Answers to questions posed during recent RSES Webinar 11/10/2015

1. What are your thoughts on formicary corrosion issues?
    a. *Formicary corrosion was extensively studied during the mid- to late-nineteen eighties. And at that time the major cause was determined to be copper tubes, lubricated during the drawing process, with lubricants containing organic acids.*

       The incidence of formicary corrosion was resolved by a simple change in the lubricant used for drawing copper tubes.

       Over a decade later formicary corrosion incidents showed a resurgence in the South and Southwest regions of the US. And again a number of OEM's collaborated to try to determine the cause of this new increase in incidents of formicary corrosion. And as coincidence would have it the most probable cause was determined to be the build-up of organic acids from building products and the accumulation of household chemicals that tended to build up on the A-coils. Although the cause was significantly isolated to organic acids and household chemical accumulation on the moist A-coils, each individual OEM took different paths to overcome their particular situation within their manufacturing processes with respect to material and manufacturing adjustments.

       It should further be noted that aluminum tube and coils appear to be more reactive than copper tube and the aluminum tube and coils have revealed an elevated incidence of rapid onset of surface corrosion especially in coastal areas.

2. What are your Thoughts on the new micro-channel all aluminum coils?
    a. *Manufacturing all-aluminum micro-channel coils requires a sophisticated brazing process that is rather costly compared to the manufacturing process for round copper tube-flat aluminum fin coils. The trend toward smaller diameter copper tubes in ACR coils has proven to be competitive in terms of performance and cost. The new pressure expansion process for round tube coils, recently introduced, has the potential to give small diameter copper tube coils a significant cost advantage over aluminum micro-channel coils.*

3. Are these methods approved for food grade and medical gas piping systems?
    a. *High-pressure press-connect joining is permitted for joints within refrigeration equipment for food storage within the limitations of equipment manufacturer's warranty.*
    b. *Brazed joints with an inert gas purge are essentially the joining method of choice for positive pressure medical gas applications as described in NFPA 99 – Health Care Facilities Code (2015 edition).*

       High-pressure press connect joining is not approved for medical gas installations at this time.

4. Do I need to do anything design wise exchanging a standard coil to a volume sized micro channel coil, regarding gas and fluid velocities or volumetric compensation to dampen fluid shock?
    a. *To our knowledge, there should not be any required modifications to the system when replacing a standard coil (3/8" copper tube-flat fin) with a MicroGroove coil (1/4" or 5mm tube-flat fin). When designing replacement coils, coil manufacturers typically account for refrigerant-side and air-side pressure losses, as well as fluid velocities. Unless specified by the coil manufacturer, the replacement coil is usually a drop-in replacement with no system modifications required.*

5. Is swaging still recommended for small diameter copper tube?
    a. *Swaging, or tube end expansion, of copper tube is a viable method for making a female socket end on copper tube. However, there are a few things that must be kept in mind when swaging copper tube. The*

female end (swaged or expanded end) should be kept as close as possible to the socket depth measurement for a soldered or brazed joint depending on the joining process to be used.

Over expansion (excessively long socket depth) and partial insertion of the tube into the swaged end can produce unintended stresses that can contribute to premature joint failure.
Research sponsored by ARI and CDA in 1997 provided data suggesting that overexpansion and partial insertion of tube into the swaged end revealed less than satisfactory joint results. That research can be obtained from ARTI Refrigeration Database by querying ARTI RDB#7501.

6. When heating up the tube, do you have suggestions about how one knows that it is heated enough to proceed to the joint?
    a. *During the brazing process, the reaction of the copper tube and fitting itself can give visual clues as to the temperature of the surface and when it is hot enough to begin making the brazed joint. As the tube/fitting is heated it will begin to turn dark/black due to the creation of surface oxides. However, as the tube/fitting approaches 800 – 1000F, the phosphorus in the copper alloy begins to become active in deoxidizing the copper surface, resulting in a bright, shiny copper appearance. This is a good indication that you are approaching brazing temperature and can begin to test the brazing alloy on the surface to see if it begins to melt. Once it begins to melt and flow easily into the capillary space the joint is ready to be fabricated. For additional information on the proper procedure for brazing please see CDA's video at https://youtu.be/07ODV2Bdqow*

7. Although I have yet to see a copper microchannel condenser, my concern, would be of dissimilar metals, especially in Florida, even 8 miles inland, I have seen very bad corrosion.
    a. *While we don't foresee any OEMs making a copper microchannel condenser (flat thin ribbon with many small passageways), many are moving towards condensers using small diameter, round copper tube (microgroove) with aluminum fins. In terms of environmental corrosion performance even in coastal areas, copper performs quite well and though it may exhibit an external color change due to the creation of an external copper oxide, this is actually protective of the copper surface, much like the skin on the Statue of Liberty. Maybe another one for John to answer.*

8. Will copper tubing take the place of stainless steel piping for the condenser in a Co2 transcritical system?
    a. *Ultimately, that will be up to the market to decide, however copper alloys offer significant benefits over stainless steel in heat exchange systems in terms of heat transfer performance. While stainless steel did have a benefit in terms of the pressure carrying capability for these systems, with the advances in the development and use of copper alloys (i.e. alloy C19400) copper tube and fittings are proven to function well even at 120 Bar (1740 psi). CO_2 systems obviously operate at much higher system pressures than other HFC refrigerant systems. CO_2 system pressure will normally range in the 80 – 100 Bar range, well within the operating pressure of 120 Bar. That being said, copper alloy C19400 tube and fittings are rated at normal operating pressures of 120 Bar and could easily take the place of other competing materials now being used in CO_2 systems.*

    The joining of C19400 copper alloy can be easily performed using existing industry standard brazing practices and commercially available BCuP filler metals.

9. What brazing alloys will be used for the new high copper containing iron alloy?
    a. *Because copper alloy C19400 contains Phosphorous (P) in the range of 15 ppm to 150 ppm it can be brazed using existing commercially available BCuP brazing alloys without the need for the application of brazing flux when both the tube and the fitting are of the C19400 alloy (or its European equivalent).*

When it is being joined to a component of a different alloy, like brass or bronze, standard brazing fluxes must be used.

10. Can copper iron alloy be flared?
    a. *Copper alloy C19400 is a very hard material in comparison to normal copper refrigeration tube (ASTM B280), alloy C12200. Thus it may prove to be more difficult to obtain a satisfactorily fabricated 45° single flare using existing industry standard flaring tools. Although, copper iron alloy C19400 exhibits excellent capacity to be cold worked.*

       It should be noted that most 45° brass flare fittings, which would be most commonly used with a copper tube system, are not recommended for working pressures above 48 Bar (700 psig).