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Water, Water Everywhere

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A while back we took several looks at a wide range of refrigerant options, but we ignored the cheapest and most common of them all. With the ASHRAE designation R-718, water has been discussed for many years as a very promising alternative to traditional refrigerants for water chillers and ice makers. Yet, it has not broken through into mainstream applications.

Professor Joe Paul, who until his recent death was president of the Science and Technology Council of the International Institute of Refrigeration, was a passionate supporter of the use of water as a refrigerant. However, he was quick to point out that the safety classification system in ASHRAE Standard 34 was deficient.

"Water," Paul said, "is obviously the most dangerous refrigerant of all, since it is the only one known to contain sharks." It is also responsible (although not in use as a refrigerant) for many more fatalities than all other refrigerants put together through drowning, floods, tsunamis and hurricanes, so it deserves to be treated with respect.

Robinson & Friday didn't know where they would get refrigerant for their leaking R-718 chiller.

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In our more familiar terms it is non-flammable and non-toxic, with no ozone depleting potential. It is cheap and plentiful. Although it is by far the largest contributor to the greenhouse effect, it is fair to say that the incremental climate change effect of water leakage from refrigeration systems would be negligible, even if every chiller in the world used R-718. So why is it not already more popular? Well, in one sense, it already is.

I read in a recent report that absorption chillers, which nearly all use water as the refrigerant fluid and lithium bromide as the absorber, account for more than two-thirds of all chiller sales worldwide. It is the vapor compression chillers that have not yet adopted R-718 in any significant volume.

Volume is the operative word here, because it is the very large specific volume of water vapor (or if you like, the very low density) that presents the greatest challenge to its use in a compressor system. The compressors need to be so huge in comparison to other refrigerants that special designs are required, using some form of turbine. Huge swept volume generally goes with low operating pressure, and sure enough, water systems for closed loop chilling run well below atmospheric pressure. This is the second big challenge for system designers. Any leak on the chiller will allow air to leak in and will stop the chiller from operating.

So, in physical terms, the compressor looks very different—physically very much larger than the evaporator and condenser that it serves and contained in what is, in effect, a vacuum flask. What about efficiency? Well, this is where the odd physical properties of water come into their own. The things that tend to make ammonia very efficient are primarily its high critical temperature and its large latent heat. Water has these attributes far more than ammonia; the latent heat is more than 50% higher and the critical temperature is hundreds of degrees higher than ammonia, which in turn is higher than any other refrigerant fluid. So, it is no surprise to find that chillers based on R-718 are capable of showing efficiencies 20% to 30% better than the best traditional chillers, provided the engineering challenges can be overcome. This could be a crucial benefit in the near future as energy restrictions begin to take a grip just at the time that we are looking for more and more comfort cooling.

Over the next few months we will take a look at various aspects of water as refrigerant, highlighting several traditional ways in which it is already widely used and showing some recently developed systems that might deliver the breakthrough we are all waiting for. Watch this space. ■

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