Refrigerant Acids and Their Treatment

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We all know that the development of acids in the refrigerant of air conditioners, refrigerators or heat pumps can severely shorten the life of the compressor and the refrigerant. But how are these acids formed, and how fast can they burn out a compressor?

First let's recall that acids are typically formed by chemical reactions with components and/or materials of construction, lubricating oils, and/or impurities. Elevated temperatures can accelerate the instability of the refrigerant and cause the formation of acids. This may be the result of improper operation, such as a failed condenser fan or a clogged airflow path. Checking for acid is a common maintenance recommendation since acidic conditions can be easily cleaned up before a compressor motor burns out. After a burnout, proper clean up is much more difficult.

If a compressor does burn out, the oil becomes extremely acidic. If all of the acid is not removed, the elevated acid levels will attack the new compressor and cause a premature motor burn out. Acid cleanup after a burn out must include changing the compressor oil and the refrigerant to reduce the acid level (and changing the compressor) as well as installing a new filter-drier. Unfortunately, however, changing the refrigerant and oil in a system still leaves trace amounts of the existing highly acidic oil throughout the system. Research indicates that residual acid shortens the life of any new compressor because the residual acid will further accelerate acid formation in the system.

A recommended procedure is to add a suction line filter-drier to trap any acid lodged in the system before it can flow back to the compressor. The purpose of this filter-drier is to keep the return flow to the compressor as acid-free as possible, therefore, the filter should be located as close to the compressor suction as practical (since these suction lines could also be contaminated with residual acid).

Even with new refrigerant, oil, and liquid-line filter-drier supplemented with a suction line filter-drier, there still must be some method of removing or flushing the residual acid from the system (note that I said *removing* or *flushing,* and not *neutralizing* the acid). Some ill-informed technicians often make the costly error of believing that the addition of a foreign substance (which forms a chemical reaction to neutralize the acid) will solve their acid problems. This is not the case.

Remember that every neutralization reaction must follow the basic laws of chemistry--acid and base react to form salt and water. The salt that forms is a corrosive metallic salt, which remains in the system to corrode components and potentially clog small passageways (such as bearing oil feed lines and expansion devices). As we know, every acid neutralization reaction leaves a residue. However, some manufactures have created a formulation where the solid residue is dissolved in another foreign substance to form a liquid residue (instead of a solid residue).

This is not a better situation. Adding more foreign substances to dissolve the salt into a corrosive liquid form makes it even more mobile and therefore potentially more damaging. In addition, the solids can still precipitate to clog small passages. Why would anyone intentionally add solvents into a system to make the salt more soluble, and thereby making the potential problem worse? The answer is marketing (not engineering)….this method allows manufacturers to deceptively claim it "leaves no SOLID residue." If you think that is bad, well some manufacturers have even gone so far as to claim that an acid-base neutralization reaction leaves no residue. How is this possible, since <u>every</u> chemical reaction will form products of the reaction? Simple…. take a lesson from politics, and alter your definition of residue! If the "Treatment" product contains a solvent to dissolve the salt, then allege that the resulting solvent with dissolved salt is not a residue, rather it is the treatment. Of course, dissolving the salt in another foreign substance, makes no engineering sense since your have made the corrosive salt more mobile, and you have added potential problems related to the foreign solvent, but from a marketing sense, you can claim "Leaves No Residue"! Any neutralization acid treatment leaves products of the reaction, and since they are foreign substances containing salt and water, that is a contamination or residue. The easiest way to steer clear of all this marketing mumbo-jumbo is to ignore the claims about residue and understand the fundamental chemistry (which you can verify in any high school or college chemistry text book). Any acid-base neutralization reaction forms products of the reaction, namely salt and water, both things I don't want in my systems!

Even more important, however, is that the corrosive salt residue of the neutralization reaction is not the only problem with neutralization acid treatments. Another severe problem is that to neutralize the acid you must add the correct amount of base. But exactly how much are you supposed to add? Adding too much base leaves a residual base which is a caustic residue and is much more corrosive than the salt residue. Adding too little base and you still have remaining acid, which will accelerate the formation of additional acid, and you have not solved the acid problem. In my experience, this is a significant problem with neutralization reactions. It's nearly impossible to add the correct amount of base into a system without knowing the exact amount of acid in the system. Read the neutralization instructions, which typically suggest adding the entire contents of the bottle. But common sense will tell you that a whole bottle can't be the correct amount of base for a range of systems and a range of acid levels (for a high acid situation *and* a mild acid problem)!

So, how *do* we deal with acid? Filter-driers do an excellent job of removing any acid or moisture passing through them. They always need to be changed whenever there is an acid or moisture problem. They are the first line of defense against current and recurring acid problems. Anyone who tells you that you can simply neutralize the acid, and there is no need to change the filter-drier, has no understanding of vapor compression technology - plane and simple!

Driers do a great job of removing acid that reaches the filter-drier, however the problem is that most of the acid is contained in the liquid oil, and with a typical oil circulation rate of a system at less than 2%, if the acid level is high, the system will burn out before enough oil passes through the filter-drier. (Of course with an oil separator installed, even less oil ever makes it to the filter-drier.)

For example, a laboratory test system (using R-22, a hermetic compressor, a new filter-dryer, and an initial acidity value of 133 Parts Per Million Acid (PPM)) was operated continuously for 32 hours and the acidity dropped 45% to 73 PPM. While this may sound great, since the filter-drier is clearly removing the acid, the bad news is that the compressor burned out before reaching 33 hours of operation. It is reasonable to assume that if we could speed the acid removal, we could avoid compressor burn out.

Clearly, without any way to accelerate the rate at which the acid is flushed into the filter-drier, the compressor will burn out (due to the elevated acid levels) before the filter-drier can remove all the acid from the compressor's oil (even with a new filter-drier).

In a comparison laboratory test (using R-22, a hermetic compressor, a new filter-dryer, and an initial acidity value of 133 Parts Per Million Acid (PPM)), this essentially identical R-22 system with 133 PPM initial acid was tested after one percent (by weight) of a patented QwikShot Acid Flush product was added to the operating system. After 20 minutes, the oil containing the acid flush product was tested for acid and it was determined that 100% of the acid was removed from the oil. Remember, without the addition of this acid flush product, the acid level only dropped 45% in 32 hours

The key here is that the acid is not neutralized by the additive, rather the acid has a greater solubility in the additive compared to the oil, and this allows the acid to prefer to mix with the additive rather than the oil. The additive/acid mixture then vaporizes with the refrigerant and travels into the filter-drier. The filter-drier then adsorbs BOTH the additive and the acid leaving no reside. In this way, the transfer of the acid is much faster: instead of a less than 2% rate when the acid is dissolved in the oil, it is more than 98% rate when mixed with the refrigerant. Since the acid is vaporized along with the acid flush and the refrigerant, it can pass through an oil separator and reach the filter-drier from anywhere in the system. The acid flush vapor reaches all parts of the system, to flush the acid from all areas into the filter-drier.

The acid flush is also adsorbed into the filter-drier and therefore *leaves no residue*! The exact rate at which the acid flush is adsorbed in the filter-drier depends on the system flow rate and drier type. However, experiments with an R-22 system have demonstrated that more than 60 percent of this particular acid flush was removed from the oil in less than six minutes. The manufacturer claims that all of the acid flush is normally removed in less than 15 minutes of operation in a typical system.

Furthermore, there are no critical damaging dosage problems associated with using this acid flushing approach, as there are with neutralizing the acid. Recall that too much neutralizer leaves the system basic, so you'd be trading an acid corrosion problem for a caustic basic corrosion problem. However, if too much acid flush is added to the system, it's simply adsorbed in the filter-drier. Wasting your money, but not causing any other problems.

Clearly, instead of neutralizing the acid, the best approach is to flush the acid into the filter-drier and let the filter-drier adsorb it. There is only one method to flush the acid into the filter-drier of an operating system, and this technology is patented (U.S. Patent Number 5,770,048). The patent can be viewed on the Internet at www.uspto.gov.

Finally, of all the acid treatment products available on the market today, only one contains a no damage guarantee, namely "No compressor warranty will be voided due to damage caused by the use of the product when properly used in any system made by any manufacturer." If they are all so safe, why don't they all offer this guarantee?