Combustible Gas Detector Systems and Environmental and Operational Factors Influencing Their Performance

API PUBLICATION 2031
FIRST EDITION, JANUARY 1991

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005

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Safety and Fire Protection Department

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FOREWORD

This publication is intended to provide information to aid in understanding fixed combustible gas detector systems that utilize the Wheatstone bridge principle, as well as the environmental factors that affect their operation.

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Suggested revisions are invited and should be submitted to the director of the Safety and Fire Protection Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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SECTION 1—GENERAL

1.1 Scope

This publication provides general information on the effects of environmental and operational factors on the reliability and maintainability of fixed combustible gas detector systems utilizing the Wheatstone bridge principle. No specific design guidelines for the layout and installation of such systems are included because many variables affect their location and operation. After consultation with the equipment manufacturer, each installation should be thoroughly evaluated in accordance with sound engineering judgment, which may include dispersion modeling.

The scope of this publication does not include the operation of toxic gas detector systems.

1.2 Purpose

There are many factors that should be considered when optimizing the performance of fixed gas detection systems:

a. Ambient temperature.
b. Elevation and location of the sensor.
c. Velocity of the air moving past the sensor.
d. Air movements near the probable leak and near the sensor.
e. Vibration.
f. Humidity of the environment.
g. Changes in response due to aging of the sensor.
h. Substances or materials that poison or interfere with the sensor.
i. Exposure of the sensor to water, other liquids, or high concentrations of gas or vapor.
j. Changes in the power supply.
k. Interferences from electromagnetic fields or radio transmissions.
l. Sensor orientation (pointing upward, downward, or horizontally).

The need to maintain and calibrate gas detectors should be considered when determining their number and location.

The following is a discussion of how these and other environmental and operational factors affect the operation of the systems. Considerations are offered to help minimize or interpret these effects.

1.3 Definitions

The *lower flammable limit* (LFL), also known as the *lower explosive limit* (LEL), is the volumetric concentration of gas or vapor in air below which it will not ignite when in contact with an ignition source; that is, below this limit the mixture is too lean to burn or explode.

The *upper flammable limit* (UFL), also known as the *upper explosive limit* (UEL), is the volumetric concentration of gas or vapor in air above which it will not ignite when in contact with an ignition source; that is, above this limit the mixture is too rich to burn or explode. Flammable limits for various gases and liquids are published in NFPA 325M.

1.4 Referenced Publications

1.4.1 GOVERNMENT CODES, RULES, AND REGULATIONS

Regulatory agencies have established certain requirements pertaining to the use, installation, and operation of gas detection equipment. In addition to federal regulations, certain state and local regulations may be applicable. The following federal documents pertain to gas detection and should be used when relevant:

Coast Guard[1]
46 *Code of Federal Regulations* Part 153, "Ships Carrying Bulk Liquid, Liquefied Gas, or Compressed Gas Hazardous Materials;" and Part 154, "Safety Standards for Self-Propelled Vessels Carrying Bulk Liquefied Gases"

MMS[2]
30 *Code of Federal Regulations* Subpart H, "Production Safety Systems," Part 250.120–250.127

DOT[3]
49 *Code of Federal Regulations* Part 193, "Liquefied Natural Gas Facilities: Federal Safety Standards"

[1] U.S. Coast Guard, U.S. Department of Transportation. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402-9325.
[2] Minerals Management Service, U.S. Department of the Interior. The *Code of Federal Regulations* is available from the address given in Footnote 1.
[3] Research and Special Programs Administration, U.S. Department of Transportation. The *Code of Federal Regulations* is available from the address given in Footnote 1.

1.4.2 INDUSTRY CODES, STANDARDS, AND RECOMMENDED PRACTICES

Various organizations have developed codes, standards, and recommended practices that are useful references for designing, installing, operating, and maintaining gas-detection systems. The following are some of the more useful documents:

API

- RP 14C *Recommended Practice for Analysis, Design, Installation and Testing of Basic Surface Safety Systems on Offshore Production Platforms*
- RP 14F *Recommended Practice for Design and Installation of Electrical Systems on Offshore Production Platforms*
- RP 500A *Classification of Locations for Electrical Installations in Petroleum Refineries*
- RP 500B *Recommended Practice for Classification of Locations for Electrical Installations at Drilling Rigs and Production Facilities on Land and on Marine Fixed and Mobile Platforms*
- RP 500C *Classification of Locations for Electrical Installations at Pipeline Transportation Facilities*

CSA[4]

- Std C22.2 No. 152, *Combustible Gas Detection Instruments*

ISA[5]

- S12.13 Part I, *Performance Requirements, Combustible Gas Detectors*
- RP12.13 Part II, *Installation, Operation, and Maintenance of Combustible Gas Detection Instruments*
- S82.01 *Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment: General Requirements*
- S82.02 *Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment: Electrical and Electronic Test and Measuring Equipment*
- S82.03 *Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment: Electrical and Electronic Process Measurement and Control Equipment*

NEMA[6]

- ICS 6 *Enclosures for Industrial Controls and Systems*

NFPA[7]

- 59A *Production, Storage, and Handling of Liquefied Natural Gas*
- 70 *National Electrical Code*
- 325M *Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*

1.5 System Description and Operation

There is a wide variety of fixed and portable devices for detecting gas concentrations. This publication is limited to fixed gas detection systems. It is important to understand that these systems are for alarm purposes and are not intended to be used as analytical devices.

Applications of combustible gas detection systems in the petroleum industry have included monitoring methane, ethane, propane and other liquid petroleum gases (LPGs), hexanes, heptanes, gasoline, hydrogen, butadiene, and various solvents. Locations in which gas detection systems are commonly used are onshore and offshore drilling and production facilities, refineries, gas processing plants, compressor stations, pipeline pumping stations, and tank ships.

A typical combustible gas detection system consists of the following components:

a. A sensor contained within a housing assembly.
b. A control unit, which processes the signal transmitted from the sensor. It may have a variety of features to permit the activation of alarms and other protective devices.
c. A display unit that presents the information in a format understandable to the operator.
d. A power supply that provides the necessary voltages and currents

The most popular sensor is currently the catalytic type, which is limited to a range of 0–100 percent of the lower flammable limit. The catalytic sensor is provided with one or more flashback arresters to prevent ignition of combustible gases outside the sensor housing. Most sensors can also be provided with other protection devices, as described in this publication.

The catalytic sensor uses a filament of platinum wire coated with one of a variety of catalysts. Any combustible gas is oxidized by the catalyst and increases the electrical resistance of the wire. Each sensor contains an active sensing element and an inactive or reference element. The reference elements are shielded so as not to oxidize the gas. This provides a means of comparing a gas-free atmosphere with the environment outside the sensor housing.

[4]Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ontario, Canada M9W 1R3.
[5]Instrument Society of America, 67 Alexander Drive, P.O. Box 12277, Research Triangle Park, North Carolina 27709.
[6]National Electrical Manufacturers Association, 2101 L Street, N.W., Washington, D.C. 20037.
[7]National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269

The resistance of the active and reference elements is measured by connecting each element to a Wheatstone bridge and measuring the current balance across the bridge. The current differential is typically transmitted to an indicating device that reads from 0 to 100 percent of the lower flammable limit.

Some sensors may use a pellistor in place of a filament. A pellistor has the catalyst attached to a small bead of a rigid porous material to increase the effective reaction surface area and the sensor's poison resistance.

1.6 Historical Background

Environmental and operational influences have been found to cause various problems in detection systems, including the following:

a. Short sensor lifetime.
b. Inaccessibility of sensors for calibration.
c. Control units that indicate an atmosphere to be safe even though the lower flammable limit has been exceeded.
d. Sensor failure caused by plugging or poor placement.

SECTION 2—TEMPERATURE

2.1 General

The temperature range over which sensors can operate varies from manufacturer to manufacturer and is generally limited by the approvals for the electrical equipment used in the detection system. Although many sensors are designed to operate at temperatures from –40°C to +80°C (–40°F to +176°F), other components of the system may have different temperature limitations. System component temperature compatibility should be verified with the manufacturers.

Operation of the detection system at the upper and lower ends of the manufacturer-approved operating temperatures may result in zero drift. Readings obtained near the maximum allowable operating temperature of some sensors may be as much as 5–10 percent lower or higher than the actual lower flammable limit concentration.

Temperature extremes may also change the transmission characteristics of the cable between the sensor and the detection system controller. This is especially a problem when any Wheatstone bridge elements, such as resistors, are located in the controller. In this case, the cable is part of the bridge, and if its length is significant, the resistance of the cable may change with ambient temperature and influence the readings. Ways to minimize the effects of temperatures are discussed in 2.5.

2.2 High Operating Temperature

Instrument readings may be lower or higher than the actual LFL concentrations when the sensor is operated at high ambient temperatures. The maximum operating temperature for the system is also limited by the allowable temperatures for the electrical components. Although the use of military-specified components can extend the allowable temperature ranges in which the system can operate, the manufacturer's installation manual should be consulted.

Sensors and controllers operating in environments having unusually high temperatures, for example, within gas turbine enclosures, require specially designed components.

2.3 Low Operating Temperature

Instrument readings may be from 5 to 10 percent higher or lower than actual LFL concentrations when the sensor is operated at very low ambient temperatures. Operation at very low temperatures may also result in zero drift.

Freezing temperatures may result in plugging the screens in the sensor with frost. Because the sensor generates a small amount of heat, experience indicates that frost should not create a problem. A problem emerges only when the temperature drops to about –18°C (0°F).

Steam released near sensors during freezing temperatures may condense and freeze, plugging the sensor screens.

2.4 Rapid Changes in Temperature

Rapid temperature changes involving the sensor may cause zero drift and span drift because of temporary Wheatstone bridge imbalance. Additionally, a rapid decrease may cause any heavy materials carried into the sensor housing to condense and clog the sensor screens. It should be noted, however, that temperature changes of up to 10°C (18°F) per hour are not generally considered excessive.

2.5 Considerations

In general, operation of the detection system within the manufacturer's approved operating temperature range results in accurate LFL readings with minimal zero drift or span drift. To minimize the effects of variations in operating temperature, consideration should be given to the following precautions:

a. Calibrate the detection system at its mean operating temperature.

Note: The gas used for calibration should also be at the mean operating temperature of the detection system

b. Ensure that all components, including the sensor, are designed for operation within the expected ambient temperature range for the location of the installation.
c. If the gas detection system will be operated outside the temperature range approved by the manufacturer, consider the following:

1. Using military-specified components that can operate over a wider range.
2. Placing as many of the electronic components of the circuitry as possible in an adjacent area having a more favorable temperature.
3. Contacting the manufacturer for advice.

d. Locate the sensor away from sources of heat, such as furnaces and engine exhausts.

SECTION 3—ELEVATION AND SENSOR PLACEMENT

3.1 General

Proper placement of the sensor is critical to ensure prompt detection of flammable gases and vapors, and some system applications may even warrant the use of advanced engineering design techniques such as dispersion modeling. Sensors are generally located to provide one or both of the following types of detection:

a. Source detection, in which the sensors are placed near the anticipated source of release.
b. Perimeter detection, in which the sensors are placed so as to surround the area to be monitored.

Although source detection may provide prompt response to a release under still-air conditions, it may be ineffective if the wind blows the gases or vapors away from the sensor. In contrast, though perimeter detection may reduce the number of detectors required, it may increase the response time for detecting gases and vapors. Because of the problems inherent in each method, some facilities choose to use a mixture of both detection methods.

3.2 Elevation Above Sea Level

The elevation of the sensor above sea level has no significant effect on its accuracy.

3.3 Sensor Placement

In determining the proper height of the sensors, the physical properties of the hydrocarbons that may be released must be considered. Pressure, temperature, density, and other factors that affect dispersion of the released material must be evaluated.

Although gases will eventually diffuse to fill an enclosed space, they will stratify in a manner determined by their densities. Heavier-than-air hydrocarbon vapors and gases, such as gasoline vapor and propane, tend to accumulate in an area close to or below grade or ground level. In contrast, lighter-than-air gases such as hydrogen and methane tend to rise and concentrate near the ceiling of a confined space.

3.4 Considerations

When determining the proper location of sensors, the following factors should be considered:

a. Locate sensors near where the materials are expected to concentrate according to their densities. A sensor nearer a potential source of release ensures a shorter response time; however, this also ensures a smaller effective area of coverage. As the sensor is moved farther away from the source of release, its response time and its effective area of coverage increase.
b. Consider the prevailing direction of air currents and wind to ensure that the hydrocarbon release will reach the sensor. Widely varying wind directions may warrant the installation of additional sensors. Ventilation smoke tubes can be used to locate sensors in areas where the airflow is uncertain. Some facilities require the use of these tubes in locating sensors because experience with the facilities indicates that the actual airflow patterns are sometimes quite different from those anticipated during the initial design.
c. Consider the accessibility of the sensors. Personnel who calibrate and maintain sensors must have access to them. If the sensors are located well above grade, consider installing platforms, ladders, and other devices to improve access. Access is increasingly important because it is becoming commonplace to install more of the electronic components in the sensor housing. If sensors are to be installed in areas where access is poor, using housings that allow the calibration gas to be piped directly to the sensor and that have most of their controls located in an accessible location remote from the sensor should be considered.
d. Locate sensors high enough above grade to reduce the possibility that they will be immersed in water during flooding or be covered by snow or ice. Sensors located within 45–60 centimeters (18–24 inches) of grade level may experience problems from the splashing of water from hoses or rain. The effects of water splashing can be reduced by using manufacturer-approved cover guards. Such guards also help protect the sensor from physical damage in the workplace.

SECTION 4—AIR VELOCITY

4.1 General

The velocity of the air moving past the sensor can have the following effects:

a. Dissipate the flammable gases and vapors more quickly, effectively reducing the actual concentration at the sensor location. Thus, the sensor may not have sufficient time to respond to the gases or vapors before the concentration dissipates.
b. Produce a differential rate of cooling of the active element in the sensor, causing a zero drift.

In areas where the air velocity does not exceed 6 meters per second (20 feet per second), most sensors can be operated without experiencing significant errors; however, where the air velocity exceeds this value, the accuracy of the sensor strongly depends on the individual design and manufacturer. For example, some sensors have reportedly been operated in air velocities of 13–27 meters per second (44–88 feet per second) without significant error while other sensors operating at the same velocities may experience up to 50 percent error.

4.2 Considerations

In general, the problems caused by excessive air velocities can be controlled or eliminated by equipping the sensors with protective covers, as discussed in 3.4. Installation of covers increases the sensor's response time for detecting gases or vapors, but the increase is small for a properly designed, installed, and maintained system.

When placing sensors, consideration should be given to the prevailing winds, heating and cooling system air-circulation patterns, and the effects of other equipment that can cause or affect air circulation. Additionally, the effects caused by the shutdown of any air-circulation equipment should be evaluated to ensure that releases that occur during periods of abnormal air circulation are detected.

SECTION 5—VIBRATION

5.1 General

Vibration of the sensor is normally only a problem when the vibration has a low frequency and a high amplitude. Experience indicates that high-frequency vibrations do not normally adversely affect the sensor.

Failure resulting from vibration typically appears as a break in the electrical circuit of the controller. Many manufacturers provide their systems with continuity checks that indicate when this type of failure has occurred.

5.2 Considerations

The following items should be considered when developing strategies to control the effect of vibration:

a. Install the sensors on flexible mounts or flexible conduit.
b. Avoid mounting sensors directly on vibrating structures, such as rotating equipment.

SECTION 6—HUMIDITY

6.1 General

Humidity generally does not adversely affect sensors at levels below 95 percent relative humidity. This is partly because the operating temperature of the sensors [approximately 400°C (700°F)] provides heat to vaporize limited quantities of water condensing on the screens; humidity, however, may affect the sensitivity and response time of sensors equipped with filters

Sensors exposed to high humidity may experience accelerated corrosion and premature failure. The buildup of acids, salts, and other material on equipment housings in high-humidity conditions can cause severe corrosion, especially of metals such as aluminum and low-chrome stainless steels.

6.2 Considerations

If both high humidity and low temperatures are expected, the manufacturer should be consulted.

Corrosion can be controlled, in part, through proper use of corrosion-resistant materials, such as stainless steels or other alloys.

SECTION 7—AGING CHARACTERISTICS

7.1 General

All sensors experience decreased sensitivity with time. The rate of loss depends on the materials to which the sensor is exposed and the frequency and concentration of these exposures.

The typical lifetime for a properly installed and maintained sensor ranges from 2 to 5 years; however, some sensors operating in relatively clean environments have remained usable after 10 years. Aging of the sensor results in gradual zero shift. In addition, poisoning of the catalytic material due to exposure to certain contaminants in the environment can significantly affect the zero, the span, and the response time of the sensor.

Exposure of the sensor to levels of flammable gases or vapors within the flammable range greatly reduces its operating life. This damage is caused by overheating of the sensor and may occur in as little as 30 seconds, depending on the condition of the sensor and the concentration of the flammable gases or vapors.

7.2 Considerations

The following practices should be considered to control the effects of aging:

a. Calibrate the sensor regularly. Some companies recommend that sensors be calibrated every 30–90 days. This frequency may be gradually reduced as experience justifies.
b. Through the proper selection of sensor locations, minimize exposure to contaminants that may poison, plug, or otherwise affect the sensor.
c. Check the calibration of the sensors after they have been exposed to high concentrations of flammable gases or vapors.

SECTION 8—EXPOSURE TO MATERIALS AND THE ENVIRONMENT

8.1 General

Experiments indicate that the sensitivity of sensors gradually decreases as the carbon number of the hydrocarbon increases. This effect is considerably greater for pellistor sensors than for filament sensors.

The sensitivity of the sensor is greatly influenced by the types of materials to which it is exposed. In general, substances that leave an involatile residue on the surface of the sensor reduce the sensor's sensitivity. Manufacturers continue to develop poison-resistant sensors, but resistance to poisoning varies from one manufacturer to another. This section reviews some of the more common substances that can cause interferences.

8.2 Inert Gases

In general, inert gases such as nitrogen do not adversely affect the sensor. Inaccurate readings are obtained if the concentration of the inert gas becomes high enough to displace the oxygen around the sensor. This is because most sensors require at least 13 percent oxygen to operate, depending on the type of flammable gases or vapors present. In addition, some inert gases, for example, carbon dioxide, have high thermal conductivities and cause inaccurate readings at high concentrations.

Note: Inert gases also influence the flammable limits of substances. Where they are present in significant concentrations, consideration should be given to calibrating the sensors with gas mixtures having the same concentration of oxygen as those found around the sensor.

8.3 Steam

Exposure of the sensor to steam can cause inaccurate readings if there is enough steam present to displace the air from around the sensor. Exposure to steam can sometimes cause plugging of the sensor screens with condensed water and possibly ice; however, this effect is controlled somewhat by the heat generated by the sensor. Steam can also wet the interior of the sensor head, thus increasing the potential for an electrical short to ground or a reduced operating life of the sensor.

8.4 Other Gases and Vapors

Exposure of the sensor to certain substances causes a temporary or permanent reduction in its sensitivity. The contaminant either coats the catalyst or strips the catalyst off the active sensor element.

The rate at which the sensitivity is lost depends on the type and concentration of the contaminant. Sensitivity changes may occur after exposures of only a few minutes. Permanent loss of sensitivity can be caused by exposure to the following substances:

a. Chlorine, which corrodes the sensor and changes resistance.
b. Organic metallic compounds, including tetraethyl lead.
c. Sulfur compounds, in particular, hydrogen sulfide.
d. Compounds of lead, zinc, tin, mercury, and certain other metals.
e. Silicones, which are found in some oils and greases.

f. Phosphate esters, which are used in some corrosion inhibitors and hydraulic fluids.
g. Aerosol forms of certain greases and sulfides.
h. Glycols.

In general, the effects of exposure to low concentrations of contaminants can be corrected by recalibration; however, some contaminants, such as silicones, even at low concentrations, can permanently destroy the function of the sensor.

Temporary loss of sensitivity can result from the exposure of sensors to halogenated hydrocarbons, including carbon tetrachloride, trichloroethylene, Halon fire extinguishing agents, and the products of the thermal decomposition of polyvinyl chloride. Sensors exposed to halogenated hydrocarbons generally recover their sensitivity after operating for a few hours in clean air. Zero adjustment or span adjustment may be necessary after severe or repeated exposure to halogenated hydrocarbons, but this varies from manufacturer to manufacturer.

8.5 Oxygen Deficiency

Detection systems can generally be operated in oxygen concentrations as low as 13 percent but may require special calibrating techniques. At oxygen concentrations below 13 percent, the sensitivity of the sensor is reduced as a result of carbon buildup on the sensor.

Where oxygen-deficient atmospheres are suspected, the general recommendations contained in 8.2 should be considered.

8.6 Oxygen Enrichment

Increased oxygen concentrations usually void the approvals for the electrical components in the explosionproof equipment and may also cause the sensor to fail more rapidly. It should be noted that increased oxygen concentrations increase the flammable range of substances and require special calibration procedures. If oxygen levels above 21 percent are expected, it is recommended that the manufacturer be contacted.

8.7 Considerations

If several types of flammable gases or vapors may be present, consideration should be given to calibrating the system with the least responsive gas or vapor.

To minimize the effects of sensor poisoning, the following items might be considered:

a. Use poison-resistant sensors, which reduce but do not eliminate the effects of contaminants. Additional information on these sensors may be obtained from the manufacturers.
b. Locate the sensors away from obvious sources of harmful contaminants.
c. Use a filter system to remove contaminants. Activated-carbon filters are available that remove a wide variety of contaminants; however, they also remove some of the flammable gases or vapors. Filters should be selected for specific substances after consultation with the manufacturer of the gas detection system.

Installation of filters is expected to result in longer response times for the sensors. Experience has shown that certain hydrocarbons may be absorbed by the carbon and gradually released over a period of time, as their level drops. This may make calibration of the sensor difficult.

Humidity also affects the sensitivity and response time of sensors equipped with filters. In general, low humidity increases the level of protection provided by the filter system but also increases the response time. High humidity has the opposite effect. A water trap should be provided in high-humidity areas to protect the filter because water vapor reduces its efficiency.

SECTION 9—PLUGGING OF SENSOR HEADS

9.1 General

For detection equipment to respond properly to atmospheric composition changes, samples must be able to pass through the sensor chamber. Because sensors are equipped with various protective devices, and passageways can be small, plugging can occur if the sensors are not regularly maintained.

9.2 Obstructions

Obstructions such as dust, insects, and paint can affect the operation of the sensor by plugging the sensor screens or the sensor itself. Dust may be a problem, especially when humidity is high.

Partial plugging of sensors can result in increased response times; complete plugging may result in no response at all.

9.3 Considerations

If plugging is expected to be a problem, the sensor should be equipped with a cover guard. The manufacturer should be contacted to determine the most effective design.

All openings on each guard should be provided with a screen to prevent entry by insects. Screens should be periodically checked for possible plugging to ensure that ventilation through the cover remains adequate.

The bottom of the cover should have several holes to allow water to drain out.

Sensors can be temporarily protected with a cover during certain kinds of work. For example, plastic bags might be tied over the sensor housing before spray painting. The manufacturer's advice may be solicited for various temporary protection methods.

Note: Any temporary covering will cause a sensor to be inoperative and must be removed when the work is finished. The use of brightly colored temporary covers helps to make it obvious that sensors are out of service.

SECTION 10—FLOODING OF SENSORS

10.1 General

Since catalytic sensors are designed to measure air/gas mixtures within well-defined limits (zero to the LFL), their exposure to vapor or liquids exceeding the LFL can be damaging and can give a false sense of security. Understanding these limitations can be of considerable help when troubleshooting and analyzing system responses.

10.2 Hydrocarbon Vapor Flooding

Exposure of the sensor to high concentrations of hydrocarbon vapor can cause the sensor to burn out rapidly. Concentrations of hydrocarbons above the LFL cause a rapid rise in the concentration indicated, followed by a rapid decline, possibly even to a much lower concentration than the true concentration. This effect is caused by depletion of the oxygen around the sensor and a reduction in the combustion reaction on the sensing element.

10.3 Liquid Flooding

Immersing the sensor in any liquid can cause permanent or temporary damage. Some materials can coat the active element in the sensor, causing recalibration difficulties, while other materials may plug the sensor's flame arresters. If the sensor is immersed in liquid hydrocarbons, the vapors released may permanently damage the sensor by overheating.

Should a liquid contact the sensor, the thermal shock may break it. The liquid may also produce an electrical short.

10.4 Considerations

To reduce the consequences of exposure to high concentrations of flammable gases and vapors, namely, false indication and sensor burnout, an alarm can be set to sound when the LFL is reached. This can be done with a latching alarm and other devices, which must be manually reset after being energized.

Problems caused by immersion of the sensor in liquids can be eliminated by locating it well above the possible flood level.

SECTION 11—POWER SUPPLY

11.1 General

Explosionproof electrical components of gas-detection systems should be designed and operated to comply with the requirements of Article 500 of NFPA 70. Failure to comply may permit the detection system to act as an ignition source to flammable atmospheres outside the equipment.

All electrical components of detection systems must be approved for the area in which they will operate. If Group A or Group B gases or vapors as defined by NFPA 70 are present, it may be more economically feasible to aspirate samples of the gas to components located in a less hazardous area. Allowance must be made for sample travel time through aspiration tubing. Assistance in classifying hazardous areas can be obtained by referencing NFPA 70, API Recommended Practices 500A, 500B, and 500C, and other sources.

When locating the detection control unit outside the area being sampled, it is important to consider the effect that this will have on the loop resistance, minimum wire size, type of cable, and wiring methods.

11.2 Power Variations

Fluctuations of ±10 percent of the nominal input voltage do not generally affect the operation of the system. If the voltage drops below the allowable level, the sensor may cool, thus reducing its sensitivity and increasing its response time. If the voltage exceeds the allowable level, the surge will generally blow the fuses or other surge protectors installed in the system.

11.3 Electrical Continuity

Breaks in the wiring of detection systems are a common problem. Other problems include corrosion buildup at splices on electrical wires, which changes the resistance of the wiring. Good electrical continuity is important because any resistance changes in the wires can cause false readings.

11.4 Battery Backup

Backup power supplies permit uninterrupted operation if the primary power supply should fail. Backup supplies are often useful during unusual circumstances at the facility, when gases or vapors are more likely to be released in conjunction with a power outage.

Should power to the sensor be interrupted for an unacceptable period of time (for example, for more than 100 milliseconds), then false alarms, relay dropout, and other problems can occur, depending on the design of the individual system.

Backup power supplies have caused few problems, because most systems in which they have been installed automatically switch to the backup supply if the primary power source fails. When problems have occurred, they have generally involved batteries that supplied either too high or too low nominal input voltages. Good practice suggests floating the gas-detection system on batteries and using a charging circuit to keep the batteries fully charged.

Batteries used in backup power supplies have occasionally experienced reduced useful life because of improper operation and recharging.

11.5 Considerations

11.5.1 POWER SUPPLY

The following considerations apply to the power supply:

a. Consider installing an alarm on the system controllers to warn of low voltage conditions. Contact the system manufacturer for additional details.

b. Should a failure caused by a power surge occur, first check all components not protected by surge-protection equipment. This would include lamps, relays, and AC components.

11.5.2 ELECTRICAL CONTINUITY

The following considerations apply to electrical continuity:

a. Detection systems should be provided with controllers that automatically monitor the continuity of the wiring system.

b. The use of continuous wires is preferable when wiring a remote leg of a Wheatstone bridge circuit. Terminal and wire splices should be kept to a minimum. If splices are used, they should be isolated in junction pull boxes rather than occurring at random throughout the wiring.

c. All splices should be soldered, and all screwed terminals must be tight.

d. Where wire fatigue can be a problem, the recommendations discussed in 5.2 should be implemented.

e. The manufacturer should be consulted on electrical lead insulation when the application environment temperature extremes exceed the equipment literature limits

11.5.3 BATTERY BACKUP

The following considerations apply to battery backup:

a. Facilities already equipped with an uninterruptible power supply (UPS) should consider using this backup supply for their gas-detection systems. Factors to be considered include a review of the existing load on the uninterruptible power supply system and the desired duration of the backup.

b. The manufacturer of the detection system should be contacted for procedures to maximize the effectiveness of batteries used in the system.

SECTION 12—INTERFERENCES

12.1 General

Unless detector systems are carefully designed and installed, they can be disturbed by outside energy sources such as radio frequency interference (RFI) and electromagnetic interference (EMI). As with other instrumentation, lightning strikes are also a potential problem. Since the detection system circuitry can act as a large antenna, existing interference possibilities should be considered in designing new systems and troubleshooting systems in service.

12.2 Radio Frequency Interference

Broadband radio interference can cause problems if precautions are inadequate. Although instrument manufacturers continue to improve RFI rejection circuitry, poor user education and use of equipment can cause problems such as errors in calibration, zero drift, and false alarms.

Older gas detection systems that were not equipped with adequate shielding or filters are more susceptible to RFI than are newer systems. Many of the problems have occurred because two-way radios or walkie-talkies were operated near the systems. Problems have also occurred aboard ships equipped with radar systems.

System problems are usually caused when the interference causes the sensor to cool. When the interference stops, for example, when the microphone key of a two-way radio is released, the full power is immediately returned, and a temperature imbalance occurs. The system senses this imbalance and operates an alarm.

Many systems are currently designed to operate normally even when exposed to radiation of 5 watts at a distance of 2 feet from the sensor, interconnecting wiring, or other electrical components, provided that the frequency ranges do not exceed 150–170 megahertz and 450–470 megahertz. It is important to note that these newer sensors are only RFI resistant and can still malfunction when conditions are different from those described above.

12.3 Electromagnetic Interference

Sensors usually produce signals of 0 to 300 milliwatts, and any electromagnetic interference can cause false readings and alarms. Electromagnetic interference has occurred when detection system cables and cables carrying heavy switching currents, such as cables to DC motors, have been run in the same raceway or bundle.

Isolated problems of interference have occurred when direct connections of alarm circuits to contactors or motor starters have been made.

12.4 Lightning and Static Electricity

With the exception of lightning strikes, static electricity does not generally affect the gas-detection system; however, static discharge can cause damage if it enters the sensor from either the signal end or the output end. This should be kept in mind if a bypass or arrester is used.

12.5 Considerations

The following considerations apply to interferences:

a. If power lines cause interference, consideration should be given to using isolation transformers and filters.
b. Radio transmitting antennas should not be placed directly in line with the sensor electronic circuitry.
c. Sensor calibrations should be made without breaking the integrity of the explosionproof housing because the housing provides good shielding against interferences from 150 to 450 megahertz.
d. Where various frequencies of RFI can be present, shielded cable between the sensor and the controller must always be used. The shield should be grounded only at the controller.
e. If a problem occurs when the control panel of the detection system is opened, this is an indication that the panel is acting as a shield from the radio frequency radiation.
f. In general, sensor cables should be kept at least 1 foot away from high-power and high-frequency cables.
g. The system manufacturer should be contacted for recommendations concerning filters, shielding, or other equipment to eliminate radio frequency problems.