Top 10 causes of valve failure

Valves are an inherent and vital part of any process plant. From the humble commodity valves used in instrumentation to the most complex control valve. They all serve a purpose, they all cost money, and they all will need to be replaced sometime in the future. Unfortunately, as we all know, unexpected failure can be a major cause for replacement. In this article we will be exploring the top 10 causes of valve failure and some mitigation strategies.

By Davi Correia,

Figure 1 – A jet engine worth around $45 million new fell off a truck. Above, the likely cause, a cheap strap.

1. Specification

It all begins here. There are two ways for a specification to lead to a valve to failure: bad data and lacking data. Bad data refers to poorly selected valve models and materials due to incorrect information. The data sheet was filled out, but the assumptions used are not in agreement with the realities of the process. This is often due to a lack of understanding of the process or of the valve operation.

Regarding the process, the designer may have made the proper selection for the normal operation of the plant, disregarding conditions such as cleanings, shutdowns, and aging that may require different valve characteristics. Misunderstanding the principles of operation for a valve also contributes to failure.

For example, a floating ball valve depends on the ball being pressed against the seat by the system pressure upstream in order to properly seal. The higher the pressure, the higher the force pressing the ball against the seat. A condition leading to a high degree of sealing is full rating pressure upstream and atmospheric pressure downstream (there is no counter-pressure trying to dislodge the ball from the seat). Well, that's what we want, no? Valves sealing? Yes, but let's say that now we need to open the valve. Depending on size and pressure class, this is may be a Herculean task. One that operators around the world may tackle with a cheater's bar, risking damaging the gear box or the valve. Even if the valve is open, high velocity flow during the initial moments of opening may cause damage to the seat or ball. The high friction between seat and ball may also lead to damage. This situation can be avoided with an equalizing line connecting upstream and downstream, so the valve can be opened under less strenuous conditions. This is not a practical solution for every case and maybe the decision is to stick to the ball valve and adapt to its limitations. Regardless of the decision, proper understanding of the principles of sealing behind a valve is necessary. A thorough analysis of every valve in an industrial plant – which may contain thousands of valves – is rarely feasible, but at least for the most critical, this a welcomed procedure. Also, it pays to have feedback from similar plants and see what has been performing and what has not.

As we saw above, bad data is about inadequate information on the data sheet. Lack of data is exactly what the name implies: some lines of the data sheet were left blank and it is up to the supplier or the EPC company to decide what is best for the application. Companies sometimes adopt this strategy in order to reduce the variety of specifications in a plant. If both PEEK and Devlon seats are considered "soft seat" in the specification, the company now has only one reference number for this model, instead of two. The cost of this simplification may or may not be paid with failure. It depends of the complexity of the applications and the quality of the suppliers.

2. Supplier

End users' assessment of supplier quality often depends on the size of the company. Small businesses rarely have the resources for a proper auditing process of possible suppliers, including adherence to quality standards such as ISO 9000, cycling tests, design review and visits to sub-suppliers. They need to rely on field proven solutions or at least buy from reputable manufacturers. Large companies commonly have strict procedures to maintain an AML (Approved Manufacturers List). A full auditing process of a new supplier is a costly endeavor, requiring the involvement of different departments and can be time consuming, frequently taking close to a year. Even after the manufacturer's addition to an AML, simplified auditing visits are still required in order to ensure that quality is being maintained.

Unfortunately, there are times when a project needs to be completed and time constraints require the purchase of a valve from an unproven

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supplier. This is far from an ideal situation, for there is no shortage of examples of valves that look good on paper and fail in the field. It is not always the case of low quality. Sometimes valves with identical specifications have very different performance in the same application, due to slightly different designs or fabrication methods.

3. Inspection

Costs associated with inspection are some of the most scrutinized by managers. A common temptation is to trim expenses when the supplier has a record of valve performance. Well, maybe this performance is a direct result of the resources that were spent in inspection. As the old saying goes: "You do not get what you expect; you get what you inspect".

Examples of valve failure related to shortcomings in the inspection process are not hard to find. An untrained professional sent to review documentation and traceability, perform all the visual and dimensional verifications and witness the pressure tests can be easily overwhelmed by the procedures. There have been cases of suppliers applying petroleum jelly on the sealing surfaces in order to pass a seat test or using measuring techniques that greatly decrease the odds of detecting leakages. Even when dealing with reputable manufacturers, there is still the possibility of approving valves with the wrong dimensions or materials. Training an inspector costs a substantial amount of money and time. It is not a case of simply providing classroom training. There must be mentoring and accompanied inspections of several suppliers in order to properly develop the skills of a good professional.

4. Transport

Transport risks are associated with impact, fall and contamination with water and/or solid particles. They involve moving the valve not only from the manufacturer to the warehouse but also from the warehouse to the final location. Valves should be preferentially transported in their original shipping packaging and properly secured to the vehicle. When they are not, failure is always a possibility. Figure 1 shows a jet engine that fell off a truck while being transported. It is hard to imagine securing a $45 million piece of equipment, weighing some 7000 kg, with a strap for 900 kg. But that is what happened. Another frequent problem is related to the removal of the valve from the original packaging in order to save space while shipping

Figure 2 – Valves with large actuators may need additional bracing. Image courtesy of Babcock Valves.

multiple items. Sometimes, even the protective plastic covers are removed, which leaves the valve internal parts exposed and prone to contamination. Transportation risks also involve rigging and lifting. For adequate procedures, always check the OEM (Original Equipment Manufacturer) manual. A final warning: proper valve transportation is not only a matter of avoiding material losses. It should be mainly a safety concern. Valves are generally heavy enough to provoke fatal accidents and even small valves may become projectiles when unsecured on a moving vehicle.

5. Preservation

Preservation risks are closely related to some of the transportation ones, namely, the removal of valves from original packaging, removal of plastic covers and storage in sun-exposed places, often with detrimental atmosphere. Long storage in offshore installations or sea transportation may require special procedures to ensure adequate preservation.

6. Installation

Proper installation procedures are generally quite well explained in the OEM manuals. It usually starts with rigging and lifting instructions, local cleaning and assembly into the piping. For Ring Type Joint gaskets, cleaning is critical. This type of metal-to-metal gasket relies on smooth surface finish to achieve sealing and such surfaces are easily damaged if proper cleaning is not performed prior to installation.

Special care should also be taken with actuated valves with large actuators, such as the one shown in Figure 2. They may require special brackets or additional bracing in order to avoid fatigue failure due to piping vibration, especially in vertical or tilted installation.

7. Commissioning

Commissioning is a highly specialized activity, which requires intensive planning for the correct execution of tasks such as cleaning, flushing, leak and performance testing. It is the last major step of a project before start-up and often subjected to a lot of pressure from management. In this environment, the temptation for by-passing some verifications and rushing some tasks is immense. Taking aside the obvious safety implications of a botched commissioning, a common cause of failure for valves in this phase is damage by debris left inside the piping. When possible, valves should be installed only after the major cleaning and flushing activities have been carried out. If not possible, keep at least the control valves off the piping and lock block valves in the open position during this phase.

8. Operation

If a valve was well handled during all the previous steps and fails during operation, it is almost certain that it was being used in a way not originally planned or in a way that is not suitable for the valve model. A classic example is the use of block valves, such as a ball valve, as a throttling valve. ▶

Figure 3 - Damage most likely provoked by erosion in a ball valve used for throttling. Image courtesy of Copeland Ball Valves.

Figure 3 shows an example of erosion damage in a valve body that was most likely produced by leaving the valve half-way between the open and closed position. Given enough time, the erosion may even "dig" through the body and cause external leakage.

9. Field maintenance

A periodic inspection is frequently advised for early detection of problems such as corrosion and leakages before they turn the valve useless. Some valve designs are more resilient to being "forgotten" than others, but no mechanical equipment can be expected to function properly after long periods of inactivity. The inspection frequency will depend on the severity of the conditions surrounding the valve, but usually should be around a year. Typical activities conducted during the inspection are cleaning and greasing valve stems in OS&Y (Outside Screw and Yoke), cycling and packing adjustment or replacement. The OEM manual should be a good source for further instructions.

10. Low quality repair

Refurbished valves by companies with no access to OEM parts and assembly methods generally fail more rapidly than the originals. If for some reason a valve should be refurbished, the course of action most prone to deliver good results is to send the valve to the OEM. If this is not possible, then the next best thing is to look for an authorized repair facility, one that was trained and certified by the OEM to perform repairs. Proper valve refurbishment requires deep knowledge of the valve design, tolerances, materials and assembly methods. Even using OEM parts, it is easy to install a soft seat in a trunnion ball valve only to have it ejected in operation due to improper assembly procedures.