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McClure, D. and Anderson, T., "A Comparison of Refrigerant Constant Monitoring Leak Detectors" (1990). *International Refrigeration and Air Conditioning Conference.* Paper 115.
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# A COMPARISON OF REFRIGERANT CONSTANT MONITORING LEAK DETECTORS

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**ABSTRACT:**

With the sweeping changes occurring in CFC usage and Government regulation, design engineers to end users alike are left with a number of questions to answer. Most of the common refrigerant gases contain chlorine in various amounts, and are easily detected in their escape to the atmosphere. New low ozone depletion refrigerants, HCFC-123 and HFC-143a, are currently available in new equipment and proposed drop-in retrofit applications. However, with HCFC-123's Acceptable Exposure Limit (AEL), 100 PPM, and both refrigerant's expense, the cost of installing a monitoring system may not only be essential environmentally but economical. This paper discusses the available means of permanent refrigerant leak detection; their sensitivities, monitoring capabilities and possible future requirements from government regulations.

## INTRODUCTION

The discovery of ozone depletion in the Antarctic region has forced government agencies across the globe to review the fully halogenated refrigerants (CFC's) as environmental safe products. This has lead to the international treaty, the Montreal Protocol, and more recently the United States EPA has drafted rules to implement the provisions of the Montreal Protocol. The resultant regulation in effect is the reduct-ion of production of CFC's to 50% of 1986 levels by 1998. An additional measure of taxing the sale of CFC's has been added by congress already started in January, 1990. It is very possible that these provisions will be tightened, and a comp-lete phase-out of CFC's will be in effect by the year 2000.

With these recent sweeping changes occurring in the industry, a number of questions remain to be answered concerning new and retrofit equipment selection. With absorb-tion chillers unable to fill every requirement, it is certain that mechanical cooling will still be a dominant choice in the future, and that the primary refrigerant gas will be a halogen (some chlorine based) compound or ammonia.

A method to minimize refrigerant losses (and costs) in these mechanical systems is the use of constant leak monitor-ing. Indeed, on two of the current refrigerant alternatives (HCFC-123, Ammonia) monitoring should be considered a necessity. By catching refrigerant leaks before the system is drained beyond the minimum level required for cooling, losses to the atmosphere can be greatly minimized. With the rising costs of refrigerant, due to taxation, monitoring becomes an economical solution as well as environmental safer installation. Leak monitoring now has a two fold cost justification: product loss and refrigerant maintenance costs minimumization (R-12 expected to reach $9.50 per pound by 1995).

Refrigerant leak monitoring methods presented in this paper are stand alone constant monitoring type, only. The methods of refrigerant gas detection are gas ionization, infared absorption and metal oxide sensor method.

## GAS IONIZATION METHOD

The gas ionization method takes advantage of the halogen gas'ability to release ions when heated. This process is specific to halogen gasses only, chlorine being the principle element used.

In this method, air to be sensed is drawn through a detector cell by means of a fan. The halogen molecules are attracted to the heated anode, and are ionized catalytically. The free ions are collected on an adjacent cathode. The re-sulting current formed by the free ions is proportional to the amount of halogen gas that passes through the detector cell (REF 1). Figure 1 shows a gas ionization detector cell.

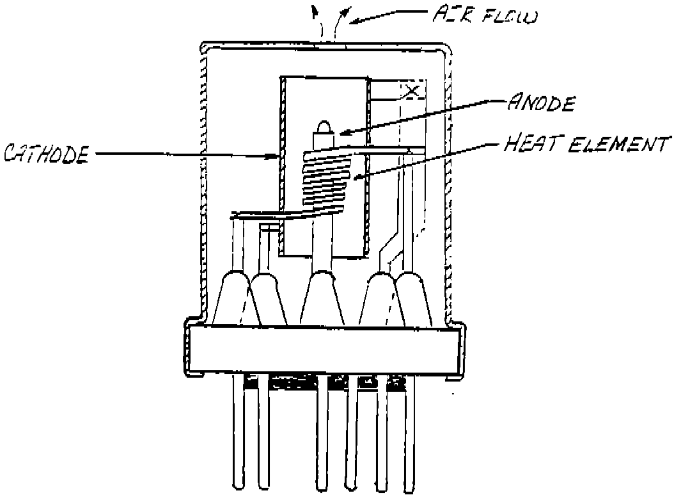


Figure 1. Gas Ionization Detector Cell

Sensitivity of this type of detector cell varies with the particular compound. As a reference, the leakage rate for a cell operated at atmospheric pressure is 0.0005 oz/yr for R-12. Other refrigerants are shown on Table 1 with their sensitivity shown as a multiplying factor of R-12 (REF 2A).

TABLE 1

SENSITIVITY OF GAS IONIZATION DETECTORS FOR VARIOUS HALOGEN GASES

| Trade Designation | Chemical Formula | Approximate Multiplying Factor By Weight |
|---|---|---|
| R-12, F-12 | CCl(2)F(2) | 1 |
| R-11, F-11 | CCl(3)F | 3/4 |
| R-13, F-13 | CClF(3) | 40 |
| R-22, F-22 | CHClF(2) | 3/4 |
| R-114, F-114 | C(2)Cl(2)F(4) | 1 1/4 |
| FC-75 | C Cl F | 100 |
| Sulferhexaflouride | SF(4) | 240 |
| Methyl chloride | CH(3)Cl | 3 |

Variables such as low pressure and sporadic anode temperatures also affect sensitivity, but current technology that is available today limits these variables to a negligeable amount. Detector cells of this nature can acquire lost sensitivity due to longterm high levels of ion flow. An example would be a leak occurring on the weekend constantly exposing the cell to the halogen gas. However, recent application of microprocessor control has minimized this problem . Generally, this type of detector cell is excellent for halogen refrigerants, except where another halogen compound (bromine, iodine) may be present or where explosive atmospheres may exist.

Equipment available today that uses this principle for automatic leak detection utilizes microcontroller principles to regulate the variables of an ionization detector cell. Another feature is direct readout in PPM's, giving a lay-person the ability to recognize a leak, and history of past levels stored in nonvolatile memory. Advances have further been made by independent unit communication link-ups, telephone alarm notification as well as PC communication packages that allow graphical readout in a user friendly form .

**INFARED ABSORBTION METHOD**

The principle of operation in the infared absorption method uses a molecule's ability to absorb radiant energy in a particular bandwidth. This method will not only identify a particular molecule, but it can measure the amount of gas that is present in a sample.

A detector cell for infared absorbtion consists of an infared light source, an air sampling cell, a standard comparison cell and a radiation detector. Infared light is admitted into each test cell, alternately, with a wheel chopper. The light beams pass through the sample/comparison cells, and pass into a radiation detector. As the infared light is absorbed into the radiation cell the infared active gas expands due to increased molecular activity. The construction of the radiation cell is airtight, and it is separated by flexible membrane. The difference in infared light input from the two light beams is measured as a change in position of the flexible membrane. This is transferred into an electrical output by a pneumatic capacitor (REF 2B). Figure 2 is a schematic diagram of a typical infared leak detector.

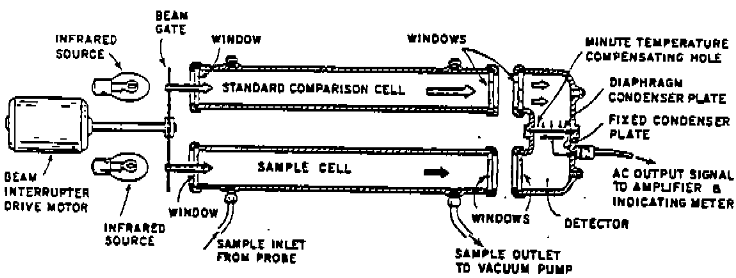


Figure 2. Infared Leak Detector

The infared detector has relatively good sensitivity. It also has the ability to specifically identify a gas, but it will only identify that particular gas reliably. Sensitivity varies with each Clorinated Hydrocarbon's infared activity, but is approximately is in the range of 0.0125 oz/yr (REF 2B).

Present day equipment that uses this method of leak detection, again, uses microprocessor control to analyze the output of the detector cell. On board outputs are two signal levels in relay form, audible output and optional outputs to drive a chart recorder, LED readout of other indicating means.

**METAL OXIDE SENSOR METHOD**

This method uses a metal oxide sensor that reacts chemically with a gas to be sensed. Metal oxide sensors do not discriminate different compounds, but it is the only method to safely detect ammonia.

As the metal oxide compound comes in contact with a chemically active gas, a reaction results. The end result is a lowering of the electrical resistance of the sensor. Resistance of the is monitored with a resistance bridge or other devise to produce a current proportional to the chance in resistance of the sensor. This will be approximately the amount of detected gas in the sensed area.

The sensitivity of metal oxide sensors is somewhat less than the first two methods. Ammonia leaks can be detected as low as 50 PPM's (0.125 oz/yr) and R-12 at 100 PPM's (0.25 oz/yr). However, the variance in sensors vary greatly (plus or minus 100 PPM/0.25 oz/yr). Since the process of lowering the resistance of the sensor is not completely reversible, sensor life is limited. Temperature also affects the sensitivity,. Usually a small amount (5%) with the specified temperatures of the sensor, but sensitivity can vary as much as 30% out of these limits. Since air to be sensed is not pumped or pulled through the sensor, it must be in the correct position to detect possible leaks. It is recommended to follow the manufacture's guidelines for placing the sensors for the best protection. Metal oxide sensors also react with other compounds that are normally present in the atmosphere.

Leak detectors using metal oxide sensors today are relatively simple in design. The resistance from the sensors (usually 1 to 4) is analyzed by simple Integrated circuits with compensating circuits for controller temperature and time delays to prevent possible false alarms. Sensitivity adjustment is accomplished via a variable potentiometer. Alarm outputs are in the form of dual level relay circuits, LED's to indicate which sensor is alarming and audible output on a high level.

**CONCLUSIONS**

Although the idea of leak monitoring is not new, the present technology presented in this paper is relatively new. History of proper applications for each method is not available, but some recommendations can be made based on each method's advantages. For small areas, with a relatively high potential of leak concentrations, the metal oxide sensor method appears as the optimum method. It has a relatively low cost, and its lower sensitivity is not a factor. For large areas to be covered with a low potential for leak concentrations, the gas ionization method should be considered. Its high sensitivity could be put to use, and its cost can be justified since a number of metal oxide sensor are needed to cover an equal area accurately. In industrial areas (or other areas) where other compounds may give false alarms, the advantages of infared absorbtion should be analyzed. Although not as sensitive as gas ionization, its gas selectivity can shield out other gases. In any application, all the pros and cons of each leak monitoring method must be weighed to effectively monitor an area for leaks.

References:


1) ASHREA Fundamentals Volume, 1985, Chapter 16

2) NASA, Leakage Testing Handbook, 1969

   a) Chapter 10

   b) Chapter 17


Acknowledgements:


1) Special thanks to SenTech Corperation, Indianapolis, IN for their information on gas ionization methods.

2) Special thans to Mine Safety Appliances Company, Pittsburgh, PA for their information on infared absorbtion and metal oxide sensor methods.