Installing Fieldbus in Hazardous Locations

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Process plants often have certain locations where explosive or flammable gases and vapors may exist through accidental or unavoidable release. The classification of hazardous locations is based on an assessment of the type of material presenting the risk (commonly known as Gas Groups, etc) and the likelihood of that material being exposed (Divisions or Zones).

The North American HazLoc Installation Codes (National Electrical Code for the U.S. and the Canadian Electrical Code for Canada) are the starting point from which all subsequent aspects of the North American HazLoc system are derived. These Codes include details on equipment construction, performance and installation requirements, and area classification requirements.

In North America, process plants are primarily concerned with Class I, Division 1 and 2 locations. Within Class I, Division 1 and 2, are four groups – A, B, C and D – where A (containing acetelyne) is the most dangerous, followed in order by B (hydrogen or gases of equivalent hazard), C (ethyl-ether vapors, ethylene or cyclo-propane) and D, the least dangerous of the four (gasoline, hexane, naptha and similar vapors).

If an area is a hazardous location, standard instrumentation cannot be used, whatever the gas hazard. All the Gas Grouping does is allow slightly more energy to be available under fault conditions before ignition takes place.

Electrical equipment and instrumentation placed in such locations are required to be protected in some way to minimize the possibility of ignition, and a wide variety of techniques have been developed. Intrinsic safety as an explosion-protection technology is particularly suited to electronic instrumentation applications since it is inherently a low-power design concept and very flexible in use.

Modern plant instrumentation and control systems often incorporate fieldbus, where the long runs of 4-20mA twisted wire pairs that run from the field-mounted instrumentation to the control room, are replaced with a multi-drop bi-directional bus carrying both power and high speed communications to field devices (up to a maximum of 32). That is, instead of 32 individual twisted pair wires, a single wire pair can connect up to 32 fieldbus instruments.

Fieldbus systems are suitable for use in many hazardous areas and all forms of electrical protection (non-incendive, flameproof, intrinsically-safe, etc) are available to suit the requirements of any site preference or experience, but having multiple devices on the same wire pair does lead to additional design issues. Intrinsically safe systems are particularly difficult since it is hard enough delivering sufficient power for a single instrument within the limitations of I.S. design; driving 10 or 16 devices is a real challenge and a variety of technical solutions have been developed.

Intrinsically Safe Operation: Entity vs FISCO

Entity solutions have been around since the 1950s. The Entity concept is based on using barriers and power supplies to limit the amount of energy that can enter a hazardous area, Figure 1. In general, Entity systems are highly reliable, especially when based on simple resistive current-limiting.

Intrinsically safe fieldbus was originally based on the Foundation fieldbus FF-816 spec, which allowed Entity parameters for field devices to be at least 24V / 250mA / 1.2W. The barriers that were available initially only allowed around 80mA per segment (for Gas Groups A, B, C, D), which equated to around four devices, an unacceptably low number of devices in a practical application.

FISCO means Fieldbus Intrinsically Safe Concept. It is based on work done by Physikalisch-Technische Bundesanstalt (PTB), the national metrology institute in Germany, and involves physically testing complete systems to ensure safety and to derive an envelope specification into which every component has to fit. To provide a FISCO solution, every part of that system, including devices, power conditioners and cable, has to comply with strict limits. These efforts by PTB and others enable FISCO power supplies to generate up to 110mA in Group A&B applications, and 250mA in Group C&D.

With 110mA available in Group A&B, a FISCO-type system can support four to five devices per segment (based on 20 mA per instrument plus power for the device coupler plus power losses over distance). However, FISCO power supplies are based on sophisticated electronic current-limiting, and therefore tend to be expensive, quite complex, and typically have lower MTBFs than conventional fieldbus power conditioners.

Newer Entity-based systems, such as MooreHawke's ROUTEMASTER, are based on a "split-architecture" approach to the barrier. Part of the barrier is in an isolator (back-of-panel) and part of it is in each of the spurs of a field-mounted device coupler, Figure 2. By splitting the intrinsically-safe current-limiting method in this way, an Entity-type system can put a full 350mA on the trunk that leads into hazardous areas with Gas Groups C&D, and still have intrinsically safe spurs that match FF816 Group A&B approved devices.

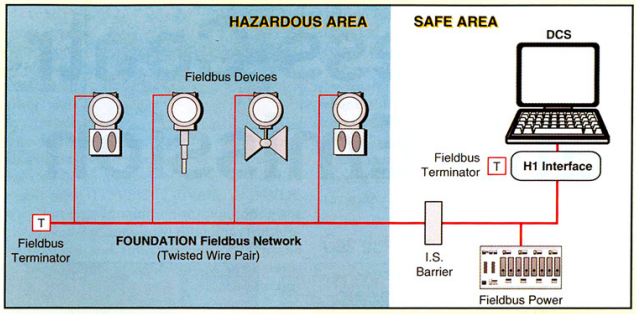

Figure 1: Entity type systems use barriers and electronic techniques to limit the amount of current entering a hazardous area. This technique has been used since the 1950s, and is the basis for most fieldbus intrinsically safe systems, but it only allows 4-5 instruments on a fieldbus segment.

Thus, an intrinsically safe Entity system is no longer limited to 80 or 110mA, or four to five devices per segment. Instead, up to 16 devices can be put on a segment, nearly four times as many as a FISCO system, with a greatly reduced cost for hardware and labor.

An Intrinsically-Safe Experience

At a chemical plant in Jacksonville, Florida, the entire process and all the equipment was in a Div 2 hazardous environment, and intrinsically safe instrumentation was preferred as the base protection technology, including the Foundation fieldbus network and components.

The plant's control engineers first looked at a FISCO-type system. Because they had about 250 instruments, this would require 50-60 FISCO segments. Considering that each segment requires an H1 card ($2500) plus a power supply, plus a device coupler, plus a fieldbus cable, the total cost for FISCO hardware alone would be about $5,000 per segment times 50-60 segments, or $250,000 to $300,000.

This does not count the time and labor involved in running 50-60 fieldbus segments into the plant, installing the consoles, enclosures and device couplers, and wiring all the components. They estimated this would cost an additional $100,000.

The ROUTE-MASTER split-architecture system can put a full 350mA on the trunk that leads into hazardous areas. Thus, they were not limited to four devices per segment; instead, they could put 16 devices on a segment, thus cutting costs to one-fourth that of a FISCO system.

The plant estimated that the split-architecture Entity-based system would require half as many H1 cards, half as many device couplers, and considerably less time and labor for installation. Therefore, they elected to install a split-architecture Entity-type intrinsically safe system.

During startup, the plant ran into a few difficulties. They had specified that all fieldbus devices had to draw less than 17 mA. But when they installed several dozen on-off valves, instead of getting 16 devices per segment, they were only able to support a maximum of nine devices, and sometimes only four devices per segment. This is because the on-off valves were actually pulling 32 mA per device and the resulting higher current demand led to large cable voltage loss. Fieldbus standards specify that devices need at least 9V to operate and on many segments, 9V could not be achieved. As a result, the segments had to be redesigned to consider the new device loads.

The ROUTE-MASTER split-architecture system can also support two trunk cables for each segment. The two trunks run separately from the power conditioner to the field devices, but they are part of the same segment as far as DCS communications is concerned. Now the total segment current is split between two cables, and the individual trunk cable voltage loss is therefore halved. Using two trunk cables solved the problem.

Although the plant's split-architecture Entity system is capable of 16 devices per segment, the plant chose to use only eight devices per segment. This is a combination of their conservative approach, plus the need for room to expand without adding more segments. The system currently has 30 ROUTEMASTER intrinsically safe fieldbus segments, supporting about 250 instruments.

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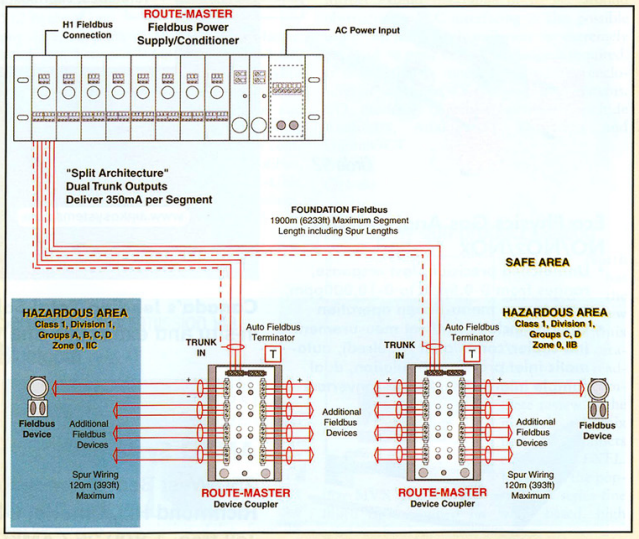

Figure 2: A split-architecture Entity approach puts part of the barrier in the power supply, and the other part of the barrier in the field. This allows up to 16 instruments to be powered on an intrinsically safe fieldbus segment.