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DuPont™ Suva®
refrigerants

Leak Detector Guidance for DuPont™ Suva® Refrigerants

Refrigeration service personnel have used leak detection equipment for years when servicing refrigeration equipment. In the past, leak detection typically was only concerned with leak pinpointing, either with an ultrasonic device, soap bubbles, dyes, thermal conductivity, or other electronic devices. Today, refrigerant leak detectors exist not only for pinpointing leaks, but also for monitoring an entire room on a continual basis. There are several reasons for leak pinpointing or area monitoring, including: conservation of expensive refrigerants, protection of valuable refrigeration equipment, reduction of fugitive emissions, and protection of employees.

Leak Pinpointing versus Area Monitoring

Leak detectors can be placed into two broad categories: leak pinpointers and area monitors. Leak pinpointers are used to check individual joints or components of a refrigeration system for leaks; whereas, area monitors are used to check the level of refrigerant vapor present in an equipment room or other location where employee or customer exposure can occur. In general, a stationary area monitor will notify you that a leak has occurred within a given space. The leak is then tracked down with a portable leak pinpointer. Due to the different nature of their applications, these two broad classes of detectors each have their own specific set of requirements and specifications, which are discussed here.

Several instrumental criteria should be considered before purchasing a monitor or pinpointer, including (but certainly not limited to): sensitivity, detection limits, and selectivity. These terms are not all independent from each other, as described below.

Sensitivity

The sensitivity of any device is defined as the amount of input (material being measured) necessary to generate a certain change in output signal. For leak detection, the material is the vapor concentration being measured and the output is the reading from a panel meter, a voltage output, or some other display device. Detectors with good (high) sensitivity require very little material to generate a large change in output signal, while detectors with poor (low) sensitivity require larger amounts of material to change the output signal. For example, a detector with high sensitivity may be able to accurately discriminate concentration levels of 1 or 2 parts per million (ppm) of vapor, while a low sensitivity detector may only be able to discriminate in increments of 20 ppm or higher.

The sensitivity of a device is determined by a number of factors. The most important factors for leak detection are the method of detection and the material being detected. For example, an ionization detector that demonstrates high sensitivity for CFC-12 may have worse sensitivity for HCFC-123 and very poor sensitivity for HFC-134a. Sensitivity differences of 100x to 1000x have been reported when comparing CFC-12 to HFC-134a with some ionization-based detectors. In this case, the variations in sensitivity would be due to less chlorine, which is very easily ionized and detected, as you move from the CFC to HCFC to HFC class of compounds. On the other hand, an infrared-based area monitor will show roughly the same sensitivity to all three compounds mentioned above.

Detection Limit

Certain analytical techniques have well-defined sensitivity values, but these do not exist for leak detectors. The most common measure of how “sensitive” a detector can be is the detection limit, which is usually defined as the minimum amount of material a unit can sense that gives a signal at least two times the background noise level. A sensitive device does not necessarily mean a low detection limit (it could have a high background electronic noise level), although the two measures of performance usually tend to coincide.

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Detection limits for monitors are measured in two ways: oz/yr for pinpointing applications and ppm for area monitoring. Portable leak pinpointers typically have detection limits reported around 0.25 oz/yr, while area monitors have detection limits as low as 1 ppm, although a more typical value is 3 to 4 ppm for most compounds.

Because sensitivity can vary greatly with different compounds, the detector must be matched to the intended application. For example, an ionization detector that claims a detection limit of 0.25 oz/yr CFC-12 does not work very well for HFC-134a detection. And, an ionization detector made specifically for HFC-134a may be too sensitive for CFC-12 leak pinpointing. Some manufacturers are now considering an option that allows the operator to choose various sensitivity settings on a single instrument, based on the application.

Selectivity

For the leak detection application, selectivity can be defined as the ability to detect only the refrigerant of interest without interference from other compounds that may be present in the area. Obviously, selectivity is not too important for leak pinpointers, because once you pinpoint the leak, its identity is known.

While selectivity requirements for area monitoring will vary with each specific installation, some general statements can still be made:

- Area monitors must work on a continuous basis and are thus exposed to more potential interfering species than a leak pinpointer, which is usually used for only minutes at a time.
- Due to the larger number of potential compounds seen (and wider range of concentrations over time), selectivity is more important for area monitors.
- Selectivity is a required feature of an area monitor if there are other species present with vastly different TLVs. For example, many equipment rooms with HCFC-123 chillers (AEL = 50 ppm) also have chillers with CFC-11 (TLV = 1,000 ppm). Without being able to distinguish between the two species, a nonselective detector will alarm when 50 ppm of either refrigerant is detected, which can lead to concern about excessive HCFC-123 exposure when, in reality, there may be no exposure to that compound and only inconsequential exposure to the CFC-11. This can also lead to many false alarms and eventual complacency toward alarms. Despite this fact, some operators prefer nonspecific detection so they can be alarmed when any refrigerant is detected. The identity of the refrigerants will be discovered once the leak is pinpointed.

The above sections discussed only the three most important instrumental factors to consider when looking at detectors; however, there are several other factors to consider about the instrument, including cost, ruggedness, and ability to be calibrated.

Types of Detectors

Using selectivity as a criteria, leak detectors can be placed into one of three categories: nonselective, halogen-selective, or compound-specific. In general, as the specificity of the monitor increases, so does the complexity and cost. Another type of detector, which does not fall into any of the above categories, is fluorescent dye.

Nonselective Detectors

Nonselective detectors are those that will detect any type of emission or vapor present, regardless of its chemical composition. Typical detectors in this category are based on electrical ionization, thermal conductivity, ultrasonics, or metal-oxide semiconductors. These detectors are typically quite simple to use, very rugged, inexpensive (normally less than $500), and almost always portable, thus making them ideal for leak pinpointing applications. However, their inability to be calibrated, long-term drift, lack of selectivity, and lack of sensitivity (detection limits usually between 50 and 100 ppm for HFC-134a) limit their use for area monitoring.

Halogen-Selective Detectors

Halogen-selective detectors use a specialized sensor that allows the monitor to detect compounds containing fluoride, chloride, bromide, and iodide without interference from other species. The major advantage of such a detector is a reduction in the number of "nuisance alarms"—false alarms caused by the presence of some compound in the area other than a refrigerant.

These detectors are typically easy to use, feature higher sensitivity than the nonselective detectors (detection limits are typically <5 ppm when used as an area monitor and <0.05 oz/yr when used as a leak pinpointer), and are very durable. In addition, due to the partial specificity of the detector, these instruments can be calibrated easily.

As an area monitor, these detectors are best suited for use in moderately clean equipment rooms where only one refrigerant must be monitored. Their lack of response to nonhalogenated compounds also allows their use in storage areas or areas where other (nonhalogenated) compounds may be present. As a leak pinpointer, these products have greatly enhanced sensitivity compared to nonselective detectors. However, because these detectors cost more than the nonselective models, the benefit of better sensitivity must be weighed against the higher cost of the product.

Compound-Specific Detectors

The most complex detectors, which are also the most expensive, are compound-specific detectors. These units are typically capable of detecting the presence of a single species without interference from other compounds. Compound-specific detectors typically are infrared-based (IR), although some of the newer types are infrared-photoacoustic based (IR-PAS).

The IR and IR-PAS detectors normally have detection limits around 1 ppm, depending upon the compound being detected. There are also several IR detectors on the market that have detection limits of approximately 10 ppm. These detectors typically have a much lower price per unit and are less complex than those with lower detection limits. For refrigerants other than HCFC-123, these units probably will yield acceptable performance.

Due to recent improvements in technology, the price of the compound-specific detectors has dropped by about 50 to 60% during the last year. For most of 1991, IR-based detectors could be purchased for approximately $10,000 per unit. Now, units with comparable performance can be purchased for only $3,500 to $4,000.

Fluorescent Dyes

Fluorescent dyes have been used in refrigeration systems for several years. These dyes, invisible under ordinary lighting, but visible under ultraviolet (UV) light, are used to pinpoint leaks in systems. The dyes are typically placed into the refrigeration lubricant when the system is serviced. Leaks are detected by using a UV light to search for dye that has escaped from the system. The color of the dye when subjected to UV light is normally a bright green or yellow and is easily seen.

Table 1
Comparison of Various Types of Leak Detectors

	Nonselective	Halogen-Selective	Compound-Specific	Fluorescent Dyes
Advantages	• Price ($250–$1,500) • Simplicity • Ruggedness	• Simple/rugged • Can be calibrated • Good sensitivity • Low maintenance	• Virtually interference-free • Can be calibrated • Good sensitivity	• Low price • Little specialized equipment required • Good detection limits • Rapid detection • Interference-free
Disadvantages	• Poor detection limits • Cross-sensitive to other species • Most cannot be calibrated	• Price ($280–$2,500) • Not compound specific • Detector lifetime/ stability • Does not meet ASHRAE 15-94 as area monitor	• Price ($3,000-$10,000); IR-PAS may be lower priced • Complexity/ maintenance • Stability?	• Potential compatibility problems • Cannot be automated • Cannot be calibrated • Some areas not observable
Vendors	• >6 for leak pinpointers • 3–4 for area monitors	• 3 for leak pinpointers • 2 for area monitors	• Several for IR • Several for IR-PAS	• 2 currently exist
Applications				
Leak Pinpointing	• HFC-134a, HCFC-123, Blends	• All HCFCs, HFC-134a, Blends	• Not recommended due to high price	• Works with most systems
Area Monitoring	• Not recommended due to cross-sensitivity and poor detection limits	• All HCFCs, HFC-134a, Blends	• All HCFCs, HFC-134a, Blends	• Not applicable
Other	• None	• Where only one refrigerant is used • In moderately clean equipment rooms	• “Dirty” environments • Multi-refrigerant environments	• None

As a leak pinpointer, fluorescent dyes work very well, because large areas can be rapidly checked by a single individual. And, the recent introduction of battery-powered UV lights has made this task even simpler. Leak rates of less than 0.25 oz/yr can be found with the dyes. The only drawback to the use of dyes is that some areas may be visually unobservable due to cramped spaces.

Recent innovations in dye technology have allowed fluorescent dyes to be used with HCFC and HFC refrigerants. One cautionary note concerning the use of fluorescent dyes: the compatibility of the specific dye with the lubricant and refrigerant should be tested prior to use. For detailed information about which lubricants and refrigerants have been tested with which dyes, contact the fluorescent dye vendors listed at the end of this document.

Which Area Monitor Is Right for You?

Deciding which area monitor to purchase and install is a complicated issue. Many factors, both instrumental and application oriented, must be considered before purchasing a monitor. Among the factors to consider are: the location of the refrigeration room and the monitor, other chemical species in the room, the degree of specificity required, the number of detectors required, and the amount of capital to be invested.

Under ASHRAE Standard 15-94, certain conditions, such as an enclosed refrigeration equipment engine room, require the use of monitors that can detect the concentration of specific refrigerants. Because most halogen-specific detectors cannot determine concentrations, their usefulness as area monitors would be limited. In addition to monitoring, the system needs the capability to close contacts to initiate alarms and building ventilation.

The location of the refrigeration equipment room plays an important part in the decision of which type of detector to purchase. If the equipment room is located and ventilated so that few outside vapors enter the room, one could possibly use a halogen-specific instrument as an area monitor. If, on the other hand, the equipment room has vapors coming in through the ventilation system that would be detected on a halogen-specific system, the use of a compound-specific instrument is probably best. An installation of the first type (fairly isolated) may be newer office buildings, supermarkets, etc. Examples of the second type (less isolated) would include many older installations where the ventilation system pulls hydrocarbon or other vapors into the building, chemical plant, processing area, manufacturing site, etc.

The presence of other chemical species in the equipment room and the desired degree of specificity will also play an important part in the decision. Many equipment rooms have multiple refrigeration systems present, often with two or more refrigerants being used. If the entire equipment room uses only one refrigerant (such as a supermarket using only HCFC-22), use of a halogen-specific detector may be acceptable. If the equipment room has multiple refrigerants present, use of a halogen-specific detector will work well, if the TLVs of the refrigerants are fairly similar. If multiple refrigerants are present and their TLVs are not very close, use of a compound-specific detector is recommended. Obviously, a compound-specific detector that can be switched either manually or automatically to search for other compounds would be best. Units of this type are just beginning to be introduced.

Two other related factors to consider when purchasing an area monitor are the number of monitors required and the amount of money that can be spent. Only the smallest equipment rooms can get by with a single detector—most rooms should have at least two. With the price of detectors typically running more than \$2,000, purchasing multiple detectors may be cost prohibitive. Several instrument manufacturers have addressed this issue by making sample manifolds that allow air from several locations to be sampled sequentially by a single detector. With the price of a manifold normally being about \$500, this option is much less expensive than purchasing several detectors.

The above factors are only some of the points to consider when purchasing an area monitor. Other considerations include: how and where alarms are indicated, who has access to the instrument, who maintains the detector, and if the detector is fail-safe. **Table 2** presents several points to consider when purchasing an area monitor. While not inclusive, this table should be enough to get started when considering which area monitor to purchase.

Table 2
Points to Consider When Purchasing an Area Monitor

Category/Concern	Features to Consider
Selectivity	• Is only one refrigerant present? • Are other materials (nonrefrigerants) stored in the equipment room? • Will the ventilation system bring potential interfering vapors into the equipment room?
Operation	• Is battery backup required? Is there access to UPS? • Is fail-safe operation required? • Who has access to instrument controls and alarms? • What is the desired maintenance schedule? • What are anticipated temperature and humidity ranges?
Instrument Parameters	• Is multi-port capability required? • What is the desired response time? • What is the baseline stability? • Is the instrument auto-zeroed? • Is temperature compensation required? • What is the minimum detection level? • How selective is the monitor?
Output/Alarm Functions	• Where is the alarm indicated? (Local vs. area alarms) • Is the alarm latching or nonlatching? • Is the alarm single or multilevel? • Can the instrument show rate-of-change of refrigerant concentration? • How are concentrations displayed? • Is computer interface present or necessary? • Who has capability to shut off alarms?
Miscellaneous	• What is the cost? • What type of enclosure is required? • Is an intrinsically safe detector required?

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