Safety considerations for flow and level instrumentation on oil storage tanks.

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ABSTRACT

The paper "FIELD DEMONSTRATION AND TECH-TRANSFER FOR THE COUNTINUOUS MEASUREMENT OF CRUDE OIL STOCK TANK EMISSIONS" by R. E. Babcock of the University of Arkansas used instrumentation for continuous measurement of the exhaust flow rate and the level from oil storage tanks.

A thermal dispersion mass flow meter was used to continuously measure the emission rate in SCFM from the vessel and a guided wave radar was used for continuous level measurement. The two sets of data were set to a data logger to provide a record of these variables.

Safety issues need to be considered when installing electronic instrumentation in a tank containing flammable or explosive materials. Both the TA2 mass flow meter and the Eclipse Guided Wave Radar required electrical power to operate and produced a 4-20 mA output signal that was sent to the data recorder. These devices put energy into a potentially explosive environment. The instruments can be safely installed following appropriate standards. They are approved for use in hazardous areas by third party agencies.

The selection and installation of the instruments must consider the appropriate agency approvals. Consideration must be given to:

1) Area classification. Hazardous areas are specified by the type of material (Class), the frequency of a hazardous condition occurring (Division) and the type of media present (Group). Both the area inside the tank and piping as well as the area surrounding the tank must be reviewed.

2) Protection Method. The primary protection methods used in instrumentation are explosion proof, non-incentive, and intrinsic safety.

Each protection method has special requirements for selecting and installing the instrument. Examples will be discussed for installing the instruments for different protection methods and in different area classifications.

INTRODUCTION

Level and Flow electronic instrumentation used by Dr.Babcock provides a continuous measurement of these process variables. The products used in the demonstration involved two relatively new technologies for level and flow measurement.

Continuous level measurement is obtained using Magnetrol's Eclipse guided wave radar. This technology has just been introduced during the past 7 years and is gaining wide acceptance. One key advantage of this technology is obtaining a level measurement without consideration to the properties of the fluid. This technology has also been proven to provide accurate level measurements in demanding applications of varying media, vapors, turbulence, or foam over a broad range of pressures and temperatures.

The measurement of emission rates from the tank was made using Magnetrol's TA2 thermal dispersion mass flow meter. This instrument offers benefits of directly obtaining a mass flow measurement of the emission flow rate in SCFM over a very wide range of operating conditions. This technology has excellent low flow sensitivity enabling it to measure very low flow rates and provide high turndown capabilities. The instrument provides a measurement of the flow rate plus the totalized flow and elapsed time indication to give total emission rates over a specific time interval. This instrument is very easy to install in the tank exhaust piping.

Both of these instruments require electrical power and provide a 4-20 mA output signal which can be sent to data logger or other device for maintaining a record of these variables.

An illustration showing the installation of these instruments is shown in figure 1.

Safety Concerns

There are safety concerns when installing an electrically powered device in a tank with flammable or explosive fluids and vapors. Standards are developed by the National Electric Code (NEC) for use of equipment in hazardous areas. Third party agencies such as Factory Mutual provide testing to insure that these standards are obtained and that the equipment is safe to use in hazardous areas.

When dealing with the use of instrumentation in hazardous areas consideration must be given to:

- Definition of the area classification and
- Protection Method used to meet these standards.

Area Classification

Area classification is defined by:
- Class – Category of the type of material
- Division - Frequency of a hazardous condition occurring
- Group – Type of flammable material based on its ignition energy

Class: Type of material

Class I – Flammable gases, vapor, or liquids are present in the air in quantities sufficient to produce an explosive atmosphere.

Class II – Combustible dust and power suspended in the air in quantities sufficient to produce an explosive atmosphere.

Class III – Flammable fibers suspended in the air in quantities to produce an explosive atmosphere.

Applications in the petroleum industry deal almost exclusively with hazardous liquids, vapor and gases which are Class I service. Approximately 85% of the all hazardous locations in North America are defined as Class I.

Division

Division: Indication of the frequency of a hazardous condition occurring. The National Electric Code as defines these:

Division 1 – Hazardous locations are where an explosive atmosphere exists continuously or intermittently under normal operating condition and under fault conditions.

Division 2 – Hazardous locations that are adjacent to a Division 1 location or where an explosive atmosphere infrequently exists when there is a fault or breakdown of equipment.

When dealing with oil storage tanks, concern must be given to both the conditions inside the tank and in the surrounding area (Figure 2). For instance, the area inside the tank is a Division 1 area where a hazardous condition continuously exists while the area outside the tank can be Division 1 or Division 2 hazardous area. This boundary between a Division 1 area and a Division 2 area outside of the tank is up to the discretion of the individual responsible for certifying an area.

Group

Group: The group classification specifies the type of the flammable material with regard to the type of vapor. The groups are based upon the ignition energy of the material. For Class I service dealing with flammable liquids and vapors, the Groups are divided into:

Group A – Atmospheres containing acetylene

Group B – Atmospheres containing Hydrogen plus a few other hydrocarbons

Group C – Atmospheres containing ethylene and similar vapors

Group D – Atmospheres containing methane, ethane, propane and other similar gases.

Groups C and D are the most common and are of concern to applications for vapors from oil storage.

Temperature Code

The last consideration is the amount of heat generated by the instrument. An instrument is classified for a specific maximum surface temperature which the device can reach during normal and fault conditions. To properly apply an instrument in a hazardous area the maximum surface temperature of the device must be less than the auto ignition temperature of any potential gases or vapor that may come in contact with the device.

The National Electric Code has established various temperature codes, which identify the maximum surface temperature that the instrument can reach. This code is part of the approval listing of the instrument.

The next step in safely applying instrumentation in hazardous areas concerns the selection of the protection method to meet the area classification.

Protection Method

There are three main protection methods used:

- Explosion Proof
- Non-Incendive
- Intrinsically Safe

Explosion proof and intrinsically safe are suitable for use in both Division 1 and Division 2 areas while non-incendive is useable only in Division 2 areas.

Explosion proof

Items that are explosion proof are designed so that the enclosure will contain an explosion and prevent flame propagation to the external atmosphere. An explosion is allowed to occur but it is confined within an enclosure built to resist the pressures created during the explosion.

This requires that the enclosure walls be thick enough to contain an explosive force. The internal pressure created during an explosion depends upon the gas or vapor that was ignited. As a result, explosion proof designs require the heavy-duty enclosure that is frequently seen in petroleum processing.

Explosion proof enclosures have historically been the primary method of protection in the petroleum industry for over fifty years.

Intrinsically safe

Intrinsically safety is a technique that insures that the amount of energy available in the instrument is too low to ignite the explosive mixture of vapor and air. The energy to the instrument is limited with the use of an intrinsically safe barrier that is located in a non-hazardous area. This limits the voltage and current going to the instrument. The power to intrinsically safe instruments is 24 VDC and the amount of current required will vary between 4 and 20 mA. See Figure 3.

Intrinsically safe designs do not depend upon the enclosure design however many instruments will use the same enclosure for both explosion proof and intrinsically safe designs. This is often a question of economics for the instrument manufacturer.

Non-incendive

The non-incendive method of protection is suitable only in Division 2 areas where hazardous conditions exist only under upset conditions. To obtain non-incendive approval, the electrical circuit is not capable of igniting an explosive atmosphere – there are no arcing or sparking components. It is important to note that this approval is based on hazardous conditions occurring only during fault conditions and not during normal operation.

The primary advantage of this method of protection is that it is less expensive to install than if the device is installed using explosion proof requirements.

Choosing a Protection Method

The decision on which protection method to use depends upon several factors – the main ones are the instrument design, installation costs, and the user's preferences.

Instrument Design.

The Eclipse Guided Wave Radar is available in either an intrinsically safe design or explosion proof design. The enclosure and external appearance is the same for both designs. The only difference is internal circuit between the intrinsically safe and explosion proof design.

To understand this difference it is necessary to look at the probe design. Because the probe has internal o-ring seals it cannot withstand an explosion. Thus the probe itself is not rated explosion proof. Therefore, to meet the safety requirements for a Division 1 area, the amount of energy going into the hazardous area of the tank must be limited. If installed as an intrinsically safe device the external safety barrier limits the energy to the instrument. However, if installed as an explosion proof design there is nothing external to the instrument to limit the energy. In order to install the probe in a hazardous area the explosion proof design incorporates internal barriers that limit the energy into the tank. Technically, this is referred to as an explosion proof design with intrinsically safe probe circuit.

Some instruments are only available as in explosion proof design such as the TA2 thermal dispersion mass flow meter. To operate this instrument requires more energy than can be supplied over a traditional intrinsically safe circuit. Four wires are required to operate this instrument – two wires for input power and two wires for the output 4-20 mA signal. The input power can be either 120/240 VAC or 24 VDC depending upon user preference. Being able to power this instrument with AC power is a preference for some customers depending upon power availability at the job site.

The probe used on the TA2 is all welded and thus meets explosion proof requirements; therefore, there is no need to limit the energy to the probe. The principle of operation requires that power, in the form of heat, is required to make the flow measurement. There is potential concern about the amount of heat that can enter the process through the probe. Testing is performed by a third party (Factory Mutual) during the approval testing of the instrument. The National Electric Code has established "T Ratings" which determine the maximum surface temperature that the instrument can obtain during a fault. With the TA2, the normal temperature difference is typically 8° C or less. For safety considerations, testing is also done under worse case conditions, which could exist if the normal protection circuit in the instrument fails. The instrument is given a T code depending on this testing. For the TA2, the T code is a T6. This is the lowest surface temperature classification. Per the NEC, a T6 code indicates that the maximum surface temperature of the probe will be no greater than 85° C. This means that the TA2 can safely be used in any application if the auto ignition temperature of the liquid or vapor is greater than 85° C.

The NFPA (National Fire Protection Association) has established Auto Ignition Temperatures for many liquids, gases, and vapors. All hydrocarbons have Auto Ignition Temperatures well in excess of 200° C. Thus the TA2 is safe to use in any application where hydrocarbon gas or vapor exists.

Installation Costs.

As indicated above, the Eclipse Guided Wave Radar is available in either an explosion proof or an intrinsically safe design. Because the explosion proof design incorporates the intrinsically safe probe circuit, this design is more expensive than the intrinsically safe design. However, the intrinsically safe design requires the use of an external barrier in the control room,. The cost of this separate safety device is greater than the price adder for the internal intrinsically safe probe circuit included in the explosion proof design of the Eclipse.

There are however, other costs saving issues by using an intrinsically safe implementation. By using the intrinsically safe installation, the wiring from the control room to the instrument can be simpler and less expensive. Heavy duty explosion proof conduit is not needed with IS designs. An all intrinsically safe installation permits the wiring to and from the instrument to be placed in cable trays. Simple cable glands can be used to seal the wiring at the instrument.

Due to savings in wiring cost, an all intrinsically safe installation may be less expensive than an explosion proof installation. However, sometimes this is not the case due to the typical preference of using conduit even in those installations when not required.

If an explosion proof installation is selected, the installation costs of the instruments can be reduced if the instrument is installed as a Division 2 non incendive device. While Division 1 is defined as inside the tank and immediately adjacent to the tank, this boundary between

Division 1 and Division 2 is subject to interpretation by the individual user. If installed in accordance with Division 1 practice, rigid explosion conduit and conduit seals between the instrument and the conduit must be installed. Installing the instrument in accordance with Division 2 practice permits the use of flexible conduit and eliminates the need for conduit seals, see figure 4. As a result Division 2 installation is less expensive than Division 1 installation. Due to cost savings, there is a growing trend to use Division 2 installation methods.

User Preference

The major determination in selecting the protection method is user preference. Typically, installations in North America use explosion proof designs while installations in Europe are generally intrinsically safe.

This is especially true in the Petroleum Processing Industry in North America, which has an overwhelming preference to explosion proof designs. It is estimated that over 90% of the installations in petroleum processing are explosion proof.

Other industries such as chemical processing and pharmaceutical may use some intrinsically safe installations, but the preference still is towards explosion proof in North America.

Conclusion.

Electronic flow and level instrumentation can safely be installed in potentially explosive environments, which exist inside oil storage tanks. Consideration must be given to the area classification and the protection method. Some instruments can be installed as either explosion proof or as intrinsically safe while others are only available as an explosion proof design. The decision on which type of installation to use is subjective generally depending upon the preferences of the individual user.

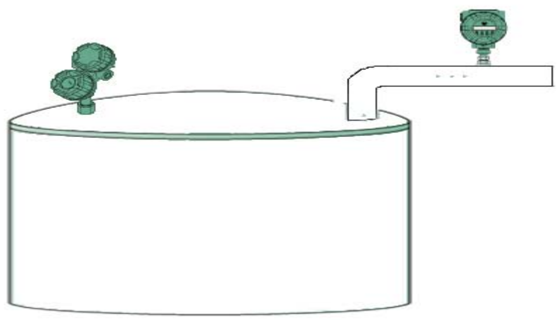

Figure 1
Eclipse and TA2 installed in oil storage tank

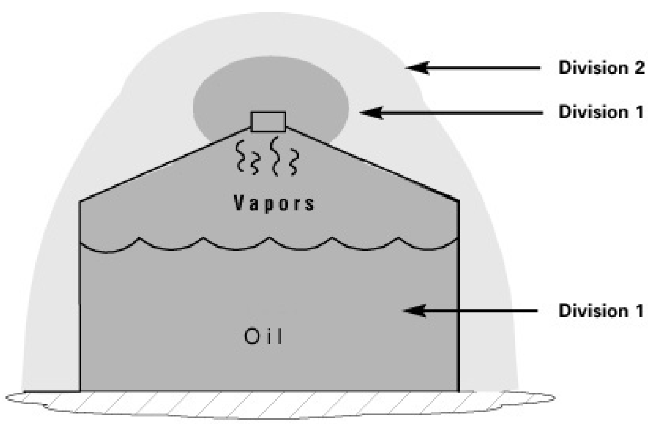

Figure 2
Area classification around a tank

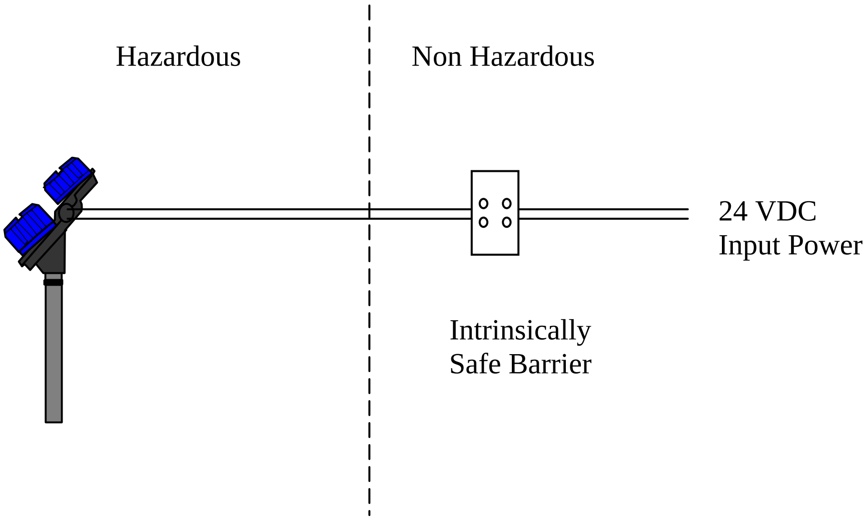

Figure 3
Intrinsically safe
installation

Figure 4
Non-incendive installation of TA2 Thermal
mass flow meter for natural gas