A Summary of Soldering and Brazing: Procedures, Materials and Equipment used in the HVAC/R Industry

Soldering and brazing are methods used in the **HVAC/R** industry to join the same or different metals together to form pressure/vacuum tight piping and tubing systems. The most popular tubing in use is made of copper. This article is meant to supplement the information found in textbooks thus providing the student/technician with a ready reference guide.

Definitions and Fundamental Concepts

Soldering is a "low temperature" process used to join the same or different metals together, using a "filler" alloy that is different than the metals being joined. The soldering process takes place at temperatures below 840^{o}F.

Brazing is a "high temperature" process used to join the same or different metals together, using a "filler" alloy that is different than the metals being joined. The soldering process takes place at temperatures above 840^{o}F.

Welding is a high temperature process whereby pieces of the same metal are joined by melting the metals and the filler metal to form one solid unit. Welding temperatures vary, depending upon the metals being joined.

Fluxes are chemicals that bind with oxygen in the air and oxygen on metal surfaces (metal oxides), removing it from the overall chemical process. An oxidation layer on metal surfaces makes soldering, brazing and welding difficult or impossible. **Fluxes should state the purpose, soldering or brazing, on the container – always read the label!! Soldering** fluxes may be either fluid, similar to water, or paste: both are quite **acidic**, therefore caution must be exercised in the use and handling of these substances. **Brazing** flux is a white paste and is also quite corrosive therefore, wash your hands thoroughly after soldering or brazing.

Note that before flux is brushed onto the working surfaces, they must be cleaned with sand cloth and/or wire brushes.

Soldering alloys used in HVAC/R usually contain **4% or 6% silver** and melt around **500^{o}F**. The silver content allows the alloy to flow easily when heated and increases capillary action between the metals being joined and the filler alloy. Stay-Brite and Stay-Brite 8 are well known examples of this type of alloy.

Silver containing alloys can be used to join copper-to-copper, copper-to-steel, copper-to-brass and brass-to-steel and **are not recommended** to be used on tubing larger than 2" in diameter, in HVAC/R applications. Soldering alloy (95/5) for plumbing is not recommended for HVAC/R applications.

Brazing alloys used in HVAC/R may contain: **0%**, **5%, 10%, 15%, or 45% silver** and melt between **1,400°F and 1,500°F**. The silver content allows the alloy to flow easily when heated and increases capillary action between the metals being joined and the alloy.

The high temperatures used for brazing form copper oxide flakes inside copper tubing. These flakes, also known as "scale" can block refrigerant metering devices and their abrasive properties can ruin the tight tolerances of compressors. It is therefore imperative that dry nitrogen gas at very low pressure is "swept" through the copper tubing and fittings during the brazing procedure.

Many silver-containing alloys can be used to join copper-to-copper, copper-to-steel, copper-to-brass and brass-to-steel and may be used on tubing, up to, and larger than 2" in diameter.

Some common brazing alloys are sold in "stick" form and may contain: **0%**, **5%, 10%, or 15%** silver plus some percentage of phosphorous and are commonly referred to as **Sil-Fos** ™. These alloys, often sold in 1 pound plastic containers, are primarily used for copper-to-copper tube joining and occasionally for copper-to-brass and definitely **not for steel-to-steel connections**. Although these alloys are "**self-fluxing**" and do not require prior application of brazing flux, the use of flux will not have a negative impact on the work being done.

The high silver content (40% to 50% Ag) alloys, commonly known as **Easy-Flow**™, will join: copper-to-copper, copper-to-steel, copper-to-brass, brass-to-steel and steel-to-steel without difficulty. They are sold in coils that weigh 1, 3, 5 and 7 troy ounces and resemble a Slinky™ toy, when the loops are pulled apart. **This type of alloy requires the use of white paste flux, specifically for brazing**. It should be no surprise that the higher the silver content, the more expensive the alloy.

Self-fluxing brass brazing rods consist of a brass rod surrounded by a layer of solid white flux. Although this rod may be used to braze copper-to-copper and brass-to-copper, it may also be used to braze steel-to-steel, to create support structures used in the HVAC&R industry.

The **welding** process is commonly used in the HVAC&R industry to join steel pipes for ammonia refrigeration systems and to join steel "angle iron" for building compressor supports, called "racks". Some employers pay a premium for HAVC&R technicians who have a welding certificate.

Torches

Soldering and brazing processes require a source of heat to melt the filler alloys. A variety of torches are used and each has its own advantages and disadvantages.

1) The simplest torch is a hand-held device that uses **propane** or **MAPP**™ gas (or either) as a fuel source. Hand-held torches are light weight, usually less than three pounds, including the torch head and a 16 ounce fuel tank, and can be used to perform most soldering jobs required in residential and light commercial installations.

   Since soldering temperatures do not produce copper oxide scale on the inside of the tubing, a dry nitrogen "sweep" and the necessary 35 pound nitrogen tank and regulator are not needed. MAPP gas torches produce more heat than propane-fueled torches can be used to solder copper, up to 1-5/8" and braze copper, up to 3/8", providing that no wind is present to carry heat energy away.

2) Air-acetylene torches use an acetylene tank and a regulator, plus a torch handle that aspirates air into a mixing chamber. The air/fuel mixture then exits the torch tip where it is ignited. An air-acetylene torch produces a flame that is hotter than MAPP gas and doesn't require an accompanying oxygen cylinder, making the apparatus lighter than an oxy-acetylene torch kit. Commonly available air-acetylene torch sets allow brazing up to 7/8" and soldering over 2 1/8" copper tubing.

3) An oxy-acetylene torch kit consists of an acetylene tank and regulator; a matching oxygen tank and regulator; a check valve for each gas; a duplex hose set – red for acetylene and green for oxygen; a hand set with a valve for each gas to "dial in" the proper fuel-to-oxygen ratio for combustion; and various tips suited to small or large jobs. It is imperative that the fuel-to-oxygen ration be set correctly for the task. A flame with a sharp, blue-white cone represents a temperature over 4,500^{o}F, which can burn through steel.

   A proper oxy-acetylene brazing flame has a medium blue inner cone and a pale blue outer cone, sometimes referred to as a "feather". When brazing, the feather should be in contact with the copper and be in constant motion. The feather portion of the flame is slightly rich in fuel and when it comes in contact with oxidized copper, the oxide is chemically removed, allowing for excellent adhesion between the alloy and the copper. Oxy-acetylene torches are used for brazing copper that ranges in size from capillary tubes to 6 inch diameter (or greater) tubing, depending upon the tip size and tank size.

   Notes:
   1) Acetylene delivery pressure (to the hand set) should **NEVER** exceed 15 PSIG!
   2) An acetylene tank that is found to be in a horizontal position should not be put into service until it has been standing for 24 hours or more.
   3) **NEVER** use oxygen to pressurize a refrigeration system! The results could be devastating!

Techniques and more Safety

Regardless of the process, filler alloys will only allow for a quality connection if they are heated above their melting points. An alloy can only penetrate the gap between the fitting and the tubing if it is in the liquid phase. Simply stated: **alloy flows where the heat goes**. Irregularly shaped globs of alloy indicate inadequate heat/temperature. If copper is heated to the point where it is red-orange in color, brazing alloys will melt and quickly fill the gap when applied. **Always keep the torch tip moving around the area of the joint!** A stationary torch flame can easily burn through copper, resulting in wasted time and requiring corrective procedures.

Remember to use a very low pressure "sweep" of dry nitrogen when brazing.

Close tank valves and relieve the pressure on the regulators when your tasks are finished. All gauges should read 0 PSIG when your torch is put away.

Always wear safety glasses/goggles and leather gloves when soldering, brazing and/or welding.

Bring a spray bottle and an operating fire extinguisher to the work area and **ALWAYS be aware of the direction that your torch flame is aimed!!!**

compiled by:

Craig J. Barnett
Professor
Los Angeles Trade-Tech College
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