Don't Treat Today's Refrigeration Systems with Yesterday's Techniques

By Robert Scaringe, P.E., PhD, President of Mainstream Engineering

Mainstream Engineering Corporation
Rockledge, Florida 32955

Today's refrigeration technicians are confronted with refrigeration systems that are vastly different than those serviced last century, but they still continually use the "tried and true" repair/maintenance techniques that used to be very effective.

The hydrofluorocarbon (HFC) refrigerants and polyolester (POE) oils of today's systems have different chemical make-ups than their predecessors--hyrdrochlorofluorocarbon (HCFC) or chlorofluorocarbon (CFC) refrigerants and mineral oil. Essentially the new refrigerants are more stable than the old refrigerants, but the oils are less stable.

Grandpa probably wanted nothing but refrigerant and oil in his refrigeration systems, but today's service technicians don't have that choice. The new refrigerants and oils for the 21st Century already have many built-in additives that were never present in the old refrigerants and oils.

The chlorides used in the CFC refrigerants had excellent anti-wear characteristics. Unfortunately chlorides are one of the reasons CFC refrigerants have been deemed bad for the environment. To fill the anti-wear void created when chlorides were eliminated from the new HFC refrigerants, oil manufacturers put in phosphorus and other additives. Plus there is a full range of aftermarket products that a service technician is enticed to add into a system. Generally, additives within a system fall under three different categories:

1. Additives that are built into today's new HFC's by the refrigerant and oil manufacturers that promote lubricity and anti-wear. These additives usually get consumed during the life of the unit resulting in sludge formation and increased wear or oxidation over time that damage the system.

2. Additives that are not intentionally added to the system, but get into the system during the manufacture or installation of the equipment. (such as acid, air, or moisture)

3. Aftermarket additives introduced by a technician that remain in the system and increase the formation of sludge or alter the equilibrium chemistry of the oil.

In general, the refrigerant and oil manufacturers have ensured that their proprietary compositions of additives are compatible within each other. However, combining these chemical additives with acid neutralizers, untested flushing fluids or leak stopping chemicals is a recipe for disaster. Many technicians also fail to realize that water and air in a system is more of a problem with the new synthetic oils.

In general, the refrigerant and oil manufacturers have ensured that their proprietary compositions of additives are compatible with each other. However, combining these chemical additives with acid neutralizers, dyes, or leak stopping chemicals can be a recipe for disaster. Many technicians also fail to realize that water and air in a system are more of a problem with the new synthetic oils.

Acid Issues are Different

Organic acids - which are milder - were once considered to be the only acids that can be formed in HFC/POE systems, however new research has changed that opinion. Mineral acids can still be formed in HFC/POE systems. For example the 2000 ASHRAE paper by K.C. Lilje "The Impact of Chemistry on the Use of Polyol Ester Lubricants in Refrigeration," examined the effect of various phosphorus antiwear additives on the formation of acid in HFC/POE systems and found strong mineral acids in the system. Therefore while the failure mechanism in HFC/POE systems may be sludge build-up due to precipitation from mild organic acids, these systems can also burn-out from strong mineral (inorganic) acids. In the example cited here a "conventional" mineral-acid (strong-acid) burnout would probably occur in about 40 hours of run-time for this situation. Thus, strong mineral acids and subsequent burn-outs can occur even in POE systems. The statement that HFC/POE systems don't form dangerous mineral (inorganic) acids is technically true. The problem is that in the real world the systems contain more that just pure HFC refrigerant and pure synthetic oil. The oils can have additives that generate mineral acids when exposed to air and or water.

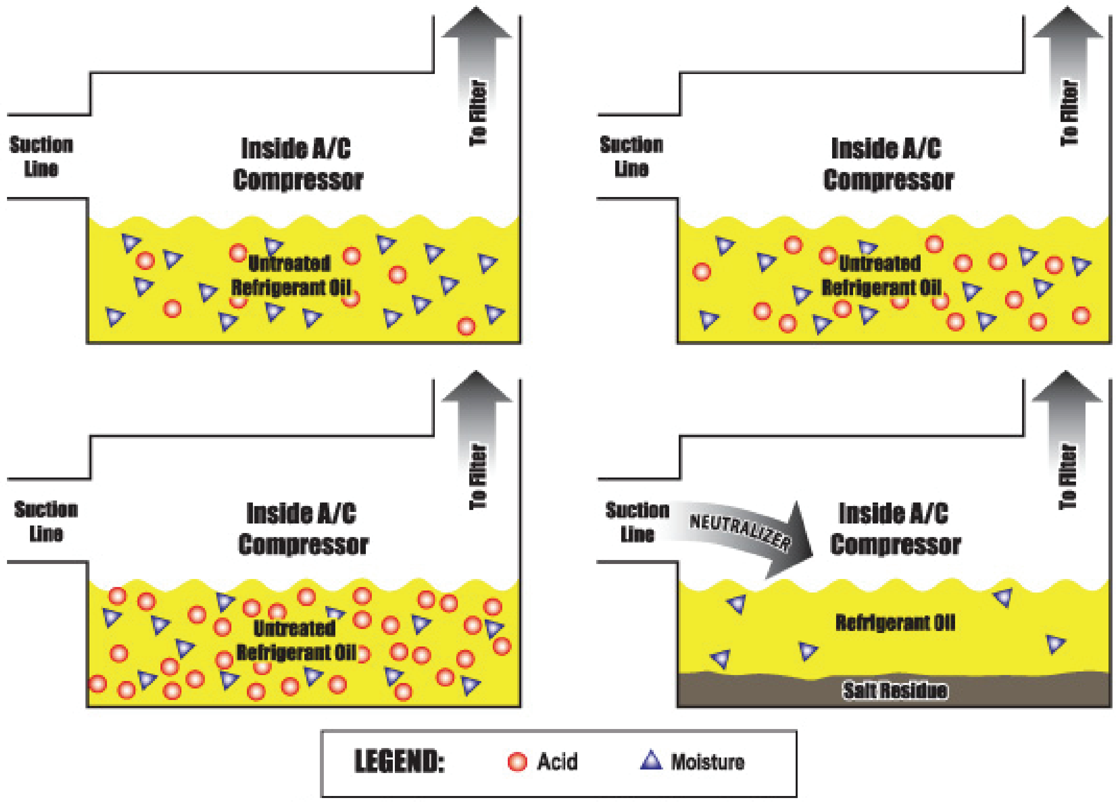
Mineral acid has always been a problem because it leads to etching of the insulation off the motor windings and subsequently to compressor burnouts. The formation is accelerated by the presence of water. In the old days, a CFC or HCFC refrigerant's breakdown into an acid quickly led to system failure. With today's HFC/POE systems however, rapid compressor burnout worries take a backseat to the threat of a POE oil breaking down into precipitous sludge leading to system failure. In the old days it was the refrigerant breaking down, whereas now it's the oil breaking down. Today, both forms of acid should warrant consideration.

An understanding of POE oil basics helps explain why the presence of water in the system exacerbates the problem. POE oil is made from organic acid in an esterification reaction. When exposed to water the POE lubricant hydrolytically decomposes back into an acid. The amount of acid generated from POE hydrolysis is dependent on the amount of water available. More water causes more acid to form. Unfortunately, POE, PVE and PAG oils are very hygroscopic with saturation values of 2,500, 6,500 and 10,000 ppm water respectively, compared to only 25 ppm for mineral oil. (That is 100-times to 400-times the water!) While PVE and PAG are different than POE and not subject to hydrolysis, they are still prone to a similar oxidative degradation which also forms sludge.

All POE oil manufacturers introduce proprietary anti-wear and anti-oxidation additives into their oils. Therefore adding something else to the mix such as an acid neutralizer, dye or leak sealing compound can cause problems that not even the HFC/POE manufacturers cannot predict.

Add water and an improper or an abbreviated evacuation to the mix, and the situation quickly worsens. In the older systems, air was more benign if it remained after evacuation. Today, the oxygen component of air reacts with the POE oil and the additives to increase the formation of precipitates and deplete the benefits of the oil additives. This makes a full evacuation critical today. Performing a token evacuation isn't good enough.

A very popular additive among service technicians is one to remove acid. Most acid removal additives are actually acid neutralizers, which should not be used. Throwing an acid neutralizer into a system will always form a precipitate, namely sludge (corrosive metallic salt), and water. This isn't an opinion, but a fact found in any chemistry book: Acid + Base forms salt and water. Also, ester oils are made from an acid esterification process. Exposing them to a base during acid neutralization is not a good idea.



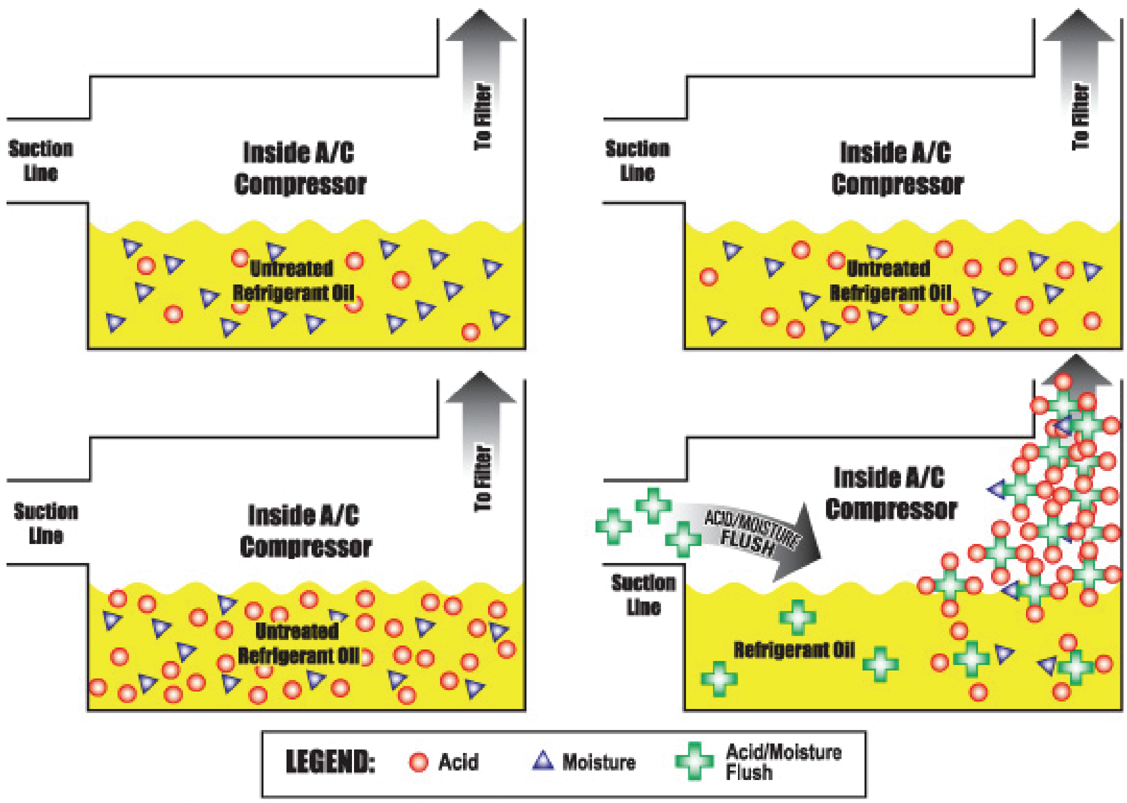
Acid neutralizers remove acid buildup, but leave precipitate (salt or sludge) and moisture behind.

Since the new HFC systems are already plagued with sludge and water problems, potentially making more water and sludge is a really bad idea. Acid neutralizers are also less attractive in HFC/POE systems because of the many proprietary additives in the POE oil that could produce a chemical reaction that results in other byproducts - in addition to the water and sludge

After repairing the cause of the acid formation; an operating system with acid or moisture content leaves the technician with three choices. The first option is to evacuate the system, replace the refrigerant and filter-driers, and put the system back in operation. However, because of the aforementioned problems with HFC/POE systems, the technician should really return to the site for acid checks several times.

The second alternative is to leave the acid in the system until the motor windings burn-out or the acid and moisture combine with the refrigerant and oil mixture to form a sludge that will seize the compressor, plug the TXV(s), or damage the system in some other way.

For systems or equipment owners that can't absorb the cost of the aforementioned alternatives, the last alternative is an acid remover, such as QwikShot® Acid Flush™, that flushes acid and also water into the filter/drier without neutralizing it. This is the product for a service tech that believes only refrigerant and oil can exist in a system. Unlike neutralizers, an acid flush is a low viscous liquid product that chemically attaches itself to acid and water and flushes both itself and anything it is carrying (acid and/or water) to the filter/drier.



True acid removers flush both acid and water from the compressor to the filter-drier, leaving no harmful sludge inside the system.

It is important to note that an acid flush isn't added until after the system is put together, charged with refrigerant, and operating. Only then can QwikShot acid flush be quickly added to the system with a patented QwikInjector® injection tool. Pouring this acid flush in before brazing, evacuating, recharging, operating as one might do with the neutralizing products will simply boil all the acid flush away during evacuation and leave the system susceptible to residual acid and water again. To be safe, only use QwikShot because it is the only acid flush product that carries a lifetime guarantee against damaging compressors and other components with a free replacement policy.

Regardless of what any neutralizing and flush product manufacturers claim, the filter/drier should always be changed. Many older systems have never had a filter/drier change, but this practice is absolutely necessary for preventing acids and moisture. A suction-line filter/drier should also be used after a burnout. If acid or moisture is present in a system, the original filter/drier probably wasn't working. Changing the filter/drier simply gives the system a fresh start and the full capacity to handle trace acids that occur during operation. If acid is treated or the system is replaced, it's a good practice to perform frequent service calls until future acid tests prove negative.

System Flushing

Grandpa's method of flushing out contaminants with R-11 is outlawed today by the Clean Air Act that bans the manufacturing and venting of CFC refrigerant, including R-11.Tests prove that traces of mineral oil left in a CHFC to HFC system conversion can potentially result in the formation of strong mineral acid that will burn out the newly converted system, even though it operates with POE oil. This is particularly common when old line sets are reused. Because it can be cost prohibitive to replace line sets when they run through finished walls, ceilings or under concrete slabs, it's critical to sometimes flush converted systems before start-up.

Particulate flushing products are either aqueous or non-aqueous. Because the aqueous varieties are water-based they should be avoided since even one drop of water can cause damaging chemical reactions with new moisture-sensitive HFC/POE systems.

Typically the non-aqueous particulate flushes come in two varieties—biodegradable, such as Qwik System Flush™, and non-biodegradable. Another consideration is that it is always a good practice to perform a Material Safety Data Sheet (MSDS) comparison between products**.** Avoiding hazardous compounds seems obvious, yet some of these products are actually quite hazardous to your health. There's no research on the carcinogenic effects to technicians or the hazards to the environment after a non-biodegradable flushing chemical is blown out of a system and into the air and ground. The problem is most service technicians don't have the equipment or experience to handle hazardous materials or they discount potential health risks. One popular flushing compound is actually HARMFUL if inhaled or contacted with the skin. For obvious reasons, I do not think you should use that product. If you don't read the MSDS, you may be exposing yourself unnecessarily.

Additionally, non-biodegradable mixes potentially become an environmental waste problem because if it is just thrown away it will eventually make its way to the underground water table. A better method of system flushing is to get the system as clean as possible with a preliminary nitrogen purge, introduce a degradable flush such as Qwik System Flush™ (Qwik – SF), re-purge with nitrogen to remove any remaining impurities, change the filter/drier, properly evacuate the system (to remove any remaining System Flush), charge with clean refrigerant, and then allow the refrigerant to filter out any other possible contaminants during operation. Independent test results confirm that Qwik System Flush removes more acid and water than any other flushing product tested.

It is further recommended to accelerate the refrigerant's cleaning process with the aforementioned safe acid/moisture flushing additive QwikShot Acid Flush (introduced into the sealed operating system). Acid Flush is absorbed into the filter/dryer and thereby safely and permanently captured.

Dye Additives

Dyes are another additive that should be avoided. It's a solid that's pulverized and then emulsified with oil. Once again, there's no concrete evidence that dyes won't add to the sludge being formed in HFC/POE systems. Dyes are popular in automotive air conditioning. One automaker even puts dyes into a/c systems at the factory to speed the leak detection process at the dealer repair level. However automotive compressors are expected to last only about 400 hours, which probably isn't a long enough gestation period for precipitates or corrosion to appear. Conversely, an residential HVAC system compressor has a minimum life expectancy of 4,000 hours and most likely can run somewhere between 8,000 and 12,000 hours if there isn't internal problems. Therefore, a dye additive should be used as a last resort after other sources of leak detection have failed.

The leading detection alternative for HFC/POE systems is still electronic sniffers even though they are subject to false alarms and are sometimes unable to determine the leak location. There is of course the old tried and true method of looking for oil residue at locations where the refrigerant and oil have leaked out. The refrigerant boils off, but the oil residue might be visible. Since most of today's POE oils have a phosphorous additive, there might be some faint fluorescing that can be spotted with an ultra violet black light (a UV blue light will usually not fluoresce the oil additives).

Today's HFC/POE systems are truly different than their predecessors a generation ago and in some ways more volatile. Good service technicians should continue to learn about and understand the differences and then adapt their service techniques appropriately to the new refrigerants and oils.

Bio: *Robert Scaringe is president of Mainstream Engineering (www.mainstream-engr.com), Rockledge, Fla., and has been involved in the development of advanced vapor-compression heat pump systems for more*

than 33 years. Scaringe has been very active in the chemistry of real HFC systems, the effects of additives, acid and moisture on system life, precipitate formation and compressor wear. He currently has more than 70 HVAC-related patents. Recently, Mainstream Engineering developed the first refrigeration compressor to fly in space on the International Space Station as well as the gravity insensitive heat pump which will be the thermal control system for the new Moon Colony and the Orion, NASA's future Crew Exploration Vehicle. Mainstream Engineering's QwikProducts HVAC/R division markets advanced patented products such as QwikShot Acid Flush to flush acid and water into the filter/drier of operating systems, F-11 System Flush, a substitute for R-11 for cleaning systems, QwikInjector Acid Flush injecting tool, QwikCheck, a five-second trace acid indicator, and QwikLug compressor terminal repair kit. More information can be found at www.qwik.com.