



# Guide Specifications on Plumbing

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Copper and  
Copper Alloy  
Building Piping  
Systems



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*Copper Development Association*

# Commentary

This Guide Specification was developed to aid those involved in the writing of specifications and construction documents involving the use of copper and copper alloy piping system products. This Guide Specification contains basic information on the standards related to the manufacture of copper and copper alloy copper piping system products and materials, the sizes, tempers and configurations available in accordance with these standards, the most common technologies used in joining the tube/pipe and fittings outlined in the standards, system installation requirements, and minimum recommendations for all of the above in a variety of building piping systems.

This Guide Specification contains the following parts:

## Part 1 - General:

Information on the standards referenced throughout the Guide Specification, provisions for quality assurance for piping system installation and requirements for the delivery, storage and handling of materials referenced in the Guide Specification. The bulk of Part 1 is made up of Section 1.1, which is a list of the most common standards related to the manufacture of copper and copper alloy piping system products and materials. The standards included were written or published by the following: American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), American Welding Society (AWS), American Society of Mechanical Engineers (ASME), National Fire Protection Association (NFPA), Manufacturers' Standardization Society (MSS), and Compressed Gas Association (CGA). The contents of this section are useful in determining whether the materials/products proposed for use in the piping system are manufactured in accordance with a nationally recognized standard, or if a component with a nationally recognized standard can be generically specified in its place.

## Part 2 - Products:

Specific information on the pipes/tubes, fittings, and joining materials allowed under this Guide Specification. The majority of this section is comprised of information regarding the composition and usage of the different joining materials allowed for joining copper and copper alloys under this Guide Specification.

### Part 3 - Execution:

Installation methods and procedures allowed under this Guide Specification for the installation of copper and copper alloy piping systems. This includes information on alternate field-fabricated fittings/connections, requirements for piping joint construction, piping protection, and hanger and support spacing. This part also contains Section 3.3 - Pipe and Fitting Applications, which matches the common pipe/tube standards with the compatible fittings standards and options available for joining the two. The options outlined in this section are based on commercially available pipe/tube and fittings sizes and also consider the availability of components based on variables such as temper and schedule or type.

### Part 4 - Piping Systems Applications:

Minimum recommendations on pipe/tube, fittings and joints allowed for specific piping system applications. This Part also includes specific installation requirements as necessary for each piping system application. Recommendations are included for the following piping system applications: water distribution piping systems (above and below ground), soil, waste and vent piping systems (above and below ground), storm drainage piping systems (above and below ground), hydronic heating piping systems (above and below ground), air conditioning and refrigeration piping systems, fuel gas distribution piping systems (natural and LP gas), fire sprinkler piping systems, non-flammable medical gas piping systems and medical vacuum piping systems.

*This Guide Specification has been prepared for the use of professionals involved in the design, specification, installation and repair of copper and copper alloy piping systems in buildings. It has been compiled from information sources that the Copper Development Association Inc. (CDA) believes to be competent. However, CDA assumes no responsibility or liability of any kind in connection with this document or its use by any person or organization and makes no representations or warranties of any kind thereby.*

*The requirements contained in this Guide Specification are intended solely as a guide for the design professional and represent minimum recommendations and requirements. These should in no way be substituted for sound engineering practice and judgment. Local codes should be consulted and used to modify this Guide Specification to meet actual project requirements.*



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**Copper Development Association**

# Part 1 • General

## 1.1 - REFERENCED STANDARDS

A. **American Society for Testing and Materials:** Standard Specification for

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| 1. ASTM B 32   | Solder Metal.  |
| 2. ASTM B 75   | Seamless Copper Tube.  |
| 3. ASTM B 88   | Seamless Copper Water Tube.  |
| 4. ASTM B 280  | Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.                               |
| 5. ASTM B 306  | Copper Drainage Tube (DWV).  |
| 6. ASTM B 584  | Copper Alloy Sand Castings for General Applications.   |
| 7. ASTM B 813  | Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube.                      |
| 8. ASTM B 819  | Seamless Copper Tube for Medical Gas Systems.  |
| 9. ASTM B 828  | Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings. |
| 10. ASTM B 837 | Seamless Copper Tube for Natural Gas and Liquefied Petroleum (LP) Gas Fuel Distribution Systems.         |
| 11. ASTM A 47  | Ferritic Malleable Iron Castings.  |
| 12. ASTM A 536 | Ductile Iron Castings.   |

B. **American National Standards Institute/American Welding Society:**

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|-------------------|---|
| 1. ANSI/AWS A5.8  | Specification for Filler Metals for Brazing.                  |
| 2. ANSI/AWS A5.31 | Specification for Fluxes for Brazing and Braze Welding.       |
| 3. ANSI/AWS B2.2  | Standard for Brazing Procedure and Performance Qualification. |
| 4. ANSI/AWS C3.4  | Specification for Torch Brazing.                              |

C. **American Society of Mechanical Engineers:**

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| 1. ASME B1.20.1     | Pipe Threads, General Purpose (Inch).   |
| 2. ASME B16.18      | Cast Copper Alloy Solder Joint Pressure Fittings.   |
| 3. ASME B16.21      | Nonmetallic Flat Gaskets for Pipe Flanges.  |
| 4. ASME B16.22      | Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.                                     |
| 5. ASME B16.23      | Cast Copper Alloy Solder-Joint Drainage Fittings - DWV  |
| 6. ASME B16.24      | Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500, and 2500. |
| 7. ASME B16.26      | Cast Copper Alloy fittings for Flared Copper Tubes.   |
| 8. ASME B16.29      | Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings-DWV.                         |
| 9. ASME B16.50      | Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings.                                      |
| 10. ASME B31.1      | Power Piping.   |
| 11. ASME B31.5      | Refrigeration Piping.   |
| 12. ASME B31.9      | Building Services Piping.   |
| 13. ASME Section IX | Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualification.                     |

D. **National Fire Protection Association:**

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|-------------|--|
| 1. NFPA 13  | Standard for the Installation of Sprinkler Systems.  |
| 2. NFPA 13D | Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Mobile Homes.                      |
| 3. NFPA 13R | Standard for the Installation of Sprinkler Systems for Residential Occupancies up to and Including Four Stories in Height. |
| 4. NFPA 14  | Standard for the Installation of Standpipe and Hose Systems.   |
| 5. NFPA 14A | Recommended Practice for the Inspection, Testing, and Maintenance of Standpipe and Hose Systems.                           |

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| 6. NFPA 25 | Standard for Inspection, Testing, and Maintenance of Water Based Fire Protection Systems. |
| 7. NFPA 54 | National Fuel Gas Code.   |
| 8. NFPA 99 | Standard for Health Care Facilities.  |

E. **Manufacturers' Standardization Society:**

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|--------------|---|
| 1. MSS-SP-58 | Pipe Hangers and Supports - Materials, Design and Manufacture.      |
| 2. MSS-SP-69 | Pipe Hangers and Supports - Selection and Application.              |
| 3. MSS-SP-73 | Silver Brazing Joints for Wrought and Cast Solder-Joint Fittings.   |
| 4. MSS-SP-89 | Pipe Hangers and Supports - Fabrication and Installation Practices. |

F. **Compressed Gas Association:**

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| 1. Pamphlet G - 4.1 | Cleaning Equipment for Oxygen Service. |
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**1.2 - QUALITY ASSURANCE**

- A. Qualify soldering processes, procedures, and solderers for copper and copper alloy pipe and tube in accordance with ASTM B 828.
- B. Qualify brazing processes for copper and copper alloy pipe and tube according to ANSI/AWS C3.4.
  - 1. Qualify brazing procedures and brazer performance in accordance with either Section IX of the ASME Boiler and Pressure Vessel Code, or AWS B2.2.

**1.3 - DELIVERY, STORAGE, AND HANDLING**

- A. Pipe and tube required by the applicable standard to be cleaned and capped shall be delivered to the job site with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
- B. Protect stored pipe and tube from moisture and dirt. Elevate above grade. When stored inside, do not exceed the structural capacity of the floor.
- C. Protect fittings, flanges, and piping specialties from moisture and dirt.

## GUIDE SPECIFICATION

# Part 2 • Products

### **2.1 PIPE AND PIPE FITTINGS**

- A. Pipe and pipe fittings as used in this specification also refer to tube and tube fittings.
- B. Pipe Threads: ASME B1.20.1 American Standard Tapered Pipe Threads for factory-threaded pipe and pipe fittings.

### **2.2 PIPES AND TUBES**

- A. General: The application of the following pipe, tube, and fitting materials and joining methods required for specific piping systems applications are indicated in Part 4 “Piping Systems Applications.”
- B. Hard Copper Tube: (Drawn Temper)
  - 1. ASTM B 75, UNS Number C12200, drawn temper, seamless copper tube, wall thickness as specified.
  - 2. ASTM B 88, Types K, L, and M, drawn temper, seamless copper tube.
  - 3. ASTM B 280, Type ACR, drawn temper, seamless copper tube.
  - 4. ASTM B 306, Type DWV, drawn temper, seamless copper tube.
  - 5. ASTM B 819, Type K and L, drawn temper, seamless copper tube.
  - 6. ASTM B 837, Type GAS, drawn temper, seamless copper tube.
- C. Soft Copper Tube: (Annealed Temper)
  - 1. ASTM B 75, UNS Number C12200, annealed temper, seamless copper tube, wall thickness as specified.
  - 2. ASTM B 88, Types K and L, annealed temper, seamless copper tube.
  - 3. ASTM B 280, Type ACR, annealed temper, seamless copper tube.
  - 4. ASTM B 837, Type GAS, annealed temper, seamless copper tube.

### **2.3 PIPE AND TUBE FITTINGS**

- A. Wrought Copper, Solder-Joint Pressure Fittings: ASME B16.22
- B. Cast Copper Alloy, Solder-Joint Pressure Fittings: ASME B16.18
- C. Wrought Copper, Grooved-End Fittings: Fabricated from ASTM B 75 Seamless Copper Tube.
- D. Cast Copper Alloy, Grooved-End Fittings: ASTM B 584 Bronze Castings.
- E. Mechanical Couplings: ASTM A 536, ductile iron, or ASTM A 47, malleable iron coupling housing fabricated to manufacturer’s specifications.
- F. Wrought Copper, Solder-Joint, DWV Drainage Fittings: ASME B16.29
- G. Cast Copper Alloy, Solder-Joint, DWV Drainage Fittings: ASME B16.23
- H. Cast Copper Alloy Flanges: ASME B16.24, Class 150 and 300, flat-face type.
- I. Wrought Copper Alloy Unions: ASME B16.22, wrought copper alloy body, hexagonal stock, metal-to-metal seating surfaces, and solder-joint, threaded, or solder-joint and threaded ends.
  - 1. Threaded Ends: Threads conforming to ASME B1.20.1.
- J. Cast Copper Alloy Unions: ASME B16.18, cast copper alloy body, hexagonal stock, with ball-and-socket joint, metal-to-metal seating surfaces, and solder-joint, threaded or solder-joint and threaded ends.
  - 1. Threaded Ends: Threads conforming to ASME B1.20.1.

- K. Cast Copper Alloy Flare Fittings: ASME B16.26
- L. Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings: ASME B16.50

*THE PROCEDURES BELOW MAY BE USED TO MECHANICALLY FORM BRANCH CONNECTIONS AND COUPLINGS WITHOUT THE USE OF FITTINGS. DELETE IF THESE PROCESSES ARE NOT ALLOWABLE FOR THE SCOPE OF THIS WORK.*

- M. Mechanically Formed Outlets: Manufacturer's standard written procedure for forming tee/branch outlet from pipe and tube shall be followed. Mechanically formed outlets shall have a collar with a height not less than three times the thickness of the branch tube wall. The branch shall be notched to conform to the inner curve of the run and shall be dimpled or otherwise impeded from penetrating the run pipe/tube. The branch tube shall also be dimpled or otherwise marked to indicate the location of the notches with respect to the run. Such marking shall be at a sufficient distance from the face of the joint to allow for a visual point of inspection after the joint is brazed. All joints constructed using this method shall be brazed. Brazing filler metals shall conform to the requirements of Article 2.4 "Joining Materials."
- N. Mechanically Formed Couplings: Couplings formed by the expansion of one tube end to form a solder-joint fitting cup may be used. Couplings formed in this manner shall be fabricated using a tool made specifically for this purpose in accordance with the tool manufacturer's standard written procedure. The formed fitting cup shall meet or exceed the dimensional requirements of ASME B16.22 for use with solder-joint connections. Solder filler metals shall conform to the requirements of Article 2.4 "Joining Materials." Fitting cup depths that are less than those required in ASME B16.22 for soldered joints may be used provided that the cup has a minimum depth equal to three times the wall thickness of the tube and the joint is brazed. Brazing filler metals shall conform to the requirements of Article 2.4 "Joining Materials."

## **2.4 - JOINING MATERIALS**

- A. Pipe Flange Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents and exterior environment.
  - 1. ASME B16.21, nonmetallic, flat, asbestos-free, full-face type for Class 150 and 300 cast copper alloy flanges. 1/8-inch maximum thickness, except where thickness or specific material is indicated.
- B. Mechanical Coupling Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents and exterior environment.
  - 1. Gasket design shall be such that the entire coupling housing is isolated from the system contents to prevent galvanic action and inhibit galvanic corrosion.
- C. Solder Filler Metal: ASTM B 32.
  - 1. Alloy Sn95 or Alloy Sn94: Tin (Sn) approximately 95%, and Silver (Ag) approximately 5%, having 0.10% maximum Lead (Pb) content.
  - 2. Alloy Sb5: Tin (Sn) 95%, and Antimony (Sb) 5%, having 0.20% maximum Lead (Pb) content.
  - 3. Alloy E: Tin (Sn) approximately 95%, and Copper (Cu) approximately 5%, having 0.10% maximum Lead (Pb) content.
  - 4. Alloy HA: Tin-Antimony-Silver-Copper-Zinc (Sn-Sb-Ag-Cu-Zn), having 0.10% maximum Lead (Pb) content.
  - 5. Alloy HB: Tin-Antimony-Silver-Copper-Nickel (Sn-Sb-Ag-Cu-Ni), having 0.10% maximum Lead (Pb) content.
  - 6. Alloy HN: Tin-Silver-Copper (Sn-Ag-Cu), having 0.10% maximum Lead (Pb) content.
  - 7. Alloy AC: Tin-Silver-Copper-Bismuth (Sn-Ag-Cu-Bi), having 0.10% maximum Lead (Pb) content.
  - 8. Alloy OA: Tin-Silver-Copper-Bismuth (Sn-Ag-Cu-Bi), having 0.10% maximum Lead (Pb) content.
  - 9. Alloy TC: Tin-Copper-Nickel-Silver-Selenium (Sn-Cu-Ni-Ag-Se), having 0.20% maximum Lead (Pb) content.
  - 10. Alloy AM: Tin-Antimony-Silver-Copper (Sn-Sb-Ag-Cu), having 0.10% maximum Lead (Pb) content.

11. Alloy WS: Tin-Antimony-Silver-Copper (Sn-Sb-Ag-Cu), having 0.10% maximum Lead (Pb) content.

*SOLDERS HAVING GREATER THAN 0.20-PERCENT LEAD (Pb) CONTENT ARE PROHIBITED FROM USE IN POTABLE WATER SYSTEMS. WHERE LOCAL CODES PERMIT, USE ALLOY Sn50 ONLY FOR NON-POTABLE WATER APPLICATIONS. DO NOT USE FOR ANY PIPING THAT MAY COME IN CONTACT WITH THE POTABLE WATER SYSTEM.*

12. Alloy Sn50: Tin (Sn) 50%, and Lead (Pb) 50%.

D. Brazing Filler Metals: ANSI/AWS A5.8.

*THE BCuP SERIES FILLER METALS ARE MORE ECONOMICAL THAN THE BAg SERIES FILLER METALS AND ARE BETTER SUITED FOR GENERAL PIPING APPLICATIONS. BAg SERIES FILLER METALS SHOULD ONLY BE SPECIFIED WHEN JOINING DISSIMILAR METALS, OR THE USE OF PHOSPHORUS CONTAINING FILLER METALS IS PROHIBITED, OR THE SPECIFIC MECHANICAL PROPERTIES AND FLOW CHARACTERISTICS OF THE BAg SERIES FILLER METALS ARE REQUIRED.*

1. BCuP Series: Copper-Phosphorus alloys. The following brazing filler metals shall be used. Brazing filler metals shall conform to the requirements of the individual piping systems specification in Part 4.
  - a. BCuP - 2: Copper (Cu) and Phosphorus (P) 7.0 - 7.5%.
  - b. BCuP - 3: Copper (Cu), Phosphorus (P) 5.8 - 6.2%, and Silver (Ag) 4.8 - 5.2%.
  - c. BCuP - 4: Copper (Cu), Phosphorus (P) 7.0 - 7.5%, and Silver (Ag) 5.8 - 6.2%.
  - d. BCuP - 5: Copper (Cu), Phosphorus (P) 4.8 - 5.2%, and Silver (Ag) 14.5 - 15.5%.
  - e. BCuP - 6: Copper (Cu), Phosphorus (P) 6.8 - 7.2%, and Silver (Ag) 1.8 - 2.2%.
  - f. BCuP - 7: Copper (Cu), Phosphorus (P) 4.8 - 5.2%, and Silver (Ag) 6.5 - 7.0%.
2. BAg Series: Silver alloys. The following brazing filler metals shall be used. Brazing filler metals shall conform to the requirements of the individual piping systems specification in Part 4. Cadmium-oxide present in brazing fumes is poisonous and cadmium-free filler metals should be utilized wherever possible.

*THE FOLLOWING FOUR FILLER METALS CONTAIN CADMIUM. CARE SHOULD BE TAKEN IN SPECIFYING THESE MATERIALS TO CONSIDER THE HEALTH AND SAFETY OF THE INSTALLER. THESE FILLER METALS SHOULD ONLY BE USED IN WELL VENTILATED AREAS OR BY INSTALLERS EQUIPPED WITH THE PROPER PERSONAL PROTECTIVE EQUIPMENT (RESPIRATORS).*

- a. BAg - 1: Silver (Ag) 44.0 - 46.0%, Copper (Cu) 14.0 - 16.0%, Zinc (Zn) 14.0 - 18.0%, Cadmium (Cd) 23.0 - 25.0%.
- b. BAg - 1a: Silver (Ag) 49.0 - 51.0%, Copper (Cu) 14.5 - 16.5%, Zinc (Zn) 14.5 - 18.5%, Cadmium (Cd) 17.0 - 19.0%.
- c. BAg - 2: Silver (Ag) 34.0 - 36.0%, Copper (Cu) 25.0 - 27.0%, Zinc (Zn) 19.0 - 23.0%, Cadmium (Cd) 17.0 - 19.0%.
- d. BAg - 2a: Silver (Ag) 29.0 - 31.0%, Copper (Cu) 26.0 - 28.0%, Zinc (Zn) 21.0 - 25.0%, Cadmium (Cd) 19.0 - 21.0%.

*THE FOLLOWING BAg SERIES FILLER METALS ARE THE MOST COMMONLY SPECIFIED OF THE BAg SERIES FOR PIPING APPLICATIONS.*

- e. BAg - 5: Silver (Ag) 44.0 - 46.0%, Copper (Cu) 29.0 - 31.0%, Zinc (Zn) 23.0 - 27.0%.
- f. BAg - 7: (cadmium-free substitute for BAg - 1) Silver (Ag) 55.0 - 57.0%, Copper (Cu) 21.0 - 23.0%, Zinc (Zn) 15.0 - 19.0%.

THE FOLLOWING BAg SERIES FILLER METALS MAY ALSO BE USED TO JOIN COPPER AND COPPER ALLOY PIPING COMPONENTS, HOWEVER THEY ARE LESS COMMONLY USED THAN THE FILLER METALS LISTED ABOVE.

- g. BAg - 6: Silver (Ag) 49.0 - 51.0%, Copper (Cu) 33.0 - 35.0%, Zinc (Zn) 14.0 - 18.0%.
  - h. BAg - 8: Silver (Ag) 71.0 - 73.0%, Copper (Cu).
  - i. BAg - 20: Silver (Ag) 29.0 - 31.0%, Copper (Cu) 37.0 - 39.0%, Zinc (Zn) 30.0 - 34.0%.
  - j. BAg - 28: Silver (Ag) 39.0 - 41.0%, Copper (Cu) 29.0 - 31.0%, Zinc (Zn) 26.0 - 30.0%, Tin (Sn) 1.5 - 2.5%.
  - k. BAg - 34: (cadmium-free substitute for BAg - 2, - 2a) Silver (Ag) 37.0 - 39.0%, Copper (Cu) 31.0 - 33.0%, Zinc (Zn) 26.0 - 30.0%, Tin (Sn) 1.5 - 2.5%.
3. Proprietary filler metals having compositions not conforming to the exact ANSI/AWS A5.8 classifications for BCuP and BAg Series filler metals shall be permitted when used according to the manufacturer's written instructions.
- E. Soldering and Brazing Fluxes: Soldering and brazing fluxes having greater than 0.20-percent Lead (Pb) content are prohibited from use in potable water systems and shall not be used.
- 1. Soldering Fluxes: ASTM B 813, liquid or paste type.
  - 2. Brazing Fluxes: ANSI/AWS A5.31, Type FB3-A or FB3-C.
    - a. The use of brazing flux is not necessary if the components being joined are wrought copper tube, wrought copper fittings and the filler metal being used is of the BCuP series.

## Part 3 • Execution

### **3.1 PIPING SYSTEMS COMMON REQUIREMENTS**

INSTALL PIPING AS DESCRIBED BELOW.

- A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, except where deviations to layout are approved on coordination drawings.
- B. Install piping at indicated slope.
- C. Install components having pressure rating equal to or greater than system operating pressure.
- D. Install piping free of sags, bends, and kinks.
- E. Install fittings for changes in direction and branch connections in hard drawn copper tube. Where approved changes in direction may also be made by bending of Types K and L tube. Type M tube shall not be bent. Branch connections may also be made using an approved mechanically formed tee/outlet.
- F. Fabricate mechanically formed tees/outlets according to manufacturer's standard written procedure. Mechanically formed outlets shall have a collar with a height not less than three times the thickness of the branch tube wall. The branch shall be notched to conform to the inner curve of the run and shall be dimpled or otherwise impeded from penetrating the run pipe/tube to a depth that would obstruct the flow of fluid through the run pipe/tube. The branch tube shall also be dimpled or otherwise marked to indicate the location of the notches with respect to the run. Such marking shall be at a sufficient distance from the face of the joint to allow for a visual point of inspection after the joint is brazed. All joints constructed using this method shall be brazed. Brazing filler metals shall conform to the requirements of Article 2.4 "Joining Materials."
- G. Fabricate mechanically formed couplings by expanding one tube end to form a solder-joint fitting cup using a tool specifically for this purpose in accordance with the tool manufacturer's standard written procedure. The formed fitting cup shall meet or exceed the dimensional requirements of ASME B16.22 for use with solder-joint connections. Solder filler metals shall conform to the requirements of Article 2.4 "Joining Materials." Fitting cup depths that are less than those required in ASME B16.22 for soldered joints may be used provided that the cup has a minimum depth equal to three times the thickness of the tube and the joint is brazed. Brazing filler metals shall conform to the requirements of Article 2.4 "Joining Materials."
- H. Piping Joint Construction: Join pipe and fittings as follows.
  - 1. Ream ends of pipe and tube and remove burrs to restore full inside diameter.
  - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe, tube, and fittings before assembly.
  - 3. Soldered Joints: Construct joints according to ASTM B 828.
  - 4. Brazed Joints: Construct joints according to ANSI/AWS C3.4.
  - 5. Threaded Joints: Ream threaded pipe ends to remove burrs and restore full inside diameter. Join pipe fittings and valves as follows:
    - a. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
    - b. Apply appropriate tape or thread compound to external pipe threads (except where dryseal threading is specified).
    - c. Align threads at point of assembly.
    - d. Tighten joint with wrench and backup wrench as required.
    - e. Damaged Threads: Do not use pipe or pipe fittings having threads that are corroded or damaged.
  - 6. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. When required, use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly. When flange bolt torque values are provided, tighten to the appropriate torque using a torque wrench.

7. **Mechanical Joints:** Grooved copper tube and grooved-tube fitting joints shall be assembled with coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's standard written procedure. Grooved ends on copper and copper alloy tube shall be roll-formed only using the appropriate roll-groove tool to construct a groove meeting the coupling and fitting manufacturer's written specifications. Cut grooving methods shall not be used on copper and copper alloy tube.
  8. **Flared Tube Joints:** Flared copper tube joints shall be made by the appropriate use of cast copper alloy fittings conforming to ASME B16.26. Flared ends of copper tube shall be of the 45-degree flare type and shall only be made with a flaring tool designed specifically for that purpose. Copper alloy tube shall be reamed to remove burrs and restore full inside diameter prior to forming the flared end.
- I. **Piping Connections:** Except as otherwise indicated, make piping connections as specified below:
1. Install solder-joint to male-thread adapters, or solder-joint to male-thread unions meeting the requirements of ASME B16.18 or ASME B16.22, adjacent to each threaded valve and threaded equipment connection in a copper tube system.
  2. Install ASME B16.24 cast copper alloy pipe flanges adjacent to each flanged valve and flanged equipment connection in a copper tube system.
- J. **Piping Protection:** Except as otherwise indicated protect piping as specified below:
1. Allowance for thermal expansion and contraction shall be provided for copper and copper alloy tube passing through a wall, floor, ceiling or partition by wrapping with an approved tape or pipe insulation, or by installing through an appropriately sized sleeve to allow for thermal movement.
  2. Protection against abrasion shall be provided where copper and copper alloy tube comes in contact with other building members by wrapping with an approved tape, pipe insulation or otherwise suitable method of isolation.
  3. No ashes, cinders, refuse, stones, boulders or other materials which can damage or break the piping or promote corrosive action shall be used in backfilling any trench or excavation in which piping is installed.

### **3.2 - HANGER AND SUPPORT INSTALLATION**

*HANGER SPACING AND ROD SIZE REQUIREMENTS TAKEN FROM MSS-SP-69. CONSULT THE LOCAL PLUMBING, MECHANICAL OR BUILDING CODE FOR REQUIRED HANGER SPACING REQUIREMENTS.*

- A. Install hangers for horizontal piping with the following maximum spacing and minimum rod sizes:

<b>Nominal Tube Size (Inches)</b>	<b>Copper Tube Max. Span (Feet)</b>	<b>Min. Rod Diameter (Inches)</b>
Up to 3/4	5	3/8
1	6	3/8
1-1/4	7	3/8
1-1/2	8	3/8
2	8	3/8
2-1/2	9	1/2
3	10	1/2
3-1/2	11	1/2
4	12	1/2
5	13	1/2
6	14	5/8
8	16	3/4
10	18	3/4
12	19	3/4

- B. Support vertical copper tube, copper pipe, or brass pipe at each floor
- C. In areas where excessive moisture is anticipated, either the piping or the support shall be wrapped with an approved tape or otherwise isolated to prevent contact between dissimilar metals and inhibit galvanic corrosion of the supporting member.

### **3.3 - PIPE AND FITTINGS APPLICATIONS**

- A. The following list contains allowable pipe, fitting and joining methods and materials combinations for piping systems included in this specification. Specific requirements for individual piping system applications are contained in Part 4 “Piping Systems Applications”.

*ALL SIZES ARE DESIGNATED AS EITHER NOMINAL TUBE SIZE (NTS) OR OUTSIDE DIAMETER (OD).*

1. Size 1/4 to 8 inches (NTS):

- a. Copper Tube with Solder/Braze Joints:
  - 1. Tube: Seamless copper tube:  
ASTM B 88 or B 75, Type K or L, annealed temper  
ASTM B 88 or B 75, Type K, L, or M, hard temper  
ASTM B 819, Type K or L, hard temper
  - 2. Fittings: Solder joint pressure fittings: ASME B16.22 wrought copper alloy  
ASME B16.22 wrought copper alloy  
ASME B16.18 cast copper alloy
  - 3. Fittings: Brazed joint pressure fittings:  
ASME B16.50 wrought or copper alloy
  - 4. Joints:
    - i. Soldered joints: ASTM B 32 filler metals according to Article 2.4, Paragraph C
    - ii. Brazed joints: ANSI/AWS A5.8 filler metals according to Article 2.4, Paragraph D

2. Size 1/4 to 2 inches (NTS):

- a. Copper Tube with Flared Joints:
  - 1. Tube: Seamless copper tube:  
ASTM B 88 or B 75, Type K or L, annealed temper
  - 2. Fittings: ASME B16.26, cast copper alloy fittings for flared copper tube
  - 3. Joints: Flared

3. Size 2 to 6 inches (NTS):

- a. Copper Tube with Grooved Ends and Mechanical Joints:
  - 1. Tube: Seamless copper tube with rolled-groove ends:  
ASTM B 88 or B75, Type K, L, or M, hard temper  
ASTM B 306 Type DWV, hard temper
  - 2. Fittings: Wrought or cast copper alloy grooved end fittings as specified in Article 2.3
  - 3. Joints: Mechanical couplings as specified in Article 2.3

4. Size 1-1/4 to 8 inches (NTS):

- a. Copper Tube with Solder/Braze Joints:
  - 1. Tube: Seamless copper tube:  
ASTM B 306, Type DWV, hard temper  
ASTM B 88 or B 75, Type K, L, or M, hard temper
  - 2. Fittings: ASME B 16.23, Cast copper alloy solder joint drainage fittings - DWV

3. Joints:
  - i. Soldered joints: ASTM B 32 filler metals according to Article 2.4, Paragraph C
  - ii. Brazed joints: ANSI/AWS A5.8 filler metals according to Article 2.4, Paragraph D

5. Size 1-1/4 to 4 inches (NTS):

- a. Copper Tube with Solder/Braze Joints:
  1. Tube: Seamless copper tube:  
ASTM B 306, Type DWV, hard temper  
ASTM B 88 or B 75, Type K, L, or M, hard temper
  2. Fittings: Copper alloy solder joint drainage fittings - DWV:  
ASME B16.29, wrought copper alloy  
ASME B16.23, cast copper alloy
  3. Joints:
    - i. Soldered joints: ASTM B 32 filler metals according to Article 2.4, Paragraph C
    - ii. Brazed joints: ANSI/AWS A5.8 filler metals according to Article 2.4, Paragraph D

6. Size 3/8 to 4-1/8 inches (OD):

- a. Copper Tube with Solder/Braze Joints:
  1. Tube: ASTM B 280, Type ACR, hard temper seamless copper tube
  2. Fittings: Solder joint pressure fittings:  
ASME B16.22, wrought copper alloy  
ASME B16.18, cast copper alloy
  3. Fittings: Brazed joint pressure fittings:  
ASME B16.50 wrought copper alloy
  4. Joints:
    - i. Soldered joints: ASTM B 32 filler metals according to Article 2.4, Paragraph C
    - ii. Brazed joints: ANSI/AWS A5.8 filler metals according to Article 2.4, Paragraph D

7. Size 3/8 to 1-5/8 inches (OD):

- a. Copper Tube with Solder/Braze Joints:
  1. Tube: ASTM B 280, Type ACR, hard or annealed temper seamless copper tube
  2. Fittings: Solder joint pressure fittings:  
ASME B16.22, wrought copper alloy  
ASME B16.18, cast copper alloy
  3. Fittings: Brazed joint pressure fittings:  
ASME B16.50 wrought copper alloy
  4. Joints:
    - i. Soldered joints: ASTM B 32 filler metals according to Article 2.4, Paragraph C
    - ii. Brazed joints: ANSI/AWS A5.8 filler metals according to Article 2.4, Paragraph D
- b. Copper Tube with Flared Joints:
  1. Tube: ASTM B 280, Type ACR, annealed temper seamless copper tube
  2. Fittings: ASME B16.26, cast copper alloy fittings for flared copper tube
  3. Joints: Flared

8. Size 1/8 to 1-5/8 inches (OD):

a. Copper Tube with Solder/Braze Joints:

1. Tube: ASTM B 280, Type ACR, annealed temper seamless copper tube
2. Fittings: Solder joint pressure fittings:  
ASME B16.22, wrought copper alloy  
ASME B16.18, cast copper alloy
3. Fittings: Brazed joint pressure fittings:  
ASME B16.50 wrought copper alloy
4. Joints:
  - i. Soldered joints: ASTM B 32 filler metals according to Article 2.4, Paragraph C
  - ii. Brazed joints: ANSI/AWS A5.8 filler metals according to Article 2.4, Paragraph D

b. Copper Tube with Flared Joints:

1. Tube: ASTM B 280, Type ACR, annealed temper seamless copper tube
2. Fittings: ASME B16.26, cast copper alloy fittings for flared copper tube
3. Joints: Flared

9. Size 3/8 to 1-1/8 inches (OD):

a. Copper Tube with Brazed Joints:

1. Tube: ASTM B 837, Type GAS, hard temper seamless copper tube
2. Fittings: Solder joint pressure fittings:  
ASME B16.22, wrought copper alloy  
ASME B16.18, cast copper alloy
3. Fittings: Brazed joint pressure fittings:  
ASME B16.50 wrought copper alloy
4. Joints: Brazed joints:  
ANSI/AWS A5.8 BAg Series filler metals according to Article 2.4, Paragraph D

10. Size 3/8 to 7/8 inches (OD):

a. Copper Tube with Brazed Joints:

1. Tube: ASTM B 837, Type GAS, hard or annealed temper seamless copper tube
2. Fittings: Solder joint pressure fittings:  
ASME B16.22, wrought copper alloy  
ASME B16.18, cast copper alloy
3. Fittings: Brazed joint pressure fittings:  
ASME B16.50 wrought copper alloy
4. Joints: Brazed joints:  
ANSI/AWS A5.8 BAg Series filler metals according to Article 2.4, Paragraph D

b. Copper Tube with Flared Joints:

1. Tube: ASTM B 837, Type GAS, annealed temper seamless copper tube
2. Fittings: ASME B16.26, cast copper alloy fittings for flared copper tube
3. Joints: Flared

## Part 4 • Piping Systems Applications

THIS SECTION CONTAINS MINIMUM RECOMMENDATIONS FOR THE MATERIALS, JOINING METHODS AND INSTALLATION REQUIREMENTS FOR SPECIFIC PIPING SYSTEM APPLICATIONS AND INDICATES WHICH OF THE OPTIONS IN ARTICLE 3.3 ARE ACCEPTABLE FOR EACH SYSTEM.

### **4.1 - WATER DISTRIBUTION PIPING SYSTEMS (BELOW GROUND)**

- A. Tube: ASTM B 88 Type L, annealed temper or Type M, hard temper
- B. Fittings: ASME B16.18, ASME B16.22, ASME B16.26, ASME B16.50
- C. Joints: Soldered, Brazed or Flared. ASTM B 32 Alloy Sn50 shall not be used.  
*Brazed or Flared joints are recommended.*

### **4.2 - WATER DISTRIBUTION PIPING SYSTEMS (ABOVE GROUND)**

- A. Tube: ASTM B 88 Type M, Hard temper
- B. Fittings: ASME B16.18, ASME B16.22, ASME B16.26, ASME B16.50
- C. Joints: Soldered, Brazed or Flared. ASTM B 32 Alloy Sn50 shall not be used.

### **4.3 - SOIL, WASTE, AND VENT PIPING SYSTEMS (BELOW GROUND)**

- A. Tube: ASTM B 306, Type DWV
- B. Fittings: ASME B16.23, ASME B16.29
- C. Joints: Soldered or Brazed

### **4.3 - SOIL, WASTE, AND VENT PIPING SYSTEMS (ABOVE GROUND)**

- A. Tube: ASTM B 306, Type DWV
- B. Fittings: ASME B16.23, ASME B16.29
- C. Joints: Soldered or Brazed

### **4.4 - STORM DRAINAGE PIPING SYSTEMS (BELOW GROUND)**

- A. Tube: ASTM B 306, Type DWV
- B. Fittings: ASME B16.23, ASME B16.29
- C. Joints: Soldered or Brazed

### **4.5 - STORM DRAINAGE PIPING SYSTEMS (ABOVE GROUND)**

- A. Tube: ASTM B 306, Type DWV
- B. Fittings: ASME B16.23, ASME B16.29
- C. Joints: Soldered or Brazed

### **4.6 - HYDRONIC HEATING PIPING SYSTEMS (BELOW GROUND)**

- A. Tube: ASTM B 88 Type L, annealed temper or Type M, hard temper
- B. Fittings: ASME B16.18, ASME B16.22, ASME B16.26, ASME B16.50
- C. Joints: Soldered, Brazed or Flared. ASTM B 32 Alloy Sn50 shall not be used.  
*Brazed or Flared joints are recommended.*

#### **4.7 - HYDRONIC HEATING PIPING SYSTEMS (ABOVE GROUND)**

- A. Tube: ASTM B 88 Type M, hard temper
- B. Fittings: ASME B16.18, ASME B16.22, ASME B16.26, ASME B16.50
- C. Joints: Soldered, Brazed or Flared. ASTM B 32 Alloy Sn50 shall not be used.

#### **4.8 - AIR CONDITIONING AND REFRIGERATION PIPING SYSTEMS**

- A. Tube: ASTM B 280 Type ACR
- B. Fittings: ASME B16.18, ASME B16.22, ASME B16.26, ASME B16.50
- C. Joints: Soldered, Brazed or Flared  
*Brazed or Flared joints are recommended.*

#### **4.9 - FUEL GAS DISTRIBUTION PIPING SYSTEMS (NATURAL AND LP GAS)**

- A. Tube: ASTM B 88, Type L, ASTM B 280, Type ACR or ASTM B 837, Type GAS
- B. Fittings: ASME B16.18, ASME B16.22, ASME B16.26
- C. Joints: Brazed or Flared. Flared joints shall not be used in concealed locations. Brazing filler metal shall be AWS A5.8 BAg Series.
- D. Installation Requirements:
  1. Copper fuel gas piping running parallel to floor joists shall be fastened to the center of the vertical face of the joist with clips not more than 6 feet apart.
  2. Copper fuel gas piping running at right angles or diagonal to floor joists or other framing members may be installed through holes drilled through the center of the member. These holes shall be at least 1 ½ times the O.D. of the tube. If the holes are less than 1 ¾" from the exposed edge of the member, steel striker plates of at least 0.0508" thickness shall be installed to protect the tube.
  3. Copper fuel gas piping running through holes or sleeves in framing members shall be protected from abrasion in the area of the hole or sleeve by wrapping the tube with an approved tape or other approved means of protection.
  4. Copper fuel gas piping running vertically through partition walls shall be protected by installing steel striker plates of at least 0.0508" thickness at the upper and lower wall plates. Striker plates shall extend a minimum of 4" above and below such wall plates.
  5. Branches in horizontal fuel gas piping shall be installed on the side or top of the run pipe at a position at or above the horizontal centerline of the run pipe. Branches for appliance drops may be installed below the horizontal centerline of the run pipe provided an approved drip leg or dirt trap is installed in the drop.

#### **4.10 - FIRE SPRINKLER PIPING SYSTEMS**

- A. Tube: ASTM B 88 Type M, hard temper
- B. Fittings: ASME B16.18, ASME B16.22
- C. Joints: Soldered or Brazed  
*Brazed joints are required for most applications, however soldered joints using ASTM B 32 Alloy Sb5 are acceptable for certain occupancy and hazard classifications.*

#### **4.11 - NON-FLAMMABLE MEDICAL GAS PIPING SYSTEMS**

- A. Tube: ASTM B 819, Type K or L. Type K shall be used for systems having an operating pressure of 185 psig or greater in sizes larger than 3-inch. Each length of tube shall be suitable for oxygen service, be permanently labeled and delivered plugged, capped or otherwise sealed to prevent contamination of internal surfaces. Plugs, caps or other seals shall remain in place until final assembly
- B. Fittings: ASME B16.22, cleaned for oxygen service. Fittings shall be suitable for oxygen service and shall be delivered plugged, capped, bagged or otherwise sealed to prevent contamination of internal surfaces. Plugs, caps, bags or other seals shall remain in place until final assembly  
*CAST COPPER ALLOY FITTINGS SHALL NOT BE PERMITTED.*
- C. Joints: Brazed using an AWS A5.8 BCuP Series filler metal without brazing flux.  
*BRAZED JOINTS BETWEEN DISSIMILAR METALS SHALL BE FABRICATED USING BAg SERIES BRAZING FILLER METALS AND BRAZING FLUX.*

D. Material Cleaning Requirements:

1. Fittings, tube, valves, and piping system components shall be cleaned for oxygen service in accordance with CGA Pamphlet G-4.1. Cleaning shall be performed by the manufacturer or a facility equipped to clean, rinse, and purge the material in accordance with CGA Pamphlet G-4.1.
2. Immediately before final assembly, fittings, tube, valves, and piping system components shall be visually examined internally for contamination. Material that has become contaminated shall not be installed.
3. On-site cleaning of the interior surfaces of fittings, tube, valves, and piping system components shall be limited to recleaning surfaces in the immediate vicinity of the joints that have become contaminated prior to brazing. These surfaces shall be cleaned by washing in a clean, hot water/alkaline solution such as sodium carbonate or trisodium phosphate (1 lb. to 3 gal. of potable water). Interior surfaces shall be thoroughly scrubbed and rinsed with clean, hot, potable water.

E. Installation Requirements:

1. Brazers shall be qualified in accordance with the requirements of NFPA 99
2. Brazing flux shall not be used in joints between copper tube and ASME B16.22 fittings.
3. In applications where copper tube must be joined to brass or bronze system components brazing flux shall be applied sparingly to the exterior surface of the tube. Brazing flux shall not be applied to the interior surfaces of the fitting.
4. During installation care shall be taken to avoid contamination of interior "cleaned for oxygen service" surfaces of piping system components. Joints shall be brazed within one hour of being cleaned.
5. While being brazed, joints shall be continuously purged with a positive flow of oil-free dry nitrogen to prevent the formation of copper oxide on the interior surface of the joint. The flow of purge gas shall be maintained until the joint is cool to the touch.
6. During and after installation, openings in the piping system shall be kept capped, plugged or sealed to avoid unnecessary loss of purge gas while brazing and to prevent contamination of the system. During brazing, a discharge opening shall be provided on the opposite side of the joint from where the purge gas is being introduced. After brazing, this discharge opening shall be capped, plugged or sealed to prevent contamination of the system.
7. Brazed joints shall be allowed to cool to the touch naturally and shall not be shock cooled. After cooling, all joints shall be cleaned with water and a stainless steel wire brush to remove any residue and permit clear visual inspection of the joint. Where flux has been permitted, hot water shall be used.
8. Field fabricated, mechanically formed tees/outlets and couplings shall not be used.

#### **4.12 - MEDICAL VACUUM PIPING SYSTEMS**

A. Tube: ASTM B 88 Type L or Type M, ASTM B 280 Type ACR, or ASTM B 819 Type L, hard temper for exposed locations. ASTM B 88 Type L, or ASTM B 280 Type ACR, soft temper for underground or concealed locations.  
*SOFT TEMPER (ANNEALED) TUBE SHALL NOT BE PERMITTED IN ANY INSTALLATION, EXCEPT UNDER-FLOOR IN CONDUITS, IF THE SYSTEM IS DESIGNED OR INSTALLED TO THE REQUIREMENTS OF NFPA 99 - 2002 EDITION.*

B. Fittings: ASME B16.18, ASME B16.22

C. Joints: Soldered or Brazed. Filler metals shall have a minimum melting temperature of 450F. *If vacuum system piping is installed concurrently with medical gas piping, brazed joints are recommended to avoid inadvertently soldering medical gas piping.*  
*SOLDERED JOINTS SHALL NOT BE USED IF THE SYSTEM IS DESIGNED OR INSTALLED TO THE REQUIREMENTS OF NFPA 99 – 2002 EDITION.*

D. Installation Requirements:

1. If vacuum system piping is installed concurrently with medical gas piping either it shall be labeled or otherwise identified prior to installation in order to preclude inadvertent inclusion into a medical gas system, or ASTM B 819 tube shall be used.
2. The outside of all joints shall be cleaned by washing with hot water after assembly and cooling.
3. After installation of the piping, but before attachment of the vacuum line to the vacuum pump(s) and receiver(s), and before installation of the vacuum alarm switches, station inlets, and gauges, the line shall be blown clear by means of oil-free, dry nitrogen (NF) or air.  
*AIR SHALL NOT BE UTILIZED FOR INITIAL BLOW DOWN IF THE SYSTEMS ARE DESIGNED OR INSTALLED TO THE REQUIREMENTS OF NFPA 99 – 2002 EDITION.*



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