Desiccants & Driers

By Norm Christopherson

Filter-driers play a pivotal role in the operation of hvac systems. At the heart of the drier is the desiccant held in the drier's cylindrical metal container. As important as the filter-drier is few actually understand how they work. Here are some details.

The word "desiccate" means to dry out completely and a desiccant is a material or substance that accomplishes the moisture removal. Moisture in the mechanical refrigeration cycle is detrimental to the operation and life of the system. The filter-drier is an accessory that performs the functions of filtering out particles and removing and holding moisture to prevent it from circulating through the system.

Moisture In A System

Consider a chemist working with chemical elements to create new substances. The chemist combines atoms of selected elements to cause them to bond or link together to form new combinations of molecular structures. These new molecular structures are called compounds. Chemists perform such creations in the process of developing new synthetic oils, refrigerants, glues, rubbers, metal allows and a host of other products that are useful in many ways.

Some combinations of atomic elements create molecular structures that can be either useful or harmful. Acids are formed when the right combination of elements are linked together chemically. If we have a use for the acid and use it for its intended purpose, all is well. However, in some cases unwanted chemical combinations occur where we least want them and where they cause serious harm. Under certain circumstances hydrochloric and hydrofluoric acids chemically form in the mechanical refrigerant system. This, of course is what we want to prevent.

Again, let us consider how the chemist facilitates the chemical bonding process. The chemist wants certain chemical reactions to take place in an effort to create new substances that hopefully have special properties that are useful. Perhaps the chemist is attempting to create a new refrigerant to replace another that is being phased-out. The chemist combines particular elements to form bonds or links that when complete meet all the qualities of a great refrigerant. A catalyst is anything that hastens, encourages or helps bring about a result. Heat is one of chemistry's most active catalysts. A chemist may purposely add heat to a beaker of chemicals to cause them to combine to form a new substance.

The HVAC System As A Chemistry Set

That's right, the mechanical refrigeration system consisting of a compressor, condenser, metering device, evaporator, copper lines, oil and refrigerant are a complete chemistry set including several powerful catalysts!

The system contains components which consist of a number of metals such as the iron casting of the compressor, copper lines, steel condenser, aluminum evaporator, brass valves and fittings and perhaps still other metals in smaller quantities. The components are assembled using still other metals and chemicals during the brazing process. Flux is applied to facilitate the chemical process of brazing and heat is applied with a torch as the catalyst.

Still other materials (chemicals) are contained in the system. Compressor motor winding insulation and varnishes, epoxy glues and perhaps rubber and gasket materials are applied. Of course, two of the major chemical materials that constantly circulate through the system are the refrigerant and oil.

The system contains a vast number of chemicals. (Everything physical is chemical and consists of atoms capable of bonding with atoms of other elements under the right circumstances) Now, if yet additional elements are introduced to the existing combination of elements making up the system the chemical bonding possibilities become still greater. During the installation or servicing of the system air consisting of hydrogen, nitrogen and oxygen may be introduced. Moisture may be introduced and flux or even powder from the inside of Armaflex insulation may get into the system. The moisture and oxygen are very active components that act as catalysts themselves.

Additional catalysts in the form of heat of compression as well as latent heat in the condenser and pressure are present. Imagine the possibilities! The chemicals present are compressed, heated and liquefied. Then they are evaporated and cooled as the pressure is released. Then, the process is continually repeated for hours, days and months until a chemical reaction takes place. On hot days the high temperature and pressure on the high side of the system reaches still higher levels. The catalysts of heat and pressure could almost make a chemist jealous.

When a chemical reaction occurs the typical chemical bonding creates hydrochloric and hydrofluoric acids. These acids then go to work breaking down the metals and other materials of construction adding soluble metal to the chemical reaction. A number of other chemical reactions may take place and the circulating refrigerant and oil carry the entire mix throughout the system where it can continue the process.

One authority on acids informs us that for every 18 degrees Fahrenheit an acid is heated, its activity level doubles.

Eventually, the motor winding insulation may be destroyed and the motor windings begin to pass electrical current between each other. As the motor begins to burnout smoldering products from the burning motor are pumped throughout the system. Remember, the motor will be cooking and burning while the compressor is pumping these products through the system. Liquid refrigerant and oil are fairly good cleaning agents so the piping where liquid refrigerant is located may remain fairly clean of the resulting debris. However, in the evaporator a distillation process is taking place, the refrigerant is changing from a liquid to a gas so the debris becomes separated from the refrigerant and begins getting deposited in the evaporator and suction line. This is why the low side of a system that has experienced a compressor burnout is where the majority of the debris is located.

Keep It Clean!

The case has been made as to how important it is to prevent chemical reactions from taking place in a system. It almost seems from what we have described up to this point that it could be difficult to prevent chemical breakdown from occurring. Fortunately, the installation crew and service technician can prevent system failure due to a chemical reaction.

It is imperative that installation and service technicians prevent foreign materials, air, moisture, brazing flux, carbon created during brazing and Armaflex insulation powder from entering or remaining in a system. Good piping practice includes bleeding a small amount of dry nitrogen through the system while brazing. Pipe ends need to be sealed prior to sliding pipe insulation over the piping. A good 500 micron evacuation should be reached to remove air and moisture before charging with refrigerant. And, the addition of a properly sized filter-drier is important on both new systems as well as anytime a system is opened for service. The filter-drier is designed to both remove any particulates that may circulate as well as collect and hold any moisture that may remain in the system. The use of a filter-drier containing a good desiccant has become even more important with the advent of R-410A systems, which utilize the highly hygroscopic synthetic Poly Ester oils.

How A Desiccant Works

Modern filter-driers contain desiccants that function on the principle of adsorption. Adsorption is not the same as absorption. The term absorption is commonly misused in the technical sense of the term. When we say that a sponge or paper towel absorbs a liquid spill we are using the term in its non-technical sense. Actually, absorption is the attraction and holding power through chemical action. Modern desiccants do not function on the basis of a chemical attraction. The desiccants commonly used in filter-

driers utilize the process of adsorption. Adsorption is a physical process and is simpler and easier to understand then the more complex chemical process of absorption.

The modern desiccant of choice is a material called zeolite. Zeolite has gained in popularity over the older desiccants activated alumina, silica gel, calcium chloride and calcium oxide. Zeolite is a mineral that occurs in nature or can be manufactured. Zeolite is an inorganic tan or gray porous solid consisting of a structure of pores and tiny chamber capable of collecting and holding moisture through capillary action. Adsorption is the physical trait of capillary action whereby moisture is drawn into small pores much like a sponge or paper towel collects liquid spills. There are hundreds of different zeolites each with its own micro sized shape, lattice structure and size. Zeolites can be selected to collect and hold many different substances according to the molecular size and structure of the specific molecule one wishes to collect. The zeolite selected for use in a filter-drier is selected to adsorb moisture while allowing refrigerant to pass through. One example of a zeolite is a very light and porous volcanic rock. Zeolite filters are used as desiccants and filters for refrigerant, acids, specific chemicals and to remove ammonia in fish tanks.

Zeolite desiccants are formed into a porous solid core, which is placed in the filter-drier container. Older loose fill desiccants like silica gel occasionally broke down into particles or dust that sometimes left the filter-drier and circulated through the system often creating a restriction especially on capillary tube systems. This was avoided by positioning the filter-drier vertically so pressure pulsations in the system did not shift the loose fill back and forth physically breaking down the loose fill. Solid core zeolite desiccant filter-driers may be installed in any position. Most solid core desiccants are molded into a cylindrical block with a tapered axial hole down the center to allow for the uniform flow of the refrigerant through the entire bed of desiccant. This is why filter-driers are directional with the direction of flow indicated on the container. Installing the filter-drier in the wrong direction causes non-uniform refrigerant to desiccant contact and increases pressure drop. Bi-flow filter-driers are available for heat pump applications.

Capacity

Capacity refers to the amount of moisture the desiccant in the filter-drier can hold. Capacity is measured in “parts per million”. One part per million (ppm) is one part of water per million parts of refrigerant. In practical terms this would be approximately equal to one drop of water in a 125-pound drum of refrigerant. Desiccant capacities are rated at 75 & 125 degrees F. The older desiccant, activated alumina had a moisture holding capacity of 4 grams of moisture per each 100 grams of desiccant. Silica gel had a moisture holding capacity of 3 grams of moisture per each 100 grams of desiccant. Modern zeolite, molecular sieve desiccants have a capacity of approximately 16 grams of moisture per 100 grams of desiccant.

The capacity of a desiccant is temperature dependent. The colder the desiccant the more moisture it can hold. Therefore, locating a filter-drier in a cooler location is an advantage. Removing a brazed filter-drier with a torch flame causes moisture to be driven out of the desiccant and into the system. Generally, it is better to cut the filter-drier out with a tubing cutter.

Location

The desiccant works better at removing and holding moisture when it is placed in a refrigerant line where the refrigerant is in the liquid state. The filter-drier is often called a "liquid line filter-drier" for this reason.

Suction Line Filter-Driers

The desiccant is still able to adsorb moisture when applied to the suction line but not quite as effectively. Special suction line filter-driers are made for cleaning up a system after a compressor burnout. A larger shell is used to minimize pressure drop on suction line driers. Suction line filter-driers marked as "HH" driers contain carbon filter material in addition to the zeolite desiccant. The carbon and zeolite are capable of capturing and holding acids as well as moisture. Suction line filter-driers used to clean up a system after a burn out should be replaced until the system is known to be clean and no longer tests positive for acids in the system. A suction line filter-drier with an excessive pressure drop across it should not be left in a system. An excessive pressure drop in the suction line reduces the volumetric efficiency of the compressor thus reducing system-operating capacity. Many suction line filter driers have a pressure tap on the inlet end so the pressure on the inlet of the drier can be compared to the pressure at the suction service valve at the compressor. Still other suction line filter-driers have pressure taps on both the inlet and outlet.

Alcohol Additives

Some technicians add alcohol-based additives to a moisture-ridden system to prevent moisture from freezing and restricting the metering device. Modern zeolite molecular sieve desiccants have the ability to adsorb these additives to an even greater degree than moisture. It is possible for a desiccant that has already captured moisture to release some of that moisture and replace it with the alcohol additive thus reducing the moisture capacity of the desiccant.

Reactivating Filter-Driers

In the past, some have attempted to reactivate and reuse a filter-drier by heating and evacuating the desiccant. Heating and evacuating does actually remove much of the moisture and allow the drier to be used again. However, oils, carbon and other particles are not removed during this reactivation attempt. In fact, the oil may be cooked into the desiccant creating new contamination possibilities. The cost of a new filter-drier is not worth the effort and is not recommended.

Don't allow a system to become an out of control chemistry set. Good piping practice, a nitrogen purge during brazing, a deep evacuation and the proper installation and use of filter-driers containing modern and effective molecular sieve desiccants will prevent many system failures. Many compressor failures are blamed on the compressor when the actual problem was caused by a system problem. That system problem may have been a chemical problem due to moisture.