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Flame Detector Types

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Optical Flame Detection

General method:

- Detecting the unique optical characteristics of flames

- Distinguishing between flame radiation and background radiation

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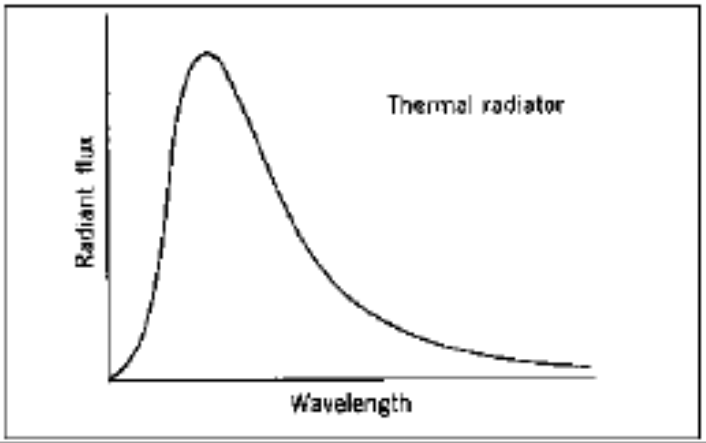
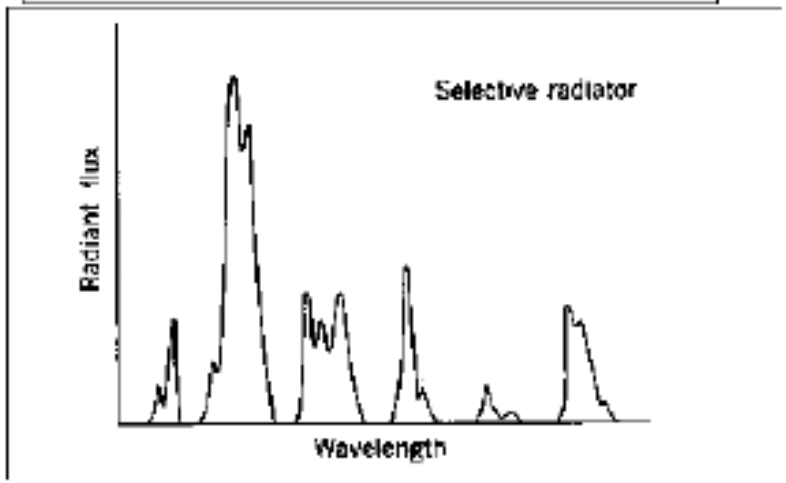


- Heated solids & liquids provide continuous spectral distribution curve



- Flames & electrical discharges provide narrow distribution characteristic of molecule type

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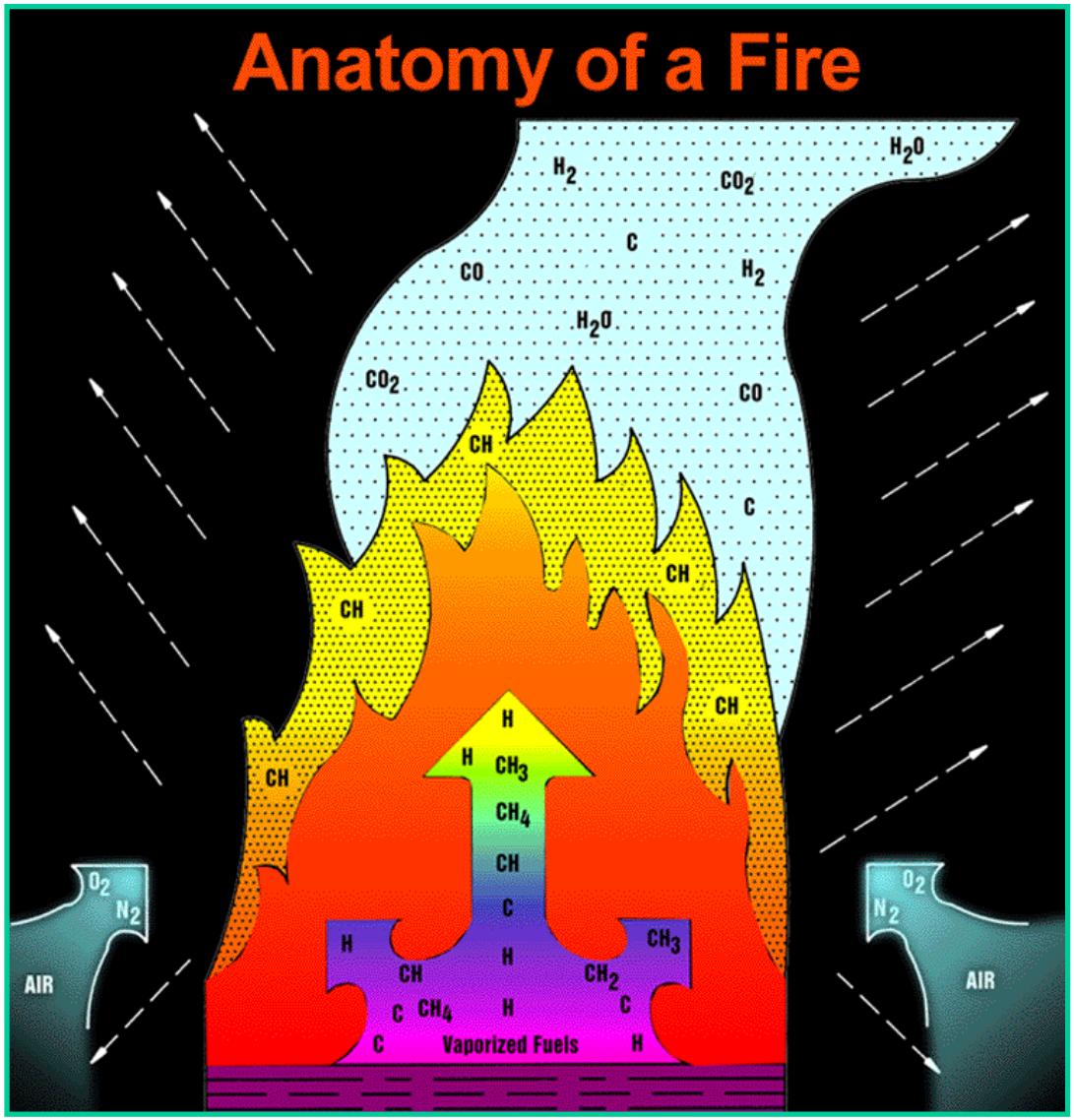

Main reaction is

$HC + O_2 = CO_2 + H_2O$

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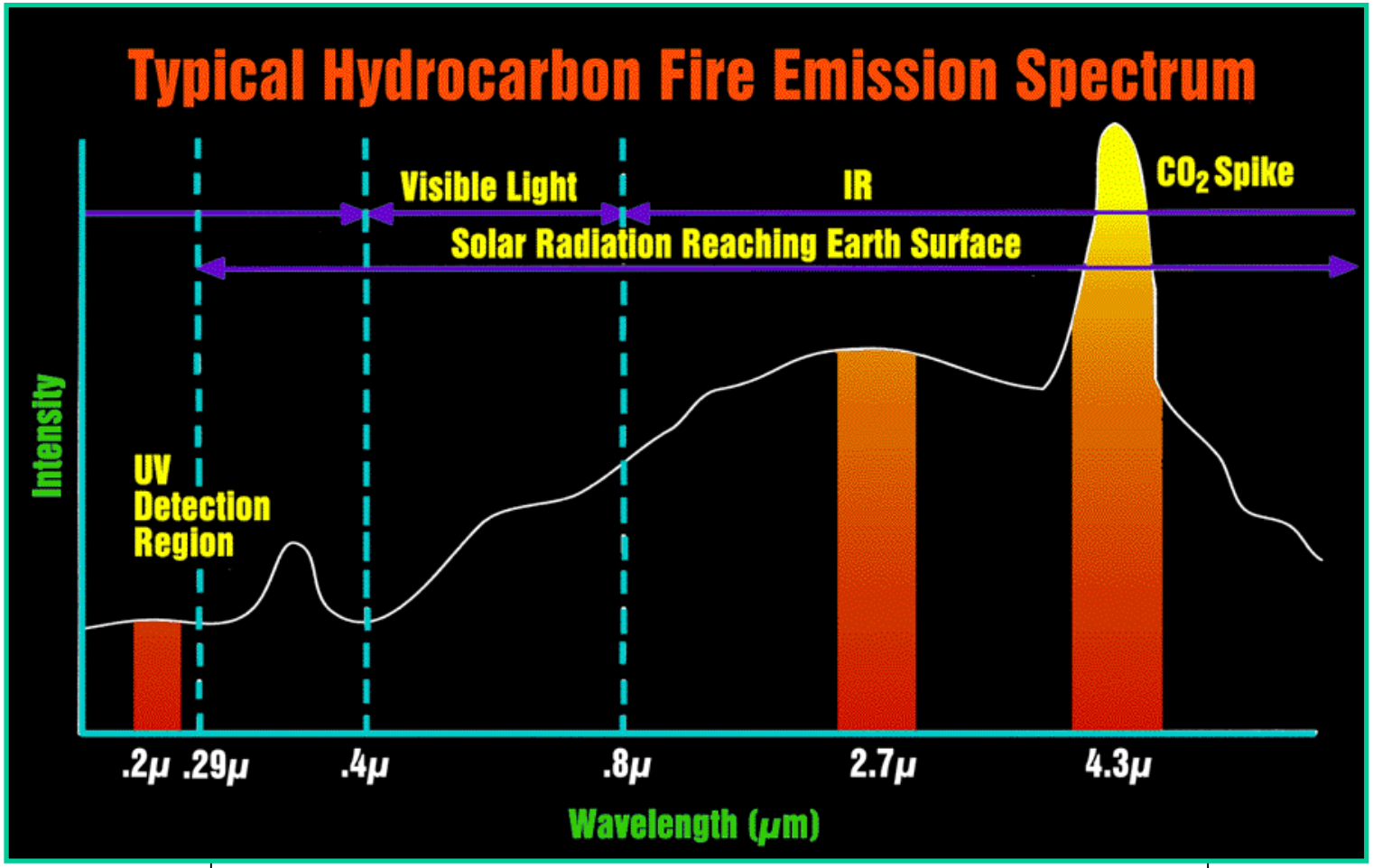
Flame Radiation Spectrum



1-10 Hz Characteristic Flickering

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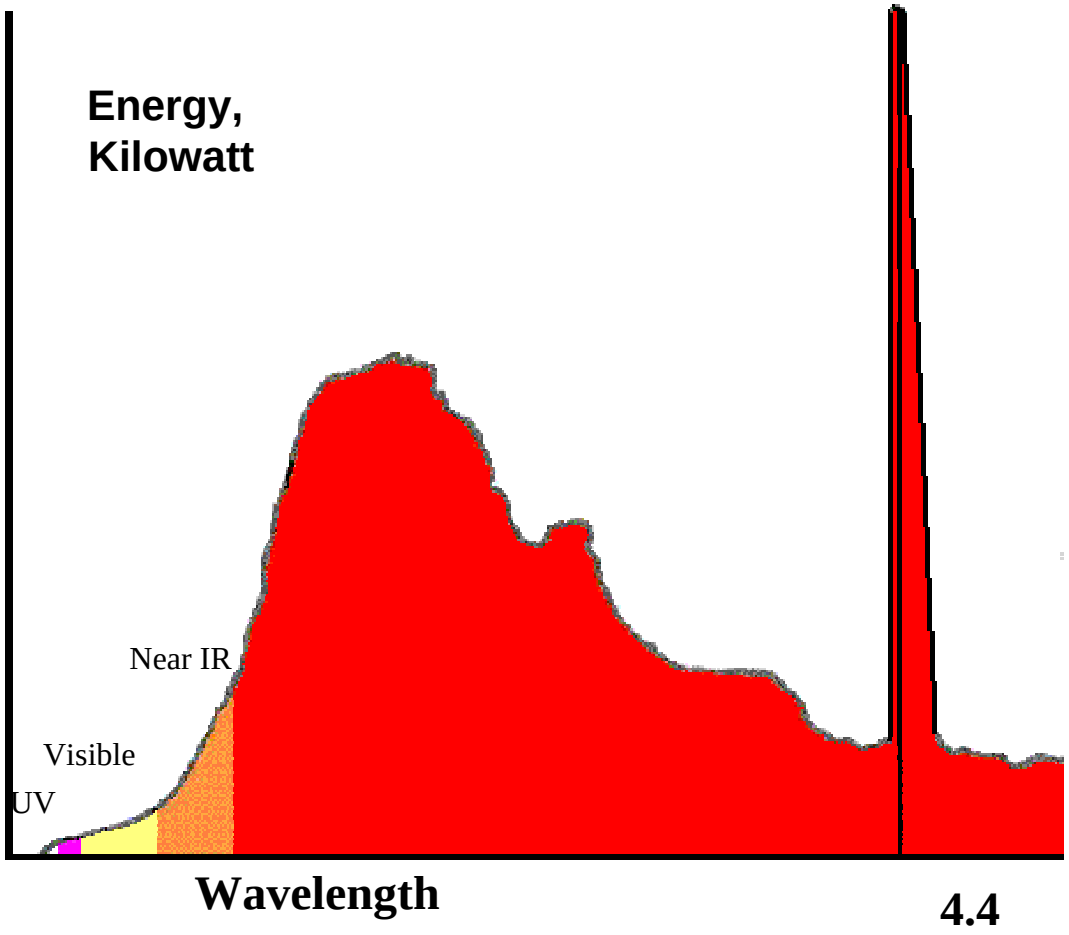
The part that we can see is mostly red-yellow caused by the Carbon in a fire.

The invisible IR part of the fire we experience as **heat**.

Non-Hydrocarbons e.g. Hydrogen, burns **light blue-** transparent (no Carbon in the flame).

It also does not have the CO2 peak at 4.4µ and can therefore is detected in a different way



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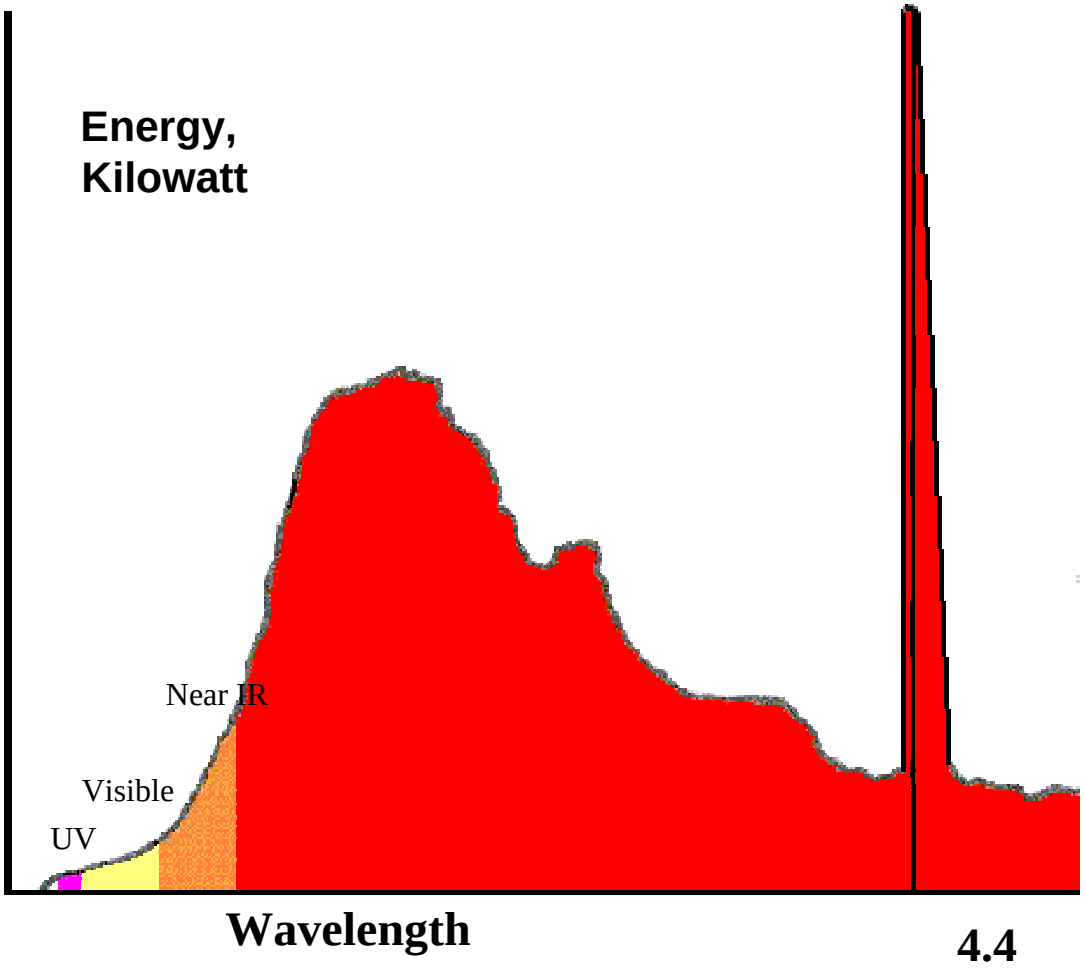
The CO2 peak in the fire represents less then 2% of the total fire energy.

A multi sensor Flame Detector has much more sensor input and can therefore be more specific or less effected by false alarms.



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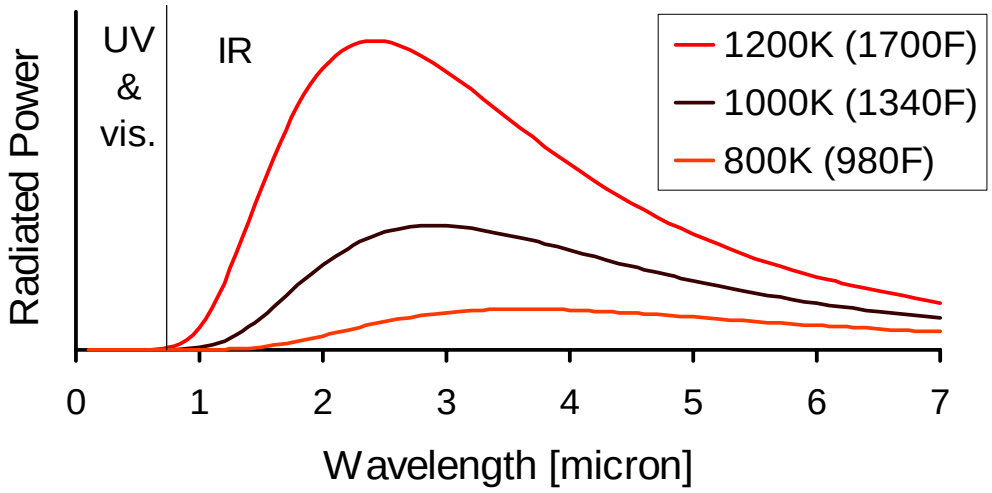
Black Body Radiation



Infrared sensors are also effected by Infrared Radiation not from a fire. The fire may be masked by this Blackbody Radiation.

Dual or Multi Infrared detectors suppress the effects of Blackbody Radiation by sensing energy just beside the CO2 radiation peak e.g. on 4.1µm. The principle works on the fact that a real Hydrocarbon fire causes a difference between the sensors.

There must be a larger difference in sensor output than the background radiation present. In other words, the detector can be desensitized when Blackbody Radiation is present.

Every object that has a temperature higher than 0º Kelvin (or -273 ºC) radiates energy and, at room temperature, the energy is already detectable by the most sensitive Infrared sensors. Sometimes, a moving hand close to the sensor is enough to generate an alarm. At 700 K, a hot object already starts to send out visible energy (glowing).

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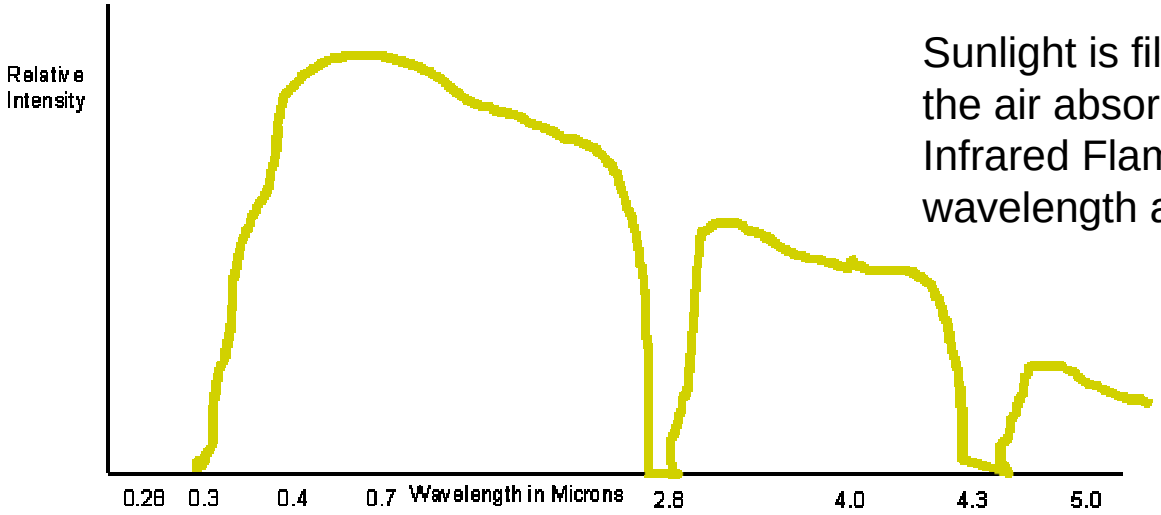
Potential "False Alarm" sources

- **The Sun**
  - High Intensity
  - Unique Radiation Peaks



The Sun radiates an enormous amount of energy. However, most gases and vapour in the atmosphere (clouds and ozone) absorb enough radiation to protect us.

Sunlight is filtered around 4.4µ. Cold CO2 in the air absorbs 4.4µ energy and therefore Infrared Flame detectors that use 4.4µ wavelength are Solar blind.

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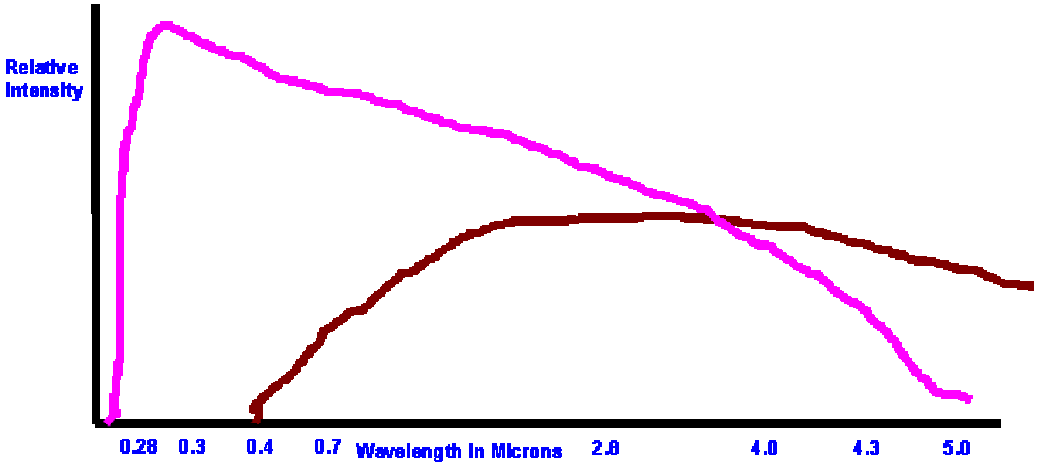
Potential "False Alarm" sources

- **Heat Sources** Radiators, electrical heaters, etc.
  - No UV, weak Visible, and medium IR radiation
  - Stable radiation

- **Arc** Lightning, Welding etc.
  - High Intensity UV radiation
  - Weak IR radiation
  - Unstable radiation
    (similar to the fire's flicker)



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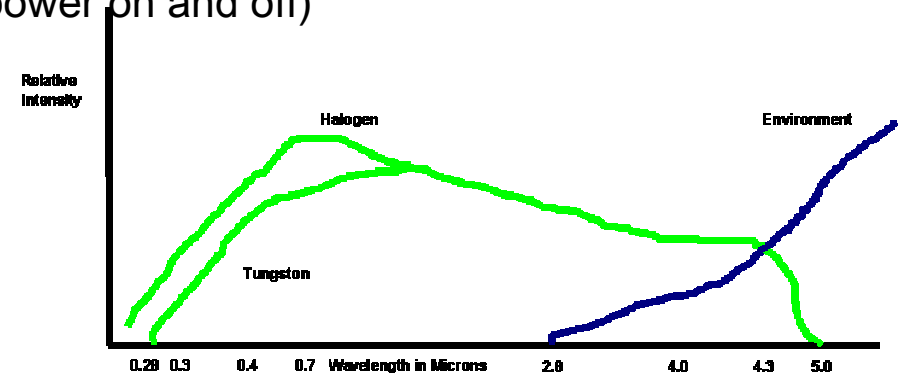
Potential "False Alarm" sources:

- **Environment:** man, the surrounding area, and other "warm" objects
  - Medium intensity IR radiation (like a std. fire at 30m)
  - Negligible UV radiation (assuming no High Voltage transformers nearby)
  - Stable radiation

- **Light Sources:** Tungsten, Halogen, Mercury etc.
  - High Intensity Visible Light, Weak IR (1 to 10% std. fire)
  - Medium Intensity UV radiation
    (for unshielded halogen lamps (≈10% std. fire)
  - Stable radiation (except when turning power on and off)



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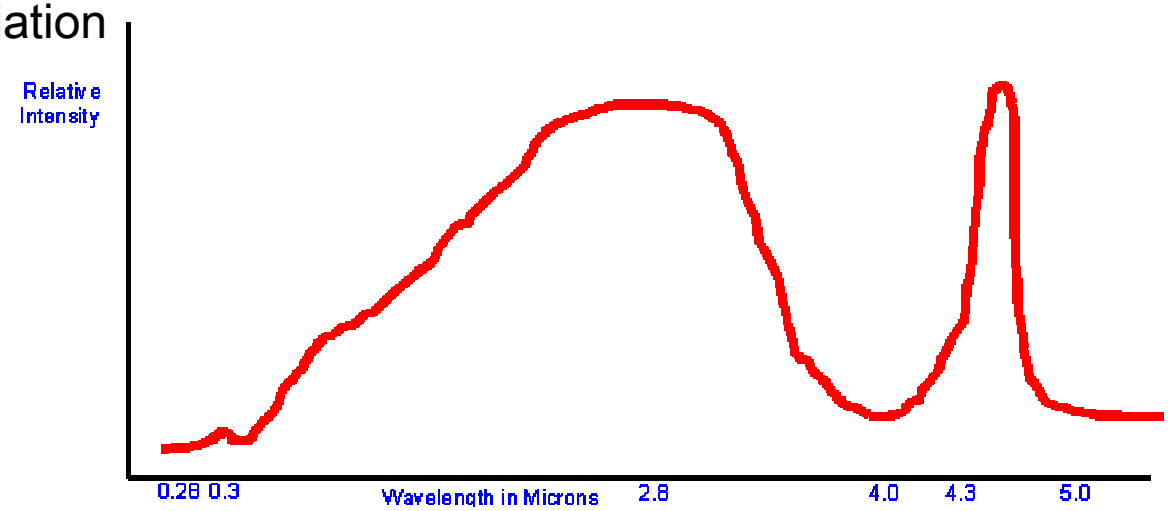
Potential false alarm sources:

- **"Friendly Fire":**
  Matches, Acetylene welding, flux burning in arc welding etc.

  - Fire-like IR emission spectrum
  - Usually higher intensity UV radiation than fire
  - Low IR intensity radiation
  - Unstable radiation



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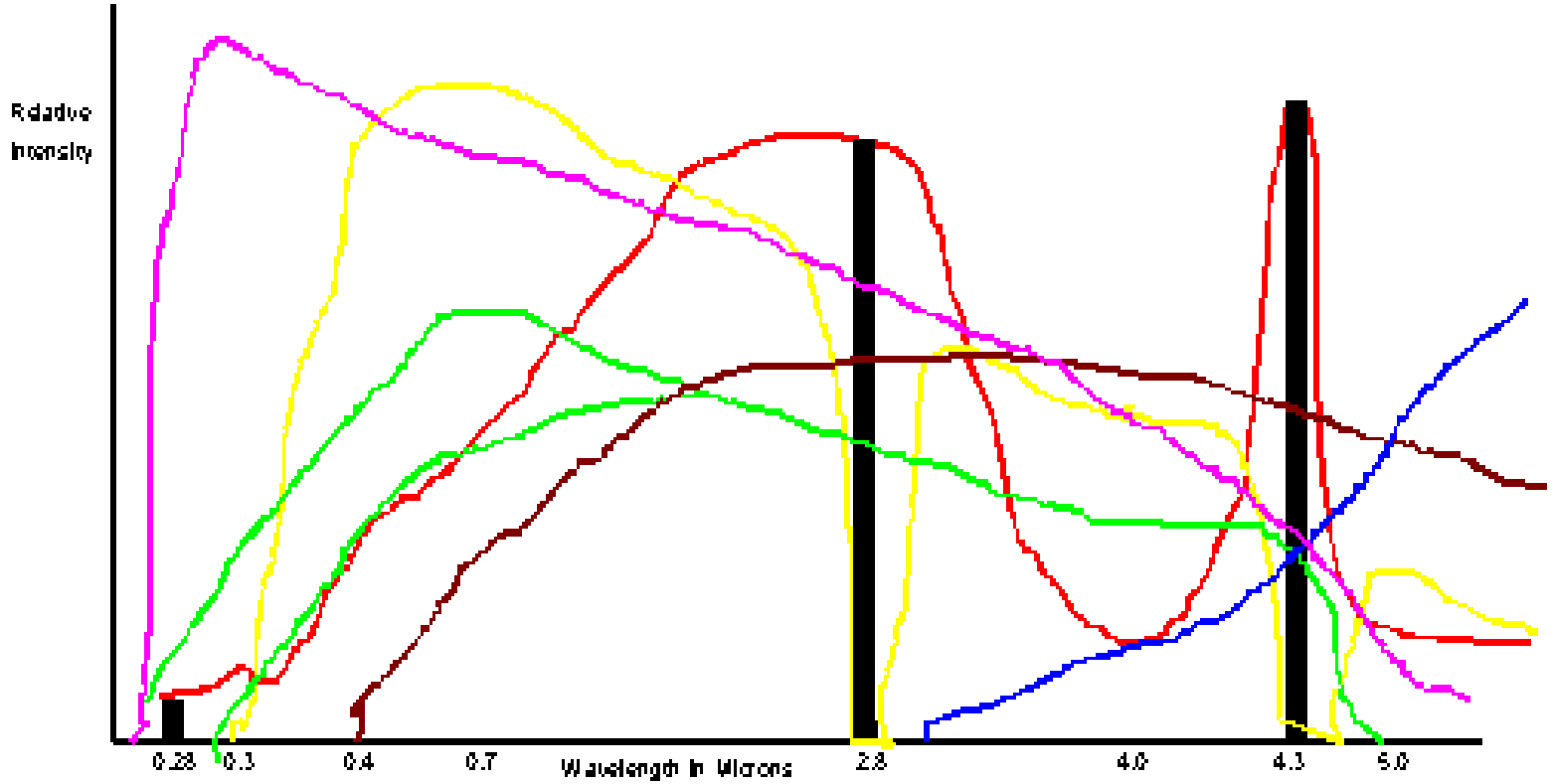
Flame Spectral Analysis

Three major spectral areas for Flame Detection :



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Are interferents present?

It is important to know if there are interferents present or that could emerge from the fire.

An inhibitors is a substance or vapour that blinds the detector. e.g.

- UV detector will be blinded by oil or grease on the lens, Hydrocarbon vapors (e.g. Xylene, Toluene), Chloride vapors etc.
- IR detector will be blinded by fog, water and ice or a salt layer on the lens (salt takes up water).
- Multi IR detector can be blinded or masked by blackbody radiation from hot machinery

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Radiation Absorbing Materials

Some materials that affect flame detector sensitivity:

Grease, dust, dirt	IR & UV absorber
Water, ice, steam	IR & UV absorber
Oil	UV absorber
Standard window glass	UV absorber
Plastic films	UV absorber

Nuisance Alarm Sources

Welding (arc & gas)	IR & UV
Corona and arcing	UV
Electric motor armatures	UV
Combustion engine backfire	IR & UV
Black body radiation	IR & UV
X-ray, nuclear radiation	UV
Hot turbines, reactors, boilers	IR
Flare stacks	IR & UV

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Basis of Optical Flame Detection

- Spectral band selection (one or more)
- Flickering frequency analysis (2-30 Hz)
- Radiation intensity thresholds
- Detection Algorithm
  (including mathematical techniques such as ratios, AND-gate comparisons, correlations and autocorrelations).

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Optical Sensors

- Flame Detector comprises one or more optical sensors, sensitive to radiation emitted at various wavelengths in different spectral bands.

- Most popular are UV and IR solid state sensors used alone or in various combinations to combat false alarms.

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Optical Flame Detection

Advantages:

- Detection distance
- Sensitivity
- Speed of response
- Reliability

Disadvantages:

- Cost

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General Considerations

Application:

- Types of fire
- Sensitivity
- Speed of response
- Damage caused by false alarm
- Damage caused by undetected fire

Environment:

- Background radiation
- Optical Interference

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Single IR Flame Detection

Advantages:

- Low Cost

Disadvantages:

- Subject to false alarms
  (in the presence of flickering IR sources)
- Poor detection performance for stable flames

Reference fire – 15m max

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UV Flame Detection

Advantages:

- Unaffected by solar radiation
- Unaffected by hot objects
- Low cost

Disadvantages:

- Subject to false alarms from UV sources (arc welding, electrical sparks, halogen lamps)

- Blinded by thick smoke, vapors, grease and oil deposits on the detector's window

Reference fire – 15m max

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Dual Optical Flame Detectors

- To limit false alarms caused by non-fire radiation sources, we use several optical sensors, filtering specific spectral bands along with advanced mathematical algorithms.

- Dual Optical Flame Detectors employ either IR/IR or UV/IR sensors.

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Dual UV/IR Flame Detectors

Two types of UV/IR optical flame detectors are available, each comprising a solar blind UV sensor and an IR sensor selected from one of the following:

- 2.7 µm IR sensor (detects H_2O radiation)
- 4.3 µm IR sensor (detects CO_2 radiation)

Reference fire – 15m max

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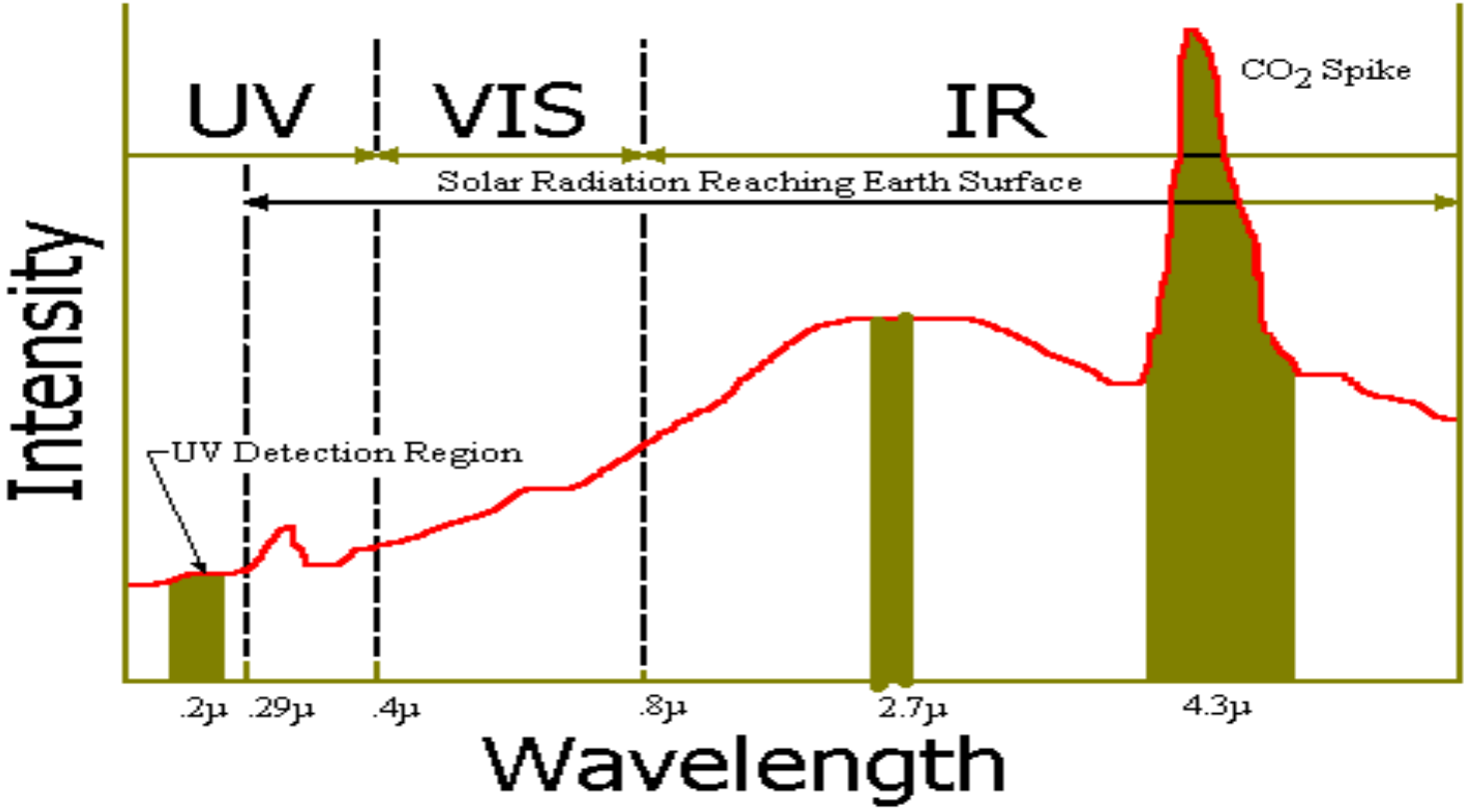

Detection of the simultaneous existence of characteristic infrared and ultraviolet radiation

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UV/IR Flame Detection

Advantages:

- Very low false alarm rate
- Unaffected by solar radiation

Disadvantages:

- Blinded by thick smoke, vapors, grease and oil deposits on the detector's window
- Moderate cost

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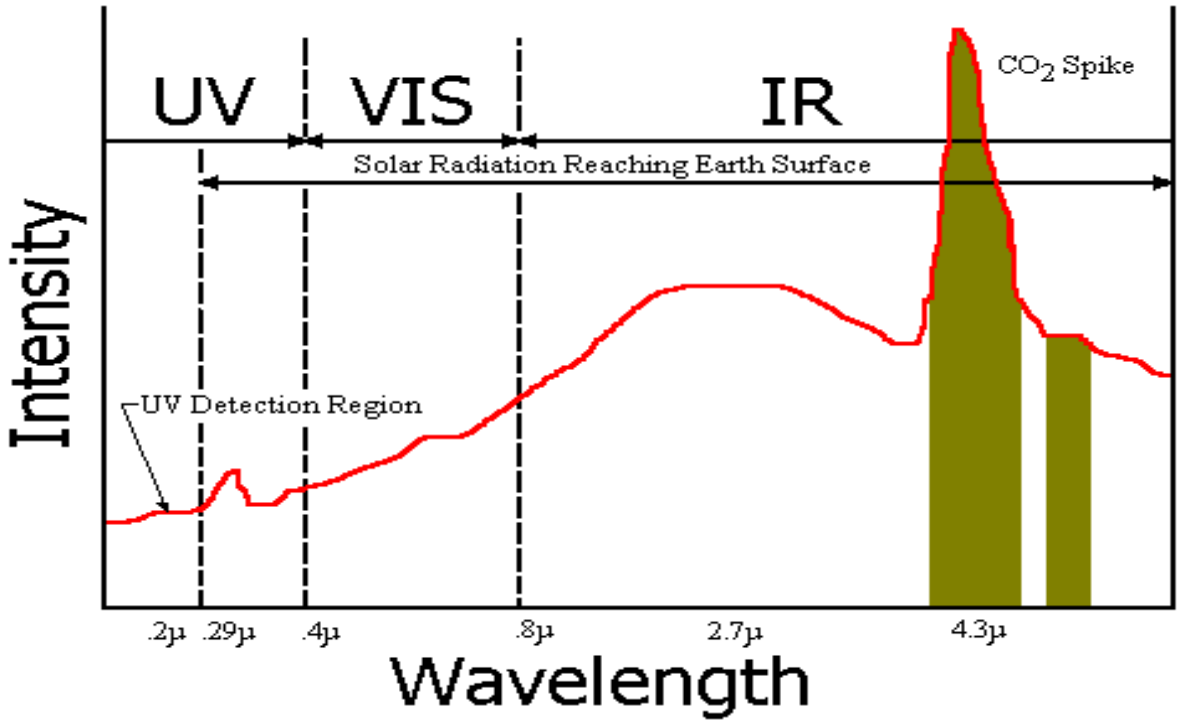
IR/IR Flame Detection



Detects the flame's characteristic infrared radiation at two different wavelengths

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IR/IR Flame Detection

Advantages:

- Moderate false alarm rate

Disadvantages:

- Affected by IR sources
- Moderate cost

Reference fire – 15m max

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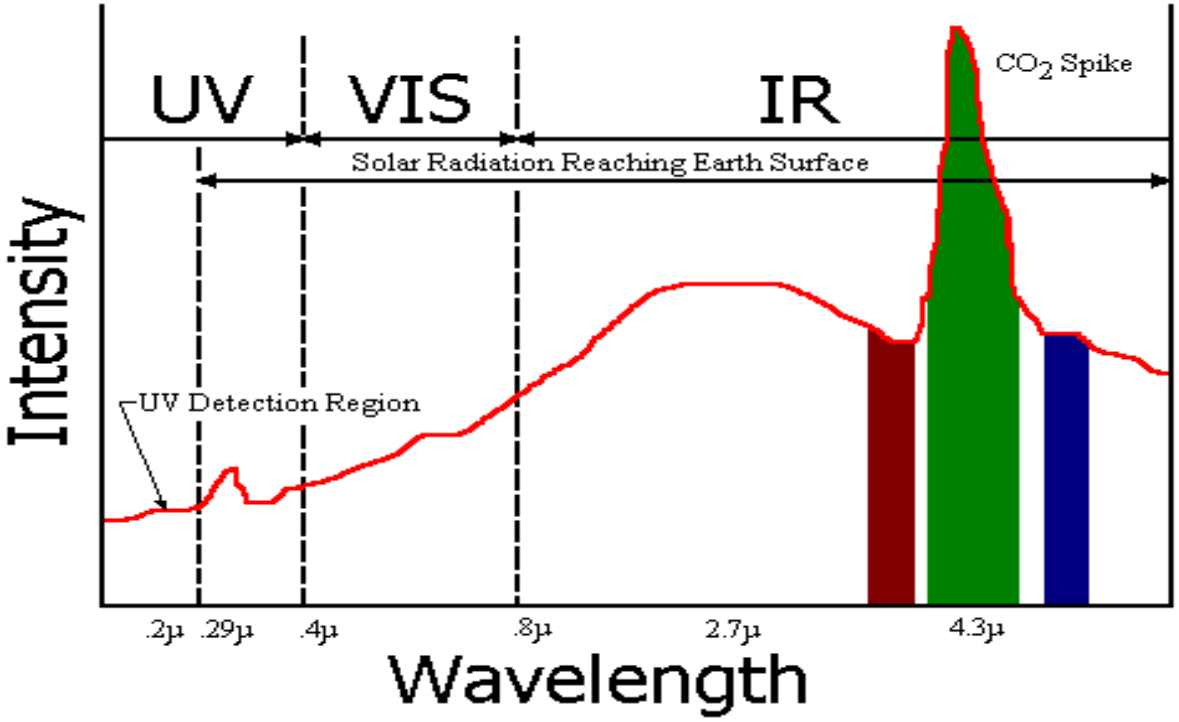
Triple IR (IR3) Flame Detection



Detection of the flame's characteristic CO_2 emission line by the use of three wavelength bands

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IR3 Flame Detection

Advantages:

- Highest immunity to false alarms
- Highest Sensitivity
- Longest detection range

Disadvantages:

- Higher cost

Reference fire – 65m max

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Multi IR – Combined Hazard Detection

- Until now, invisible Hydrogen flames could only be detected using UV or UV/IR detectors and limited to only 5 - 10m detection range.

- Now an IR3 solution combines to offer a single detector that can detect hydrocarbon and hydrogen fires
  – and at significantly improved distances

N-heptane – 65m
Methane – 30m
Hydrogen – 30m

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Multi IR – Combined Hazard Detection

- This new detector utilises a 4-IR sensor combination

  - one sensor each for HC and H_2 flame detection
    plus
  - two reference sensors common to both.

- Virtually same spec as IR3 with all the benefits of long distance detection and the highest false alarm immunity

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The Detector Choice

- Single UV
- Single IR
- Dual UV/IR (2 types)
- Triple IR (IR3)
- Multi IR

All from Spectrex!