About Solenoid Valves

Solenoid valves and solenoid water valves are electrically operated devices that control the flow of liquids. Solenoid valves are electro-mechanical devices that use a wire coil and a movable plunger, called a solenoid, to control a particular valve. The solenoid controls the valve during either the open or closed positions. Thus, these kinds of valves do not regulate flow. They are used for the remote control of valves for directional control of liquids. Solenoid water valves have two main parts: the solenoid and the valve. After the coil receives a current, the actuating magnetic field is created. The magnetic field acts upon the plunger resulting in the actuation of the valve, either opening or closing it.

Solenoid valve manufacturers produce two general types: direct-acting and pilot-operated. Direct-acting solenoid valves have a plunger that is in direct contact with the primary opening in the body. This plunger is used to open and close the orifice. The pilot-operated solenoid valve works with a diaphragm rather than a plunger. This valve uses differential pressure to control the flow of fluids. The air-venting valve is opened to allow the pressure to equalize and permit the fluids to flow through.

Solenoid valve manufacturers design their products for many applications. Their most common use is as solenoid water valves, oil valves, gas valves, steam valves, solvents valves, cryogenics valves, air and vapors valves, as well as many other applications as hydraulic valves and pneumatic valves. Typical environments for solenoid valves are in medical and biomedical equipment, analytical instrumentation, semiconductors, HVAC and other industrial OEM environments. A unique feature that solenoid valve manufacturers equip their products with is an automatic triggering from remote locations by different voltages, making them useful in rough or hazardous locations.

Important items to consider when looking at solenoid valves are proportionality, linearity, frequency response, repeatability, power consumption, leakage, life expectancy and cost. With so many types of solenoid valves and other related valves, the application requirements are very important. Because solenoid valves are designed to perform operations, ranging from water valves, air valves, pneumatic valves, or used in applications such as ones to restrict, meter and maintain the flow of liquid and gaseous materials, they are widely used in vastly different fields and industries.

Types of Solenoid Valves

- 2-Way solenoid valves **are used for hydraulic and pneumatic applications. 2-Way solenoid valves have two ports called pressure and service ports.**
- 3-Way solenoid valves **are for hydraulic and pneumatic applications. 3-Way solenoid valves have three ports, one being the pressure port, one the tank and the last, the service port.**
- Air solenoids **are control air flow in a pneumatic system.**
- Air valves **regulate the release of air.**
- Hydraulic solenoid valves **use fluid pressure and are ported through the return line to the reservoir.**
- Miniature solenoid valves **fit easily into a small area and also measure or dispense small amounts of material. Mini solenoid valves are particularly useful in medical applications.**
- Plastic valves **are primarily used in applications that involve corrosion or chemicals.**
- Pneumatic solenoid valves **are similar to the hydraulic version**

in that they both use pressure. However, the return port of a pneumatic valve, which uses air, is exhausted to the atmosphere.

- Proportional solenoid valves **have direct-acting control valves with linear characteristics. Proportional solenoid valves control accuracy, hysteresis and repeatability within close tolerances.**
- Rotary solenoids valves **have three bearing balls that ride on an inclined plane and turn linear motion into rotary motion. The magnetic arrangement permits direct rotational motion.**
- **Solenoid water valves** are electrical devices that control water flow.

Solenoid Valve Selection Guide

Solenoid valves are used in many common industrial applications such as automatic faucets and automatic flush toilets, refrigeration machines, dental and medical equipment as well as commercial washing machines. But how do you go about selecting the right solenoid valve to meet the requirements of your application ? Here are some brief guidelines.

Key determinants in the selection process:

1. Flow rates
2. Inlet and outlet pressures
3. Types of valves
   - pinch valves
   - diaphragm valves
   - brass valves
   - piston valves
4. Available electrical power
5. Temperature requirements
6. Overall system design

FLOW RATES are important in determining the size of the valve needed. Inlet and outlet port sizes typically vary from 1/8" to 3" and are usually threaded. The higher the flow rate needed, the larger the valve. The fine adjustment is the orifice inside the valve. A typical valve comes with a number of orifice size options depending on the required flow rates and working pressures as well as the purity of the fluid being delivered. Both the flow rate and the resulting pressure drop are interrelated. The flow rate increases with the square root of the increase in pressure differential. Each valve has a defined flow curve and the flow coefficient (Cv) can be calculated to measure the flow rate of specific fluids.

lNLET AND OUTLET PRESSURES are also critical to performance. Most solenoid valves will operate at pressures up to 200 psi. Direct acting valves have a fast response time but a limited to a 1/2" maximum flow orifice diameter. This is because the force to open and close the valve equals the orifice area times the pressure. The greater the surface area or pressure, the greater the force required. For larger orifice valves, a piloting mechanism is needed. In this case, the solenoid only opens and closes the pilot orifice, which bleeds fluid behind the seal of the primary orifice, causing it to open. Usually a 5 psi pressure differential between inlet and outlet is needed for effective operation.

The TYPE OF FLUID is critical in determining a valves construction. The valve body can be brass, nickel plated brass, stainless steel or plastic. The seal can be various elastomers: NBR, EPDM, PTFE or FPM. Corrosive fluids require stainless steel or plastic bbodies as well as PTFE or FPM seals. If no direct contact with the fluid is desired, a pinch valve can be used. Pinch valves will squeeze 1/8" - 3/8" OD silicone or similar hardness tubing. The tubing should be approximately Shore A 55 hardness. The pinch force determines the power (wattage) of the solenoid . The valves are panel mountable and can be latching. Latching means the valve can be held open or closed for a preset time by a permanent magnet. Reversing polarity terminates the latch.

Diaphragm valves (also known as isolation or dry valves) are used where limited contact with the fluid is desired. These valves contain a diaphragm that can be made from EPDM, silicone or Viton ruubber. The valve bodies are either plastic or stainless steel. The fluids wet only the valve body and the diaphragm. These valves are typically lever assisted direct acting. The valves contain a low dead volume and are cleanly swept by fluids. A three way version provides three ports: inlet, outlet and common. Maximum working pressures are 40 psi. The response time is about one to two seconds, which can prevent the water hammer effect in plumbing systems.

When the fluid is a non corrosive water, steam, refrigerant, oil or gas, brass is recommended. These valves can be direct acting or internally piloted depending on pressures and flow rates. They can also be two way and three way. Brass can be nickel plated to provide increased corrosion resistance with lower cost than a stainless steel valve.

For high pressures (up to 290 psi) and high temperatures (up to 360 degrees F), a piston valve can be used. These valves are operated by using compressed air to actuate a piston connected to the main seal. They are typically used in industrial applications because of the broad flow ranges, robust construction and seal integrity.

AVAILABLE ELECTRICAL POWER is a key determinant in valve selection. Some applications require low power consumption DC (AA batteries) and others high voltage AC. Voltage ranges from 24 to 240 VAC and 12 to 48 VDC. Typically medical or laboratory instruments need minimal heat build up so lower power consumption is desirable. Vending machines operate on low voltage due to the safety requirements of the field service technicians. Most coils have connector pins but also can have flying leads.

TEMPERATURE REQUIREMENTS of a solenoid valve are determined by the seal material. NBR and neoprene are operable at media temperatures from -20 to +90 degrees C, PTFE from -45 to +200 degrees C, EPDM from -30 to +155 degrees C and FPM from -10 to 150 degrees C.

THE OVERALL SYSTEM DESIGN is very important in solenoid valve selection. A normally closed (NC) valve is opened when energized. A normally open (NO) valve is open and flowing without power and closed when energized. Some valves have a manual override. Others can have a flange design or can be mountable on a manifold.

Power management boosts solenoid-valve performance

Next-generation solenoids draw less power and produce more force.

Solenoids have long been used to control valves and fluid flow. A typical solenoid converts an input voltage to magnetic force that attracts a moveable core which, in turn, opens or closes a valve. Different size solenoids provide specific flow and pressure ratings, and are often customized to meet customer requirements.

Despite their proven use in fluid-control applications, the downside is that most solenoids do not have power-management capabilities — and this wastes energy. That's because solenoids require a lot of power to open a valve but substantially less to then hold the valve open. But today's solenoids are designed to continuously draw maximum power, and most of the time the excess power converts to heat.

Normally a solenoid valve opens in a fraction of a second and then is left on for several seconds, minutes, hours, or even days. A typical application involves a flow-control valve where a solenoid is energized for 10 min while a tank fills. The solenoid requires 10 W for the first 60 msec and then only 2 W to hold the valve open. But because it draws 10 W continuously, the solenoid wastes 8 W of power for virtually the entire operating cycle.

RedHat Next Generation solenoid valves have built-in power-management capabilities.

Next-generation solenoids with electronic power-management capabilities eliminate this drawback. An ASIC (Application Specific Integrated Circuit) built into the solenoid provides a simple timing function. It permits high in-rush current for the 60 msec needed to shift the valve, and then throttles back power to the level required to hold the valve in place.

An obvious benefit is that this can substantially reduce power consumption and cut operating costs. Equipment manufacturers can also downsize power supplies and switching devices to save money without sacrificing safety or performance.

Power management offers several other advantages. One is that it substantially increases dc pressure ratings. Manufacturers often prefer 24 Vdc because it is safer and wiring simpler than 120 Vac. But in the past users often had no choice but to use ac solenoids that produce higher forces and can operate higher-pressure valves. Force output is directly related to temperature rise in the coil, and dc ratings are generally one-fourth to one-third that of ac ratings. For example, an ac solenoid valve might be rated for 150 psi and 140*F maximum ambient temperature, while a comparable dc valve would be rated for only 40 psi and 104*F.

Because a power-management circuit minimizes temperature rise in the coil, efficiency improves dramatically. The result is dc pressure ratings that now meet or exceed ac levels.

This particularly benefits users of fieldbus-controlled devices. Ac produces interference on dc communication lines, so as users migrate to fieldbus controls, ac signals must be carried on separate lines or shielded from the communication lines. A dc system eliminates this headache.

Another benefit involves inductive loads. De-energizing a solenoid causes the magnetic field to collapse, which in turn causes an induced voltage spike to oppose the change in current. This inductive voltage spike travels through the power line and can damage solid-state or mechanical switches. Users often add an RC "snubber" circuit to protect the switch.

Asco has found that power-management circuits attenuate the inductive spike before it leaves the coil. Switching devices do not see an inductive load, extending life and reliability and eliminating the need for snubber circuits. For example, the company's Next Generation solenoid valves effectively increase switch life by up to four times.

Housing the power-management circuit within the solenoid protects the electronics from the environment — whether harsh chemicals, washdowns, or rain and sleet. And it makes the transition to next-generation solenoids transparent to the user. The solenoid platform also offers other electronic benefits, such as bus communications and the flexibility to add control, safety, and diagnostic capabilities in the future

Solenoid Valve Terms

Analog Position Sensor – Position sensor whose voltage output differs through various values.

Bubble-Tight Sealing – A circumstance in which there is no leakage of air from between the internal sealed ports of the valve, whether in the energized position or not, in a five second time period. Soap bubbles are used to detect leakage.

Closed State – A situation in which the tubing is pinched in the valve.

Coil Voltage – The maximum voltage to which the coil must be energized for the valve to achieve its highest specified capacity.

Continuous Duty – Energizing a solenoid valve at a constant level of power for its entire on-time.

Current Drain – The quantity of current in amperes flowing through a solenoid valve coil when it is energized.

Cycle – The normal opening and closing of a valve.

Cycle Rate – The measure of how many times a valve is able to open and close within a set period of time.

Duty Cycle – Proportion of time that the solenoid receives power.

Flow Control – A feature that allows for the manual reducing or controlling of flow.

Flux Plate – Magnetic steel plate that helps transmit magnetic flux in the magnetic circuit of a solenoid valve from the enclosure to the sleeve construction. A flux plate is necessary on valves with a body construction consisting of a non-metallic body.

Frequency Response – Changes with the output variable in steady-state conditions, caused by a sinusoidal input variable.

Gain – Association of input to output or the sensitivity of a device.

Hysteresis – The variation between up-scale and down-scale outcomes in equipment response, when exposed to the same input from the opposite direction.

Normally Closed – A term that refers to a valve that is closed when unenergized.

Normally Open – A term that refers to a valve that is open when unenergized.

Open Loop – A system in which direct feedback is not supplied to gauge the response.

Position Sensing – Employing electronic sensors to watch the position of the valve and provide electronic feedback.

Pulse and Hold – Increases function of solenoid valves by reducing power consumption and heat generation. The valve is opened and held open at decreased power.

Pulse Width Modulation (PWM) – A technique that utilizes a modulated wave function to control analog devices.

Repeatability – The ability of the equipment to generate consistent results on successive tests.

Stroke – The space the plunger covers during a state change.