Explosive Gas Detection and Applications[1]

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ABSTRACT

Industry is becoming more aware of the hazards to life and property that accompany the use of flammable gases and vapors. These problems are becoming so complex that specialized knowledge is necessary to guarantee proper selection of equipment and to maintain the equipment after installation. The selection and use of explosive gas detection equipment should be a coordinated effort between the Safety Engineering and Instrument Engineering Departments. Combustible gas analyzers using the principles of catalytic combusion exhibit the simplicity, flexibility and stability of operation which are the ideal requirements for solvent extraction installations.

INTRODUCTION

Precautionary measures, i.e., the enforcement of safety regulations and the proper use of combustible vapor detection equipment, should lead to safe and economical solvent extraction. Continuous and portable detection systems employing the catalytic combustion principle for combustible gas analysis have exhibited the characteristics of simplicity, flexibility and stability of operation that are ideal for solvent extraction applications. The Safety Engineer and Instrument Engineer ought to be aware of the properties of combustible vapors and become knowledgeable about instruments utilizing the principle of catalytic combustion.

Flammable liquids, such as hexane, evolve combustible vapors which, when mixed with air, can be readily ignited by electrical sparks, static discharges, open flames and any heated surface of sufficient size and temperature. The evolution of vapors from a particular flammable liquid is, of course, a function of temperature and pressure. By experimentation, mixtures of the combustible gas or vapor in air can be divided into three groups:

1. Those below the lower explosive limit (LEL). These mixtures will support combustion (burn) but will not propagate flame away from the source of ignition.
2. Those between the LEL and the upper explosive limit (UEL). This is commonly known as the explosive or flammable range. These mixtures will propagate flame. Large volumes of combustible gases or vapors in these concentrations, if ignited, can cause extensive property damage and loss of life.
3. Those above the UEL. These mixtures will not propagate flame because they are too rich to burn. However, the addition of air to these mixtures will create mixtures in the flammable range and, therefore, these concentrations must be considered equally dangerous.

When handling, storing or processing large volumes of flammable liquids or combustible gases, reliable combustible gas detection systems can give warning that the vapor or gases in an area are approaching the LEL and that corrective measures must be taken. In some cases, these measures can be initiated by the gas detection system itself. Although present day instruments can respond in less than one second, if all conditions necessary for an explosion should suddenly occur, such as the bursting of a pipeline or the rupture of a vessel, releasing large volumes of liquid or gases into the atmosphere, an explosion cannot be prevented. Industry is becoming more and more aware of the hazards that accompany the use of flammable gases and vapors. In the past, these problems were primarily the concern of the Safety Engineer. However, the instrumentation required to cope with these problems is becoming so widely used that it is necessary to guarantee proper selection of equipment and maintenance once it is installed. Consequently, the role of the Engineering Department has become increasingly important. For example, the location of sensor points is or prime importance. A sensor for the detection of hexane should be located at a low point since hexane is heavier than air. But forced ventilation patterns must be considered also.

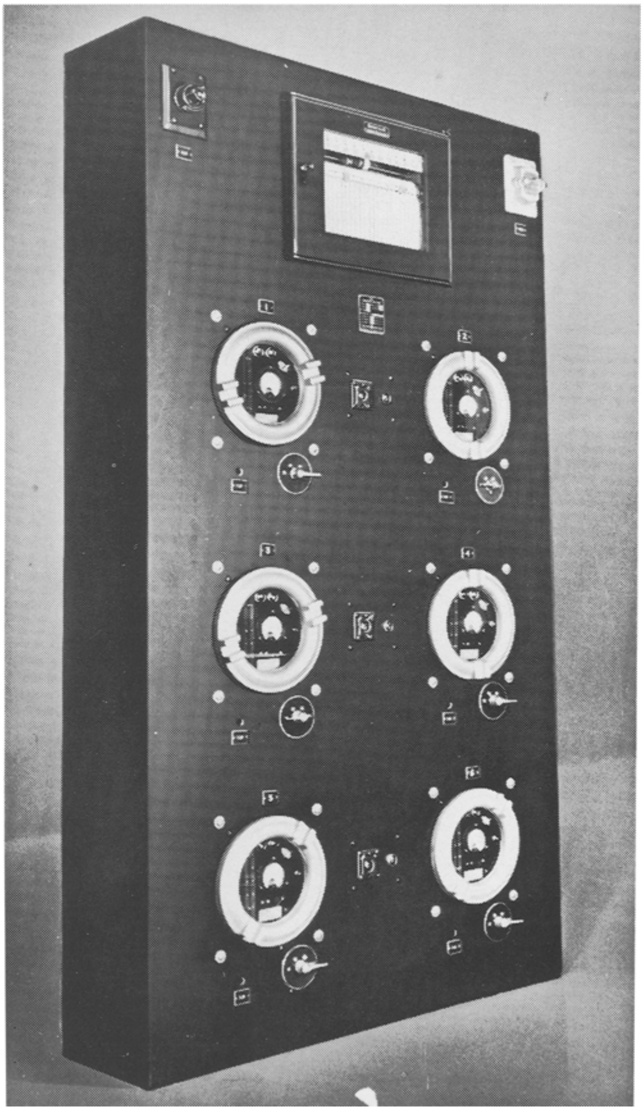

FIG. 1. Six point combustible gas monitor.

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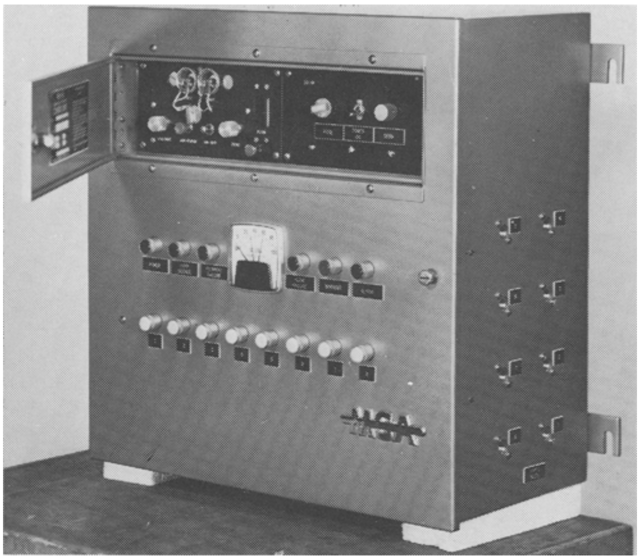

FIG. 2. Eight point sequential combustible gas wall mount analyzer.

Combustible Gas Detection Systems

Practical and effective detection systems must fulfill the following requirements: maximum reliability; long-term stability; little maintenance; quick response to any flammable gas or vapor that may be present in the sample; insensitivity to other atmospheric contaminants or constitutents such as carbon dioxide or water vapor; and simplicity of operation which can be readily understood and serviced by general purpose maintenance personnel.

Considerable study has been given to the characteristics of a number of gas detection methods to be employed for this purpose. Detection methods based on absorption of IR energy, gas density difference, the thermal conductivity characteristics of gases, and many other methods have been examined. Although instruments based on these principles have proven extremely valuable for some applications, particularly in the process control area, they are inherently too complex or subject to interference from other atmospheric contaminants that may be present at sample locations. However, these requirements are met almost entirely by the instruments utilizing catalytic combustion. Instruments of this type have been in use for over 40 years and are commonly referred to as hot-wire detectors.

These detectors employ the heat of combustion of flammable gases or vapors to measure the quantity of these

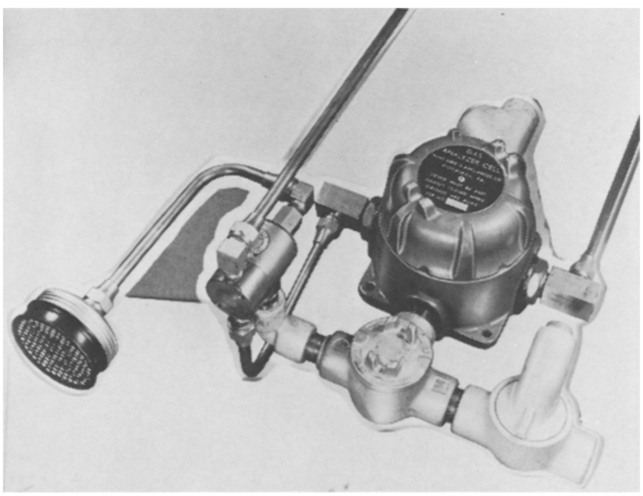

FIG. 3. Remote flow cell module.

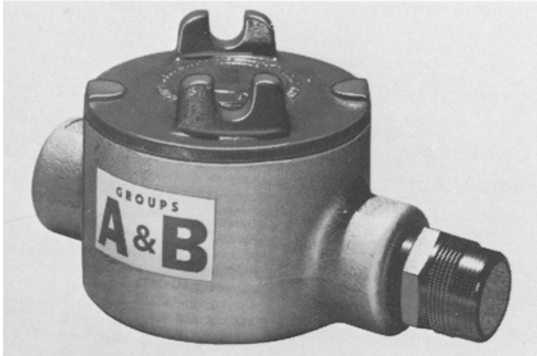

FIG. 4. Remote diffusion head sensor.

gases. The measuring element, a filament, is a relatively small platimun coil, heated by an electric current. When a mixture of flammable gas or vapor in air is brought in contact with this coil, rapid combinations of combustible gases or vapors with the oxygen in the sample takes place at the surface of the filament coil. This burning of the combustible gas or vapor increases the temperature of the filament, thereby causing a proportional change in its resistance. This change in resistance causes an unbalance in the measuring circuit which caused the meter or recorder to be deflected in an amount proportional to the concentration of the combustible in the sample within the range of 0-100% of the LEL.

In a flow type system, one, two or more filaments are mounted in a sample block. This block is referred to as a combustion chamber and is fitted with flashback arrestors at the inlet and outlet ends of the chamber to prevent passage of flame from the inside of the chamber to the atmosphere. The filaments are connected to form a Wheatstone Bridge to continuously measure the resistance of the filament and thus indicate the gas concentrations.

Because the filament is expendable and the most important component of the combustible gas detection system, extensive research over the past 40 yr has been oriented toward increasing its stability and service life for use in continuous duty systems. At first, filaments had an average life of approximately 200 hr of continuous duty. Today, equipment is available having a minimum life of 4,500 hr of severe service and a second type having a minimum life of 10,000 hr of average service. Needless to say, stability improved as the service life increased.

Silicone compounds are finding more and more use in industry. In the coating of fabrics, such materials are sometimes used as antifoaming agents. It has been found that concentrations of less than 1 ppm of silicone vapors can rapidly kill the catalytic activity of a platinum filament. Therefore, when silicone substances are present, hot wire combustible gas detectors should not be used. Nondispersive IR analyzers, which are somewhat more sophisticated, and perhaps slightly more expensive, are not affected by silicone compounds and can be used as combustible gas detection systems when silicone or related substances are present. Three types of hot wire systems are available: tube sampling, remote head and diffusion head.

Tube sampling types are induced sample flow systems, using a suction pump or air-operated aspirator to draw a sample of the atmosphere from the test area, through tubing, to the combustible gas detector for analysis. This type readily lends itself to a multiple sample point operation for a single combustion chamber; however, it is limited to gases or flammable liquids having a flashpoint below 70 F. Systems are available in both explostion proof, Class I, Group D, Division 1 construction, and non-explosion proof construction.

Remote head types are also of the induced sample flow type using a pump or aspirator to draw a sample through the combustion chamber. However, in this case, the combustion chamber is located in the area to be tested. A cable connects the combustion chamber to the control cabinet, and a metal tube connects the remote head to the suction pump, mounted in the remote control cabinet. The head is explosion proof; the control cabinet is of general purpose construction. The head can be located up to 500 ft away from the control cabinet. Although installations of this type are slightly more costly than the tube sampling system, it responds quickly and is not affected by the distance of the head from the control unit. Furthermore, it can be used on flammable liquids having flashpoints higher than 70 F, in some cases, without modification, or, in other cases, such as sampling from inside of the ovens, by heating the head to the temperature of the oven being sampled. This method does not lend itself readily to multiple sampling situations with a single detection head.

The diffusion head type is designed to locate the analysis head directly at the point of sampling. The sample flows into the head by diffusion due to convection currents created by the heat of the filaments within the detection head. As no sample pump is required, the installation is simple and the cost is minimal. The detector head is explosion proof and is designed to meet the requirements for Class I, Group B, Division 1 hazardous areas. The control modules are available in nonexplostion proof and also in explosion proof design for use in Class I, Group D, Division 1 areas.

The diffusion head system consists of three different configurations of control modules to be used with the same remote explostion proof head. One type is so manufactured that multiple modules can be placed in a single cabinet, which will be located at a central area, to monitor many remotely located diffusion heads for combustible concentrations. A second design is a single point wall mounted unit which is also of the general purpose configuration and its primary design features lend itself to the single point applications. The third version is a completely explosion proof module which can be mounted directly into a hazardous area.

The detector element is designed so that all four legs of the Wheatstone Bridge are located at the point of sampling. This allows all four legs of the bridge to be acted upon by the same temperature, pressure and humidity, thus improving the zero stability of the instrument. The use of the diffusion head type of combustible gas detector has also provided an increase in response time. The diffusion head will sense and indicate the combustible gas concentrations on the control module in less than one second. This is possible because the connection between the sensing head and the indicating module is by electrical wire. The response time due to sample transport delays encountered with tube sampling type of instruments is eliminated.

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