Should solenoid valves be classed as commodity items?

For long-term reliability and plant availability, it's better to look beyond purchase price.

Addressing the reliability issue

There are those who view solenoid valves as merely a commodity, and there are those who are interested in long-term reliability. Unfortunately, however, low cost and high reliability may be divergent ambitions when it comes to valves. Engineers seeking operational longevity and high-quality performance should think beyond initial purchase price, as any other strategy is likely to cost far more in the long run.

The technology: The overall reliability of any system in a process plant cannot exceed the reliability of the final link in the control chain. In many cases this final link is the remotely-operated valve that starts or stops the process. Often, these valves are piloted by a "simple" solenoid valve.

A solenoid valve is essentially a device for electrically interrupting or diverting the flow of fluid in a pipe. There are many different types of solenoid valve, but all operate on the fundamental principle of an orifice being covered or uncovered to allow, stop or divert flow. Applications are varied, ranging from valve actuation control for standard on/off and control valves, the control of specialist valves such as High Integrity Pressure Protection Systems (HIPPS) and Emergency Shutdown (ESD) valves, through to the direct control of fluids in applications like fire deluge control or the control of utilities such as steam, water and air. Solenoid valves are also widely used in pneumatic systems and controls. In all cases, reliability of operation is paramount.

The problem: Driven by cost pressures, some engineers and purchasers buy solenoid valves based on price. They specify a solenoid valve that will do its job but mistakenly believe all valves are created equal, thinking that very little can go wrong with these seemingly simple devices that typically comprise of a coil, plunger and sleeve. On that basis people may see the solenoid valve as a commodity item. The reality, however, is far different: a highly-engineered solenoid valve may come with a higher purchase price, but its lifetime costs are far lower than other "commodity" counterparts.

To support the false economy theory, consider a conventionally engineered solenoid valve. These tend to use O-rings as valve stem packing to prevent leakage; a design that has many flaws. The sealing ability of the O-ring reduces over time due to the deterioration of the rubber, subsequently enabling fluid to pass. Contaminants in the fluid or fluid residue are then able to accumulate on the valve stem, causing increased friction. Some designs require a breathing hole to ensure smooth valve stem movement. However, a breathing hole exposes the valve internals to contaminants from the atmosphere, which can also build up on the stem.

All of these facts can lead to slower response times and potential failures. In ESD and HIPPS situations, every fraction of a second is vital. In order to overcome this increased friction, some suppliers will use a stronger spring force so that as the friction increases the valve will still operate. In order to overcome this spring force, a high FFR (Force Friction Ratio) is required, subsequently demanding a higher power solenoid. As the power increases more heat is generated. An increase in temperature can negatively affect the lifetime of the solenoid. In addition to the potentially reduced lifespan, a higher powered coil may also affect installation costs as thicker wiring may be required, or engineers may have to have fewer valves on the same control loop.

Failed solenoid valves result in downtime, with all of its inconvenience and cost. Moreover, what if the solenoid valve is found to be seized in an ESD situation? In extreme cases, it could prove fatal.

Reliability: There are many ways to define reliability, but in engineering terms, it emphasises dependability in the lifecycle of a product. Reliability describes the ability of a system or component to function under stated conditions for a specified period of time without malfunction or failure.

Reliability is, of course, closely related to system safety in that both use common methods for their analysis and may require input from each other. It also focuses on the cost of failure caused by system downtime, replacement parts, repair equipment, personnel and warranty claims.

The coil: One of the most essential parts of any solenoid valve is the coil, which has a significant impact on solenoid valve reliability. The role of the coil is to create a magnetic force that lifts the core/armature to either open (when the valve is NC – normally closed) or close (when valve is NO – normally open). As a result, the coil is fundamental to the operation of a solenoid valve. Without it, the internal components cannot be moved when energised. In other words: if the coil fails, the valve fails.

Some suppliers of solenoid valves will purchase coils from sub-suppliers. These sub suppliers do not have a vested interest in making sure the coils are optimised. They are presented with a drawing and a specification, and they supply to that specification. Other suppliers, however, take responsibility manufacturing of the coil in-house. This enables them to monitor every aspect of the process, improving and innovating – rather than developing a design that then becomes frozen in time.

To produce a reliable coil, its manufacture should be in accordance with IEC 335 standards for electrical devices. Another point to note is that standard coils are available for insulation classes E, F and H. The insulation class determines the coil's maximum operating temperature for a specific life. For instance, according to the European standard IEC 335, Class H coils should meet 20,000 hours at 180°C, while Class F should meet 20,000 hours at 155°C. However, according to the American UL standard, this is 30.000 hours for both Class H (at 180°C) and F (at 155°C). An optimised solenoid valve in this regard will feature a high grade copper wire, thus meeting the most stringent global standards, including UL Class H isolation lacquer, ensuring long life expectancy in practical situations.

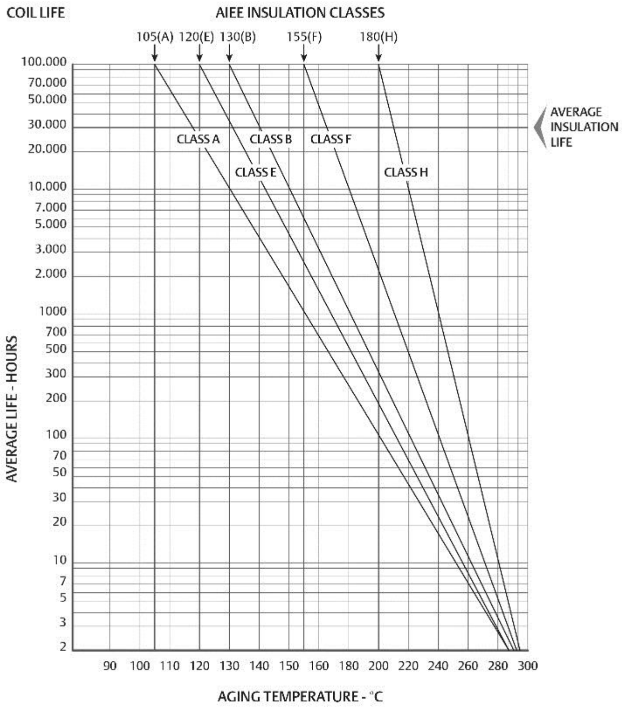


Figure 1: Coil lifetime expectancy

The holy grail of coil manufacture is the "perfect wound" coil. Perfect wound means that the coil winding is totally uniform with each subsequent winding sitting perfectly on top of the one below. A perfect wound coil approaches 100% efficiency and also ensures there is a reduced risk of hot spots, which are potential failure points.

Figure 2: a perfect wound coil

Once the coil has been wound, it should be encapsulated to provide insulation and protection from damage and moisture. Epoxy encapsulation provides the best performance, as it is an excellent isolator and is non-hygroscopic. Ultimately, any coil manufactured for use in a solenoid valve must be designed and tested for continuous service, as well as meet thermal endurance specifications according to IEC 216.

The solution: The design philosophy of any successful solenoid valve should centre on achieving the highest levels of reliability and safety. This is why conventional designs based on O-rings for valve stem packing and breathing holes represent considerable risk.

Instead, innovation is required to develop a reliable solenoid valve, one that is packless, low friction and non-sticking. So, what would such a valve look like? Well, located between the valve stem and body, a special two-layer dynamic seal could be deployed that avoids the use of any rubber which, as already discussed, is prone to perish. The inner layer seal (U-ring) that is in contact with the valve stem, could be made of PTFE and be supported by an elastomer O-ring. The type of elastomer used for O-rings is medium-resistant, would preload the PTFE U-ring and provide static sealing. In combination with a valve stem that is polished to a micron level surface finish, this design would effectively prevent any sticking and minimise friction on the stem.

The risk of sticking would also be reduced by eliminating the need for breathing holes. In short, a non-breathing valve does not allow any ingress of dirt from the atmosphere. As a result, it is more reliable and operates when required to do so.

A design of this nature has a low FFR which eliminates the need for a heavy spring and allows for a low-power (1.8W, 0.5W IS) coil to be utilised. This has many advantages. For instance, when upgrading plant, it means that new solenoid valves can be installed without having to upgrade cabling or add more power supplies. As such, a low power coil makes it possible to do more with the same infrastructure, such as power more devices. An added benefit is that lower power equals lower temperature, which in turn promotes a longer operating life whilst reducing operating costs.

Additionally, quality valves come with “fit for purpose” instruction manuals for installation and maintenance tasks. These manuals also offer advice on how to apply “clean” media and maximise protection via filters and exhaust devices to avoid any ingress of debris that could compromise functionality and/or longevity.

Extreme operating conditions: The reliability of solenoid valves is even more vital in extreme operating conditions. For example, consider valve actuator control in Arctic conditions. It is well documented that the reliability level of solenoid valves reduces as temperature decreases. However, what if an on-site tested cabinet solution could be provided? One that included certified solenoid valves which operate in temperatures as low as -60°C and as high as +90°C.

Similarly, what if a solenoid valve could be designed to operate in corrosive environments, such as those containing sour gas, where sulphide stress cracking is commonplace? Here, any materials for internal and external components would have to be NACE compliant. It is then important to consider high vibration applications. In all extreme operating conditions it is advisable to seek out solenoid valves that offer corrosion resistance and long service life, preferable ones that are certified by recognised industry authorities, such as Exida and TÜV.

The final thing to consider are potentially explosive atmospheres. Here, engineers should seek out solenoid valves that come with a wide range of explosion-proof options and certification which make them suitable for use in hazardous environments, namely ATEX, IECEx, NEMA/UL/CSA, CU TR, NEPSI, PESO, INMETRO and KOSHA.

The Emerson solution: Emerson's ASCO 327 Series is a universal, 3/2, direct acting (balanced poppet) solenoid valve available in multiple variations of materials, power, flow and certification. The valve is suitable for a wide variety of applications, such as actuator piloting, compressor unloading and utilities control, and also as part of a broader offering of engineered solutions that includes actuator control packages, redundant control systems and bypass panels.

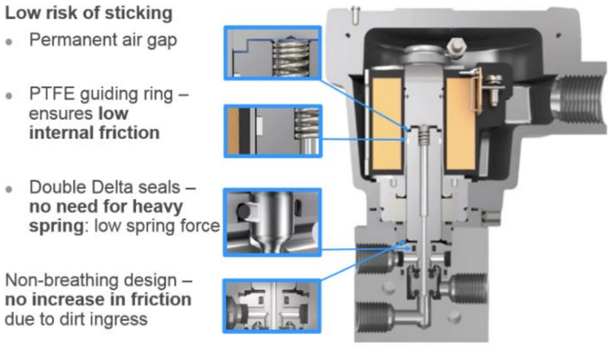
Figure 3: the ASCO 327 series solenoid valves

With its unique design and strong safety accreditation, the 327 Series is a proven safe, reliable and adaptable solution that can withstand even the most demanding environments in the process industry. The valve is explosion proof and exceeds the stringent requirements of the oil & gas sector.

The robust build quality of the 327 ensures reliable operation, while the non-breathing design, unique seal construction and extended coil life make these advanced solenoid valves inherently reliable to ensure the long-lasting safety of the application. Furthermore, each valve coil is designed and manufactured in-house by Emerson.

There are many features of the 327 that are designed to dramatically reduce engineering time and commissioning costs. For instance, the valve's unique under-pressure manual operator (MO) can be removed without isolating the valve or shutting down the instrument air system.

Further benefits include low-power options that reduce the size of power supplies and cabling, NACE-compliant materials that cut corrosion risk, epoxy H Class coils for extreme long life expectancy, inherent vibration resistance, and the presence of a permanent air gap – even when energised – that reduces any risk of sticking caused by residual magnetism.



The outcome: To help outline the benefits of selecting high-quality, reliable solenoid valves, consider an ESD valve piloting application at an oil refinery. For a typical ESD application, the solenoid valve is energised to open the process valve during normal operation. Thus, in the event of an emergency, the solenoid valve must de-energise and close quickly to shut down the process valve. As this type of solenoid normally operates in standby mode for long periods, O-ring ageing and increased friction will slow down its closing response.

To measure the closing response time of a solenoid valve after a period in standby mode, a dormancy test was conducted. The result showed that the ASCO 327 was much faster than the major competitor product, which incidentally had a larger spring return force. Therefore, ASCO valves demonstrate more consistent and reliable behaviour over time than competitor products.

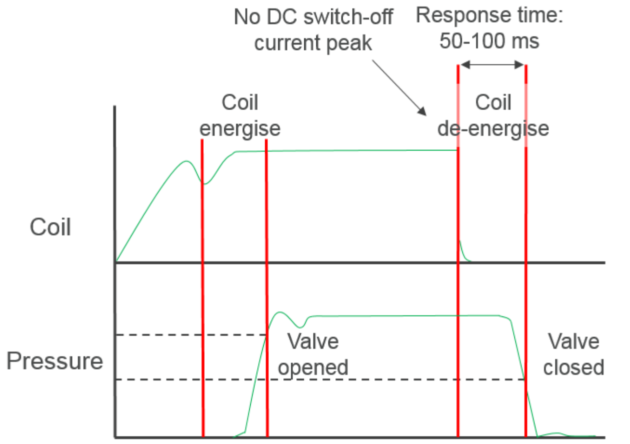


Figure 3: A fast closing solenoid valve increases the safety of your application

In total, more than 1 million ASCO 327 Series solenoid valves have been installed successfully over the course of the past 25 years, a fact that tells its own story.

A major contributor to such impressive success levels is that Emerson laid down the basic architecture for this type of solenoid valve more than 50 years ago, leveraging experience that stretched back over a century ago when the first industrial ASCO solenoid valve was introduced. Each 327 is meticulously manufactured in-house using refined production processes that comply with the highest quality standards.

Conclusion: Shopping around for a low cost commodity solenoid valve will seem like a good deal in the first instance. After all, some engineers simply view valves as open/close devices for interrupting or diverting flow in a pipe. However, for those who want to be certain that their solenoid valve will open or close instantaneously when required, even after a long period in standby, highly engineered solutions are the only choice.

Find out more by visiting www.asco.com, sending an email to enquiries.asco.uk@emerson.com or calling +44 (0)1695 713 600.

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