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Still Water

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We are still thinking about the role of water in refrigeration, so we turn to the old-style absorption refrigerators. I was asked the question recently “why is the hydrogen pressure in a refrigerator so high?” If you are thinking “what hydrogen?”, then what follows may come as a surprise.

Refrigerators now are almost all built with compressors using R-134a (about two-thirds of the market) or R-600a, aka isobutane, which is almost universal in Europe and accounts for about one-third of the global market. However, from the earliest domestic refrigerators, developed around the turn of the 20th century, until the mid 1970s, the absorption cycle was commonly used. These machines usually had a small electric heater to drive the system but could be powered by gas, which makes them popular in small refrigerators for mobile homes and RVs.

The absorption cycle was originally developed in the 1850s in France—before the idea of using a compressor to drive refrigerant around the system caught on—and it initially used a mixture of water and ammonia. In these systems the ammonia is the refrigerant and the water is there to provide the impetus for the ammonia to migrate from one part of the system to another. The early French systems worked in a batch process, gradually transferring the strong ammonia solution from one part of the system (like the high-pressure receiver in a vapor compression system) via the evaporator to the low-pressure side.

They would then need to be re-primed, like rewinding an old clock, before being set to work again. In large systems the addition of a solution pump to raise the strong ammonia solution to high pressure enabled the process to be automated, but this was not desirable for the domestic units, especially the gas-fired ones. This is where the hydrogen comes in.

The addition of a third fluid is sometimes credited to Albert Einstein and his colleague Leo Szilard but respect

probably should go first to the Swedish inventors Baltzar von Platen and Carl Munters, of desiccant wheel fame. By creating a three fluid system, they managed to get rid of the need for manual intervention without using a mechanical pump. A liquid trap at the condenser outlet (like the drain from a basin or a toilet) keeps the hydrogen gas in the evaporator. As ammonia gas condenses and flows through the trap, it encounters this zone of the system where the hydrogen creates a low partial pressure for the ammonia. The total pressure in the system remains the same, but if the ammonia only accounts for a small proportion of it then it will boil at low temperature, creating the cooling effect. The boiled ammonia is sucked back into the pool of water where it is heated to separate it from the water and sent back up to the condenser. The whole system runs at about 200 psig (1400 kPa), which means the ammonia condenses

at about 100°F (38°C). When the liquid drains to the evaporator it boils under a partial pressure of 10% of the condenser pressure, at about 6.5 psig (45 kPa), which is -15°F (-26°C).

If this seems improbable check the January 2013 column, which featured the insights of the self-taught English

natural philosopher, Mr. John Dalton. So the answer about high operating pressure is, in effect, “because it wouldn’t get cold enough otherwise.” The pressure needs to be high enough for pure ammonia to condense at whatever temperature the kitchen is; so there needs to be enough hydrogen in the low-temperature part of the circuit to ensure the ammonia gets cold enough to be useful when it gets there.

One quirk of these systems is that, on rare occasions and particularly after long periods switched off, the liquid trap at the condenser outlet would dry out, allowing the hydrogen to flow up from the evaporator and stop the condenser from working. The solution to this dryout was to turn the refrigerator upside down for a moment, enabling the pool of liquid in the bottom of the unit to flow back into the trap. It was watching my father do this to an ancient fridge when I was about seven years old, and we had just arrived at a holiday cottage, that first captured my interest in all things fridgy. This really was a dark art. Of course, you had to remember to take the eggs and milk out first otherwise it would be pancakes for breakfast, lunch and supper. ■

Keeping everything upside down isn't really necessary.



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