Air Conditioning and Refrigeration Systems Oil Fouling

➢ Abstract

Air conditioning and refrigeration systems contain a compressor in which, during the normal course of the refrigeration process, the compressor's lubricating oil comes in direct contact with the refrigerant. Since the early days of refrigeration and air conditioning technology, the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) have addressed the results of the **interaction between the compressor oil and the refrigerant. This mixture continuously migrates throughout the entire air conditioning or refrigeration system**.

In the Refrigeration Handbook, published by ASHRAE, it is stated **that some lubricating oil is lost from all compressors during normal operation**. Since oil inevitably leaves the compressor with the discharge gas, systems using halocarbon refrigerants must return this oil at the same rate at which it leaves.[1] ASHRAE states that unless oil is removed periodically or continuously from the point where it collects, **it can cover the heat transfer surface in the evaporator, reducing performance.**[2]

➢ Effects on the System

As the oil and refrigerant mix, the chemical composition of both is drastically altered. Pressure and temperature characteristics of this refrigerant/oil mixture will be different from pure refrigerant. In addition, the viscosity of the oil is reduced by dilution with refrigerant, thereby increasing the probability of poor lubrication in the compressor. It matters little whether the refrigerant is miscible or immiscible with the oil. Contaminating oil films are deposited throughout the system, and it is these oil deposits that ultimately cause multiple problems.

The result of oil contamination is frequently noticed at the expansion device. Materials dissolved in the refrigerant-lubricant mixture, under liquid line conditions, may precipitate at the lower temperature in the expansion device, resulting in restricted or plugged capillary tubes or sticky expansion valves. A few milligrams of these contaminants can render a system completely inoperative.3 Any migrating oil in any refrigeration or air conditioning system is costly, both in kWh consumption and money and lost time spent on maintenance and repairs.

Equipment suppliers may state that in a particular system, migrating oil concentration has been reduced to only one percent. The one percent being referred to is one percent of the total oil volume. If a compressor holds four quarts, or 128 ounces of oil, then at one percent, 1.28 ounces is flowing through the system at any given time. Since a capillary tube, oil pressure switch, or expansion valve can be fouled with a few milligrams of oil, when one percent of any oil charge is flowing constantly through the system, the system will become fouled.

➢ Effects on Heat Transfer

Oil fouling of the heat transfer surfaces of air conditioning and refrigeration systems, will cause a loss of about *7% efficiency the first year*, 5% the second year, and 2% per year the following years. This loss will continue to accumulate until equilibrium is reached between flow force and adhesion. At this point the oil boundary layer formed has achieved its maximum thickness, producing maximum loss of efficiency. Usually, the efficiency degradation will peak somewhere between 20% and 30 %. Published ASHRAE information confirms these observations. According to ASHRAE, performance is degraded by as much as 30% due to the build-up of lubricants on internal surfaces.4 higher percentages up to 40% have been observed in systems 20 years old or older.

➢ Managing the Problem

The oil that finds its way into the system must somehow be managed.5 The obvious question then becomes how to manage this troublesome oil. Some of the techniques used by manufacturers to control migrating oil include the use of mechanical devices such as separators, skimmers, drums, heat sources, suction risers, traps and pumps. According to ASHRAE's Handbook, these high-tech designs are not efficient enough to remove all of the unwanted oil. Most of this oil can be removed from the stream by an oil separator and returned to the compressor. Coalescing separators are far better than separators using only mist pads or baffles; however, even they are not 100% effective. Although the mechanical solutions may reduce the problems of restricted or plugged capillary tubes or sticky expansion valves, they do not resolve the boundary layer fouling over time.

➢ The Solution

The thermal transfer efficiency loss is being resolved using the technology that the Federal Energy Management Program has classified as Polarized Refrigerant Oil Additive (PROA). In this technology, a non-invasive polarized molecule chemically displaces all organic residues adhering to metallic surfaces by virtue of a more powerful van der Waals' force. This electronic attraction overcomes the weaker bonds holding any organic contaminant to a metallic surface. The polarized particle tightly bonds to the metal surfaces in a one-molecule-thick layer and prevents the recurrence of oil contamination on heat transfer surfaces. **The particle is highly conductive itself and restores the lost 20% to 30% thermal transfer efficiency. An added benefit is that the capillary tubes and expansion valves are also cleaned and protected.**

➢ Conclusion

Mechanical devices yield efficiency improvements in the two-to-four percent range, with a Return on Investment (ROI) of three to ten years. The Polarized Refrigerant Oil Additive solution, with an ROI of less than one year, presents a radical shift from "how we've always done it." The new technology is gaining acceptance due to the ASHRAE published information and the potential for 20% to 30% energy savings.

➢ *Added by US RT:*

"The role of lubricants in refrigeration compressors is to reduce friction, prevent wear and also to act as a seal between the high and low pressure sides of the compressor. In the rest of the system, however, the presence of **lubricants acts as a contaminant which reduces the system efficiency**."

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1 1986 ASHRAE Handbook, Refrigeration, Chap. 3.6
2 Ibid. Chap. 4.4
3 1998 ASHRAE Handbook, Refrigeration, Chap. 6.7
4 "A Survey of Refrigerant Heat Transfer and Pressure Drop Emphasizing Oil Effects and In-Tube Augmentation;" ASHRAE Winter Symposium of 1987; Schlager, Pate, and Bergles.
5 1998 ASHRAE Handbook, Refrigeration, Chap. 2.9
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