Copper Development Association Inc.
Copper Alliance

A Practical Update on Advanced Copper Alloys and On-Site Joining Methods for HVACR Systems

A Practical Update on Advanced Copper Alloys and On-site Joining Methods for HVACR Systems

Cu

Presented by:

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Exel Consulting Group

Copper Development Association Inc.

- North American arm of the global copper industry
- World's foremost resource on copper and copper alloy applications
- Develop and share knowledge related to the use of copper products
- Support and promote technologies, systems, applications and solutions
- Develop and maintain a team of professionals
- Promote sustainability and encourage environmental responsibility

Presentation Outline

- Advantages of Copper Alloys in HVACR Applications
- Working with Copper Tube and Fittings
  - ✓ Copper Tube Basics
  - ✓ Understanding Pressure and Ratings
  - ✓ Brazing Basics
  - ✓ Joining Without a Flame
- Press-Connect Joints for High-Pressure HVACR Systems
- Small Diameter “MicroGroove” Tubes in ACR Coils
- Copper Tube for Extra High-Pressure Applications (CO_2 and Propane)
- Closing Comments

Copper Alloys – Advantages In HVACR Applications

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- Economical
  - ✓ Ease of forming and joining → Shorter installation time, material savings
  - ✓ Long life, high level of reliability → Lower number of call-backs
- Excellent Field Workability
  - ✓ Fast, strong, leak-free joints
  - ✓ Easily joined with or without a flame
  - ✓ Provide for easily made field repairs
- Excellent Corrosion Resistance
  - ✓ Many alloys reveal high resistance to organic acids

Copper Alloys – Advantages In HVACR Applications

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- Provides for High Thermal Conductivity
  - ✓ Copper = 399 W/mK or 231 Btu/hr-ft-°F
  - ✓ Aluminum = 235 W/mK or 136 Btu/hr-ft-°F
  - ✓ Stainless Steel = 14 W/mK or 8.1 Btu/hr-ft-°F
- High Strength
  - ✓ Thin tube walls still reveal ability to handle high pressures
- Formability
  - ✓ Easily bent reduces joints (possible leak locations) at fittings
  - ✓ Allows for building contour following

Copper Alloys – Advantages In HVACR Applications

Cu

- Safe
  - ✓ No volatile compounds, no toxic degradation products
  - ✓ Can be joined without a flame
- Dependable
  - ✓ Well defined national manufacturing standards
  - ✓ Permanently marked for ease of identification
  - ✓ Accepted material for HVACR applications in every major mechanical code
- Recyclable
  - ✓ Copper can be used over and over without degrading content or properties
  - ✓ Very little copper will ever be found in landfills

Copper Tube - Basics

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Copper tube for HVACR applications is an almost pure material

- ACR tube and wrought copper fittings are manufactured from alloy C12200
  - ✓ 99.9% Copper (Cu)
  - ✓ 0.015% to 0.040% Phosphorous (P)

Copper tube is available in coils or straight lengths

- Coiled copper tube is annealed or soft drawn
- Straight length tube is available hard drawn or annealed

Copper Tube - Basics

Cu

Most commonly used tube for HVACR applications is ASTM B280 (ACR)

- Type ACR
  - ✓ Color coded **Dark Blue**
  - ✓ Wall thickness is approximately equal to type "**L**" ASTM B88
  - ✓ Available in coils (annealed, soft temper) ⅛" O.D. to $1^{5}/_{8}$" O.D.
  - ✓ Available in straight lengths (drawn, hard temper) ⅜" O.D. to 4⅛" O.D.
  - ✓ Shipped cleaned and capped

Copper Tube - Basics

Cu

Tube can be plastic coated for aggressive environments.

Can be pre-insulated and pre-charged for line sets

Copper Tube – Understanding Pressure and Ratings

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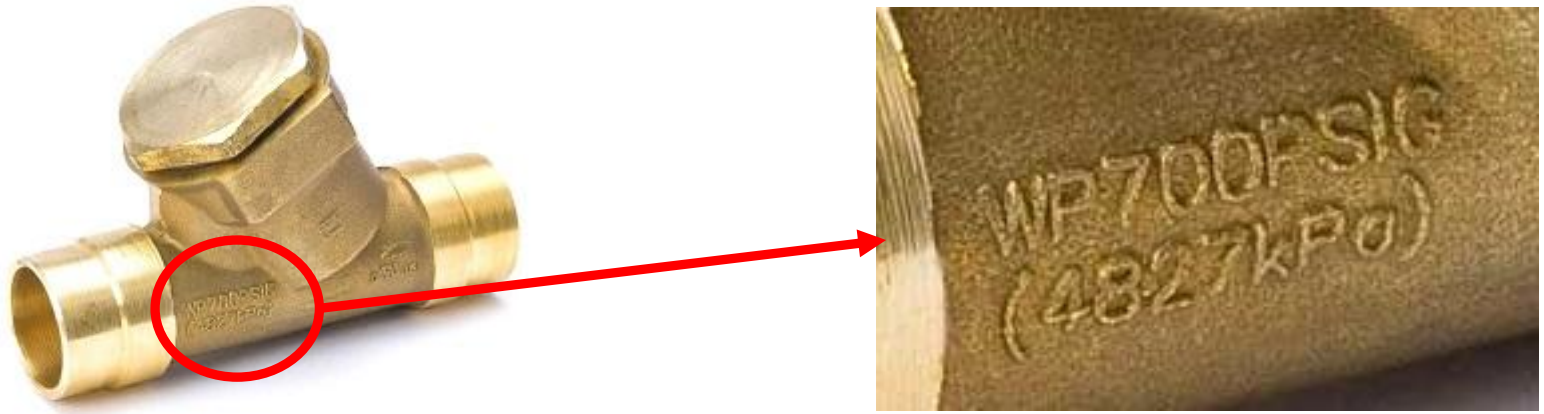
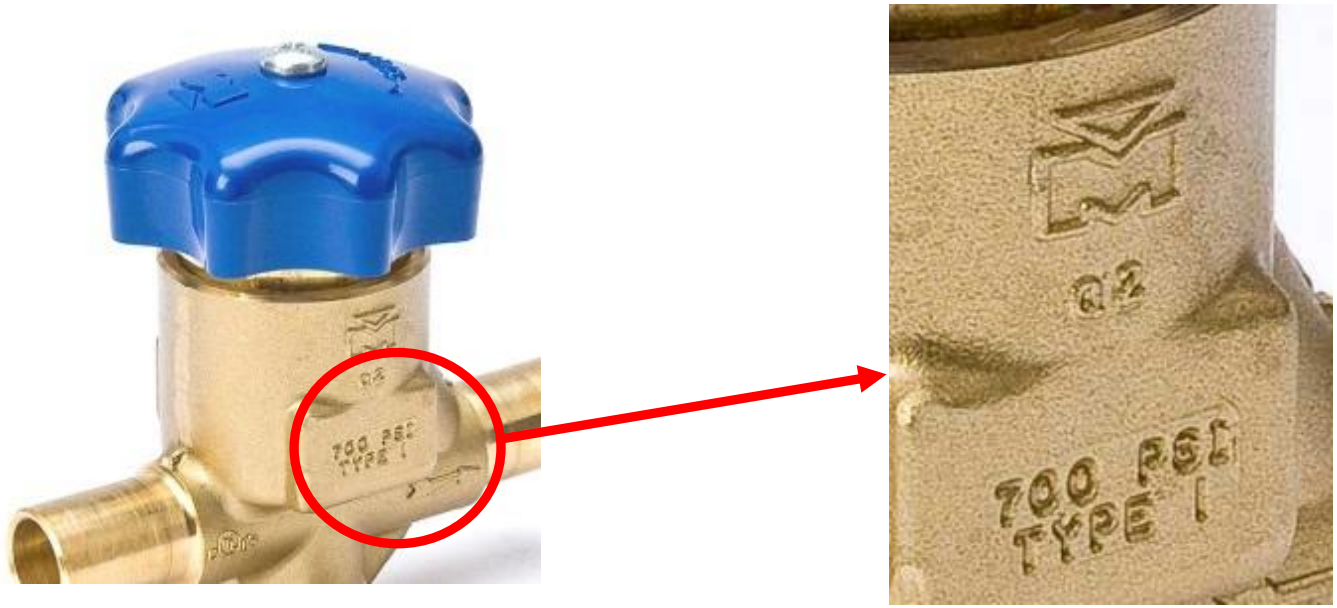
- Newer refrigerants require higher operating pressures
- HFC and natural refrigerants (CO_2 and propane) operating pressures have increased over 50% from the older CFC/HCFC type refrigerants
  - ✓ CFC's (R12) phased out in favor of HCFC's (R22)
  - ✓ HCFC's phased out in favor of HFC's (134a, 404a 410a, etc.)
  - ✓ R290 = propane, operating pressure approx. 600 psi
  - ✓ R744 = CO2, operating pressure over 1,000 psi
- ACR Copper Tube is now rated to 700 psi at 250°F per UL-207

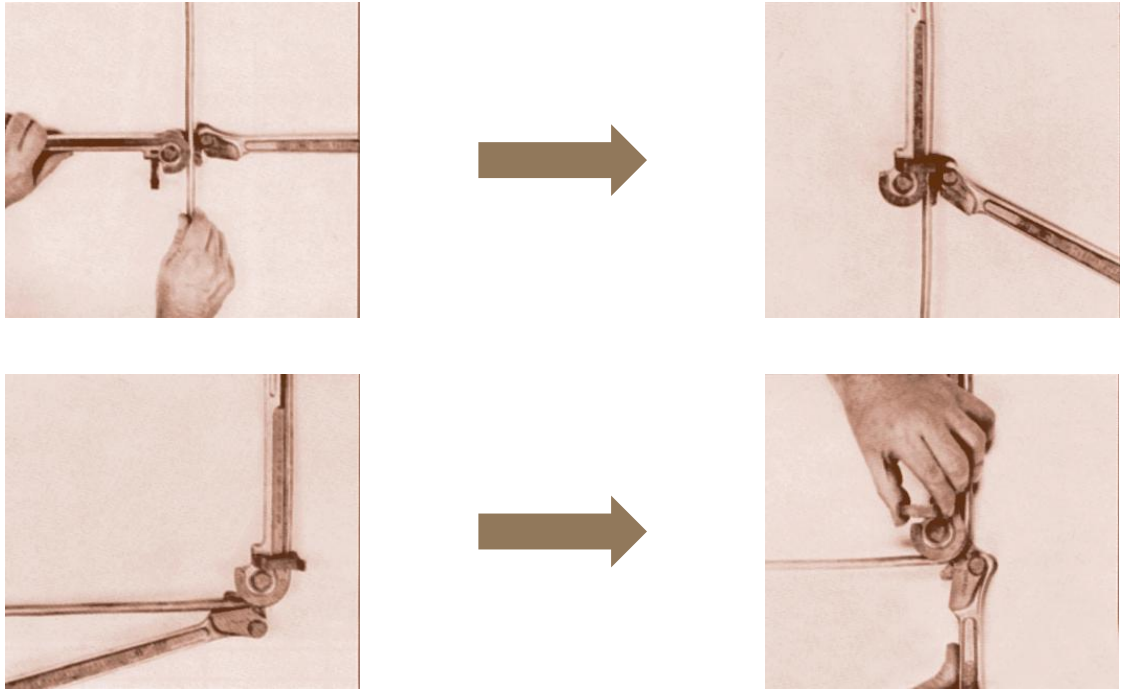
Copper Tube – Understanding Pressure and Ratings



Copper Tube – Understanding Pressure and Ratings

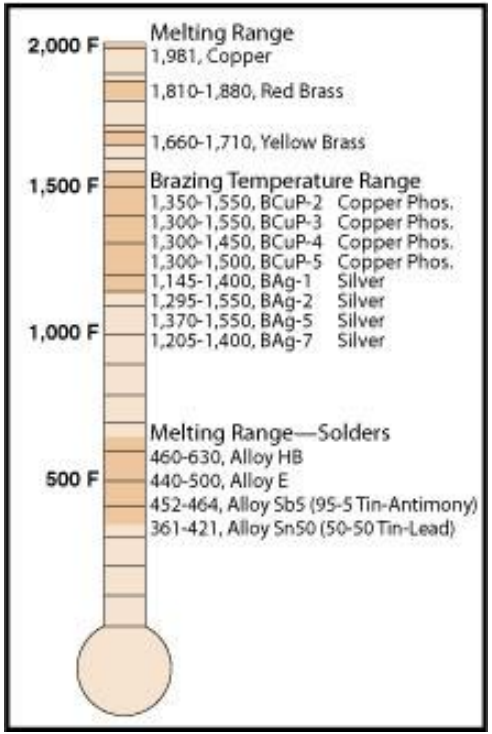


Working With Copper - Bending



Working With Copper – Brazing Basics

- Brazing is preferred for most ACR Applications
- Requires higher temperature than solder
  - ✓ Solder – 350°F – 600+°F
  - ✓ Braze - 1100°F - 1550°F
- Provides higher joint strength than solder
- No flux need for copper tube to wrought copper fittings when BCuP alloys are used



Working With Copper – Brazing Basics
Brazing Alloys

BCuP – Brazing Copper Phosphorous

- Most common for ACR
- Contains Phosphorous (P) which acts as a fluxing agent
- Silver (Ag) from 0% to approximately 15.5%

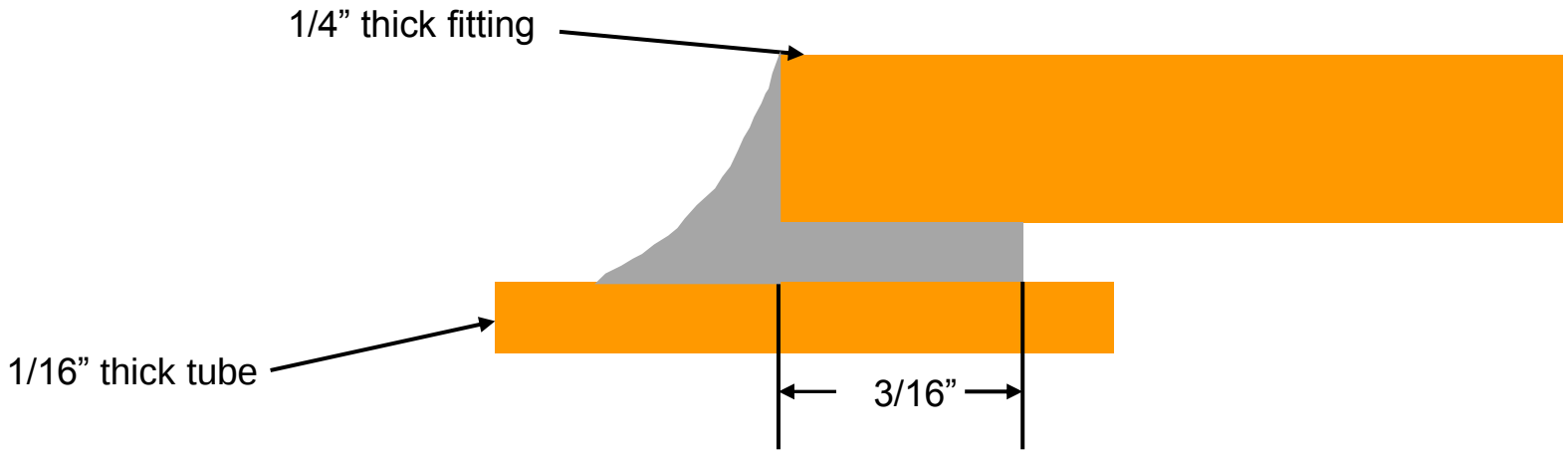
Working With Copper – Brazing Basics
Brazing Alloys

- BAg – Brazing Silver
  - High Silver (Ag) bearing alloys
    - ✓ 24% to 93%
  - Do not contain Phosphorous (P)
  - Normally used for joining dissimilar metals (i.e. copper to steel)
  - Require the use of brazing flux

Working With Copper – Brazing Basics
AWS “3-T Rule”

Depth of Penetration for a satisfactory Braze Joint – AWS “3-T” Rule

- Penetration of the filler metal alloy into the capillary space to a depth equal to or greater than three (3) times the thickness of the thinnest material to be joined shall provide a joint that will be stronger than the tube or fitting.
- Addition of a well developed concave fillet will provide additional strength to the joint.



Working With Copper – Brazing Basics

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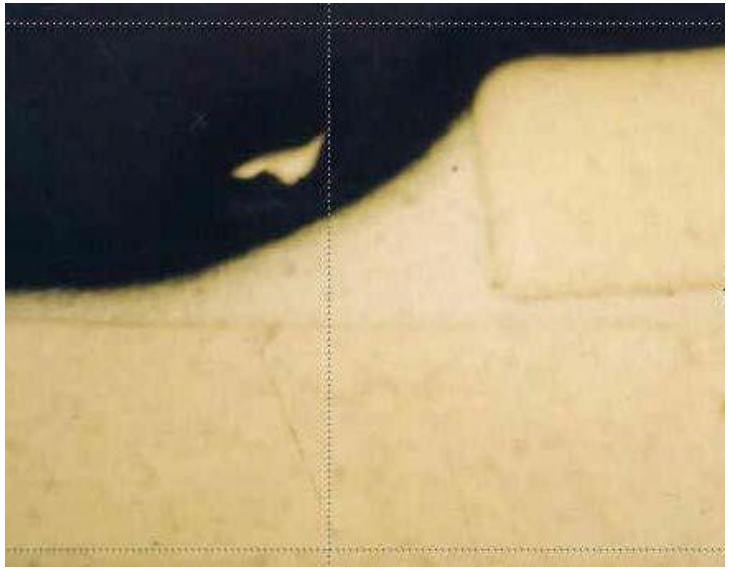
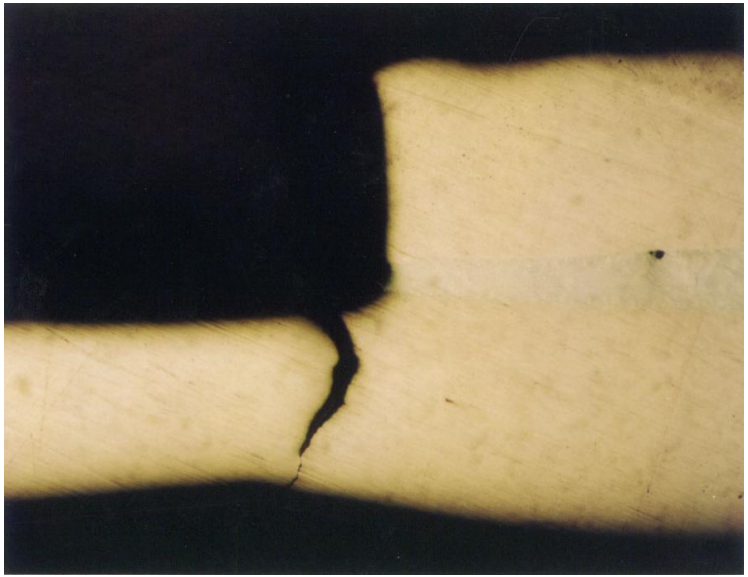
Insufficient fillet development can lead to fatigue fractures



Braze joint with satisfactory fillet

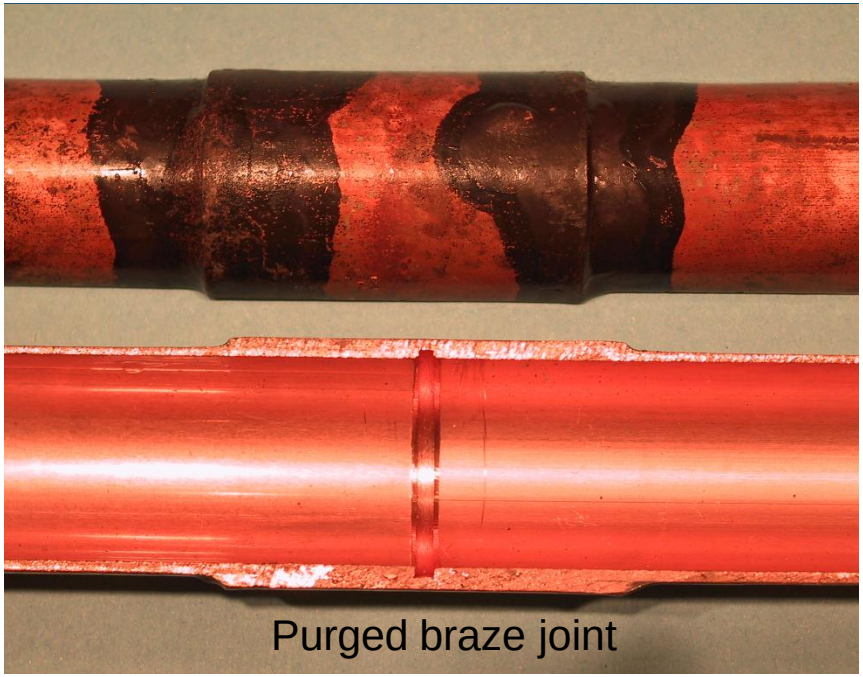


Note lack of fillet and fatigue fracture

Working With Copper – Brazing Basics
Purging

Purging with an inert gas, such as nitrogen, displaces the oxygen inside the tube and prevents the development of oxides on the inside of the tube.

Un-purged braze joint



Purged braze joint

Working With Copper – Brazing Basics

Six Important Installation Steps

- **Measure** - Tube must be measured so it will socket to base of fitting cup
- **Cut** – Tube must be cut perpendicular to run of tube
- **Ream** – Remove inside and outside burr
- **Clean** – Oxides must be removed form O.D. of tube and I.D. of fitting
- **Flux** – Apply flux if required (will be explained in later slide)
- **Apply Heat and Alloy** – Apply heat to tube and fitting to brazing temperature

Working With Copper – Brazing Basics
Application of Heat

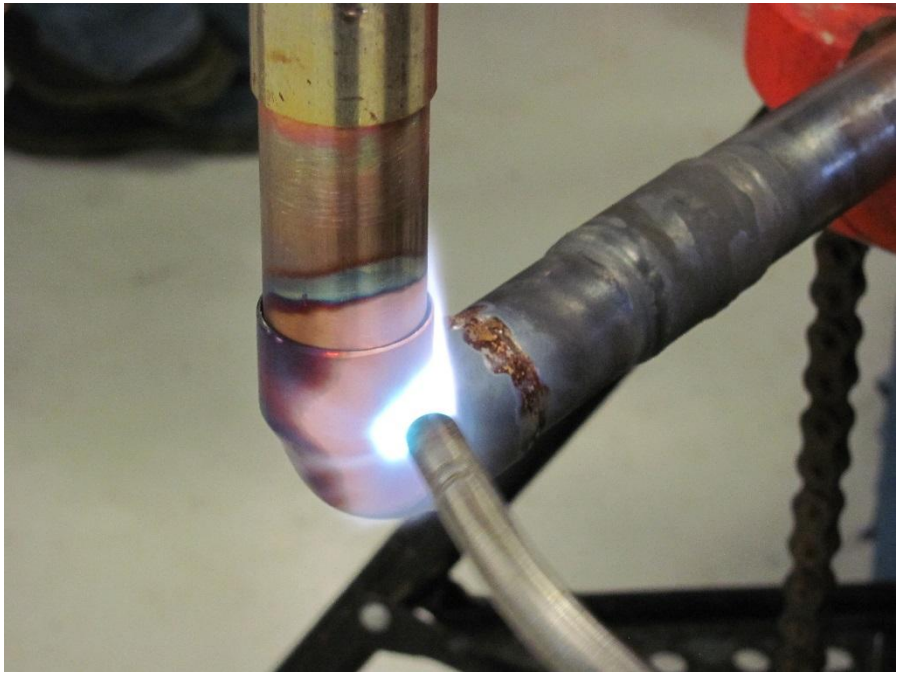
Use of a neutral flame is highly recommended.

- Oxy-fuel

Working With Copper – Brazing Basics – Application of Heat

Use of a neutral flame is highly recommended.

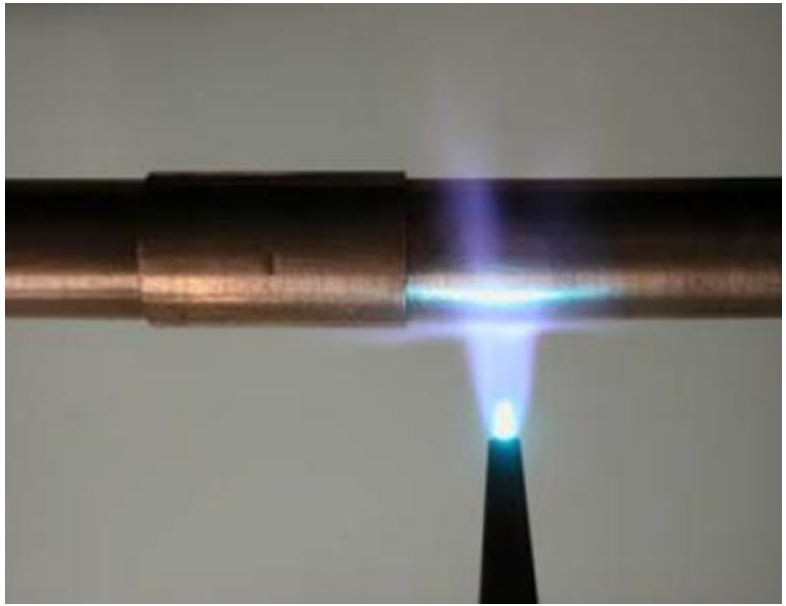
- Oxy-fuel
- Air-fuel



Working With Copper – Brazing Basics
Application of Heat and Alloy

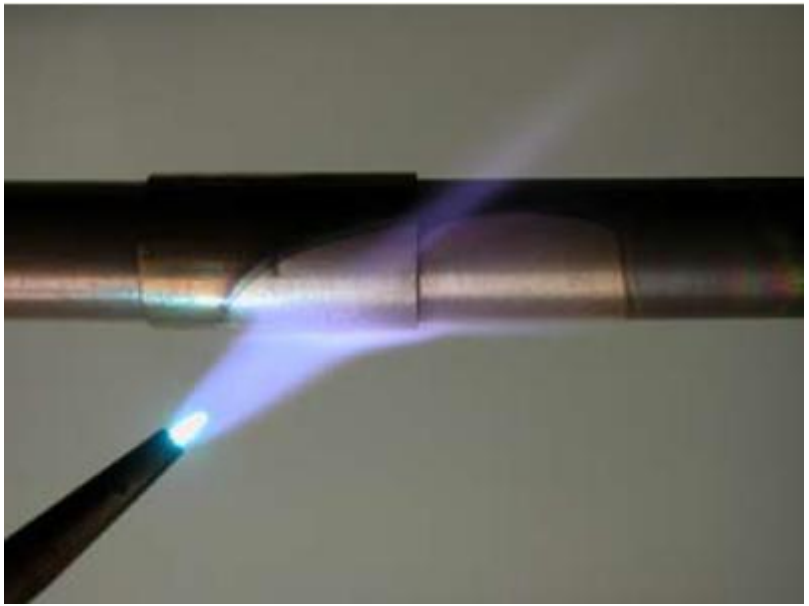
Begin by pre-heating the tube and fitting on the bottom 2/3 with the torch perpendicular to tube and fitting.

Heat tube first and then fitting.



Working With Copper – Brazing Basics
Application of Heat and Alloy

Once tube and fitting are pre-heated angle torch from the base of fitting towards the tube and use a sweeping motion to bring the tube and fitting to the brazing temperature.



Working With Copper – Brazing Basics
Application of Heat and Alloy

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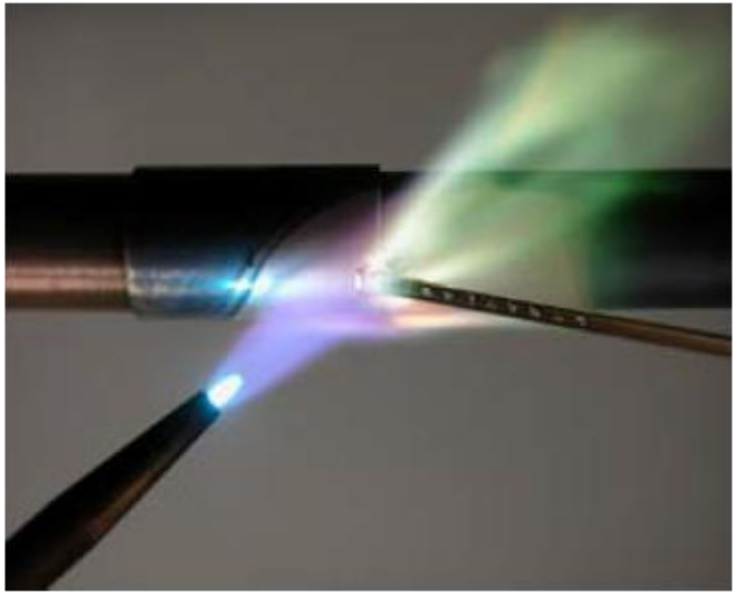
Begin feeding alloy from the bottom of the joint to the top.

Braze alloy will melt and flow into the fitting space by capillary action. And will flow towards the greatest amount of heat (the torch flame).



Working With Copper – Joining Without an Open Flame

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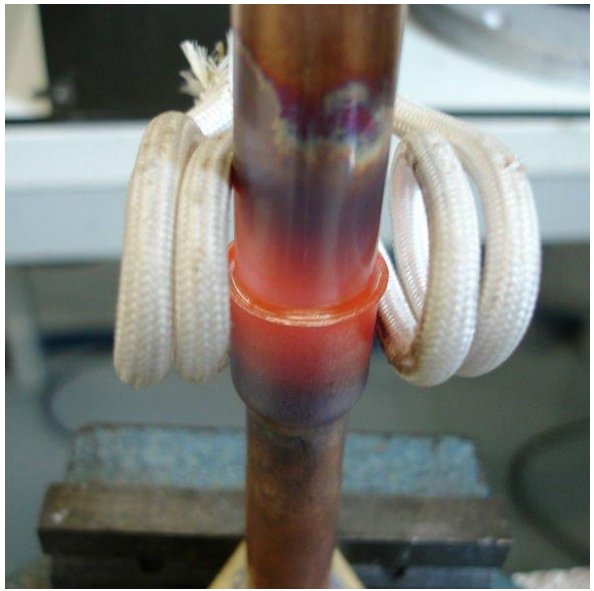
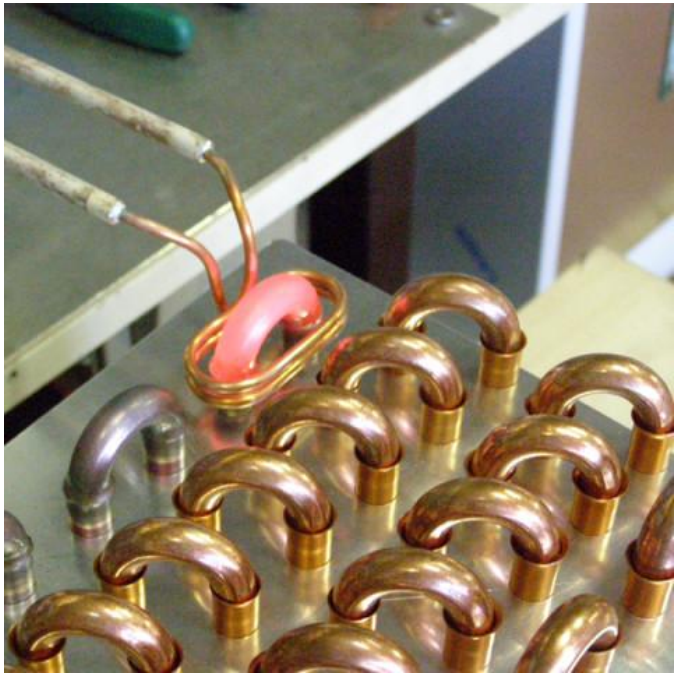
Induction brazing





Working With Copper – High Pressure Press-Connect Joints

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Advances in press-connect and O-ring material technology are now such that press-connect joining can be used for high pressure HVACR applications.

Specially designed press-connect fittings and press jaws are required for high pressure HVACR joints.

- Rated for 700psi at 300°F
- 360° double crimp required

Working With Copper – Installation
High Pressure Press-Connect Joints

Cu

Prepare tube ends

- Remove I.D. burrs and chamfer cut tube ends
- Examine fitting to endure “O” ring is in place
- Mark tube for full insertion prior to assembly

Working With Copper – Installation
High Pressure Press-Connect Joints

Cu

Select proper jaw and insert into pressing tool.

Working With Copper – Installation
High Pressure Press-Connect Joints

Ensure tube is inserted completely into fitting to the tube stop as evidenced by the visible insertion mark

Working With Copper – Installation
High Pressure Press-Connect Joints

Cu

Place the pressing jaw over the bead on the fitting and ensure the tool and jaws are at a 90° angle (perpendicular) to the centerline of the tube.

Depress the tool trigger and begin the pressing cycle

Working With Copper – Installation
High Pressure Press-Connect Joints

When the pressing cycle is complete, release the pressing jaw and visually inspect the completed joint.

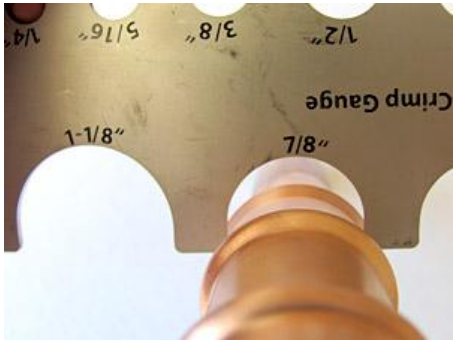
Make certain the tube has remained completely socketed into the fitting and the required press identification mark is visible on the double 360° crimp.

Working With Copper – Installation
High Pressure Press-Connect Joints

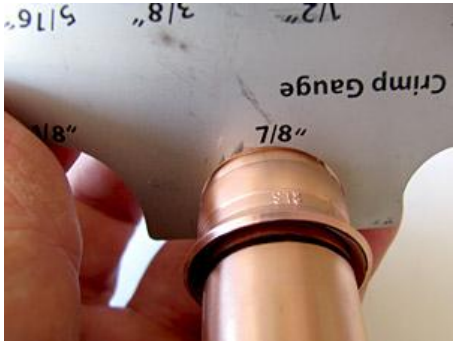
Using the go-no-go gage check the completed press to ensure the pressing process has been completed correctly.

Go-No-Go Gage

Improperly crimped joint



Properly crimped joint



Working With Copper
Benefits of High Pressure Press-Connect Joints

Cu

No Flame Required

- No need for purging – no high temperatures to induce oxide formation.

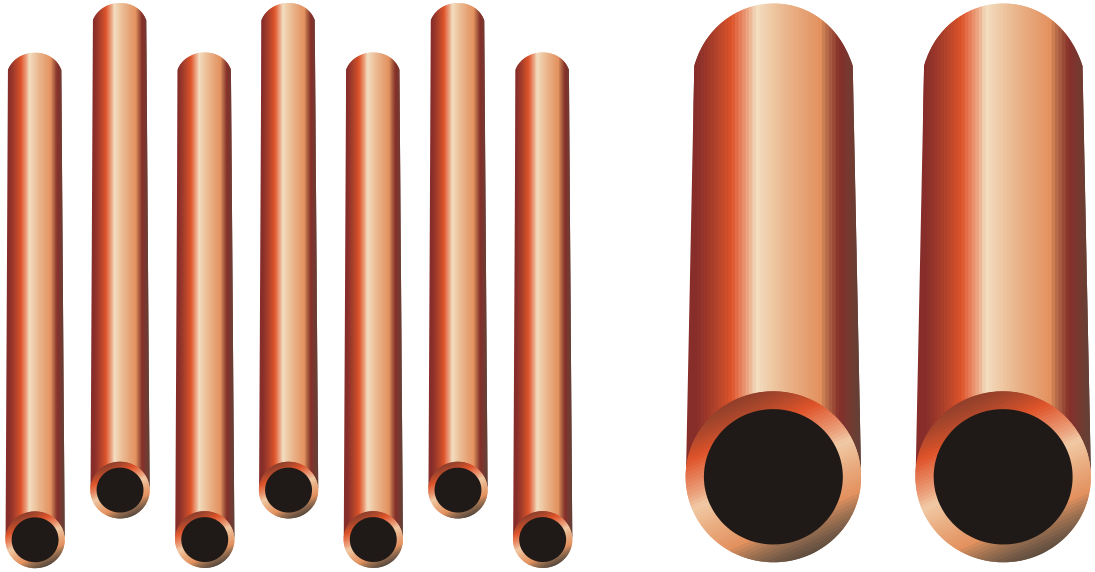
Short Installation Time

- Time savings increase with larger size tubes and fittings

Approved for Many Refrigerants

R32	R407C	R452A
R125	R407F	R507
R134a	**R410A**	R513A
R143a	R447A	R1234yf
R290 (propane)	R448A	R1234ze
R404A	R449A	
R407A	R450A	

New Trends in Coil Design
MicroGroove™ Small Diameter Copper Tubes

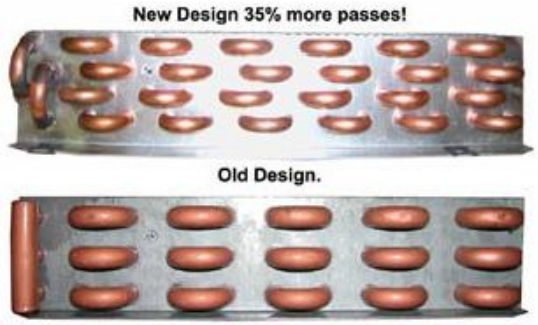


New Trends in Coil Design
MicroGroove™ Small Diameter Copper Tubes

Cu

Benefits of Small Diameter Copper Tubes

- Energy efficient
- Less Material
- Less Refrigerant
- Durability
- Design Flexibility
- Proven Economical Manufacturing
- New Manufacturing Technology



New Trends in Coil Design
MicroGroove™ Small Diameter Copper Tubes

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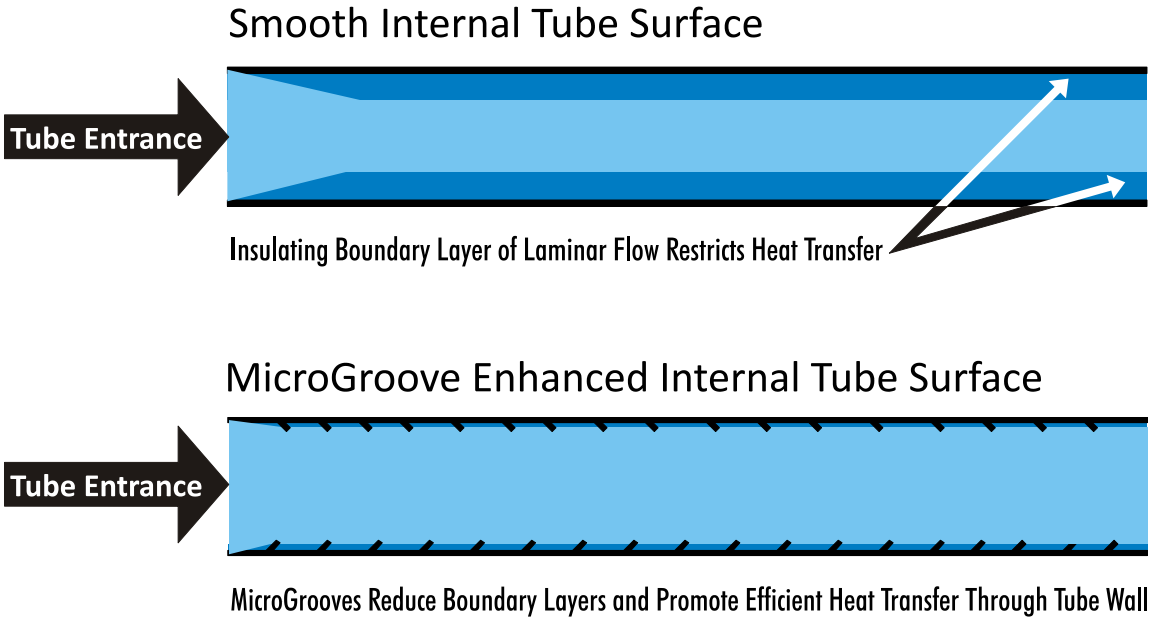
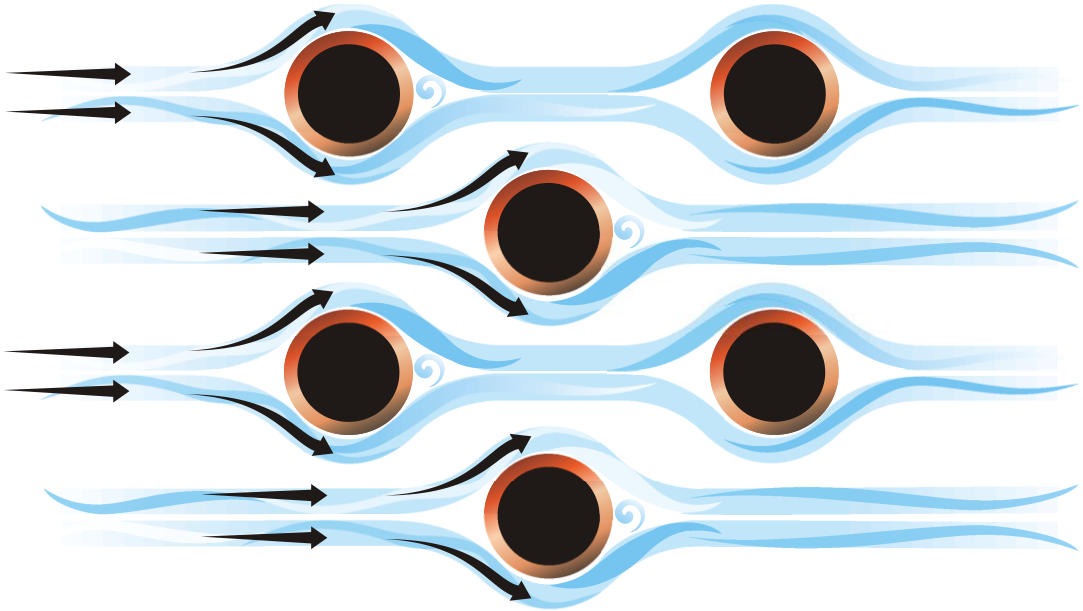
Refrigerant Flow Inside the Tubes



New Trends in Coil Design
MicroGroove™ Small Diameter Copper Tubes

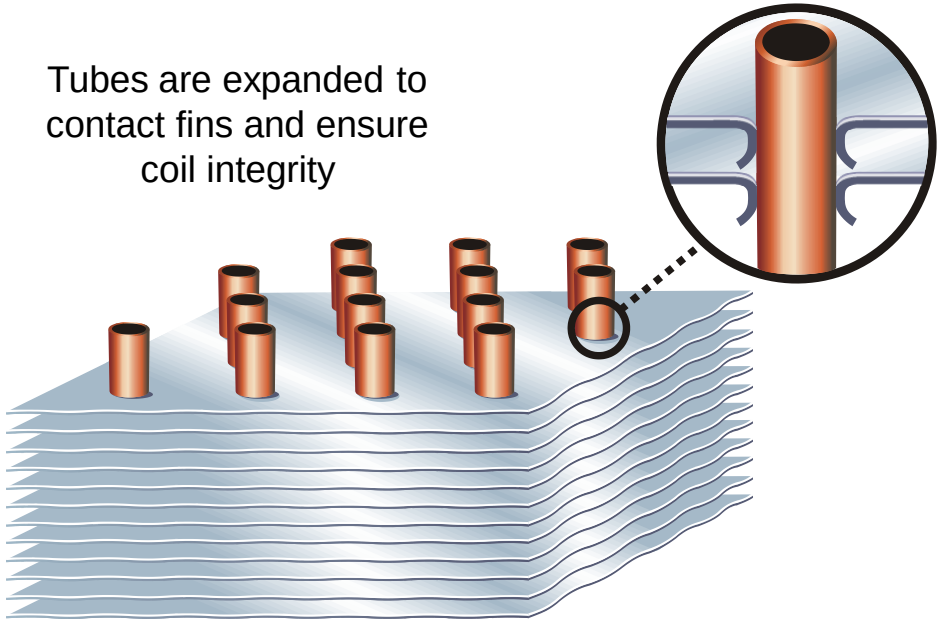
Air Flow Outside the Tubes



New Trends in Coil Design
MicroGroove™ Small Diameter Copper Tubes

Copper Tube – Flat Fin Coil Manufacturing

Tubes are expanded to contact fins and ensure coil integrity



New Trends in Coil Design
MicroGroove™ Small Diameter Copper Tubes

Improved Coil Manufacturing – Pressure Expansion of Copper Tube Coils

Mechanical Expander

Pressure Expander

New Trends in Coil Design
MicroGroove™ Small Diameter Copper Tubes

Cu

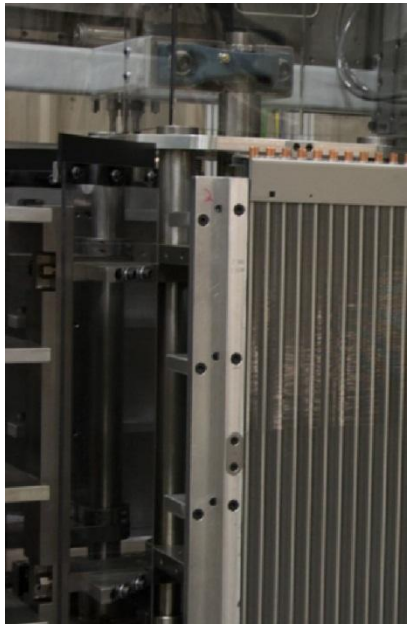
Improved Coil Manufacturing – Pressure Expansion of Copper Tube Coils

For Coil Manufacturers:

- Eliminates mechanical bullets and rods
- Expansion speed of 30 seconds per coil
- Substantial reduction in scrap rate
- Reduced Material Usage
- Zero deformation of inner tube enhancements

For Field Service Professionals

- Lower cost condenser and evaporator coils
- Renewed interest in copper tube-aluminum fin cols



New Trends – Use of Existing Copper Alloys for Extra High Pressure Rated Copper Tube and Fittings

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Existing Copper Alloy UNS C19400 – Copper Iron Alloy

- Chemical Composition
  - ✓ Cu – 97% min.
  - ✓ Pb – 0.03% max.
  - ✓ Zn – 0.05% - 0.20% min/max range
  - ✓ Fe – 2.1% - 2.6% min/max range
  - ✓ P – 0.015% - 0.15% min/max range
- Melting temperature 1990°F (copper tube is 1981°F)
- Excellent characteristics for soldering or brazing
- Same brazing procedure and filler metals as used for existing copper to copper brazed joints
- Will hold a magnet (due to the 2%+ Fe in the alloy)

Certified UL pressure ratings to 120 BAR (1740 psi @ 250°F) 130 BAR in the EU

- Pressure ratings account for brazing

Summary – Copper Alloys in HVACR Applications

Cu

- Versatile
- Economical
- Excellent Field Workability
- Corrosion Resistant
- High Thermal Conductivity
- High Strength
- Formable
- Safe
- Dependable
- 100% Recyclable

Please submit your questions

THANK YOU

Thank you for attending this webinar

For additional information please feel free to visit – www.copper.org

Cu

Copper Development Association Inc.

Copper Alliance

Communicate – Connect – Influence – Support – Inspire