GRUNDFOS

WHITE PAPER

Intrinsically Safe Control Equipment

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This White Paper will discuss intrinsically safe control equipment: what it is, what it is not, and how to apply it. In order to understand intrinsically safe control equipment, it is necessary to first understand the nature of the environment in which this equipment is used.

HAZARDOUS ENVIRONMENTS

Hazardous environments are defined and categorized in the National Electrical Code (NEC)[1] as follows:

I. Class – the broad physical characteristics of the environment
   A. Class I – gases or vapors
   B. Class II – dust
   C. Class III – fibers or filings

II. Division – how the flammable material would normally be found in the specific area
   A. Division 1 – hazardous material is normally found free in the atmosphere
   B. Division 2 – hazardous material is normally stored in a closed container

III. Groups – specific types of hazardous materials will fall into a group according to the ignition temperature of the substance, its explosion pressure, and other flammable characteristics:
   - The only substance in Group A is acetylene, which makes up only a very small percentage of hazardous locations.

     Consequently, very little equipment is available for this type of location. Acetylene is a gas with extremely high explosion pressures.
   - The materials in Group B make up another relatively small segment of classified areas. This group includes hydrogen and other materials with similar characteristics.
   - Groups C and D are the most usual Class I groups and comprise the greatest percentage of all Class I hazardous locations.

     Many of the most common flammable substances, such as butane, gasoline, natural gas, and propane, are found in Group D.
   - Groups E, F, and G cover dust locations. These groups are classified according to the *ignition temperature* and the *conductivity* of the hazardous substance.

     Conductivity is an important consideration in Class II locations, especially with metal dusts.
   - Metal dusts are found in Group E and include aluminum and magnesium dusts as well as other metal dusts of similar nature.
   - Group F atmospheres contain materials such as carbon black, charcoal dust, coal, and coke dust.
   - Group G contains grain dusts, flour, starch, cocoa, and other similar types of materials.

In pumping applications, we are primarily concerned with the first two classes. The specific definition of these classes and divisions according to the NEC is as follows:

CLASS I LOCATIONS

Class I locations are those in which flammable gases or vapors are, or may be, present in the air in quantities sufficient to produce explosive or ignitable mixtures.

CLASS I, DIVISION 1 LOCATIONS

A Class I, Division I location is defined as a location in which

(1) hazardous concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions; or

(2) hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operation or leakage.

CLASS I, DIVISION 2 LOCATIONS

A Class I, Division 2 location is defined as a location in which

(1) volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in the case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or

(2) hazardous concentrations of gases or vapors are normally prevented by positive mechanical ventilation and which may become hazardous through failure or abnormal operation of the ventilation equipment.

CLASS II LOCATIONS

Class II locations are those locations which are hazardous because of the presence of combustible dust.

REAL WORLD CONDITIONS

In sewage pump applications, the different types of flammable gases are virtually infinite because people will throw ***anything*** down the drain. Even if nothing "foreign" is flushed, methane gas is certainly to be expected.

In storm drain pump applications, there is also a real possibility of a hazardous environment existing in a wet pit sump. For example: Consider the pumping station at a highway underpass.

The equipment is designed to pump the runoff from the surrounding hills and highway. Most of the time, this consists of rainwater, dirt, and whatever oils and debris that are washed off the road by rain.

But, consider a potential accident where either an automobile fuel tank is ruptured or a tank truck is overturned. Now the situation has changed dramatically. The sump that was intended for storm water is being filled with a mixture of water and gasoline or diesel oil.

Gasoline and diesel oil will float on the surface of the water in the sump, which means they probably will not be pumped out of the pump for quite a while as there is always a certain amount of liquid left at the end of the pumping cycle.

When the conditions in the sump are right, the temperature can rise to the point that the gasoline begins to vaporize and mix with the air above the liquid. When this mixture reaches the right ratio of oxygen to gasoline vapor, any spark can ignite it.

If, in either case (the sewage pump or storm drain pump), the liquid level was such that the electrical equipment was never exposed to the "air" (gas), then there would be little to be concerned about.

However, since the pump exists to eliminate the fluid from the sump, this assures that the gas will be present. We must take precautions to assure the motor – and, just as importantly, the electrical controls that are located in the basin – do not cause an explosion.

PREVENTING EXPLOSIONS

In addition to using explosion-proof motors, the pilot devices that carry a current must also be considered. Here are some ways to prevent a flammable mixture from exploding:

- Use explosion-proof (NEMA 7)[2] pilot devices. However, these are expensive to buy, expensive to install, and difficult to obtain. All of the wiring within the hazardous environment must be in rigid conduit and meet all of the requirements of Article 501-4 of the NEC.
- Install the pilot device outside of the hazardous environment. This can be accomplished by using ball and rod types of pilot devices that are confined in the sump.

  Many displacement types of level controls will accomplish this separation. However, portions of the pilot devices are exposed outside the wet well and may be damaged.
- Use intrinsically safe controls. Intrinsically safe equipment and wiring are defined as equipment and wiring that are incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most ignited concentration. This equipment is suitable for use in Division I locations.

You may want to note that there is no reference to voltage in this definition. However, reducing the control voltage to 24, 12, or even 6 volts does not eliminate the possibility of a spark as anyone who has dropped a wrench across the battery terminals in a car will attest.

The definition of intrinsically safe control equipment and wiring consists of two elements:

(1) ELECTRICAL ENERGY

A combination of voltage and current that will result in a spark when contacts are made, or break. As noted above, reducing the voltage alone does not eliminate this problem.

(2) THERMAL ENERGY

Thermal Energy refers to the possibility of any conductor being connected from a hot terminal to ground, and the conductor itself becoming hot enough to ignite the gases in the sump.

INSTALLING INTRINSICALLY SAFE CONTROL EQUIPMENT

When an intrinsically safe control is used, ***the control panel must be mounted out of the hazardous environment***, and all conduits leading to the panel must be sealed in accordance with section 501-5 of the NEC.

When these conditions are met, the wiring methods used for the control wiring can be the same as in ordinary locations, and any nonvoltage-producing switch may be used. This means that the pilot devices used with the intrinsically safe control circuit do not have to be explosion proof themselves. This applies only to the pilot devices (i.e., bulbs, micromatic, etc.).

The intrinsically safe relays have nothing whatsoever to do with the motor enclosure. If the motors are to be mounted in the hazardous area, they must be suitable for that environment.

In a similar manner, all alarms (audible or visual) that are to be mounted in the hazardous area must be approved for that specific environment. The fact that the control circuit is intrinsically safe does ***not*** remove the requirement for proper wiring of these devices.

CONCLUSION

The specific application to individual installations will have to take into consideration the customer's preferences, the physical conditions surrounding the installation, and the local inspection authority (electrical inspector).

Although the initial cost of a control panel with an intrinsically safe control circuit is higher than those without, the installed cost of the system may be less. The customer may use non-explosion proof pilot devices such as the bulb control, and the junction box and wiring inside the sump do not have to be explosion proof when the intrinsically safe panel is properly installed.

REFERENCES

1. National Fire Protection Association (NFPA) (2008). *NFPA 70: National Electrical Code, 2008 Ed.* Quincy, MA: NFPA. http://www.nfpa.org.
2. National Electrical Manufacturers Association (NEMA), 1300 North 17th Street, Suite 1847, Rosslyn, VA 22209; http://www.nema.org.

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