduction stations due to black powder contamination. This microscopic contaminant ravages internal components when it travels at velocity within the process medium. It can collect in gas pipelines, leading to flow loss and premature failure of equipment. In some cases, PCVs were failing after just 44 days in service.

What's more, the erosion of internal components was causing a serious safety concern due to the risk of fugitive gas emissions via the valve body.

In 2005 Severn was appointed to conduct a detailed technical review of high profile valve failures associated with black powder at the Berri Junction Pressure Reducing Station in Jubail.

WO 20" ASTM 600# PCVS FROM DIFFERENT OEMS WERE PRESENTED FOR STUDY		
	OEM VALVE 1	**OEM VALVE 2**
VALVE TECHNOLOGY	A multi stage pressure reduction trim had been used, with the conventional 'under the plug' flow direction.	A multi-labyrinth disc stack trim design was intended to control the velocity of the gas and with it the black powder to minimise its erosive effect.
PERFORMANCE	The valve was removed from service due to increasing noise and vibration and an inability to control the process.	The valve lasted 44 days, then failed to provide the level of control required at the metering station and was removed from service.
INSPECTION REPORT	The valve trim was severely eroded, passageways had been blocked and the 'inside to out' flow had resulted in severe erosion of the valve body walls.	One section of the stack had been eroded completely, creating a direct path for the gas with no velocity control. The unused areas of the stack (above the eroded section) were blocked with black powder and their ability to pass flow if needed was questionable. However, the 'outside to in' flow direction had prevented body wall erosion.

The inspection concluded that primary failure causes were related to four major factors

1. **Trim material**
2. **Trim & pressure envelope flow passage geometry**
3. **Fluid velocities developed with the pressure let-down process**
4. **Trim flow passage blockage / seizure**

These findings were used to develop a control valve specification addressing the four factors to mitigate risk of failure. Severn was commissioned to retrofit the two OEM valves that had been presented for inspection, in line with the new specification.

The PCVs were deployed in a highly demanding severe service application, exacerbated by black powder contamination. They were subject to strict criteria surrounding maximum noise levels and a high level of rangeability was required. What's more, they had to be supplied with a five-year operational warranty.

The solution

Severn's specialist control valve engineers applied their experience in erosion prevention for sand-laden applications to the black powder challenge. They researched the properties of black powder and overlaid this with specific failure mode information for the two OEM valves and extensive Repair Intelligence associated with control and choke valve erosion. This combination of insight underpinned the development of a customised design to maximise the longevity of the valves.

Olympus Park,
Quedgeley,
Gloucester, GL2 4NF.

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E: sales@severnvalve.com

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Key aspects of the design

- Use of hard materials such as Tungsten Carbide in a combination suited to application characteristics.
- When component size or cost parameters prevented the use of solid Tungsten Carbide, a thick Tungsten Carbide cladding was used. This provides far superior erosion resistance to sprayed Tungsten Carbide coatings typically used for anti-galling in ball valve applications.
- Mechanical containment of the hard, relatively brittle components.
- Control of velocity levels and flow geometry through the trim and the valve body at magnitudes capable of sustaining capacity while reducing the erosion rate. Channelling high velocity media through a tortuous path results in better management of its erosive energy and is only achievable with a globe style valve design.
- New low failure rate manufacturing processes for the large Tungsten Carbide parts.

The trim materials were a variation of Severn's Level 3 erosion resistant trim. Tungsten Carbide components made up the throttling and erosion risk areas whilst other materials of proven durability combined to ensure the five-year warranted operational life was met and exceeded. Valve design and material selection were underpinned by knowledge of actual valve performance, which was fed into the process to create a continuous improvement cycle.

SOLUTION / BENEFIT MATRIX	
SOLUTION	**BENEFIT**
Control fluid velocity	Reduced particle velocity yields high reduction in erosion
Hard trim materials	Erosion resisting materials extend component life
Significantly increased flow path size, simple geometry	Reduces tendency to block More easily 'blown through'
Controlled plug-to-cage running clearances	Minimises axial clearance flow erosion
Maximised balance seal section in durable material	Prevents extrusion Reduces wear Reduces vibration

Both donor valves were successfully retrofitted at an approved third party workshop by local Severn technicians, then tested and commissioned. Severn P-Series 200in^2 actuators were also retrofitted to each valve complete with side mounted hand wheel and instrumentation to provide lock-on air failure.

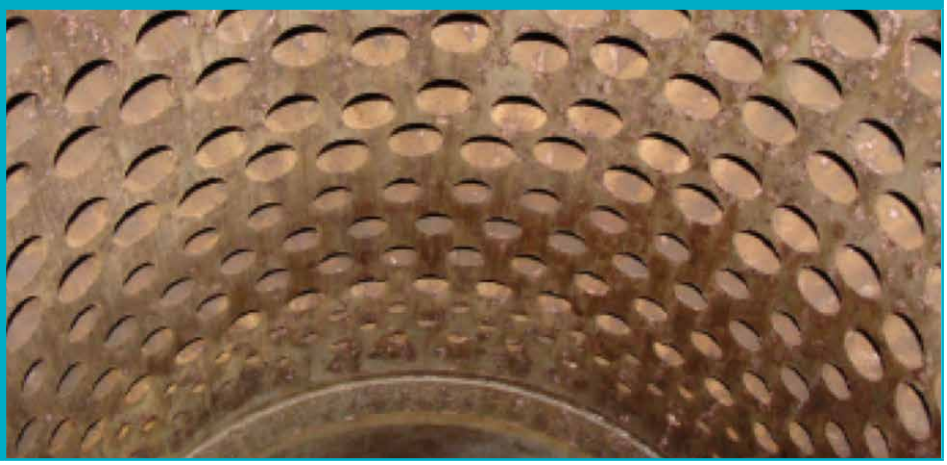
The outcome

In service, the retrofitted PCVs immediately met the required performance criteria. This smoother operation continued for the long term, indicating that internal components were not suffering any adverse effects of erosion.

After five-and-a-half years of uninterrupted service, Saudi Aramco needed to install higher capacity valves and the retrofitted valves were made available for inspection. The following observations were made of the three-cage assembly:

INNER CAGE

Excellent condition with no erosion or degradation. Some black powder was lodged in the holes above the active part of the trim, however it was loosely packed and disintegrated when disturbed.



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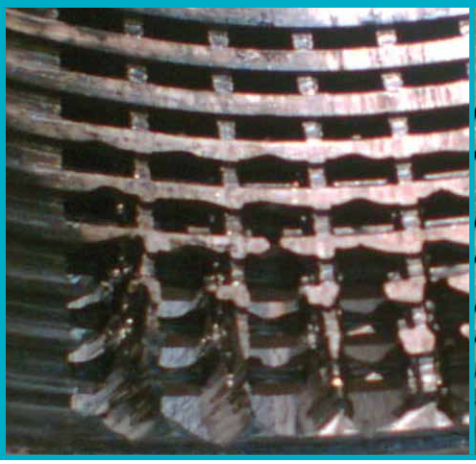
There was evidence of some erosion on both components, but not significant enough to be detrimental to the operation or structural integrity of the cages or their assembly.

OUTER AND MID CAGES

INSPECTION

The inspection provided sound evidence for the efficacy and commercial viability of the valve retrofit design. It extended operational life in this very severe application, ensuring continued gas supply to associated industries and eliminated the serious safety concern linked to fugitive gas emissions via eroded valve body components. Upon completion of the inspection, the valves were rebuilt as found, tested and stored for future use as spare valves by Saudi Aramco.

AFTER 44 DAYS



AFTER 5 YEARS

Conclusions

Black powder is a highly erosive contaminant that can significantly compromise plant safety, integrity and productivity. Ten years ago, Saudi Aramco's most experienced and talented engineers were tasked with finding a solution to mitigate the problem cost-effectively. Severn's highly-engineered, customised control valve technologies enabled them to achieve this goal.

Previously, OEM control valves were failing in as little as 44 days. Likewise, alternative valve types, such as ball valves, would struggle to handle the extreme pressure let-down requirements, and would be unlikely to last longer than six months.

Experience shows that once control of the process has been lost, the impact can be devastating. Intelligently engineered control valves that have a proven track record handling this harsh contaminant are the most viable option.

They deliver on three counts

1. **Minimal downtime**
2. **Maximum productivity**
3. **Better long term cost profile**

About Severn

Engineering specialist Severn is the world leader in black powder control valve applications. It has an extensive, proven track record mitigating the impact of black powder contamination through the custom design and manufacture of highly engineered valves.

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