PREVENT REFRIGERANT LEAKS IN COPPER TUBING INSTALLATIONS

OVERVIEW

Refrigerant leaks in high-pressure copper-tubing systems are largely preventable. The following will greatly reduce the chances of long-term, slow leaks in high-pressure systems (such as VRV/VRF, data centers, grocery, etc.):

- **Use bendable/proper copper tubing:**
  - Bendable quality, H55 temper, "half-hard"
  - Certified ACR tubing that meets ASTM B280 strict dimensional tolerances
  - If using O-ring style mechanical connectors, ensure the tubing does not have significant incised text
- **Reduce the number of joints and potential leak points:**
  - Bending the copper tubing eliminates two joints at every change of direction vs traditionally brazed elbow fittings
  - Using a proper tool, swaging the copper tubing eliminates a joint at every union vs traditionally brazed coupling fittings
- **Use modern brazing techniques:**
  - Internal brazing rings remove the guess work and ensure a proper braze
- **Thoroughly check for leaks:**
  - Pressure test with 95/5 and use hydrogen trace gas leak detector
  - Confirm a leak-free system during evacuation

USE BENDABLE AND DIMENSIONALLY CERTIFIED COPPER TUBING

Copper with an H55 temper (also referred to as "half-hard") results in bendable quality tubing that has the same minimum strength rating as standard H58 temper, hard copper tubing. This is achieved during manufacturing by maintaining the same minimum hardness but limiting the maximum hardness to a level that allows 25% elongation of the copper before failure, and the use of proper bending and swaging tools will stay under this 25% elongation limit. Not only is H55 temper copper tubing code-approved, but it is also reliable and well-proven in high-pressure refrigerant applications.

Most ACR Type L copper tubing sold in the U.S. is not certified to meet ASTM B280 strict dimensional tolerances and is noted as such in manufacturers' pricing sheets. This means the tubing dimensions such as OD and wall thickness can be undersized. While acceptable for low-pressure soldering applications, this can cause leaking issues with both mechanical connectors and brazing where precise dimensions are required. Reftekk bendable H55 copper tubing is manufactured to the proper ASTM B280 tolerances.

ASTM B280 requires ACR copper tubing to have incised or physically embedded text that will not rub/wear off. From many manufacturers, these markings are too deep for an O-ring to properly seal. If using O-ring style mechanical connecters, it is imperative to use copper tubing with minimally embedded text to prevent leaks.

REDUCE THE NUMBER OF JOINTS AND POTENTIAL LEAK POINTS

Bendable quality H55 copper tubing is designed to be bent and swaged with the use of proper tools. By both bending and swaging, most projects can eliminate at least 50-75% of potential leak points, depending on the size and layout of the project.

Bending the copper tubing eliminates two joints at every change of direction vs traditionally brazed elbow fittings, thus eliminating two potential leak points. The Reftekk Digi-Bender is a bending tool that provides proper bend radii to safely remain under the 25% elongation limit of H55 copper tubing.

Furthermore, an additional joint is eliminated at every joint when swaging the copper to create a socket vs the use of coupler fittings. Please note nearly all coupler fittings commercially available are designed for soldering; while these fittings *can* be used for brazing, they are not ideal. There are two key differences between sockets designed for soldering vs brazing:

> **1) Socket Depth.** Soldering acts as an adhesive, and, as such, requires a deep socket for the strength of the joint. On the other hand, brazing is performed at a higher temperature and fuses the materials together, and a full-strength braze can be achieved with a very shallow socket depth (two times wall thickness). While the depth of a solder socket can be used for brazing, it is not ideal as it increases the distance the brazing material is required to travel to achieve a full-depth braze, and this in turn requires more time and heat during the brazing process which can lead to volatilizing the phosphorous in the brazing material, and this can result in pinhole size refrigerant leaks. A shallower socket is more ideal for brazing.
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> *For more information on socket depths, please refer to the Reftekk White Paper, "Dimensions of Brazing Sockets vs Solder Sockets."*

> **2) Socket Gap Tolerances.** This is the gap/void the brazing/solder material must fill between the outside of the male tubing and the inside of the female socket. While soldering is relatively unaffected by looser socket gap tolerances, brazing requires a tight fit, and the looser the socket gap tolerance, the less strength a brazed joint achieves. Additionally, looser socket gap tolerance results 1) more brazing material required, and 2) less capillary action to draw the brazing material through the socket, both of which increase the time and heat required to braze the joint, and this can lead to the same issue of volatilizing the phosphorous described previously.

While there are numerous swaging tools on the market, most are not acceptable for high-pressure, brazed applications. Rather, they are designed for low-pressure, soldering applications, having deep socket depths and loose tolerances, and they **should not** be used for brazing applications. As of the date on this document, the Reftekk Swage-X is the only swaging tool known to be acceptable for brazing applications.

USE MODERN BRAZING TECHNIQUES

Traditional brazing methods attempt to achieve a full-depth braze by drawing brazing material inward from outside the joint. As the inside of the joint is not visible, the installer has no way of knowing if a full-depth braze has been achieved. This uncertainty often leads to more time and heat placed on the joint, and this can lead to the same issue of volatilizing the phosphorous described previously. With this traditional method, every joint will have variance in the quality of the braze, increasing the likelihood of leaks.

The issues associated with traditional brazing methods are solved with the use of internal brazing rings. Prior to brazing, these rings are placed on the inside of the joint, reversing the traditional flow of brazing material as it is now drawn toward the outside of the joint. As the brazing material becomes visible when reaching the outside edge of the joint, the installer now has a visual indicator when the brazed joint is completed, guaranteeing a repeatable full-depth brazed joint that has not been overheated.

THOROUGHLY CHECK FOR LEAKS

After the refrigerant system has been installed but prior to system startup, the piping system should undergo a 24-hour pressure testing procedure at 550-600 PSIG. If the pressure does not hold steady, leaks are present. While installers should easily be able to locate large leaks, smaller leaks are more difficult to find. To locate these smaller leaks, installers typically use an outdated method of soap bubble testing, spending significant time at every joint in the piping system. In many cases, the insulation has already been installed and must be removed and re-installed.

A significantly faster and more leak-sensitive solution exists: using a hydrogen gas detector. Rather than pressurizing the piping system with pure nitrogen, a non-critical mixture of 95% nitrogen and 5% hydrogen can be used. Hydrogen, being the smallest and lightest molecule, will travel upward from any leak. This makes it easy to find the leaks, as the hydrogen gas detector can simply and quickly be run along the top side of the piping. With hydrogen being such a small molecule, it will either pass through insulation or come out the seams, any installed insulation can remain in place. Additionally, the high sensitivity of hydrogen gas detectors will find leaks that are not feasibly detected by soap bubble testing.

For more information on hydrogen gas leak detection, please refer to the Reftekk White Paper, "Testing with Tracer Gases."

After all leaks are believed to be found, and again prior to system startup, the piping system should undergo a proper evacuation to remove both non-condensables and moisture. With the use of proper evacuation equipment, the system can be confirmed whether it is leak-free. If any leaks are deemed present, the system should be repressurized with the non-critical mixture of 95% nitrogen and 5% hydrogen and checked again for leaks with the hydrogen gas detector. After the leaks are found and fixed, the evacuation process should be restarted.

For a detailed process on proper evacuation, please refer to the Reftekk White Paper, "Evacuation of Refrigerant Piping Systems."