Air/Acetylene Torches

Much of this information is summarized from the Copper Development Association, Copper Tube Handbook: Industry Standard Guide for the Design and Installation of Copper Piping Systems. Refer to this document and the handbook to answer the assigned questions.

Many pipefitting and plumbing tasks such as preheating, soldering and brazing require the application of intense heat. A variety of hydrocarbon fuels are used in combination with oxygen supplied by compressed oxygen cylinders or from ambient air. The most common fuel gases are methane, propane, butane, MAPP (methyl acetylene propadiene) and acetylene. Acetylene in particular has qualities which make it especially useful in Acetylene/air torches for soldering and brazing copper piping systems for plumbing, sprinkler fitting and refrigeration systems.

Acetylene is a colorless gas with a characteristic pungent odor. (See MSDS). It is formed by the combination of Calcium Carbide (CaC2) and water. The chemical composition is a triple bond between Hydrogen and Carbon (h-C=C-H) the chemical symbol for Acetylene is C2H2. Acetylene is one of the base materials combined to manufacture many products. Acetylene combined with Hydrogen Chloride forms Polyvinyl Chloride (PVC). Acetylene combined with Hydrogen Cyanide that forms Acrylonitrile, which is the A in ABS.

Heat is a measure of the amount of thermal activity (in the Imperial system given as British Thermal Units or BTUs) and temperature is the measure of its intensity (in the Imperial system given as degrees Fahrenheit). The amount of heat of the acetylene gas is given as 1470 BTU's per cubic foot. This is compared to 1000 BTUs per cubic foot given of by natural gas. The flame temperature of acetylene is 3087° Celsius (5589° Fahrenheit), the highest flame temperature of any fuel gas aside from hydrogen. Natural gas has a maximum flame temperature of 4600° F (2538° C). By definition soldering is the process of joining materials with alloys that melt at a temperature of less than

840° F and brazing is virtually the same process but with alloys that melt at a temperature above 840° F. Air-acetylene torches are capable of either process. (See “Lead Free Solders for Drinking Water Plumbing Systems”).

Acetylene is stored in distinctively shaped cylinders that are usually painted black. When Acetylene in its gaseous form is under pressure of more than 15 PSI it becomes very unstable and will explode with extreme violence of self-ignite in air. It is therefore stored as a liquid or more correctly it is dissolved in liquid Acetone (a common cleaning agent). The tank is filled with a mixture of porous material (lime, diatomaceous earth, charcoal, asbestos and cement) which holds the acetone and acts as a shock absorber. Inside the tank the pressure will reach a maximum of 250 PSI at 70°F. When the tank valve is opened the acetylene comes out of the acetone much like the Fizz of carbon dioxide out of a carbonated soft drink. A regulator valve only allows a pressure of 15 PSI. Acetylene tanks must be stored and used upright otherwise the acetone can be released which will make for an improper flame. Acetylene tanks have fusible plugs that melt and allow the contents of the tank to escape if the tank is exposed to temperatures above 220° F (104° C). This is to prevent explosions if the cylinders are in fire. Better to release the contents than have an explosion. Never heat an Acetylene tank to get gas out faster.

Acetylene tanks are designated by letters with C being the largest cylinders (usually used for oxy-acetylene torches) B tanks are the most common for air acetylene torches. A very small tank called the MC tank is sometimes used for air-acetylene. MC stands for motor coach because these tanks were used to light the lamps on early automobiles. The MC tank holds 10 cubic feet of acetylene and the “B” tank holds 40 cubic feet.

Fuel gas requires oxygen for proper combustion. With oxy-acetylene cutting and welding outfits some of the oxygen is supplied from a cylinder of compressed oxygen and some from the surrounding air. With air-acetylene torches all of the oxygen comes from the surrounding air. This arrangement does not enable the high temperatures required for cutting steel but is sufficient (around 3000°F) for most brazing work done on copper tubing.

Air/Acetylene Torches

The air-acetylene torch consists of two main components, the regulator and the torch head. The regulator is attached to the acetylene tank with a connector that is sized according to tank size. The regulator serves the function of reducing the pressure of the acetylene in the tank from 250 PSI to something less than 15 PSI. The heat required for a job depends on the size of the flame that in turn depends on the adjustment of the regulator adjustment. The torch head is the handle of the torch with the connection point for various sized tips. Air for combustion is drawn into the torch tip by the venturi effect of the Acetylene gas flowing past a hole in the base of the torch tip. The effect of injecting the air for combustion in this manner also allows for a thorough mixing of gas and air.

The torch head is connected to the regulator by a hose. The hose is rubber or neoprene with a braided nylon mesh forming an inner layer. Hose size is generally 3/16” and 12 feet in length.

The torch head has a needle valve to control the flow of gas to the torch head. Most often this valve is used fully opened or closed by may be used for throttling to adjust flame size. The torch tips are available in a variety of sizes and configurations, including tips with multiple openings arranged in a circular pattern. The sizes are often identified by the size of a soldering job they could be expected to perform i.e. ½” – 3” soft soldering with 95/5 solder (See Uniweld Operating Instructions). It is critical to choose the appropriate tip size. The tips have a fine mesh metal filter that prevents any debris from reaching the orifice. The orifice is the precisely sized hole through which the Acetylene flows immediately prior to burning at the tip end. The orifice configuration also determines the amount and pattern of air that is injected to provide oxygen to the flame.

Recently swirl pattern torches have been developed such as the “Turbo Torch” or Thruster by Uniweld. These torches have much more efficient air injection and mixing resulting in much higher temperatures available. The torches are favored by refrigeration mechanics and are capable of brazing and silver soldering. The tips are usually the quick connect type that simplifies changing sizes.

Soldering and Brazing with the Air-Acetylene Torch

Soldering is the process of joining metals with a nonferrous filler material below 840° F. The solder is drawn into a capillary space provided on copper fittings. A proper capillary space is between 0.002 and 0.005 inches. Heat is applied to the pipe first and then to the fitting, moving the torch flame in a Figure 8 movement towards the base of the fitting cup. Solder is applied to the joint and when the correct temperature is reached the solder is drawn into the capillary space by the heat. If the surfaces have been properly cleaned with an emery cloth or wire brush wetting will occur where the solder will flow evenly to the entire internal surface area of the joint. Flux usually petroleum based and slightly acidic, is used to help eliminate oxides and to assure the even flow of solder. In the past lead and tin alloy solders were chiefly used for plumbing. These alloys had some features that made them very convenient to work with. Commonly used solder was 50/50 solder; half lead and half tin. This solder had a comparatively broad temperature range where it was workable and was easily applied. (See chart of eutectic points and Table 14.6). Concerns about lead contamination of drinking water and groundwater supplies led to the elimination of lead-based solders and their replacement with Lead Free Solders (see attached pamphlet) The current plumbing code allows solders that have .2% lead but most plumbers use the 100% lead free variety. A commonly used lead-free solder is 95/5, an alloy of 95% tin and 5%

antimony. This solder forms strong joints (see “Table 14a: Pressure-Temperature Ratings of Soldered and Brazed Joints”) but has a narrower range of working temperatures, which makes it trickier to work with. A very popular lead free alloy is Silvabrite, which has a “pasty” or workable range similar to 50/50 solder.

Care must be exercised when soldering to ensure that the pipe is free of water otherwise the torch will not be able to raise the tube to the melting temperature of the solder or stream on the inside of the pipe blows the solder out of the joint. Achieving the water free state is sometimes difficult when doing service work on systems that have been in service. Code requires that all parts of a domestic water system be arranged to permit the complete draining of the pipe. A valve or pipe is opened on a lower level to remove the water and all the taps and or valves above are opened to admit air. This can be a time consuming procedures and sometimes getting all the water out is near impossible. Some strategies include connecting compressed air and blowing out the system to using bread. When the later strategy, a plug of bread is stuffed down the pipe and the bread gradually dissolves and can be discharged out a valve or tap. Devices are available that freeze the pipe to allow work on a near by section of the system. This system allows repair work to be done without draining down the whole system that can be a significant saving in time.

Brazing is a similar procedure to soldering except performed at a higher temperature and using different alloys or fillers. Flux is not required when the joint is being made between identical non-ferrous metals but is required when joining copper to brass or other dissimilar metals. See Table 14.7 for Fluxing recommendations) The fluxes used for brazing are usually water based and free flowing. Fluxes float oxides out of the joint and prevent further oxidization of the joint as a result of heating the metal. Fluxes also serve as a temperature indicator because when the flux turns clear and water like under the heat the joint is near the right temperature for brazing. Careful attention to the selection and application of flux is critical.

Filler material can be a variety of alloys with combinations of copper, silver, tin, phosphorous, zinc and cadmium. Brazing filler materials are in two main categories; those containing 30- 60% silver and copper alloys that contain phosphorus. (See chart 14.12 “Brazing Filler Materials”). Various alloys have characteristics that make them suitable for specific applications. Some filler materials have a greater strength some have greater flexibility although the main determinant for joint strength in brazed fittings is capillary space clearance.

Purging and Evacuating

Raising the temperature of metals increased the rate of oxidation. On the outside of the tube joint the oxides form flakes and can be easily wiped away. Insert the tube the oxides may flake off and plug orifices, filters and valves. The solution to this is to braze without having oxygen present. The procedure is to purge the oxygen from the line and replace it with an inert gas that will not allow oxides to form. Inert gases commonly used for this procedure are Nitrogen, Argon and Carbon Dioxide. The tubing is set up with a manifold and hoses are attached through Schrader valves. Inert gas is allowed to flow gently through the pipe until the braze is complete.

Once the brazed joint has been allowed to cool it is pressure tested with the inert gas and then the tubing and system are evacuated. A vacuum pump is attached to the manifold and all the contents of the line are removed. This procedure is used on medical gas lines, oxygen lines and refrigeration lines. It is particularly important on refrigerant systems because any residual moisture inside the tube, even a trace amount, could combine with the refrigerant to form an acid that would eat out the walls of the pipe and various internal components like compressor valves, coils, etc. Evacuating the system established a near vacuum inside the pipe and in vacuum water will boil at room temperature. AS the humidity is vaporized it is pumped out of the piping system. If a system has been badly contaminated this process may be repeated a number of times back-filling the pipe with dry Nitrogen and evacuating.

The indicator that the system has been cleaned out completely is when the vacuum gauge holds steadily for an extended period. If the system cannot hold a deep vacuum it is an indication of a leak or of a contaminant.