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The High Cost of Oil Contamination

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The most common and most costly of all the refrigerant contaminants is also the most benign — oil. While moisture, acids, and particulates do physical damage to the refrigerant side of chillers, oil merely reduces efficiency and ramps up energy costs. But higher efficiency and lower energy costs are what we're all after.

How prevalent is oil contamination in today's chillers? If the systems you work with aren't very new, odds are that they contain excess oil in the refrigerant, oil that is degrading chiller performance.

In American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) research project 601-TRP, samples of refrigerant from 10 randomly selected operating chillers were analyzed for oil content. All of the chillers were found to contain excess oil in varying amounts. The three with the lowest amounts had been serviced and had their refrigerant recycled in the last six years, but the oil content in these three was 3-7 percent. The oil content in the refrigerant of the remaining chillers was 9-20 percent. That spells out a significant drop in capacity.

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Oil contamination can be caused by several factors, including gasket failure, but the most common cause of oil migration in comfort chillers is the continued use of a chiller at low loads during the beginning or end of the cooling season.

How much does excess oil in the evaporator degrade performance? Table 1 gives typical ranges for minor contamination levels.

Another ASHRAE study, "Effects of Oil on Boiling of Replacement Refrigerants Flowing Normal to a Tube Bundle, Part 1: R-123 and Part 2: R-134a," concludes: "Flow of 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 (by weight) oil, the heat transfer coefficient is reduced by one-third from its no oil baseline. At substantial oil content (5-15 percent), a 40-50 percent reduction (in heat transfer) is noted."

Part 2 of the ASHRAE study reached the same 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."

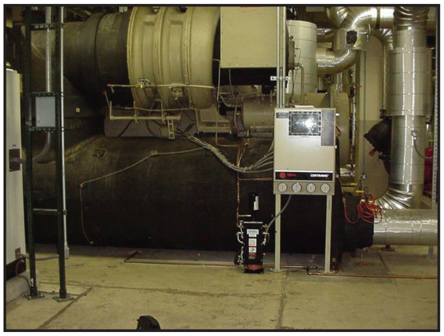
IDENTIFYING AND REMOVING

Until recently, little has been done to identify and remove excess oil from chillers until it becomes a major problem. Why?

First, aside from decreasing efficiency, oil on the refrigerant side does no damage to the system and gives no indication of its presence. Second, it costs more to learn of its presence. Most mechanical contractors routinely perform oil analysis to detect moisture, acids, and metal fragments. But refrigerant analysis, which reveals the presence of oil, is more expensive so it is usually not performed.

And since oil usually accumulates gradually in refrigerant through migration, the attendant loss in efficiency is usually diagnosed to be some other cause. It isn't until performance has significantly degraded that oil is suspected.

The most common way of dealing with oil has been to wait until it becomes a serious performance problem, belatedly identify oil as the cause, pull the charge to be shipped away for reclamation, then install a fresh charge. This is an expensive solution both in the ramped up power demands for the chiller and the cost of decontaminating and replacing the entire refrigerant charge.



OIL IN EVAPORATOR	PERFORMANCE LOSS
1-2%	2-4%
3-4%	5-8%
5-6%	9-11%
7-8%	13-15%

SENSIBLE OIL DECONTAMINATION

Then in the 1990s, two companies developed portable refrigerant reclamation systems that could be taken directly to the job site and decontaminate refrigerant on site. The online capability is particularly important to manufacturers who use process cooling.

In one instance a major film and fiber manufacturer called one of those companies soon after discovering oil in the refrigerant of one of the fiber manufacturer's 10,000-pound process chillers. If the on-site staff shut down the line to remove the oil, it would cost $10,000 an hour in lost production.

One of the reclamation companies brought its decontamination system to the site. The system was connected to the evaporator and circulated the system's refrigerant through the decontamination system, removing all of the oil and returning clean refrigerant to the chiller as it continued to operate. The project was completed with no system downtime and no loss in production.

In another case, a major textile manufacturer had both air and non-condensable contamination problems on an R-134a process chiller. As in the previous case, the company could not afford to shut down the line. Also unusual was the fact that this system used the compressor to sub-cool the refrigerant in the evaporator to 40°F. Then the refrigerant was pumped directly to the air handlers. This process was used because of its ability to dehumidify huge amounts of air.

Technicians for the other company that had developed a refrigerant reclamation system used that system to side stream 2,000-pound batches of the oil-laden R-134a and distill and filter the refrigerant and return it to the system until the entire 16,000-pound charge was returned to ARI-700 standards. More than 100 gallons of oil were removed along with the noncondensables. And there was no interruption to manufacturing.

While these decontamination methods were a vast improvement over the old method, they were still stopgaps and not a permanent solution to refrigerant side contamination. After decontamination, the oil would continue to migrate and eventually performance would deteriorate and a new reclamation would be needed.

A PERMANENT SOLUTION

This year a more permanent solution was introduced by Redi Controls. The OAM 200 Purger system is a retrofit for both high- and low-pressure centrifugal chillers and removes oil, acids, and moisture from the refrigerant.

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"The OAM 200 Purger was primarily designed to remove oil," said Mark Key, vice president of marketing for Redi Controls.

"The acid and moisture removal are bonuses. Advantages are that it connects easily to an operating chiller, performs passively and independently of the chiller whether it is operating or not, and has no effect on chiller operation, other than increasing efficiency, regaining capacity, and decreasing energy usage. Once the excess oil has been removed, the purger returns any excess oil that migrates to the refrigerant side to the chiller's oil sump where it belongs."

The purger uses most of the technology of the old distillation process with some additions. It attaches to the refrigerant charging valve at the base of the evaporator and uses heat to vaporize the refrigerant, routing it through a filter-drier and back to the evaporator. The separated oil itself is filtered to remove moisture and acids, and it's returned to the sump.

One of the most important features is that it operates constantly, even when the chiller is shut down. It pulls out refrigerant, removes oil and other contaminants, and returns clean refrigerant to the evaporator and clean oil to the sump around the clock, all year long.

One of the latest customers to benefit from the new technology was an R.J. Reynolds research and development laboratory in Winston-Salem, N.C.

"We do an annual refrigerant analysis of the five chillers in this building," said Mike Duncan, utilities maintenance technologist for the facility. "This year we discovered excess oil in one — a 750-ton unit. Since it often doesn't always run at full load because other chillers are working as well, we figured that's what caused the oil to migrate."

The company ordered the purger and installed it.

"The chiller wasn't operating, but we started recovering oil right away," said Duncan. "In two or three weeks we had recovered 15 gallons of oil. We don't know how much better the system is going to perform, but with 15 gallons of oil out of it, we know it's going to work a lot more efficiently. The best thing is that we only had to do this once, instead of every year." ■