SAMPLING IN MINES AND/OR IN EXPLOSIVE ATMOSPHERES

Murray Jacobson*

Environmental sampling in areas where flammable materials are present, such as mines, tunnels, refineries, and chemical plants, necessitates the use of intrinsically safe or explosion-proofed electrically operated devices. The type of hazardous atmosphere dictates the requirements for safe operation. The designation of the classification of the hazard, the provisions for operating under hazardous conditions, and the agencies responsible for approving the equipment are described in the following paragraphs.

The nature and degree of hazard existing in a particular location are denoted by modified National Electrical Code (1) specifications of Class I, II, or III; Group A, B, C, D, E, F, or G; and Division 1 or 2.

The class designation typifies the nature of the hazardous material.

Class I locations contain flammable gases or vapors in the air in quantities sufficient to comprise an ignitable explosive mixture.

Class II locations are those in which combustible dusts are present in concentrations sufficient to result in fire or explosion.

Class III locations are those in which the combustible material is fibrous or flyings not normally suspended in the atmosphere in quantities to produce ignitable mixtures.

Group designations are more specific subclassifications of the nature of the hazard.

The Groups recognized in Article 500 are:

Group A, atmosphere containing acetylene.

Group B, atmosphere containing hydrogen or gases of equivalent hazard such as synthetic gas.

Group C, atmospheres containing ethyl ether vapors, ethylene, or cyclopropane.

Group D, atmospheres containing gasolene, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, lacquer solvent vapors, or natural gas.

Group E, atmospheres containing metal dusts including aluminum, magnesium and their alloys, and other metals of similar hazardous characteristics.

Group F, atmospheres containing coal, coke, or carbon black dusts.

Group G, atmospheres containing flour, grain, or starch dusts.

Divisions define the probability of hazardous materials being present in ignitable concentrations.

Division 1 is a location where the ignition probability of the atmosphere is relatively high, i.e., where

(a) hazardous concentrations exist continuously, intermittently, or periodically under normal conditions, or

(b) hazardous concentrations exist frequently because of repair or maintenance operations or leakage of equipment, or

(c) breakdown of equipment or unexpected failure might create hazardous concentrations and also cause failure of electrical equipment.

Division 2 is a location which is presumed to be hazardous only in abnormal situations, i.e., as a result of accident which results in container failure. Some of these are:

(a) locations where flammable liquids or gases are handled, processed, or used but are normally confined in closed containers or systems.

(b) areas which are rendered non-hazardous by forced ventilation, which could become a hazard if the ventilating equipment fails.

(c) areas adjacent to Division 1 locations where hazardous concentrations of vapors or gases could be transferred, unless prevented by positive ventilation with adequate protection against ventilation failure.

The nature of the fire and explosion hazards of specific materials is a function of their relative ease of ignition. The various parameters constituting the relative ignitability are given for specific gases, liquids and solids in numerous publications. (2,3,4,5,6,7,8,9,10,11)

Equipment and associated wiring approved as intrinsically safe may be used in any hazardous location for which it is approved. Intrinsically safe equipment and wiring is incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture. Abnormal conditions include accidental damage to any part of the equipment or wiring, insulation or other failure of electrical

*Pittsburgh Field Health Group, Bureau of Mines, U.S. Department of the Interior, Pittsburgh, Pa.

components, application of over-voltage, adjustment and maintenance operations, and other similar conditions.

The application of the principle of intrinsic safety to electrical equipment and wiring for use in hazardous location represents an approach which is quite different from the normal methods such as explosion-proof protection. In an intrinsically safe system, safety is provided by the design of the system, not by the addition of protective measures to the system. Safety, therefore, exists for the life of the equipment, during maintenance, and in spite of maintenance.

For sampling in mines or tunnels or other underground areas where electrical or other sources of power are unavailable or difficult to obtain, battery operation is most desirable. Rechargeable batteries of the lead-acid, nickel-cadmium, or silver-zinc types are suitable for this purpose.

For coal mines, in particular, where methane gas is an ever present hazard, the U.S. Bureau of Mines has specified the requirements for the electrical circuits of equipment and instruments for use in methane atmospheres. These requirements, given in the appropriate Bureau of Mines Schedules, contain the following:

1. All intrinsically safe equipment must be intrinsically safe for methane atmospheres.

2. All possible combinations of failures must be considered in determining whether or not energy levels might rise above a permissible safe level under fault conditions.

3. All possible modes of failure must be considered.

Instruments approved by the U.S. Bureau of Mines for use in methane atmospheres are listed in a series of publications. (12,13,14,15,16)

Other hazardous concentrations can be encountered by the industrial hygienist in his sampling of the environment. The specifications for electrical requirements for these conditions have been prepared by the Instrument Society of America in their latest publication. (17)

Suitable equipment for use in specific atmospheres is approved by Underwriters Laboratory (18) or by Factory Mutual Engineering Corporation. (19)

When intrinsically safe instruments or equipment cannot be obtained, then explosion-proof housings are required. The use of explosion-proof housings is based on the fact that in many types of electrical equipment the quantity of energy available to a combustible mixture during normal operation or during probable and non-preventable faults is well above that required for ignition. One way in which such equipment can be employed safely in a hazardous location is to provide an enclosure so constructed that, if ignition does occur around the equipment, the flame cannot propagate outside the enclosure and spread to the surrounding atmosphere. In order to perform this function the enclosure must contain the internal explosion forces without damage and cool any gases which escape so that they cannot ignite the flammable mixture surrounding the enclosure. Explosion-proof enclosures are not gas-tight. It is expected that gas or vapor will enter the enclosure and be ignited if there is an ignition source.

BIBLIOGRAPHY

1. National Electrical Code, N.B.F.U., No. 70, 1962.
2. National Fire Protection Association, Fire Protection Handbook, Section 6, Chapters I-VII, Twelfth Edition, 1962.
3. Baumeister, T., and L. S. Marks. Standard Handbook for Mechanical Engineers, Section 7, Seventh Edition, 1967.
4. Hartmann, Irving, M. Jacobson, and R. P. Williams. Laboratory Explosibility Study of American Coals. BuMines Rept. of Inv. 5052, 1954.
5. Jacobson, Murray, J. Nagy, A. R. Cooper, and F. J. Ball. Explosibility of Agricultural Dusts. BuMines Rept. of Inv. 5753, 1961.
6. Jacobson, Murray, J. Nagy, and A. R. Cooper. Explosibility of Dusts Used in the Plastics Industry. BuMines Rept. of Inv. 5971, 1962.
7. Jacobson, Murray, A. R. Cooper, and J. Nagy. Explosibility of Metal Powders. BuMines Rept. of Inv. 6516, 1964.
8. Nagy, John, H. G. Dorsett, Jr., and A. R. Cooper. Explosibility of Carbonaceous Dusts. DuBmines Rept. of Inv. 6597, 1965.
9. Dorsett, Henry G., Jr., and John Nagy. Dust Explosibility of Chemicals, Drugs, Dyes, and Pesticides. BuMines Rept. of Inv. 7132, 1968.
10. Nagy, John, A. R. Cooper, and H. G. Dorsett, Jr. Explosibility of Miscellaneous Dusts. BuMines Rept. of Inv. 7208, 1968.
11. Zabetakis, Michael G. Flammability Characteristics of Combustible Gases and Vapors. BuMines Bull. 627, 1965.
12. Brunot, H. D. Permissible Mine Equipment Approved to January 1, 1953. BuMines Bull. 543, 1954.
13. Lee, F. R., and R. L. Evans. Permissible Mine Equipment Approved by the Bureau of Mines During 1953-62. BuMines Inf. Circ. 8220, 1964.
14. Lee, F. R., and R. L. Evans. Permissible Mine Equipment Approved by the Bureau of Mines During 1963-64. BuMines Inf. Circ. 8299, 1966.
15. Lee, F. R. Permissible Mine Equipment Approved by the Bureau of Mines During 1965-66. BuMines Inf. Circ. 8372, 1968.
16. Lee, F. R. Permissible Mine Equipment Approved by the Bureau of Mines During 1967-68, BuMines Inf. Circ. 8463, 1970.
17. Magison, E. C. Electrical Instruments in Hazardous Locations. Plenum Press, New York, N.Y., 1966.
18. Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago, Ill. 60611.
19. Factory Mutual Engineering Corp., 1151 Boston-Providence Turnpike, Norwood, Mass. 02062.

AIR SAMPLING INSTRUMENTS

For Evaluation of Atmospheric Contaminants

Fourth Edition

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS

First Edition 1960
Second Edition 1962
Third Edition 1967
Fourth Edition 1972

This edition may be ordered from the American Conference of Governmental Industrial Hygienists, P.O. Box 1937, Cincinnati, Ohio 45201
PRICE: $12.50