Detecting Hydrogen & Gas Fires: Seeing the Unseen

By Cliff Anderson

Hydrogen usage is growing. The general public sees and reads about hydrogen as an alternative fuel for cars. However, the big use for hydrogen is found in hydrocarbon processing and other important manufacturing processes. Hydrogen is the first element on the periodic table and is an essential element in the manufacturing of many of our everyday products. We must have respect for its explosive properties, but not be afraid of it. We must understand how to safely store, transport, and use hydrogen. We also must know how to detect and to respond when it escapes its confines.

The Nature of Hydrogen

Under day-to-day conditions, people cannot see, smell, or taste the presence of hydrogen gas. Hydrogen, however, is very flammable and requires only a small amount of energy to ignite. In fact, if leaking from a pipe at a high enough pressure, hydrogen gas can self ignite without the aid of an external energy source.

A hydrogen flame poses special dangers beyond those posed by hydrocarbon flames because human senses cannot easily detect it. If you come upon a hydrogen fire, you will not see it – even up close. You might see an area ahead of you shimmer as you would see a mirage. You might see sparkles, dust particles briefly burning. You might think your eyes are playing tricks on you.

In addition, you will not feel the heat as you approach the flame. You won't feel the heat of the hydrogen fire because very little infrared (IR) radiation is present; the IR radiation gives us the sensation of heat when we stand next to a fire.

Because there is little radiant heat emitted to the environment and nothing to see, your senses won't warn you to stop. You might walk directly into the flame.

The physical flame has more "punch" than a hydrocarbon flame, i.e., the temperature is higher. The result? If the flame impinges on another piece of equipment, the heat of a hydrogen flame will have a stronger effect than a hydrocarbon flame of the same size. Objects in the flame path will heat faster, which could cause a second event to occur – creating a possible chain reaction of serious events.

The Strategy of Detecting Hydrogen

The safest protection strategy against a hydrogen fire is to prevent the hydrogen from escaping by following good process maintenance practices. If, however, a leak does occur, the area should be well ventilated to prevent hydrogen build up. Also in place should be a gas detection system to alert operators to the leak before it ignites. But if the leak does ignite, you need to detect the flame quickly and accurately.

Working together, gas detectors and flame detectors can quickly identify a gas leak or the resulting flame. Gas and flame detectors should work as partners to monitor the same area.

For example, an enclosed battery room can contain hydrogen generated from the batteries. Sitting in the control room, an operator might be alerted to a burp of hydrogen gas. If the alarm generated by the gas detector stops, will the operator think the burp was truly a short-duration small hydrogen leak? Or has the hydrogen ignited and turned into a flame? The operator will not know unless the flame is detected.

Gas Detection Technologies

Gas detection represents the first line of defense in the case of a hydrogen release. Ideally, actions can be taken to stop the hydrogen release before a fire or explosion. Two of the common technologies for combustible gas detection are infrared and catlytic bead.

An infrared gas detector responds to gases that absorb IR radiation – such as methane and propane (hydrocarbons). But because hydrogen is not a hydrocarbon, IR gas detectors do not detect it and should not be used.

This leaves only catalytic bead type detectors for detecting hydrogen at lower flammable limit (LFL) levels. In fact, a catalytic bead sensor detects any combustible gas that combines with oxygen to make heat. If the gas can burn in air, this detector will sense it.

Figure 1: Det-Tronics x3302 Multispectrum IR flame detector.

The catalytic gas sensor (or Pellistor) usually consists of a matched pair of platinum wirewound resistors, one of which is encased by a bead of ceramic. The active catalytic bead is coated with a catalyst; the reference catalytic bead remains untreated. This matched pair is then enclosed behind a flameproof sinter, or porous filter. In operation, the beads are resistively heated. When a combustible gas comes in contact with the catalytic surface, it is oxidized. Heat is released, causing the resistance of the wire to change. The reference bead, or passive bead, maintains the same electrical resistance in clean air as the active bead, but does not catalyze the combustible gas. The sensor compares the currents. If the current is different, the detector can alarm. If there is no gas cloud, both beads will have the same current.

The catalytic bead sensors do have shortcomings, however. For example, they don't annunciate when they fail. Also, they are susceptible to poisoning and dying from chemicals such as silicon hydrides – common chemicals in industrial environments. In these cases, the porous filter gets clogged so that the active bead cannot sense gas and becomes the same as the reference bead. If the active bead cannot sense gas, the operator back in the control room won't know. Periodic testing is required to ensure proper sensor operation.

In placing the gas detectors, consider that hydrogen is the lightest gas and floats up quickly while dispersing easily. Make sure the gas sensor is close to and above where a leak might occur. For example, a gas detector could be located above a valve stem.

Flame Detection Technologies

The partner to gas detection is flame detection. Hydrogen presents several flame-detection challenges. Hydrogen burns a pale blue to nearly invisible flame. Technologies to detect hydrogen fires include flame detectors that sense the non-visible spectrum of electro magnetic radiation, which includes ultraviolet (UV) and IR radiation.

But in the beginning was the broom. Picture this. A worker walks along a catwalk adjacent to hydrogen lines. As he walks, he holds a dry grass broom in front of him sweeping the air. He walks slowly. If the broom catches fire, he stops and knows a hydrogen fire is ahead. This method is still used today.

Fortunately, safety system manufacturers offer tools beyond the broom. They've developed technologies such as thermal detectors, UV flame detectors, and multispectrum IR flame detectors.

Thermal detectors

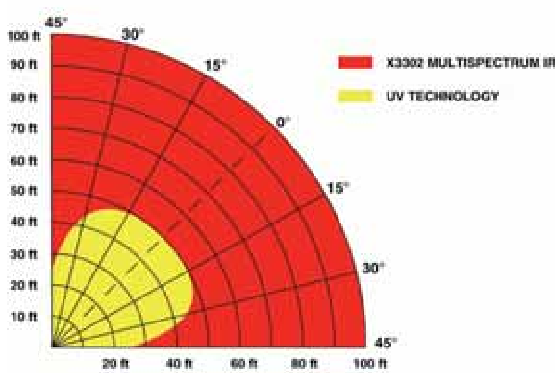
Because a thermal detector will not alarm unless it feels the heat, positioning a thermal detector directly above the probable site of a hydrogen fire is logical. However, the source of the hydrogen leak might create a fire that is directed away from the detector. The hydrogen fire's low IR radiation may not be enough to set the radiant heat detector into alarm. Thermal detectors are helpful, but proper positioning is the biggest challenge.

UV detectors

UV detectors use basic anode/cathode Geiger-Muller vacuum tubes. UV radiation enters the vacuum tube through a quartz window and strikes the cathode. An electrical impulse is created. This is a basic technology that dates back to the beginning of the 20th century.

Hydrogen fires, compared to hydrocarbon fires, emit little visible light and little IR radiant heat. Instead, energy is radiated primarily in the UV band. Therefore, without doubt, UV detectors excel at detecting hydrogen fires. In addition, they have a good detection range and can see a 24-inch plume flame up to 50 feet away (see figure 2).

Figure 2. Hydrogen fire detection ranges for UV and multispectrum IR flame detectors



HORIZONTAL FIELD OF VIEW TO HYDROGEN FIRE
(24 INCH PLUME, WITH 100 GRAMS/MIN FLOW RATE)

DETECTOR	ON AXIS DISTANCE IN FEET	OFF AXIS DISTANCE IN FEET
X3302	100	100
UV TECHNOLOGY	50	25

UV detectors, however, are sensitive to arcs, sparks, welding, lightning, and other UV-rich sources. When those relatively safe conditions are present, UV detectors could go into alarm condition. False alarms can be expensive and can reduce people's sensitivity to potential hazards. Therefore, users should match the appropriate technologies to the applications they face.

UV detectors, with their very fast response time and good detection range, are best suited for applications where the false-alarm sources can be controlled, such as in enclosed rooms. But keep in mind that most enclosed rooms have ventilation ducts that can reflect UV from lightning and welding – thus causing UV detectors to alarm.

Multispectrum IR detectors

Multispectrum IR flame detectors use a combination of IR sensor filters and software analysis to both see the flames and reduce false alarms. Some multispectrum IR detectors have been designed specifically to detect the low IR level of hydrogen fires using a unique set of IR filters.

These special multispectrum IR flame detectors have very good detection range with good response time to hydrogen flames, but do not incur false alarms for arcs, sparks, welding, and lightning. In addition, the multispectrum IR detector has complete solar resistance and is insensitive to artificial lights and most "blackbody" radiation, which plague other detection technologies.

By selecting the optimum IR filter set, some available detectors have doubled the UV range and can detect a 24-inch plume fire at 100 feet (see figure 2). The result is increased flame sensitivity with discrimination of non-flame sources in situations where traditional flame detectors are unsuitable.

The multispectrum IR detectors do have limits, however. For example, their detection range is reduced with the presence of water or ice on the lens. To mitigate the problem, some detectors are manufactured with lens heaters that melt ice and accelerate the evaporation of water.

For most applications, indoors and out, multispectrum IR flame detection has become the preferred choice for detecting hydrogen fires.

Understanding and strategy are keys

Hydrogen is a valuable element with a growing list of uses. Like all combustible products, hydrogen can be a threat to people and property. But by understanding its gas and fire characteristics, we are able to formulate reasonable strategies to continuously monitor and quickly detect leaks and mitigate fires.

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