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CONTROL ENGINEERING

Inspecting instruments installed in hazardous locations

A difficult, time-consuming, and expensive task is made much simpler with wireless instruments to relay information from flow, pressure, temperature, level, and other field transmitters.

A major trend in process industries is the increasing use of wireless flow, pressure, temperature, level, and other field transmitters. While these instruments are widely used to provide inexpensive, easy-to-install measurements in unclassified areas of process plants, they can also be used in hazardous locations (Figure 1). This article explains the difficulty, time, and expense involved when installing and maintaining traditional two-wire or fieldbus transmitters, and shows how wireless transmitters avoid almost all those problems.

Figure 1: *Installing and maintaining wired instruments in a hazardous location can be difficult and expensive. Wireless transmitters can solve these problems. All graphics courtesy: Emerson Process Management*

Hazardous requirements

Many strategies exist for safety in process installations. The simplest strategies to minimize risk in a hazardous area are to keep instrumentation out of the area altogether, or make the area less hazardous through process improvements.

But when instruments must be installed in hazardous areas, all of the wiring must be installed and maintained to the relevant standards to prevent an ignition of explosive environments. The costs of protecting wired 4 to 20 mA and fieldbus instruments in hazardous areas are significant.

Field transmitter wiring requires wiring, conduits, cable trays, field junction boxes, and marshalling cabinets. If the instrument is 4-wire, it must have separate power wiring. All wiring systems must meet the requirements of IEC 60079 for the type of protection that the circuit is certified for. This could be "EX ia" for intrinsically safe, "Ex d" for explosion-proof, or one of the other types of protection permitted.

Installing these wiring systems can be quite expensive, but costs don't stop with installation as initial and periodic maintenance are required to ensure that the protection level is being maintained. IEC 60079 covers inspection of electrical equipment in hazardous areas. IEC 60079-14 requires that an initial inspection must be carried out when the equipment is first installed. IEC 60079-17 says the interval between inspections shall not exceed three years without seeking expert advice.

Although complete inspections have to be done at least every three years, the grade of inspection and the interval between inspections should take into account the type of equipment; that is, some devices may need to be inspected more often than every three years depending on the environmental conditions of the installation. Continuous and visual inspections, as defined below, should be done on a regular basis, or whenever maintenance work is done in the area. Close and detailed inspections may require opening enclosures and using specialized tools so such inspections can be done during shutdowns or when the area is safe.

There are four grades of inspections defined in IEC 60079-17:

Key concepts

- Installing traditional instrumentation in hazardous areas involves wiring infrastructure that can be very expensive.
- Many wireless field instruments are suitable for installation in hazardous areas, without that infrastructure.
- Wireless devices also avoid the need for regular wiring inspections.

Table: EC 60079-17 Inspection Schedule for EX "i," "iD," and "nL"

Check That:		Grade of inspection		
A	**Equipment**	**Detailed**	**Close**	**Visual**
1	Circuit and / or equipment documentation is appropriate to the EPL/Zone requirements of the location	X	X	X
2	Equipment installed is that specified in the documentation - Fixed equipment only	X	X	
3	Circuit and / or equipment category and group are correct	X	X	
4	Equipment temperature class is correct	X	X	
5	Installation is clearly labelled	X	X	
6	Enclosure, glass parts, and glass-to-metal sealing gaskets and / or compounds are satisfactory	X	X	
7	There are no unauthorized modifications	X		
8	There are no visible unauthorized modifications		X	X
9	Safety barrier units, relays, and other energy-limiting devices are of the approved type, installed in accordance with the certification requirements, and securely earthed when required	X	X	X
10	Electrical connections are tight	X		
11	Printed circuit boards are clean and undamaged	X		
B	**Installation**			
1	Cables are installed in accordance with the documentation	X		
2	Cables are screened and earthed in accordance with the documentation	X		
3	There is no obvious damage to the cables	X	X	X
4	Sealing of trunks, ducts, pipes and / or conduits is satisfactory	X	X	X
5	Point-to-point connections are all correct	X		
6	Earth continuity is satisfactory (e.g. connections are tight, conductors are of sufficient cross-section) for non-galvanically isolated circuits	X		
7	Earth connections maintain integrity of the type of protection	X	X	X
8	Intrinsically safe circuit earthing and insulation resistance are satisfactory	X		
9	Separation is maintained between intrinsically safe and non-intrinsically safe circuits in common distribution boxes or relay cubicles	X		
10	As applicable, short-circuit protection of the power supply is in accordance with the documentation	X		
11	Compliance with specific conditions of use (if applicable)	X		
12	Cables not in use are correctly terminated	X		
C	**Environment**			
1	Equipment is adequately protected against corrosion, weather, vibration, and other adverse factors	X	X	X
2	No undue external accumulation of dust and dirt	X	X	X

1. Continuous supervision—defined as frequent attendance, inspection, service, care and maintenance of the electrical installation by skilled personnel who have the knowledge and skills to maintain the equipment in accordance with IEC 60079-17 Clause 4.5.

2. Visual inspection—an inspection (Figure 2) that identifies, without use of access equipment or tools, defects that would be apparent to the eye, such as missing bolts or damaged cables.

3. Close inspection—defined as an inspection that encompasses aspects covered by a visual inspection and identifies defects that are apparent only by the use of equipment and tools, such as loose bolts or damaged cable glands.

4. Detailed inspection—defined as an inspection that encompasses everything covered by a close inspection and identifies defects that are only apparent by opening the enclosure and using tools and test equipment. Detailed inspections can find loose terminations or incorrect grounds.

These inspections include all equipment located in the hazardous area, and any protection device located in the safe area (in the case of "EX ia"). In practice, this is difficult and expensive to achieve. Some wiring systems may be routed in such a manner as to make inspection very difficult. Process plants have internal permitting procedures that must be followed when entering hazardous areas, adding further costs. And there is, of course, the time required to make inspections, to document work done, and to keep required records.

It's important to verify that an installation conforms to a detailed equipment list and circuit diagrams. These and any other documentation listing specific conditions of use must be made available for the inspector. Often the equipment list has not been updated with equipment changes as plant modifications are carried out, due to either failed equipment being replaced with alternatives, or new wiring additions.

If clarification has to be sought regarding the installation and associated documentation, this adds to the time

Figure 2: *Instruments and wiring systems in hazardous locations must be inspected regularly. During a visual inspection, a certified technician looks for obvious faults.*

taken to carry out the inspection. Reducing the number of equipment items reduces the burden of keeping equipment lists updated, and wireless instruments are one of best ways to address this issue.

Typical issues found during inspections include:

- Incorrect or damaged cable gland
- Damaged cables
- Non-IS (intrinsically safe) circuits installed with IS circuits
- Incorrect segregation of IS and non-IS circuits
- Wrong zener barrier or galvanic isolator fitted
- No earth on zener barrier
- Non-IS earths connected to IS earth, and
- Equipment not as scheduled.

The table on page P9 describes the types of inspections typically required for traditional instruments and their associated wiring systems, and as can be seen they are quite extensive. But there is a simplifying solution, one that eliminates wires and their associated equipment.

Installing wireless instruments

Wireless devices that have been certified to the relevant protection level for the hazardous area can reduce the amount of equipment installed in the hazardous area, such as the wiring and supporting infrastructure needed with a traditional wired installation. Wireless process transmitters (Figure 3) are typically battery powered, which eliminates the need for power wiring, and battery power is safe for use in most hazardous areas.

For example, a refinery in Mexico was having problems with its cooling towers. The wired cooling tower instrumentation was old, and most measuring devices were out of service. Measurements were difficult because the process environment was corrosive to wiring, mainly due to hazardous chemical vapors. As a result, these areas were poorly instrumented. Consequently, control was poor, operations were inefficient, and the towers required a great deal of maintenance.

Installing wired instruments was deemed too expensive because of the cost of equipment and its supporting infrastructure, and because the corrosive environment would degrade the instrumentation and raise maintenance costs. Required inspections would add further costs, making wired instrument installation impractical.

Instead, the refinery installed 122 wireless sensors and transmitters in enclosures to protect the instruments from the environment. Because these instruments are rated for use in the area, no special protective measures were required.

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Cutting costs with wireless devices

Adoption of wireless equipment can have significant impact on both CAPEX (capital expenditures) and OPEX (operating expenses).

In the CAPEX phase, the design of a circuit using a wireless device achieves cost savings. By removing the wires, conduit, cable tray, field junction boxes, and marshalling cabinets, equipment costs are reduced and savings are realized in creating drawings and equipment schedules. This also reduces space and weight requirements, which can be very important in some industries where space is limited and weight is a factor.

The cost of installation must also be considered, as not having to install equipment required for wired instruments reduces labor costs and can speed up installation and commissioning times. This also allows for a reduction of facilities required to support this type of work, such as cabins, access equipment, and more.

Wireless field devices also reduce OPEX, especially the cost of hazardous area inspections, because much less equipment has to be inspected. Only the instruments themselves have to be inspected, and possibly the wireless gateways if they are installed in the hazardous area. But in many instances, gateways can be installed outside the

Figure 3: *Battery-powered field devices, such as this WirelessHART level sensor, can be used in hazardous environments, including tanks containing flammable materials.*

hazardous area. For the same reason—fewer pieces of supporting devices—the number of repairs will be reduced.

Wired vs. wireless inspections

The cost of installing, inspecting, and maintaining wired 4 to 20 mA or fieldbus process instruments in a hazardous area is very high because of the need to support those instruments with infrastructure including power supplies, wires, conduit, and marshalling cabinets. All of these items need to be protected to avoid igniting a flammable or explosive atmosphere, all the equipment needs to be inspected on a regular basis, and repairs are often required to keep the entire system safe.

If we look at a typical intrinsically safe DP (differential pressure) transmitter using a hardwired solution, the inspection would generally require:

1. Instrument (equipment) for condition, type and certification matches equipment schedule
2. Cable gland at instrument type and condition
3. Cable gland at field junction box type and condition
4. Cable between instrument and field junction box type and condition
5. Terminals in field junction box tightness and compliance with installation requirements
6. Cable gland for main cable from safe area
7. Cable to main safe area condition and type
8. Safety barrier unit, relays, and other energy-limiting devices to ensure their condition, type, and certification matches equipment schedule
9. Cable screens are earthed in accordance with documentation
10. Sealing of trunks, ducts, pipes, or conduits is satisfactory
11. Point-to-point connections are correct
12. IS circuit earthing and insulation resistance are satisfactory
13. Separation is maintained between IS and non-IS circuits
14. Compliance with specific conditions of use
15. As applicable, short-circuit protection of the power supply is in accordance with the documentation.

Looking over the list, it's clear that most inspection tasks relate to cables and associated equipment, so removing that equipment from the circuit reduces the number of inspection tasks.

So if that wired device was replaced with a wireless transmitter, such as a WirelessHART device, the inspection list would be somewhat shorter:

1. Instrument (equipment) for condition, type and certification matches equipment schedule

That's it. The other 14 points are no longer applicable as no cables are used to connect the device to the safe area. Of course this assumes that the gateway is mounted in a safe area, as is the normal practice. But even if the gateway is mounted in the hazardous area, it is still a reduction in the quantity of wired circuits to inspect. **ce**

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The two main wireless device protocols are:
ISA-100.11a:
www.isa100wci.org
WirelessHART:
www.hartcomm.org
For more information, visit:
www.emersonprocess.com
www.controleng.com/wireless