



## **FREQUENTLY ASKED QUESTIONS ABOUT FLAME DETECTION**

### **Q: What types of optical flame detectors are available?**

There are various types of optical flame detector that utilise the various spectral bands that are emitted by the fire:

- UV - single sensor type.
- IR - single sensor type.
- UV/IR - dual sensor type.
- IR2 - dual IR sensor type.
- IR3 - Triple IR sensor type.
- CCTV - Image processing type.
- Multi IR - multi IR sensor type

The unique flame radiation spectral pattern allows several spectral ranges to be employed simultaneously in the various detection devices.

Optical Flame Detectors usually employ several optical sensors, working in specific spectral ranges (usually narrow bands) that record simultaneously the incoming radiation at the selected wavelengths. The signals recorded by each sensor are analyzed according to a pre-determined technique that includes one or more of the following:

- Flickering frequency analysis.
- Threshold energy signal comparison.
- Mathematical ratios and correlations between various signals.
- Comparator techniques (and-gate techniques).
- Correlation to memorized spectral analysis.

Modern optical flame detectors employ several of the above mentioned techniques in order to provide enhanced reliability and accuracy.

### **Q: Why are the optical flame detectors so important?**

For many years optical flame detectors have been an integral part of automatic fire detection systems.

Optical detectors can 'see' a fire from a long distance without the smoke or heat needing to get to the detector first. Light travels extremely fast so the detector 'sees' (reacts) extremely quickly to flaming fires that can be up to 65m away and only 0,01m<sup>2</sup> (1ft<sup>2</sup>) in size.

This feature makes optical flame detectors very effective in large open or critical areas where other fire detection methods would not work.

**Q: What is UV Flame Detection?**

The UV spectral band, because of its short-wave characteristics, is absorbed in the surrounding atmosphere by air, smoke, dust, gases and various organic materials. Hence UV solar radiation dispersed in the atmosphere (especially at wavelengths shorter than 300 nanometers - the solar blind spectral band) being absorbed by the surrounding atmosphere, will not create false alarms for the UV flame detector. The UV spectral signature of some flames has a pattern that can be readily recognized over the background radiation. UV detectors based on this technology detect flames at high speed (3-4 milliseconds) due to the high-energy UV radiation emitted by fires and explosions at the instant of their ignition. However, this discernible UV radiation emitted by a flame from a distance (several meters) in outdoor applications can be attenuated by atmospheric pollutants such as smoke, smog, hydrocarbon vapors and organic material accumulated on lenses or detector windows. In addition, the occurrence of random UV radiation from stimuli such as: lighting, arc welding and radiation, X-rays, solar radiation (not absorbed by the atmosphere, due to holes in the ozone layer and solar bursts), causes false alarms in UV detectors.

Because of these factors UV detectors are mostly used for indoor applications, where no direct or reflected sunlight radiation or lightning UV spikes can penetrate the protected area. The detectors should be shielded from exposure to organic vapors that may cause radiation absorption, and located in areas that are not exposed to UV sparks from welding or high voltage equipment.

**Q: What is IR Flame Detection?**

Infrared radiation is present in most flames. The flame temperature and its mass of hot gases (fire products) emit a specific spectral pattern that can be easily recognized by employing IR sensor technology. However, the flames are not the only source of IR radiation; in fact any hot surface (e.g. oven, incandescent lamp, halogen lamp, furnaces and solar radiation) emits IR radiation that coincides with the flame IR radiation wavelengths. In order to discern the flame spectral signature from other IR source spectral signatures, various parameter analysis and mathematical techniques are employed. The most accepted are flickering analysis and narrow band IR threshold signals processed in the IR 4.1 - 4.6micron wavelengths. However, these IR detectors are still subject to false alarms caused by blackbody radiation (heaters, incandescent lamps, halogen lamps, etc.). Most single band IR detectors are based on pyroelectric sensors with a 4.4 micron optical filter, and a low frequency (1-10 Hz) electronic band pass filter (characteristic of a flickering flame). This type of detector identifies a fire when the IR radiation emitted from a 1 sq. ft. gasoline pan fire at 4.4micron from a distance of 15m is above a predetermined value.

The single frequency IR detectors respond only to a certain flicker and radiation intensity at 4.4micron. Thus, they are sensitive to flickering or modulated blackbody radiation. Under certain conditions, it is possible for flickering caused by such things as shimmering water, rotating lights or interrupted thermal radiation to be interpreted as fire by single frequency IR detectors. Radiation sources other than fire will cause this type of detector to false alarm under the above mentioned conditions.

At the relevant wavelength, the radiation from a black body, at 1300°K at a distance of 15m, is approximately equivalent to the radiation from a 1ft<sup>2</sup> gasoline pan fire at

the same distance. The same level of radiation is attained from a  $1\text{ft}^2$   $700^\circ\text{K}$  blackbody at a distance of 5m and for a temperature of  $400^\circ\text{K}$  at 1m distance.

The single IR detectors are used mostly for indoors applications, however for short distances (up to 20m) in areas where false alarm stimuli (listed above) are not expected, they are used also outside. In order to improve their reliability, a Built-in-test (BIT) feature is incorporated into the detector.

In order to minimize or eliminate the above listed false alarms, dual wavelength technology has been adopted for optical fire detection.

This dual wavelength technology has two major branches:

- UV/IR spectral bands.
- Dual IR/IR spectral bands.

### **Q: What is UV/IR Flame Detection?**

The dual spectrum UV/IR technology employs a solar blind UV sensor with a high signal-to-noise ratio and a narrow band IR sensor. The UV sensor itself is a good fire detector but it is easily activated by alarm stimuli such as arc welding, lighting, X-rays and solar spikes. In order to prevent false alarms caused by these sources, an IR sensing channel was added, working at 2.7micron or 4.1- 4.6micron spectral ranges. These IR spectral channels exhibit the spectral signature characteristic to fire and, in addition to the fire's UV spectral signature, are considered reliable for most mid-range applications. However, even this advanced technology has its limitations, since each type of fire has its own specific ratio of UV to IR output. For example, a hydrogen flame generates a lot of UV radiation with very little IR, while a coal fire will generate little UV radiation and a high amount of IR radiation. Hence the dual UV/IR detector must combine both signals and compare them accordingly to distinguish a fire signature from false alarm stimulus.

To ensure the reliability of the fire signal, a discriminating circuit compares the UV radiation threshold signal, the IR threshold signal, their ratio as well as their flickering mode. Only when all parameters satisfy the detection mathematical algorithm is a fire signal alarm confirmed. However, UV radiating sources such as welding, electrical arcs, lighting (high voltage coronas), torches, solar spikes; as well as IR radiating sources such as heaters, incandescent lamps, halogen lamps, etc., are sources for false alarms. Since these false alarms affect both UV and IR channels, certain scenarios may occur when a fire is present. A serious problem may occur when a strong UV source (welding) is present and a fire ignites.

Such a scenario will produce two UV signals (one strong and the other weak) thus blocking the detectors logic from further comparison with the IR channel, and preventing the fire detection.

Unwanted solar spikes in the UV (in the spectral band where fires emit most of their UV energy) combined with flickering IR sources (such as moving objects in front of hot sources) are liable to cause UV/IR detectors to false alarm, even when a fire is not present.

### **Q: What is Dual IR/IR Flame Detection?**

In order to eliminate false alarms, dual wavelength technology combining two narrow spectral ranges in the near IR spectral band had been selected. Since hydrocarbon flames emit energy of a continuous nature in the near IR (0.9micron - 3.0micron) and a unique peak at the 4.3micron - 4.5micron (caused by a hot CO<sub>2</sub> fire product), these features are the "heart" of most dual IR detectors. Common dual IR flame detectors employ two narrow bands 0.9micron and 4.3micron for fire signal analysis or a combination of short wavelength 0.8-1.1micron and long wavelength 14-25 micron IR channels. Some of the dual IR detectors include, in addition to one near IR channel for fire detection, a channel for the background detection in the 4.7-16micron IR band.

However, an additional approach to dual IR detection technology has emerged in the last years, where the fire main spectral characteristic feature at 4.3 - 4.5 micron is analyzed thoroughly. The basis to this analysis is the "differential spectral" approach, where two spectral ranges are analyzed; one spectral range is emitted strongly by the fire, while the second spectral range is emitted weakly by the surrounding thus the ratio between these two signals gives a substantial mathematical tool for fire signal processing. The most popular selected wavelengths include one band within the 4.2 - 4.7micron (emitted by CO<sub>2</sub>) and another within 3.8 - 4.1micron (near the CO<sub>2</sub> peak) that serves as background energy monitoring. This type of IR detector senses the radiation at these two channels and processes the input signals based on the following parameters:

- Flickering analysis.
- Radiation intensity above a certain threshold.
- The ratio between the two signals received at the two sensors.

However, since most of these dual IR detectors use the 4.3micron sensor as their main channel for fire recognition (where the CO<sub>2</sub> emission peak exists), they suffer from atmospheric attenuation, especially at long range detection applications.

### **Q: What is Triple IR Flame Detection - IR3?**

The IR3 detector utilizes a combination of three IR sensors. One covers the typical CO<sub>2</sub> flame emission spectral band, and the two other sensors cover different adjacent specially selected spectral bands, where black body emitters and background radiation are interfering.

While the CO<sub>2</sub> emission band sensor is responsible for the detection of the flame radiation, the other sensors are sensitive to all other non-fire radiation sources. The Triple IR employs dedicated algorithms processed by a microprocessor analyzing radiation intensity, ratios, correlations, threshold values, and flickering signals obtained from the three sensors.

The spectrum of flame radiation measured by the detector is influenced by the distance between the detector and the fire and by the concentration of the CO<sub>2</sub> gas in the atmosphere.

Two factors that limit the detection range of the dual IR detectors have been addressed by the Triple IR (IR3) Technology:

- The fire's radiation intensity around the 4.3micron peak strongly decreases as the distance increases. The input signal received by the sensor is very weak (and the more CO<sub>2</sub> in the atmosphere, the higher absorption of this wavelength and the lower signal received). Thus the threshold defined in dual IR/IR type detectors could be omitted and not recognized as fire.
- The ratio between the 4.3micron spectral band and the background 4.0micron spectral band approaches equality (1) and ceases to be typical of the ratio existing in fires. Once the ratio is 1 or near 1, the algorithm processing the fire signals gives a 'no fire' signal though a fire may occur at that very moment.

The first limiting factor may be reduced by choosing a sensor with a wide band spectral range of 4.2 - 4.6micron. This will enhance the input signal, however will not solve the problem discussed in the second factor (b). The ratio between the two IR channels becomes equal for a long distance fire or in the case of high concentration of CO<sub>2</sub> in the atmosphere. This criteria, when employed in the IR/IR fire detectors, makes the distinction between flames and false alarm sources (electrical heaters) almost impossible. The parameter of a black body radiator emission required a third sensor.

The high sensitivity of the IR3 is achieved by extracting extremely low signals deeply buried in noise by adopting digital correlation techniques. This counts for the high sensitivity and long detection range while the immunity of the IR3 detector to false alarms is maintained. For comparison, the standard optical flame detector's range is 15-20m, while the Triple IR offers an extended detection range up to 65m. Triple IR detectors will not false alarm to any continuous, modulated or pulsating radiation sources other than fire (including any other sources such as a black or gray body radiation).

When compared to standard UV/IR or IR/IR detectors, the Triple IR although slightly higher in cost, is very cost effective since one IR3 detector provides extended coverage that allows the use of less detectors. Its high reliability provides a very low cost of ownership (very low false operation rate).

This technique has been extended to detect the invisible flames from a hydrogen fire. Here the detection sensor is looking for the H<sub>2</sub>O emissions typical of H<sub>2</sub> fires whilst the two background sensors, as always, will ensure that the fire is that and not a false alarm.

The latest **model 40/40M** goes one step further and combines the two detection sensors and two background sensors to form a quad-IR detector that detects hydrocarbons and hydrogen.

#### **Q: What is a CCTV Flame Detector?**

CCTV Flame detector is a self-contained, IR3 flame detector (see above for benefits) that also incorporates a color video camera.

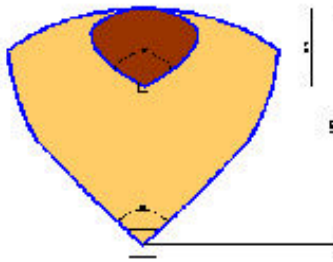
The color video camera enables the user to investigate the monitored area, identify the fire's source and location and help select the best response to the situation (e.g. activation of fire suppression). Configuration can be made for a live color video picture

signal at all times, on request or only when a fire is detected. Therefore, the detector is also useful for standard CCTV purposes.

**Q. How do I select the correct detector for my application?**

See our [Detector selection guide](#) for assistance

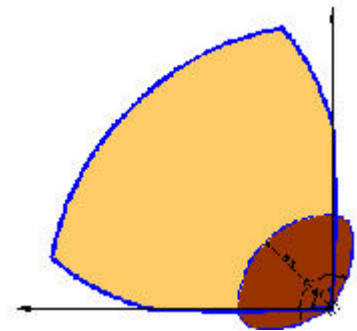
**How to locate and install flame detectors:**



**Q: What is an optical flame detector's field of view?**

All flame detectors have between 90° up to 120° cone of vision. One can assume that the wider the cone of vision the more area the detector can cover. However this is both **misleading** and in many cases **totally incorrect!!**

In the case of the IR3 detector which has a 100° cone of vision but can see a 0.1 m<sub>3</sub> (1x1sq.ft) fire at a distance of 65 m (215 feet) - **the area the detector can cover is far greater (six times) than that of a detector with a 120 degree cone of vision which can only see the same size fire at 15M (50 ft)!**

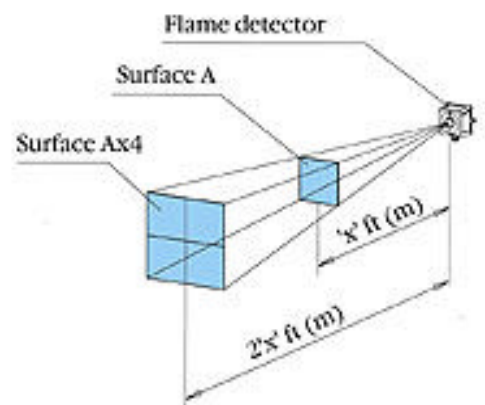


Most flame detectors are placed in the corner of a structure so as to get maximum coverage along both walls and into the area. In this scenario the additional 30 degree is meaningless as it **is outside the walls of the building.**

When deciding installation locations, the Spectrex [aser Detection Area Coverage Pointer](#) can assist by defining the 90° cone of vision on site

**Q. What is effect on detection at greater distances? Inverse Square Law**

Since both sensitivity and range are related to fire size, if the detector is placed further away from (or closer to) the fire source, the detectable fire size will vary according to the inverse square law\*. So, doubling the detection distance results in only 25% of the radiant energy reaching the detector; or conversely, for the same response time, the surface area of the fire then needs to be 4 times larger!



For example, if a standard UV/IR detector, capable of detecting a 0.1m<sup>2</sup> (1 ft<sup>2</sup>) fire at 15m (50 ft), is located at 30m (100 ft) detection distance, the minimum fire then needs to be 0.4m<sup>2</sup> (4 ft<sup>2</sup>). Conversely, at a 5m (15 ft) range, a fire of only 0.01m<sup>2</sup> (0.1 ft<sup>2</sup>) would operate the alarm.

*\*This calculation cannot be used indefinitely. As distance increases, factors such as water vapor, cold CO<sub>2</sub> and flame flicker have more impact.*

### Q. What is the detection distance for different materials/ fuels?

Not all materials emit the same levels of IR and/or UV radiation. Therefore, the distance at which the flame detector will detect a standard size fire of 0.1m<sup>2</sup> (1ft<sup>2</sup>) varies accordingly

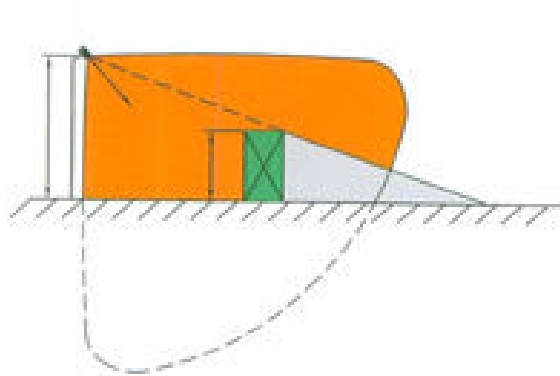
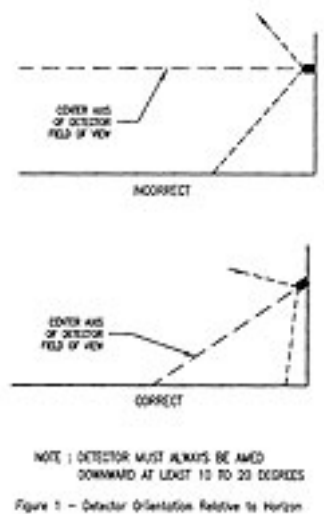
### Q. What are the different 'sensitivity' settings for on the IR3 models?

Spectrex IR3 flame detectors are all able to detect at long distances (up to 65m) but there are times when that is not preferred due to the possibility of detection overlap when working with specific zones or areas of detection that adjoin each other e.g. aircraft hangars. Therefore, it is possible to set the sensitivity to detect a standard fire at different distances e.g. 15, 30, 45 or 65m. We set a factory default but the sensitivity can be changed at site using a laptop/PC with free Spectrex software and special connection cable (with RS485/232 converter).

### Q. How can the detector see the fire?

Flame detection range is much influenced by how the detector is installed.

- Try to experience what the detector can 'see'.
- Mount the detector so that it covers the objects/area that need protection.
- The detectors should where possible be mounted looking down at an angle to prevent dirt, dust and moisture from collecting on the windows.
- Avoid potential false alarm sources in the cone of vision - such as flares, engine or turbine exhaust



### Q. How to Watch out for 'Blind Spots'?

Locate another detector in the opposite corner - this also provides redundant cover should the other detector become blocked.

### Q. How do I decide on the no. of detectors required?

Important factors are:

- The fuels to be detected and their sensitivity on the particular detector type
- The distance at which detection is to take place and
- The minimum fire size to be detected
- All sources of nuisance radiations or possible inhibitors
- Environmental conditions
- Desu can assist with detector layout in large open areas and can plot detector area coverage 'cones' on to you drawings.

## False Alarms and Inhibitors

Various false alarm stimuli that are naturally found in the environment, such as: flare stack, direct and reflected sunlight, artificial illumination, hot boilers and engine exhausts.

During maintenance work additional false alarm stimulus can be generated by arc welding, electric heaters, incandescent and discharge lamps. Generally the types of fires that are of interest for petrochemical industry include gasoline, kerosene and jet fuel sprays, diesel pools, propane jet and diesel spray, with radiant heat output from 10 to 250 kW. Some of these petrochemicals, like kerosene and aromatic compounds are also used as solvents and diluents in many industries.

The effective range for a flame detector is the minimum distance at which the detector will respond reliably to a predetermined quoted fire. It accounts for loss in sensitivity of the detector caused by obscurants in the air, dirt accumulated on the detector window as well as to the various fire products that may absorb some of the fire radiation.

False alarms are the worst that can happen apart from non-detection. The user loses faith and maybe a real fire alarm is ignored.

- **UV** detectors false alarms to the radiation of Arc Welding, Halogen lamps or high pressure mercury lamps (without the protective glass), corona and static arcs.
- **IR** detectors may false alarm to chopped black body radiation and in some cases direct chopped sunlight.
- **Multi IR** sensors are less susceptible to blackbody radiation or chopped sunlight but may get insensitive.  
An inhibitor is a substance or vapour that 'blinds' the detector. It is important to know if they present in the area or emerging from the fire
- **UV** detectors will be blinded by oil or grease on the window, some hydrocarbon vapours like Xylene, Toluene, Chloride vapours etc.
- **IR** detectors may be blinded by fog, water and ice or a salt layer on the window.
- **Multi IR** detectors may be blinded or masked by blackbody radiation from hot machinery or direct sunlight.

## **Testing**

### **Q: How can a flame detector be tested?**

A frequently asked question is how to test optical flame detectors located in hazardous environments (that require the use of explosion proof equipment) and difficult to reach locations. For this purpose, special flame simulators that mimic the spectral signature of the flames have been developed. **Using a Flame Simulator is the only sure method to perform a full functional test.**

Most optical flame detectors have automatic integral self-tests for checking the window cleanliness and sensor operation. These detectors include UV, UV/IR, Single Band IR, Triple Band IR, etc. However, these automatic tests do not constitute a full functional "end to end" detector test. The automatic self-tests only **partially** check the operational readiness of a detector since the actual alarm outputs are not activated (and rightly so as these tests are often performed every 15 minutes).

However, to comply with NFPA standards and other regulatory authorities, "end to end" testing of Fire Protection Alarm Systems, including detectors, should be performed periodically. Many Plant Managers of high valued assets and facilities, including Life Safety, mandate quarterly "end to end" testing of their entire Fire Protection Systems using an external Flame simulator.

Using an external portable Flame Simulator is the best method of performing a full functional test of the Detector and the Fire Protection System "end to end" without the need to start a real fire (which is not permitted in hazardous areas and can be dangerous in non-hazardous areas). This is true for all flame/fire detectors (whether or not they have automatic self-test features) installed as part of a fire detection/protection system.

Using a Flame simulator is the **only** non-hazardous and safe method to test any flame detector's sensors, internal electronics and its alarm activation software, viewing window lens cleanliness, terminal wiring integrity, actual relay activation, and the proper functionality of any other outputs that are used. Also, since most detectors are installed in a fire protection alarm system, using a Flame simulator is the only practical method to test the complete fire alarm system and that all the system wiring and cabling and system control panel(s) is properly installed.

Using an external Flame simulator also verifies that the detector has an unobstructed, clear view of the fire threat area. Since **all** electro-optical radiant energy fire and flame detectors are line-of-sight devices, they must be properly positioned and oriented with an unobstructed view of the threat area so that they can "see" in order to detect flames/fires. A physical obstruction in the detector's partial or full field of view can seriously compromise the integrity of the fire detection ("blind") and protection system such as:

- Such things as paint overspray, masking tape, storage boxes, vehicles, and hanging garments such as hats, coats, tarpaulins, etc. physically covering the detector's window viewing lens.

- Detector mounting bracket breakage, failure or misalignment where the detector is improperly aimed at the fire threat area. Like a human being watching for a fire, the detector must be "looking" in the right direction of the fire and not be "staring" at the ground or in the wrong direction. Since most optical fire and flame detectors are used in industrial applications, vibration, physical impact, maintenance, cleaning, etc. can cause improper detector orientation resulting in unprotected detection zone even though the detector is reporting a successful automatic self-test to the Fire Alarm Panel. This kind of "false security" can be disastrous if an actual fire occurred in this unprotected area.
- Storage boxes, crates, equipment, or air ducts and pipes placed or installed after fire protection system commissioning that are in the detector's direct field of view of the threat area. Again, a detector with automatic self-test will report to the Fire Alarm Panel that it is working properly even though it is unable to alarm to a fire occurring in its detection coverage area.

Using an external Flame simulator verifies that an optical flame detector's viewing window cleanliness and its internal electronic operation, similar to an internal automatic detector self-test. However, importantly, it will also functionally test its critical alarm outputs, whether relay activation, 4-20mA alarm output, RS-485 digital data output including ModBus, etc., the detector and system's wiring terminals, cabling and its connections, Fire Alarm Panel functionality, proper alarm notification, and, if desired, actual suppression release, etc.

It must be noted and emphasized: If an actual suppression/extinguishant release **is NOT desired**, this action **MUST BE DISABLED** at the Fire Alarm Releasing Panel. To comply with NFPA standards (and AHJ requirements), "end to end" testing of Fire Protection Alarm Systems, including detectors, should be performed periodically. Many Plant Managers of high valued assets and facilities, including Life Safety, mandate quarterly "end to end" testing of their entire Fire Protection Systems using an external Flame Simulator.

Another important factor is the distance at which testing can be done. Many other detector testers have to be operated immediately in front of the detector face. Not so with SharpEye - our long range simulators will operate up to 9m (30 ft) from the detector, thus avoiding the high cost and inconvenience of providing access (e.g. scaffolding) to perform this vital function.

Desu offers various SharpEye optical flame simulators to test all the different SharpEye models. All models can be rented or purchased from Desu All are Ex approved for use in the hazardous area.

#### **Q. How often should I test my Flame Detectors?**

Calibration of our Flame Detectors is not required although we recommend testing as frequently as local regulations and ambient conditions dictate. Flame Detectors are a vital part of your safety system and you need to verify proper operation and alarm sequences. Spectrex Long Range Flame simulators provide the ideal method for this vital check

## **Applications**

### **Q. Will the detector respond to a smouldering fire?**

No, Spectrex flame detectors will not detect this type of fire. A smoke detector is more suited for this application indoors

### **Q: Which detector can I use to detect a MIBK (Methyl Isobutyl Ketone) flame?**

Methyl Isobutyl Ketone is a solvent used in many industries for cleaning and chemical processes. Its flame can be detected by UV, UV/IR and IR3 Detectors. The UV detectors can be used to detect MIBK flames unless there is some potential source of false alarm present inside the building (i.e. electric sparks, welding or halogen lamps). The Triple IR detector provides the maximum detection range for detecting these flames.

### **Q: Can the IR3 be used for LPG applications?**

Yes. The IR3 detector features an enhanced flame detection immunity based on the recognition of the fire radiation CO<sub>2</sub> peak, in addition to the usual flicker and intensity criteria. The standard IR3 detector is designed to detect all organic fires, including smoky fires where the height of the CO<sub>2</sub> peak compared to other parts of the fire spectrum is less pronounced. Since LPG fire is always a clean fire with a very high CO<sub>2</sub> peak, the IR3 detector was designed with increased range and detection reliability for LPG and other clean fires. The 40/40I and 40/40M can detect an LPG or LNG fire at up to 30m

### **Q. Are your Flame Detectors solar blind?**

Yes, our Detectors only respond to UV radiation in the solar blind region of the radiation spectrum. Q- Will your Detectors respond to lightning or arc welding? Arc welding and lightning are two major UV radiation sources. The only Spectrex Flame Detector that will respond to arc welding and / or lightning is the UV-only models 20/20U-UB and 40/40U-UB Flame Detectors. Where arc welding and lightning are or may be present, please use our UV/IR or IR3 Flame Detectors which will not false alarm to these sources.

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