Driers and Moisture Indicators

The characteristics of refrigeration driers are discussed in Chapter 49. However, it is in order here to point out that aside from care in the manufacture of the equipment, the use of refrigerant driers is the main method used to combat the effects of contaminants in a refrigerant system.

In the past the refrigeration serviceman had no way of knowing whether the system was dry enough. Even after changing the drier, the moisture level might still be sufficiently high to cause corrosion. This problem has been simplified with the introduction of *moisture indicators*. These devices utilize a moisture sensitive paper which changes color according to the moisture content of the refrigerant.[47] By using this device the moisture level in the system can be easily checked. The color change in the moisture indicator normally takes place at a moisture level that is low enough to be considered safe. Manufacturers' instructions should be followed carefully, because in addition to the moisture concentration the color change point is also affected by the liquid line temperature and the particular refrigerant used.

REFERENCES

[1] A. H. Bushey: ASRE research task force reports on contaminants (REFRIGERATING ENGINEERING, February 1957, p. 47).

[2] E. W. McGovern: Copper plating in refrigerating compressors (*Service News*, September 1938. Issued by E. I. duPont deNemours & Co., Inc.).

[3] E. W. McGovern: Chemical effects in refrigerating systems (REFRIGERATING ENGINEERING, May 1942, p. 376).

[4] H. Steinle and W. Seeman: The cause of copper plating in refrigerating machines (*Kältetechnik*, *5*, No. 4, 1953, p. 90). See also H. Steinle and W. Seeman (*Kältetechnik*, *3*, No. 8, 1951, p. 194).

[5] H. Steinle: Tests on copper plating in refrigerating machines (*Kältetechnik*, *7*, No. 4, 1955, p. 101).

[6] D. E. Kvalnes and H. M. Parmelee: Behavior of Freon-12 and Freon-22 in sealed-tube tests (REFRIGERATING ENGINEERING, November 1957, p. 40).

[7] R. T. Divers: Better standards are needed for refrigeration lubricants (REFRIGERATING ENGINEERING, October 1958, p. 40).

[8] H. O. Spauschus: Copper transfer in refrigerant-oil solutions (ASHRAE Journal, June 1963, p. 89).

[9] H. M. Elsey, L. C. Flowers and J. B. Kelley: A method of evaluating refrigerator oils (REFRIGERATING ENGINEERING, July 1952, p. 737).

[10] F. J. Norton: Rates of thermal decomposition of $CHClF_2$ and CF_2Cl_2 (REFRIGERATING ENGINEERING, September 1957, p. 33).

[11] D. D. Wile: Non-condensibles: power kiters; refrigerant wastrels (*Industrial Refrigeration*, January 1959, p. 12).

[12] H. O. Spauschus *et al:* Material stabilities in vapor compression refrigeration systems (*XI International Congress of Refrigeration*, Munich, Germany, September 3, 1963).

[13] H. O. Spauschus and R. S. Olsen: Gas analysis—a new tool for determining the chemical stability of hermetic systems (REFRIGERATING ENGINEERING, February 1959, p. 25).

[14] F. G. Peck: Alcohol in refrigerating systems (REFRIGERATING ENGINEERING, December 1956, p. 67).

[15] H. Heckmatt: Separation of mineral lubricating oil from Freon-12 in refrigerators (*Proceedings of the X International Congress of Refrigeration*, Vol. II, p. 64).

[16] W. C. Percival: Quantitative determination of fluorinated hydrocarbons by gas chromatography (*Analytical Chemistry*, January 1957, p. 20).

[17] *Quality Specifications and Methods of Analysis for the 'Freon' Fluorinated Hydrocarbon Refrigerants* (*Technical Bulletin* B-8 Freon Products Division, E. I. duPont deNemours & Co., Inc.).

[18] A. W. Diniak, E. E. Hughes and M. Fujii: Determination of water content in "Freon-12" circulating in a refrigeration system (REFRIGERATING ENGINEERING, February 1954, p. 56).

[19] W. R. Brisken: Moisture migration in hermetic refrigeration systems (REFRIGERATING ENGINEERING, July 1955, p. 42).

[20] W. A. Pennington: Refrigerant sampling (REFRIGERATING ENGINEERING, March 1950, p. 261).

[21] H. M. Parmelee: Solubility of air in "Freon-12" and "Freon-22" (REFRIGERATING ENGINEERING, July 1951, p. 573).

[22] B. J. Eiseman, Jr.: Effect of elastomers of "Freon" and other halocarbons (REFRIGERATING ENGINEERING, December 1949, p. 1171).

[23] L. A. Philipp and B. E. Tiffany: Thermodynamics of sulfur dioxide oil systems (REFRIGERATING ENGINEERING, May 1934, p. 248).

[24] V. A. Williamitis: How chemical stability assures long attention-free performance of sealed refrigeration systems (*General Motors Engineering Journal*, *2*, No. 1, 1955, p. 22).

[25] *Handling "Freon" Fluorinated Hycrocarbon Compounds in the Laboratory* (*Kinetic Technical Bulletin* 14, Freon Products Division, E. I. duPont deNemours & Co., Inc., 1953 and 1955).

[26] H. O. Spauschus and G. C. Doderer: Reaction of refrigerant 12 with petroleum oils (ASHRAE JOURNAL, February 1961, p. 65).

[27] H. M. Elsey and L. C. Flowers: The reaction between electrical insulating paper and monochlorodifluoromethane (REFRIGERATING ENGINEERING, April 1956, p. 31).

[28] J. J. Lingane: Automatic coulometric titration with electrolytically generated silver ion: determination of chloride, bromide and iodide ion (*Analytical Chemistry*, April 1954, p. 622).

[29] J. L. Mason, G. R. Whitnah, and E. M. Larson: The Study of Vapor-Cycle Refrigerants for High Performance Aircraft (Wright Air Development Center *Technical Report* 56-93, *Astia Document* No. AD151008, PB-131761, February 1958).

[30] B. J. Eiseman, Jr.: Reactions of chlorofluoro-hydrocarbons with metals (ASHRAE Journal, May 1963, p. 63).

[31] Properties and Application of the "Freon" Fluorinated Hydrocarbons (*Technical Bulletin* B-2, Freon Products Division, E. I. duPont deNemours & Co., Inc., 1959).

[32] R. E. Kirk and D. F. Othmer: *Encyclopedia of Chemical Technology* (Vol. 1, Interscience Publishers, Inc., New York, 1947).

[33] *Corrosion and Its Prevention* (Air Conditioning and Refrigeration Institute, 1958, p. 20).

[34] H. Steinle: Chemical reactions between refrigerants and oils in refrigerating machines (*Kältetechnik 2*, No. 7, 1950, p. 174).

[35] H. Steinle: Development and testing of lubricants for refrigerating machines (Presented at ASHRAE Semi-annual Meeting, January 27–29, 1964, New Orleans, La.).

[36] W. O. Walker, S. Rosen, and S. L. Levy: Stability of mixtures of refrigerants and refrigerating oils (ASHRAE JOURNAL August, 1962, p. 59).

[37] C. J. Rizzuti, G. D. Staffin, and A. W. Jenkins: Effects of additives and oil refining on refrigerant-refrigerator oil stability (ASHRAE JOURNAL, July 1962, p. 31).

[38] A. F. Brewer: Good compressor performance demands the right lubricating oil (REFRIGERATING ENGINEERING, October 1951, p. 965).

[39] R. T. Divers and Walter West: Hermetic compressors in modern applications (ASHRAE JOURNAL, April 1964, p. 55).

[40] H. Steinle: Examinations of the behavior of plastics in hermetic units (*XI International Congress of Refrigeration*, Munich, Germany, September 3, 1964).

[41] J. P. Harrington and R. J. Ward: Polyester film insulation for hermetic motors (ASHRAE JOURNAL, April 1959, p. 75).

[42] W. McMahon, H. A. Birdsall, G. R. Johnson and C. T. Camilli (*Chemical and Engineering Data*, January 1959, p. 57).

[43] C. J. Bushouse: Degradation of polyester film by alcohols (ASHRAE JOURNAL, September 1961, p. 61).

[44] R. T. Divers: Electrical insulation and hermetic motors (REFRIGERATING ENGINEERING, August 1957, p. 33).

[45] E. A. Beacham and R. T. Divers: Some practical aspects of the dielectric properties of refrigerants (REFRIGERATING ENGINEERING, July 1955, p. 33).

[46] B. J. Eiseman, Jr.: How electrical properties of "Freon" compounds affect hermetic system's insulation (REFRIGERATING ENGINEERING, April 1955, p. 61).

[47] A. B. Guise and W. O. Krause: A simple moisture indicating device for refrigerating systems (REFRIGERATING ENGINEERING, December 1957, p. 39).

BIBLIOGRAPHY

J. P. Hurtgen and A. R. Mounce: New insulation system for hermetic refrigeration motors (ASHRAE JOURNAL, July 1959, p. 60).

H. M. Elsey, J. B. Kelley, and R. B. Sharpe: Estimating water content of certain dried but uncharged hermetic refrigerating compressors (ASHRAE TRANSACTIONS, Vol. 5, 1959, p. 651).

W. O. Walker, S. Rosen, and S. L. Levy: A Study of the factors influencing the stability of mixtures of refrigerant-22 and refrigerating oils (ASHRAE TRANSACTIONS, Vol. 66, 1960, p. 445).

W. O. Krause, A. B. Guise, and E. A. Beacham: Time factors in the removal of moisture from refrigerating systems with desiccant type driers (ASHRAE TRANSACTIONS, Vol. 66, 1960, p. 465).

CHAPTER 49

MOISTURE IN REFRIGERANT SYSTEMS

Sources and Effects; Drying Methods; Moisture Measurement; Desiccants, Adsorption and Chemical Reactions of Desiccants; Driers, Selecting A Drier, Testing and Rating

THE AMOUNT of moisture in a refrigerant system must be kept below an allowable maximum in order to provide satisfactory operation. Therefore, it is imperative that moisture be removed from refrigerant system components during manufacture and assembly, and that precautions be taken to guard against entry of moisture into the system during installation or service operations. Furthermore, any moisture which enters the refrigerant system should be removed as rapidly as practicable.

SOURCES OF MOISTURE

Moisture may be present in a refrigerant system as a result of:

1. Faulty drying of equipment at factory and in service operations.
2. Introduction during installation or service operations in the field.
3. Low-side leaks, resulting in entrance of moisture-laden air.
4. Leakage of water-cooled condenser.
5. Oxidation of certian hydrocarbons of oil to produce moisture.
6. Wet oil, refrigerant, or both.
7. Decomposition of motor insulation in hermetically sealed units.

The drying of equipment in the manufacturer's plant is discussed in Chapter 47.

Proper installation and service procedures will eliminate the sources listed in items 2, 3 and 4. The subject of moisture in refrigerants is discussed in Chapter 19. Lubricants are discussed in Chapter 50. If refrigerants and oils are purchased to meet specifications, and properly handled after receipt, the moisture content generally will be low enough to avoid difficulty. Oils to be used for low-temperature systems may be further dehydrated. See the sections on Hermetic Motor Insulation and Motor Burnouts in Chapter 48.

EFFECTS OF MOISTURE

The presence of moisture in a refrigerating system may result in one or all of the following undesirable effects:

1. Freezing at expansion valves or capillary tubes, or formation of ice in evaporators.
2. Corrosion of metals to form sludge.
3. Flapper valve failure.
4. Copper plating.
5. Chemical damage to insulation or other system materials.

Ice separates from fluorinated hydrocarbons, methyl chloride, methylene chloride, butane, and isobutane whenever the amount of moisture is sufficiently great and the temperature of the refrigerant low enough. The low refrigerant temperature causes formation of ice in expansion valves, capillary tubes, and evaporators. In low-temperature units a plugged expansion valve or capillary tube may result due to the separation of wax from oil-refrigerant mixtures.[1] The presence of wax may be demonstrated by washing the expansion valve with a small amount of carbon tetrachloride, and evaporating the solution so obtained. The presence of white wax or an extremely viscous oil-wax mixture proves that wax is the cause of trouble although this does not rule out moisture. The wax separation characteristics (see section on Floc Tests in Chapter 50) of the oil should be determined,[1] and if they are not satisfactory, another oil should be used.

The separation of water as ice is related to the solubility of water in a refrigerant. The solubility of water varies with the different refrigerants mentioned and is great enough in ammonia, carbon dioxide, and sulfur dioxide so that freezing does not occur. The greater the solubility of water in a refrigerant, the less likely is it that ice will separate. The curves of Fig. 1 show the solubility of water in certain halogenated hydrocarbons.[2] No data are available for butane and isobutane.

Studies[3,4] have shown that iron, aluminum, and copper corrode quickly in the presence of liquid water and fluorocarbon refrigerants. Water dissolved in these refrigerants corrodes slowly even when its concentrations approach the individual saturation points.

The mechanism of corrosion, which results in the formation of metallic salts (sludges) has been studied.[5] Water reacts with sulfur dioxide, methyl chloride and Refrigerants 11, 12, 21, 22, 113, and 114 (hydrolysis[5,6]) when sufficient moisture is present, to form sulfurous, hydrochloric, and hydrofluoric acids. These acids react with iron, copper, and aluminum to form metallic salts (sludges) of well defined composition. Hydrolysis accounts for only a little acid. The greater portion is derived from direct action of the refrigerant and oil at higher than normal operating temperatures.[7,8] By chemical analysis[9] of these salts, it is possible to demonstrate their

The general responsibility for this chapter is assigned to TC 1.11, Sorption.