Table 20 Application of Pipe, Tube, and Fittings for Heating and Air Conditioning

Application	Materials Commonly Used	Application	Materials Commonly Used
Chilled water	Type K or L hard copper, wrought iron, or black steel, Schedule 40	Hot water heating[a]	Type K or L hard copper, black steel, or wrought iron, Schedule 40
Cooling tower	Type K or L hard copper, wrought iron, or black steel, Schedule 40	Refrigerant[a]	Type K or L hard copper, wrought iron or black steel, Schedule 40
Underground water		Steam heating	
2-in. and smaller	Type K soft copper, galvanized wrought iron, or galvanized steel, Schedule 40 (for corrosive soils, a coated steel pipe should be used)	Supply 125 psi and less	Type L hard copper, black steel, Schedule 40, standard fittings
		125 to 250 psi	Type K hard copper, black steel, Schedule 40.
2½-in. and larger	Type K, soft copper cast iron, Class 150, galvanized wrought iron, or galvanized steel, Schedule 40 (for corrosive soils, a coated steel pipe should be used)	Return pipe All sizes	Type K or L hard copper, black wrought iron or steel, Schedule 40. Standard fittings
City water—inside building	Type K or L hard copper, galvanized wrought iron, or galvanized steel, Schedule 40	Receiver vent All sizes	Copper drainage tube DWV, galvanized wrought iron or steel, Schedule 40. Standard fittings
Underground rain water conductors		Sanitary[d,e]	
Small installations	Vitrified clay or cast-iron soil	Small installations Waste:	
Under paved areas	Vitrified clay or cast-iron soil	1½-in. and smaller	Copper drainage tube DWV, galvanized wrought iron or steel, Schedule 40
Large installations 8-in. and smaller	Cast-iron soil XH or vitrified clay	2-in. and larger	Cast iron, copper drainage tube DWV, galvanized steel, Schedule 40, or vitrified clay
10 to 24-in.	Vitrified clay or concrete	Vents: 2½-in. and smaller	Copper drainage tube DWV, galvanized wrought iron or steel, Schedule 40
30-in. and larger	Vitrified clay or concrete	3-in. and larger	Cast iron, copper drainage tube DWV, or galvanized steel, Schedule 40
5 feet outside bldg. and under paving	Cast-iron soil XH or vitrified clay	Large installations Waste:	
Interior rain water conductors		2-in. and larger	Cast iron, galvanized steel, Schedule 40, copper drainage tube DWV or vitrified clay
Small installations	Copper drainage tube DWV, black or galvanized wrought iron or steel Schedule 40	Vents:	
Large installations	Copper drainage tube DWV, cast-iron soil XH, black or galvanized wrought iron or steel, Schedule 40	2-in. and larger	Cast iron, galvanized steel, Schedule 40, or copper drainage tube DWV
Panel heating[a]	Type K or L hard or soft copper, black steel or wrought iron, Schedule 40	Gas (all kinds) All sizes	Black steel, Schedule 40, malleable iron fittings

[a] Panel heating copper fittings should be soldered with 95-5 solder: Steel fittings should be welded.
[b] All underground feed and return lines buried in slab, should be equipped with fittings as outlined for panel heating.
[c] Refrigerant fittings on copper pipe must be wrought copper. All welded fittings should be long turn.
[d] House sewer to main should be cast iron XH.
[e] Materials must comply with local plumbing codes.

action of a column under excessive compression. In fact, a pipe line in compression is identical to a column. Column criteria can therefore be used for selecting the action of supports to resist lateral thrust.

A common equation for determining safe column loads is Euler's formula:

$$S = \pi^2 E \left(\frac{k}{l}\right)^2 \quad \text{(for cast iron see Equation 8)} \qquad (5)$$

where

S = allowable column load, pounds per square inch.
k = radius of gyration, inches.
l = column length, inches.

$$k^2 = \frac{I}{A} = \frac{(D_o)^2 + (D_i)^2}{16}$$

Equation 5 is sometimes modified by a correction factor C to the following:

$$S = C\pi^2 E \left(\frac{k}{l}\right)^2 \qquad (6)$$

From Equation 6:

$$l = \pi k \sqrt{\frac{CE}{S}} \qquad (7)$$

This equation is not used for column construction but is sufficiently accurate for the work of a heating engineer.

The equation is modified for cast iron because of its poor tensile strength. It is generally acceptable to use one-half the value of S from Equation 5 for cast iron, so the safe column load S_1 for cast iron is:

$$S_1 = \frac{\pi^2 E}{2}\left(\frac{k}{l}\right)^2 \quad \text{for cast iron.} \qquad (8)$$

It is permissible to allow the l/k ratio for steel to go as high as 120, but for cast iron the desirable maximum is taken as 70. It is not to be understood that a fracture will occur at l/k ratios in excess of those given, rather it is to be understood that lateral support should be given for those ratios and for those magnitudes of stress. If an expansion joint is used, this will, of course, relieve the compressive stress.

Example 2: For *Example 1* given in the preceding section, the constraining force for a 1-in. pipe was 9630 lb. What is a required spacing for lateral support for this pipe?

Answer: Using Euler's formula, Equation 5 gives:

$$S = \pi^2 E \left(\frac{k}{l}\right)^2$$

so $$l = \pi k \sqrt{E/S}$$

For a 1 in. Schedule 40 steel pipe

$k = 0.4205$ in.
$E = 30{,}000{,}000$ psi.
$S = 9630 + 0.494 = 19500$ psi.
$l = 51.8$ in.

Therefore, lateral supports on 4-ft centers are adequate.

The other type of load requiring some support is the bending stress due to the weight of the pipe, its insulation, and of the fluid being carried. There is also the bending moment that may be caused by the flexure of the pipe. A discussion of flexure loading is beyond the scope of this chapter.

Since hangers should always be designed to take the bending moment (including buckling) from the pipe, it is necessary to design the hangers or supports for the maximum bending stress. Even with perfect support spacing there will be some sagging; therefore, the supports should be on a gradient if it is necessary to prevent pockets. Such a condition arises for condensate piping.

Typical bending and deflection equations are given in Table 18, in order that supports can be properly sized, and, if necessary, pitched. These equations are typical beam equations. If more complex loadings exist, proper beam equations can be applied. Such equations are found in standard texts on mechanics of materials.

The recommended maximum spacing of hangers and the minimum diameter of hanger rods are given in Table 19.

By application of the equations given in this section and the section on Expansion and Flexibility, it is possible to determine the proper location and type of support for straight lines. There are two types of supports, anchors and hangers.

Anchors are used to guide the expansion or to fix the pipe. They are needed to take the stress out of the line and translate the stresses to the foundations. In that way, all stress can be taken out of the line before it can be transferred to such equipment as boilers or pumps. By means of solid anchors, the anchors can be used to divide the piping into isolated sections that cannot transmit the stresses to other sections.

Hangers are used to support the piping and to take out the bending stresses. They are of the spring, roller, or rod type. Such types generally allow the free movement of the pipe and yet maintain full support.

The *Code for Pressure Piping*, ASA B31.1, has strict requirements for the materials used in hangers and supports. The structural properties have a safety factor of five, and consequently there is little chance of failure due to a sudden change of load.

There is a type of support for almost every conceivable requirement. Complete information can best be obtained from a hanger manufacturer.

Table 21 Relative Cost Index for Schedule 40 Steel Pipe and Type L Hard Copper Tube[a]

Nominal Size, in.	Schedule 40 Steel Pipe	Type L, Hard Copper Tube
⅛	0.30	0.19
¼	0.46	0.25
1	0.54	0.28
1¼	0.61	0.40
1½	0.66	0.46
2	0.76	0.68
2½	1.00	1.00
3	1.25	1.25
4	1.63	2.00
5	2.19	2.90
6	2.87	3.65
8	3.44	—
10	4.52	—
12	5.67	—

[a] Cost index is based on material and labor costs, assuming straight run piping, ideal installation conditions, hangers every 10 ft, fittings every 8 ft, ⅛ in. to 2 in. steel pipe screwed, 2½ to 12 in. steel pipe welded, copper tube with sweat fittings. Data are given in relative cost (not dollar cost) per unit of length.

APPLICATION OF PIPE, TUBE, AND FITTINGS

In the application of pipe, tube, and fittings it is necessary to comply with regulations contained in local codes and ordinances and in voluntary industry codes.[1,2] Table 20 is offered as a guide to current practice in heating and air conditioning. It is based on practice in a number of consulting engineers' offices and information extracted from Reference 8. It should be borne in mind that selection of material to be used will also be influenced by the familiarity of local artisans with methods of using different materials.

Economic Considerations

Table 21 shows the comparative installed costs of Type L copper and Schedule 40 steel pipe. The data in Table 21 were