HEED THE WARNING

Optimizing plant performance requires more than running within alarm limits

AVOID BAD Turns WITH
ROTATING EQUIPMENT

CHLORINE PROCESS
PARES POWER USE

OUTSIDE OF OPERATING ENVELOPE

BATCH PROCESSING GETS A BOOST
RETHINK PROCESS SEALS
Many process plants handle hazardous gases or liquids in high-pressure vessels and piping fitted with instrumentation. Because of safety and legal concerns, the hazardous materials must not migrate from the process into the instruments’ wiring systems.

For the past 20 to 30 years, the chemical industry primarily has relied upon conduit and cable seals to provide this protection. However, this method doesn’t always work very well, as pointed out in a 2008 paper [1]:

“Experience has shown that conduit or cable seals do not provide the necessary protection to prevent the migration of process fluids under pressure through the wiring system. Despite this, the CEC [Canadian Electrical Code] and NEC [National Electrical Code] process seal requirements have been largely ignored… The exception is in Alberta, where healthy economic activity in the oil and gas sector and the cooperative efforts of the regulator and industry has heightened awareness of the issue.

In other words, today many process plants aren’t correctly implementing the traditional process sealing guidelines defined within the NEC and CEC. Even sites that do comply often are spending inordinate amounts of time and money because they aren’t taking advantage of a simpler solution now available.

Endress+Hauser and other process instrument manufacturers now integrate certified process seals directly into their devices, negating the need for additional cable and conduit sealing in certain applications. So, in this article, we’ll look at techniques for process sealing, and explain the concept of integral process sealing.

CONCERNS WITH SECONDARY SEALS
Conduit and cable seals (Figure 1), also known as explosion-proof seals, are designed to prevent the passage of hazardous fluids and flames from one portion of an electrical installation to another. A conduit seal is a small junction box in the conduit run filled with an epoxy material that seals both ends of the wiring bundles. Wiring repair or replacement requires installation of a new seal. A similar seal also can be installed with a cable.

An electrical device installed in an area classified as hazardous also should be isolated from pressurized processes by a primary process seal (Figure 2). One side of that seal contacts process fluids at normal operating conditions. So, failure of the primary seal can subject conduit or cable seals to the process pressure and, thus, may result in transmitting explosive gas or vapor to unclassified areas. Article 501.5(F)(3) of the NEC requires that where devices with a single primary seal are installed: “an additional approved seal, barrier or other means shall be provided to prevent the flammable or combustible fluid from entering the raceway or cable system… if the primary seal fails. The additional approved seal or
barrier and the interconnecting enclosure shall meet the temperature and pressure conditions to which they will be subjected upon failure of the primary seal, unless other approved means are provided to accomplish the purpose...”

A note to Article 501.5 warns: “Unless specifically designed and tested for the purpose, conduit and cable seals are not intended to prevent the passage of liquids, gases or vapors at a continuous pressure differential across the seal: Even at differences in pressure across the seal equivalent to a few inches of water, there may be a slow passage of gas or vapor through the seal. Temperature extremes and highly corrosive

### Table 1. Integral seals are the latest option but many users aren't familiar with them.

<table>
<thead>
<tr>
<th>Process seal approach</th>
<th>Advantage</th>
<th>Disadvantage</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double block and bleed</td>
<td>Well-understood installation approach.</td>
<td>Installation not NRTL safety certified to specified working pressures and temperatures. Seals not rated for process pressure service. Sealing of crimped spade/ring type connectors with epoxy required.</td>
<td>Two external explosion-proof seals, connecting hardware. Engineering and labor to install. Explosion-proof drain required. Cost may be $180 to $300 plus other wiring conduit.</td>
</tr>
<tr>
<td>Mineral insulated cable</td>
<td>Addresses the potential for pressurized gas and liquids to migrate though the wiring into the electrical system. Conduit not needed.</td>
<td>Comparatively more expensive installation. Installation is permanent; wiring repair or replacement may require installation of a new cable.</td>
<td>Depending on the size and number of conductors, a single termination can take between 1 to 2 hours’ labor. Cost may be $100 to $400.</td>
</tr>
<tr>
<td>Venting junction box</td>
<td>Well-understood installation approach using readily available components.</td>
<td>Not NRTL safety certified to specified working pressures and temperatures; no third-party recognition of the safety/suitability of a design/installation. Junction box placement and size must be engineered for the hazardous material and pressures. As shown by “vented box” experiments, this solution does not work as well as originally thought.</td>
<td>Junction box, mounting hardware, engineering and installation labor. Cost may be $150 to $275.</td>
</tr>
<tr>
<td>External process conduit seal</td>
<td>May be NRTL safety certified to specified working pressures and temperatures depending on version. Some versions can be provided with seal-failure detection alarms.</td>
<td>Wired in the field with additional components at extra cost.</td>
<td>Seal package, mounting hardware and installation labor. Cost may be $150 to $300.</td>
</tr>
<tr>
<td>Wiring feed-through process seal</td>
<td>NRTL safety certified to specified working pressures and temperatures depending on version.</td>
<td>Vent needed between transmitter housing and seal requiring additional components.</td>
<td>NRTL certified seal with high-pressure-rated potted feedthroughs. Cost may be $75 to $125 plus required conduit connection hardware.</td>
</tr>
<tr>
<td>Certified ANSI/ISA 12.27.01 integral process seal (marked “dual seal” or “single seal”)</td>
<td>NRTL safety certified to specified maximum working pressure (MWP). Can eliminate several external secondary seal requirements and associated junction boxes, conduit seals and glands. Standard wiring used. Connections can be installed and deinstalled quickly.</td>
<td>New &quot;single seal&quot; and &quot;dual seal&quot; ratings not yet widely known. Transmitters may use one of several acceptable seal failure mechanisms that still may not match current plant requirements for every application.</td>
<td>Process seal function included in the transmitter usually at no additional cost so arguably the lowest cost installation and reinstallation (field replacement of transmitter).</td>
</tr>
</tbody>
</table>
liquids and vapors can affect the ability of seals to perform their intended function.

The CEC also mandates a secondary seal (Figure 2) in the electrical conduit, cable and wiring systems leading to the safe area: "Secondary seals shall be provided between devices containing a primary seal and conduit or cable seals where failure of a single component in the device containing the primary seal could allow passage of process fluids."

TRADITIONAL APPROACHES

Plants long have relied on several sealing methods for electrical cable and conduit in hazardous areas [2]:

**Double block and bleed.** This approach combines two explosion-proof conduit seals with a venting tee connection between them. The first seal stands between the process and the electrical system and is expected to leak if exposed to unexpected high pressure. The leaking gas or liquid vents to atmosphere or a collection/monitoring system. The second seal, which should be under less pressure, acts as the secondary barrier for the electrical system and, thus, keeps gas and liquids from going farther.

If stranded wiring is used, gas and liquids under pressure can migrate though the wiring. The crimped/spade connectors on the process side must be sealed by epoxy to prevent entry.

**Venting junction boxes.** These boxes function similarly to the double block and bleed arrangement. Instead of a venting tee, the enclosure itself is vented. It is expected to allow fluid or gas that may enter from the process connection under high pressure to dissipate to atmosphere while preventing the flow of fluids into conduit and wires leaving the enclosure.

The challenge to successful use of a vented enclosure is ensuring the vent is sized and designed to an essentially zero atmosphere pressure differential in the enclosure at the maximum pressure the cable may face.

**Mineral insulated (MI) cable.** Such cable sometimes is used to provide a barrier to pressurized gas and liquids migrating into an electrical system. The metal sheath and solid mineral filling make an MI cable mechanically robust and resistant to impact — it can be struck repeatedly with a hammer and still provide adequate protection for a circuit. An MI cable won’t allow propagation of an explosion and isn’t likely to initiate an explosion even during circuit fault conditions. Metal sheathing won’t contribute fuel or hazardous combustion products to a fire and can’t propagate a fire along a cable tray or within a building.

While the MI cable is very tough, at some point each run of cabling requires termination, typically at a junction box in an electrical room. These terminations are vulnerable to fire, moisture or mechanical impact.

**Certified external process conduit seal.** These
specialized field-installed seals are warranted to prevent gases or fluids under continuous pressure from migrating through the electrical system. They suit process areas that store, process or transport fluids under pressure.

**Wiring feed-through process seal.** Explosion-proof feed-through receptacles — sometimes called ultra-high-pressure seals — provide a safe and efficient way to implement explosion-proof protection in Class 1, Division 1 and Class 1, Division 2 hazardous areas. The seal is fully potted with a force-resistant compound that also provides a barrier to gases or liquids migrating though the wire strands. It installs directly in standard conduit entries in explosion-proof enclosures without requiring a poured seal, conduit or extensive wiring.

All these traditional seal solutions work when properly engineered and installed. In some cases, however, plants simply don’t spend sufficient time and money to design and install what can turn out to be a relatively expensive and complex system.

For example, installing MI cable is a very time-consuming manual process. The cable can crack if bent repeatedly during installation. It requires a minimum bend radius and support, and can’t be installed where vibration is present. Moreover, it needs protection if chemical damage is possible. MI cable not only is much more expensive than a standard PVC-sheathed armored cable, but also takes about 65% longer to install.

To some companies, the cost of a failure can make all such costs irrelevant. Others may take the risk. Fortunately, integral process seal devices provide a way to address this potential hazard, while at the same time reducing installation and maintenance costs.

**A NEWER OPTION**

Integral sealing built into process-connected devices such as flow meters and pressure transmitters can provide best-practice process seal safety. Integral sealing beats traditional secondary sealing solutions in a number of ways.

First, integral sealing is safer because the factory-installed seals undergo more-thorough inspecting and testing than practical with field-installed cable and conduit seals. Second, built-in sealing is less expensive because no special design and installation requirements or additional field engineering and external components are needed. Finally, integral sealing follows the superior practice of managing the migration of process fluids at the source, as opposed to mitigating them within the electrical system.

The NEC now recognizes instrumentation with integral process seals.

In 2003, ISA introduced a new standard, “Requirements for Process Sealing Between Electrical Systems and Flammable or Combustible Process Fluids,” ANSI/ISA 12.27.01, to deal with process seals [3]. It defines two types of protection: a “single seal” device and a “dual seal” device (Figure 3).

A single seal rating requires more rigorous testing than the dual seal one. In addition to fatigue cycling testing at the extreme rated temperatures and pressures, specific leakage and burst pressure tests confirm the single seal’s integrity under the process temperature and pressure ratings.

The dual seal rating assumes that if the primary seal fails under process conditions, a second internal seal will withstand the process pressure and temperatures for a short period of time. A primary seal failure is signaled by a designed venting of the process gas/fluids (after one minute) or by some kind of non-venting indication (after one minute).

The NEC now recognizes instrumentation with integral process seals.

The very robust single-seal device construction and testing requirements in the standard are intended to eliminate the need for a second seal. The dual seal requirements recognize that less-stringent primary seal requirements could result in a failure and, therefore, include a redundant or second seal
to compensate. This may cause some confusion in that the “single seal device” defined in the ANSI/ISA standard does not require a secondary seal.

Nationally recognized testing laboratories (NRTLs) are certifying “single seal” and “dual seal” devices. Equipment listed to the ANSI ISA 12.27.01 standard and marked either “single seal” or “dual seal” (Figure 4) provide acceptable means of preventing the migration of process fluids under pressure through the wiring system. Both options are considered to have a negligible probability of failure.

What all this means is that if you use integrated seals, you don’t have to provide any additional external conduit, cable, primary or secondary process seals. NEC 2011 517.17 says that process-connected electrical equipment that is listed and marked “single seal” or “dual seal” doesn’t require an additional means of sealing.

Table 1 shows the advantages, disadvantages and costs of the various process sealing methods. The maximum working pressure (MWP) is defined for each single seal or dual seal device.

Integral sealing, available in devices from many process instrumentation manufacturers, outperforms traditional cable and conduit seals in terms of safety, cost and long-term reliability.

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