Important specifications for selection

Right Solenoid Valve for an Application

Solenoid valves are usually considered an accessory in the process valve industry; however, while there is some truth to this, these accessories are crucial to the proper operation of any system that uses them.

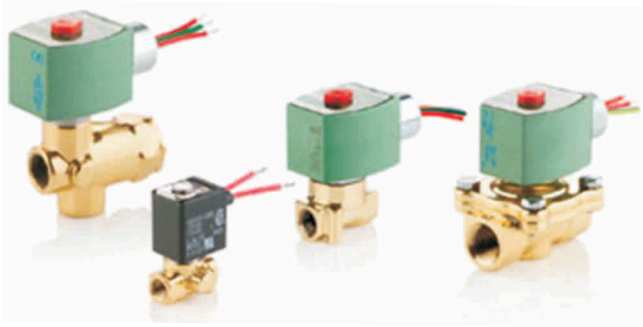

Figure 1. 2-way solenoid valves used to start and stop the flow of media in a pipe train

The solenoid valve has many features that need to be considered when creating a specification. Eight specification points should be addressed to correctly choose the right solenoid valve for an application. These specification points are:

- **Type**
- **Operation**
- **Media**
- **Size**
- **Pressure**
- **Atmosphere**
- **Voltage**
- **Extras**

More information on these eight points is included in this article.

TYPE

The type of solenoid valve refers to whether that valve is a 2-way, 3-way or 4-way. A 2-way valve (Figure 1) has two port connections-a pressure or input port (port 1) and an outlet port (port 2). These valves are used to stop the flow of a fluid or start the flow of a fluid in a piping configuration. Usually, a 2-way valve is referred to as a 2/2 valve, which means the valve has two ports and two positions. The positions are: 1) on or energized and 2) off or de-energized.

Three-way valves (Figure 2) are those that have three ports-a pressure or inlet port (port 1), a cylinder port (port 2) and an exhaust port (port 3). A 3-way valve's most common application is for process valve automation. The solenoid valve sends air to a spring return actuator or cylinder, which creates rotational or linear movement to open or close a process valve. In this case, the media is usually compressed air or gas that is creating work, which is where the term "fluid power" is derived. The power of

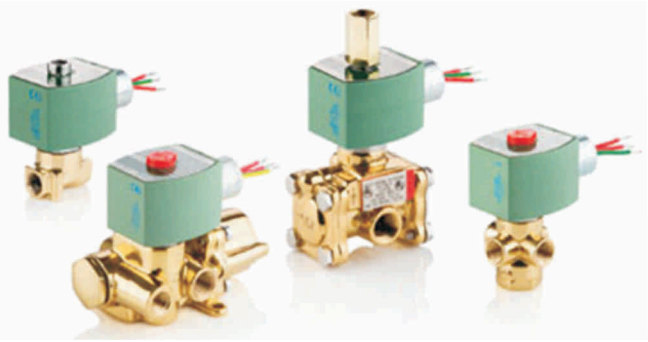

Figure 2. Basic 3- and 4-way valves typically used for process valve automation

a compressed gas or pressurized liquid is controlled to create mechanical work. Three-way valves are usually referred to as 3/2 valves-they have three ports and two positions.

Four-way valves (Figure 2) can have four or five ports-a pressure or inlet port (port 1), two cylinder ports (ports 2 and 4), and one or two exhaust ports (port 3 and possibly a port 5). The exhaust ports can either have both cylinder ports sharing a common exhaust port or have each cylinder port with its own exhaust port. This valve's primary use is also for process valve automation. For double-acting or non-spring return actuators and cylinders, a 4-way valve must be used. Air flow in a 4-way valve is more complicated than air flow in some other types. For example:

- In cases where the valve is de-energized or off: The pressure port to cylinder port 2 is open while cylinder port 4 to exhaust is open.
- In cases where the valve is energized or on: The pressure port to cylinder port 4 is open while cylinder port 2 to the exhaust is open.

Since the actuator or cylinder does not have a spring on one side, it must rely on fluid power from a 4-way valve to open and close. Four-way valves can be referred to as 4/2 or 5/2 valves, and they can have four or five ports and two positions.

There are other configurations such as the dual solenoid, fail-in-last-position, 3/3, and 5/3 solenoid valves, but explanations are best left for another article.

OPERATION

Operation is a word used to describe if a valve is normally open (NO), normally closed (NC) or universal (U). NO and NC refers to the state of a 2-way solenoid valve when de-energized or off. NO, NC or U is used to describe the state of a 3-way valve when it is de-energized or off. Below is a table that describes operation modes of 2-way and 3-way valves.

These operational modes do not apply to 4-way valves since a 4-way functions the same as two, 3-way valves where one is NC and the other NO.

MEDIA

Media are the types of fluid that flow through the valve. Typical solenoid valve media are air, inert gas, fuel gas, water, oil and steam. Media are a very important consideration in solenoid valve specification because the materials of the valve must be compatible with the media. If the valve internal materials are not considered, internal corrosion can take place.

Media temperature also is an important consideration, and in selecting the right valves, it is useful to know what minimum and maximum media temperatures are. High temperature media such as steam can have adverse effects on the valve's coil temperature rise.

Regardless of what the media are, however, the valves need to be clean and free from debris left from piping installations. When using a valve with a gas media, such as compressed air, installing a filter before the inlet of the valve is recommended. When using a valve with liquid media, a strainer is recommended. In all cases, installers should check with the manufacturer for recommended filtration values, which should vary depending on the specific solenoid valve used.

Miniature solenoid valves are used in medical device and scientific applications.

SIZE

Size may seem obvious when choosing a solenoid valve, but a few considerations need to be noted

Valve Type	NC Operation	No Operation	U Operation
2- Way Solenoid Valve De-Energized	1 to 2 Closed	1 to 2 Open	Not Applicable
2-Way Solenoid Valve Energized	1 to 2 Open	1 to 2 Closed	Not Applicable
3-Way Solenoid Valve De-Energized	1 to 2 Closed, 2 to 3 Open	1 to 2 Open, 2 to 3 Closed	Enter pressure at any port. Can be Used as No, NC or diverter valve*
3-Way Solenoid Valve Energized	1 to 2 Open, 2 to 3 Closed	1 to 2 Closed, 2 to 3 Open	Enter pressure at any port. Can be Used as No, NC or diverter valve*

1* Pressure Port 2* Cylinder or outlet port 3* Exhaust Port
*A diverter valve is used to divert media from 1 port and toggle the flow between the 2 other ports

beyond a pipe thread connection. Size has a direct effect on media flow, a fact that is not determined by pipe size but by the size of the orifice in the valve that the media must flow through. Flow requirements can be specified in any of the following units: gallons per minute for water or liquids, standard cubic feet per hour for gases, pounds per hour for steam. However, Cv (Imperial Flow Coefficient) and Kv (Metric Flow Coefficient) are by far the most common method of specifying valve flow. Care should be taken when specifying flow-solenoid valve manufacturers are not consistent in the way they test and rate the flow of the valves. If flow is a crucial part of a specification, it is best to test that flow in the application before making a final selection.

PRESSURE

Pressure rating of a valve is the maximum differential pressure applied into the pressure or inlet port when the valve orifice is closed that the valve can withstand without significant leakage. But there's more to the situation than that. This maximum pressure is usually tested at the valve's minimum-rated temperature and the valve's maximum-rated temperature for a large number of cycles. This is another point of inconsistency in the valve manufacturing world. Not every maker pressure-rates solenoid valves the same way. If the valve has third-party approval, there is consistency; however, if there is not a requirement for third-party approval such as UL, not all valves are equal.

The main differences between manufacturers' pressure ratings are factors of safety. If maximum pressure is a crucial specification point, those specifying should check with the manufacturers to see how they rate their products. Be aware that many valves have minimum pressure ratings as well- you must have at least a specific amount of pressure for the valve to operate correctly. This is most common in low-power pilot valves. For these valves, air pressure is used to create movement in the valve. Without this minimum pressure, the valve can be energized, but nothing will happen. If a minimum pressure is not specified, the application should be checked to ensure that the minimum system pressure will not fall below the solenoid valve's rated minimum pressure.

Table 1.A Sample of Global Hazardous Environment Requirements

North America

- NEC (National Electric Code)
- Class/Division or Zones
- UL (Underwriters Laboratories)
- CSA (Canadian Standards Association)
- FM (Factory Mutual International)
- CRN (Canadian Provinces) (Canadian Registry Number)
- ATEX - Aex (Atmospheric Explosive)

European Union

- IEC (International Electric Code)
- ATEX Ex Zone 0, 1, or 2
- Method of Protection
  - d (Explosion-Proof Enclosure)
  - Ia (Intrinsic Safety
  - m (Encapsulation)
- Gas group
- Temperature Code

Outside North America and European Union

- IEC (International Electric Code)
  - IECEx Zone 0, 1, or 2
  - Method of Protection
  - INMETRO (Brazilian Approvals)
  - GOST (Russian Federation Approvals)
  - KOSHA (Korean Approvals)
  - NEPSI (Chinese Approvals)

ATMOSPHERE

Atmosphere encompasses a few areas critical to valve selection. These areas are ambient temperature, ingress protection and environment.

Ambient temperature ratings really need close attention to maximize the life of the solenoid valve. The minimum temperature rating depends on the mechanical operation of the valve as far as what elastomers are used in static and dynamic sealing areas. The maximum temperature rating of a solenoid valve is usually limited by the coil. The higher the ambient temperature, the more difficult it is for the coil to dissipate heat, and the more inefficient the coil becomes. Remember that temperature of the media will affect the heat dissipation ability of the coil as well.

Ingress protection is a term that defines a coil's ability to withstand external ingression of dust and water. The most common coil ingress protection rating is Type 4, 4X in North America or

IP-65 in Europe. Type 4, 4X means the coil or coil enclosure is watertight, dust-tight and corrosion-resistant. IP-65 means dust-tight and able to withstand 6.3 mm nozzle water jets from any direction. These ratings are given not only to coils, but to electrical enclosures.

Environment of a solenoid valve can refer to the media in the environment that may affect the external parts, such as the humid, salty air present on the gulf coast of the United States. In the case of the gulf coast air, the valve body material would most likely be a series of stainless steel such as

316L.

A common mistake in solenoid specifications is choosing an internal elastomer based on external environmental conditions. Most of the time, a valve's elastomers are internal only and are only affected by the media inside the valve. In other words, if 316L stainless steel is chosen for a valve in a salt-laden environment, choosing a fluoropolymer elastomer when the valve is used for instrument air may not be needed. The fluoropolymer might typically be specified because of a user's perceptions regarding corrosion resistance, but it might be an unnecessary expense.

Environment can also mean media in the atmosphere such as acetylene that may cause an explosion if ignited by a spark or heat. This area could be addressed in an entirely different article because hazardous environment requirements are truly a place where "the devil is in the details." An abridged version is given in Table 1.

There are so many nuances and details in making sure the correct agency approvals are obtained that even the most experienced people make mistakes. Such decisions, however, are usually part of the user specification. The plant in which the user is installing the equipment will already have received designations of the required approvals and methods of protection. Some users have multiple areas designated within each plant with different approval requirements depending on the media that could or would be present in those areas of the plant. These decisions have to be made when the plant is designed, and they are reviewed by the appropriate safety officials and insurance companies. However, hazardous environment considerations are an area of major expense for end users and for solenoid manufacturers. The initial cost to get approvals is just the beginning of that cost. Next come regular plant inspections, file fees and paperwork change charges.

VOLTAGE

Voltage is a simple, but still vital part of the specification process. It merely is the voltage of the system to which the valve is wired. Most coils are designed per UL requirements to operate at +10% to -15% of the rated voltage because of normal voltage fluctuations in the line or from the source. However, care is needed with voltage range tolerances, because all coils are not designed this way. The information needed to determine coil design is in the valve manufacturer's installation and maintenance sheets or catalog information. When specifying voltage do not assume that the manufacturer knows whether voltage requirements are AC or DC. When specifying DC voltage, the letters DC should be written out after the voltage value: as in 24/DC. When specifying AC voltage, the frequency should be included (For example: 120/60 or 230/50).

A solenoid valve manifold is used for fluid power and process valve automation applications. One manifold can contain several 3- and 4-way solenoid valves together.

EXTRAS

The extras category in specification points can mean just about anything. For example, if something like extra-long lead wires, manual operator, mounting bracket, manual reset, functional safety data, certificates of compliance, low power or bus system compatibility is added, it can be mentioned under "extras." Many extra features are possible, but not always available on every solenoid valve. Those specifying solenoid valves need to use this category to list what's not listed in the other categories.

Many areas must be considered when selecting solenoid valves. A catalog cannot answer all the questions because there are many optional features that may not be included. To be sure the right valve is selected, list specific considerations along with quantities and needed lead times. What is not optional needs to be outlined. If some flexibility in the specification exists, options can be recommended, which is especially helpful when lead times are crucial. A good technical support representative can not only find a valve that meets specification needs, but be able to find one that can be delivered in desired time frames.

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