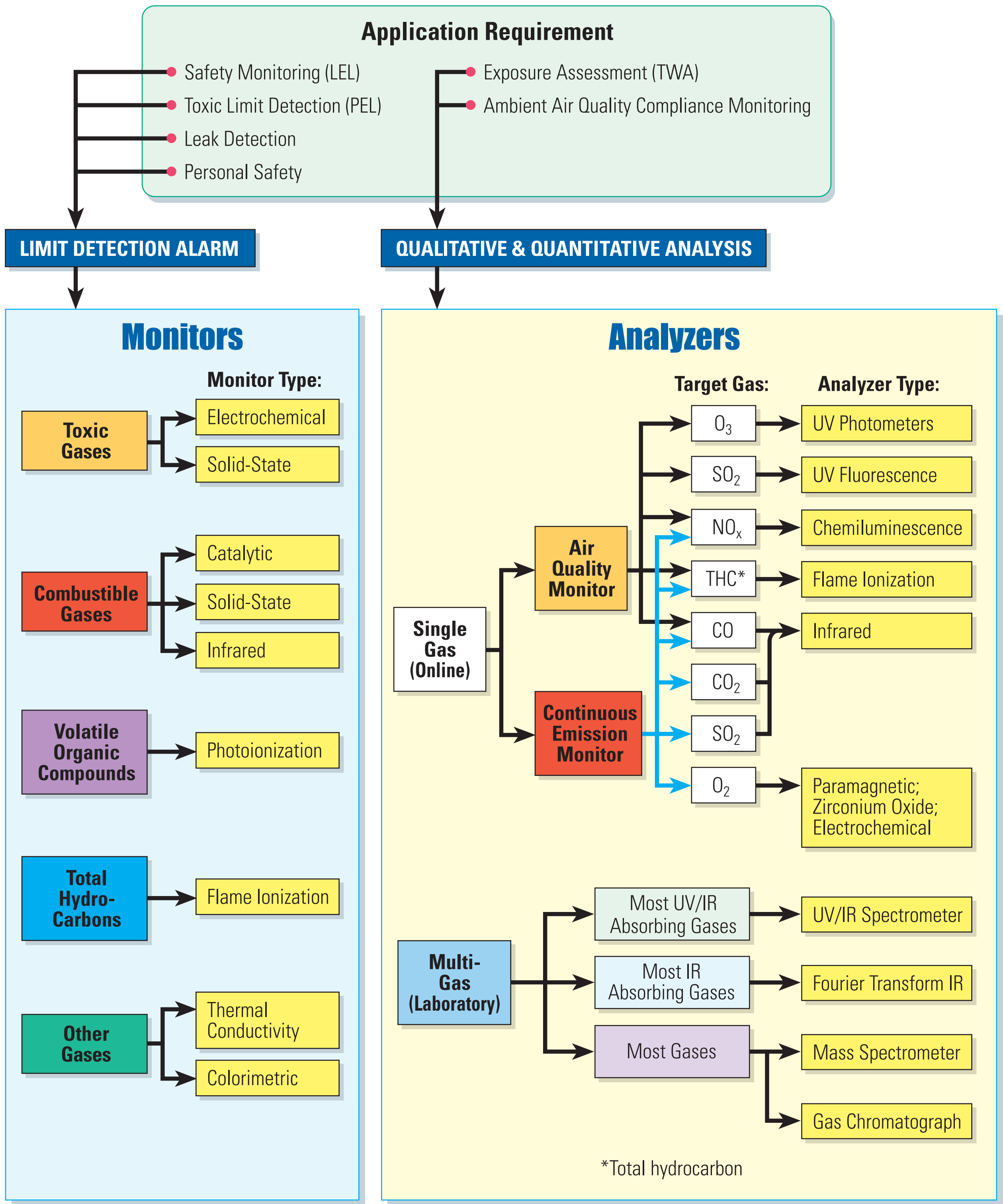
Sensor Selection Overview



Chapter 8

Sensor Selection Guide

Each of the following sensors—electrochemical, catalytic bead, solid state, infrared and photoionization detectors—must meet certain criteria to be practical for use in area air quality and safety applications. Some of the basic requirements are:

1. The sensor should be designed for a housing that is *small and rugged*. The sensor should be suitable for use in hazardous locations and harsh environments, and, it should also be explosion-proof. The sensor should be cost-effective, designed for installation and use in industrial production areas, and installable at a reasonable cost.

2. For portable applications, the instruments should have *reasonable energy consumption* and the option of powering the instruments with batteries should be easily available. The instruments should be small and portable so they can be carried easily. They should be safe for use in industrial environments. Preferably, the instruments should be certified as intrinsically safe for use in a hazardous area.

3. The *operation and maintenance* of the instruments should be *easily performed* by regular plant personnel with minimal special training requirements.

4. In stationary installations, the sensors should be *able to function continuously and reliably* for a period of time, preferably longer than 30 days. The sensor

should be able to function in an industrial environment for at least two years or longer and should be replaceable or renewable at a reasonable cost. It should be easy to install into a multi-point system and be managed by a controller or a computer controlled distribution system.

5. The *cost* of the instruments should be reasonable so that multiple sensors can be installed to effectively protect the area.

Four of the five sensors discussed in this book all meet the above criteria. The exception is the photoionization detector. The PID is a good detector for portable applications but is limited by the lamp because it has a relatively short life expectancy and the frequency of maintenance required may not be practical for stationary applications. However, there are PID stationary instruments available that can be useful as long as users are aware of the limitation.

There are other types of sensors which meet the above criteria, but most have limitations. For example, thermal conductivity sensors are mostly used for high concentration applications and are not widely used as gas monitors.

Factors to Consider When Selecting Sensors

One of the most frequently asked questions regarding sensors is: "Which sensor is the best?" Of course, there is no simple answer to this question. Each sensor has certain capabilities and limitations, and thus the suitability of a given sensor depends largely on the application in which it is to be used. Thus, to choose the correct sensor, one must first properly define the application. The illustration on page 102 shows an overview of various application requirements and their detection technologies. It is common for manufacturers to exaggerate the capabilities of the sensors that they offer and downplay sensors that they do not offer.

In determining which sensor to use for a given application, the following factors/observations should be considered:

A. *Realistically define what objective one is trying to accomplish* and define an instrument specification that meets the minimum requirements. The specifications should define the gases and ranges of the sensors. The ranges or the concentration of the gases to be measured should be 3 to 5 times the actual monitoring concentration. As with a voltmeter, one should always select a range higher than the actual voltage to be measured. For example, select a 50-volt range to measure a 12-volt battery.

B. Determine the *background gases* in the monitoring area. In cases where the background gases cannot be determined, a representative sample should be analyzed. A major cause of sensor failure is the presence of background gases that the instrument's manufacturers did not take into consideration. The selectivity or specificity of the sensor must be acceptable for the application.

C. The *temperature ranges* in which the sensor is to be installed should be within the sensor specifications and should be suitable for the gases to be monitored. For example, jet engine fuels have very low vapor pressure. It is useless to install a sensor to measure the combustible range in a hangar if the temperature will never exceed 100° F because the vapor concentration cannot reach combustible levels. In this example, it is more appropriate to measure in ppm ranges.

   The temperature changes between day and night, and during summer and winter, should also be considered. A wide temperature change can cause moisture condensation. This is particularly important in a confined space such as a closed container where air circulation is poor.

D. A typical specification for *humidity* is 95% non-condensating. The occurrence of condensation is a function of temperature change, as seen on wet windows and car windshields in the morning. Normally, there is no problem in normal industrial background environments, even during the hot summer months in coastal areas such as the Gulf of Mexico, as long as the air circulation is normal. Areas with poor air circulation can often be the cause of condensation.

Both solid-state and catalytic sensors have heated elements. In addition, their transmitters are designed to operate at 14-24 VDC, which generates heat. Therefore, the sensor transmitters are always a few degrees warmer than the environment in order to minimize the possibility of condensation. Electrochemical sensors normally require relatively much less power; therefore, the temperature of their transmitters is similar to the surrounding temperature. In this case, it is easier for condensation to occur.

E. In applications requiring the sensors to be constantly *exposed to gas*, special considerations are required and the sensor specifications and the suppliers of the sensors may need to be consulted. A properly designed sampling system may make difficult or otherwise impossible applications possible to handle.

It is difficult to mention every consideration needed, but a carefully evaluated and studied application can yield savings in both time and money.

With the specifications of the sensors, one can decide which sensor best meets one's requirements. There is no general consensus that establishes which sensor is the best for a given application. Hence, the information that follows contains some guidelines that may be helpful in making the proper selection of a sensor.

Toxic versus Combustible Gas Monitoring

Gas monitoring applications are generally classified into toxic or combustible range monitoring. Toxic gas monitors are generally used for human health protection and the ranges of the monitors are 3 to 5 times higher than the permissible exposure limits. For most gases, ranges are in ppm concentrations.

For combustible applications, ranges are typically 100% lower flammable limits or a fraction of these ranges, such as 50% LFL. The gas concentrations are high and are generally in the range of several percent.

In other words, for toxic gas applications, a sensor must be able to measure gases at low concentrations while, for combustible gas monitoring, a sensor must measure high gas concentrations.

Summary

Electrochemical Sensors. Except for oxygen applications, electrochemical cell sensors are designed to be used as toxic gas monitors. These sensors are only suitable for low concentration ppm ranges. For portable applications, the electrochemical sensor has many advantages: it has very low power consumption, responds quickly to gas, and is not affected by humidity. Also, the sensors are only exposed to gas periodically, which maximizes the sensor life.

Electrochemical sensors are therefore a good choice for portable instruments. Electrochemical sensor life expectancy is two years; however, depending on the application, it can be much shorter. The cost of replacement sensors is high, especially when the number of instruments in use is large. The annual budget and labor to keep the instruments functioning need to be considered.

There are approximately 20 gases that can be monitored by electrochemical sensors. For the rest of the gases (for ppm ranges), solid-state sensors or PIDs will need to be used.

Catalytic Sensors. In portable combustible gases in the LEL ranges, a catalytic sensor is good for normal, simple applications. The sensors can last for a long time because they are used sporadically in portable applications. Catalytic sensors are relatively inexpensive but one has to make sure they are made by reputable suppliers.

Infrared and Solid-State Sensors. For gases that can poison the catalytic sensors and make them impossible to use, the choice is between infrared sensors and solid-state sensors. Depending on the gases to be detected, infrared sensors have the better performance but detection of gases is limited. On the other hand, solid-state sensors can detect most chemicals in the LEL ranges.

In stationary applications, the sensors are constantly exposed to environmental background gases. For toxic gas applications, it is generally favorable to use solid-state sensors, especially when the number of sensors is sizable. In applications where interference can be a problem, it is best to study the sensor specifications and to consult with the supplier.

For stationary combustible gas applications, the choice is among catalytic sensors, solid-states sensors and infrared sensors, which are fully described in Chapters 4, 5, and 6 respectively.

There are no standardized specifications for a gas monitor. The following table entitled “Typical Specifications for Gas Monitoring Instruments” is a summary of several “requests for quotation” from customers and is presented here as a reference.

Typical Specifications for Gas Monitoring Instruments

Remote Sensor Transmitter Specifications

Gas to Be Monitored: Methyl Bromide, 0–500 ppm.

Sensor: Solid-state sensor

Temperature: –10° C to 45° C.

Humidity: 95% RH, noncondensing.

Accuracy: 5%

Response Time: 50 seconds to 90% full scale

Background: Normal environmental conditions

Transmitter shall be certified for use in Class 1, Div. 1, Groups B, C, D areas. Provides functional adjustments without the need to open the transmitter's cover, and provides protection for outdoor applications.

Power: 14 VDC to 24 VDC

Output: 4–20 mA linear output.

Controller Specifications

1. Four-channel control unit, microprocessor-based.
2. Independent digital display of reading for each channel. Provides calibration functions, three alarm settings, and diagnosis functions.
3. Three-level alarm set points (low, mid, high) with LED indicator for each alarm.
4. Relays: SPDT, 5 amp. 220 VAC max. resistive
   Common relays for each alarm level (3 relays per channel)
   Options: Individual relays for each alarm level (3 relays per channel)
   "Fault" relays for each channel, indicating electrical fault of the sensor
5. 4-20 mA analog output signal for each channel.
6. Wall-mounted weatherproof NEMA 4X enclosure.
7. Provide 24 VDC, 500 mA for each sensor module, accepts and processes 4-20 mA transmitter output signal.