Water on the Inside

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This article is the thirteenth in a series exploring refrigeration and heat pump concepts without using jargon.

It is important to remember that when air leaks into a refrigeration system it brings other stuff with it. Like an onion, the other stuff is mostly water. In fact, every 9 lbs (4 kg) of air that get into a system bring 1 oz (30 mL) of water with them. This doesn't sound like a lot, but when you purge the air out of the system it leaves the water behind so over weeks and months it can build up. A system that leaks 1 lb (0.5 kg) of air every day will have two and a half pints of water (1.2 liter) in it after a year. The effect of that water depends very much on the type of refrigerant used. I've detailed three very different situations; hopefully, at least one of them is of interest to you.

Fluorocarbons do not dissolve in water to any significant extent, so the liquid water passes from the condenser mixed in with the liquid refrigerant. When it gets to the expansion valve, if the temperature drops below the freezing point, the water solidifies and blocks the valve. Game over. The main symptom of this situation is low suction pressure because you can't get enough refrigerant through the blocked valve to keep the system going. However, it can be quite a puzzle because if the system is off for a long time before it is investigated then the ice may have melted by the time the "blocked" valve is opened up for examination.

Ammonia and water are very fond of each other, and solutions of "aqua-ammonia" are used in many applications from window-cleaning to print-making. They are also, of course, used in absorption refrigerators. This means that water cannot freeze in the expansion valve and so it passes, in solution with the liquid ammonia, to the low pressure side of the system.

If the expansion valve outlet connects directly to the evaporator, which connects directly to the compressor then the water will pass through the system and back to the compressor. All sorts of problems, from dilution of the oil to rusting of the compressor internals might occur, but if the water quantity is small the plant will probably continue to operate normally.

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It's still always better to fix the leak than to have to deal with the consequences.

If the system has a receiver vessel on the low pressure side, such as a surge drum or accumulator, then the water will collect in the vessel and will be pumped around the evaporator. There are reports of ammonia systems with up to 25% water content in the surge drum still functioning, albeit inefficiently. More on that later.

The water builds up in the low pressure liquid because it is much more soluble in liquid ammonia than in gas. The evaporated ammonia gas carries almost no water back to the compressor. The only way it can get out of the system is to draw off a sample of ammonia/water liquid and distil it to boil off the ammonia and leave the water behind. This process can be easily automated if necessary, but as I wrote last month, it is always better to fix the leak than to have to deal with the consequences.

Carbon dioxide is also soluble in water, but not to the same extent as ammonia as any lover of soda pop or champagne can tell you. There are two additional considerations when carbon dioxide systems are contaminated by water. Once the solution is saturated, which requires more than 600 parts of carbon dioxide per million of water at 32°F (0°C) (but only 120 part per million at –40°F [–40°C]), any additional carbon dioxide forms carbonic acid. If oxygen is also present (and remember the water probably snuck in with an air leak) then heavy corrosion can occur.

With very high levels of water, clathrates may form. These are lattices of bonded carbon dioxide molecules that form cages, which trap water molecules. Carbon dioxide clathrates can form solids up to 50°F (10°C), which is another way of blocking expansion valves and filters. They also vanish if the system is idle for too long and so can be difficult to diagnose.

In all cases, with any refrigerant (except R-718), water spells trouble. If you can't keep it out of the system then you have to get it out, regularly.

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