Refrigeration is the transfer of heat from a lower temperature region to a higher temperature region. The most common refrigeration cycle—used in home refrigerators—is the vapor-compression refrigeration cycle. This cycle has four components, as seen in Figure 1:

→ Compressor;
→ Condenser coil;
→ Expansion valve; and
→ Evaporator coil.

The beginning of the refrigeration cycle starts at point 1 (see the lower right section of Figure 1). At this step, the refrigerant in the system is saturated—or a superheated vapor—and has a low pressure. This low-pressure refrigerant in the suction line is then driven through the compressor to point 2 (see the upper right section of Figure 1).

The compressor compresses the saturated vapor, increasing the pressure and temperature, turning it into a superheated vapor. Next, the superheated vapor flows through the condenser coil. There, two processes occur: 1. the refrigerant is condensed, or changes from a vapor to a liquid; and 2. the refrigerant is subcooled from its superheated state. The cooler refrigerant is now present as 100% liquid in the liquid line at point 3 (see the upper left section of Figure 1).

After the refrigerant passes through the expansion valve, it takes the form of a mixture—consisting of 75% liquid and 25% vapor. This mixture now has a temperature lower than the refrigerated space. The expansion valve controls the flow of the refrigerant to the evaporator coil.

Finally, the liquid/vapor mixture enters the evaporator coil, as seen at point 4 (see the lower left section of Figure 1). Here, the mixture completely evaporates—changing from a liquid to a gas—by absorbing heat from the refrigerated space. The refrigerant then exits the evaporator coil as a saturated vapor and reenters the compressor, completing the cycle. In a home refrigerator, this process keeps food cold.

Brazing alloys/methods

Brazing in the HVACR industry is much different from brazing in the plumbing industry. Solder alloy is adequate for plumbing components, due to the prevalence of low-pressure water or fluid lines. However, refrigeration cycles and air-conditioning systems are high-pressure, high-temperature systems requiring true braze alloys that are stronger than solder alloys.

This section will focus on alloy selection; gas and torch selection; brazing method; nitrogen purge; and system evacuation and charge.

Alloy selection

The HVACR industry uses these four common base materials: copper, brass, steel and aluminum. There are two general types of brazing filler metals used for joining copper tube. Classified according to their components, they are AWS A5.8 BCuP (Brazing-Copper-Phosphorus) and AWS A5.8 BAg (Brazing-Silver).

BCuP filler metals are preferred for joining copper tube and fittings. The phosphorus in them acts as a fluxing agent and the lower percentage of silver makes them relatively inexpensive. When copper tube, wrought copper fittings and a BCuP brazing filler metal are used, fluxing is optional due to the self-fluxing action of the phosphorus. A number of alternative filler metals are available for brazing in this industry, as well.

The choice of filler metals for brazing depends on four main factors:

→ Dimensional tolerance of the joint;
→ Fitting type and material (cast or wrought);
→ Desired appearance; and
→ Cost.
A variety of alloys is available and the most common joints faced in the field are copper-to-copper; copper-to-brass; copper-to-steel; and copper-to-aluminum and aluminum-to-aluminum. Although some refrigeration joints may require joining stainless-steel valves or tubing to other base materials. Source: RSES SAM Chapter 630-41A.

**Gas and torch selection**

After determining which alloy to use for the application, the next step is selecting the correct gas and torch type. There are four main gases used in the HVACR industry for brazing:

- **Propane gas**—This gas has a flame temperature of roughly 1,800°F (982°C). Use this gas primarily for aluminum-to-aluminum joints and aluminum-to-copper joints, as it has the lowest flame temperature.

- **MAP Pro gas**—MAP Pro gas is a propylene-propane gas mixture with a flame temperature of roughly 2,200°F (1,204°C). It can be used for aluminum-to-aluminum joints and aluminum-to-copper joints.

- **Air-acetylene**—This gas has a flame temperature of around 2,700°F (1,482°C). This type of brazing requires a cylinder of acetylene gas and incorporates atmosphere air to produce the torch flame. Air-acetylene is primarily used for copper-to-copper, copper-to-brass and copper-to-steel joints. It is not recommended for aluminum joints, as the flame temperature is significantly higher than propane or MAP Pro gas and can melt the aluminum base metals.
Clean refrigeration oils and dirt or soot off parts before installing new components or when repairing leaks in installed systems.

Once the proper gas is selected, choose the correct torch tip before starting to braze. Each torch body manufacturer has a list of recommended torch tips, based on the size of the tubes being brazed. Contact your torch body manufacturer for proper sizes.

Brazing method
After selecting the correct gas and torch type, it is time to braze. Remember these key steps to producing a leak-proof, quality joint:

→ **Good fit**—Make sure the joints fit together well and the clearance is 0.002–0.005 in. (0.05–0.13 mm).

→ **Clean metals**—Surfaces must be clean and free of contaminants. Clean refrigeration oils and dirt or soot off parts before installing new components or when repairing leaks in installed systems. Also, be sure to properly cut and ream tubes to remove any burs.

→ **Proper flux**—Use the correct flux for each application of base metals. Flux for this industry comes in three forms: paste, flux cored and flux coated. Use paste flux with any solid-wire product. When brazing with aluminum, additional flux is not needed, as the flux is inside the wire of the alloy.

→ **Fixturing of parts**—Make sure that all tubes seat against the bottom of valves and fittings.

→ **Proper heating**—When brazing in HVACR, use the correct heating method to form leak-proof joints. When heating the joints, apply uniform heat over both the fitting and the tube by constantly moving the torch back and forth over the joint.

→ **Final cleaning**—After brazing with either paste flux or with flux-cored or -coated alloy, the flux residue must be cleaned off the parts to prevent corrosion. Remove residue using hot water and mechanically cleaning the flux off the joints. Flux from flux-cored aluminum products does not need to be cleaned.
Nitrogen purge
When brazing in HVACR, keep the inside of the tube free of oxidation by purging the system with nitrogen. Nitrogen acts as a cover gas to prevent surface oxidation inside of the tubes. Note that the industry’s move toward polyolester oil (or POE oil) requires purging with nitrogen during brazing. POE oil is very hygroscopic (water-loving) and reacts with residual moisture in the system if not purged with nitrogen.

System evacuation and charge
Once brazing is complete, and you have removed flux residue from parts, the next step is checking for leaks in the system. To ensure that moisture is vacated, the lines must have an evacuation to 500 microns, measured with a micron gauge. If the system cannot be evacuated to 500 microns, this may indicate a leak. Finally, charge the system with the required refrigerant per customer or industry specification.

Conclusion
In summary, choosing the correct brazing alloy and flux, the correct torch and gas, and then following the proper brazing methods helps technicians produce leak-proof, quality HVACR joints. Following industry-specific practices of purging then charging the system to the correct pressure prevents contamination and joint failure. 

Lucas Milhaupt originally published this feature as a two-part blog available at www.lucasmilhaupt.com/en-US/about/blog. For additional technical information on brazing or for more information, visit www.lucasmilhaupt.com.

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