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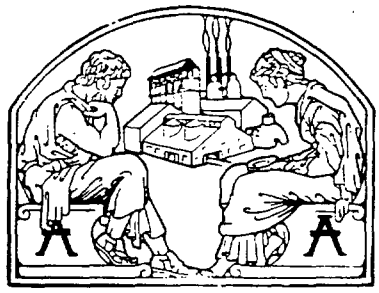

COMBUSTIBLE GAS AND VAPOR DETECTORS

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Introduction

As an introduction to the general subject, it should be recalled that a combustible gas or vapor, dispersed in air, will form an explosive mixture only over a definite range of concentrations characteristic of that material. Certain gases form flammable mixtures over extremely wide concentrations and represent serious explosion hazards when leakage occurs. In this respect the most dangerous gases, and their flammable limits are ethylene oxide (3-100%), acetylene (2.5-81%), and hydrogen (4-75%). Special equipment and precautions are required when testing for these or in testing for other combustible gases in oxygen-rich atmospheres. Concentrations below the lower explosive limit cannot burn explosively because of insufficient fuel; those above the upper limit will not explode because lack of oxygen does not permit rapid propagation of the flame. However, concentrations above the upper explosive limit must be regarded as extremely hazardous because dilution of the mixture with air will bring it into the explosive range.

03122433

IN RE: ABRAMS November 1992

NWBB-0020089

Description and Use of Combustible Gas Indicators

Combustible gas indicators are calibrated in terms of the lower explosive limit, generally designated the "0-100% LEL" scale. A few are calibrated in decimal values, the LEL having a value of 1.0. The purpose of this system is the prevention of misinterpretation of "%LEL" as percentage concentration of gas. An example will illustrate: for acetone vapor in air, the limits of flammability are 2.6 to 12.8% by volume. Therefore, in an atmosphere containing 1.3% acetone vapor, a meter reading of 50% LEL or 0.5 LEL would be expected. However, each manufacturer calibrates his instruments against a particular gas or vapor (e.g. methane, hexane, and benzene are common) and reference charts or tables of conversion factors are necessary to convert meter readings to accurate values for other materials. These charts or tables are available from the supplier, usually without additional charge, and should be requested when an instrument of this kind is purchased.

In addition to the 0-100% LEL scale, certain combustible gas indicators carry a second scale representing a ten-fold increase in sensitivity. This is commonly designated as the 0-10% LEL scale, but may be marked 0-1000 ppm (parts per million). A dual-range instrument makes possible the monitoring of combustible vapors at concentrations too low to be explosion hazards but which may be dangerous to health when inhaled. An atmosphere may be safe from an explosion standpoint yet quite dangerous from an inhalation standpoint. The dual-range instrument therefore serves a double purpose and is the better buy.

03122434

IN RE ABRAMS November 1992

MWBB-0020099

Principles of Operation

Most combustible gas indicators operate on the same general principle: combustion or flammable material on a heated platinum wire (working filament) which forms one leg of a Wheatstone bridge. The resulting heat of combustion increases resistance of the working filament and unbalances the bridge. This unbalance, being proportional to the temperature and thus to the amount of combustible gas, is shown on the meter in terms of the lower explosive limit. Near the working filament, but protected from the air sample, is an identical (reference) filament which forms the adjacent leg of the bridge circuit. The reference filament compensates for changes in ambient temperature and voltage Operating temperatures of working filaments vary from one brand to another. Some manufacturers stress the safety and long life of their low temperature filaments while others prefer higher temperatures. The latter have the advantage of giving better performance on the more difficult oxidizable materials (such as methane) and of avoiding contamination of the filament by tetraethyl lead in gasoline vapors.

Types of Detectors Available

Several suppliers offer both portable and fixed detectors. The latter, in single- or multipoint models, may be had with a simple alarm (horn, bell or light), indicating meter, or graphic recorder; while the more complex systems may have all these and control auxilliary ventilation equipment as

03122435

IN RE: ABRAMS November 1992

MWBB-0020091

well. The permanently installed detectors are generally of single range (0-100% LEL). Permanently-installed detectors use either a sampling pump or, in the lower priced models, depend upon diffusion of air-vapor mixtures to the working filament through a porous cover, e.g. sintered metal, which acts as a flash-back arrestor and coarse filter. Most portable types use a rubber squeeze-bulb or small electric pump to draw the atmosphere sample through a special hose, conditioning filter, flash-back arrestor, and then over the working filament. The electric pump results in steady meter readings rather than the oscillations produced by the squeeze bulb.

The only advantage of the permanently-installed detector is, of course, the capability for continuous monitoring of one or several fixed areas. Such systems are more expensive, costing about $500 to $1, 500 (for certain explosion proof models) for a single station, plus $200 to $500 for each additional station. Also, they lack the flexibility to explore and define a situation, or easily to meet changing needs. It is recognized that there are situations where full-time monitoring would be very desirable if placement of sensing heads could be made in the areas of greatest hazard. In most cases this may be difficult to determine.

Meaning of Approvals by Certifying Agencies

The prospective buyer may be confused by various "approvals" conferred upon combustible gas indicators. Chief among these are Bureau of Mines, Factory Mutual, and Underwriters Laboratories. The Bureau of Mines,

03122436

IN RE: ABRAMS November 1992

HWBB-0020092

as the name indicates, was set up to concern itself with the safety of mining operations. As such, its approval of a combustible gas indicator extends only to use underground in atmospheres containing methane. The ignition temperature of methane is higher than that of other gases and much higher than for organic vapors. It is therefore clear that approval or lack of approval by the Bureau of Mines means little when looking at meters intended for use in our plants and in the presence of a variety of combustible gases and vapors.

Approval of Factory Mutual or Underwriters Laboratories means, primarily, that flame arrestors and case will not permit a flame, originating within the case, to escape and propagate a flame or explosion outside. Approvals are occasionally restricted to certain groups of materials. For the benefit of those who may not be familiar with the Occupancy Classes and Atmospheric Groups, a description is appended. For general use, our requirements should be adequately met by equipment approved for Class I, Group D. It should be noted that instruments of the type under discussion do not respond to explosive dusts, Groups E, F, or G. Since the cost of these FM or UL tests is high and must be borne by the manufacturer, the latter usually submits only his low cost, high sales volume model for approval. If this model passes, one can be reasonably sure that the higher priced instruments of the same manufacturer are at least as safe.

Calibration and Proper Use is Essential

Before taking a portable combustible gas indicator into a contaminated area, the instrument must be turned on and the zero adjustments made in a "clean" atmosphere. If hazardous concentrations are expected in the area to be tested, it is good practice to leave the instrument on until one has

03122437

IN RE: ABRAMS November 1992

returned to a "clean" environment to avoid switching in a potentially explosive situation. An extension tube is required for sampling atmospheres inside operating equipment, or tanks, or reaching into manholes. Such tubes should be made of a material that is impervious to the combustibles that may be present.* In using sampling probes and tubing, care must also be taken to avoid loss of easily condensable vapors in the line. This is a common source of error in testing for solvent vapors, and warming of the instrument sampling system and associated tubing to a temperature slightly above ambient or process temperature may be required.

Regardless of the type or brand of equipment selected, readings may be relied upon only if the system is occasionally checked against a known gas mixture. Only experience will indicate how frequently checking is required but testing before each day's use is suggested to those starting with a new piece of equipment. Cylinders of compressed gas-air mixtures, with certificates of analysis, are available from several suppliers: Linde (sold through J. T. Baker Chemical Company), Matheson, Mine Safety Appliances Company,** Union Industrial Equipment Company, and Davis Emergency Equipment Company. These are satisfactory for the "fixed gases" but are impractical for easily condensable vapors such as those of paint solvents. Test kits are

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* Conditions under which a nonconducting and/or nonsparking probe are indicated cannot be prescribed here but may be of concern in special situations.

** In addition, Mine Safety Appliances Company manufacturers a Field Calibrator Kit whereby one small "sparklet" type cylinder of isobutane may be used to calibrate a large number of instruments. (Isobutane is used in this service because its ignition temperature is the same as that of methane.)

MWBB-0020094

IN RE: ABRAMS November 1992

also available which are convenient and inexpensive. A very simple one is the Johnson-Williams "Gas Indicator Test Kit" which contains sealed gas ampoules filled with methane at atmospheric pressure. For use, an ampoule is broken inside a plastic bottle to give a methane-air mixture equivalent to 22% LEL. Since methane is somewhat more difficult to oxidize than other gases, satisfactory performance on a methane standard assures normal response to other combustible gases and vapors.

03122439

IN RE: ABRAMS November 1992

MWBB-0020095

APPENDIX

Occupancy Classes and Atmospheric Groups*

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

Group A, Atmospheres containing acetylene;

Group B, Atmospheres containing hydrogen, or gases or vapors of equivalent hazard such as manufactured gas;

Group C, Atmospheres containing ethyl ether vapors, ethylene, or cyclopropane;

Group D, Atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, lacquer solvent vapors or natural gas;

Group E, Atmospheres containing metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics;

Group F, Atmospheres containing carbon black, coal or coke dust;

Group G, Atmospheres containing flour, starch, or grain dust.

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* Taken from 1965 National Electrical Code of the National Fire Protection Association.

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