Understanding IAQ TOOL CHARACTERISTICS

Techs must take into account a number of performance parameters when using sensor technologies

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Each characteristic of indoor air quality (IAQ) is measured using a specific type of sensor. In some instances, technicians can choose from several alternative sensor technologies. In every case, their decisions about which sensor technology to use and how to employ it, must take into account a number of performance parameters:

- Accuracy.
- Response time.
- Stability over time and in varying environmental conditions.
- Strength, durability and longevity.
- Portability and ease of use.
- Ease of adjustment and calibration.
- Cost.

In most cases, product designers must make tradeoffs to deliver an affordable end-product that meets user needs and expectations. A "perfect" instrument is something few could afford.

Air temperature

In this section, I will review the technologies used to measure the various air-quality parameters, the nature and limitations of those technologies and what users need to know to get the best results.

➤ **Sensor technologies.** Though household thermometers may employ expanding liquid (alcohol or mercury) or a bimetallic strip attached to a pointer, professional instruments generally use one of two sensor technologies: the thermocouple or the bead thermistor.

Most common in the service industry is the thermocouple, which looks like a bead on the end of two wires. The sensor is a combination of two metals that when joined together and presented with a temperature, creates a voltage differential across the connected wires.

Thermocouples have little mass and, therefore, respond quickly to temperature changes. This is significant when measuring air, a gas with relatively low density and limited ability to quickly heat or cool a material.

The thermistor uses a different technology. A small resistor in the device receives a voltage or current. Resistance in the device varies as temperature changes, causing output current or voltage to change as well.

A third electronic technology is infrared, which is typically used in non-contact thermometers. Infrared thermometers do not measure air temperature, but measure

➤ Knowing and understanding your IAQ tools is key to attaining the proper reading.

the infrared radiation emitted from surfaces. Infrared thermometers provide the greatest accuracy at short distances and provide an indirect indication of air temperature at best.

➤ **Technology characteristics.** Because simpler circuitry is needed to convert thermistor signals into temperature readings, instruments using thermistors are likely to cost less than those using thermocouples. Thermocouples can perform from near absolute zero (-460° F) to thousands of degrees F. Thermistors operate over a limited temperature range (approximately –30° F to 180° F). This range likely is adequate for IAQ applications.

In terms of response time, both technologies perform well. But response time also is affected by the overall design of the test instrument. If the temperature sensor is enclosed in a massive housing, the surrounding material is liable to affect the speed with which air heats or cools the sensor, thus slowing response time.

Minimal response time requires minimizing mass and that means shrinking components. If carried to an extreme, this could affect instrument durability.

➤ **Stability and drift.** The thermistor temperature sensor is stable and does not drift like some other sensors. However, the temperature-sensing function can drift over time due to other components used and the layout of the circuit design.

In design and manufacture, care must be taken in the layout of the printed circuit board that connects with the thermistor. Ionic contamination from soldering flux residues can cause performance degradation. This increases as the impedance of the circuit increases. Good analog design is essential to achieving optimal temperature performance.

➤ **User guidance.** Allow for instrument "settling time" when measuring temperature. The mass of a temperature tester may slow response time in rapidly changing conditions. In simple terms, it takes a while for the instrument to reach ambient temperature. In addition, the instrument's electronic circuitry will perform differently as temperatures vary, so the circuitry too must settle and stabilize.

Humidity

➤ **Sensor technologies.** The sling psychrometer traditionally is used to measure humidity. It consists of two bulb thermometers, one of which is surrounded by a wet cloth. When the device is slung through the air, moisture evaporates from the wet bulb and cools the thermometer. The dryer the air, the greater the temperature difference between the wet and dry thermometers.

A more convenient alternative is a hand-held humidity meter that uses a capacitance sensor technology. A semi-permeable membrane in the sensor becomes more conductive as humidity increases and moisture penetrates the membrane. The meter interprets this change in terms of humidity level.

➤ **Technology characteristics.** The sling psychrometer is accurate when used correctly, but also is relatively slow and cumbersome. The hand-held meter is much faster and easier to use, but over time airborne contaminants will reduce its ability to absorb moisture. You cannot clean the sensors, so if they get contaminated or old, they must be replaced.

➤ **Stability and drift.** Users should be aware that the performance of humidity meters will decline over time. The rate of change will depend on how and where they are used.

➤ **User guidance.** Testing to determine accuracy and to calibrate the instrument requires sophisticated and expensive equipment beyond the means of the individual user. You can return instruments to the manufacturer or to an independent testing laboratory to verify their performance. If out of spec, the sensor of an expensive instrument may be replaced. In the case of a less costly instrument, the user may choose to replace the tool.

Airborne particles

➤ **Sensor technologies.** The particle counter uses a pump to pull a sample of air into a space called the view volume, where particles intersect with a laser beam. The particles reflect differing amounts of light based on their size. Photo detectors "see" these light flashes and convert each one to a millivolt signal. Larger particles reflect more light and create a stronger signal. Signals within a

➤ **There is a variety of IAQ tools, each with their own set of characteristics.**

certain millivolt range are counted in one size "bin," particles in another range are put into another bin and so on.

➤ **Technology characteristics.** Extremely high levels of particles can affect accuracy of the counter. Particles may collect within the intake passage and measurement chamber. If these particles are dislodged during a subsequent test, they can cause a misleading spike in the particle count.

➤ **Stability and drift.** Laser particle counter technology generally is stable over time, but you need to observe the manufacturer's recommended calibration interval to maintain optimal performance.

➤ **User guidance.** Operating the air pump for a period of time before taking a reading will help to flush particles out of the instrument. Users can calibrate the instrument for a zero particle count by applying a high-efficiency particulate arrestance (HEPA) filter over the air intake port.

Carbon dioxide

➤ **Sensor technologies.** CO_2 sensors use a non-dispersive infrared technology. Incandescent light is projected through a small sample cell called the "bench link." The CO_2 present in the test sample will absorb a specific wavelength of the projected light.

A filtered infrared detector at the other end of the chamber measures the amount of light at the wavelength that passes through the chamber. As CO_2 levels increase, the gas absorbs more light, which reduces the strength of the electric signal emitted by the detector.

➤ **Technology characteristics.** Design affects both the performance and accuracy of a CO_2 tester. The length of the test chamber or "bench" is important, because a longer chamber enables the light to pass through a larger air sample and more CO_2 molecules before reaching the detector, making greater accuracy possible. A test instrument that pumps air through the test chamber will respond faster than a dispersion unit that does not pump the air.

Changes in air temperature, pressure and density will affect the accuracy of CO_2 test results. CO_2 meters must be adjusted before use to compensate for changes in air pressure and temperature. Some instruments are built to compensate automatically for changing conditions.

➤ **Stability and drift.** The CO_2 sensor will degrade and drift over time due to loss of sensitivity and declining bulb performance. Airborne contaminants will pass through the sensor filter (assuming there is one) and accumulate on the interior walls, emitter and detector of the sensor.

This contamination will affect the intensity of the light source, as well as the signal strength of the optical filter/detector. The more contaminants (smoke, dust) the sensor detects, the faster the degradation of the signal strength. Another factor affecting long-term stability of the sensor is degradation of the light source. Like any bulb, it will burn out.

➤ **User guidance.** You need to calibrate a CO_2 sensor annually to compensate for the reduced output of the bulb and collection of contaminants. CO_2 meters can be tested and user-calibrated using a standard span gas that contains a known percentage of CO_2. You can achieve a rough calibration by using outdoor air, which likely will contain 350 to 450 parts per million of CO_2. Use dry nitrogen, which contains no CO_2, as a zeroing gas.

Carbon monoxide

➤ **Sensor technologies.** Carbon monoxide testers use an electrochemical gel sensor technology.

➤ **Technology characteristics.** The gel sensor has a limited life span (two years), and changes in temperature and ambient humidity levels can affect accuracy.

➤ **Stability and drift.** Prolonged exposure to humidity levels below the ideal 50 percent relative humidity level can dry the gel sensor and cause the instrument readings to drift out of spec. The changeable nature of CO sensor technology means that users must calibrate their CO meters frequently (monthly) to ensure accuracy. Most CO meters can be user-calibrated using a span gas containing a known percentage of CO. They can be zero calibrated (zeroed) in free air.

➤ **User guidance.** Calibrate the instrument when you receive it to ensure that it is set for your environment. If your environment changes (for instance, if humidity increases during the summer) recalibrate. Simply transporting the instrument from a humid outdoor environment into a dryer air-conditioned space should not cause problems. Environmental changes over a longer period are the issue.

In conclusion, accuracy is fundamental for those who measure, monitor and control air quality in workspaces. By choosing instruments based on an in-depth understanding of their specifications and performance characteristics, using them properly, and maintaining and calibrating them as recommended, you can ensure yourself and your clients of accurate measurements and effective guidance to improve IAQ.◆

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