Flow control that's safe and sound

Hybrid actuators are a good choice when operating valves in hazardous locations.

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Key points:

- Standard solenoid valves pose an ignition danger near hazardous materials.
- Valves with pneumatic and magnetic actuators require no electricity, making them inherently safe in hazardous locations.

Resources:
PneuMagnetic LLC,
www.pneumagnetic.com

On/off flow-control valves are the traffic lights of piping systems, controlling movement of air, gases, and liquids. Most common is the packless solenoid valve. It generates a magnetic field that penetrates the valve body to open and close the flow-blocking element. This eliminates the need for a seal (packing) between the inside of the valve and external mechanical drive. The compact, leakproof, reliable design has only one moving part. And technicians can install and replace solenoid coils without opening or disturbing the piping.

However, using solenoid valves in hazardous locations requires special consideration of the environment and power requirements. Here's a look at valves for hazardous applications, and how to upgrade standard solenoid valves with pneumatic/magnetic actuation.

Classifying hazards

Designers specifying solenoid valves in hazardous locations must first determine the type and level of risk through a systematic-hazard analysis. General concerns for electrical installations include fire, explosion, and shock hazards. The **National Fire Protection Assn.**'s NFPA 70 (NEC), NFPA Article 500, NFPA 496, and **American Petroleum Institute**'s API RP 500 specify classifications and requirements for electrical systems in hazardous areas in North America.

Areas are classified by hazardous substances (such as *gas* or *dust*); exposure probability (for example, *flammables always present*); and flammable materials. Different protection levels are required based on this classification system.

Also consider nonelectrical hazards, including potential environmental contamination from fluids. When specifying valves to control noxious or hazardous fluids, pay attention to potential leaks from valve seals, typically packings around mechanical-control elements. These leaks can result in anything from nuisance housekeeping issues with water or oil to full-blown safety hazards

from ammonia or chlorine.

Long-term system integrity is also important. Consider how maintenance affects integrity and safety. And even if installed and maintained per code, what is the likelihood incidental impact, abrasion, or chemical attack will affect long term safety?

Valve actuation

Solenoid valves dominate the marketplace. They come in a tremendous variety from many manufacturers. They are compact, easy to connect to controls, and operate at high speeds over long distances. But in hazardous applications electric-valve operators, by their very nature, are potential fire and explosion initiators.

That's not to say that electric valves cannot operate safely in hazardous areas. But design requirements are exacting and can be expensive. (See the accompanying sidebar, "Fire and explosion-protection systems," for more details on explosion-proof, intrinsically safe, and purged systems.)

All-pneumatic valves for fluid control are simple and reliable. They eliminate fire and explosion hazards by removing the hazard initiator: electricity. This makes them desirable for use in hazardous locations.

Pneumatic-control signals come from pilot valves located in nonhazardous areas. Small-diameter flexible tubing, either metallic or plastic, carries the air signals, minimizing space requirements in and around equipment. Pneumatic-control lines are also not as susceptible to compromise or likely to produce secondary safety impacts, compared to electrical control signals.

Pilot valves are considerably less expensive than intrinsically safe (IS) barriers and, with today's ultraclean control-system air supplies, they can often mount inside electric-control enclosures without posing corrosion risks for the electronics. In addition, manifold-mounted pilot valves provide high density and small footprint for multivalve applications. Even larger-C_v pilot valves typically take up less space than a bank of IS barriers. Pilot valves do not have the restrictive wiring requirements of IS barriers which yields even more space savings. Added up, pneumatics becomes a cost-effective solution to valve installations in hazardous applications.

Pneumatic actuation is also well suited for continuous-valve cycling. Unlike electric coils in which excessive heat from rapid cycling can hasten failure, pneumatics can cycle continuously with no ill effects. The lack of coil heating can be a benefit in applications that have thermal restrictions for the process fluid or surroundings. In addition, there is no hum, as with ac coils.

Although most solenoid-valve suppliers sell pneumatic versions of their products, the breadth of offerings is typically much narrower, especially in sizes below 1 to 2 in. Most pneumatic alternatives are larger than electric valves of the same capacity.

Pneumatic process valves can have a variety of different actuators, mountings, and seals. Type of actuation deter-

Flow-control valves used in potentially flammable or explosive settings generally require expensive explosionproof or intrinsically safe protection. Valves with pneumatic-magnetic actuators may be a better option.

The PneuMagnetic actuator is a drop-in replacement for the OEM coil on direct-acting solenoid valves and requires no valve modifications. It provides the same powerful on/off magnetic field as solenoid coils with the same control of flow. The design needs no packing or fluid seal between the valve actuator and body, which eliminates leakage issues.

mines how pneumatic pressure and flow are converted to mechanically operate a valve. For low-C_v valves, strokes are short and convoluted diaphragms often provide force and stroke directly without any sliding action. Larger-C_v valves, which use piston actuation, are for applications that require longer strokes or smaller packages.

Magnetic actuation

Probably the biggest drawback to pneumatic valves is that most require a mechanical link between the pneumatic actuator and flow-control element. And this element requires a seal, commonly a packing or O-rings, to keep fluids from escaping. Bellows and diaphragm seals are also used, but these tend to be costly and bulky.

As noted earlier, fluid seals are a prime source of environmental contamination and can present a safety hazard. Magnetically coupled valve actuators eliminate this headache. These self-contained pneumatic-magnetic devices use pneumatic force to shift a tubular-shaped permanent magnet which, in turn, drives the valve armature with the same magnetic force a solenoid normally provides.

Because a magnetic, not mechanical, connection shifts the valve, there is no need for a packing or fluid seal. This eliminates leaks inherent in other valves.

An inexpensive air pilot using a small-diameter, flexible pneumatic line shifts the magnetic valve — much the same as with traditional pneumatic-actuated valves. No electricity, wiring, conduit, or intrinsically safe barriers are required.

The PneuMagnetic actuator from **PneuMagnetic LLC,** for example, is a drop-in replacement for the OEM coil on direct-acting solenoid valves and requires no valve modifications. It provides the same powerful on/off magnetic field as solenoid coils with the same control of flow.

In fact, dc-solenoid valves typically have lower pressure capabilities than their ac versions. Advances in rare-earth magnets let PneuMagnetic actuators operate at the same valve pressures as equivalent ac versions. Rated life is at least 7 million cycles.

Because PneuMagnetic actuators fit directly on solenoid-valve bodies, this makes a wider range of valves available to the system designer. For instance, actuators currently available fit several major brands of solenoid valves.

Hybrid systems

Another option is to combine the benefits of IS and pneumatics. This can be a robust and cost-effective way to control valves in hazardous locations. Several suppliers offer IS pilot valves and IS I/O systems that carry high-

Fire and explosion-protection systems

The three most common ways to protect electric systems are explosionproof (EX), purged, and intrinsically safe (IS). Each has its pros and cons.

Explosionproof

EX systems protect by enclosing all wiring and wired devices within suitable piping and enclosures. This prevents any internal explosion from releasing gases, sparks, or flames which could ignite hazardous substances outside the enclosure. EX is a low-tech, durable approach to providing electric power to classified areas. High levels of electric power can be protected using EX, but it is expensive in both material and labor. It's also expensive and difficult to modify and maintain.

Solenoid coils rated for EX service cost more than standard versions. In addition, EX circuits consume a relatively large amount of space because every valve must have a rigid, sealed conduit connection for providing electrical power. This conduit must be routed through the equipment and plant until it terminates in a nonclassified (safe) area. And conduit must carefully connect to the valve coil so there is no undo strain on the valve bonnet. This often requires a hazard-rated slip-joint fitting or expensive flexible conduit at the valve-coil connection.

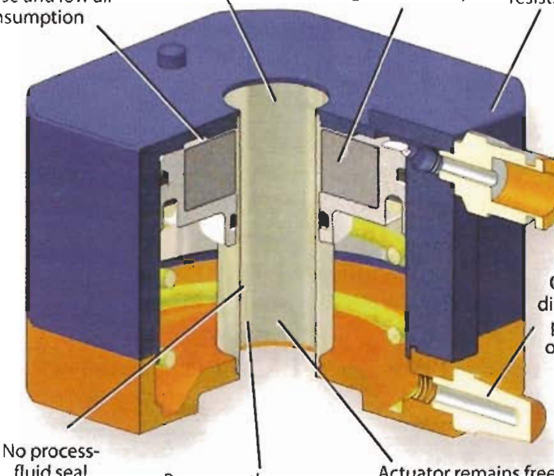
Wiring within the conduit must be sealed with a flame barrier (concretelike filler sealing wires within its own special conduit fitting) to prevent flame propagation. So, in addition to the fluid pipe, there is a second pipe/conduit to contain the wiring. Further, EX systems cannot be serviced without securing the substances which make the area classified. This puts the process out of service during maintenance.

Purged systems

Purged systems use a controlled and monitored air or inert gas to keep the electrical system under higher pressure than ambient. This prevents external flammables from leaking into the conduit and enclosure where they can be exposed to ignition sources.

This avoids the need for total system sealing, as with EX, but still requires conduit as well as secure and monitored purging hardware. As with EX, purged systems cannot be serviced without securing the substances which make the area classified.

Pneumatic-magnetic actuator



Magnetically coupled valve actuators use pneumatic force to shift a tubular-shaped permanent magnet which, in turn, drives the valve armature. An inexpensive air pilot using a small-diameter, flexible pneumatic line shifts the valve — much the same as with traditional pneumatic-actuated valves. No electricity, field wiring, conduit, or intrinsically safe barriers are required.

speed, long-distance control signals. Pneumatic outputs make a final short connection to the valves and, thus, provide low-cost valve actuation and control.

Combined with magnetically coupled valves, this hybrid design takes the best from both technologies and, in many installations, offers the highest performance at the lowest installed cost.

Making choices

When using valves in hazardous environments, design choices come down to balancing performance, cost, and reliability. Explosionproof (EX) and purged systems are still the only real choices for high-power devices like motors. But for valves, they are costly to install and maintain and severely limit flexibility for future changes.

IS solves the space issues of EX and provides significant installation savings for long runs and multidrop valve applications. Cost per node for barriers and IS-rated valve coils can be high but it provides fast, long-distance valve actuation and simple field wiring.

Pneumatics provides the flexibility and ease of installation of IS without stringent wiring requirements and at a lower cost per node. And with pneumatic systems, there is no fire/explosion initiator.

Magnetically coupled actuators on solenoid-valve bodies provide pneumatic operation of packless valves. It provides the safety and economy of pneumatic valves, as well as the diverse selection of solenoid valves, without process-fluid seal-leakage problems. Magnetically coupled actuators also let designers use the same valve body for both hazardous and nonhazardous applications by exchanging the coil for the magnetic actuator. This saves money because separate inventories do not have to be maintained for hazardous and nonhazardous-valve applications. **MD**

Intrinsically safe

Intrinsically safe designs avoid the labor and space-consuming conduit of EX and purged systems by keeping the valve electric-control-signal power at a level too low to initiate ignition. It requires special low-power/low-energy coils; electronic barriers that provide isolated low-power connections to the classified area; and wiring that protects the intrinsic circuit from noncontrolled power.

There is a cost trade-off, however, because IS valve coils, barriers, and enclosures all add significant costs. In short-distance applications with few valves, IS may be more expensive than EX or purged systems. But for long runs, crowded physical space, or multidrop valve applications, the savings can be substantial.

From the outside, an IS system looks as simple and uncluttered as a nonhazardous installation. Control equipment is located remotely in nonclassified areas and wiring to valve coils uses plastic-jacketed cable about the size of LAN cable. Valve coils can be slightly larger than standard coils, but otherwise, the field wiring looks unremarkable. There are, however, special wiring requirements.

- IS cables cannot be run in raceways with non-IS conductors unless secured to maintain at least a 2-in. separation or separated by a continuous, grounded partition.
- IS and non-IS circuit conductors must be separated by securing conductors to maintain at least 2-in. separation.
- Separate compartments or enclosures are preferred for separating IS and non-IS circuits.
- IS conductors must be labeled over their entire length to identify them as such. Light-blue color coding may be used in lieu of labels as long as this color is not used for other non-IS circuit conductors.

Engineers must not mix IS and non-IS circuits. And different IS circuits must also be protected from each other, though this is usually straightforward.

Typical installations have a separate enclosure (which does not have to be rated for classified areas) for housing IS barriers and wire terminations. Wiring within this enclosure must be secured so that loose wires from protected and nonprotected sides of the barriers cannot touch. The goal is a complete physical and electrical barrier between protected and nonprotected circuits.

When servicing IS systems, technicians must maintain all the protection requirements. This is especially true of the wiring restrictions. Unlike EX systems, IS systems can be serviced without having to secure the substances which make an area classified.