

Combustible Gas Detector Sensor Drift: Catalytic vs. Infrared

Catalytic bead combustible sensor technology dates to the 1830s and has been used for decades to measure concentrations of many combustible gases. The infrared spectrum was discovered in 1800; the 1950s saw a surge in use of the infrared spectrum for many technological applications, including gas detection. This paper is intended to provide an overview and comparison of these two gas detection technologies. Both sensor types offer advantages and disadvantages; conditions determine the better choice for specific applications.

Catalytic Bead Sensor

The catalytic bead or "hot wire" sensor is the most common combustible gas detector type (*Figure 1*). This detector consists of four elements within a Wheatstone Bridge circuit; two elements are fixed resistors and two are exposed filaments or elements that are exposed to atmosphere (*Figure 2*). One element, the detector, reacts with combustible gas, causing a rise in element temperature, producing a resistance change that results in bridge imbalance. The inactive element or compensator responds as an active element to temperature and humidity changes, keeping the bridge balanced during normal atmospheric changes. The detector's resistance change and resulting bridge imbalance is proportional to the atmosphere's combustible gas concentration.

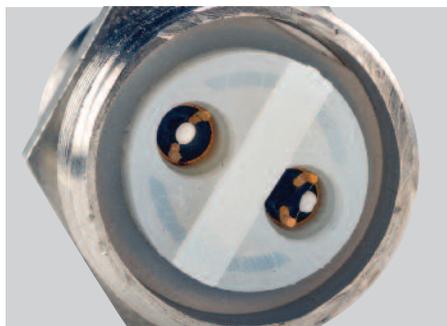


Figure 1: Cutaway view of catalytic bead sensor

Catalytic sensors respond to any combustible gas or vapor to which they are exposed. This technology has been in service for 80+ years; catalytic sensors have always been robust, as well as easy to install and use.

Because the sensor runs hot (surface temperature $\sim 500^{\circ}\text{C}$), as does a light bulb, it can burn out. The cause may be a filament breaking open and can be preceded by an upscale drift, as the filament thins out as metal is vaporized. This process causes resistance to climb and the bridge circuit to become unbalanced, due to age, impurities within the materials, or repeated high combustible gas concentration exposure.

A second mode of catalytic combustible sensor drift is caused by corrosion, mostly from combustion by-products. Hydrocarbon combustion always produces water and carbon dioxide; halogenated hydrocarbons such as methyl chloride or difluoroethane (R-152a) also produce corrosive materials such as HCl and HF. These materials combine with water and form enough acid on basic sensor elements to attack weld joints and base metal components, introducing another variable into the active sensing mechanism and displays as baseline drift. Drift direction, positive or negative, will depend upon which side of the bridge is corroding at a faster rate.

Another drift mechanism is absorption of liquid material by porous metal flash-back arrestors. If the material is of low vapor pressure (i.e. oil or high-flashpoint solvents) it will evaporate at a very slow rate and introduce a continuous source of hydrocarbon to the sensor until it is all finally "cooked" off, returning the sensor to normal operation.

A notable safety hazard is that of flashback arrestor saturation, as gas and vapors are blocked from entering the sensor and are therefore not detected.

In addition, the catalyst may be affected by inhibitors such as lead or silicon that may be present in the sample, reading as span loss rather than baseline drift, and eventually leading to a completely inactive sensor. Due to combustion reaction, catalytic sensors require oxygen to operate. Catalytic sensors cannot read gas concentrations accurately above the LEL. Operators may be required to investigate alarm conditions using another instrument to verify status.

Infrared Combustible Sensors

Infrared combustible gas detectors offer solutions to all previously mentioned problems. This sensor type consists of a single IR source, a beam splitter, and two detectors (*Figure 3*). One detector is used to monitor the characteristic hydrocarbon wavelength. The other is a reference that monitors an atmospheric "window" where no IR active gases are normally present. Infrared energy is emitted from the source, passes through the gas cell, and reflects back to the detectors. If no hydrocarbons are present within the gas sample, then energy reaching the detector is the same. If, however, some combustible hydrocarbons are present, they will absorb some IR energy at that wavelength, thus reducing the amount received by the analyte detector.

The reference detector always receives the same amount of energy; the difference between the two detectors will be proportional to the amount of gas present in the sample. The gas sample enters and leaves the cell unchanged. Nothing has been transformed, substituted, or removed from it.

As the IR source ages, its energy level may be reduced. Because there is only one source, the energy level reduction will affect both sensors equally and no imbalance is detected. If optical materials (window and mirror) are dirty, the instrument can detect an unacceptably low energy level and signals **INSTRUMENT FAULT**. A simple cleaning returns the instrument to normal operation. If liquid has splashed onto the optics, the **INSTRUMENT FAULT** signal will warn users of the situation and the cleaning operation is again required.

No extremes of temperature are needed or created for this detection method, resulting in less stress on construction materials. Since no combustion occurs, no corrosive combustion by-products are produced. In addition, an extremely stable sensor baseline is produced.

Finally, all IR detector active components are housed within a sealed chamber behind an inert sapphire window, isolated from the sample. Even the most corrosive stream components cannot attack the source or detectors due to this hermetic seal. Since all electronics and active components are sealed away from the combustible gas environment, there is no need for a flashback arrestor, providing the added advantage of improved gas response. The close coupling of the electronics to the IR sensor does however limit its high temperature operation. Exceeding the operational temperature limit can cause IR sensor drift or failure.

Due to component precision and assembly, IR sensors have higher initial cost than do catalytic detectors. Infrared sensors do not require oxygen to operate; however they do not detect all combustible gases (for example, hydrogen), as they are limited to detection of hydrocarbons.

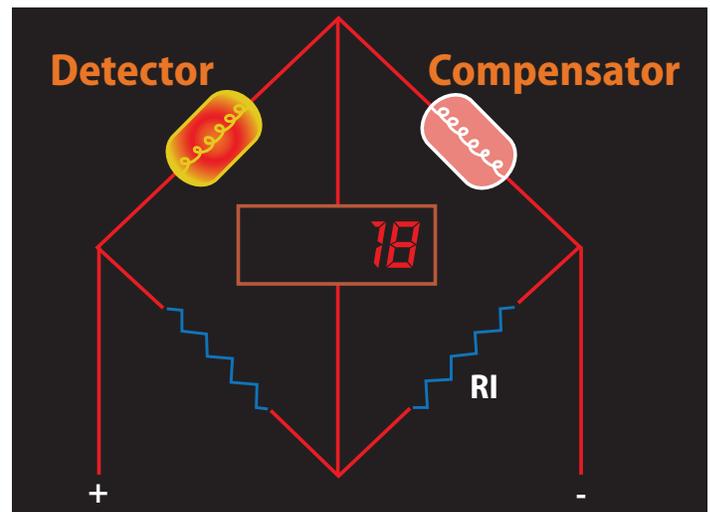


Figure 2: Wheatstone Bridge circuit

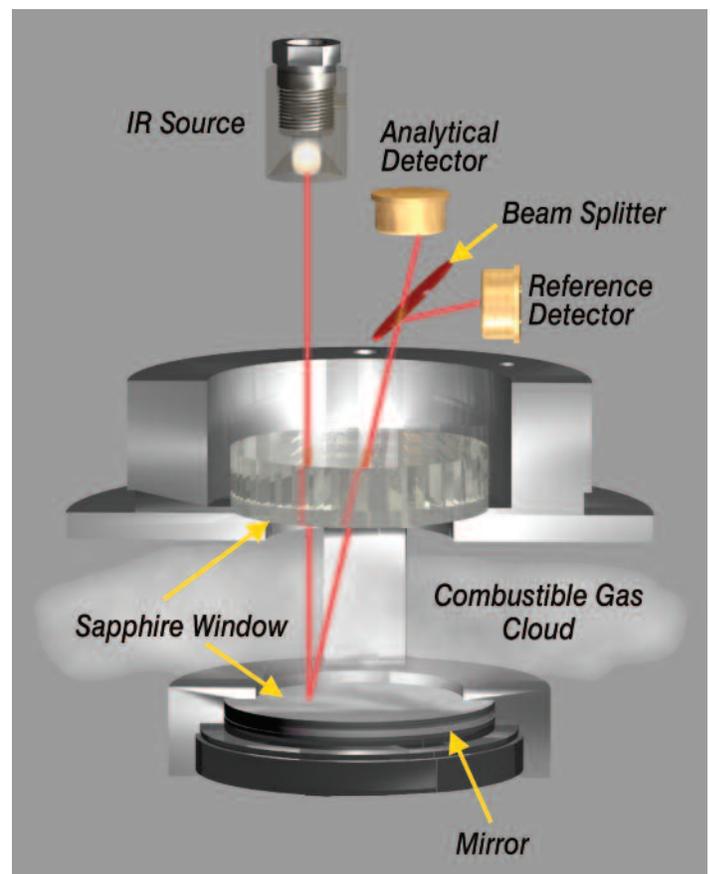


Figure 3: Typical design for an infrared combustible sensor

Note: This bulletin contains only a general description of the products shown. While uses and performance capabilities are described, under no circumstances shall the products be used by untrained or unqualified individuals and not until the product instructions including any warnings or cautions provided have been thoroughly read and understood. Only they contain the complete and detailed information concerning proper use and care of these products.



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