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The Safety Company

Flame Detection Handbook

Principles of Optical Flame Sensing Technologies and Industrial Flame Detection Systems



FIRST EDITION

This handbook is intended to introduce users to key concepts and terminology used in the proper application of optical flame detection systems, and to cover considerations involving hazard assessment execution, operating principles, global approvals, instrument and system selection, accessories, coverage best practices, and general data (found in the informational appendices).

The Handbook contains:

- A glossary containing many essential flame detection terms and abbreviations.
- A summary of some key principles of flame monitoring optical methods.
- Reference data – including physical properties and flammable limits – for the most commonly flammable liquids and gases, in industrial and various other environments.
- A comparison of the most widely-used flame detection technologies.
- Mapping and Field of View (FOV) coverage.
- Self-diagnostic tests/routines to help ensure proper operation.
- False alarm sources and rejection capabilities.
- Flame detection performance specifications/guidance.
- Flame hazards common to specific applications within major industries.
- A summary of key gas detection instrumentation approvals information, including hazardous locations classification.
- MSA's exclusive Sensor Placement Guide, detailing important factors one can take into consideration when determining flame (and gas) sensor placement for optimum onsite coverage.

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Introduction to Fire Signatures and Alarm Signaling

Characteristics of Fires, Flames, and Explosions

Combustion/Flame Chemistry of Volatile Liquids, Gases, and Solids

Fire Alarm Signaling Overview

Characteristics of Fires, Flames, and Explosions

- Fires can cause large losses (human and materials).
- Chemical reaction requiring three components: fuel, oxygen, and an ignition source (fire triangle). If any one of these three components is missing, a fire cannot start.
- Ignition can be caused by convection, conduction, or radiation.
- Several types of combustion processes depending on the combustion rate: Slow combustion (no flames and temperatures very low), normal combustion (controlled combustion process), explosion (very quickly), detonation (very quickly and propagates rapidly).

Simple hydrocarbon fuels combine with oxygen to produce carbon dioxide and water through combustion. This chemical process involves rapid oxidation or burning of a fuel, releasing heat and light. During combustion, atmospheric oxygen reacts with the fuel to produce carbon dioxide, carbon monoxide, and water. Hydrocarbons are generally easily ignitable and burn freely in open-air situations..

Types of Fires

Fires are classified by the type of fuel they burn:

NFPA CLASSIFICATION

CLASS OF FIRE	TYPE OF FIRE	APPROVED FIRE EXTINGUISHER
A Ordinary Combustibles	Wood, paper, cloth	Type A; Type A-B
B Flammable Liquids	Gasoline, paints, oils, grease	Type A-B; Type B-C; Type A-B-C
C Live Electrical Equipment	Electrical wiring, fuse box	Type B-C; Type A-B-C
D Combustible Metal	Metals	Bucket of Sand
K Commercial Cooking Equipment	Commercial cooking oil appliances	*Wet Chemical

*Class K extinguishers may require specific training, including when they should be used or not used. For example, the extinguishing agents in many Class K extinguishers are electrically conductive and should only be used after electrical power to kitchen appliance has been shut off.

Types of Fires

Fires are classified by the type of fuel they burn:

EUROPEAN CLASSIFICATION

CLASS OF FIRE	TYPE OF FIRE
A Ordinary Combustibles	Class A fires involve ordinary combustible materials such as wood, paper, fabric, and plastics. These fires are fueled by organic substances and typically leave behind ash after combustion. To extinguish Class A fires, water or Class A fire extinguishers are commonly used. The key is to cool the material and eliminate the heat source.
B Flammable Liquids and Gases	Class B fires are fueled by flammable liquids and gases, including gasoline, oil, and propane. They can be extremely dangerous due to the rapid spread of flames. Firefighters combat Class B fires using foam, carbon dioxide, or dry chemical extinguishers. These agents smother the fire by cutting off its oxygen supply.
C Electrical Equipment	Fires involving electrical equipment fall into Class C. These fires can be tricky to handle because of the risk of electrocution. De-energizing the electrical source is the first step, followed by using a non-conductive extinguishing agent like carbon dioxide or dry chemical powder.
D Combustible Metals	Class D fires involve combustible metals such as magnesium, titanium, and sodium. These fires require specialized extinguishing agents like dry powder designed for the specific metal involved. Water should be avoided at all costs, as it can exacerbate the situation by reacting with the metal.
F Cooking Oils and Fats	Class F fires are typically found in kitchens and involve cooking oils and fats. These fires burn at very high temperatures and can be challenging to extinguish. Specialized wet chemical extinguishers are used to suppress the flames ,cooling the oil and preventing re-ignition.

*Source: https://www.hsestudyguide.com/classes-of-fire-as-per-european-standard/

Theoretically, in any combustion, a minimum ratio of air to fuel is required for complete combustion. The combustion, however, can be made more readily complete, and the energy released maximized, by increasing the amount of air. An excess of air reduces the ultimate temperature of the products and the amount of released energy. Therefore, an optimum air-to-fuel ratio can usually be determined, depending on the rate and extent of combustion and final temperature desired. Air with enriched oxygen content or pure oxygen, as in the case of an oxyacetylene torch, will produce a high temperature. The rate of combustion may be increased by finely dividing the fuel to increase the surface area and hence its rate of reaction and by mixing it with the air to provide the necessary amount of oxygen to the fuel.

Explosions

Explosions are one of the most destructive events that can transpire. Explosions may occur too quickly for conventional fire protection systems to be effective. Once an explosion occurs, damage may result from several events:

1. **Overpressure** – The pressure developed between the explosion's expanding gas and its surrounding atmosphere;
2. **Pulse** – The differential pressure across a plant as a pressure wave passes, which might cause collapse or movement;
3. **Projectiles, missiles, and shrapnel** – Items thrown off by the blast of expanding gases, which might cause damage or escalation of the event.

Explosion overpressure levels are generally considered one of the most critical measurements. Estimates are normally prepared on the amount of overpressure that can be generated at various damaging levels. These levels are commonly referred to as overpressure circles. They are typically drawn from the point of ignition and for the sake of expediency and highest probability as the point of leakage or release unless some other likely ignition point is identified.

Typical locations where fire risk exposures are considered prevalent are:

- Open flame heaters, such as gas or propane heaters
- Pumps handling combustible materials
- Reactors
- Compressors
- Large amounts of combustible materials contained in vessels, columns, and drums

The American Petroleum Institute (API) publication 2218 provides further guidance on the exact nature of items and conditions that the industry considers prudent for protection.

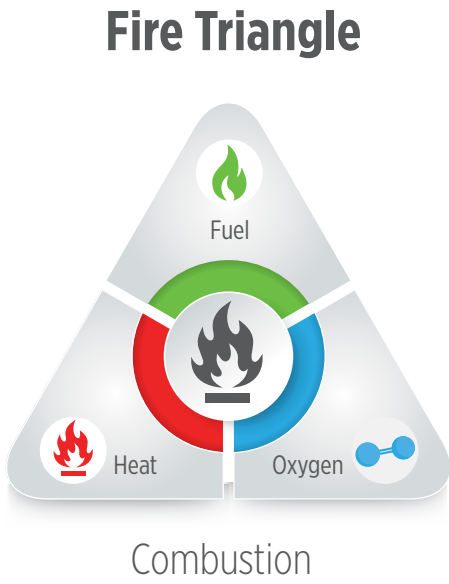
Combustion/Flame Chemistry of Volatile Liquids, Gases, and Solids

Hydrocarbon materials must be first in a vapor condition before combustion processes can occur. For any gaseous material this is an inherent property. Liquids, however, must have significant vapor emissions in order for flammable concentrations to be present for combustion processes to occur. Therefore, hydrocarbon liquid releases are relatively less dangerous than gaseous releases.

Gases, by their nature, are immediately ignitable (versus liquids that must be vaporized to support combustion) and can produce a fast-burning flame front that generates into an explosive force in confined areas. If pressurized gas leak fires are extinguished, but the leakage is not stopped, the vapors can again be reignited and produce an explosive blast.

When an ignition source is brought into contact with a flammable gas or a mixture of gases, a combustion chemical reaction will occur at the point of introduction, provided an oxidizer is present, normally oxygen. The combustion components are commonly graphically referred to as a simple fire triangle, fire tetrahedron, or fire square (see image on right).

Combustion normally travels from the point of ignition throughout the body of the gas and air mixture. Combustion continues until the fuel is exhausted if sufficient air (i.e., oxygen) is available or until a suppression mechanism interrupts the process.



Combustion/Flame Chemistry of Volatile Liquids, Gases, and Solids

The basic equation for the chemical reaction of methane in ideal combustion is provided by the following:

$$CH_4 + 2O_2 = CO_2 + 2(H_2O)$$

Carbon monoxide, carbon dioxide, nitrogen, and water vapor are typical exhaust gases from ordinary combustion. If other materials are present, they can form additional compounds, some of which may be highly toxic. Imperfect combustion, often occurring during accidental fires and explosions, results from turbulence, inadequate oxidizer supply, and other factors, leading to the production of free carbon (smoke), carbon monoxide, and other byproducts (Figure 1).

The combustion process emits heat and light. The amount of heat released varies with the fuel, measured in calories or Btu. Ordinary combustibles release a moderate amount of heat, while hydrocarbons release significantly more. For instance, the ideal combustion of 0.45 kg (1 lb) of methane releases about 25,157 kJ (23,850 Btu). Combustion products typically reach 1200°C (2192°F), a common temperature for hydrocarbon fires. Steel melts around 1370°C (2500°F) but loses its strength well before this, making hydrocarbon fires particularly destructive to industrial processes.

In normal atmospheric conditions, fire is initiated by a combustible material coming into contact with a heat source. The spread of fire occurs due to direct flame impingement or the transfer of heat to the surrounding combustible materials. Heat transfer occurs by three principle mechanisms—conduction, convection, and radiation.

Conduction is the movement of heat through a stationary medium, such as solids, liquids, or gases. Steel is a good conductor of heat, as is aluminum, therefore they can pass the heat of fire if left unprotected.

Convection involves the transfer of heat from one location to another via a moving medium, such as heated gas. Large masses of air heated by flame convection currents can rapidly raise the temperature of combustible materials in their path to their ignition temperature. When structural barriers like ceilings or decks prevent the heated air from rising, the fire can spread laterally, forming a heat layer that grows in depth and intensity. In enclosed spaces, this can lead to ambient temperatures exceeding the ignition point, causing simultaneous combustion everywhere, a phenomenon known as flashover.

Combustion/Flame Chemistry of Volatile Liquids, Gases, and Solids

Radiation transfers energy through electromagnetic waves, similar to how light travels through the atmosphere. When these waves encounter an object, the object's surface absorbs their energy. The heat transfer rate by radiation is roughly proportional to the fourth power of the temperature difference between the radiating source and the receiver. Thus, radiant heat transmission from fires is a significant factor in fire incidents. This underscores the importance of cooling exposed surfaces of process equipment, storage tanks, and vessels, as well as fireproofing structural supports. When a hydrocarbon release ignites, various fire and explosion events can occur, depending on the material type, release rate, ignition point, and surrounding environment.

Fire Development Stages

Incipient Stage
Little visible smoke occurs but invisible aerosols are generated

Smoldering Stage
Visible smoke is generated along with Carbon Monoxide

Flaming Stage*
Open flames generated along with high levels of CO_2

Heat Stage or Flashover*
Gases and aerosols ignite and can carry fire to other areas

**Stage where an optical flame detector is applicable. Without a flame, the energy level required to create an alarm is not present.*

Flame Anatomy

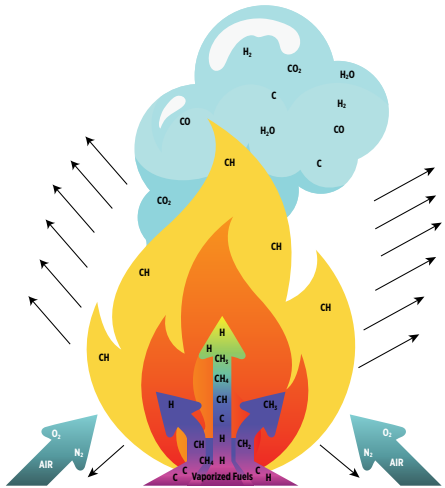


Figure 1. Incomplete combustion can lead to the production of harmful byproducts such as carbon monoxide and particulate matter (smoke and soot).

Fire Alarm Signaling Overview

Each type of detector output signal plays a vital role in ensuring the effectiveness and reliability of fire alarm systems. Fire alarm relays and fault relays provide essential interfaces and monitoring capabilities, while analog 4-20 mA and HART protocols offer robust communication methods for transmitting and managing sensor data. Together, these components ensure a comprehensive and responsive fire alarm signaling system.

Key Functions of Analog 4-20 mA Signals

Function	Description
SENSOR DATA TRANSMISSION	Transmits sensor data over long distances without significant loss of signal quality.
RELIABLE COMMUNICATION	Provides a stable and noise-immune signal, ensuring accurate data transmission in industrial environments.
LINEAR OUTPUT	Offers a linear relationship between the sensor measurement and the signal transmitted, allowing for precise monitoring.

Benefits of Analog 4-20 mA Signals

Benefit	Description
LONG DISTANCE TRANSMISSION	Capable of transmitting signals over long distances with minimal signal degradation.
NOISE IMMUNITY	Less susceptible to electrical noise, making it reliable in industrial settings.
INDUSTRY STANDARD	Widely accepted and used across various industries, ensuring compatibility with a range of devices.

Features of Analog 4-20 mA Signals

Feature	Description
STANDARDIZED SIGNAL	The industry standard for analog signals, ensuring compatibility with a wide range of devices.
CURRENT LOOP	The current loop format (4-20 mA) allows for consistent signal strength, even over long cables.
DIAGNOSTICS	Can help in diagnosing issues like open circuits (0 mA) or power loss (below 4 mA).

Fault Relays

Key Functions of Fault Relays

1. **System Monitoring:** Continuously check the status of the fire alarm system to ensure all components are functioning correctly.
2. **Fault Detection:** Identify issues such as open circuits, short circuits, ground faults, and obscured optics.
3. **Alerting Maintenance Personnel:** Provide immediate notification of detected faults to facilitate quick troubleshooting and repairs

Types of Faults Monitored

Wiring Faults: Detects breaks, shorts, or grounding issues in the wiring of the fire alarm system.

Device Malfunctions: Identifies faults in detectors, manual call points, and other devices connected to the system.

Power Supply Issues: Monitors the main power supply and backup batteries to ensure they are providing the required power.

Key Features of Fault Relays

1. **Continuous Monitoring:**
   Real-Time Status: Provides real-time monitoring of the system's status to ensure immediate detection of any issues.
   Diagnostic Information: Offers detailed information about the nature and location of the fault, aiding in quick diagnosis and repair.
2. **Fail-Safe Design:**
   Normal State Energized: The relay remains energized under normal operating conditions.
   De-Energize to Signal Fault: The relay de-energizes to indicate a fault, ensuring faults are detected even if power is lost.
   Reliable Operation: Guarantees the relay defaults to a safe state in the event of a failure, maintaining system integrity.
3. **Alert Mechanisms:**
   Visual and Audible Indicators: Activates lights and sounders to alert maintenance personnel of faults.
   Remote Signaling: Can send fault signals to remote monitoring stations or building management systems.

Key Features of Fault Relays (cont.)

4. **Programmable Options:**
   Customizable Settings: Allows for the programming of specific responses to different types of faults.
   Integration with Other Systems: Can be programmed to interact with other building management systems for comprehensive fault management.
   Redundancy: Often includes redundant components to ensure continued operation even if one part fails.
   Self-Diagnostics: Capable of performing self-diagnostics to ensure all components are functioning correctly and to detect potential issues before they become critical.

Fire Alarm Relays

1. **Instant Relays:**
   Instant relays are designed to activate immediately upon detecting a fire signal from the fire alarm system. They are crucial for prompt response actions such as:
   Activating Notification Devices: Instantly trigger bells, horns, strobes, and other alert mechanisms to notify building occupants.
   Initiating Immediate Controls: Quickly signal HVAC systems to shut down, release fire doors, or activate fire suppression systems to contain the fire.

Key Features of Instant Relays

Immediate Activation: Responds without delay to ensure swift action.

Simple Configuration: Easy to set up for immediate response actions without complex programming.

2. **Timed Relays:**
   Timed relays, also known as delay relays, are configured to activate after a preset time delay following a fire alarm signal. This delay allows for specific response strategies, such as:
   Staggered Notifications: Sequentially activating different alarm zones or devices to manage evacuation processes.
   Coordinated System Responses: Delaying certain actions to allow initial responses to take place first, such as ensuring all exits are unlocked before activating suppression systems.

Key Features of Time Relays

Adjustable Delay: Time delay settings can be customized according to specific safety protocols.

Coordinated Responses: Facilitates complex response strategies by timing the activation of different devices.

Programmable: Allows for detailed configuration to meet the unique needs of the facility.

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Detector Output Signals

2. **Programmable Relays:**
   Programmable relays offer advanced functionality and flexibility for integrating fire alarm systems with various building management systems. They are essential for:

   Custom Response Plans: Tailoring the activation sequences and timing to the specific safety protocols and layout of the building.

   Multi-Function Capabilities: Configuring relays to perform multiple actions based on different fire alarm conditions.

   Enhanced Control: Allowing for complex logic and control schemes to manage a wide range of devices and systems.

   Key Features of Time Relays

   User-Friendly Programming: Easy-to-use interfaces for setting up and modifying relay functions.

   Versatile Application: Suitable for a variety of scenarios, from simple notifications to complex building management tasks.

   Remote Configuration: Often supports remote programming and monitoring for ease of maintenance and adjustments.

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HART Protocol

The Highway Addressable Remote Transducer (HART) protocol is a hybrid analog and digital communication protocol used in fire detection systems for advanced diagnostics and control. It allows for:

Enhanced Data Communication: rovides both the traditional 4-20 mA signal and additional digital communication over the same wiring.

Device Configuration and Calibration: Facilitates remote configuration, calibration, and diagnostics of devices.

Two-Way Communication: Enables communication with devices to retrieve information about their status and performance.

Key Features of HART Protocol

Compatibility: Works with existing 4-20 mA infrastructure while adding digital communication capabilities.

Rich Data: Provides detailed device diagnostics and performance data.

Remote Access: Allows for remote monitoring and configuration of fire detection equipment..


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When Are Optical Flame Detectors a Best Fit

Hydrocarbon Hazard Applications

Common Non-Hydrocarbon Hazard Applications

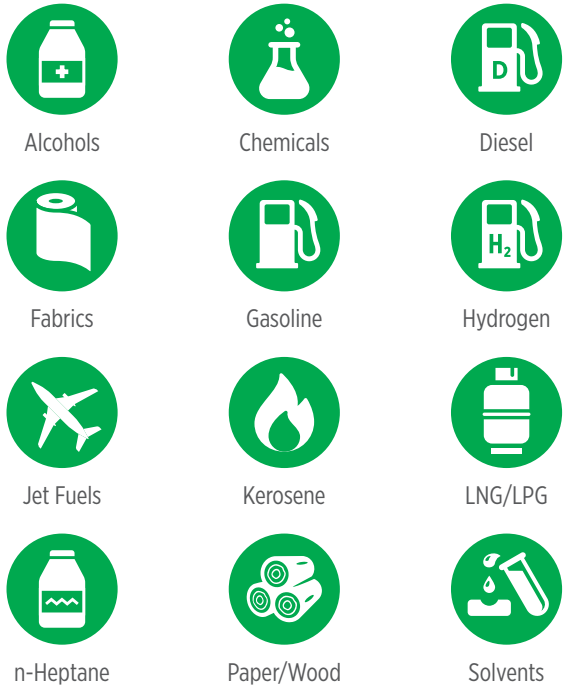
Flame Detection System Performance and Design Requirements

Flame Detection Applications & Technologies

Engineers in a wide range of hazardous process and manufacturing industries, as well as government and institutional facilities, require continuous flame monitoring equipment to prevent catastrophic fires that endanger employees, equipment, infrastructure, and surrounding communities.

Typical Flame Hazards

The range of potential flammable hazards is expansive and growing as materials and processes become more complex. Increasingly sophisticated flame sensing technologies with embedded intelligence can help to reliably detect the most common potential ignition sources:

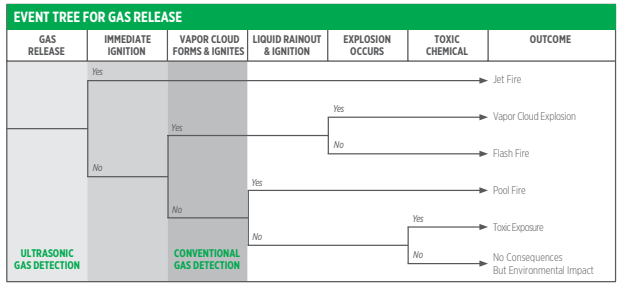


Some of the most challenging industrial environments for flame detection include:

- Aerospace
- Automotive
- Chemical Plants
- Food/Beverage
- Oil/Gas Distribution
- Oil/Gas Production
- Oil/Gas Refineries
- Pharmaceuticals
- Power Generation
- Textiles
- Warehouses
- Wood & Paper Plants

Gas Release Event Tree

The importance flame detection can be visualized using an event tree for gas releases. After the gas leak begins, the gas can either be immediately ignited or accumulate and later ignite with various possible outcomes. A well-placed flame detector can respond to burning gas in the event it ignites and creates flames.



Examples of Heat and Ignition Sources

Typical process industry hydrocarbon fire events can be categorized as follows:

- Jet fire
- Pool fire
- Spill fire (drip fire)
- Solid materials fire (wood, powder, metal)
- Gaseous fire (low pressure, high pressure/jet fire, explosive/flash fire)

Common Flame Hazard Applications

Location or Facility	Hazard	Fixed Detector Type Options	Reference
OFFICE	Ordinary combustibles Electrical fire	MPS, heat, smoke	NFPA 101
ACCOMMODATION	Ordinary combustibles Electrical fire	MPS, heat, smoke	NFPA 101
KITCHEN OR CAFETERIA	Ordinary combustibles Cooking/grease fire Electrical fire	MPS, heat	NFPA 101
CONTROL ROOM	Ordinary combustibles Electrical fire	MPS, smoke	NFPA 96
SWITCHGEAR ROOM	Electrical fire	MPS, smoke, optical, projected beam	NFPA 75
TURBINE PACKAGE	Electrical fire Hydrocarbon fire	Heat, optical	NFPA 850
PROCESS UNIT	Hydrocarbon fire	MPS, heat, optical	NFPA 30
PUMP STATION	Hydrocarbon fire Electrical fire	MPS, heat, optical	NFPA 30
LOADING FACILITY	Hydrocarbon fire	MPS, heat, optical	NFPA 30
TANK OR VESSEL STORAGE	Hydrocarbon fire	MPS, heat, optical	NFPA 30
OFFSHORE DRILLING OR PRODUCTION FACILITY	Hydrocarbon fire Electrical fire	MPS, smoke, heat, optical	NFPA 30 API 14C
LIQUIFIED NATURAL GAS (LNG) FACILITIES	Hydrocarbon fire Electrical fire	MPS, smoke, heat, optical	NFPA 59A
LABORATORY	Hydrocarbon fire Electrical fire	MPS, heat	NFPA 45

General Hazards of Common Petroleum Commodities

(Under typical process operations and conditions)

Commodity	Explosion	Pool Fire	Jet Fire	Smoke
Methane	✓		✓	
LNG	✓	✓	✓	
Ethane	✓		✓	
Propane	✓		✓	
Butane	✓		✓	
LPG	✓	✓	✓	✓
Crude oil	✓	✓		✓
Gasoline	✓	✓		✓
Diesel		✓		✓
Kerosene		✓		✓

Note: MPS - Manual Pull Station; also known as Manual Activation Callpoint (MAC)

Flame Detection System Performance Design Requirements

When configuring a flame detection system for a plant and evaluating the various flame detection technology alternatives available today on the market, the following flame detector performance criteria may be considered relative to plant and regulatory requirements:


False Alarm Immunity


Detection Range


Response Time


Field of View (FOV)


Operating Temperature Range


Communication Capabilities


Self Diagnostics (COPM)

Application Coverage Basics

Hazardous operations analysis can reveal:

- Flammable and Life Safety hazards present
- High-risk gas leak/cloud formation/ accumulation scenarios
- Most likely origin & first-contact points and accumulation zones

Definition of the detector performance specifications can reveal:

- Identify fuels that must be detected
- Enable optimal flame sensing technologies
- Layers of protection
- Enable identification of optimal detector locations and coverage

Key goals:

- No high-risk gas leak origin, or accumulation zones are left unprotected
- Maximize coverage while enabling easy access for calibration, maintenance, cleaning, testing, etc.

Flame Detection System Performance Design Requirements

Performance Considerations

Review jobsite flame detection performance requirements:

- Flammable fuel types and fire size
  Example 1: Natural gas/methane fire hazard; fire to be detected = 32" tall plume
  Example 2: Gasoline spill fire hazard; fire to be detected = 1' x 1' pan fire equivalent
- Possible false alarm sources – any changes or site modifications?
- Existing detector sensitivity settings per detector install location
  – 100% (high)
  – 75% (medium)
  – 50% (low)
- Recommend evaluation of existing flame coverage maps! Why? Because what looks good on in a coverage mapping study may in reality not be an acceptable location or coverage approach due to a number of unidentified variables.

What is an Industrial Fire & Gas System?

Continuously monitors life-safety hazards and other abnormal situations in an industrial facility or process including:

- Fire
- Combustible and/or toxic gas release or presence
- Manually-initiated Fire or Emergency Alarm signals

Key functions:

- Detection including fire, gas, smoke, heat, other initiating device signals
- Operating logic – typically defined within Cause/Effect matrix
- Fire and Gas alarm notification – typically horns, strobes, digital communications
- Hazard mitigation outputs – typically emergency shutdown (ESD), fire, suppression, isolation

Keys to success:

- Hazard and Operability (HAZOP)
- Proper detection placement to enable early warming
- Proper hazard mitigation actions to prevent escalation of the incident
- Proper installation, operation, and maintenance practices
- Proper training for accurate diagnosis, corrective actions, and fast return back to full production

Performance Testing of Flame Detectors

There are several companies which undertake performance testing and approval of flame detectors.

FM (Factory Mutual) in the U.S. is the most widely recognized test agency and most flame detectors are tested and approved to standard FM3260.

The live fire tests evaluate the detection performance based on the standard fuel n-Heptane. False alarm rejection performance and detection performance in the presence of non-fire radiation sources is also evaluated.

Manufacturers can also request for the detector to be tested on various other fuels, to cover their customer's specific applications.

The test protocol and environment must be the same for all manufacturers and all types of detectors.






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Principles of Optical Flame Detector Operation

Sensing Technologies Summary and Comparison

Field of View Definition and Characterization

Overcoming False Alarm Sources

Self-Check Diagnostics

Sensing Technologies Summary and Comparison

Motivators to install Fire/Flame Detectors

- Fear of actual loss / catastrophe
- Legal / fire department requirements
- Insurance premium benefit
- Recognition of risk / preventative measure
- National, regional, or local fire codes
- Safety of assets, people and property

Human surveillance

- Manual Pull Station (MPS) / Manual Activation Callpoint (MAC)
- Telephone reporting
- Portable radios

Smoke detectors

1. Ionization
2. Photoelectric
3. Dual chamber
4. Laser
5. Very early smoke detection and alarm (VESDA)

Thermal or Heat Detectors

1. Fusible plastic tubing (pneumatic)
2. Fusible optical fiber
3. Bimetallic strip or wire
4. Fusible plug (pneumatic pressure release)
5. Quartzoid bulb (pneumatic pressure release)
6. Fusible link (under spring tension)
7. Fixed-temperature detector
8. Rate of rise detector
9. Rate compensated
10. Combination rate of rise and fixed temperature

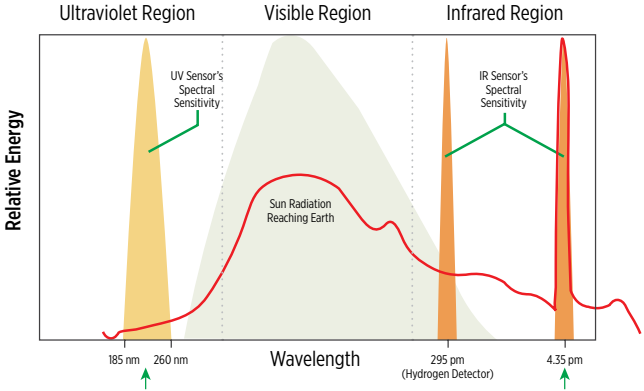
Sensing Technologies Summary and Comparison

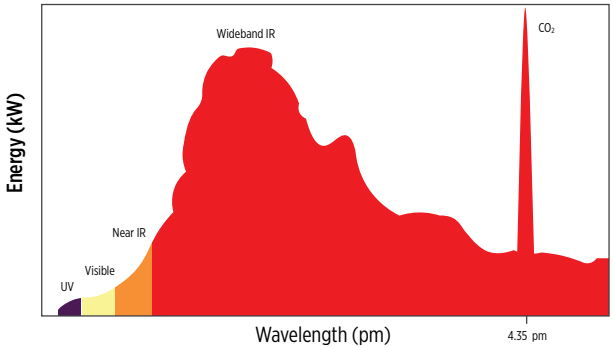
Optical Detectors: Spectral Energy Emission Signatures

- Open flames generate spectral emissions dependent upon fuel composition
- Most flammable fuels generate consistent flame emissions signatures
- Hydrocarbon (solid, liquids or gas) flames create this general signature

Optical Detectors: Hydrocarbon Fire Signatures

- High emissions of Ultraviolet Radiation
- High emissions of Infrared Radiation
- Presence of light, smoke, and airborne debris





Sensing Technologies Summary and Comparison

There are six types of optical detectors used in the process industries:

1. Ultraviolet (UV)
2. Single-frequency infrared (IR)
3. Dual-frequency infrared (IR/IR)

Rarely in use technologies

4. Ultraviolet/infrared—simple voting (UV/IR)
5. Ultraviolet/infrared—ratio measurement (UV/IR)
6. Multispectrum/Multiband

Most commonly used technologies

Flame detectors alarm at the presence of light from flames, usually in the ultraviolet and/or infrared range. The detectors are set to detect the light flicker of a flame. They may be equipped with time-delay features to eliminate false alarms from transient flickering light sources.

Each of the six types of detectors listed has advantages and limitations, making each more or less suitable for an application or a specific risk. Flame detection for a particular model has to be analyzed by evaluation of its technical specification to the expected fire development.

Sensing Technologies Summary and Comparison

Ultraviolet (UV) Detectors

These detectors respond to the relatively low energy levels produced at wavelengths between 0.185 and 0.245 µ. These wavelengths are outside the range of normal human visibility and outside that of sunlight.

Advantages

The UV detector is a general all-purpose flame detector. It responds to most burning materials but at different rates. The detector can be extremely fast, i.e., less than 12 ms for special applications (e.g., explosive handling). It is generally indifferent to the physical characteristics of flames and does not require a "flicker" to meet signal input functions. It is not greatly affected by deposits of ice on the lens. Special modules are available that can be used in high-temperature applications up to 125°C (257°F). Hot blackbody sources (stationary or vibrating) are not normally a problem. A UV detector is blind to solar radiation and most forms of artificial light. An automatic self-testing facility can be specified or it can be tested with a handheld source at a distance up to 10 m (30 ft) from the detector. Most models can be field adjusted for either flame sensitivity or time delay functions.

Limitations

A UV detector is rarely in use today. It may respond to electrical arc from welding operations. It can be affected by deposits of grease and oil on the lens. This reduces its ability to sense a fire. Lightning with long-duration strikes can cause false alarm problems. Some vapors, typically those with unsaturated bonds, may cause signal attenuation. Smoke may cause a reduction in signal level seen during a fire. It may produce a false alarm response when subject to other forms of radiation such as from radiological testing, i.e., nondestructive testing (NDT), which is periodically performed on process system vessels and piping.

Sensing Technologies Summary and Comparison

Single-Frequency Infrared (IR) Detectors

Most single-frequency IR detectors respond to infrared emissions from the narrow CO_2 band at 4.35 µ. They may require the satisfaction of a flicker frequency discrimination at between 2 and 10 Hz.

Advantages

A single-frequency IR detector responds well to a wide range of hydrocarbon fires and is blind to welding arcs except when very close to the detector. It can see through smoke and other contaminants that could blind a UV detector. It generally ignores lightning, electrical arcs, and other forms of radiation. It is blind to solar radiation and resistant to most forms of artificial lighting.

Limitations

Single-Frequency IR detectors are rarely in use today. There are few models with automatic test capability. Testing is usually limited to handheld devices of only 2 m (7 ft) from the detector or directly on the lens test unit. It can be ineffective if ice forms on the lens. It is sensitive to modulated emissions from hot blackbody sources. Most of these detectors have fixed sensitivities. The standard is being under 5 s to a petroleum fire of 0.1 m2 (1.08 sq. ft.), located 20 m (66 ft) from the detector. Response times increase as the distance increases. It cannot be used in locations where the ambient temperature could reach up to 75°C (167°F). Its response is dependent on fires possessing a flicker characteristic so detection of high-pressure gas flames may be difficult.

Sensing Technologies Summary and Comparison

Dual- or Multiple-Frequency Infrared (IR/IR) Detectors

This flame detector responds to infrared emissions in at least two wavelengths. Typically, CO2 reference at 4.35 µ is established and a second reference channel that is away from the CO_2 and H_2O wavelengths is made. It operates when the two signals are confirmed as synchronous and that the ratio between the two signals is correct.

Advantages

It responds well to a wide range of hydrocarbon fires and is blind to welding arcs. It can detect fires though smoke and other contaminants, although the signal pickup will be reduced. It generally ignores lightning and electrical arcs. It has minimal problems with solar radiation and artificial lighting. It is also insensitive to steady or modulated blackbody radiation. There is a high level of false alarm rejection with this model of detector.

Limitations

This type of detector is rarely in use today. Detectors with complete blackbody rejection capability are usually less sensitive to fires than a single-frequency infrared optical detector. Because its discrimination of fire and non-fire sources depends upon an analysis of the ratio between fire and reference frequencies, there can be a variation in the amount of blackbody rejection achieved. A detector's degree of blackbody radiation rejection is inversely proportional to its ability to sense a fire.

Sensing Technologies Summary and Comparison

Ultraviolet/Infrared (UV/IR) Detectors

There are two types of detectors under UV/IR classifications – a simple voting device and a ratio device. Both types respond to frequencies in the UV wavelength and IR in the CO_2 wavelength. In both types, alarm signaling is activated in response to detection of the simultaneous presence of UV and IR signals. In a simple voting device, an alarm is generated once both conditions are met. In a ratio device, satisfaction of the ratio between the level of UV signal received and the IR signal received must also be achieved before an alarm condition is confirmed.

Advantages

UV/IR detectors respond well to a wide range of hydrocarbon fires and are indifferent to welding or electrical arcs. There are minimal problems with other forms of radiation. They are blind to solar radiation and artificial lighting. They ignore blackbody radiation. Their fairly fast response is slightly better than a single-frequency IR detector but not as fast as a UV detector. The simple voting type will respond to a fire in the presence of an arc welding operation. It is not desensitized by the presence of high background IR sources. The flame sensitivities of the simple voting detector can be field adjusted.

Limitations

The sensitivity to a flame can be affected by deposits of IR- and UV- absorbing materials on the lens, if not frequently maintained. The IR channel can be blinded by ice particles on the lens, while the UV channel can be blinded by oil and grease on the lens. Smoke and some chemical vapors will cause reduced sensitivity to flames. UV/IR detectors require a flickering flame to achieve an IR signal input. The ratio type will lock out when an intense signal source such as arc welding or high steady-state IR source is nearby. Flame response for a ratio type is affected by attenuators, while in the voting type there are negligible effects.

Sensing Technologies Summary and Comparison

Multispectrum/Multiband

Multispectrum flame detectors monitor several wavelengths of predominate fire radiation frequencies by photocells. They compare these measurements to normal ambient frequencies through microprocessing. Where these are found to be above certain levels, an alarm is indicated. False alarms may even be “recognized” due to certain patterns.

Advantages

These detectors have very high sensitivity and very encouraging stability. In certain circumstances, the microprocessor has the capability to be programmed to recognize certain fire types.

Limitations

May be inadvertently mis-programmed. High sensitivity could lead to too much FOV in some applications.

IR/Closed-Circuit Television (CCTV) – CCTV/IR^3 Technologies

Advantages

CCTV/IR^3 flame detectors combine video cameras with three IR sensors covering multiple infrared spectral regions. These devices have the same benefits as Multiple-Frequency Infrared detectors, but also include viewing capabilities. The addition of video allows operators to monitor areas remotely for fire and to checkout alarms prior to determining the best response.

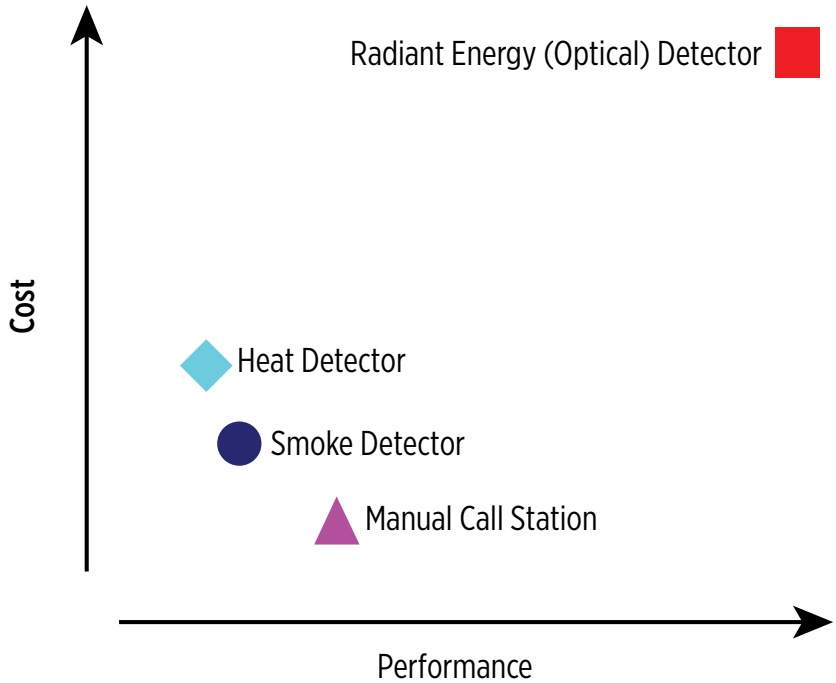
Limitations

The detection range of the infrared detectors is up to 200 feet (61 m) from the flame source; however, the video camera coverage is typically less than the full infrared detection range. The operating temperature range for the video camera is narrower than for the IR^3 detector array. Their cost is higher relative to other flame detector types. These detectors may be vulnerable to cybersecurity threats. Additional cable may be required to pass visible signal to monitor.

Comparison of Fire Detector Types

	Detector Type	Speed	Cost
Type of Detection			
Human	Human Telephone Portable Radio MPS/MAC	Moderate Moderate Moderate Moderate	Expensive Moderate Expensive Moderate
Smoke	Ionization Photoelectric VESDA Laser	Fast Fast Very fast Extremely fast	Moderate Moderate High Moderate - high
Heat	Fusible link Plastic tube Fusible plug Quartzoid bulb Optical fiber Bimettalic wire Heat act/rate of rise	Low to moderate Low to moderate Low to moderate Low to moderate Low to moderate Low to moderate Low to moderate	Moderate Low Moderate Moderate Moderate Low to moderate Moderate
Optical	IR UV IR/IR IR/UV Multiband Video camera	Very fast Very fast Very fast Very fast Very fast Fast	High High High High High Expensive

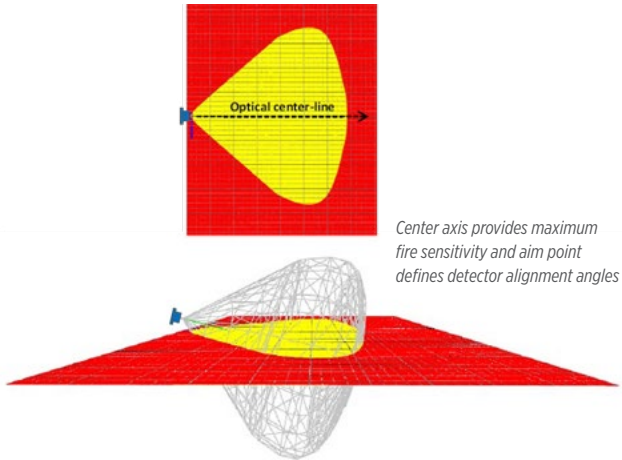
Comparison of Fire Detector Types



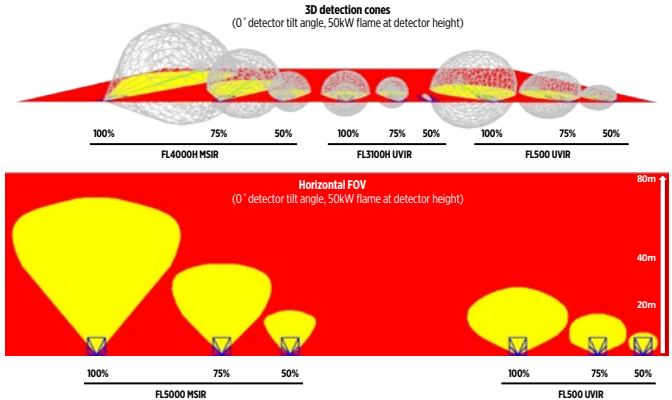
Field of View Definition and Characterization

A flame detector's field of view is typically proportional to the effective range of the detection distance. For example, the most common types of optical flame detectors have a 90 to 120 degree field of view. One might think that the wider the FOV, the larger the area and volume of effective coverage. That is not necessarily the case, as a wider field of view can limit the maximum detection distance. For this reason, it is often necessary to place flame detectors at the corners of buildings or aligned in a series with overlapping coverage to achieve the required coverage.

The flame detector's center axis is generally the vector of maximum sensitivity; meaning it normally defines maximum detection range to a specific fire type/size. This is often referred to as a the "on-center or on-axis aim point" of the detector.



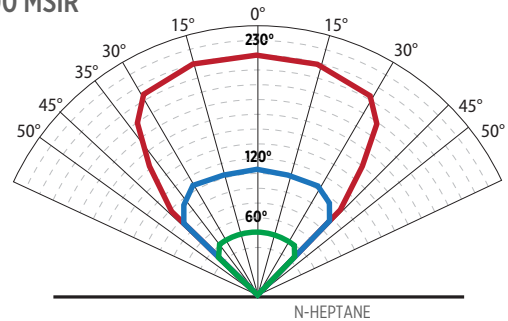
Center axis provides maximum fire sensitivity and aim point defines detector alignment angles



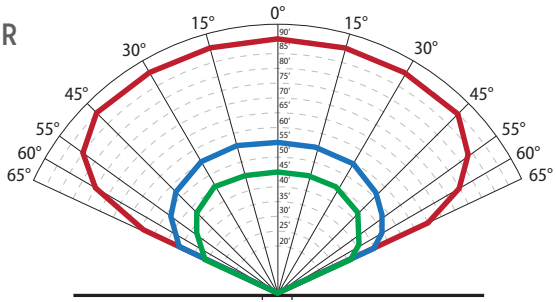
Field of View Definition and Characterization

FoV Benchmarks

FL5000 MSIR



UV/IR



No	Fuel	Size	Distance ft (m)	Average Response Times
1	Heptane	1 x 1 ft²	230 (70)	7
2	Methanol	1 x 1 ft²	160 (49)	9
3	JP4	1 x 1 ft²	150 (46)	8
4	Methane	1 ft plume	80 (24)	7
5	Butane 100% (6" dia burner)	1 ft plume	112 (34)	13.1
6	Propane (6" dia burner)	1 x 1 ft²	125 (38)	14.9
7	Crude Oil	1 x 1 ft²	80 (24)	4.5
8	Ethanol	1 x 1 ft²	170 (52)	8
9	Wood	1 x 1 ft²	130 (40)	9.5
10	JP4	1 x 1 ft²	160 (49)	6.9
11	JP5	1 x 1 ft²	160 (49)	7.5
12	JP8	1 x 1 ft²	160 (49)	9.2
13	Gasoline	1 x 1 ft²	170 (52)	5
14	Jet Fuel A	1 x 1 ft²	170 (52)	15
15	Marina Fuel	1 x 1 ft²	200 (61)	3
16	Kerosene	1 x 1 ft²	170 (52)	4

TABLE CHART			
Horiz.	High	Mid	Low
0°	90°	55°	45°
±15°			
30°		55°	45°
-30°		55°	45°
45°	90°		
-45°	90°		
60°	75°		
-60°	75°		
65°	50°	40°	30°
-65°	50°	40°	30°

Overcoming False Alarm Sources

What are common false alarm sources?

- Jet engine afterburners
- Truck exhaust, boilers, turbines, reactors
- Flare stacks
- Arc welding
- Lightning
- Grinding
- Corona discharge
- X-ray operations

UV Alarm Sources

Fire Alarm Discrimination

- UV detection in the 1850-260 nanometer range
  - No response to sunlight and most artificial lighting
  - Welding, lightning and x-rays will be detected
- IR detection at 4.35 micron range
  - CO2 spike generated from hydrocarbon fires
  - Flicker discrimination algorithm minimizes response to heat
- Combination UV/IR detectors provide enhanced false alarm rejection
  - Applicable to hydrocarbon fuels only
- MSIR detectors provide enhanced false alarm rejection
  - Special signal processing used

UV Technology

UV detectors respond to radiation in the UV region of approximately 180-260 nanometers. UV flame detectors operate at relatively high speed with good sensitivity up to 50 feet (15 m) from the flame source. These detectors are best suited for indoor use and are unaffected by sunlight (solar blind) and hot objects. They are, however, vulnerable to false alarms triggered by other UV sources such as: arc welding, lightning, halogen lamps, and electrical sparks. Thick smoke and/or grease build-up on the sensor window can also cause failures due to attenuation of the incident UV radiation. Their cost is relatively low compared to other types of flame detectors.

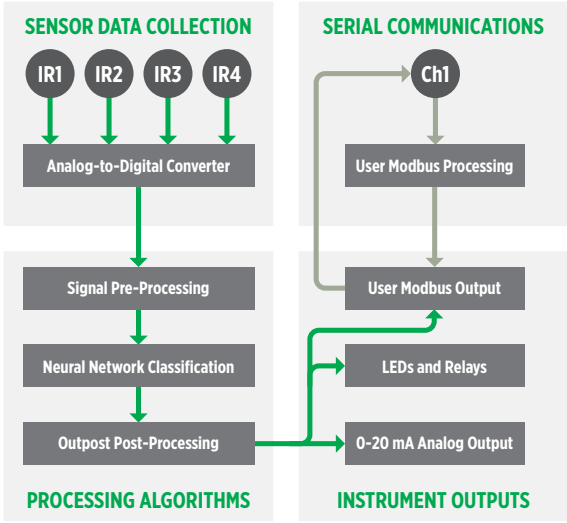
UV/IR Technology

When a UV optical sensor is integrated with an IR sensor, a dual band detector is created which is sensitive to both UV and IR radiation emitted by a flame. The combined UV/IR flame detector offers increased immunity over the UV detector. UV/IR flame detectors, when combined with flicker discrimination circuitry, reduce the possibility of false alarms caused by arc welding, lightning, sunlight, and hot objects. They operate at moderate speed and are suited for both indoor and outdoor use up to 90 feet (27 m) from the flame source, but are affected by thick smoke and grease deposits on the detector window. Cost is moderate as compared to other flame detector types.

Overcoming False Alarm Sources

Infrared Technologies

Dual and triple IR flame detectors use multiple infrared spectral regions to further improve differentiation of flame sources from non-flame background radiation. Both types of IR flame detectors are well suited to locations where combustion sources produce particularly smoky fires. These flame detectors operate at moderate speed with a range of in excess of 300 feet (91 m) from the flame source—both indoors and outdoors. These instruments exhibit relatively high immunity to infrared radiation produced by arc welding, lightning, sunlight, and other hot objects that might be encountered in industrial backgrounds. Their cost is high relative to other types of flame detectors.



MSIR/ANN Flame Detector Model

Self-Check Diagnostics

To meet the highest reliability standards, continuous optical path monitoring (COPM) diagnostics are often built into optical flame detectors, as is the case with those manufactured by MSA. The self-check procedure is designed to ensure that the optical path is clear, the detectors are functioning, and additionally, the electronic circuitry is operational. Self-check routines are programmed into the flame detector's control circuitry to activate about once every two minutes. If the same fault occurs twice in a row, then a fault is indicated via the 0-20 mA output, and also initiated over the RS-485 serial communication link and processed via a Modbus or HART operator interface system to alert the maintenance staff.

What is Continuous Optical Path Monitoring (COPM)?

COPM test is to ensure window surfaces are not dirty and validate that sensors are working properly.

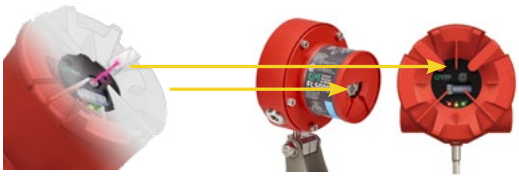
COPM test energizes every 2 minutes and two continuous test failures results in fault.

COPM fault is the most common flame detector fault.
How this can be cleared:

1. Clean the optical window AND reflectors with cleaning solution.

2. If condensation/water/ice, use the rain guard or heater

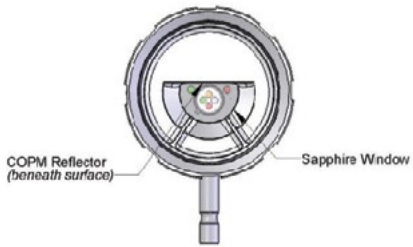
3. If issue persists, the sensors might have an issue. Replace optical module with known good module and commission with test lamp.



COPM Reflectors

Optical Self-Test Function – COPM

- Compromised "dirty" optics will adversely impact flame detection performance
- Built-in self-test function = Continuous Optical Path Monitoring (COPM)
- COPM Optical path once every 2 minutes to ensure optical windows are not dirty and validate that test sources and sensors are working properly



Self-Check Diagnostics

Onboard Diagnostics at a Glance

HART Communications

- HART = Highway Addressable Remote Transducer
- Two-way digital communication between HART field instrument and HART master device or system over 4-20 mA analog instrumentation current signal loop
- Each HART device provides 35-40 data items:
  - Device status and diagnostic alerts
  - Process variables and units
  - Loop current and % range
  - Basic configuration parameters
    - Upper and lower range values
    - Loop test
    - Force loop current to specific value
- Manufacturer and device tag
- Standard commands for easy access
- Access to valuable HART communication information from the field device requires that a HART master device be used with the specific HART instrument's DD file present within the HART master device.

HART COMMUNICATION PROTOCOL


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Global Flame Detection Approvals Summary

National and International Flame Detection Approval Agencies Summary

National and International Flame Detection Approval Agencies Summary

Importance of Certification

Certification from recognized national and international approval agencies ensures that flame detectors:

Meet Safety Standards: Products comply with stringent safety requirements, reducing the risk of failure and enhancing protection.

Ensure Reliability: Certified flame detectors are tested for reliability and performance, providing confidence in their operation.

Enhance Market Acceptance: Certification from reputable agencies is often a prerequisite for product acceptance in various markets and industries.

Compliance with Regulations: Ensures adherence to local and international regulations, facilitating legal compliance and market access.

Certified flame detectors are essential for ensuring the safety and protection of people, property, and the environment in commercial and industrial settings.

What Codes & Standards Apply to (Fire and Gas) Systems?

- F&G code compliance is a legal obligation in most countries

Codes: Equipment selection and installation

- BS 5839 (British UK code)
- NFPA72 (U.S. code) – National Fire Alarm Code
- DIN 14675 (German Institute for Standardization)

Product Standards: Detection Devices and Systems

- EN54 (European Union Standards)
- FM (Factory Mutual US approvals)
- UL Standards (Underwriters Labs – U.S. approvals)

International Codes and Standards

Safety Systems, Devices, and Procedures

- IEC 61508 – Functional Safety of Electrical/Electronic/ Programmable safety related systems
- IEC 61511 –Functional Safety – Safety Instrumented Systems for process industry sector
- ISA S84.01 Application of SIS for the Process Industries

Gas Detection

- EN 60079-29-1 Requirements for performance of detectors for flammable gases used in potentially explosive atmospheres
- EN 60079-29-2 Selection, installation, use and maintenance of detectors for flammable gases & oxygen

Flame Detection

- EN54 10 Requirements for performance of flame detectors

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National and International Flame Detection Approval Agencies Summary



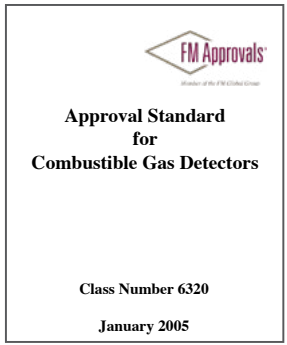
North America Codes & Standards

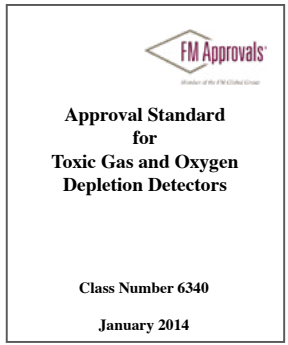
Factory Mutual 3260 Approval Standard

- Sets baseline performance requirements
  - Defines Field of View limits and performance attributes
- Not every detector is capable of detecting all fuels
- False Alarm rejection capability is not the same
- According to ANSI, Certification = Beneficial to End-Users
- Establishes standard fire/flame parameters
  - Liquid fuels (1 x 1 foot test pan)
  - Gaseous fuels (flame plume height/pressure/nozzle)
  - Solid fuels (mass, square footage, arrangement)

National and International Flame Detection Approval Agencies Summary











Key Approval Agencies

Agency	Region	Description
UNDERWRITERS LABORATORIES (UL)	United States	UL certifies products for safety, performance, and reliability. UL 268 and UL 1484 are relevant standards for flame detectors.
FM APPROVALS (FM)	United States	FM Approvals certifies products for safety and performance, focusing on fire prevention and loss control. FM 3260 is a key standard for flame detectors.
CANADIAN STANDARDS ASSOCIATION (CSA)	Canada	CSA provides testing and certification for flame detectors to ensure they meet Canadian safety standards. CSA C22.2 is a relevant standard.
EUROPEAN COMMITTEE FOR ELECTROTECHNICAL STANDARDIZATION (CENELEC)	Europe	CENELEC develops European standards for electrical equipment, including flame detectors. EN 54-10 is a key standard for flame detectors.
VDS SCHADENVERHÜTUNG GMBH (VDS)	Germany	VdS certifies fire protection and safety products, including flame detectors, according to German and European standards.
INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)	International	IEC provides global standards for electrical and electronic equipment, including flame detectors. IEC 61508 and IEC 60079 are relevant standards.
SOCIÉTÉ GÉNÉRALE DE SURVEILLANCE (SGS)	International	SGS offers testing, inspection, and certification services to ensure flame detectors meet international safety and performance standards.
BRITISH STANDARDS INSTITUTION (BSI)	United Kingdom	BSI develops standards and provides certification for flame detectors in the UK, including BS EN 54-10.
STANDARDS AUSTRALIA	Australia	Standards Australia develops and certifies standards for flame detectors to ensure safety and reliability in Australian markets.
JAPAN FIRE EQUIPMENT INSPECTION INSTITUTE (JFEII)	Japan	JFEII provides testing and certification for flame detectors to ensure compliance with Japanese safety standards.

Summary of Key Standards

Standard	Description
UL 268	Standard for smoke detectors for fire alarm systems, applicable to flame detectors in specific configurations.
UL 1484	Standard for residential gas detectors, ensuring safety and performance in detecting gas-related fires.
FM 3260	Performance standard for flame detectors used in fire alarm systems.
CSA C22.2	Canadian standard for electrical safety, applicable to flame detection devices.
EN 54-10	European standard for flame detectors, specifying requirements for design, performance, and testing.
IEC 61508	International standard for functional safety of electrical/electronic systems, including flame detection systems.
IEC 60079	Explosive atmospheres – standards for equipment used in hazardous areas, applicable to flame detectors.
BS EN 54-10	British standard for flame detectors, detailing requirements for construction, performance, and testing.

Example Certifications for Flame Detectorst

1. **UL Listed Flame Detectors:** Products certified under UL 268 or UL 1484 ensure high safety and performance standards, commonly used in residential and commercial applications in the United States.
2. **FM Approved Flame Detectors:** M 3260 certification ensures that flame detectors meet stringent fire prevention and loss control requirements, widely accepted in industrial and commercial sectors.
3. **EN 54-10 Certified Flame Detectors:** Compliance with the European standard EN 54-10 ensures flame detectors are suitable for use in fire alarm systems across Europe.
4. **IECEx Certified Flame Detectors:** Flame detectors with IECEx certification meet international standards for use in explosive atmospheres, ensuring safety and reliability in hazardous environments.


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MSA Optical Flame Detector Models

UVIR

MSIR

MSA Optical Flame Detector Models

Optical Flame Detector Lineup



FL500
Hydrocarbon Fires Only



FL500-H2
Optimized for Hydrogen Fires

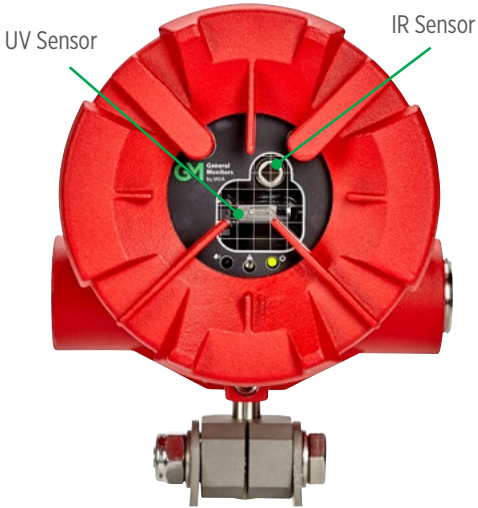


FL5000
Hydrocarbon Fires Only

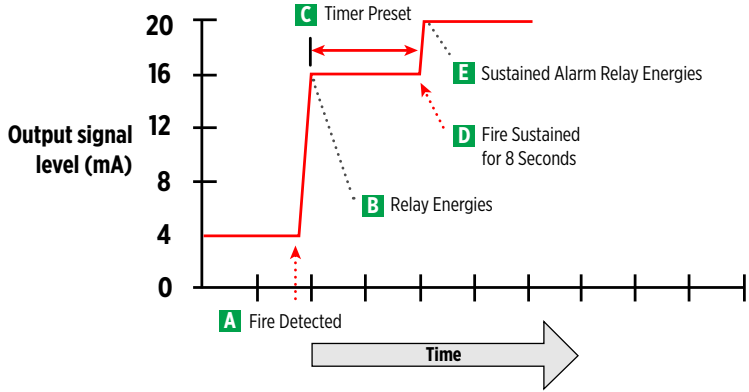
UV/IR

Flame Detectors Use “Gate Technology”

FL500 and FL500-H2 Detectors



IR only signal	8.0 ± 0.2 mA
UV only signal	12.0 ± 0.2 mA

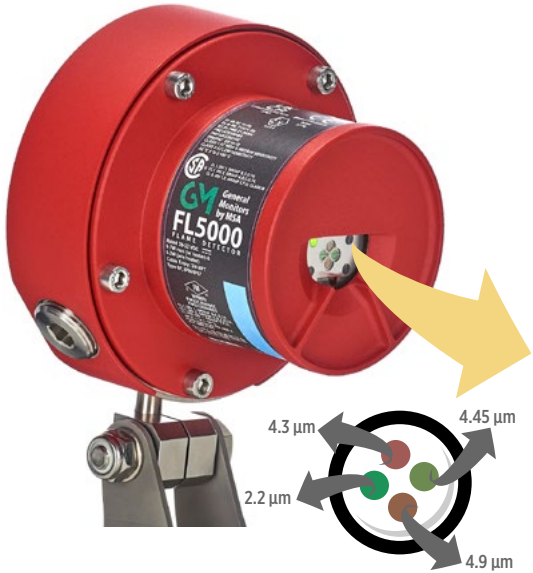


A	A fire is detected.
B	An increase from 4 mA steady state to 16 mA triggers the 'instant alarm'.
C	A configured time delay is in place to activate fire suppression or weed out nuisance alarms.
D	After a pre-set time delay, which is adjustable (often set at 8 seconds), the signal level jumps up to 20 mA (i.e., sustained alarm).
E	Sustained alarm is initiated.

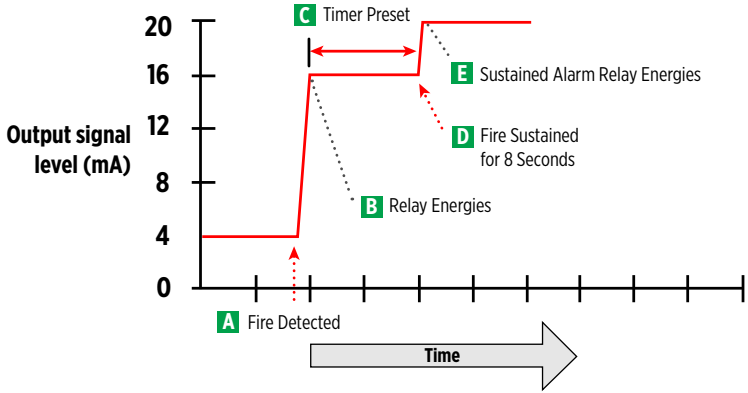
MSIR

MSIR Flame Detectors Use IR Sensors and Processing Algorithms

FL5000 Detector



4 IR sensors work in tandem to look for fires and evaluate background noise to prevent false alarms.



A	A fire is detected.
B	An increase from 4 mA steady state to 16 mA triggers the 'instant alarm'.
C	A configured time delay is in place to activate fire suppression or weed out nuisance alarms.
D	After a pre-set time delay, which is adjustable (often set at 8 seconds), the signal level jumps up to 20 mA (i.e., sustained alarm).
E	Sustained alarm is initiated.

Comparative Strengths and Limitations



MSIR Detector



UV/IR Detector

MSIR	UV/IR
Strengths • High-sensitivity and extended FoV is optimal for large areas • For dirty, oily areas • For smoky/sooty fires	**Strengths** • Hydrogen (-H2) model available • Wider 60 degree FoV optimal for short, wider spaces • Fast alarm response • Typically a lower cost technology
Weaknesses • Careful aiming required to avoid flares, other radiant energy sources • Slightly slower alarm response	**Weaknesses** • Can be more easily blinded by silicone flame, dirt, soot, oil, solvent vapors, water, and ice • Ultraviolet energy can be detected at very long distances due to reflectivity

Key Strengths and Benefits

Model	Technology	Detectable Fuels	Key Strength	Additional Benefit 1	Additional Benefit 2	Additional Benefit 3
FL500	UV/IR	Hydrocarbons (HC)	Immunity to false alarms	130 deg Field of View	UV & IR only pre-alarms	Proven technology
FL500-H2	UV/IR	Hydrogen + HC	Detection of hydrogen and HC flames	125 deg Field of View	UV & IR only pre-alarms	Proven technology
FL5000	MSIR	Hydrocarbons (HC)	Best detection range & false alarm immunity	Heated optics; HART, Bluetooth communications	Best resistance to optical contaminates	Best Test Lamp response range



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Optical Flame Detector Accessories

Test Lamps, Optical Protection, Weather Protection

Optical Flame Detector Accessories



Rain Guard Kit (PN 712006-1)



Air Curtain (PN 712880-1)



Retrofit Kit (PN 10242703)



Flame Bracket (PN 71370-1)



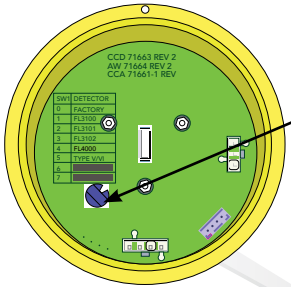
Window Cleaning Solution (PN 10272-1)

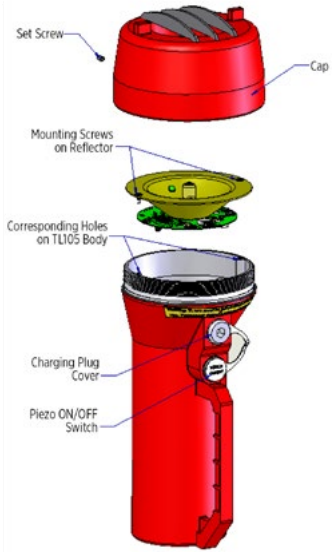


TL105 Test Lamp (PN TL105-1001)

Optical Flame Detector Accessories







TL105 Test Lamp

- Alarm response testing in classified areas
- Compatible with UV/IR and MSIR detectors
- UV/IR detection range = approx. 20 feet on center
- MSIR detection range = approx. 35 feet on center
- Explosion-proof cast aluminum housing
- CSA, ATEX, IECEx approved
- Rechargeable/replaceable batteries
- Easy grip handle integral with housing
- Spring return on/off switch to conserve battery life

Optical Flame Detector Accessories



Flame Bracket

The bracket must be ordered as a separate accessory with the FL5000.

Compatible with the FL5000, FL500, FL500-H2, FL4000H, FlameGard 5, FL31xxH, and FL31xx.



Air Curtain

The air curtain is recommended for detectors that are frequently cleaned due to COPM faults.

Excellent for dirty/dusty environments.



Rain Guard Kit

Easily clips onto and secures to the face of the detector.

The rain guard is recommended for any outdoor application in an effort to reduce COPM faults.



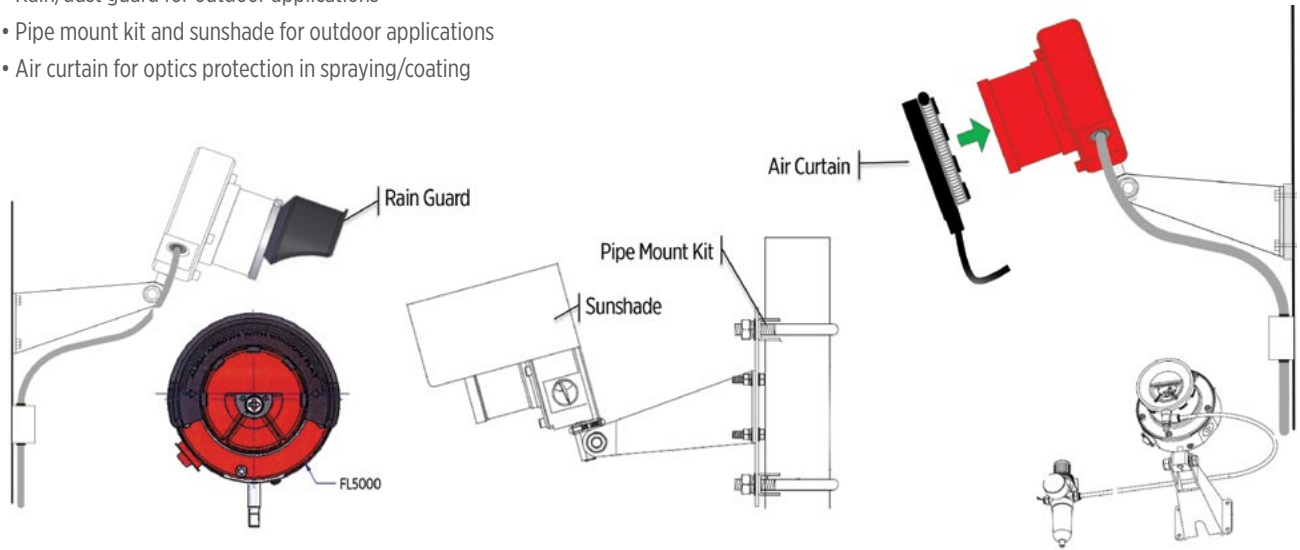
Window Cleaning Solution

Cleaning solution to be used for cleaning the sapphire window and COPM reflector.

Provided in an easy-to-use spray bottle.

Optical Flame Detector Accessories

- Rain/dust guard for outdoor applications
- Pipe mount kit and sunshade for outdoor applications
- Air curtain for optics protection in spraying/coating




MSAsafety.com

Flame Detector Coverage, Installation, Operation and Maintenance

Flame Coverage and Mapping Basics

Installation, Operating, and Maintenance Best Practices

Flame Coverage and Mapping Basics

Optical flame detectors sense radiant energy from an open flame by employing infrared, visible, and/or ultraviolet sensors, usually in signal-processing combination within a single detection instrument. The design and installation of optical flame detection systems is intended to provide early and fast detection of an ignition event and subsequently to enable execution of automatic mitigating actions and alarm notification to people and systems potentially affected by the fire alarm.

To achieve a high-performing flame detection system, application engineers start with a detailed hazard evaluation of the area to be protected and select the optimal flame detection sensing technology to match the radiant energy emission signature expected from the flammable materials to be detected. Since different fuels emit unique flame spectra, not all detectors can detect flames equally. Further, the presence of optical contaminants and non-fire radiant energy sources within monitored zones can have a significant impact on the performance of certain sensing technologies and installation locations. In some cases, additional optics protection accessories are required to help ensure 24/7 availability.

Customers have a variety of fixed optical flame detection technologies to choose from. The most common types are Multi-Spectrum Infrared (MSIR) and Ultraviolet/Infrared (UV/IR) flame detectors. MSIR detectors use multiple infrared sensors monitoring different spectral frequencies for hydrocarbon fire detection. MSIR detectors offer an extended field of view optimal for large area monitoring and are a good option where maintenance is limited. However, they can be blinded by water, ice, & snow. Careful aiming in outdoor applications is recommended.

UV/IR detectors use a single UV & IR sensor and perform 'AND gate' voting to detect most hydrocarbon fires and some non-hydrocarbon fires. They can help enable fast alarm response and an optional UV-only pre-alarm is useful in electrostatic paint and transformer applications. UV/IR detectors have a comparatively wider field of view, but shorter detection range and can be blinded by silicones, dirt, soot, oil, solvents, water, and ice.

It is recommended to always confirm fuel/flame detectability before specifying an optical flame detector and look for certified performance test reports to confirm your proposed flame detection performance specification. This specification can serve as the fundamental coverage template enabling proper assessment of different onsite installation points and alignment angles.

Flame Detector Coverage Installation, Operation and Maintenance

After the hazardous area analysis is completed, onsite coverage using the optimal flame detection technology and preliminary performance specification can be assessed. Common approaches include geographic or scenario coverage assessments. The geographic approach assesses coverage within a defined geographic fire ignition zone covered by one or more detectors, while the scenario approach specifies the most likely fire scenarios within a zone that can be detected with consideration given to frequency and catastrophic magnitude using defined coverage arrangements. In both cases, known physical obstructions must be identified and layouts must ensure proper coverage despite these obstructions.

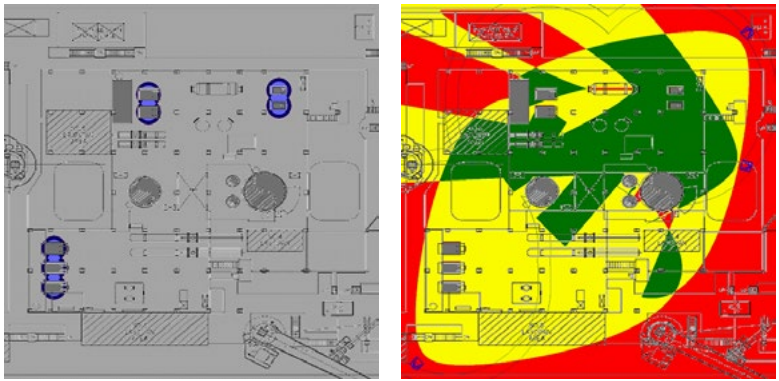


Image on left is area to be protected. Image on right shows scenario coverage after 3 flame detectors installed in area.

In some applications, cross zone voting will be used to enhance reliability. An example is one flame detector in alarm will drive audible/visual alarm devices, and two detectors in alarm (2oo2) within a single zone, or even 2oo3 voting will drive mitigation or ESD action. Anytime cross-zone voting is desired, redundant or triplicated coverage of the high-risk zones will be required, and a coverage map is highly recommended for all cross-zone voted coverage applications.

Flame Detector Coverage Installation, Operation and Maintenance

Fire and Gas (F&G) Mapping Solutions

- In the past years, F&G detector placement has relied upon experience, common practices, and prescriptive standards

Fire and gas mapping services are now available that:

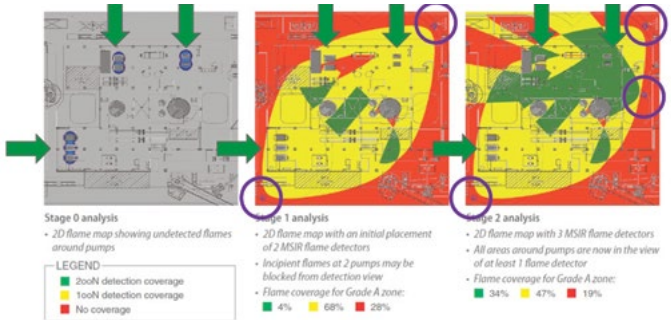
- Use a systematic approach to quantify flame and gas risks and to position detectors for the highest detection coverage
- Place detectors in appropriate locations to achieve best possible coverage
- Follow recommendations outlined in ISA's TR84.00.07 Technical Report

MSA F&G Mapping reports include:

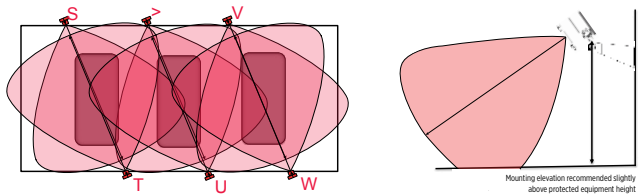
- F&G detector placement maps
- Detection coverage factor by zone grades
- Residual risk in each zone
- Summary of detector quantities
- Effigy Flame and Gas Mapping 3D software tool
- Plot plan of area to be mapped
- Process flow diagram
- Placement of detectors in appropriate locations to achieve best possible coverage

Major equipment and materials:

- Pumps, compressors, vessels, heat exchanges, piping, manifold, etc.



Example of proper application mapping



Installation, Operation, and Maintenance Best Practices

Installation Pre-Work

Complete Hazard Operability (HAZOP) Study

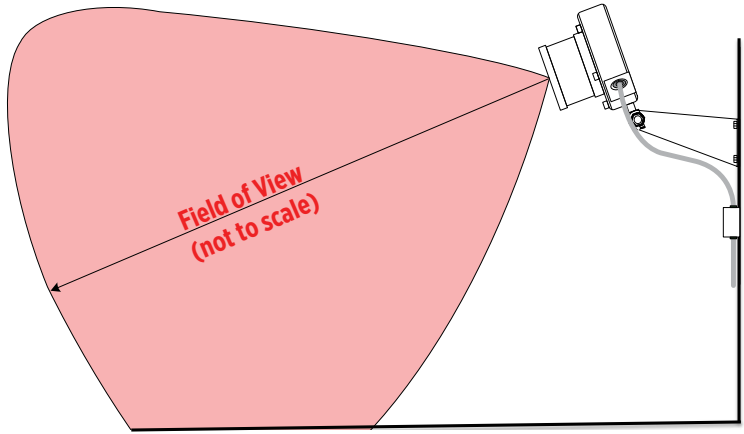
- Identify flammable and toxic risks & release scenarios

Define High Risk Flammable/Toxic Zones

- Optimal detection technologies for each hazard

Complete FGFD Coverage Mapping Study

- Define coverage and install locations
- Define Hazardous Area(s) Classification
- Define Environmental and Site Challenges
- Define instrument installation requirements
- Mechanical requirements
- Diagnostic considerations
- Wiring requirements
- Power supply requirements
- Performance considerations
- Application accessories



Installation, Operation, and Maintenance Best Practices

Installation Best Practices

Installation contractors should be qualified, licensed, and understand what it is they are installing. Detailed documentation and training should also be readily available on the specific system installation requirements. Here is a short list of typical installation concerns and best practices:

1. System power supply should be properly sized and of proper type/rating. If a back-up power source is required, this should be monitored and properly sized. The power distribution design should include sub-breakers to enable powering up/down the system in logical sections rather than just all at once.
2. Ground fault monitoring is a common requirement. Best practice is to proceed on the premise that ground fault monitoring is required.
3. All detector power and signal cabling requirements should be clarified including cable shields and termination as required. Remember that it is necessary to use cable glands in accordance with the ATEX zone classification, gas and cable type.
4. Detector mounting location structure must be solid and robust. Mounting structure vibration and movement is wholly undesirable and can lead to nuisance alarm problems. Also, all detection instruments should have a field tag attached with an instrument tag number easily visible.
5. A flame (and gas) detector setup table spreadsheet is recommended identifying instrument Tag #s for all detectors, installation location/elevation using GPS coordinates, programmable settings including sensitivity, time delay setting, latching or non-latching relay configuration, normally energized or normally de-energized relay coils, calibration information (gas detectors), and other configuration settings.

Installation, Operation, and Maintenance Best Practices

Commissioning Best Practices

After installation is complete and the system and all field devices are powered up and operating in a 100% fault-free mode, system commissioning can begin. It is important to note that system commissioning and integrated testing are two different concepts, and both must be completed successfully to properly evaluate flame detection system operation as well as its interaction with other systems.

Commissioning is a systematic process that provides documented confirmation that all system functions are working according to the intended design criteria set forth in project documents and satisfactory to the owner's operational needs. This includes complying with applicable laws, regulations, codes, and standards. A commissioning checklist is generally developed that spells out specific system functions, critical input and output signals, devices, and operational logic that must be tested and validated before the system can be considered fully commissioned.

The system commissioning checklist should generally include line-item checks for proper functional testing of power redundancy/battery back-up (if required), system ground fault monitoring (if required), critical output functions and related input actuation, field testing methodology for all flame detectors—and manual fire alarm signaling devices including alarm voting criteria (cross-zone or multi-sensor confirmation).

The best test of any optical flame detection system is a real onsite fire test using the fuel type and fire size called out within the project's optical flame detection performance specification. While optimum with respect to evaluating flame detection system performance, in many cases this type of real fire performance testing is either unacceptable or not practical due to fire risk or operational issues. In this case the owner/end user will need to identify the desired methodology of confirming onsite flame detector coverage and response time delivered by the system during the commissioning phase.

After completion, the Commissioning Engineer typically prepares and submits a commissioning report including as-built drawings, cause/effect logic, and an updated system database of all information developed, changed, or modified during the full commissioning process.

Installation, Operation, and Maintenance Best Practices



Operations, Maintenance, and Training

A fire detection system maintenance logbook should be managed and maintained that includes all system activities and events logged by instrument tag number. Typical logbook entries include Alarms, Faults, Tests, Visual Inspections, and Cleaning activities logged by tag number, date and time, and person. In addition, a routine visual inspection procedure should be established where the frequency of inspection points is defined, including detector faceplate status LEDs that are visually inspected for normal or trouble status, visual confirmation that no foreign material or obstructions are present that will block the field of view of any detector, and that alignment angles appear normal. If there are any optics protection accessories installed, these should also be inspected to ensure they are working properly. Finally, a functional test using a test lamp should be routinely executed. Be sure to bypass any suppression discharge apparatus before performing a functional fire detector alarm test.

Operations and Maintenance Personnel should generally know how to perform basic system diagnostic and troubleshooting procedures, including how to:

- Identify where and when a fire alarm or fault occurred
- Bypass the alarm function on a system for routine detector service
- Perform a visual inspection and clean the optics of a flame detector
- Locate the system logbook and electrical schematics
- Troubleshoot a basic trouble/fault condition
- Communication with a flame detector using HART
- Perform a response test using a test lamp
- Aim/re-aim a flame detector using information from the detector setup table
- Set the rocker switches on a flame detector
- Follow recordkeeping procedure for logging troubles, alarms, cleaning activities, etc.
- Power-up/power-down a system
- Understand annual system inspection and alarm response testing plan and who to call for technical assistance

Hazard Area Classification

Hazardous Area Classification

- Explosive gas atmosphere is present, or likely to be in quantity to require special precautions for the design, construction, installation and use of electrical equipment

Non-Hazardous Area Classification

- Explosive gas atmosphere is not expected to be present in quantity to require special precautions as listed above

Two Main Hazardous Area Classification Systems

- Class/Division System (most common in North America)
- Zone system (rest of the world)

Classes & Divisions

Classes Define Explosive/Ignitable Substances:

Class I Location: Flammable gases/vapors may be present

Class II Location: Combustible dusts may be present

Class III Location: Ignitable fibers of flyings may be present

Division defines probability of an explosive material being present and capable of forming an explosive mixture:

Division 1 Location: High probability of producing an explosion due to continuous/intermittent presence under normal operating conditions.

Division 2 Location: Low probability of producing an explosion due to presence only during abnormal conditions for a short period of time.

Combustible Gas Groups

- Combustible gases are divided into 4 groups
- Groups rate flammable gases in relation to other known substances
- Classification based on max explosion pressure and safe clearances between parts of a clamped joint

Class	Division	Group	Material
CLASS I	Division 1 & 2	A	Acetylene
CLASS I	Division 1 & 2	B	Hydrogen, Butadiene, Ethylene Oxide, Propylene Oxide
CLASS I	Division 1 & 2	C	Ethylene, Cyclopropane, Ethyl Ether
CLASS I	Division 1 & 2	D	Propane, Acetone, Ammonia, Benzene, Butane, Ethanol, Gasoline, Methanol, Natural Gas

Code Compliance Requirements

- Explosion-proof equipment has been available and used longer than other protection methods in the oil and gas industry
  - For many years, Class I, Division 1 area classification meant a project install was going to require explosion-proof equipment, metallic explosion proof conduit and strategically placed conduit seals
- Other approved designs and cabling types are available including mineral-insulated or metal-sheathed armored cables
- Additional code-driven requirements exist for special hazard projects
  - Always consult your local authority having jurisdiction (AHJ) to ensure your project's equipment, design and installation is compliant with all relevant and applicable national and local electric and fire codes

Environmental Challenges

Arctic Cold

- Operating Temperature rating requirements specified

Tropical Humidity and Monsoon Rainfall

- Ingress Protection (IP) rating requirements specified

Presence of Corrosive Vapors, Liquids and Gases

- Material of construction requirements specified

Poor Earth Ground Connectivity

- Offshore platforms
- Arctic settings - permafrost
- Corrosive soils with high moisture or salt content, high temperatures

Jobsite Challenges

- High vibration levels - rotating equipment, heavy trucks
- High electromagnetic interference (EMI/RFI)
  –Variable Frequency Drives (VFD) power conductors
- Difficult access for routine maintenance purposes
- Unmanned facilities - remote distant locations
  – Self-diagnostics capability specified
  – Remote access methods specified
- Existing documentation, or lack thereof (existing sites)

Performance Considerations

- Review jobsite flame detection performance requirements: Flammable fuel types and fire size

  Example 1: Natural gas/methane fire hazard; fire to be detected = 32" tall plume

  Example 2: Gasoline spill fire hazard to be detected = 1' x 1' pan fire equivalent

- Possible False Alarm Sources - any changes or site modifications?
- Existing Detector Sensitivity Settings per detector install location
  – 100% (high)
  – 75% (medium)
  – 50% (low)
- Recommend evaluation of existing flame coverage maps. Why?

Installation Best Practices

Electrical

- Grounding
- Power supplies
- Cabling - new and existing

Mechanical

- Site inspection / walk-thru
- Conduit, seals, breathers and drains
- Instrument installation

Final Inspection and Documentation

Grounding

Good Earth Ground connection is always required

- Lack of good grounding is dangerous and increases risk of equipment failure
- If fault currents have no path to ground, they will find unintended paths including people

When we talk about grounding there are two different types:

Earth Grounding: The intentional connection to a ground electrode placed in the Earth

Equipment Grounding: Ensures that operating equipment is properly grounded (reference)

- Ground faults occur when an unintentional path enables electrical current to flow directly to the earth ground
- NFPA 72-compliant Fire Alarm Systems must monitor all conductors and devices for Ground Faults – Ground Fault Monitor (GFM) is required along with relevant proper installation techniques. Improper FGFD installation techniques can result in system ground faults

Power Supplies

Most FGFD system field device power is typically 24 VDC

- Some high hazard systems require redundant power sources (separate isolated power feed or battery backup system with charger)
- Some gas panels support 120 or 240 VAC input power (include internal 24 vdc power supply for connected field devices)

Always ensure supply is properly sized for your system power load:

- Must support full power load sized for your system power load
- Newer detectors use 32-bit microprocessors, heaters, etc.

Proper battery back-up sizing calculations are required for deluge

- FM-approved automatic extinguishing release systems require battery backup to support 24 hours in normal mode and 5 minutes in full alarm

Power Supply Requirements

- Properly-sized power supply in good working condition may be reusable
- Ensure proper capacity for desired power consumption load

Quick Reference Power Consumption Calculation Worksheet

	Total Power Consumption @24 VDC		
FL5000	Total Qty	Nominal Power (Amps)	Max Power (Amps)
	1	0.14	0.18
	2	0.28	0.36
	3	0.42	0.54
	4	0.56	0.72
	5	0.70	0.90
	6	0.84	1.08
	7	0.98	1.26
	8	1.12	1.44

	Total Power Consumption @24 VDC		
FL500 UV/IR	Total Qty	Nominal Power (Amps)	Max Power (Amps)
	1	0.14	0.20
	2	0.28	0.40
	3	0.42	0.60
	4	0.56	0.80
	5	0.70	1.00
	6	0.84	1.20
	7	0.98	1.40
	8	1.12	1.60

Cabling Requirements

Stranded copper cable is recommended over solid core copper cable.

- Easier to route, withstand vibration and flexing without fatigue
- Select proper type, # of conductors, wire size, insulation, shielding per manual

Power Cabling

- Always design cabling system to deliver 24 VDC measured at device
- Select proper conductor size to overcome voltage drop on long runs

Signal Cabling

- Select proper type, size, # of conductors for signal type per manual
- Define shielding requirements: foil, braid, termination point

Some flame and gas detectors require alignment and aiming

- Flexible cabling required to support this requirement

Existing Field Wiring

Inspect all existing detector field wiring prior to making a decision about re-use.

- Identify existing wiring type, size, ratings, condition
- Measure to ensure 24vdc is delivered to detector location
- Recommend successful Insulation Resistance (Megger) field test. Always disconnect all field devices first.

Do not re-use existing detector field wiring if:

- Insufficient gauge (size) – can lead to voltage drop
- Improper type or insufficient number of conductors
- Poor condition (cracked/damaged insulation, water damage or corrosion evident)
- Cable routing is improperly routed near high EMI/RFI conductors (VFDs) – can cause nuisance interference.





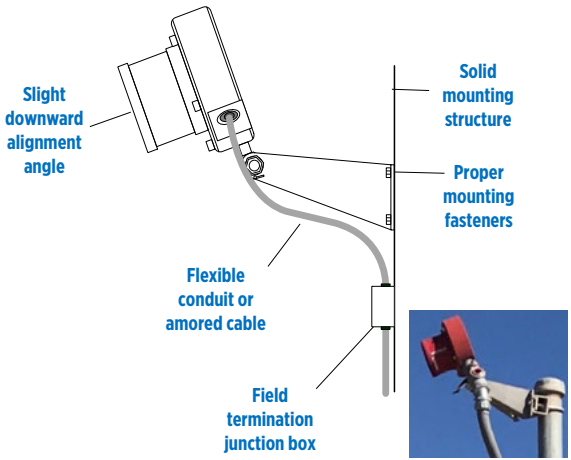
Electrical Installation Summary

- Ensure system to power supply is proper type/size, proper installation location with fused logical power distribution defined. Be aware of long cable runs and voltage drops.
- Power feed and signal output cabling specifications and termination requirements must be well defined. Shielded cabling and termination requirements defined.
- High EMI sources (VFDs) identified and cable routing specified to avoid these sources and associated cabling
- Ground fault monitoring requirement defined. Flame system installers should proceed as if GFM is required.

Mechanical Requirements

New mounting bracket may be required.

- 4 mounting fasteners per bracket
  - .24" diameter mounting holes
  - Use proper fastener type and size
- 2 each 2/4" - 14 NPT or 25 mm conduit entries. Conduit seal recommended within 18".
- Flex Cabling required within 1 meter of detector
- 14-22 AWG stranded wire acceptable range
- Detector optics should be viewable from ground!



Onsite Installation Walk-Through

- Coverage maps showing preliminary installation locations should be validated by onsite inspection
- Why is onsite validation recommended?
  - Undocumented physical obstructions blocking field of view
  - Inadequate mounting structure or accessibility
  - High structural vibration levels
  - High heat levels, clouds of process smoke, steam
  - Other problematic conditions - use common sense!
- Locations should support proper coverage along with easy access for cleaning, maintenance, testing. Difficult access = generally reduced maintenance
- Coverage map modification may be required “post-commissioning” to reflect final locations





Conduit and Cable Trays

- Most US gas and flame detector wiring and cables are pulled/ installed through metallic conduit
- Conduit continues to be the mainstay of most gas and flame power and signal cabling distribution
- Cable trays are making inroads into many industrial plants along with armored cabling
- Explosion-proof installations using conduit systems have additional requirements including:
  - Conduit seals
  - Conduit breathers
  - Conduit drains





Conduit Seals

- NEC 501.5 requires that seal fittings filled with approved compound be installed in conduits entering explosion proof enclosures. Exception: Approved instruments with specific labeling stating “conduit seal not required”.
- Seals limit internal volume and prevent an explosion from traveling throughout the conduit system.
  – Block gas movement to a non-hazardous area through connecting raceways and stop internal pressure piling effects
- Standards seals are **not** intended to prevent the passage of liquids, gases or vapors at pressures continuously above atmospheric. Must be installed within 18” of a detector for Class I, Division I explosion-proof installations



FGFD Instrument Conduit Seal Requirements per NFPA 70 – National Electric Code Article 501			
Hazardous (Classified) Location	**Instrument Hazardous Location Marking**	**Instrument “Conduit Seal” Marking**	**“Conduit Seal” Requirement**
Class 1, Division 1	Class 1, Division 1	No conduit seal marking present on instrument.	Within 18” of entry point*
Class 1, Division 2	Class 1, Division 1		
Class 1, Division 2	Class 1, Division 2		Conduit seal not required
Class 1, Division 1	Class 1, Division 1	“Conduit seal not required” present on instrument label.	Conduit seal not required
Class 1, Division 2	Class 1, Division 1		
Class 1, Division 2	Class 1, Division 2		

** Conduit seals in Class I, Division 1 & 2 locations must meet the requirements of NEC, Section 501.15(C).*

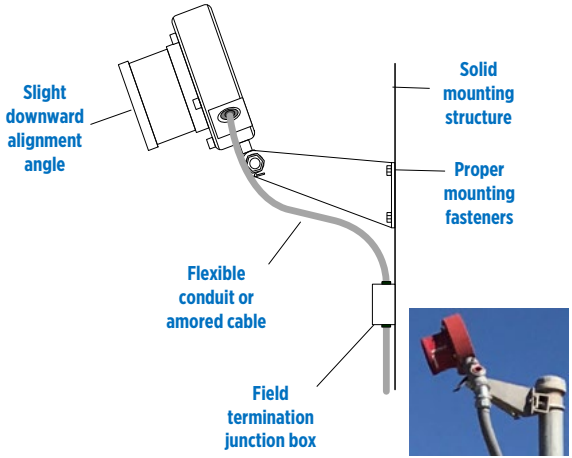
Conduit Breathers and Drains

Conduit systems will breathe and can collect condensation, especially in humid environments.

- Detection devices optimally will have conduit routing entry from below the instrument rather than from above
- Conduit systems should be slightly sloped for control
- Drains and breathers are installed in conduit systems to minimize condensation and drain accumulated condensate
- Breathers are installed in upper section of conduit system and drains installed in lower section of conduit systems
- At least one breather should be used with each drain
- Class I, Division 1 and Division 2 designs are available

Flame Detection Installation Recommendations

- Proper mounting brackets always required for proper alignment and aiming
- 4 mounting fasteners per bracket. .24" mounting holes. Use proper fastener type and size.
- 2 each 3/4" - 14 NPT or 25 mm conduit entries. Conduit seal recommended within 18" for aiming
- Flex Cabling recommended within 18" for aiming
- 14 – 22 AWG stranded wire acceptable range
- Detector optics should be viewable from ground! Status LED indicator.



Final Inspections

- Power supply properly installed, wired, tested with zoned breakers/fuse disconnects. Supports powering up/down in sections rather than “all at once”
- System panel/logic solver tested for proper power-up and fault-free operation
- Detectors installed in proper locations, aligned, inspected as per coverage map. Stainless tags attached for easy field identification.
- All detector field wiring terminations inspected and compliant with instruction manual. No shorts, opens, ground faults, proper operating voltage measured at each device
- Programmable settings inspected/verified accurate per documentation/manual
- No field junction boxes, enclosures, or conduit left open and exposed
- Begin sectional power-up after all field inspections confirmed proper and compliant

Documentation Best Practices

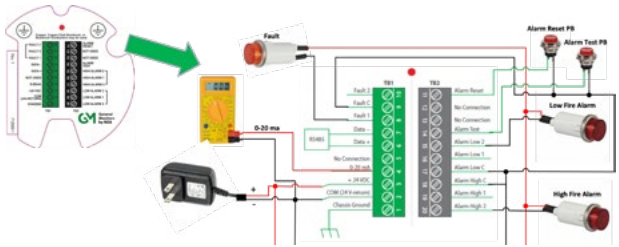
All field-adjustable detector settings are defined in spreadsheet or log including:

- Tag name – should reflect detector type (e.g. CGD101 = Combustible Gas Detector)
  - TGD101 = Toxic Gas Detector
  - FD101 = Flame Detector
  - OPGD101 = Open Path Gas Detector
- Installation location – geographic coordinates or traceable description
- Gas calibration type/concentration (Ex: Methane, 50% LEL cal gas in air
- Flame sensitivity settings (high, medium, or low). Flame detector - sustained fire time delay setting: 8 seconds, 10 seconds, etc.
- Alarm relays setup (if used)
  - Alarm threshold settings
  - Latching or non-latching relay configuration
  - Normally energized or normal de-energized relay coils
- Accessories present: Weather guards, visors, air curtains, etc.

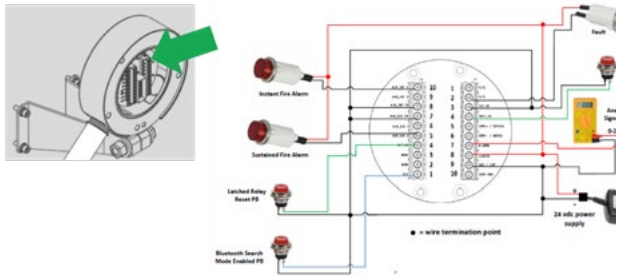
Summary

- Completion of project installations pre-work is essential to define specific hazards, code requirements, technologies, and challenges
- Electrical installation considerations include proper grounding, system power supplies, cabling, and termination guidance
- Mechanical installation considerations include jobsite inspection to validate coverage map locations, proper conduit system design and installation, and device mounting practices
- Final inspections should always be completed before powering up to ensure smooth, on-time commissioning event
- All detectors, hazards and settings should be defined in a master log

FL500 Benchtop Test Wiring Example



FL5000 Wiring Example





Appendices

Glossary of Flame Detection Terms and Abbreviations

Abbreviation List

Appendix F: National Electrical Manufacturers Association (NEMA) Classifications

Fire Resistance Testing Standards

Glossary of Flame Detection Terms and Abbreviations

Glossary	
ACGIH	American Conference of Governmental Industrial Hygienists
AIT	Auto Ignition Temperature
ALARM SIGNAL	Signal indicating an emergency exists that requires immediate action, such as a fire signal or explosive or toxic gas alarm.
ANALOGUE / ANALOG OUTPUT	Standard mA output from a sensor or transmitter. Normally described as 4-20mA. The alternative is a mV bridge output from a catalytic type sensor.
APPARATUS GROUP	The classification of flammable gases into groups that are associates with required apparatus design standards.
ASPHYXIATION	Death resulting from lack of oxygen.
ATEX	European Explosive Atmospheres Directives (ATmosphere EXplosives).
BASEEFA	British Approvals Service for Electrical Equipment in Flammable Atmosphere – UK Safety Certification.
BINARY MIXTURE OF GAS	A mixture of two gases only.
BLAST	The transient change in gas density, pressure, and velocity of the air surrounding an explosion point.
BMS	Building Management System.

Glossary	
BLOW-OUT	A high-pressure release of hydrocarbons, which may or may not ignite, that occurs when a high-pressure oil or gas accumulation is unexpectedly encountered while drilling a well and the mud column fails to contain the formation fluid, which is then expelled through the wellhead bore.
BOILING LIQUID EXPANDING VAPOR EXPLOSION (BLEVE)	The nearly instantaneous vaporization and corresponding release of energy of a liquid upon its sudden release from a containment under greater than atmospheric pressure and at a temperature above its atmospheric boiling point.
BREATHING ZONE	10 in/25 cm radius from nose to mouth.
BRIDGE CIRCUIT	Wheatstone Bridge circuit used in catalytic detector design.
CAS NUMBER	Chemical Abstracts Service. CAS registry number used to identify substances without the ambiguity of chemical nomenclature.
CONTINUOUS OPTICAL PATH MONITORING (COPM)	Optical self-test of a flame detector's sensors, self-test source lamps, and optical window surfaces.
CAUSE/EFFECT LOGIC	Method of defining Boolean relationships (operating logic) between input device signals and output device signals.
DAMPER POSITION SWITCH	Sites with fire dampers may need to either open or close in a fire alarm. Most close in alarm to limit the spread of fire.
DCS (DISTRIBUTED CONTROL SYSTEMS)	Computerized process control system where autonomous loop controllers are distributed throughout the system. FGFD systems often communicate operating status to a DCS.
DEFLAGRATION	The propagating chemical reaction of a substance in which the reaction front advances into the unreacted substance rapidly, but at less than sonic velocity in the unreacted material.
DETONATION	A propagating chemical reaction of a substance in which the reaction front advances into the unreacted substance at greater than sonic velocity in the unreacted material.
ESD (EMERGENCY SHUT DOWN)	System that minimizes consequences of an emergency situation such as loss of control, hydrocarbon or toxic gas release, fire or explosion, or other hazardous or potentially catastrophic event.

Glossary	
EVACUATION SIGNAL	Distinctive signal advising occupants to evacuate.
EXPLOSION	A release of energy that causes a blast
FIELD OF VIEW (FOV)	Optical flame detector zone of coverage/detection.
FIRE ALARM CONTROL PANEL (FACP)	Electrical panel that monitors fire detection devices and drives notification devices and mitigation systems.
FIRE ALARM	Signal initiated by an initiating device such as a manual fire pull, smoke, heat, or automatic fire detector, sprinkler flow switch or other
FIREBALL	A rapid turbulent combustion of a fuel-air cloud whose energy is emitted primarily in the form of radiant heat, usually rising as a ball of flame.
FLASH FIRES	A fire resulting from the ignition of a cloud of flammable vapor, gas, or mist in which the flame speed does not accelerate to sufficiently high velocities to produce an overpressure, because there is not sufficient congestion or confinement present to produce high-velocity flame speed
GAS ALARM	Alarm signal initiated by combustible or toxic gas detector indicating Low or High concentration detected.
GROUND FAULT MONITOR (GFM)	Electrical leakage from power to ground. Must be monitored on NFPA 72 compliant fire alarm systems.
HAZARD & OPERABILITY STUDY (HAZOP):	Rigorous study of process hazards.
HEAT DETECTOR	Thermal-sensitive fire alarm device; fixed, linear
HIGHWAY ADDRESSABLE REMOTE TRANSDUCER (HART)	Digital communication protocol used for device configuration, calibration, and diagnostics.

Glossary	
IMPLOSION	An inward rupture normally caused by inadvertent vacuum conditions in a vessel or tank
INITIATING DEVICE CIRCUIT (IDC)	Input circuits that typically cause a fire alarm control panel to sound alarms, operate relays, or discharge suppression.
INFRARED (IR)	Spectral energy type; sensed by most optical flame detectors.
JET OR SPRAY FIRES	Turbulent diffusion flames resulting from the combustion of a liquid or gas continuously released under pressure in a particular direction.
MANUAL CALL POINT OR PULL STATION	Fire alarm IDC that requires human intervention for activation; distinct from automatic fire alarm device activation.
MAPPING	Methodology to determine fixed gas and flame detection (FGFD) coverage in a high-risk zone.
MULTI SPECTRUM INFRARED (MSIR)	Specific type of optical flame detector that uses multiple infrared sensors to detect fires.
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	Organization defining US fire codes.
NOTIFICATION APPLIANCE CIRCUIT (NAC)	Supervised output from FACP that powers alarm horns, strobes, bells, or chimes.
OPTICAL FLAME DETECTOR (OFD)	Detects radiant energy from an open flame.
OIL, GAS & PETROCHEMICAL (OGP)	Activities related to the extraction, processing, and transportation of oil and gas..
OVERPRESSURE	Any pressure relative to ambient pressure caused by a blast, either positive or negative.
PROGRAMMABLE LOGIC CONTROLLER (PLC):	Industrial digital computer that is ruggedized and adapted for the control of manufacturing processes.

Glossary	
PRIMARY/SECONDARY POWER SUPPLIES:	Fire Code requires fire system to have either two sources of power (primary & secondary) or a single UPS.
RELEASING CIRCUIT	Supervised output from FACP that activates fire suppression system release valves; may include an Abort function.
REMOTE TERMINAL UNIT (RTU)	Device that communicates electrically or digitally with a DCS or SCADA system.
RUNNING FIRE	A fire from a burning fuel that flows by gravity to a lower elevation. The fire characteristics are similar to pool fires except a running fire is moving or draining to a lower level.
RUPTURES OF INTERNAL VESSEL EXPLOSIONS	A catastrophic opening of a container (i.e., tank, vessel, or pipe), commonly from overpressure or metallurgical failure, resulting in the immediate release of its contents.
SAFETY INSTRUMENTED SYSTEM (SIS)	System composed of sensors, logic solvers, and final elements for the purpose of bringing a process to a safe state when predetermined conditions are violated. Other terms commonly used include emergency shutdown system (ESD, ESS), safety shutdown system (SSD), and safety interlock system.
SHELTER-IN-PLACE (SIP)	A method of protection in which instead of escaping from a fire risk, toxic vapors, radiation, etc. (because avenues of escape are unavailable or time consuming to reach) an individual protects themselves in the immediate vicinity to avoid injury, such as in an adequately protected structure or building. Shelter-in-place cannot be utilized where available oxygen supplies are insufficient or cannot be isolated from contaminants.
SIGNALING LINE CIRCUIT (SLC)	A supervised/monitored fire alarm circuit that carries data to and from connected field devices and also provides field device power.
SINGLE POINT FAILURE (SPF)	A location in a system in which if failure occurs it will cause the entire system to fail, because backup or alternative measures to accomplish the task are not available
SMOKE	The gas products of the burning of carbonaceous materials made visible by the presence of small particles of carbon, and the small particles, which are liquid or solid consistency, are produced as a byproduct of insufficient air supplies to a combustion process.

Glossary	
SNUFFING STEAM	Pressurized steam (water vapor) used to smother and inhibit fire conditions in the process industries.
SPILL OR POOL FIRE	The release of a flammable liquid and/or condensed gas that accumulates on a surface forming a pool, where flammable vapors burn above the liquid surface of the accumulated liquid.
SPRINKLER	A water deflector spray nozzle device used to provide distribution of water at specific characteristic patterns and densities for purposes of cooling exposures, suppression of fires, and to air in vapor dispersions
SPRINKLER SUPERVISORY	Devices on fire sprinklers that monitor inputs such as water tank level, valve tamper switch, temperature, and pressure switches.
SUPERVISED CIRCUIT	Circuit that is monitored for wiring breaks, short circuit, disconnection/removal of initiating devices or notification appliances, power failure, battery disconnection, or off-normal position.
SUPERVISORY	Signal type where a device monitored by the fire alarm system is currently in an off-normal condition.
SUPERVISORY CONTROL & DATA ACQUISITION (SCADA)	System and Software often used to remotely control a network of PLCs and monitoring functions.
TRANSMISSION CONTROL PROTOCOL/ INTERNET PROTOCOL (TCP/IP):	Digital Communication Protocol over the Internet.
TRIPLE MODULAR REDUNDANT (TMR)	A system that employs a 2 out of 3 (2oo3) voting scheme to determine the appropriate output action. It is based on the application of three separate operating systems running in parallel.
TROUBLE SIGNAL	A signal initiated by the fire alarm system or device indicative of a fault in a monitored circuit or component.
UPS - UNINTERRUPTIBLE POWER SUPPLY	A device that provides emergency power to a load when the primary power source fails.

Glossary	
UV (ULTRAVIOLET)	Spectral energy type related to Optical Flame Detection to detect the presence of ultraviolet radiation emitted by flames.
VAPOR CLOUD EXPLOSION	The explosion resulting from the ignition of a cloud of flammable vapor, gas, or mist in which flame speeds accelerate to sufficiently high velocities to produce significant overpressures.
VAPOR PRESSURE (VP)	The pressure exerted by a volatile liquid as determined by ASTM D.323, Standard Method of Test for Vapor Pressure of Petroleum Products (Reid Method).
VOTING LOGIC 1oo1, 1oo2, 2oo2, 2oo3 ONE OUT OF ONE, ONE OUT OF TWO, ETC.	Shorthand expression the number of inputs that must be in agreement to effect an executive action, for example, shutdown. For example, in a 2oo3 failsafe switch configuration, two of the three switches must be open to produce a shutdown.
WHAT-IF ANALYSIS (WIA)	A safety review method by which "what-if" investigative questions (i.e., brainstorming and/or checklist approach) are asked by an experienced and knowledgeable team of the system or component under review where there are concerns about possible undesired events. Recommendations for the mitigation of identified hazards are provided.
ZONE	A specified area within a building, facility, or process.

Abbreviation list

1oo2	One out of two
2oo2	Two out of two
2oo3	Two out of three
ABS	American Bureau of Shipping
AC	Alternating current
AFFF	Aqueous film-forming foam
AFHA	Arc Flash Hazard Analysis
AIA	American Insurance Association
AIChE	American Institute of Chemical Engineers
AIT	Auto-ignition temperature
ALARP	As low as reasonably practical
ANSI	American National Standards Institute
API	American Petroleum Institute
ASA	American Acoustical Society
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASSE	American Society of Safety Engineers
ASTEM	American Society for Testing Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BACT	Best available control technology
BEAST	Building evaluation and screening tool
BLEVE	Boiling liquid expanding vapor explosion
BMS	Burner management system
BOM	Bureau of Mines
BOP	Blow-out preventer
BOSS	Blow-out spool system
BPCS	Basic process control system
BPD	Barrels per day
BSEE	Bureau of Safety and Environmental Enforcement
BS&W	Basic sediment and water
BTA	Bow-tie analysis
BTU	British thermal unit

Abbreviation list

°C	Degrees Centigrade
CAD	Computer-aided design
CCPS	Center for Chemical Process Safety
CDS	Closed drainage system
CFM	Cubic feet per minute
CFATS	Chemical Facility Anti-Terrorism Standard
CFR	Code of Federal Regulations
CHA	Chemical hazard analysis
CHAZOP	Computer Hazard and Operability Study
CO_2	Carbon dioxide
CPI	Chemical process industry
CSB	Chemical Safety and Hazard Investigation Board
CVD	Combustible vapor dispersion
DCS	Distributed control system
DIERS	Design Institute of Emergency Relief Systems
DHS	Department of Homeland Safety

DOT	Department of Transportation
EHAZOP	Electrical Hazard and Operability Study
EOC	Emergency Operations Center
EIV	Emergency isolation valve
EOR	Enhanced oil recovery
EPA	Environmental Protection Agency
ESD	Emergency shutdown
ESDV	Emergency shutdown valve
ERP	Emergency response plan
ESPs	Electrical submersible pumps
EU	European Union
FAR	Fatal accident rate
FGFD	Fixed Gas and Flame Detection
FM	Factory Mutual
FMEA	Failure modes and effects analysis
FMECA	Failure modes, effects, and criticality analysis

Abbreviation list

HAZOP	Hazard and operability analysis
HIPS	High-integrity protective systems
HMIS	Hazardous material information system
HRA	Human reliability analysis
H_2S	Hydrogen sulfide
HVAC	Heating, ventilation, and air conditioning
IEEE	Institute of Electronic and Electrical Engineers
ILP	Independent layers of protection
IMO	International Maritime Organization
IR	Infrared
IS	Intrinsically safe
ISA	Instrument Society of America
LEL	Lower explosive limit
LNG	Liquefied natural gas
LOTO	Lock out tag out
LPG	Liquefied petroleum gas
MODU	Mobile offshore drilling unit
MMS	Mineral Management Service
MPS	Manual pull station
MSDS	Material safety data sheet
MSHA	Mine Safety and Health Administration
NACE	National Association of Corrosion Engineers
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NRC	National Response Center
OE	Operational excellence
OSHA	Occupational Safety and Health Administration
OWS	Oily water sewer
PAH	Pressure alarm high
PAL	Pressure alarm low
PC	Personal computer
PCV	Pressure control valve

Abbreviation list

PDQs	Drilling, production and quarters platforms
PFD	Process flow diagram
PHA	Preliminary hazard analysis or process hazard analysis
PI	Pressure indicator
PIB	Process interface building
PIPITC	Petroleum and Chemical Processing Industry Technology Cooperative
P&A	Plugged and abandoned
P&ID	Piping and instrument drawing
PLC	Programmable logic controller
PLL	Potential loss of life
PML	Probable maximum loss
POB	Personnel on board
PPM	Parts per million
PS	Pressure sewer
PSH	Pressure switch high
PSI	Pounds per square inch
PSM	Process safety management
QRA	Quantifiable risk assessment
RCA	Root cause analysis
RPM	Revolutions per minute
RRF	Risk reduction factor
RV	Relief valve
SEMS	Safety and environmental management systems
SIL	Safety integrity level
SIP	Shelter-in-place
SPM	Single-point moorings
SSP	Site security plan
SVA	Security vulnerability analysis
TMR	Triple modular redundant
TNT	Trinitrotoluene
TSR	Temporary safe refuge

Abbreviation list

UEL	Upper explosive limit
ULCC	Ultra large crude carrier
UPS	Uninterruptable power supply
USCG	United States Coast Guard
UVCE	Unconfined vapor cloud explosion
VCE	Vapor cloud explosion
WIA	What-if analysis

Appendix F

National Electrical Manufacturers Association (NEMA) Classifications

The following is a general description of NEMA electrical equipment enclosure definitions from NEMA Publication 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

B-3.1 TYPE 1—GENERAL PURPOSE

A general-purpose enclosure that is intended to primarily prevent contact with the enclosed apparatus. It is suitable for general-purpose applications indoors where it is not exposed to unusual service conditions and is primarily designed to keep out solid foreign objects such as falling dirt.

B-3.2 TYPE 1A—SEMI-DUST TIGHT

A semi-dust-tight enclosure that is similar to a type 1 enclosure, with the addition of a gasket around the cover.

B-3.3 TYPE 1B—FLUSH TYPE

A flush-type enclosure that is similar to a type 1 enclosure, but is designed for mounting in a wall and is provided with a cover that also serves as a flush plate.

B-3.4 TYPE 2—DRIP PROOF INDOORS

A drip-tight enclosure that is intended to prevent contact with the enclosed apparatus and in addition is so constructed as to exclude falling moisture or dirt, but is not dust-tight. Type 2 enclosures are suitable for applications where condensation may occur, such as encountered in cooling rooms and laundries.

B-3.5 TYPE 3—DUST TIGHT, RAIN TIGHT, AND SLEET (ICE) RESISTANT OUTDOOR

A weather-resistant enclosure intended to provide suitable protection against specified weather hazards. It is suitable for indoor or outdoor use. It is intended to provide a degree of protection against ingress of water (rain, sleet, snow), falling dirt and windblown dust, and be undamaged from the formation of external ice on the enclosure.

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B-3.6 TYPE 3R—RAIN PROOF, SLEET (ICE) RESISTANT, OUTDOOR

A weather-resistant enclosure intended to provide suitable protection against specified weather hazards. It is suitable for indoor or outdoor use. It is intended to provide a degree of protection against ingress of water (rain, sleet, snow), falling dirt, and be undamaged from the formation of external ice on the enclosure. They are to meet the requirements of Underwriters' Laboratories, Inc., Publication No. UL 508, Industrial Control Equipment, applying to "Rainproof Enclosures."

B-3.7 TYPE 3S—DUST TIGHT, RAIN TIGHT, AND SLEET (ICE) PROOF—OUTDOOR

A weather-resistant enclosure intended to provide suitable protection against specified weather hazards. It is suitable for indoor or outdoor use. It is intended to provide a degree of protection against ingress of water (rain, sleet, snow), falling dirt and windblown dust, and the external mechanism remain operable when ice laden.

B-3.8 TYPE 3X—DUST TIGHT, RAIN TIGHT, AND SLEET (ICE) PROOF—OUTDOOR, CORROSION RESISTANT

A weather-resistant enclosure intended to provide suitable protection against specified weather hazards. It is suitable for indoor or outdoor use. It is intended to provide a degree of protection against ingress of water (rain, sleet, snow), falling dirt and windblown dust, an additional level of protection against corrosion and damage from the formation of external ice on enclosure.

B-3.9 TYPE 3RX—RAIN TIGHT, AND SLEET (ICE) PROOF – OUTDOOR, CORROSION RESISTANT

A weather-resistant enclosure intended to provide suitable protection against specified weather hazards. It is suitable for indoor or outdoor use. It is intended to provide a degree of protection against ingress of water (rain, sleet, snow), falling dirt, an additional level of protection against corrosion, and damage from the formation of external ice on enclosure.

B-3.10 TYPE 3SX—DUST TIGHT, RAIN TIGHT, ICE RESISTANT, CORROSION RESISTANT

A weather-resistant enclosure intended to provide suitable protection against specified weather hazards. It is suitable for indoor or outdoor use. It is intended to provide a degree of protection against ingress of water (rain, sleet, snow), falling dirt and windblown dust, an additional level of protection against corrosion, and the external mechanism remain operable when ice laden.

B-3.11 TYPE 4—WATERTIGHT AND DUST TIGHT

A weather-resistant enclosure intended to provide suitable protection against specified weather hazards. It is suitable for indoor or outdoor use. It is intended to provide a degree of protection against ingress of water (rain, sleet, snow, splashing water, and hose-directed water), falling dirt and wind-blown dust, and damage from the formation of external ice on the enclosure. Type 4 is suitable for applications on loading docks and in water pump houses but not in electrically classified areas.

National Electrical Manufacturers Association (NEMA) Classifications

B-3.12 TYPE 4X—WATERTIGHT, DUST TIGHT, AND CORROSION RESISTANT

A weather-resistant enclosure intended to provide suitable protection against specified weather hazards. It is suitable for indoor or outdoor use. It is intended to provide a degree of protection against ingress of water (rain, sleet, snow, splashing water, and hose directed water), falling dirt and wind-blown dust, an additional level of protection against corrosion and damage from the formation of external ice on enclosure.

B-3.13 TYPE 5—DUST TIGHT WATERTIGHT

An indoor enclosure with a degree of protection against settling dust, dirt, and noncorrosive liquids (dripping and splashing).

B-3.14 TYPE 6—SUBMERSIBLE

Enclosures intended for indoor or outdoor use primarily to provide a degree of protection against entry of water during occasional temporary submersion at a limited depth (6 ft of water for 30 min). They are not intended to provide protection against conditions such as internal condensation, internal icing, or corrosive environments. Type 6 enclosures are suitable for applications where the equipment may be subject to temporary submersion. The design of the enclosure will depend upon the specific conditions of pressure and time. It is also dust-tight and sleet (ice)-resistant.

B-3.15 TYPE 6P—PROLONGED SUBMERSIBLE

An enclosure for indoor or outdoor use to provide a degree of protection against directed pressurized water application (hose-directed water), entry of water during prolonged submersion at limited depth, an additional level of protection against corrosion and damage from external ice formation.

B-3.16 TYPE 7— (A, B, C, OR D) HAZARDOUS LOCATIONS – CLASS I AIR BREAK

National Electrical Code (NEC), Class I, Division 1, Group A, B, C, or D-Indoor Hazardous Locations-Air-break Equipment—Type 7 enclosures are intended for use indoors, in the atmospheres and locations defined as Class I, Division 1 and Group A, B, C, or D in the National Electrical Code. The letter or letters A, B, C, or D which indicate the gas or vapor atmospheres in the hazardous location shall appear as a suffix to the designation “Type 7” to give the complete NEMA designation and correspond to Class I, Division 1, Group A, B, C, or D, respectively, as defined in the NEC. These enclosures shall be designed in accordance with the requirements of Underwriters’ Laboratories, Inc., “Industrial Control Equipment for Use in Hazardous Locations,” UL 698, and shall be marked to show the Class and Group letter designations.

B-3.17 TYPE 8— (A, B, C, OR D) HAZARDOUS LOCATIONS – CLASS I OIL IMMERSED

National Electrical Code (NEC), Class I, Division 1, Group A, B, C, or D-indoor Hazardous Locations-Oil-immersed Equipment—Type 8 enclosures are intended for use indoors, in the atmospheres and locations defined as Class I, Division 1 and Group A, B, C, or D in the National Electrical Code. The letter or letters A, B, C, or D which indicate the gas or vapor atmospheres in the hazardous location shall appear as a suffix to the designation "Type 8" to give the complete NEMA designation and correspond to Class I, Division 1, Group A, B, C, or D, respectively, as defined in the NEC. These enclosures shall be designed in accordance with the requirements of Underwriters' Laboratories, Inc., Publication No. UL 698, "Industrial Control Equipment for Use in Hazardous Locations," and shall be marked to show the Class and Group letter designations.

B-3.18 TYPE 9— (E, F, OR G) HAZARDOUS LOCATIONS—CLASS II

National Electrical Code (NEC), Class II, Division 1, Group E, F, or G-indoor Hazardous Locations-Air-break Equipment—Type 9 enclosures are intended for use indoors in the atmospheres defined as Class II, Division 1 and Group E, F, or G in the National Electrical Code. The letter or letters E, F, or G, which indicate the dust atmospheres in the hazardous location, shall appear as a suffix to the designation "Type 9" to give the complete NEMA designation and correspond to Class II, Division 1, Group E, F, or G, respectively, as defined in the NEC.

These enclosures shall prevent the ingress of explosive amounts of hazardous dust. If gaskets are used, they shall be mechanically attached and of a noncombustible non-deteriorating, vermin-proof material. These enclosures shall be designed in accordance with the requirements of Underwriters' Laboratories, Inc., Publication No. UL 698, "Industrial Control Equipment for Use in Hazardous Locations," and shall be marked to show the Class and Group letter designations.

B-3.19 TYPE 10—MINE SAFETY AND HEALTH ADMINISTRATION (MSHA) EXPLOSION-PROOF

An enclosure designed to meet the explosion-proof requirements of the US Mine Safety and Health Administration (MSHA) requirements as defined in 30 CFR, Part 18, (Schedule 2G). The equipment is to be used in mines with atmospheres containing methane or natural gas, with or without coal dust. Additional information may be found in their Bulletin 541 and Information Circular 8227.

B-3.20 TYPE 11—CORROSION-RESISTANT AND DRIP-PROOF OIL-IMMERSED-INDOOR

Type 11 enclosures are corrosion-resistant and are intended for use indoors to protect the enclosed equipment against dripping, seepage, and external condensation of corrosive liquids. In addition, they protect the enclosed equipment against the corrosive effects of fumes and gases by providing for immersion of the equipment in oil. They are suitable for applications such as chemical plants, plating rooms, sewage plants, etc.

National Electrical Manufacturers Association (NEMA) Classifications

B-3.21 TYPE 12—INDUSTRIAL USE

An indoor enclosure design without knockouts for use in industries where it is desired to exclude such materials such as foreign objects, for example, dirt, dust, lint fibers, flyings, and ingress of liquids, for example, dripping and light splashing.

B-3.22 TYPE 12K—INDUSTRIAL USE, WITH KNOCKOUTS

An indoor enclosure design with knockouts for use in industries where it is desired to exclude such materials such as foreign objects, for example, dirt, dust, lint fibers, flyings, and ingress of liquids, for example, dripping and light splashing.

B-3.23 TYPE 13—OIL TIGHT AND DUST TIGHT INDOOR

An indoor enclosure design for use in industries where it is desired to exclude such materials such as foreign objects, for example, dirt, dust, lint fibers, flyings, and ingress of liquids, for example, dripping and light splashing and a degree of protection against spraying, splashing, and seepage of oil or/and noncorrosive coolants.
They are intended for use indoors primarily to house pilot devices such as limit switches, foot switches, pushbuttons, selector switches, pilot lights, etc.

Hazardous Atmosphere / NEMA Classification

	Type 7				Type 8			
	A	B	C	D	A	B	C	D
Hazardous Atmosphere								
Acetylene	✓				✓			
Hydrogen		✓				✓		
Diethly ether, ethylene, cyclopropane, etc.			✓				✓	
Gasoling, hexane, naphta, etc.				✓				✓

NEMA Type 7 (indoor) and Type 8 (indoor and outdoor). Applications for hydrocarbon environments. Ref. NEMA publication 250. Appendix B-3.

Fire Resistance Testing Standards

API Spec. 6FA Specification for Fire Test for Valves, Reaffirmed 2011

API Spec. 6FB Specification for Fire Test for End Connections, Reaffirmed 2011

API Spec. 6FC Specification for Fire Test for Valves with Automatic Backseats, 2009

API Spec. 6FD Specification for Fire Test for Check Valves, 2008

API Bul. 6F1 Technical Report on Performance of API and ANSI End Connections in a Fire Test According to API Specification 6FA, 1999

API Bul. 6F2 Technical Report on Fire Resistance Improvements for API Flanges, 1999

API Std. 607 Testing of Valves-Fire Type—Testing Requirements, 2010

ASTM E-84 Test Method for Surface Burning Characteristics of Building Materials, 2013

ASTM E-108 Test Methods for Fire Test of Roof Coverings, 2011

ASTM E-119 Test Methods for Fire Tests of Building Construction and Materials, 2012

ASTM E-136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C, 2012

ASTM E-162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source, 2013

ASTM E-648 Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source, 2010

ASTM E-662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials, 2013

ASTM E-814 Test Method for Fire Tests of Penetration Firestop Systems, 2011

Fire Resistance Testing Standards

ASTM E-1529 Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies, 2006

ASTM E-2032 Guide for Extension of Data from Fire Resistance Tests Conducted in Accordance with ASTM E-119, 2009

IEEE 1202 Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies, 2006

IMO A763 (18) Guidelines for the Application of Plastic Pipes on Ships / Guide for Certification of FRP Hydrocarbon Production Piping Systems (ABS Publication 137), 2005

NFPA 251 Standard Methods of Tests of Fire Resistance of Building Construction and Materials, 2006

NFPA 252 Standard Methods of Fire Tests of Door Assemblies, 2012

NFPA 253 Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source, 2011

NFPA 257 Fire Tests for Window and Glass Block Assemblies, 2012

NFPA 259 Standard Test Method for Potential Heat of Building Materials, 2013

NFPA 260 Standard Methods of Tests and Classification System for Cigarette Ignition Resistance of Components of Upholstered Furniture, 2013

NFPA 262 Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces, 2011

NFPA 268 Standard Test Method for Determining Ignitability of Exterior Wall Assemblies Using a Radiant Heat Energy Source, 2007

NFPA 288 Methods of Fire Tests of Floor Fire Door Assemblies Installed Horizontally in Fire Resistance-Rated Floor Systems, 2007

SOLAS Standard Fire Test (Chapter II) UL 9 Fire Test of Window Assemblies, 2009

UL 10A Tin-Clad Fire Doors, 2009

UL 10B Fire Tests of Door Assemblies, 2009

Fire Resistance Testing Standards

UL 10C Positive Pressure Fire Tests of Door Assemblies, 2009

UL 263 Fire Tests of Building Construction and Materials, 2011

UL 555 Fire Dampers, 2012

UL 555S Smoke Dampers, 2013

UL 723 Test for Surface Burning Characteristics of Building Materials, 2013

UL 790 Standard Test Method for Fire Tests of Roof Coverings, 2013

UL 1256 Fire Test of Roof Deck Constructions, 2013

UL 1479 Fire Test of Through-Penetration Fire Stops, 2012

UL 1666 Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts, 2012

UL 1685 Vertical Tray Fire-Propagation and Smoke Release Test for Electrical and Optical-Fiber Cables, 2010

UL 1709 Rapid Rise Fire Tess of Protection Materials for Structural Steel, 2011

UL 1715 Fire Test of Interior Finish Material, 2013

UL 1820 Fire Test of Pneumatic Tubing for Flame and Smoke Characteristics, 2013

UL 1887 Fire Test of Plastic Sprinkler Pipe for Flame and Smoke Characteristics, 2013

UL 2080 Fire Resistant Tanks for Flammable and Combustible Liquids, 2000

UL 2196 Tests for Fire Resistive Cables, 2012

UL 2431 Durability of Spray-Applied Fire Resistive Materials, 2012

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Note: This Bulletin contains only a general description of the products shown. While product uses and performance capabilities are generally described, the products shall not, under any circumstances, be used by untrained or unqualified individuals. The products shall not be used until the product instructions/user manual, which contains detailed information concerning the proper use and care of the products, including any warnings or cautions, have been thoroughly read and understood. Specifications are subject to change without prior notice. MSA is a registered trademark of MSA Technology, LLC in the US, Europe, and other Countries. For all other trademarks visit https://us.msasafety.com/Trademarks.

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1400-029-MC / 08.2024
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