1 - INTRODUCTION

Tube brazing is an important part of the installation procedure for both new and replacement compressors. It is of fundamental importance that high quality brazing be performed in order to avoid eventual reprocessing due to leakage at welded (brazed) joints.

In an effort to improve brazing techniques, this report will cover the how to's of achieving better welds, faster welds, and lowering the consumption of brazing materials.

2 - OXYACETYLENE BRAZING

2.1 NATURE OF FLAME

The heat source is chemical in origin, formed by two gases:

- Oxygen : combustion activator (**comburent**)

- Acetylene : **combustible** gas

The oxyacetylene flame is obtained when the two gases (oxygen and acetylene) combine in a torch and are ignited.

The maximum temperature of an oxyacetylene flame is approximately 3100°C (5600°F), close to the tip of the bright inner cone, as shown in figure 1.

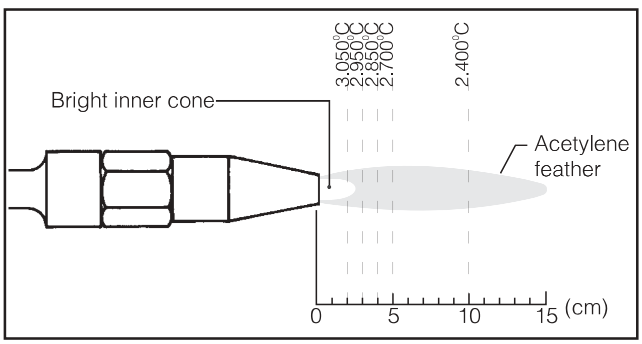

FIG. 1 - COMBUSTION TEMPERATURES IN DIFFERENT FLAME REGIONS

2.2 FLAME CHARACTERISTICS

There are three (3) basic kinds of flame in the oxyacetylene brazing process:

2.2.1 NEUTRAL FLAME

The neutral flame is created by igniting a gas mixture with equal parts of oxygen and acetylene. This flame is destructive to the metal oxides that are usually created during the brazing process. This flame type is recommended for copper to copper welds.

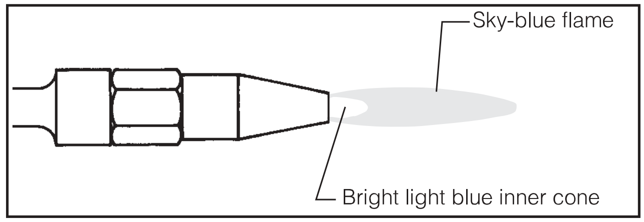

FIG 2. - VISUAL CHARACTERISTICS OF NEUTRAL FLAME

2.2.2 OXIDIZING FLAME

The oxidizing flame is created by igniting an oxygen-rich mixture of oxygen and acetylene. This flame is hotter than the neutral flame and is recommended for brass brazing only.

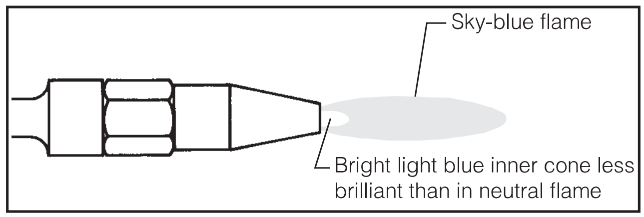

FIG. 3 - VISUAL CHARACTERISTICS OF OXIDIZING FLAME

2.2.3 REDUCING OR CARBURIZING FLAME

The reducing flame is created by sparking an acetylene-rich mixture of oxygen and acetylene. It is a cooler flame than the neutral type and it is highly recommended for brazing copper and steel connections. The reducing flame is also used for brazing aluminum and its alloys.

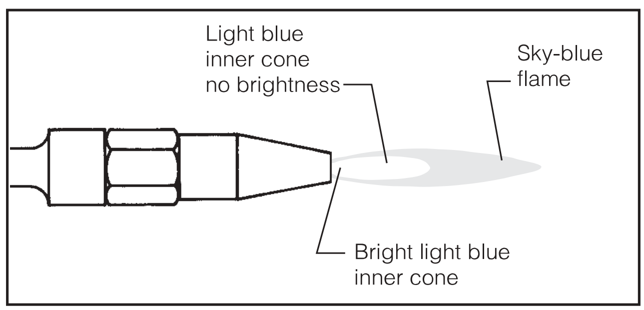

FIG. 4 - VISUAL CHARACTERISTICS OF REDUCING FLAME

2.3 CAPILLARY ACTION

This is the phenomenon through which the filler metal is introduced to the junction to be brazed by the attraction of base material molecules.

The liquefied filler metal always tends to flow to the hottest point of the heated joint, however, this only happens when:

- the brazing surface is clean

- the joint clearance between the parts to be brazed is correct

- the faying surfaces of the parts to be brazed are hot enough to melt the filler metal.

2.4 TUBE JOINT CLEARANCE AND INSERTION OVERLAP

In order to produce a high quality weld, careful attention must be given to the joint clearance between the tubes and the minimum insertion length. Figure 5 highlights this point in more detail.

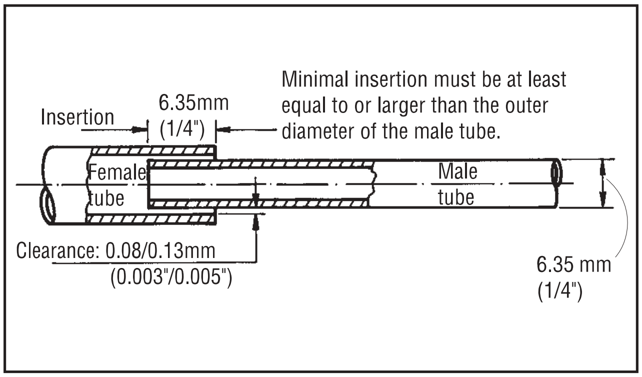

FIG. 5 - TUBE JOINT CLEARANCE AND INSERTION OVERLAP

2.5 CLEANING OF TUBES TO BE BRAZED

Tubes which are to be brazed must be free of oil, grease, oxidation, paint or any other foreign substance which could jeopardize the bonding of materials. Special care must be taken when flux is used to facilitate brazing. The use of powder fluxes in the smallest possible quantity is recommended. They, like the paste fluxes, can become sources of contamination in the refrigeration system causing, for example, capillary tube blockage. This risk is greater in systems using R 134a since the flux, like other alkaline agents, can react with ester oil and produce salts. These salts can then create deposits that may block flow through the capillary tube. Brazing flux is used for the following purposes:

- to clean the area to be joined
- deoxidize the area to be joined
- facilitate flow of filler metal

2.6 PREHEATING

To provide a more efficient brazing homogeneity, the contact surfaces of the two parts to be connected should be preheated. In particular, pay close attention to the areas around the insertion depth region. For flat surface, preheating is performed by circular movements of the flame on the entire surface to be brazed.

Figure 6 shows the different temperatures measured on a surface when the distance of the inner cone tip to the surface changes, while using a steady carburizing flame.

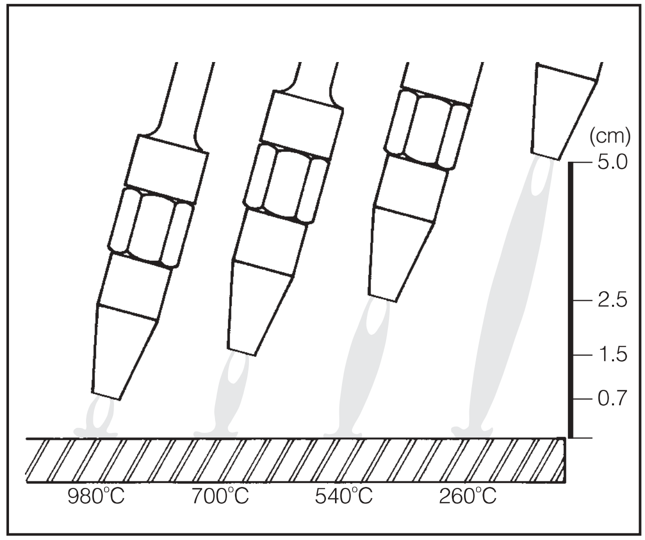

FIG. 6 - TEMPERATURE X DISTANCE FROM INNER CONE TIP TO PART

When referring to preheating in refrigeration, where tube brazing is usual, it is easily noticed that the conventional torch is not convenient for brazement quality and productivity. In this case, the use of torch like the one shown on figure 7 is recommended. Besides a better productivity, the use of this type of torch presents the following advantages:

- faster heating or preheating
- less torch movement during brazing
- higher fluidity and therefore better filler metal joint penetration

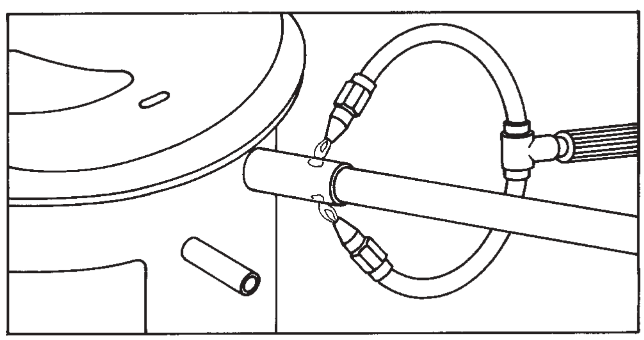

FIG. 7 - A MORE ADEQUATE TORCH FOR TUBE BRAZING

IMPORTANT: The brazing of compressors with copper connectors requires additional care as well as a specific procedure concerning preheating. More information is available in item 3.2.2.

3 - TUBE BRAZING PROCESSES IN REFRIGERATION SYSTEMS

3.1 COPPER PLATED STEEL CONNECTORS WITH COPPER OR COPPER PLATED STEEL TUBES

3.1.1 FILLER METAL / BRAZE FLUX AND FLAME ADJUSTMENT

For this type of brazing, high fluidity silver-base filler rods are used with a silver content varying from 50% to 25%. This type of connection requires the help of brazing flux. However, it must always be remembered that the amount of flux should be minimized and preference must be given to the powder type, as fluxes constitute a form of contamination in the refrigeration system.

This kind of brazing requires a carburizing or reducing type of flame (with a small excess of acetylene).

3.1.2 BRAZING SEQUENCE

3.1.2.1 Make sure that the tube to be brazed is free of grease, oil, paint, oxides or any other foreign substance which could jeopardize the bonding of the materials.

3.1.2.2 Before heating the tubes apply the flux on the brazing joint.

3.1.2.3 With the torch, heat both the male and female tubes, from point A to point B and vice versa. Remember to avoid putting the flame into direct contact with the part coated with flux. (Fig. 8)

NOTE: Heat the steel tube at a slightly higher temperature than that used with the copper tubes.

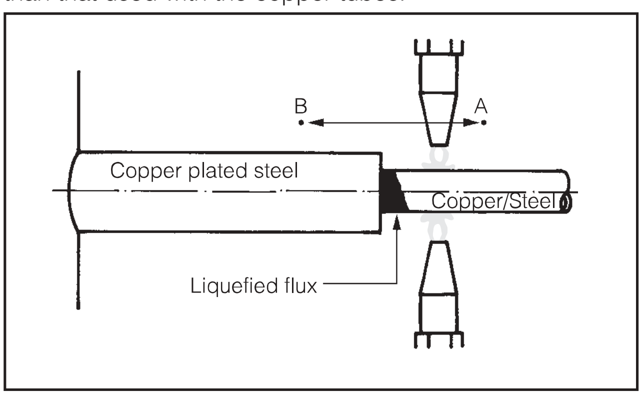

FIG. 8

3.1.2.4 Immediately after preheating the tubes and after flux liquefying, apply the tip of the filler rod (preheated) to the brazing joint.

NOTE: Do not force the filler rod. Simply touch it to the joint to be brazed and let it melt until it flows completely throughout the joint.

3.1.2.5 When the filler rod begins to melt, apply the torch from point A to point B and vice versa until the filler metal penetrates between the tubes. (Fig. 9)

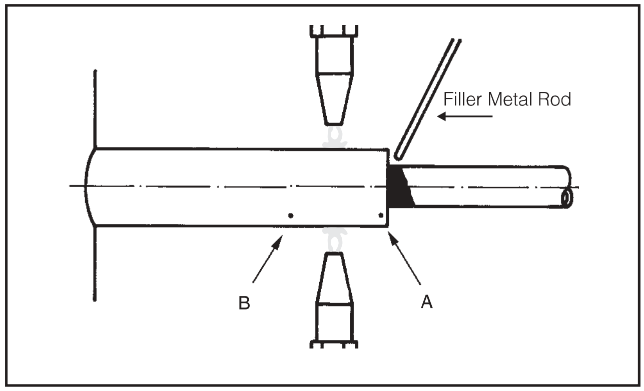

FIG. 9

IMPORTANT: Never put the flame into direct contact with the filler metal rod. Let it liquefy through heat transmission from the tubes.

3.1.2.6 Remove the flame and leave the filler rod for some seconds on the joint, then remove it.

3.1.2.7 The appearance of the connection must be in accordance with figure 10.

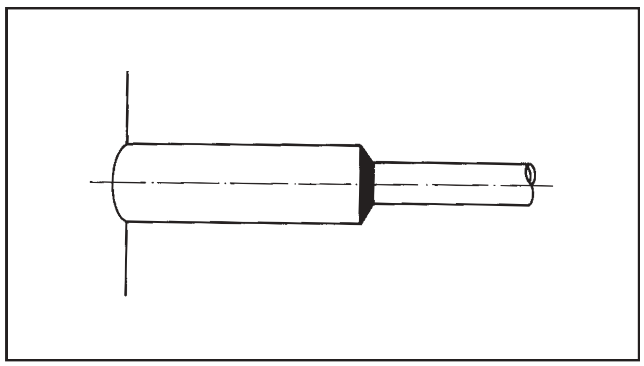

FIG. 10 VISUAL CHARACTERISTICS OF A GOOD-LOOKING BRAZEMENT.

3.1.2.8 Should porosity be suspected or identified in the brazement, heat joint again, moving the torch from point A to point B and vice versa (see fig. 9). If necessary, add the least possible amount of filler metal.

3.2 COPPER CONNECTORS WITH COPPER TUBES

3.2.1 FILLER METAL / BRAZING FLUX AND FLAME ADJUSTMENT

For this kind of brazing, use silver-base filler rods with a silver content of 15% to 5%. Copper-Phosphorus filler metal rods, with high fluidity characteristics can also be used. It is not necessary to use fluxes for this kind of brazing. The flame type recommended for this weld is the neutral flame.

3.2.2 SPECIAL CARE IN BRAZING COPPER CONNECTORS

When brazing copper connectors, **special care must be taken to avoid any damage to the weld joining the copper connector to the compressor housing**. Damage to this weld, as well as any other system joint, will cause refrigerant leakage and eventual rework.

For this purpose, the flame has to be directed away from the compressor and must be more intense at the very end of the female tube (the final 6mm is recommended), as shown in figure 11. The flame-type must be neutral and the filler metal rod should be as described in item 3.2.1. Thus, avoid direct flame over the brazing spot on the compressor housing and carry out connector preheating only on the area close to its tip.

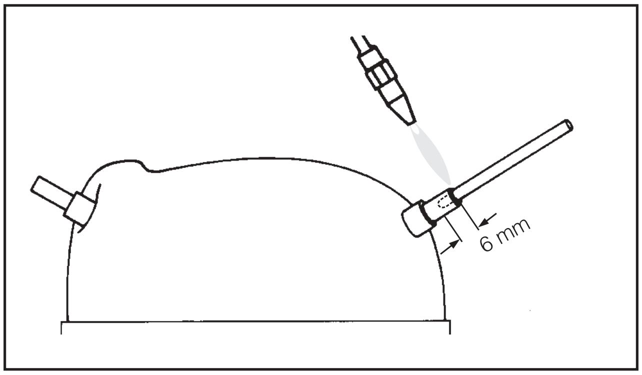

FIG. 11 - SPECIAL CARE IN BRAZING COPPER CONNECTORS

IMPORTANT: Avoid stress in the tubes to be brazed. Under these conditions there is a high probality of cracks occuring in the copper tube as well as in the material to be added.

3.2.3 BRAZING SEQUENCE

3.2.3.1 Make sure that the tube to be brazed is free of grease, oil, oxides, paint or any other foreign substance which could jeopardize the bonding of the materials. Preheating of the connector must follow recommendations as set down in the above item 3.2.2.

3.2.3.2 Heat male and female tubes uniformly up to the ideal brazing temperature moving the flame from point A to point B and vice versa. (fig. 12)

3.2.3.3 Apply the filler rod tip to the area to be brazed.

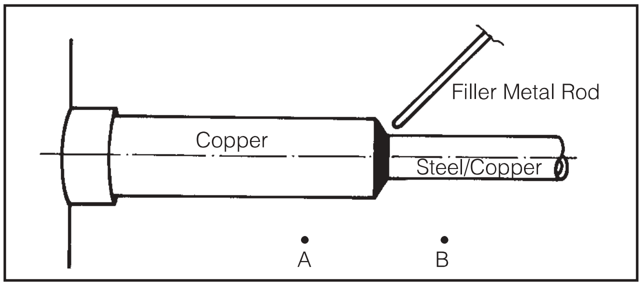

FIG. 12

NOTE: Do not force the filler rod. Simply touch it to the joint to be brazed and let it melt until it flows completely throughout the joint.

IMPORTANT: Do not direct the torch flame directly on to the filler rod. Allow it melt through simple contact with the tube.

3.2.3.4 Remove the flame and leave the filler rod for some seconds on the joint, then remove it.

3.2.3.5 Should porosity be suspected or identified in the brazement, heat joint again, moving the torch from point A to point B and vice versa (see fig. 9). If necessary, add the least possible amount of filler metal.

3.3 COPPER CONNECTORS TO STEEL TUBES

Filler metal, brazing flux and flame adjustment follow the same information as stated in item 3.1. However, special care must be taken when brazing copper connectors (see item 3.2.2).

4 - USUAL FAILURES IN BRAZING

4.1 INSUFFICIENT JOINT PENETRATION

This kind of failure is generally found when the torch is directed only to the joint itself without heating the adjacent areas. Tubes inadequately heated impair brazing capillarity and the filler metal liquefies only where the flame was applied (Fig. 13).

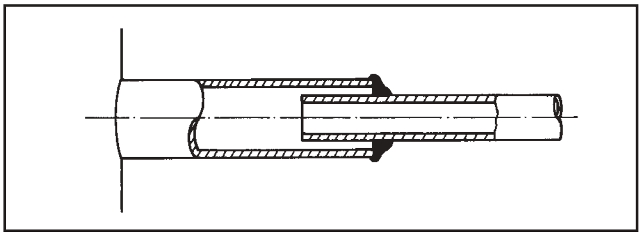

FIG. 13 - INSUFFICIENT BRAZING JOINT PENETRATION

4.2 TUBING OBSTRUCTION

This failure occurs by the excessive use of filler metal and is generally accompanied by excessive joint clearance, insufficient insertion overlap and/or inadequate heat distribution (Fig. 14).

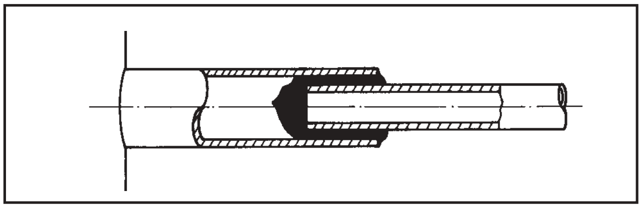

FIG. 14 - TUBE OBSTRUCTION

4.3 CRACKING, BRITTLENESS AND POROSITY

These three failures are generally caused by excessive heating of the tubes to be brazed.

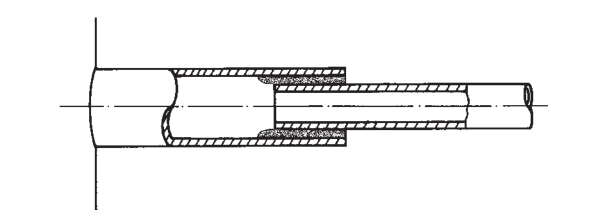

FIG. 15 - POROSITY

4.4 USE OF INADEQUATE FLAME

This item is very important and has a big influence on the brazing results.

Bad flame adjustment can result in an inadequate preheating, melting of base metal, bad heat distribution, low fluidity and bad adherence of the filler metal.

These aspects result in a poor-looking brazement, as well as base metal brittleness and porosity.

For correct flame adjustment and its application to each kind of material to be brazed, see item 2.2.

IMPORTANT: Excessive application of filler metal does not improve welding resistance at all. It only increases the consumption of filler metal, oxygen and acetylene and further reduces brazer productivity.

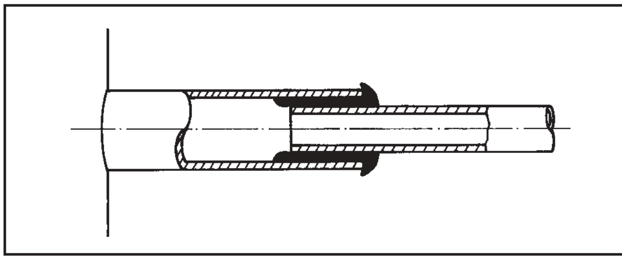

FIG. 16 - BRAZING WITH EXCESS OF FILLER METAL

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