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The High Cost of Ignoring Chiller Oil Buildup

Failure to control excessive oil buildup in a chiller's refrigerant can badly impact capacity and efficiency. Here's how it happens and some suggestions on how to solve and even prevent the problem

BY MARK KEY

Oil entrained in a chiller's refrigerant charge unnecessarily costs owners thousands of dollars each year in wasted energy and also causes a significant decrease in chiller system capacity.

Every chiller owner needs to address this issue in order to improve chiller efficiency and to obtain substantial energy savings. An hvac contractor or service tech aware of the impact of oil in refrigerant can make a big difference when this problem arises.

Oil enters the chiller's refrigerant charge as it is circulated through the chiller's compressor. In low-pressure chillers (R-11, R-113 and R-123) the oil is used as a lubricant for the centrifugal pump and it seeps through the compressor's seals and becomes entrained in the refrigerant charge.

This same process occurs with high-pressure centrifugal chillers (R-12, R-22 and R-134a most commonly). High-pressure screw chillers (R-12, R-22 and R-134a) utilize oil for lubrication, as a coolant and as a sealing mechanism on screw rotary tips.

Oil inevitably finds its way into the refrigerant charge. In fact, the oil problem extends into other systems, including high-pressure reciprocating chillers, certain rack systems and ammonia refrigeration systems to name a few.

When oil gets into the evaporator, it mixes with refrigerant and degrades system efficiency and capacity. This occurs when the evaporator tubes become coated with oil, creating a thermal barrier. The heat transfer efficiency is retarded and drastically reduces the cooling effect.

An additional concern focusing on oil in a chiller's refrigerant charge was noted in an article in the April 2002 issue of *RSES Journal*. In the article, titled "Making 'Cents' of Preventive Maintenance for Centrifugal Chillers," author Tom Brown notes that "rust particles falling to the bottom of the evaporator shell mix with the oil and can cause improper lubrication, premature parts wear and clogged valves and orifices.

"By comparing the results of the refrigerant analysis against a chiller's historical operating data, experts can reliably diagnose the condition of a chiller and make recommendations accordingly, pinpointing the causes of contamination in the process," he continues.

Oil's impact on heat transfer

Although it is common knowledge that oil buildup occurs, the impact on the system's capacity and energy costs only now are being understood. The following studies note the importance for chiller owners and service contractors to recognize and address this problem.

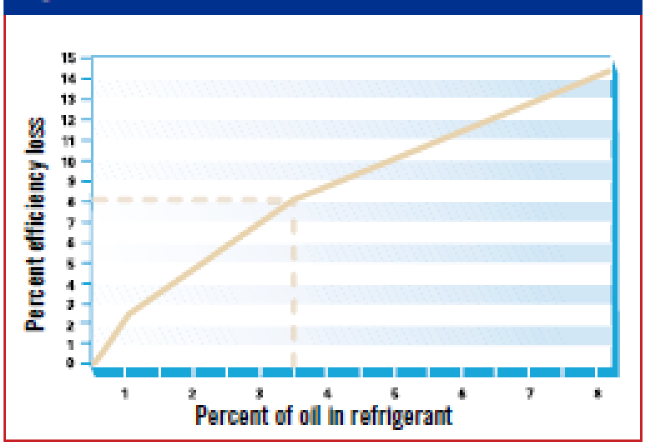
ASHRAE conducted a study titled "Effects of Oil on Boiling of Replacement Refrigerants Flowing Normal to a Tube Bundle, Part I: R-123 and Part II: R-134a." The study concludes: "Flow boiling results have been obtained for the low-pressure refrigerant, enhanced boiling tube in the presence of R-123. This enhanced tube shows a marked decrease in heat transfer with the addition of even a small amount of oil throughout various heat loadings. Even at 1 percent to 2 percent oil, the heat transfer coefficient is reduced by one-third from its no-oil baseline. At substantial oil content (5 percent to 15 percent), a 40 percent to 50 percent reduction (in heat transfer) is noted."

Part 2 of the ASHRAE study reached a similar conclusion: "Flow boiling results have been obtained for a newer enhanced boiling tube with R-134a. This enhanced tube shows a decrease in heat transfer with the addition of even a small amount of oil throughout various heat loadings. Even at 1 percent (by weight) oil, the heat transfer coefficient is reduced by 25 percent from its no-oil baseline. At higher oil content, a 30 percent reduction has been typically measured."

Trane also has studied the effects of oil on chiller efficiency, which led to the company's development of a new oil-free chiller. According to the manufacturer, the oil necessary to lubricate other chillers has the potential to contaminate the refrigerant, degrading energy efficiency. CFC chiller designs typically allow oil absorption of 3 to 7 percent, increasing operating costs by up to 15 percent, Trane claims.

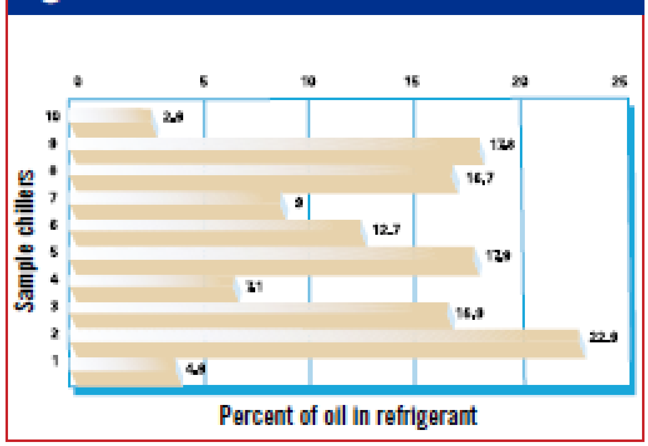
Oil, as a contaminant, significantly impacts chiller efficiency. The more that oil contaminates the refrigerant, the more efficiency is lost and the more money is spent on energy. If the refrigerant charge in a chiller contains even 3.5 percent oil, it could mean up to an 8 percent loss in efficiency, which will impact operating cost, Trane states. (Figure A illustrates the effect that oil, shown as units of percent oil in refrigerant, can have on efficiency, shown as

Figure A.



The graph shows the impact of oil content in refrigerant in terms of efficiency loss.

Figure B.



This graph shows oil content as a percentage of refrigerant in 10 older CFC-11 chillers.

a percent of efficiency loss.)

Over 30 years this equates to almost $350,000 or more than twice the initial cost of the chiller. It also would increase the utility-generated greenhouse gas emissions by more than 4 million pounds of CO_2.

The company further states that the typical concentration of oil in chillers today can be surprisingly high. Figure B shows average oil content (as a percentage of refrigerant) in 10 typical, older CFC-11 chillers to be 13 percent. The efficiency loss is 15 to 20 percent or higher.

Solutions to oil's impact

Figures provided by Trane support the findings in an additional ASHRAE Study titled, "ASHRAE Research Project 601-TRP." In this study, refrigerant samples were taken from 10 operating chillers and analyzed for oil content. All contained excess oil in varying amounts from 3 percent (enough to degrade performance) to 23 percent.

Trane calculated the impact of excess oil on a 1,000-ton chiller operating at 2,000 equivalent full-load operating hours at 8 cents per kwh, $15 per kwh demand and 0.576 kwh/ton. An 8 percent impact on annual cost of operation would be $11,520.

While the studies do show some slight variance, they strongly support each other in the fact that some oil ultimately finds its way into a chiller's refrigerant charge and significantly increases the amount of energy required to run the chiller.

This increased energy consumption drastically increases a chiller owner's electric bill. In addition, the system is losing a significant amount of capacity, and a harder working system increases its potential for breakdown.

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