Copper Brass Bronze
Design Guide

FIRE SPRINKLER SYSTEMS

CDA
Copper Development Association

Introduction

Copper, with its unique combination of economy and versatility, has proven itself repeatedly in piping systems. With established solid performance, these same qualities which have made it the material of choice in other applications prove its ability for use in fire sprinkler systems. Copper has long-established advantages over steel and plastics.

Copper is lightweight and compact, which eases fabrication and installation and saves on the space needed to install tube in confined areas. Copper systems can be economically fabricated by soldering or brazing using conventional equipment or electric resistance tools. Joining is done with standard fittings or mechanical tee-pulling devices. Bending and forming of the tube is easy due to copper's ductility. Modification and repair is simplified. In occupied spaces the installation is clean and copper can be easily fit into tight spaces and around fixtures. The corrosion resistance of copper, both external and internal, helps to maintain a neat appearance and provides superior flow characteristics.

In terms of installed costs and material integrity, copper provides a low maintenance project with excellent economy. The result is beneficial to everyone from the contractor to the building owner.

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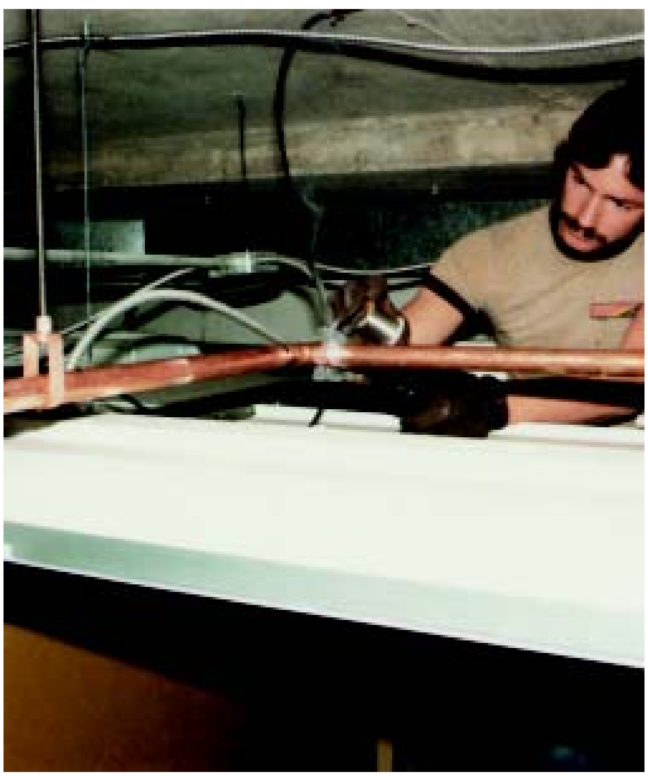


Figure 1. Copper fire sprinkler system in a commercial building being installed with electric resistance heating.

Figure 2. Copper is very effective in residential applications, such as this multi-family unit.

NFPA Standard and Model Code Acceptance

Copper is an effective material for sprinkler systems in a large variety of construction — especially in residential, light hazard, and certain ordinary hazard occupancies. It is NFPA[(1)] approved for all types of Light Hazard Classification with no restrictions imposed. Copper systems have been in reliable service for decades, due to superior performance and economy.

NFPA 13, Standard for the Installation of Sprinkler Systems, Light Hazard Occupancies includes the following types of occupancies:

- Apartments
- Churches
- Clubs/Restaurants
- Dormitories
- Dwellings
- Hospitals
- Hotels & Motels
- Institutions
- Nursing Homes
- Office Buildings
- Public Buildings
- Rooming Houses
- Schools
- Townhouses

1963 The National Fire Protection Association (NFPA) includes hanger spacings for copper conductors in NFPA 13 (Section 3-15.1.11).

1968 NFPA approves Type L copper tube as a conductor (Section 3-1.1.4), revises the hanger spacings, approves torch brazing, and recognizes copper's excellent corrosion resistance.

1969 Copper Development Association begins a full-scale fire-test program aimed at finding the most functional and cost-effective system.

1974 NFPA 13 (Sections 3-1.1.1 & 3-1.1.4) includes use of Types K and M copper as suitable conductors and the use of type 95-5 tin-antimony solder for joining copper tube and fittings (Section 3-1.1.1).

1976 Composite copper-steel systems are accepted where steel risers supply copper branch lines in high-rise buildings.

1980 NFPA 13D is published for one- and two-family dwellings, and approves the use of copper.

1989 NFPA 13R for residential occupancies up to four stories, is published approving the use of copper.

(1) National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

National Model Building and Fire Code Agencies

National Model Codes recommend standards that are the bases for state and local code requirements. Regulated by strict codes for safety and durability, copper is readily accepted in the fire sprinkller industry. Building codes officials recognize copper's time proven qualities.

BOCA - BOCA International
4051 Flossmoor Road
Country Club Hills, IL 60478
(708) 799-2300 www.bocai.org

IAMPO - International Association of Plumbing and Mechanical Officials
20001 Walnut Drive, South
Walnut, CA 91789
(909) 595-8449 www.iampo.org

ICBO - International Conference of Building Officials
5360 S. Workman Mill Road
Whittier, CA 90601-2298
(562) 699-0541 www.icbo.org

ICC - International Code Council
5203 Leesburg Pike (Suite 600)
Falls Church, VA 22041
(703) 931-4533 www.intlcode.org

NFPA - National Fire Protection Association
One Batterymarch Park
Quincy, MA 02269-9703
(800) 344-3555 www.nfpa.org

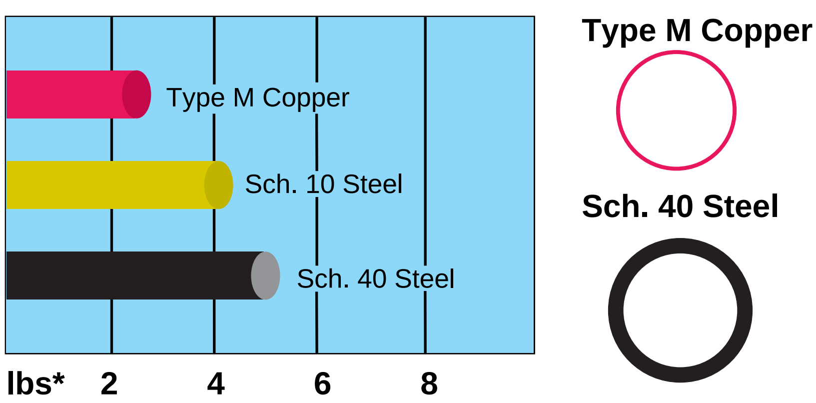
SBCCI - Southern Building Code Congress International
900 Montclair Road
Birmingham, AL 35213
(205) 591-1853 www.sbcci.org

Ease of Handling

Copper's combination of rigidity with light weight makes both shipping and storing easier for the contractor. Copper tube is easier to handle. It does not have the fragility of plastic nor the weight of steel. In on-site storage, copper tube, unlike plastic alternatives, is unaffected by exposure to sunlight. Copper will not support combustion or produce toxic gases.

Comparisons to steel in wall thickness and weight show another advantage of copper. Smaller pipe sizes can be used, which means greater economy and less overall weight for shipping, storing, handling and installing.

Due to copper's installation flexibility, the choice of field or shop fabrication allows for freedom in engineering design. Copper is ductile; it can be bent without producing kinks in the tube or causing it to collapse. Bending in the field can be done cold using hand tools, and shop bending may utilize either hand or power bending machines. Fabrication of copper is possible in a very small work area. Heavy pipe threading machines are replaced with portable, easy-to-use hand tools, making the job much easier and cleaner.



*Weight is based on pounds per linear foot for 2" diameter tube and/or pipe, including water.

Figure 3. Comparative wall thicknesses and weights of copper tube vs. steel pipe.

Hangers, Supports and Fittings

Copper systems require fewer hangers and supports than do plastic piping systems because of the rigidity of copper. In general, at least one hanger is required for each horizontal tube length installed. For hanger spacing detail, see **Table 5,** page 10.

Tube straps, U-hooks, or perforated straps are all acceptable hangers where structural conditions permit. Flat iron (steel band) hangers, ring hangers, and clevis hangers may also be employed and are made to copper tube sizes. Standard pipe size (SPS) steel band and ring hangers can also be used. Special plating or painting of ferrous hangers is not required when used with copper tube since the potential for galvanic corrosion of the hangers is slight, except in wet or corrosive atmospheres, for example, where special coated sprinklers are required.

Pressure fittings are available in all standard tube sizes and in a wide variety of patterns. Typically, with copper systems the fittings are smaller than with steel or plastics.

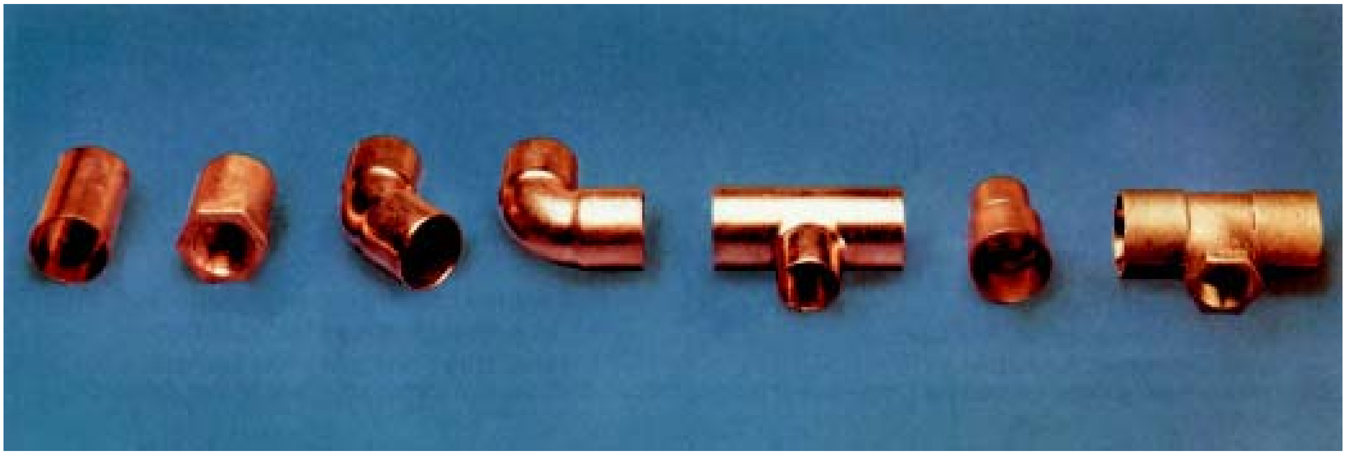


Figure 4. Typical fittings used in copper fire sprinkler installations.

Joining Techniques

Copper tube and fittings can be joined by soldering or brazing and are leak-free due to the positive metallic-bonded joints. Soldering and brazing are fast and efficient methods of joining with standard torches and a variety of gases, facilitating high productivity on the job site.

There are also electric resistance soldering hand tools which employ heating electrodes for joining tube and fittings **(Figure 5).** The tools are lightweight and should be considered when an open flame is a concern.

Another advancement in joining technology is a hand tool designed to enable the quick formation of outlets, thus reducing the number of tee fittings and soldered/brazed joints. **(Figure 6)** The mechanical branch forming tool enables you to produce copper tube outlets from 1/2 inch to 4 inches. Records show this state-of-the-art forming tool can save 10% to 25% on site costs.

Mechanical grooved joining offers a practical alternative to soldering and brazing copper water tube. Grooved-end piping systems have a proven and reliable performance record. This method of joining pipe has been used on steel and iron pipe in plumbing, HVAC, fire protection, process piping and related applications since 1925. This method of mechanical joining is available in a system for copper tube in sizes from 2 through 8 inches **(Figure 7).** Included are copper couplings, 45 and 90 degree elbows, straight tees and grooved flange adapters.

Finally, a copper system can be tested without delay immediately after it has been completed. If a leak does occur, the system can be either drained or quick-frozen in the area of the joint and promptly repaired.

Figure 5. Electric resistance hand tools are suitable for joining copper tube.

Figure 6. Hand-held tool for pulling outlets to quickly form tee connections.

Dealing with Space Limitations

Buildings with Light Hazard Occupancies are often designed with severe mechanical space limitations. Copper's excellent properties not only allow smaller pipes to be used **(see Figure 8)**, but also allow the tube to be bent to bypass obstructions if necessary. Connections are clean and easy and can be made in very tight spaces. This becomes a significant advantage in retrofit installations. Frequently, details of the actual construction site may not exactly match the drawings. Last minute design changes may be needed. If copper is used, job changes are rarely a problem because the system can be adjusted in the field to accommodate variations from the plans. *Only changes that are within the limitations of your hydraulic calculations should be made.*

Figure 7. Mechanical grooved-end joining system for copper piping.

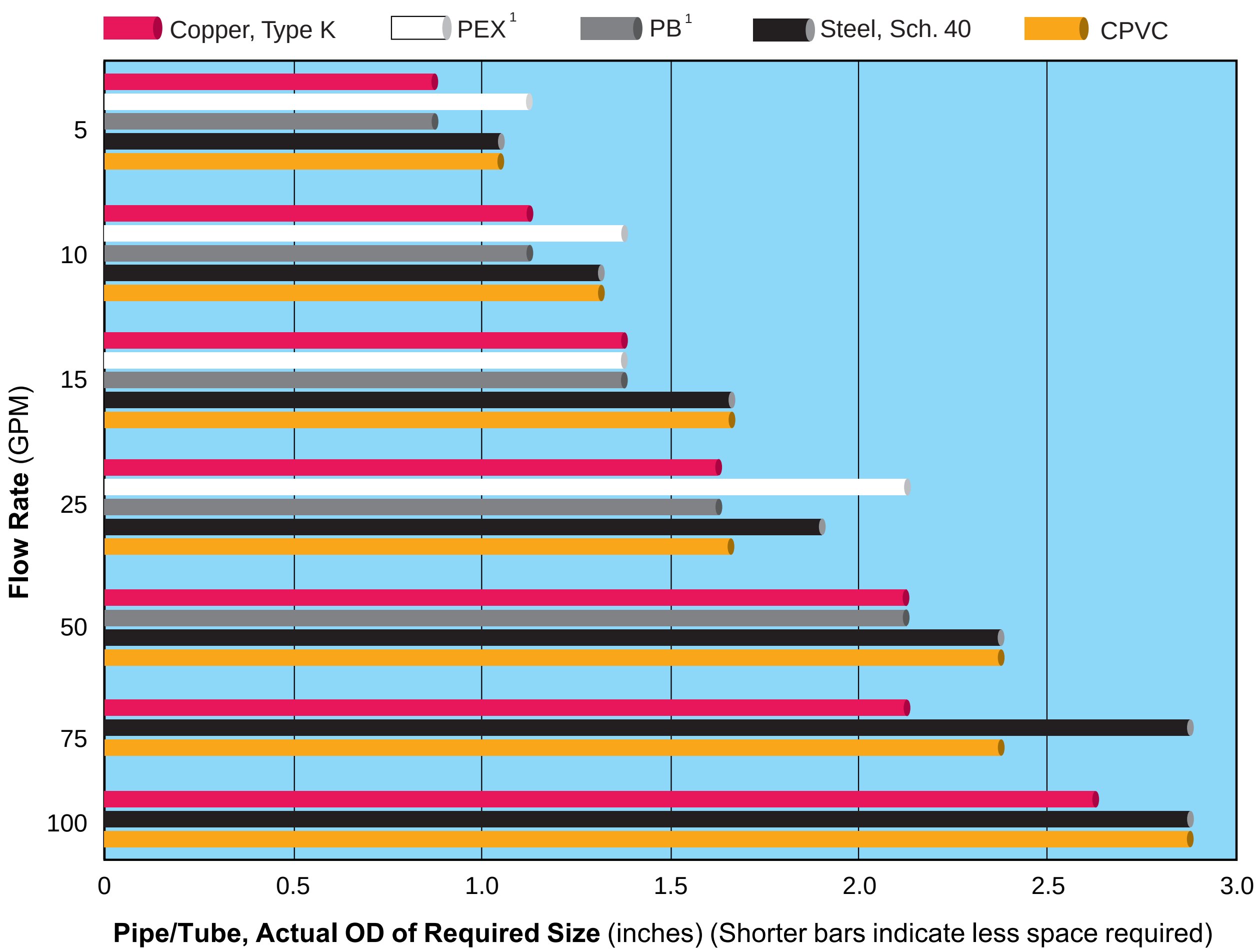
Performance

The assured performance offered by copper fire sprinkler systems is important to everyone involved — the architect, engineer, building owner, contractor, insurer, and fire service personnel.

Copper tubing exhibits excellent resistance to damage from internal and external corrosion. It does not develop internal surface roughness or experience a gradual narrowing of the passage caused by internal corrosion. The potential for plugging of sprinkler head orifices and small diameter branch lines is significantly reduced with copper tube since the normal thin, protective corrosion film in the tube bore does not flake off. This also reduces the need for periodic maintenance flushing operations. Copper is also highly resistant to external sources of corrosion, including exposure to moisture, most chemical fumes, process vapors, and similar atmospheres.

The superior flow capacity of copper permits reduced cross- and feed main-sizing in many hydraulically calculated systems. In pipe schedule systems this advantage is reflected in the increased number of sprinklers permitted by applicable standards for copper lines of two-inch and larger. Furthermore, NFPA recognizes the use of ¾-inch copper tube in sprinkler applications while the minium size requirement for steel pipe is one inch.

Copper is an inherently safe material. It will not burn or support combustion, nor does it decompose to toxic gases. Also, it will not carry fire through floors, walls and ceilings. A copper system maintains its integrity and ability to carry water where planned when exposed in a fire situation. Copper tube will not deteriorate with age or become embrittled and fail, but remains effective for the life of the installation. Should any part of the system be damaged, it can be repaired quickly and easily, often by soldering or brazing in a new piece. Tees for new sprinkler drops can also be mechanically formed in place using hand tools.



[1]not available in sizes over 2-inch, nominal size.

Figure 8. Minimum Pipe/Tube OD Required for Various Flow Rates at 5 psi/100 ft. pressure drop

Contents

1. Physical Characteristics of Copper Tube

For use in fire protection systems, three types of seamless drawn copper tube (Type K, L and M) are currently accepted by NFPA 13, 13D and 13R. For all three types, the outside diameter is equal to the nominal diameter plus 1/8 inch. However, wall thicknesses (and thus inside diameters) vary. Type M copper tubing has the thinnest wall and is also the least costly. Type L is the second thinnest. Type K tube has the thickest wall, the smallest inside diameter, the greatest cost, and is not widely used. Types L and K are used where bending is required. All copper tube is available in drawn (hard) temper in straight lengths (ordinarily 20 feet long). Types K and L are also available in annealed (soft) temper, supplied in either 20-foot straight lengths or in 100-foot coils for sizes up to 1 inch and 45-foot coils for sizes up to 2 inches.

Wrought and cast copper and copper alloy solder joint pressure fittings are accepted by NFPA 13, 13D and 13R. These are available in a wide choice of configurations for use with each type of copper tube.

Table 1. Dimensions and Physical Characteristics of Tube, Types L and M

SIZE (inches)	O.D. (inches)		I.D. (inches)		WALL THICKNESS (inches)		CROSS SECTION OF BORE (inches²)		WEIGHT (lbs/ft) TUBE ONLY		WEIGHT (lbs/ft) TUBE & WATER	
TYPE	L	M	L	M	L	M	L	M	L	M	L	M
3/4	0.875	0.875	0.785	0.811	0.045	0.032	0.484	0.517	0.46	0.33	0.66	0.55
1	1.125	1.125	1.025	1.055	0.050	0.035	0.825	0.874	0.66	0.47	1.01	0.84
1 1/4	1.375	1.375	1.265	1.291	0.055	0.042	1.257	1.309	0.88	0.68	1.43	1.25
1 1/2	1.625	1.625	1.505	1.527	0.060	0.049	1.779	1.832	1.14	0.94	1.91	1.73
2	2.125	2.125	1.985	2.009	0.070	0.058	3.095	3.170	1.75	1.46	3.09	2.83
2 1/2	2.625	2.625	2.465	2.495	0.080	0.065	4.773	4.890	2.48	2.03	4.54	4.14
3	3.125	3.125	2.945	2.981	0.090	0.072	6.813	6.980	3.33	2.68	6.27	5.70
4	4.125	4.125	3.905	3.935	0.110	0.095	11.978	12.163	5.38	4.66	10.56	9.83

2. Friction Loss Tables

Table 2. Friction Loss (psi per linear foot) for Types L and M Copper Tube with "C Factor" = 150*

Velocity: 0-10 feet per second | 11-20 feet per second

GPM	3/4" L	3/4" M	1" L	1" M	1 1/4" L	1 1/4" M	1 1/2" L	1 1/2" M	2" L	2" M
1	.001	.001								
1.5	.003	.003	.001	.001						
2	.005	.004	.001	.001						
2.5	.008	.006	.002	.002	.001	.001				
3	.011	.009	.003	.003	.001	.001				
3.5	.014	.012	.004	.003	.001	.001	.001.	.001		
4	.018	.015	.005	.004	.002	.002	.001	.001		
4.5	.022	.019	.006	.005	.002	.002	.001	.001		
5	.027	.023	.007	.006	.003	.002	.001	.001		
5.5	.032	.028	.009	.008	.003	.003	.001	.001		
6	.038	.033	.010	.009	.004	.003	.002	.001		
6.5	.044	.038	.012	.010	.004	.004	.002	.002		
7	.051	.043	.014	.012	.005	.004	.002	.002	.001	.001
7.5	.058	.049	.016	.014	.006	.005	.002	.002	.001	.001
8	.065	.055	.018	.015	.006	.006	.003	.003	.001	.001
8.5	.073	.062	.020	.017	.007	.006	.003	.003	.001	.001
9	.081	.069	.022	.019	.008	.007	.003	.003	.001	.001
9.5	.089	.076	.024	.021	.009	.008	.004	.003	.001	.001
10	.098	.084	.027	.023	.010	.009	.004	.004.	.001	.001
10.5	.107	.092	.029	.025	.011	.010	.005	.004	.001	.001
11	.117	.100	.032	.028	.011	.010	.005	.005	.001	.001
11.5	.127	.108	.035	.030	.012	.011	.005	.005	.001	.001
12	.137	.117	.037	.033	.013	.012	.006	.005	.001	.001
12.5	.148	.126	.040	.035	.015	.013	.006	.006	.002	.002
13	.159	.136	.043	.038	.016	.014	.007	.006	.002	.002
13.5	.171	.146	.047	.040	.017	.015	.007	.007	.002	.002
14	.183	.156	.050	.043	.018	.016	.008	.007	.002	.002
14.5	.195	.166	.053	.046	.019	.017	.008	.008	.002	.002
15	.208	.177	.057	.049	.020	.018	.009	.008	.002	.002
16	.234	.200	.064	.055	.023	.021	.010	.009	.003	.002
17	.262	.223	.071	.062	.026	.023	.011	.010	.003	.003
18	.291	.248	.079	.069	.028	.026	.012	.011	.003	.003
19	.321	.274	.088	.076	.031	.029	.014	.013	.004	.003
20	.353	.302	.096	.084	.035	.031	.015	.014	.004	.004
21	.387	.330	.105	.092	.038	.034	.016	.015	.004	.004
22	.422	.360	.115	.100	.041	.037	.018	.017	.005	.004
23	.458	.391	.125	.108	.045	.041	.019	.018	.005	.005
24	.495	.423	.135	.117	.048	.044	.021	.019	.005	.005
25	.534	.456	.146	.127	.052	.047	.022	.021	.006	.005
26	.574	.490	.157	.136	.056	.051	.024	.022	.006	.006
27	.616	.525	.168	.146	.060	.055	.026	.024	.007	.006
28	.659	.562	.180	.156	.064	.058	.028	.026	.007	.0007
29	.703	.600	.192	.167	.069	.062	.030	.028	.008	.007
30	.748	.638	.204	.177	.073	.066	.031	.029	.008	.008

GPM	1" L	1" M	1 1/4" L	1 1/4" M	1 1/2" L	1 1/2" M	2" L	2" M	2 1/2" L	2 1/2" M	3" L	3" M	4" L	4" M
31	.217	.188	.078	.070	.033	.031	.009	.008	.003	.003	.001	.001		
32	.230	.200	.083	.075	.035	.033	.009	.009	.003	.003	.001	.001		
33	.243	.212	.087	.079	.037	.035	.010	.009	.003	.003	.001	.001		
34	.257	.224	.092	.084	.040	.037	.010	.010	.004	.003	.002	.001		
35	.271	.236	.097	.088	.042	.039	.011	.010	.004	.004	.002	.001		
36	.286	.248	.103	.083	.044	.041	.011	.011	.004	.004	.002	.002		
37	.301	.261	.108	.098	.046	.043	.012	.011	.004	.004	.002	.002		
38	.316	.275	.113	.103	.049	.045	.013	.012	.004	.004	.002.	002		
39	.332	.288	.119	.108	.051	.048	.013	.014	.005	.004	.002.	.002		
40	.348	.302	.125	.113	.054	.050	.014	.013	.005	.005	.002	.002	.001	
41	.364	.316	.131	.118	.056	.052	.015	.014	.005	.005	.002	.002	.001	.001
42	.380	.330	.137	.124	.059	.055	.015	.014	.005	.005	.002	.002	.001	.001
43	.397	.345	.143	.129	.061	.057	.016	.015	.006	.005	.002	.002	.001	.001
44	.415	.360	.149	.135	.064.	059	.017	.016	.006	.005	.002	.002	.001	.001
45	.432	.375	.155	.140	.067	.062	.017	.016	.006	.006	.003.	002	.001	.001
46	.450	.391	.162	.146	.069	.065	.018	.017	.006	.006	.003	.002	.001	.001
47	.468	.407	.168	.152	.072	.067	.019	.018	.007	.006	.003	.003	.001	.001
48	.487	.423	.175	.158	.075	.070	.019	.018	.007	.006	.003	.003	.001	.001
49	.506	.440	.182	.164	.078	.073	.020	.019	.007	.007	.003	.003	.001	.001
50	.525	.456	.188	.171	.081	.075	.021	.020	.007	.007	.003	.003	.001.	001
51	.545	.473	.196	.177	.084	.078	.022	.021	.008	.007	.003	.003	.001	.001
52	.565	.491	.203	.184	.087	.081	.023	.021	.008	.007	.003	.003	.001	.001
53	.585	.508	.210	.190	.090	.084	.023	.022	.008	.008	.003	.003	.001	.001
54	.605	.526	.217	.197	.093	.087	.024	.023	.008	.008	.004	.003	.001	.001
55	.626	.544	.225	.204	.096	.090	.025	.024	.009	.008	.004	.003	.001.	001
56	.648	.563	.232	.211	.100	.093	.026	.024	.009	.009	.004	.004	.001	.001
57	.669	.581	.240	.218	.103	.096	.027	.025	.009	.009	.004	.004	.001	.001
58	.691	.600	.248	.225	.106	.099	.028	.026	.010	.009	.004	.004	.001	.001
59	.713	.620	.256	.232	.110	.102	.029	.027	.010	.009	.004	.004	.001	.001
60	.736	.639	.264	.239	.113	.106	.029	.028	.010	.010	.004	.004	.001	.001
61	.759	.659	.272	.247	.117	.109	.030	.029	.011	.010	.004	.004	.001	.001
62	.782	.679	.281	.254	.120	.112	.031	.029	.011	.010	.005	.004	.001	.001
63	.805	.700	.289	.262	.124	.116	.032	.030	.011	.011	.005	.004	.001	.001
64	.829	.720	.298	.270	.128	.119	.033	.031	.012	.011	.005	.005	.001	.001
65	.853	.741	.306	.277	.131	.122	.034	.032	.012	.011	.005	.005	.001	.001
66	.878	.763	.315	.285	.135	.126	.035	.033	.012	.012	.005	.005	.001	.001
67	.902	.784	.324	.293	.139	.130	.036	.034	.013	.012	.005	.005	.001	.001
68	.927	.806	.333	.302	.143	.133	.037	.035	.013	.012	.005	.005	.001	.001
69	.953	.828	.342	.310	.147	.137	.038	.036	.013	.013	.006	.005	.001	.001
70	.979	.850	.351	.318	.151	.140	.039	.037	.014	.013	.006	.005	.001	.001
71		.873	.361	.327	.155	.144	.040	.038	.014	.013	.006	.006	.001	.001
72		.896	.370	.335	.159	.148	.041	.039	.014	.014	.006	.006	.002	.001
73		.919	.380	.344	.163	.152	.042	.040	.015	.014	.006	.006	.002	.002
74		.942	.389	.353	.167	.156	.043	.041	.015	.014	.006	.006	.002	.002
75		.966	.399	.361	.171	.160	.044	.042	.015	.015	.007	.006	.002	.002

21-30 feet per second

> 30 feet per second

GPM	1¼" L	1¼" M	1½" L	1½" M	2" L	2" M	2½" L	2½" M	3" L	3" M	4" L	4" M
76	.409	.370	.175	.164	.046	.043	.016	.015	.007	.006	.002	.002
77	.419	.379	.180	.168	.047	.044	.016	.015	.007	.006	.002	.002
78	.429	.389	.184	.172	.048	.045	.017	.016	.007	.007	.002	.002
79	.439	.398	.189	.176	.049	.046	.017	.016	.007	.007	.002	.002
80	.450	.407	.193	.180	.050	.047	.017	.016	.007	.007	.002	.002
81	.460	.417	.197	.184	.051	.048	.018	.017	.008	.007	.002	.002
82	.471	.426	.202	.188	.052	.049	.018	.017	.008	.007	.002	.002
83	.481	.436	.207	.192	.054	.051	.019	.018	.008	.007	.002	.002
84	.492	.446	.211	.197	.055	.052	.019	.018	.008	.008	.002	.002
85	.503	.456	.216	.201	.056	.053	.020	.018	.008	.008	.002	.002
86	.514	.466	.221	.206	.057	.054	.020	.019	.008	.008	.002	.002
87	.525	.476	.225	.210	.059	.055	.020	.019	.009	.008	.002	.002
88	.536	.486	.230	.214	.060	.056	.021	.020	.009	.008	.002	.002
89	.548	.496	.235	.219	.061	.058	.021	.020	.009	.008	.002	.002
90	.559	.506	.240	.224	.062	.059	.022	.020	.009	.009	.002	.002
91	.571	.517	.245	.228	.064	.060	.022	.021	.009	.009	.002	.002
92	.582	.527	.250	.233	.065	.061	.023	.021	.010	.009	.002	.002
93	.594	.538	.255	.238	.066	.062	.023	.022	.010	.009	.002	.002
94	.606	.549	.260	.242	.068	.064	.024	.022	.010	.009	.003	.002
95	.618	.560	.265	.247	.069	.065	.024	.023	.010	.010	.003	.002
96	.630	.571	.270	.252	.070	.066	.024	.023	.010	.010	.003	.003
97	.642	.582	.276	.257	.072	.068	.025	.024	.010	.010	.003	.003
98	.655	.593	.281	.262	.073	.069	.025	.024	.011	.010	.003	.003
99	.667	.604	.286	.267	.074	.070	.026	.024	.011	.010	.003	.003
100	.679	.615	.292	.272	.076	.071	.026	.025	.011	.010	.003	.003
105	.744	.674	.319	.297	.083	.078	.029	.027	.012	.011	.003	.003
110	.811	.734	.348	.324	.090	.085	.031	.030	.013	.012	.003	.003
115	.880	.797	.378	.352	.098	.093	.034	.032	.014	.014	.004	.004
120	.952	.862	.409	.381	.106	.100	.037	.035	.016	.015	.004	.004
125		.930	.441	.411	.114	.108	.040	.038	.017	.016	.004	.004
130			.474	.441	.123	.116	.043	.040	.018	.017	.005	.004
135			.508	.473	.132	.124	.046	.043	.019	.018	.005	.005
140			.543	.506	.141	.133	.049	.046	.021	.019	.005	.005
145			.580	.540	.151	.142	.052	.049	.022	.021	.006	.005
150			.617	.575	.160	.151	.056	.053	.023	.022	.006	.006
160			.696	.648	.181	.170	.063	.059	.026	.025	.007	.006
170			.778	.725	.202	.191	.070	.066	.030	.028	.007	.007
180			.865	.806	.225	.212	.078	.074	.033	.031	.008	.008
190			.956	.891	.248	.234	.086	.082	.036	.034	.009	.009
200				.979	.273	.257	.095	.090	.040	.038	.010	.010
210					.299	.282	.104	.098	.044	.041	.011	.011
220					.326	.307	.113	.107	.048	.045	.012	.012
230					.354	.333	.123	.116	.052	.049	.013	.013
240					.383	.361	.133	.126	.056	.053	.014	.014
250					.413	.389	.144	.135	.060	.057	.015	.015

GPM	2" L	2" M	2½" L	2½" M	3" L	3" M	4" L	4" M
260	.444	.418	.154	.146	.065	.061	.016	.016
270	.476	.449	.166	.156	.070	.066	.018	.017
280	.509	.480	.177	.167	.075	.070	.019	.018
290	.543	.512	.189	.178	.079	.075	.020	.019
300	.578	.545	.201	.190	.085	.080	.021	.021
310	.614	.579	.214	.202	.090	.085	.023	.022
320	.651	.614	.227	.214	.095	.090	.024	.023
330	.689	.650	.240	.226	.101	.095	.026	.025
340	.729	.687	.254	.239	.107	.101	.027	.026
350	.769	.725	.268	.252	.113	.106	.028	.027
360	.810	.764	.282	.266	.119	.112	.030	.029
370	.852	.804	.297	.280	.125	.118	.032	.030
380	.895	.844	.312	.294	.131	.124	.033	.032
390	.939	.886	.327	.308	.138	.130	.035	.034
400	.984	.928	.343	.323	.144	.136	.036	.035
410		.972	.359	.338	.151	.142	.038	.037
420			.375	.354	.158	.149	.040	.038
430			.392	.369	.165	.155	.042	.040
440			.409	.385	.172	.162	.044	.042
450			.426	.402	.179	.169	.045	.044
460			.444	.419	.187	.176	.047	.046
470			.462	.436	.194	.183	.049	.047
480			.480	.453	.202	.190	.051	.049
490			.499	.470	.210	.198	.053	.051
500			.518	.488	.218	.205	.055	.053
510			.537	.507	.226	.213	.057	.055
520			.557	.525	.234	.221	.059	.057
530			.577	.544	.243	.229	.061	.059
540			.597	.563	.251	.237	.064	.061
550			.618	.583	.260	.245	.066	.063
560			.639	.602	.269	.253	.068	.065
570			.660	.622	.278	.262	.070	.068
580			.682	.643	.287	.270	.073	.070
590			.704	.663	.296	.279	.075	.072
600			.726	.684	.305	.288	.077	.074
610			.748	.705	.315	.297	.080	.077
620			.771	.727	.324	.306	.082	.079
630			.794	.749	.334	.315	.085	.081
640			.818	.771	.344	.324	.087	.084
650			.842	.793	.354	.334	.090	.086
660			.866	.816	.364	.343	.092	.089
670			.890	.839	.374	.353	.095	.091
680			.915	.863	.385	.363	.097	.094
690			.940	.886	.395	.372	.100	.096
700			.965	.910	.406	.383	.103	.099

GPM	3" L	3" M	4" L	4" M
710	.417	.393	.105	.102
720	.428	.403	.108	.104
730	.439	.413	.111	.107
740	.450	.424	.114	.110
750	.461	.435	.117	.112
760	.473	.445	.120	.115
770	.484	.456	.123	.118
780	.496	.467	.125	.121
790	.508	.478	.128	.124
800	.520	.490	.131	.127
810	.532	.501	.135	.130
820	.544	.513	.138	.133
830	.556	.524	.141	1.36
840	.569	.536	.144	.139
850	.581	.548	.147	.142
860	.594	.560	.150	.145
870	.607	.572	.154	.148
880	.620	.584	.157	.151
890	.633	.596	.160	.154
900	.646	.609	.164	.158
910	.659	.622	.167	.161
920	.673	.634	.170	.164
930	.686	.647	.174	.167
940	.700	.660	.177	.171
950	.714	.673	.181	.174
960	.728	.686	.184	.177
970	.742	.699	.188	.181
980	.756	.713	.191	.184
990	.771	.726	.195	.188
1000	.785	.740	.199	.191

* Based on Hazen-Williams formula:

$$P = \frac{4.52\,Q^{1.85}}{C^{1.85}\,d^{4.87}}$$

Where:
- P = friction loss, psi per linear foot
- Q = flow, g.p.m.
- d = average I.D., in inches
- C = constant, 150

3. Friction Losses: Fittings and Valves

Table 3. Pressure Loss in Fittings and Valves Expressed as Equivalent Length of Tube, feet.

Fitting Size (inches)	Fittings					Valves			
	Standard Ells 90°	Standard Ells 45°	90° Tees side branch	90° Tees straight run	Coupling	Ball	Gate	Btfly	Check
3/4	2	0.5	3	–	–	–	–	–	3
1	2.5	1	4.5	–	–	0.5	–	–	4.5
1 1/4	3	1	5.5	0.5	0.5	0.5	–	–	5.5
1 1/2	4	1.5	7	0.5	0.5	0.5	–	–	6.5
2	5.5	2	9	0.5	0.5	0.5	0.5	7.5	9
2 1/2	7	2.5	12	0.5	0.5	–	1	10	11.5
3	9	3.5	15	1	1	–	1.5	15.5	14.5
3 1/2	9	3.5	14	1	1	–	2	–	12.5
4	12.5	5	21	1	1	–	2	16	18.5

Notes: The equivalent length values above are actual values for copper fittings based on a C factor of 150 in the Hazen-Williams friction loss formula. They are actual values and need not be increased by the correction factor of 1.51 as indicated in NFPA 13 to translate values developed for fittings with a C factor of 120. The lengths shown are rounded to the nearest half foot.

4. Tube Bending Guide

Table 4. Bending Guide for Copper Tube*

Tube Size (inches)	Tube Type	Temper	Min. Bend Radius (inches)**
3/4	K,L K,L	Annealed Drawn	3 3
1	K,L	Annealed	4
1 1/4	K,L	Annealed	9

* NFPA 13, Sec. 2-3.6 allows bending K and L copper tube.
NFPA 13D and 13R have no restrictions on bending copper tube.
** Bending done with mechanical tools.

5. Hanger Spacing

Table 5. Hanger Spacing

Tube Size (inches)	Horizontal run Hanger spacing (feet)
3/4, 1	8
1 1/4, 1 1/2	10
2, 2 1/2, 3	12
3 1/2 to 8	15

6. Hanger Sizing

Table 6. Hanger Sizing

Copper Tube		SPS Steel Band or Ring Hanger	
Tube Size (inches)	Nominal O.D. (inches)	Size (inches)	Minimum I.D. (inches)
3/4	0.875	1/2 or 3/4	0.840 or 1.050
1	1.125	3/4 or 1	1.050 or 1.315
1 1/4	1.375	1	1.315
1 1/2	1.625	1 1/4	1.660
2*	2.125	2	2.375

* Above 2-inch, use the same SPS hanger size as the tube size.

7. Soldering and Brazing Information

NFPA 13, 13D and 13R recognize the use of 95-5 tin-antimony solder for the joining of wet-pipe copper fire sprinkler systems.[1]

For all copper systems, NFPA 13 recognizes the use of filler metals for brazing which withstand higher temperatures. NFPA 13 allows the use of BCuP-3 and BCuP-4 brazing filler metals. For more information, refer to AWS A5.8, ("Specification for Brazing Filler Metal").*

Excellent results are attained in using a non-aggressive soldering or brazing flux which should be applied sparingly in a thin, even coating to both tube and fitting. The fluxes best suited for soldering copper and copper alloy tube should meet the requirements of ASTM B 813. The fluxes used in brazing are different in composition to soldering fluxes and can not be used interchangeably.

1. To consistently make satisfactory soldered joints, follow the sequence of joint preparation and operations prescribed in ASTM Standard Practice B 828.

References

ANSI: American National Standards Institute, Inc. 1819 L Street NW Washington, DC 20036.

ASME: The American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10016-5990.

ASTM: American Society for Testing and Materials, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.

*AWS: American Welding Society, 550 N.W. LeJeune Road Miami, FL 33126.

Table 7. Typical Consumption of Solder per 100 Joints

Tube Size (inches)	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Solder* (pounds)	0.60	0.90	1.1	1.5	2.4	3.2	4.3	7.5

*Pounds per 100 joints includes an allowance of 100% to cover wastage and loss for tube sizes up to 2 inches and 25% for 2 1/2 inches and larger. Flux requirements are usually 2 ounces per pound of solder.

CAUTION

Careless workmanship, especially during flux application, can result in corrosion of tube and sprinkler heads long after the sprinkler system has been installed. If excessive flux is used, the residue inside the tube can cause corrosion. In an extreme case, such residual flux can actually lead to perforation through the tube wall causing leakage. To guard against this danger, it is important to follow the correct joining procedures as stated in the ASTM B 828.

8. Material Specifications

Table 8. Specifications for Tube, Fittings, Solder and Brazing Alloys and Flux

Materials	Applicable Specification or Standard
TUBE:	
Seamless Copper Tube	ASTM B 75
Seamless Copper Water Tube (Type K, L and M)	ASTM B 88
General Requirements for Wrought Seamless Copper and Copper-Alloy Tube	ASTM B 251
Copper Drainage Tube (DWV)	ASTM B 306
FITTINGS:	
Cast Copper Alloy Solder Joint Pressure Fittings	ASME B 16.18
Wrought Copper and Copper Alloy Solder Joint Pressure Fittings	ASME B 16.22
Cast Copper Alloy Pipe Flanges and Flanged Fittings	ASME B 16.24
JOINING MATERIALS:	
Brazing Filler Metal (Classification BCuP-3 or BCuP-4)	ANSI/AWS A 5.8
Solder Metal (95-5 Tin-Antimony, Alloy Grade Sb5)	ASTM B 32
Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.	ASTM B 813
Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings	ASTM B 828

RELEVANT COPPER DEVELOPMENT ASSOCIATION LITERATURE

Residential Fire Sprinkler Systems (A4010)

Copper vs. CPVC for Automatic
Fire Sprinkler Systems (A4026)

The Copper Tube Handbook (A4015)

Copper Tube Sizing Calculator and Handbook (A4005)

Guide Specifications on Plumbing (A4018)

Soldering and Brazing Copper Tube and Fittings (A1143)

Application Bulletins — Copper Fire Sprinkler Systems:
- Pelican Bay Apartments, Mesa, Arizona (410/5)
- Peabody Court Hotel, Baltimore, Maryland (405/4)
- Wanamaker House Apartments, Philadelphia, Pennsylvania (406/4)
- Stone Creek Apartments, Tyler, Texas (404/4)

Phoenix Municipal Building: Copper Installation (4014)

Contractor Finds Copper System Saves
More than Just Pennies (4043)

CDA
Copper Development Association

A4003-96/02