

The background of the cover features several copper tubes and coils of varying lengths and diameters, arranged on a dark, textured rock surface. The lighting highlights the metallic sheen of the copper. On the left side, there is a vertical strip of light gray rectangular blocks.

**COPPER TUBE IN DOMESTIC
WATER SERVICES
DESIGN AND INSTALLATION**

**COPPER DEVELOPMENT ASSOCIATION
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COPPER TUBE IN DOMESTIC WATER
SERVICES
DESIGN AND INSTALLATION

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Copper Development Association (limited by guarantee) is a non-trading organisation sponsored by the copper producers and fabricators to encourage the use of copper and copper alloys and to promote their correct and efficient application. Its services, which include the provision of technical advice and information, are available to those interested in all aspects of existing and potential uses of copper. The Association also provides a link between research and the user industries and maintains close contact with other copper development organisations throughout the world.

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1 Introduction

This publication brings together basic information on a wide range of applications of copper tube in domestic water services. The majority of copper tubes and fittings available today have been developed over the past sixty years for use in hot and cold water services. During that period smaller diameter and thinner wall tubes have been introduced and the number of applications has increased significantly. New uses include residential fire sprinkler systems. This publication does not set out to be a detailed design guide but rather to give basic information on the range of actual and potential applications for copper tube in domestic water services. A companion publication entitled 'Copper in Domestic Heating Systems', publication 39, covers the use of copper in a number of forms and products in a wide range of domestic central heating systems.

The purpose of this publication is to assist the architect, designer and specifier as well as the operator in the understanding of the correct use of copper and copper alloys in domestic water service systems. Unvented hot water systems and regulations concerning standards of water quality together with the incidence and dangers of Legionnaires' Disease have highlighted the potential advantages of copper in domestic water services.

It should be noted that corrosion problems have occasionally arisen in certain soft water installations in the United Kingdom and elsewhere. In the rare

instances where problems have occurred these can be attributed to a combination of effects, including changes in the water supply, defects in design, incorrect installation techniques and failures to observe recommended commissioning and maintenance procedures. This publication therefore gives general guidance on good practices to reduce the potential incidence of the various forms of corrosion that may occur.

1.1 Advantages of copper tube

The properties that make copper tube the preferred material for domestic water services include the following:

- ease of installation
- ability to be easily joined and manipulated
- high strength
- high ductility
- ease of fabrication
- corrosion resistance
- suitability for use with potable and other waters
- potential as bactericide
- bio-fouling resistance
- availability in a range of metric sizes compatible with fittings and other system components
- guaranteed British Standard quality products

2 Copper Tubes

Copper tubes for domestic water services should be manufactured to BS EN 1057. This specification covers a range of sizes with appropriate tempers and wall thicknesses to meet a wide range of service requirements and conditions. Tubes to BS EN 1057 are

specifically designated for water and gas in sanitary and heating applications and meet the requirements of BS 6700. Annealed tube is designated BS EN 1057 - R220 and half-hard tube is designated BS EN 1057 - R250.

OD mm	Wall thickness, mm								
	0.6	0.7	0.8	0.9	1.0	1.2	1.5	2.0	2.5
6	W X		Y						
8	W X		Y						
10	X	W	Y						
12	X		Y						
15		X			Y				
22				X		Y			
28				X		Y			
35						X	Y		
42						X	Y		
54						X		Y	
66.7						X		Y	
76.1							X	Y	
108							X		Y
133							X		
159								X	

NOTE: BS EN 1057 specifies copper tubes which were available in BS 2871 Part 1. W - indicates BS 2871:Part 1 Table W tube size
X - indicates BS 2871:Part 1 Table X tube size Y - indicates BS 2871:Part 1 Table Y tube size

Table 1 Dimensions for tube to BS EN 1057

2.1 Maximum working pressures

The maximum working pressures at temperatures up to 65°C are calculated using the following formula:

$$P = \frac{20Ft}{D-t}$$

Where P = maximum working pressure (bar)
F = design stress (N/mm²)
t = minimum wall thickness (mm)
D = maximum outside diameter (mm)

Tubes installed underground, laid under floors or in other inaccessible places must be able to withstand twice the maximum working pressure.

The values of F used in the above formula depend upon the condition of the tube and are given in Table 2.

Condition	F(N/mm ²)
Annealed O, R220	46
Half-hard 1/2H, R250	60
Hard H, R290	72.5

Table 2 Design stress values for 65°C

Tubes in the 1/2H and H condition locally annealed during fabrication e.g. during hot bending, silver brazing or the attachment of welded fittings, should have the working pressure calculated from the design stress F in the annealed condition. Certain large diameter and/or thick walled copper tubes may be

subjected to over annealing during fabrication. This may result in the design strength being below that quoted for the annealed condition. If in doubt in these circumstances the customer should seek advice from the tube manufacturer.

Design stress values (F) for copper tubes operating at temperatures in excess of 110°C up to a maximum of 200°C are given in BS 1306 and typical values for tube in the annealed condition are given in Table 3.

Temperature °C	110	150	175	200
Max. admissible stress for annealed, R220, condition, N/mm ²	40	34	26	18

Table 3 Design stress values for working temperatures in excess of 65°C

Values for intermediate temperatures may be interpolated as required.

2.2 Chemical composition

The chemical composition of copper tubes to BS EN 1057 shall conform to the following requirements:

Cu + Ag: min. 99.90%

0.015% ≤ P ≤ 0.040%

Grade of copper designated Cu-DHP or CW024A.

3 Fittings

Various jointing techniques using either compression (Figures 1 & 4), capillary (Figures 2 & 3) methods or push-fit fittings are available. They employ gunmetal, brass (including dezincification resistant brass - see Appendix C) and wrought copper fittings in sizes up to 67mm, compression and capillary fittings being manufactured to BS EN 1254. Fittings of 67mm and larger are generally considered to be specialist and reference should be made to the tube and fittings manufacturers. Flanges and bolting to BS 4504: Part 2 are available for larger size copper tube. Copper tube may also be brazed and welded either directly or by means of copper or copper alloy weld fittings. The most

common methods for joining copper tubes involve the use of the following:

Compression Fittings	Type A - Non-manipulative Type B – Manipulative
Capillary Fittings	Soft Solder - End Feed Integral Solder Ring
Push-fit Fittings	
High Duty Fittings	Silver Brazing - End Feed Integral Brazing Ring

Maximum Temperature (°C)	From 6mm up to & including 34mm	Over 34mm up to & including 54mm	Over 54mm up to & including 108mm
30	25 bar	25 bar	16 bar
65	25 bar	16 bar	16 bar
110	16 bar	10 bar	10 bar

Table 4 Maximum working temperatures and pressures for capillary joints using tin/silver, tin/copper solder.

Maximum Temperature (°C)	From 6mm up to & including 54mm	Over 54mm up to & including 108mm
30	16 bar	10 bar
65	10 bar	6 bar
110	6 bar	4 bar
120	5 bar	3 bar

Table 5 Maximum working temperatures and pressures for compression joints

Note: High duty fittings containing high melting point solders may operate at higher working temperatures and/or pressures. Other higher duty welded and flange fittings may also operate at higher pressures and/or temperatures. For these applications the fittings manufacturer should be consulted.

All these methods of joining copper tubes, with the exception of the recently introduced push-fit fittings, have been used satisfactorily over a period of sixty years proving beyond doubt their suitability for water and other services. It is recommended that, where applicable, fittings used should also only be those approved under the 'Kitemark' scheme of the British Standards Institution.

3.1 Lead free solders

Legislation has resulted in a ban on the use of lead-containing solders in both new and repaired potable water systems. Major manufacturers of integral ring fittings have introduced individual marking schemes for lead-free solder fittings. In the case of end-feed fittings the onus is on the specifier and installer to ensure that lead-free, tin-copper or tin-silver solders, as specified in BS EN 29453 are used exclusively in potable water installations.

3.2 Joining dissimilar metals

Copper tube and copper and copper alloy fittings may be used in combination with a wide range of other materials. Some of the more commonly used combinations are listed as follows:

- a Copper/cast iron: Copper tubing may be connected to cast iron piping by a copper (or copper alloy) union/ferrule. The union to cast iron pipe joint is a screwed connection, whilst the copper tube to ferrule is a compression or capillary joint.
- b Copper/uPVC: Copper tubing may be connected to large diameter uPVC mains piping by means of a saddle and union or ferrule. The joint between the copper tube and the union or ferrule is again a compression or capillary fitting. Tubes of smaller sizes may be connected by a copper alloy union adapter with a compression or capillary fitting for the copper tube connection and a solvent weld screwed fitting between the uPVC pipe and the union.
- c Copper/polyethylene: Copper tube may be connected to polyethylene pipe by means of a copper or copper alloy union adapter. Compression joints are used for both materials with an additional pipe liner for the polyethylene

pipe connection. Copper and copper alloy compression fittings to BS EN 1254 Part 3 are specified for polyethylene piping.

- d Copper/stainless steel: Copper tubing may be joined to stainless steel piping by means of a copper or copper alloy compression or capillary fitting. The relative area relationship is of importance e.g. copper tube attached to the inside of stainless steel water storage vessel will result in the severe and rapid corrosion of the storage vessel. A phosphoric acid based flux is recommended.
- e Copper/lead: Copper tubing may be joined to lead piping by use of a copper or copper alloy adapter with a mechanical joint between the adapter and the lead pipe. The use of wiped joints is no longer permitted between the tail of the union adapter and the lead piping. Note: Copper pipe should not be incorporated into a lead piping system unless suitable precautions are taken to prevent corrosion.

To avoid the possibility of galvanic corrosion the direction of flow in pipework should always be from the less noble to the more noble metal, e.g. galvanised steel → un-coated iron → lead → copper. An example is the pick up of 0.1 mg/l or more of copper in water which encourages the corrosion of galvanised coatings.

Corroded end: anodic – least noble
Zinc
99% aluminium
Aluminium-copper alloys
Steel or iron
Cast iron
Chrome-iron (active)
18/8 Mo steel (active)
Lead-tin solders
Lead
Tin
Brasses
Copper
Bronzes
Copper-nickel alloys
Silver solder
Chrome-iron (passive)
18/8 Mo chromium-nickel austenitic steel (passive)
Silver
Graphite
Protected end: cathodic – most noble

NOTE: In practice galvanic corrosion is not a serious problem unless the potential difference is greater than about 200mV. (the 1/4 volt criterion).

Table 6 Galvanic series of metals and alloys

4 Design Considerations

4 Design Considerations

Detailed layout and pipe sizing requirements are determined by the design engineer responsible for the system. General notes for guidance bringing out some of the points that have proved important in practice are given in the following sections. Users of this publication should ensure compliance with such statutory requirements, rules and regulations as may be applicable to the particular installation, including Building Regulations and British Standard Specification BS 6700.

4.1 Water velocities

Problems can arise due to excessive water velocities which in extreme conditions can cause premature failure by one of several mechanisms including erosion/corrosion and/or cavitation. The maximum recommended water velocity in copper cold water service pipes, irrespective of outside diameter, is 3 m/s, and for hot water recirculating systems 1.5 m/s. If the pipe diameter initially chosen gives a design velocity greater than that recommended above, an appropriate larger diameter pipe should be used. Pipes should be sized to ensure that the maximum design flow rates given in BS 6700 do not result in excessive water velocities in copper tubes. It is important to recognise that sluggish flow, at velocities below 0.5 m/s, associated with the over-sizing of pipework, especially in long horizontal runs may also cause problems resulting from the deposition of detritus. This may result in pitting corrosion, especially in the lower segments of the tube. Good design and operation is needed to avoid these possible problems. There is also a possibility of corrosion occurring in pipework running only partially filled. Cavitation may occur immediately following rapid changes in cross-section, such as within outlet fittings and this will also result in noise which can be reduced by lowering the pressure and hence the water velocity.

Note: Water flow resistance data for tubes and fittings are given in Appendix H

4.2 Pipe layout

An important objective, particularly in large and complex installations, is to avoid, where possible, pipe runs where stagnant or semi-stagnant conditions prevail for long periods. With some types of water such conditions tend to encourage the pick-up of trace quantities of metals, including copper, which can be avoided if there is a regular flow of water at reasonable velocities through the pipes.

Measures to reduce such problems include the following:

- a Vertical riser or drop systems should be considered for use rather than a horizontal

distribution system. In addition ring type mains incorporating short vertical risers will reduce stagnant areas.

- b There should be an adequate number and size of 'washout' valves on the underground main supply and also on the internal systems at the bottom risers.
- c Drinking water pipework should be sized for the minimum practicable diameter but with velocities not exceeding 3 m/s.
- d Direction of the pipe 'fall or rise' should be indicated on the installation drawings, with particular attention paid to eccentric reducers on end reduction tees. Branch connections from horizontal mains should be taken off the top or bottom as appropriate to ensure correct air venting and complete draining of the system on emptying.
- e Separation of fire-fighting hose reel and drinking water supplies is essential.
- f Where necessary, cold water services should be insulated to avoid undue pick-up of heat, e.g. from adjacent hot water pipes. Alternatively they should be installed below hot water pipes.
- g Any part of a system intended to be used only intermittently should be fitted with isolating valves as well as drain valves installed at the lowest point.
- h Long branch main lines supplying only isolated or little used services should be avoided.
- i Dead end lines or vertical drops to outlets that are rarely used can be sources of problems when sedimentary matter settles out in stagnant water.

4.3 Protection of piping

Protection against frost damage is essential by use of adequate insulation. This is particularly important in ventilated and unheated roof spaces, and similar unheated and/or draughty locations. The following precautions should be taken in the laying and fixing of cold water services:

- 1 Underground pipes should be buried at least 750 mm and not more than 1350mm underground where practicable. This does not apply to pipes installed in the ground under permanent buildings or structures.
- 2 Service pipes protected by ferrules to the top of the main should be taken into the building at the

same depth underground by use of a 'swan's neck' and if un-insulated should rise vertically within the building at least 750mm from the outside wall.

- 3 The rising main to the storage cistern should be carried up on a warm inner wall, not inside a cavity wall.
- 4 If outside pipes have to be installed above ground they should be adequately insulated and draw-off points provided to drain down the exposed pipes in frosty weather. The draw off point should be installed above ground to prevent contamination. Insulation by itself will not prevent the freezing of water filled pipework over a period of time hence the need for drain down facilities. The only safe alternative is to provide trace heating in the absence of heated building protection.

Some manufacturers of rigid phenolic foam insulation materials recommend that a moisture barrier be installed at the tube/lagging interface. Moisture between the tube and the lagging may lead to external corrosion of the copper tube. When using rigid phenolic foam insulation reference should always be made to the manufacturers installation instructions.

4.4 Underground services

When copper pipework is installed underground it shall be to BS EN 1057 (formerly BS 2871: Part 1 Table Y) and unless the soil or building materials are known to be non-aggressive, it is advisable to protect the outer surface of the tube by means of a factory applied plastic coating or suitable water proof wrapping. Underground services shall not be laid in contact with contaminating materials such as foul soil, or passing through any sewer, drain or cesspool. In some areas the Water Authorities may specify that the copper tube is externally coated with a factory applied polyethylene coating. In addition all copper alloy fittings installed underground shall be dezincification resistant, to specification BS EN 12164, BS EN 12165 or BS EN 12167 material designation CW602N, (formerly CZ132), or dezincification immune, such as gunmetal. Compression fittings shall be of the manipulative type to BS EN 1254 Part 2 Type B. Precautions should be taken to minimise the effects of ground movement on pipes and fittings buried underground. Where relative movement between the main and service pipes is anticipated the connection should be made with a flexible joint. Pipes passing through walls from unstable ground should be fitted with telescopic joints and to maintain gradients towards washouts and air vents supports should be provided from stable foundations. Pipes should be firmly anchored at bends to withstand thrust loads and should be capable of meeting a test pressure of twice the maximum working pressure.

4.5 Expansion joints

The coefficient of thermal expansion of copper is 16.8×10^{-6} per $^{\circ}\text{C}$, hence a 1 metre length of copper tube becomes $(1+0.0000168T)$ metre when heated by $T^{\circ}\text{C}$. For example, an increase in temperature of 60°C will increase the length by one mm for every metre of tube. In the case of copper tube in domestic hot water and heating installations the limited size of rooms and hence straight pipe runs, together with the many bends and offsets that normally occur will result in thermal movement being accommodated automatically. However where long straight pipe runs, exceeding 10 m, are encountered, allowance for expansion should be made. Suitable types of expansion joint are shown in Figures 5, 6 and 7.

Expansion bellows and expansion loops may be accepted with regard to the expansion of pipes carrying hot water. Where copper tubes pass through walls, floors and ceilings, they should be able to move as a result of expansion and contraction. This can be arranged by passing the tube through a sleeve or length of larger diameter pipe fixed through the whole thickness of the wall, floor or ceiling, or by means of flexible joints on either side of the wall.

4.6 Fixings

All pipework should be adequately supported. There are various types of fixing clips and brackets to meet specific requirements. A few of the fixings available are shown in Figure 8 but a greater selection is illustrated in manufacturers' catalogues and this information will help to decide the most appropriate pattern.

Suitable intervals for pipe supports are given in Table 7.

Size of Pipe (OD) mm	Intervals for Vertical Runs mm	Intervals for Horizontal Runs mm
6	0.6	0.4
8	0.9	0.6
10	1.2	0.8
12	1.5	1.0
15.0	1.8	1.2
22.0	2.4	1.8
28.0	2.4	1.8
35.0	3.0	2.4
42.0	3.0	2.4
54.0	3.0	2.7
67.0	3.6	3.0
76.1	3.6	3.0
108.0	3.6	3.0
133.0	3.6	3.0
159.0	4.2	3.6

Table 7 Spacing for Copper Tube Supports

Bracing should not be at less than 12 m centres to avoid swaying when pipes are fixed by hanging brackets in suspended ceiling spaces. The distance between anchor fixings and expansion joints in hot water lines is determined by the type of joint used and the amount of movement within the joint itself. Figures 9 and 10 show how a pipe run should be anchored by means of two supports at each change of direction, with an expansion device in the centre. If the expansion joint has a 25 mm depth of socket (Figure 9) then the length of pipework each side of the joint, with a temperature difference of 60° C can be 12.5 m (1 mm of movement within the expansion joint permits 1 m of pipe length between joint and anchor point). In order to avoid possible breakdown of branch joints connected to a heating or hot water main, it may be advisable to use the branch joints as anchor fixings. If however the branch is connected to the moving pipe the leg of the branch should be free to move. Suitable pads should be inserted between the pipe and clip to avoid abrasion due to thermal movement. All pipe runs should be aligned correctly to prevent undue strain. This is particularly important when fixing pipes to a plastic cistern. Suitably protected backing plates or washers without sharp edges should be fitted at the connection points between the pipes and the cistern.

4.7 Air locks and water hammer

Air locks can be prevented by the design and installation of systems to facilitate the removal of air during filling and subsequent operation. Pipes should have a slight rise to a cistern, vent pipe or an automatic air release valve along their complete length and should wherever possible fall to the drain-off points. Pipes should be laid to avoid obstructions and across solid foundations to prevent local undulations causing airlocks. Excessive pressure rises in pipework can lead to premature failure of joints and possible damage to fittings. If unacceptable water hammer occurs in a system due to the installation and operation of fittings and appliances suitable measures should be taken to limit the resultant pressure rises or surges. This can be achieved by fitting air or gas loaded vessels or special mechanical water hammer preventers.

4.8 Services embedded in concrete

Copper has excellent resistance to corrosion by potable waters and is not attacked by normal types of cement, concrete or plaster. However, it should not be brought into contact with acid plasters, acid cements or coke breeze. Cement additives such as foaming amines should not be allowed to come into contact with unprotected copper tube, nor cleaning fluids which may permeate through screeds to embedded copper pipes beneath. The installation of tubes and fittings embedded within solid walls or floors is precluded except where it may be readily exposed, or alternatively if installed in a sleeve or duct which may be readily removed or replaced.

Annealed copper in domestic hot water system applications is strong enough to withstand the

compressive stresses set up since the coefficient of expansion of concrete is less than that of copper. That applies when the temperature of the water circulating in the embedded pipes does not exceed 60° C provided that the straight line pipe runs between embedded fixing points do not exceed about 15 m in length. In such cases no problems arise if the copper pipe is laid on the concrete base and covered with a sand and cement screed provided that access is provided.

Pipes conveying water at temperatures above 60° C particularly if there are any branch connections, must be given facilities within the solid structure for thermal movement. Small diameter pipes (6 to 10 mm) can be laid directly on the concrete base in a snake-like pattern and should be plastic sheathed, or similarly covered, to avoid adhesion of the final screed to the metal pipe. Larger diameter pipes (12 to 28 mm) should be laid in purpose-made ducts not less than 50 mm wide and 100 mm deep. If insulating material is used it should be of a water repellent type. The insulated pipework within the ducts should then be covered with dry sand or similar to about 25 mm above the top of the insulation. If the pipe run exceeds 10 m in length, suitable expansion joints with permanent access points should be fitted. Pipes in excess of 35 mm in diameter should be installed in accessible ducts, being suitably clipped or alternatively supported on roller fixings with horseshoe brackets at every 10 m to avoid the pipe jumping from the rollers.

4.9 Thermal insulation

Consideration should be given to conserving energy by use of suitable thermal insulation for pipes conveying hot water. A range of factory insulated copper pipes are available from the major manufacturers. In addition supply pipes containing cold water for domestic purposes should be installed so that, as far as is reasonably practical, the water will not be warm when drawn from the tap. If the cold supply cannot be installed away from hot water pipes or other sources of heat then it should be adequately insulated. If neither of these measures are practicable then the cold pipe should be installed below the hot pipe. This requirement should not conflict with the need to provide adequate insulation and/or a source of heat to provide frost protection in otherwise unheated locations.

Frost protection can be achieved by means of trace heating cables attached to insulated pipework in exposed locations. Where pipes and/or fittings cannot be positioned to provide adequate protection then they should be insulated and provided with a means of draining. If installed outside a building the insulation should be weatherproof. Generally these outside installations will be required to be fitted with a servicing and a draining valve inside the building.

Details of the recommended sizes and performance of thermal insulating materials to BS 5422 and BS 3958 are contained in BS 6700. It should be appreciated that

smaller diameter pipes require a proportionately greater thickness of insulation. Adequate space should be allowed around tube fixings for the required thickness of insulation to be added after installation. Wherever possible the insulation should be continuous over tube and fittings but allowing access to valves for operation. Air spaces between pipework and the insulation will improve the overall insulating properties of the insulated pipework. The insulating material should be resistant to or protected by suitable covering from mechanical damage, ingress of moisture, and vermin. In the case of insulated tubing to be installed underground it should also be water proof and resistant to attack by any corrosive chemicals within the subsoil.

In the case of factory insulated copper tubing

manufacturers recommend procedures for insulating joints and fittings and for the removal and replacement of insulation during the jointing process. Data is available on the performance of factory insulated copper tube under different operating conditions. Additional advantages of factory insulated copper tube include the reduction in water flow noise, high quality appearance and surface finish, with no painting required and improved safety due to low surface temperatures when carrying hot water. Insulated copper tube sheathed with an internally castellated plastic coating traps an air layer to give improved insulation performance. The colour coding of pipework should be blue for water and yellow for gas. It should be noted that white insulated copper tube is generally supplied for exposed central heating system pipework.

5 Jointing Methods

The manufacturers of fittings for copper tubes provide literature describing their products and full instructions on the use of their fittings. This literature should always be consulted by the user, but the following notes are included for general guidance.

5.1 Compression fittings

Type 'A' non-manipulative compression fittings to BS EN 1254 Part 2, as the name implies, do not require any working of the tube end. The joint is made tight by means of a loose ring or sleeve which grips the outside of the tube when the cap nut is tightened. This type of fitting can be used on half-hard and hard tube supplied in straight lengths and annealed tube up to and including 12 mm OD, but should not be used with annealed tube above 12 mm OD unless a suitable internal support is provided.

Making a non-manipulative compression joint requires the following steps:

- 1 Cut the tube end square using a tube-cutter.
- 2 Remove both internal and external burrs.
- 3 Ensure outside surface is free from deep scratches or other mechanical damage
- 4 Re-round tube ends if necessary. (Always on annealed tube.)
- 5 Slip compression nut and then compression ring onto tube
- 6 Insert tube end into fitting up to the tube stop.
- 7 Tighten the compression nut finger tight and then fully tighten with an appropriate size spanner by the number of turns recommended by the fittings manufacturer.

Type 'B' manipulative compression fittings to BS EN 1254 Part 2 require the end of the tube to be flared, cupped or belled with special forming tools (in some cases supplied by the fittings manufacturer) after the end of the tube has been cut square and de-burred. The

formed end of the tube is compressed against a shaped end of the corresponding section on the fitting or against a loose thimble, when the cap nut is tightened. This type of fitting is not suitable for use with hard temper tube. The operations in making a joint are as for Type 'A' fittings with the addition of the flaring, cupping or bell operation. Care should be taken to ensure that the tube is not distorted during cutting. Annealed tube should always be re-rounded using a suitable tool before offering to the fitting to make the joint. This type of fitting shall be used for installations underground and shall be made from dezincification resistant or immune materials.

5.2 Capillary joints

Capillary fittings to BS EN 1254 Part 1 have sockets made to close tolerances, so that a controlled small gap exists between the outside of the tube and the socket into which molten soft solder or brazing alloy is drawn by capillary action. The jointing metal may be incorporated in the fitting or may be fed into the capillary space during the jointing operation. The soft solders now used to meet water quality requirements are lead-free alloys as specified in BS EN 29453. Other solders having special properties, such as improved creep strength can, in some cases be supplied to special order. For high pressure and/or temperature applications, appropriate brazing alloys covered by BS 1845 should be used. Brazing techniques and the design of brazed joints are detailed in BS 1723 and bronze welding in BS 1724.

Copper tubes may be directly joined by the use of zinc-free self-fluxing brazing alloys. The tube ends are formed, by special tools, to provide close tolerance capillary joints. The joints are filled by capillary action with a suitable brazing alloy filler rod using an oxy-propane blowtorch. Copper alloy tubes and fittings require the use of a suitable flux and a compatible filler

alloy. Copper tubes may also be joined directly by welding using a compatible welding rod or alternatively a weld type fitting may be used to join the tubes. In these circumstances, due to the amount of heat applied to the tube end, the maximum working pressures must be calculated using annealed material design stresses. Note: These alternative joining techniques are detailed in BS 6700.

Making a capillary joint requires the following steps:

- 1 Cut tube square
- 2 Remove burr inside and outside
- 3 Abrade the tube and fitting socket with a cleaning pad
- 4 Apply flux to tube end only
- 5 Insert tube fully up to stop
- 6 Turn the tube in the socket to spread the flux
- 7 Wipe off excess flux
- 8 Apply heat
- 9 Apply solder or brazing alloy (not necessary when using integral solder ring fittings)
- 10 Allow joint to cool without disturbance and then clean

Overheating during the making of joints and use of excessive flux should be avoided. Pipework should be flushed out immediately after soldering is completed. If excessive quantities of adherent corrosive flux residues remain in the pipework problems with internal corrosion or contamination of the water supply may occur.

Badly made joints or bends causing excessive turbulence or localised high water velocity may result in deterioration of the immediate area by means of erosion corrosion or cavitation. Entrained air bubbles in the water from a leaking valve or an incorrectly made joint in an area of negative pressure, e.g. upstream of a pump or downstream of a partially opened valve, may also on occasion give rise to this form of corrosion.

5.3 Push-fit fittings

Push-fit fittings are extremely reliable and highly versatile. As the tube is inserted into the fitting it passes through a release collar and then a stainless steel grab ring. The grab ring has a series of teeth that open out and grip onto the outside of the copper tube. A support sleeve inside the fitting will help in alignment of the tube and when the tube is fully inserted, to the tube stop, an 'O' ring is compressed between the wall of the fitting and the tube. For a secure joint to be formed the tube must pass through the 'O' ring and reach the tube stop.

These fittings can be disconnected, and the operation is as simple as forming the joint. Simply follow the manufacturers instructions for removal of the tube.

Push-fit fittings are suitable for all above ground hot and

cold domestic water services, including both direct and indirect heating systems. They are also ideal for use in smallbore and microbore central heating systems and in pressurised unvented heating systems within the permitted temperature and pressure limits.

5.4 Press-fit fittings

These have a copper body, with a recess that holds an 'O' ring seal. The seal is squeezed onto the tube with a specialist tool. This type of fitting lends itself to pre-assembly techniques.

5.5 General procedures for all fittings

5.5.1 Measuring

Measuring the length of tube is not really part of the jointing process, but inaccuracy can affect joint quality. If a piece of tube is too short it will not reach all the way into the socket of the fitting and a proper joint cannot be made. If the tube is too long it may not be possible to achieve correct alignment especially if the tube forms part of an installation partially fixed in length.

5.5.2 Cutting to length

Annealed copper tube in 6, 8 and 10 mm OD sizes should be cut with a junior hacksaw. Rotary tube cutters are commonly used for cutting other copper tube up to 54 mm size. Larger size cutters for tube up to 159 mm are available. Straight end cuts can also be made manually with a hacksaw using a vice and care should be taken to avoid damage or distortion of the tube. A blade with 32 teeth per inch minimises burrs that should always be removed before fitting. Where many lengths are to be cut, the use of power equipment significantly reduces the time involved. Power hacksaws, circular saws (with fine metal cutting blades) and abrasive cut off wheels are all generally suitable. Guidance from equipment manufacturers should be sought in order to match the saw blade or abrasive disc to the cutting requirements. Whatever cutting method is used, it is important that the tools are in good condition and that the tube end is cut square to the axis.

5.5.3 Deburring of tube ends

The tube cutter will leave a small burr, which should be removed, using the reamer attached to the cutter or some other appropriate tool. If the tube is cut with a hacksaw there may be both burrs and slivers, which should be removed and not allowed to enter the tube bore. This can be done with a flat metal reamer (most disc cutters are so equipped), a three sided reamer, or a half round, mill-bastard file. If a flat metal reamer is employed, care should be taken to avoid expanding the tube end. Proper size and fit are necessary for sound joints.

5.5.4 Re-rounding of tube ends

Before assembling the joint, it is good practice to ensure that the tube end is satisfactorily rounded. The tube end should be re-rounded as required with a suitable tool. It is good practice always to re-round annealed tube that

has been supplied in coil form. Excessive ovality of the tube end will prevent the correct size gap being achieved with capillary fittings.

5.5.5 Jointing plastics coated copper tube

A circular incision is made in the plastic and this portion is removed, exposing that part of the tube to be inserted into the fitting. Two lengthways slits are made in the plastic and the plastic is then carefully peeled back and secured with tape to allow cleaning of the joint area. When applying heat to a joint the plastic close to the joint area should be covered with a damp cloth. On completion of the joint the plastic is repositioned along the tube and secured with tape, the tape also covering any exposed tube between the two ends of the plastic. Any exposed ends should be sealed with tape to prevent ingress of water between the plastic coating and the copper tube.

5.6 Detailed procedures for capillary fittings

5.6.1 Cleaning

In order to promote solder flow and bonding, the surfaces to be joined must be free from dirt, oxide films and residual grease and oil. The areas to be cleaned are the inside and end of the socket of the fitting and also the tube end for a distance up to 10 mm beyond the point where the end of the socket of the fitting will be situated. Suitable cleaning materials include fine emery cloth (00) and non woven nylon pads impregnated with silicon carbide or aluminium oxide abrasives. For the manual cleaning of sockets, particularly those of 28 mm and smaller size, special wire brushes are more practicable than sand or abrasive pads. Machines are available which combine the functions of cleaning the tube ends and sockets using wire brushes. Where fast cleaning is desired but the purchase of a special machine is not warranted, a power drill mounted in a vice can be equipped with wire brushes to clean the inside of the fitting, care should be taken to avoid enlarging the socket. Tube end fittings are made to close tolerances and abrasive cleaning should not remove a significant amount of metal. If too much metal is removed during cleaning, the capillary space may become so large that a poor joint will result.

5.6.2 Fluxing

The cleaned surfaces should be fluxed as soon as possible. Once fluxed, tube and fittings should be assembled promptly. If fluxed surfaces remain exposed, the flux will tend to pick up dust and dirt. Such entrapped particles tend to weaken the soldered joint. Flux should be thoroughly stirred when a new container

is opened and also periodically during use. The flux can be applied with a small brush or a clean lint free cloth. Cloths are apt to pick up dirt and should be cleaned or changed as necessary. Tube ends should never be dipped in flux. Fingers should not be used to apply flux and it should be noted that flux is harmful to the eyes. All prepared joints should be completed within a single working day. Fluxed and assembled joints remaining unsoldered at the end of the day should be disassembled and wiped free of flux. They should be re-cleaned, re-fluxed and reassembled when work resumes. Particular care should be exercised to avoid leaving excess flux inside the completed joint. Only sufficient flux should be applied to the clean surface of the tube end to form a thin film over the surfaces to be joined.

5.6.3 Assembling

The joint should be assembled by inserting the tube into the fitting socket making sure that the tube is firmly up to the tube stop. A small twist will help spread the flux over the two surfaces. After removing any excess flux with a cloth, the joint is ready for soldering.

5.6.4 Heating

Heat is usually applied with a propane or butane torch or with an air-acetylene or oxy-acetylene torch with appropriate size burner. The flame should be played on the fitting and kept moving to heat the whole joint area, so as to avoid local overheating. Excessive heat can char the flux and destroy its effectiveness and in some circumstances can cause cracking of cast fittings. In the case of integral-ring capillary fittings heating is continued until a complete ring of solder or brazing alloy appears around the mouth of the socket. Heating should then be stopped and the joint allowed to cool without disturbance.

5.6.5 End feed fittings

When the joint is hot enough, the solder or brazing alloy wire or rod should be applied to the mouth of the socket and should melt on contact with the tube. The flame should then be moved away. If the solder does not melt, remove the solder, continue to heat, then try again. For larger fittings a multiple tip or ring type torch may be useful. After the initial application of the solder, complete penetration and filling of the joint can be effected by alternating the application of heat and solder. If the metal is properly cleaned and fluxed, capillary action should draw all the solder needed into the joint and pre-tinning is not necessary. It is important that the clearances between the tube and fitting should not be excessive.

6 Bending of copper tubes

The bending of copper tubes by machine can be carried out without filling as the special formers and guides employed support the sides of the tube preventing it from becoming oval, flat or rippled. Both machine and hand methods of bending are described below. Copper tube to BS EN 1057 may be supplied in half hard, R250, temper in straight lengths or annealed, R220, coils, both of which are suitable for bending. BS EN 1057 hard temper tube, R290, is supplied in straight lengths and is generally not suitable for bending.

There is little difficulty in machine bending copper tubes as the necessary skills can be developed with practice. The bending of copper tubes by hand methods, however, may often be required, especially in the larger sizes of tube, for which machines are expensive.

6.1 Bending by machine

The purchase of a bending machine will prove economical where numerous bends are required in the smaller sizes of tube. Machines of various types and sizes, worked by direct hand power, are constructed to bend copper tubes up to 42 mm diameter, and are small and light enough to be transported to site. For diameters greater than this, ratchet action or geared machines should be used. Smaller benders, up to 22mm, can be carried in the toolkit.

6.2 Distortion of tube in machine made bends

The design of bending machine formers enables the

throat and sides of the bend in an unloaded tube to be supported against collapse. Corrugations will, however, occur in the throat of a bend if the pressure of the roller on the back guide is exerted in the wrong place. The correct pressure point is in front of the bending point, where the tube touches the former before bending takes place. These two points move forward maintaining the same distance apart as the bend is made. If the pressure point is advanced too far in front of the bending point, corrugations will occur.

It should be noted that bending tubes greater than 54mm diameter and forming tight radius bends (i.e. with inside radius less than 3 times the tube diameter) are generally considered to be specialist operations and reference should be made to equipment and product manufacturers.

6.3 Steel springs

Flexible spiral springs may be used to support the tube walls while the bend is made. Springs to BS 5431 are available for bending tubes in all standard sizes from 10 to 22 mm half-hard (R250) tube diameters, which is the maximum size for spring loading. Only easy bends should be attempted, as the minimum radius to the throat is approximately 3 diameters for all sizes up to 22 mm. Note: Bending springs are not suitable for bending copper tube coils.

7 Commissioning

All systems should be thoroughly flushed out as soon as possible after installation to remove foreign matter. The flushing should continue until the flush water is completely clear, and the system should then be pressure tested in accordance with BS 6700. Ideally the systems should, where appropriate, be correctly sterilised to BS 6700. Tests to prove the waters transmitted through the newly installed system are suitable for human consumption should be carried out as necessary and the system put immediately into full use so that there is never any protracted period when pipes are full or partially full of stagnant water. (See Appendix E for specific procedures associated with the prevention of Legionnaires' Disease.) In practice, however, long periods may elapse between the installation and bringing into use, especially in large buildings with complex services. Consideration then has to be given to the action to be taken to minimise the possibility of water contamination problems that might develop. In any event it is necessary to flush out thoroughly and pressure test at the earliest possible moment after installation. Subsequent possible actions to cover protracted periods before putting the system into use are:

- a to keep the system completely full and to run water off from all draw off points to introduce fresh water into all the pipes regularly. Whenever possible the flushing water should be fed into the highest point and at the highest pressure the system will safely withstand, and be flushed out at low points through properly sized full bore valves or plugged wash out points as incorporated in the design. Any filters, meters, pump traps, valves, controllers, non-return valves and items of equipment which may be damaged or prevent adequate flushing, should be removed during the flushing operation.
- b to drain completely and dry out as far as possible by blowing air through the system, and then to seal off to prevent ingress of water and foreign matter. However, this may prove difficult in practice in complex installations in large buildings.

When the completed building is finally connected to the permanent water supply, and until it is occupied, all

draw off points should be opened twice a week in sequence for a sufficient period of time to ensure that the water does not stagnate and to draw fresh clean water into the whole system to assist in the development of the normal protective internal films within the pipework.

7.1 General site operations

It is important to ensure that all open pipe ends are correctly fitted with temporary caps at all times during construction. This particularly applies to external mains installed in open trenches that are eventually back filled. Surface and rainwater should be pumped continuously out of all open trenches during the whole of the time

pipework is being installed. This includes night time and weekends/holidays. Every precaution should be taken to keep foreign matter (metal filings, cleaning materials, dirt, etc.) out of all water installations at all times. If a fitting is disconnected at any time then every part of any pipe conveying water to that fitting shall be disconnected. This is to prevent contamination of the water supply by any stagnant water remaining in the pipe. It will also ensure that corrosion of the pipework and fittings does not occur due to stagnation conditions. This does not apply for 60 days to allow replacements to be obtained and fitted. In these circumstances it is important to ensure that the dead leg is flushed out thoroughly and treated as a pre-commissioned pipe.

Appendix A

Pitting Corrosion of Copper Tubes

It should be emphasised that the number of copper tubes affected by pitting corrosion is an extremely small percentage of the total amount manufactured and installed in the United Kingdom. The majority of copper tubes give satisfactory service over many years. Two forms of corrosion to which copper tubes are susceptible under specific circumstances are recognised and described in the literature.

A1 Carbon film

This form of pitting, sometimes referred to as 'Type 1', corrosion can cause premature failure in copper cold water pipes carrying hard or moderately hard deep well waters. Two factors are involved in this form of attack. Firstly the water must be capable of supporting it: organic matter found in surface derived water provides inhibition against attack, and only deep well waters can support it. Secondly, attack occurs only when a thin film of carbon is formed within the bore of the tube during the manufacturing process. The cleaning processes now used by major manufacturers ensure that copper tubes

meet the requirements of BS EN 1057 concerning the absence of deleterious films in the bore.

A2 Hot, soft water

This type of pitting corrosion, sometimes referred to as 'Type 2', is extremely rare in the United Kingdom: it seldom causes failure in less than about ten years. Carbon films are not a factor in this type of attack. It occurs in hot water pipes in some soft water areas specifically if the operating temperature is above 60°C. This should be borne in mind when specifying higher temperatures in an attempt to eliminate problems associated with Legionnaires' Disease. (See also section on Commissioning and Appendix E).

A3 Flux

Excessive use of flux resulting in flux runs within the bore of the tube may cause corrosion and should be avoided. Hence the need to use fluxes sparingly and according to manufacturers instructions.

Appendix B

Condition of Water

It is advisable to check the pH of the water supply entering the building on a regular basis. One of the most significant factors responsible for the internal deterioration of water mains and supply pipes is low pH of the water. The ideal pH level for water supplies is close to 8. If a pH of 6 - 6.5 or less is recorded, then the water should be treated to increase the value to an acceptable level. Low pH water may affect the mains and service pipes in the following ways:

- a If the pH of water in concrete lined mains is low, (in some areas it may be as low as 5) there is

every likelihood that the linings will deteriorate leading to deposits and possible corrosion, in the copper service pipe system.

- b A low pH increases the cupro-solvency of the water. If this is combined with excessive water velocities there can be erosion in which the pits are scoured out and premature failure may result.
- c A low pH increases the rate of dezincification of duplex brass fittings, possibly leading to premature leakage.

It should be pointed out that there are no known public water supplies in this country with which copper cannot be used entirely satisfactorily, since supplies are treated to remove any acidity before being delivered to the mains. There are, however, some private water supplies derived from wells, bore-holes and streams which are excessively corrosive towards most metals and under such conditions consideration should be given to onsite water treatment or alternative materials.

Untreated corrosive waters when carried in copper pipes may have a sufficiently solvent action on copper to produce a green coloration in combination with soaps. This coloration appears in the form of green stains upon sanitary fittings, or on cloths or sponges etc used with soapy water. While these stains may be inconvenient, they are not generally considered harmful. Green staining is more likely to occur with hot water than with cold, because the heating of acid water increases its solvent action. Green stains on sanitary fittings can be removed by washing with a dilute solution (5 percent by volume) of hydrochloric acid, but care should be taken to rinse the article afterwards with a dilute soda solution and clean water.

B1 Water mains

The layout and condition of the water main may be an important factor in the build up of sediments within the supply and distribution system. Large buildings with extensive distribution systems should not be connected at the end of a large water main. The Water Company should be requested to establish a ring main to ensure that there is adequate flow to avoid a build up of a sedimentary matter. Otherwise sediment may enter the building system and initiate discoloration problems either directly, or by causing corrosion resulting in slight dissolution of copper and contamination of the water.

Very large ring mains on the low side of a building on a sloping block have been found to accumulate sludge due to very low draw off rates. Facilities for the flushing of mains should therefore be provided. Iron oxides from rusty steel water mains may deposit in the copper distribution pipe system and over a period of time may absorb copper causing the loose deposits to become greenish blue in colour. Normally, water flowing through the pipes at reasonable pressures will remove these loose deposits. However, it has been found that in some cases stagnant water has remained in copper pipes for considerable periods, sometimes up to two years or more, during the construction period and in these instances problems of significant discoloration have developed.

B2 Discoloration of water supplies

Substances that cause discoloration in water are undissolved solids such as rust (iron oxides), colloidal type suspensions of clay or silica, organic matter, deposited calcium carbonate and small amounts of copper salts, usually combined with the above mentioned materials.

B3 Treatment of acid waters

In some areas where the water is particularly 'soft' and may tend occasionally toward the acid side of neutral, new installations of copper tubing may give rise to the staining of sanitary ware and copper pick-up, resulting in a slightly metallic, astringent taste to the water. Copper is not a toxic metal and the taste problems can be avoided by running the tap for a few minutes to clear the pipes. The condition will slowly improve as protective films build up on the inside surface of the tubes. In some waters this may take weeks or even a few months, but if it persists longer than this, expert advice should be sought with a view to increasing the hardness of the water supply concerned.

Appendix C

Dezincification Resistant Brass

For fittings such as joints, bends, stop-cocks and taps normal, duplex brass gives excellent service in contact with most UK potable waters. However in some areas of the country the presence of otherwise harmless constituents in the potable water makes it aggressive to duplex brass producing a form of attack known as dezincification. In such waters zinc can be leached from duplex brass leaving a mass of porous copper. Although the occurrence of dezincification is small, materials that are resistant or immune to this form of corrosion are recommended in sensitive areas. In 1980 British Standard Specifications were issued for a new type of brass which combined the economy and convenience of duplex brass with the corrosion resistance typical of more expensive materials. This brass meets the demanding criteria set by the consumer authorities and has received full approval for use in

contact with aggressive potable water and also for use underground where contaminated soil waters may have to be considered. Dezincification resistant brass, designated CW602N (formerly CZ132), is specified in BS EN 12164, BS EN 12165, BS EN 12167 and BS EN 12168. There are other dezincification resistant alloys, most notably CW709R. Fittings for use in underground installations should be either manufactured from dezincification resistant brass or dezincification immune material, e.g. gunmetal.

C1 Waters causing dezincification

Hard waters do not normally cause dezincification. This type of corrosion is found in certain areas with soft water containing critical combinations of chloride content, temporary hardness and pH and known as meringue dezincification. Since water companies may

now obtain their supplies from a variety of sources and vary the areas served, it is not possible to give an accurate geographical indication of susceptible areas. The possibility that particular water supplies may cause dezincification should be checked with the local water company operations controller before installing duplex brass fittings. In areas where the water supply is aggressive, dezincification can occur in water supply

fittings such as stopcocks, tees, elbows and connectors. It is accelerated by increased temperature and the fittings in a domestic hot water system are therefore more susceptible than those in cold water systems. It does not occur in terminal fittings such as taps nor in closed loops as found in the primary circuit of a central heating system.

Appendix D

Calculating Tube Thickness

Once the design stress of the copper has been determined, and if the maximum working pressure and the specified external diameter of the tube is known, then the thickness required to withstand the internal pressure can be determined by the following formula:

$$t = \frac{pD}{2f+p}$$

where

- t is the thickness (mm)
- p is the pressure (N/mm²)
- f is the circumferential tensile stress or design stress (N/mm²)
- D is the outside diameter (mm)

The above formula applies only to thin wall tubes where the ratio, k, of external diameter to internal diameter is less than 1.1. The majority of tubes for building service applications meet this condition although an additional thickness allowance may be required for bending.

Appendix E

Copper and Legionnaires' Disease

A number of measures have been introduced or recommended to prevent the occurrence of Legionnaires' Disease in both hot and cold water systems in institutional and other buildings with large plumbing heating and air conditioning systems. A number of the preventative measures have not adequately taken into account their effect on the materials within the system. Although materials other than copper have been recognised as potential sources of growth of the bacterium *Legionella pneumophila* the potential role of copper as a bactericide has been largely overlooked. There is some evidence based on a limited survey carried out by the PHLS to suggest that substantially 'all-copper' systems tend to be free of *Legionella pneumophila*. In addition research being carried out by ICA tends to confirm this view with regard to other bacteria which are destroyed when in contact with copper based components.

However this is only part of the story as some of the steps being taken to control the growth of *Legionella pneumophila* may be associated with an unacceptable rate of corrosion of copper components. In particular, whilst the dosing of water systems with 20-50 ppm of free

chlorine as a one-off, or occasional disinfection measure of short duration (1-3 hours) is acceptable, it is inadvisable for a copper system to be left charged with water containing these levels of chlorine overnight or during lengthy periods between commissioning and bringing into service. If carried out correctly, adequate disinfection can be achieved in a relatively short time and there is no advantage to be gained from these extended time periods. However, low level continuous chlorination with 1-2 ppm poses no problem.

With respect to hot water systems, and the recommendation to store water centrally at 60^o C and to distribute water at temperatures no less than 50^o C there is a clear need to ensure due regard is taken of the necessity to avoid excessive water temperatures. In soft water areas holding water for long periods at temperatures above 60^o C can accelerate pitting corrosion of copper tube and in hard water areas this situation will increase the precipitation of hardness salts in the pipes and calorifiers. Thus calorifiers should be fitted with accurate temperature controls so as to achieve preservation of microbial quality without detriment to the longevity or cleanliness of the system. *L. pneumophila* is killed within

a few minutes at 60^o C and between 50-60^o C survives for only 1-2 hours. In copper systems viable organisms that have survived heating to temperatures above 50^o C may be discouraged from multiplying in the downstream water but it should be recognised that the presence in the water system of other unsuitable materials may protect the organism from the relatively hostile environment within a copper calorifier and pipes.

All drinking water outlets should be connected either to the main supply directly or through a properly constructed and protected storage cistern. Oversized and unprotected cisterns provide opportunities for microbial growth and contamination of the water entering the system. Detailed advice on the design, construction and commissioning of water services is given in BS 6700.

Individual water companies can advise on any relevant local water quality characteristics.

Within the National Health Service the method of sterilisation is recommended in HTM27, whilst the Health and Safety Executive have issued Guidance Note EH 48 on the precautionary measures to be taken to combat Legionnaires' Disease in water supply and heating systems. The Chartered Institution of Building Services Engineers, CIBSE, has also produced a Technical Memorandum TM13 giving guidance on minimising the risk of Legionnaires' Disease. These documents set out general principles and have been written on the understanding that their successful implementation requires careful attention to the practical requirements of each water system and the building function.

Appendix F

Vented and Unvented Domestic Hot Water Systems

Unvented hot water systems allow the accommodation of expansion water in both systems which are cistern fed and those connected directly to a supply pipe. This is achieved by either an expansion vessel or within the pipework of the system itself. The preferred method is by means of an expansion vessel that accommodates the increase in volume due to thermal expansion without overflowing or creating undue pressure in the system.

The system with an expansion vessel must contain a check valve to prevent backflow of hot water into the supply pipe. Expansion within an enlarged secondary system pipe is not allowed if any form of check valve is installed upstream to prevent backflow into the supply pipe. The enlarged pipe is to accommodate the expansion of heated water and at the same time provide sufficient cold water to be displaced back into the supply pipe.

In conventional vented systems the vent pipe from the secondary system shall not vent into the combined feed and expansion cistern connected to the primary circuit. Irrespective of the type of system, copper tube is suitable for use throughout the hot water supply and distribution systems. The maximum working pressure within a sealed primary circuit is 3 bar, whilst in an unvented hot water storage vessel or secondary circuit it shall not exceed 6 bar. The highest water temperature shall not exceed 100^o C at any point in the system. This is to prevent the generation of highly dangerous 'flash' steam from a pressurised system.

Note: The expansion vessel in a sealed primary circuit shall be sized to accommodate the increase in volume of water when heated from 10^o C to 110^o C. All

commonly used copper tube listed in BS EN 1057 is capable of withstanding working pressures in excess of 6 bar at temperatures up to 110^o C.

F1 Pipe sizing

Detailed methods of pipe sizing taking into account the recommended hot and cold water flow rates are contained within BS 6700 for domestic water systems and hence they are not repeated in this publication.

However there are a number of minimum tube sizes required for specific pipe runs within the heating systems and these are listed in Table 9 quoting the relevant outside diameter (OD) of the copper tube. The tube sizes quoted in this Appendix are based on BS EN 1057 thick walled tube, (formerly Table Y) which has the smallest nominal bore.

F2 Cold water feed pump

The cold water feed pipe to a hot water storage vessel or water heater should be sized in accordance with BS 6700 requirements.

F3 Open vent pipe

An open vent pipe should be fitted to every vented primary and secondary circuit and water heater systems. The vent pipe should not be less than 22mm OD. The length of any vent pipe should be determined in accordance with the requirements of BS 6700. In a pumped circuit due allowance should be made for the head induced by the circulating pump to prevent pumping over and thus causing the introduction of air into the system. This can accelerate the rate of corrosion of metals less noble than copper in a mixed metal system.

F4 Hot water storage vessels

The heating coil in a hot water storage vessel will have been sized and installed by the manufacturer to meet the performance requirements of the vessel to BS 1566: Part 1. The copper coil shall be of one piece construction to prevent the contamination of the primary and secondary circuits due to failure of any contained joints.

F5 Direct systems

Direct systems are designed for gravity circulation and the flow and return pipes between the boiler and storage vessel should not be less than 28 mm OD (or 22 mm OD for small solid fuel back boilers.)

F6 Indirect systems

Pipe sizing will depend upon whether the hot water circuit is gravity fed or is pumped together with the heating circuit.

F7 Vented primary circuit

In the case of a gravity circuit the pipe sizing is as for the direct system. If the circuit is pumped the minimum diameter is 15 mm OD.

F8 Sealed primary circuit

The pipe sizing is as for the vented primary circuit. Indirect cylinders fitted in these circuits should have primary heating coils capable of operating at 0.35 bar in excess of the pressure relief valve setting. All copper tube to BS EN 1057 is capable of meeting this requirement up to a pressure relief valve setting of 10 bar.

F9 Secondary distribution systems

BS 6700 tables the maximum lengths of un-insulated distribution pipes related to the bore size of the pipe.

Largest OD along length of Distributing Pipe (mm)	Maximum length (m)
≤15	20
>15≤22	12
>22≤28	8
>28	3

Table 8 Maximum length of un-insulated distribution pipe

F10 Minimum distribution pipe sizes

Outlet fittings	Minimum diameter of tube (OD) mm
WC valve	15
Wash basin tap	15
Spray tap or mixer	10
Bath tap	22
Sink tap	15*
Urinal cistern	15
Shower head	15

*22mm if same storey as feed cistern

Table 9 Minimum distribution pipe sizes

Details of specific vented and unvented systems are beyond the scope of this publication and reference should be made to the companion volume 'Copper in Domestic Heating Systems'. However it should be appreciated that in order to meet statutory regulations unvented systems are required to have a number of protective devices to prevent explosion, including temperature and pressure relief valves. These protective devices should normally be factory installed. In the event of the operation of a relief valve the discharge shall be via an air break to a tundish. Copper is a suitable material for the discharge pipe from the temperature relief valve and shall be not less than the size of the valve outlet in diameter. Similarly, vent pipework shall be sized to carry away the maximum energy output from the heater, hence the minimum outside diameter of 22 mm.

The introduction of unvented systems has provided opportunities for copper as a piping material able to withstand the enhanced pressures and temperatures. At the same time it has maintained the reputation gained over many years for reliable, long term trouble free service in hot and cold water service systems.

See figures 11-14 for layouts of direct and indirect vented and unvented systems.

Appendix G

Prefabricated Copper Pipework

There are three situations where prefabrication can be applied with advantage. In the domestic field, identical pipework units can be developed for installation in a large number of houses, which need not themselves be identical. The second case is in large multi-occupational buildings such as hospitals, office blocks and high rise domestic accommodation, where a large number of units

needed make it economical to design and prefabricate a special unit for that particular building. A third, rather different case, is the unusual building which poses pipework problems which can be most economically solved by one off prefabrications produced in the ideal conditions of a workshop.

G1 Benefits

In every case the fact that the bending, brazing, welding, branch forming and assembly are done in a workshop environment instead of under the varied and often difficult conditions encountered on site, represents one of the major benefits of prefabrication. Local authorities and private developers alike are more than ever anxious to cut down pipework failures due both to difficult on site working conditions and to the shortage of skilled labour. Benefits for the designer include the opportunity to take a second look at the design both to improve the functional design and the economics of fabrication. The availability of fittings need not be an overriding consideration since bends can be pulled and branches inserted at any angle. For the contractor, the advantages of prefabrication include the virtual absence of scrap and the near elimination of pilfering, due to the problems of disposing of an identifiable complete unit. The difficulties of making accurate cost comparisons preclude the presentation of precise figures, but it has been suggested that savings of up to 40% can be obtained on installed costs by utilising prefabrication rather than on site methods. Having opted for prefabrication copper emerges as the preferred material, both because of its well known inherent properties such as corrosion resistance and for its ease of bending and fabrication which can be exploited to the full in the workshop environment.

G2 Specialist equipment

Considerable investment is necessary to produce pipework of the quality and in the quantities required to optimise the benefits of prefabrication. The equipment required includes machines capable of pulling thin wall copper tubes to tight radii and socketing, cutting,














reaming and deburring machinery. In addition there is a need for annealing facilities, gas/air jointing equipment and adequate test facilities for quality control and to replace time consuming on-site testing. Building services engineers need to involve other specialists - consultants, architects, contractors and sub-contractors - in all stages of building design and construction. It is particularly necessary to include that specialist prefabricator as a member of this team. It is important to recognise that a prefabricated services system should be designed for the building and not vice versa. The flexibility of copper is such that, with good design practice, it can form the basis of a prefabricated unit suitable for any type of building service application. Although the need for detailed planning and collaboration brings a new dimension to the building services contract, the benefits are considerable.

G3 Wider applications

Although the most obvious examples of prefabricated services may appear to be found in big projects, it is capable of far wider applications. In both low and high rise housing prefabrication has advanced in step with the growth of industrialised building, but the trend now is to develop a complete bathroom/ plumbing unit which, with equally easily produced variants, can meet the requirements of a number of different house designs. Prefabrication of this type need not be restricted to the new housing market where its flexibility makes it applicable both for the local authority and private developer sectors. It can be applied in conversion and modernisation work, either for upgrading an existing bathroom or where a small room is being converted to a bathroom/toilet.














Appendix H

Water flow resistance through compression and capillary fittings, used with copper tube to BS EN 1057 R250

Nominal size (mm)	Temp of water (°C)	EQUIVALENT LENGTHS IN METRES												
		Tee (compression or capillary)			Reducing Tee (compression or capillary)		Pitcher Tee (compression)		Pitcher Tee (capillary)			Elbow (compression)	Elbow (capillary)	
														
6	15.5	0.010	0.16	0.14	0.18	0.11	0.010	0.10	0.082	0.013	0.11	0.11	0.12	0.08
	65	0.014	0.20	0.17	0.23	0.14	0.015	0.12	0.11	0.017	0.14	0.14	0.16	0.10
	115	0.016	0.21	0.19	0.25	0.15	0.017	0.13	0.12	0.019	0.16	0.16	0.18	0.11
8	15.5	0.017	0.25	0.21	0.27	0.17	0.019	0.15	0.13	0.021	0.18	0.18	0.20	0.13
	65	0.021	0.31	0.27	0.35	0.22	0.024	0.19	0.17	0.026	0.22	0.22	0.24	0.16
	115	0.024	0.33	0.29	0.38	0.24	0.026	0.20	0.19	0.030	0.24	0.24	0.27	0.17
10	15.5	0.023	0.34	0.29	0.36	0.23	0.026	0.21	0.18	0.029	0.24	0.24	0.27	0.18
	65	0.030	0.42	0.37	0.45	0.30	0.032	0.26	0.24	0.036	0.29	0.29	0.33	0.21
	115	0.032	0.46	0.41	0.50	0.33	0.037	0.28	0.27	0.041	0.33	0.33	0.37	0.24
12	15.5	0.030	0.44	0.37	0.48	0.30	0.034	0.27	0.24	0.037	0.31	0.31	0.35	0.23
	65	0.039	0.55	0.49	0.59	0.39	0.042	0.32	0.31	0.046	0.38	0.38	0.42	0.28
	115	0.041	0.59	0.52	0.65	0.42	0.047	0.36	0.35	0.053	0.41	0.41	0.48	0.30
15	15.5	0.043	0.59	0.53	0.65	0.43	0.046	0.39	0.33	0.049	0.43	0.39	0.45	0.31
	65	0.050	0.68	0.62	0.75	0.50	0.056	0.43	0.41	0.059	0.50	0.47	0.56	0.37
	115	0.054	0.78	0.68	0.85	0.56	0.062	0.47	0.47	0.067	0.54	0.53	0.63	0.40
18	15.5	0.052	0.74	0.64	0.80	0.54	0.057	0.46	0.44	0.064	0.52	0.49	0.59	0.39
	65	0.063	0.89	0.77	0.97	0.65	0.073	0.55	0.53	0.078	0.60	0.58	0.70	0.46
	115	0.067	0.95	0.84	1.1	0.70	0.076	0.58	0.58	0.084	0.63	0.61	0.76	0.49
22	15.5	0.068	1.0	0.83	1.0	0.69	0.071	0.59	0.57	0.082	0.64	0.63	0.74	0.49
	65	0.085	1.1	1.0	1.2	0.84	0.090	0.71	0.69	0.10	0.76	0.75	0.90	0.60
	115	0.089	1.3	1.1	1.5	0.94	0.10	0.78	0.79	0.11	0.84	0.83	1.0	0.65
28	15.5	0.10	1.4	1.2	1.5	0.97	0.10	0.81	0.81	0.11	0.87	0.87	1.0	0.68
	65	0.12	1.6	1.4	1.7	1.2	0.12	0.98	0.98	0.14	1.0	1.0	1.2	0.83
	115	0.13	1.7	1.5	2.1	1.3	0.13	1.1	1.1	0.16	1.1	1.1	1.4	0.89
35	15.5	0.13	1.8	1.5	1.9	1.3	0.13	1.0	1.1	0.16	1.0	1.1	1.3	0.91
	65	0.15	2.0	1.7	2.2	1.5	0.15	1.2	1.2	0.17	1.2	1.3	1.5	1.0
	115	0.16	2.3	2.0	2.5	1.7	0.17	1.4	1.4	0.20	1.3	1.4	1.7	1.2
42	15.5	0.16	2.3	1.9	2.4	1.6	0.16	1.2	1.4	0.20	1.1	1.4	1.5	1.1
	65	0.18	2.6	2.2	2.8	1.9	0.21	1.4	1.6	0.22	1.3	1.7	1.8	1.4
	115	0.20	2.9	2.5	3.2	2.1	0.22	1.7	1.8	0.25	1.5	1.9	2.0	1.5
54	15.5	0.22	3.1	2.7	3.4	2.3	0.26	1.8	2.1	0.28	1.3	2.1	2.1	1.7
	65	0.24	3.6	3.2	3.9	2.6	0.30	2.0	2.4	0.30	1.5	2.4	2.4	1.9
	115	0.26	4.0	3.4	4.3	2.8	0.32	2.2	2.5	0.33	1.5	2.5	2.6	2.0
76.1	15.5	0.35	4.7	4.1	5.1	3.4	0.35	2.5	3.0	0.44	2.0	3.0	2.9	2.4
	65	0.40	5.6	4.8	6.0	4.0	0.40	2.9	3.6	0.49	2.4	3.6	3.4	2.8
	115	0.49	6.0	5.2	6.6	4.3	0.42	3.1	3.9	0.49	2.9	3.9	3.8	3.0
108	15.5	0.52	7.4	6.5	7.9	5.3	0.52	3.7	4.8	0.61	2.9	4.8	4.2	3.7
	65	0.61	8.5	7.3	9.1	6.1	0.61	4.3	5.5	0.73	3.6	5.5	4.9	4.3
	115	0.61	9.4	7.9	10	6.5	0.67	4.6	6.0	0.80	3.7	6.0	5.2	4.7
133	15.5	0.64	9.2	7.8	9.7	6.5	0.65	4.4	5.8	0.78	3.9	5.8	4.9	4.6
	65	0.77	11	9.4	12	7.8	0.77	5.3	7.1	0.95	4.7	7.1	5.8	5.5
	115	0.78	12	10	13	8.4	0.84	5.7	7.6	1.0	4.9	7.6	6.3	6.0
159	15.5	0.83	12	10	13	8.4	0.80	5.6	7.6	1.0	5.0	7.6	5.9	5.9
	65	0.97	14	12	14	9.6	0.97	6.3	8.6	1.2	5.8	8.6	6.7	6.7
	115	0.98	15	12	16	10	1.0	6.7	9.3	1.2	6.1	9.2	7.2	7.2











COPPER TUBE IN DOMESTIC WATER SERVICES
DESIGN AND INSTALLATION

Water flow resistance through compression and capillary fittings, used with copper tube to BS EN 1057 R220 and

Nominal size (mm)	Temp of water (°C)	EQUIVALENT LENGTHS IN METRES												
		Tee (compression or capillary)			Reducing Tee (compression or capillary)		Pitcher Tee (compression)			Pitcher Tee (capillary)			Elbow (compression)	Elbow (capillary)
														
6	15.5	0.009	0.15	0.13	0.17	0.10	0.009	0.09	0.08	0.012	0.10	0.10	0.11	0.078
	65	0.013	0.18	0.16	0.21	0.13	0.014	0.11	0.10	0.016	0.13	0.13	0.15	0.094
	115	0.014	0.19	0.17	0.23	0.14	0.015	0.12	0.11	0.017	0.14	0.14	0.16	0.10
8	15.5	0.016	0.24	0.20	0.26	0.16	0.018	0.15	0.12	0.020	0.17	0.17	0.19	0.12
	65	0.020	0.29	0.25	0.33	0.21	0.022	0.17	0.16	0.025	0.20	0.20	0.23	0.15
	115	0.022	0.31	0.28	0.36	0.22	0.025	0.19	0.18	0.028	0.22	0.22	0.25	0.16
10	15.5	0.022	0.33	0.28	0.35	0.22	0.025	0.20	0.18	0.027	0.23	0.23	0.26	0.17
	65	0.029	0.40	0.35	0.43	0.29	0.031	0.25	0.23	0.034	0.28	0.28	0.31	0.20
	115	0.030	0.43	0.38	0.47	0.31	0.034	0.26	0.26	0.039	0.31	0.31	0.35	0.22
12	15.5	0.029	0.43	0.36	0.46	0.29	0.033	0.26	0.23	0.036	0.30	0.30	0.33	0.22
	65	0.038	0.53	0.47	0.56	0.38	0.040	0.31	0.30	0.044	0.36	0.36	0.40	0.26
	115	0.040	0.57	0.51	0.63	0.41	0.046	0.35	0.34	0.052	0.40	0.40	0.46	0.29
15	15.5	0.041	0.57	0.51	0.62	0.41	0.044	0.38	0.32	0.047	0.41	0.38	0.43	0.30
	65	0.048	0.65	0.59	0.71	0.48	0.053	0.41	0.38	0.056	0.47	0.44	0.53	0.35
	115	0.052	0.74	0.65	0.81	0.53	0.059	0.45	0.44	0.064	0.52	0.50	0.60	0.38
18	15.5	0.051	0.73	0.63	0.79	0.53	0.056	0.46	0.43	0.063	0.51	0.48	0.58	0.38
	65	0.062	0.88	0.75	0.95	0.64	0.073	0.54	0.52	0.076	0.59	0.57	0.69	0.45
	115	0.066	0.93	0.82	1.0	0.68	0.075	0.57	0.57	0.082	0.62	0.60	0.75	0.48
22	15.5	0.067	0.97	0.82	1.0	0.68	0.070	0.58	0.56	0.080	0.63	0.62	0.73	0.48
	65	0.083	1.1	0.96	1.2	0.82	0.088	0.69	0.68	0.10	0.74	0.73	0.88	0.58
	115	0.086	1.2	1.1	1.4	0.91	0.095	0.76	0.77	0.11	0.82	0.80	0.98	0.63
28	15.5	0.095	1.3	1.0	1.4	0.95	0.095	0.79	0.79	0.10	0.85	0.85	0.98	0.66
	65	0.12	1.6	1.3	1.6	1.1	0.12	0.95	0.95	0.13	1.0	1.0	1.2	0.80
	115	0.12	1.7	1.5	2.0	1.3	0.13	1.0	1.1	0.15	1.1	1.1	1.3	0.87
35	15.5	0.13	1.8	1.5	1.9	1.3	0.13	1.0	1.1	0.16	1.0	1.1	1.3	0.91
	65	0.15	2.0	1.7	2.2	1.5	0.15	1.2	1.2	0.17	1.2	1.3	1.5	1.0
	115	0.16	2.3	2.0	2.5	1.7	0.17	1.4	1.4	0.20	1.3	1.4	1.7	1.2
42	15.5	0.16	2.2	1.9	2.4	1.6	0.16	1.2	1.4	0.19	1.1	1.4	1.5	1.1
	65	0.18	2.5	2.2	2.7	1.8	0.21	1.4	1.6	0.22	1.3	1.7	1.7	1.4
	115	0.20	2.9	2.5	3.2	2.0	0.22	1.7	1.8	0.24	1.4	1.8	2.0	1.5
54	15.5	0.22	3.1	2.7	3.4	2.2	0.25	1.7	2.0	0.27	1.3	2.0	2.1	1.6
	65	0.24	3.6	3.2	3.9	2.6	0.30	2.0	2.4	0.30	1.5	2.4	2.4	1.9
	115	0.26	4.0	3.4	4.3	2.8	0.32	2.2	2.5	0.33	1.5	2.5	2.6	2.0
76.1	15.5	0.35	4.7	4.1	5.1	3.4	0.35	2.5	3.0	0.44	2.0	3.0	2.9	2.4
	65	0.40	5.6	4.8	6.0	4.0	0.40	2.9	3.6	0.49	2.4	3.6	3.4	2.8
	115	0.49	6.0	5.2	6.6	4.3	0.42	3.1	3.9	0.49	2.9	3.9	3.8	3.0
108	15.5	0.52	7.4	6.5	7.9	5.3	0.52	3.7	4.8	0.61	2.9	4.8	4.2	3.7
	65	0.61	8.5	7.3	9.1	6.1	0.61	4.3	5.5	0.73	3.6	5.5	4.9	4.3
	115	0.61	9.4	7.9	10	6.5	0.67	4.6	6.0	0.80	3.7	6.0	5.2	4.7

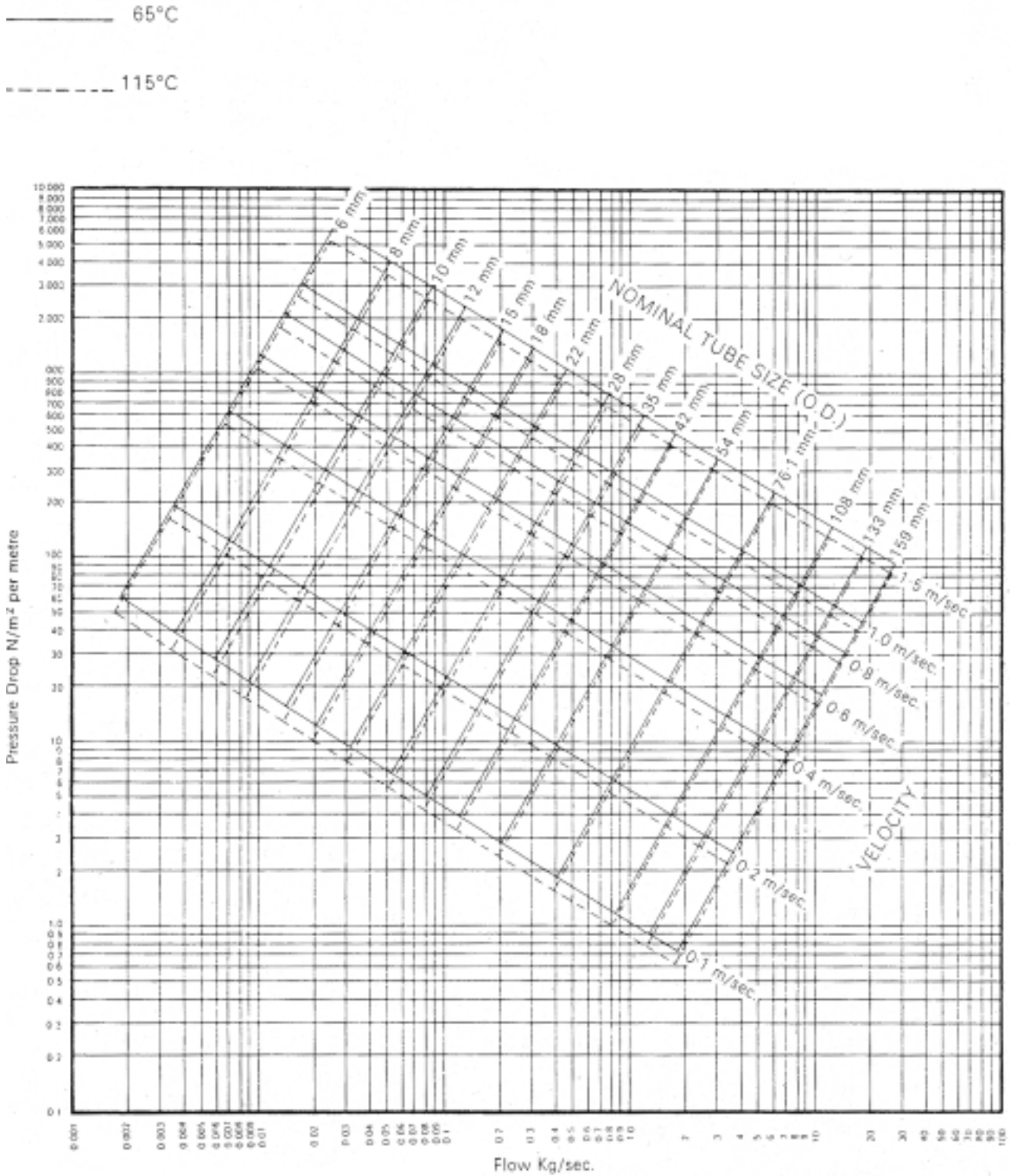
COPPER TUBE IN DOMESTIC WATER SERVICES
DESIGN AND INSTALLATION

R250 (formerly BS 2871: Part 1: Table Y).

EQUIVALENT LENGTHS IN METRES														Temp of water (°C)	Nominal size (mm)
Twin elbow (compression)		Twin elbow (capillary)		Bend (compression or capillary)	Return bend			Reducer (compression or capillary)		Angle valve	Gate valve	Stop-cock			
					(compression)	(capillary)		$\frac{D_1}{D_2} = 2$	$\frac{D_1}{D_2} = 3$						
															
0.059	0.064	0.089	0.086	0.057	0.070	0.16	0.070	0.033	0.032	0.50	0.048	0.96	15.5	6	
0.071	0.078	0.11	0.11	0.071	0.088	0.19	0.088	0.042	0.039	0.62	0.060	1.2	65		
0.075	0.082	0.12	0.12	0.077	0.097	0.21	0.097	0.044	0.042	0.65	0.066	1.3	115		
0.092	0.10	0.14	0.14	0.090	0.11	0.26	0.11	0.051	0.049	0.79	0.079	1.5	15.5	8	
0.11	0.12	0.18	0.17	0.11	0.14	0.31	0.14	0.064	0.060	0.96	0.10	2.0	65		
0.12	0.13	0.20	0.19	0.12	0.16	0.34	0.16	0.068	0.065	1.0	0.11	2.0	115		
0.13	0.14	0.20	0.19	0.12	0.15	0.36	0.15	0.069	0.066	1.1	0.10	2.1	15.5	10	
0.15	0.17	0.24	0.23	0.15	0.19	0.43	0.19	0.087	0.079	1.3	0.14	2.6	65		
0.17	0.19	0.27	0.26	0.16	0.21	0.48	0.21	0.091	0.086	1.4	0.16	2.8	115		
0.16	0.18	0.25	0.25	0.16	0.20	0.46	0.20	0.089	0.082	1.4	0.16	2.7	15.5	12	
0.20	0.22	0.31	0.30	0.19	0.24	0.54	0.24	0.11	0.10	1.7	0.19	3.4	65		
0.22	0.24	0.35	0.34	0.21	0.28	0.63	0.28	0.12	0.11	1.9	0.22	3.7	115		
0.23	0.25	0.35	0.32	0.22	0.27	0.62	0.27	0.10	0.11	1.9	0.21	3.6	15.5	15	
0.26	0.30	0.41	0.38	0.24	0.33	0.71	0.32	0.12	0.13	2.2	0.24	4.4	65		
0.28	0.32	0.45	0.43	0.27	0.36	0.81	0.36	0.13	0.14	2.4	0.27	4.7	115		
0.28	0.30	0.43	0.41	0.25	0.33	0.79	0.33	0.16	0.15	2.5	0.28	4.7	15.5	18	
0.34	0.38	0.52	0.47	0.31	0.39	0.95	0.39	0.19	0.18	3.0	0.33	5.6	65		
0.36	0.39	0.56	0.51	0.34	0.41	1.0	0.41	0.19	0.18	3.1	0.36	6.0	115		
0.36	0.39	0.56	0.50	0.34	0.42	1.0	0.42	0.20	0.19	3.2	0.36	6.1	15.5	22	
0.45	0.49	0.67	0.59	0.40	0.49	1.2	0.49	0.24	0.22	3.8	0.43	7.2	65		
0.48	0.53	0.74	0.66	0.45	0.53	1.4	0.53	0.25	0.23	4.1	0.48	7.9	115		
0.50	0.57	0.79	0.66	0.47	0.57	1.4	0.57	0.28	0.27	4.4	0.50	8.4	15.5	28	
0.62	0.68	0.92	0.80	0.56	0.65	1.7	0.65	0.33	0.30	5.3	0.59	10	65		
0.66	0.73	1.0	0.88	0.61	0.71	1.9	0.71	0.34	0.31	5.6	0.66	11	115		
0.69	0.76	1.0	0.85	0.60	0.69	1.9	0.69	0.38	0.35	6.0	0.69	11	15.5	35	
0.80	0.86	1.2	1.0	0.71	0.80	2.2	0.80	0.45	0.42	6.8	0.77	13	65		
0.87	0.96	1.3	1.1	0.80	0.85	2.5	0.85	0.48	0.44	7.6	0.87	14	115		
0.87	0.94	1.3	1.0	0.74	0.84	2.4	0.84	0.48	0.45	7.4	0.90	14	15.5	42	
1.0	1.1	1.5	1.2	0.87	0.96	2.7	0.96	0.54	0.51	8.7	1.0	16	65		
1.1	1.2	1.6	1.3	0.97	1.1	3.2	1.0	0.57	0.54	9.5	1.2	18	115		
1.2	1.4	1.8	1.4	1.0	1.1	3.4	1.2	0.75	0.63	11	1.3	19	15.5	54	
1.5	1.6	2.1	1.6	1.2	1.3	3.9	1.4	0.87	0.72	12	1.5	22	65		
1.5	1.7	2.2	1.7	1.3	1.3	4.3	1.4	0.87	0.71	13	1.6	25	115		
1.8	1.8	2.6	1.7	1.5	1.5	4.9	1.6	1.0	0.93	16	1.9	29	15.5	76.1	
2.2	2.4	3.1	2.4	1.8	1.8	6.0	1.9	1.2	1.0	19	2.4	34	65		
2.3	2.5	3.2	2.5	1.9	1.9	6.6	2.0	1.2	1.2	20	2.5	37	115		
2.9	3.2	4.1	3.2	2.2	2.1	7.9	2.2	1.6	1.5	25	3.0	45	15.5	108	
3.3	3.7	4.6	3.7	2.5	2.4	9.2	2.6	1.8	1.7	29	3.5	52	65		
3.5	3.8	4.9	3.8	2.7	2.5	10	2.7	1.9	1.8	31	3.7	56	115		

COPPER TUBE IN DOMESTIC WATER SERVICES
DESIGN AND INSTALLATION

Water flow resistance through copper tube to BS EN 1057 R250 (Formerly Table X) .

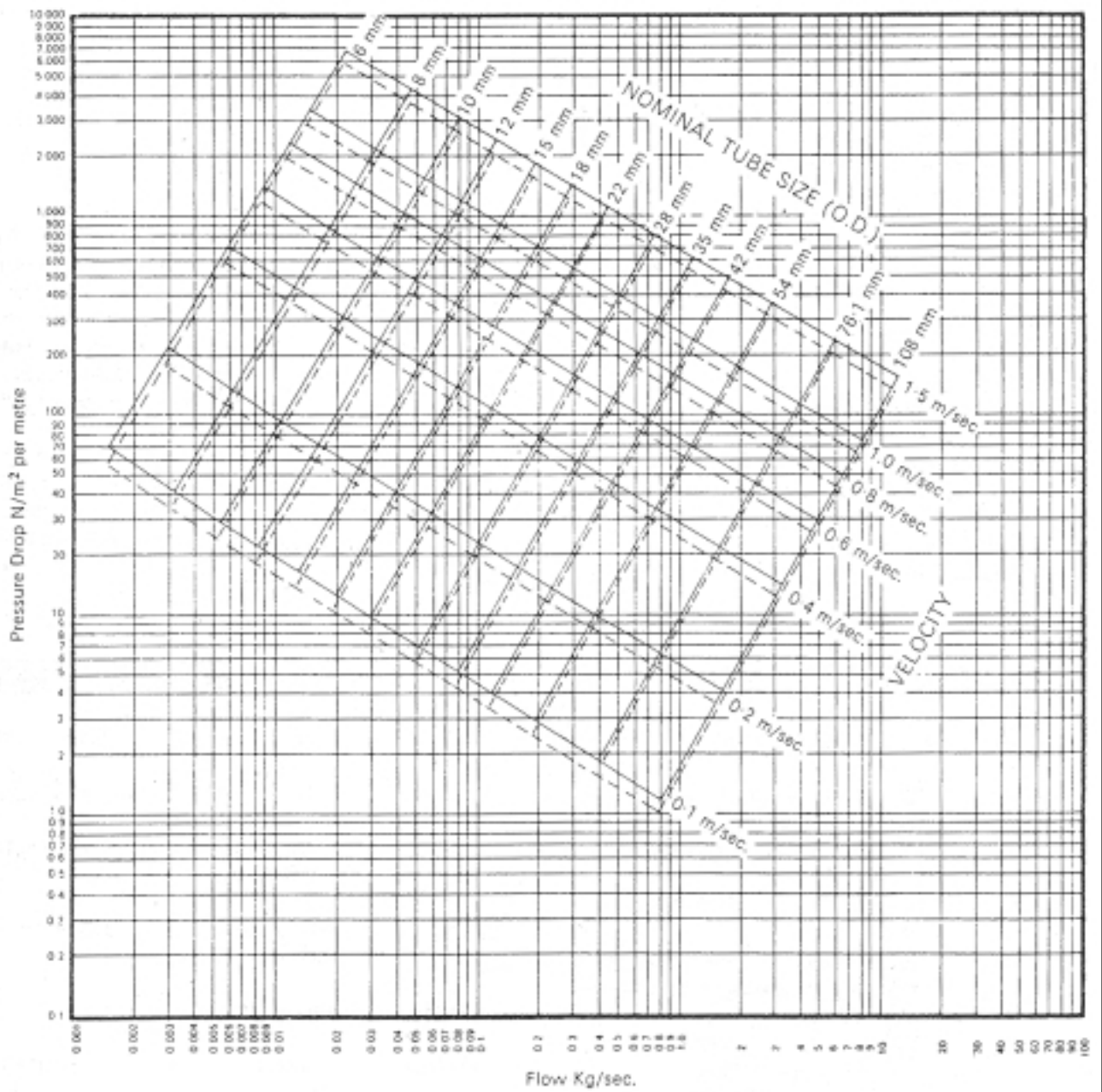


COPPER TUBE IN DOMESTIC WATER SERVICES
DESIGN AND INSTALLATION

Water flow resistance through copper tube to BS EN 1057 R220 and R250 (Formerly Table Y).

————— 65°C

- - - - - 115°C



Appendix I

Regulations and Statutory Requirements

The Building Regulations 1985

Materials and workmanship

Any work to which a requirement of the Building Regulations applies must, in accordance with Regulation 7, be carried out with proper materials and in a workmanlike manner.

Compliance may be shown in a number of ways, for example by following the relevant British Standard or British Board of Agrément Certificate. Further guidance is given in the Approved Document on Materials and Workmanship.

Hot water storage

Part G3 of the Building Regulations requires that if the hot water storage system does not incorporate a vent pipe to atmosphere adequate precautions should be taken to prevent the temperature of the stored water at any time exceeding 100° C. The maximum working pressures quoted in this publication for copper tube are based on maximum operating temperatures not exceeding 110° C.

Insulation of heating services

Part L5 of the Building Regulations requires that hot water pipes should have adequate thermal insulation unless they are intended to contribute to the heating of part of a building that is insulated. The provisions meeting the requirements regarding maximum thermal conductivity and rates of heat loss are also tabled in L5.

A range of insulating materials are available for copper tubes including factory fitted plastic sleeving and post

installation insulation. Reference should be made to the manufacturers' literature for details of the thermal performance of insulated copper pipework. It should be noted that some plastic coated copper tube is produced primarily for corrosion protection in aggressive environments such as acid soils. In these circumstances the insulating properties may not be adequate for hot water applications.

British Standards Specification BS 6700

'Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages'.

This Specification brings together in one publication virtually all aspects of hot and cold water supply within a building and its immediate surroundings. It does not cover water treatment, fire fighting systems and water supply for industrial treatments.

The term 'domestic water service' is defined as the system of pipes, fittings and connected appliances installed to supply a building with water for ablutionary, cleaning, sanitary, culinary and laundry purposes. The specification deals with the plumbing aspects of both the hot water conveyed for use and hot water conveyed for space heating. However it does not cover domestic central heating installation appliances.

The scope of this publication 'Copper Tube in Domestic Water Services' is similar to that of the British Standard Specification whilst concentrating on aspects of copper tube usage.

References

British and European Standard Specifications	BS 1566	Copper indirect cylinders for domestic purposes.
BS EN 1057	Copper and copper alloys – Seamless round copper tubes for water and gas in sanitary and heating applications.	Part 1 Specification for double feed indirect cylinders. Part 2 Specification for single feed indirect cylinders.
BS EN 1254	Copper and copper alloys – Plumbing fittings Part 1 Fittings with ends for capillary soldering or capillary brazing to copper tubes. Part 2 Fittings with compression ends for use with copper tubes. Part 5 Fittings with short ends for capillary brazing to copper tubes.	BS 1710
		Specification for identification of pipelines and services
		BS 1723
		Brazing
		BS 1724
		Specification for bronze welding by gas
BS 1306	Specification for copper and copper alloy pressure piping systems	BS 1845
		Specification for filler metals for brazing.

BS 3958	Specification for thermal insulating materials	The Water Fittings and Materials Directory Water Research Centre, Water Byelaws Advisory Service, 660 Ajax Avenue, Slough, Berks. SL1 4BG
BS 4504	Specification for flanges and bolting for pipes, valves and fittings: Metric series Part 3: Section 3.3 Copper alloy and composite flanges	Technical Memorandum TM13 'Minimising the Risk of Legionnaires' Disease' The Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London, SW12 9B5
BS 4800	Schedule of paint colours for building purposes	'Copper in Domestic Heating Systems' Publication TN39, June 1988 'Dezincification Resistant Brass' Information Sheet IS 36, November 1982 Copper Development Association, Verulam Industrial Estate, 224 London Road, St Albans, Herts. AL1 1AQ
BS 5422	Method for specifying thermal insulating materials on pipes, ductwork and equipment (Temperature range -40°C - +700°C)	'Methods of Sterilisation' HTM27, Department of Health and Social Services, Her Majesty's Stationery Office
BS 5431	Specification for bending springs for use with copper tubes for water, gas and sanitation	Other sources of information
BS 6700	Specification for Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages.	'Plumbing Engineering Services Design Guide' The Institute of Plumbing 64 Station Lane, Hornchurch, Essex
BS EN 12164	Rod for free machining purposes.	
BS EN 12165	Wrought and unwrought forging stock	
BS EN 12167	Profiles and rectangular bar for general purposes.	
BS EN 29453	Soft solder alloys – Chemical compositions and forms.	
BS EN ISO 9000	Quality management and quality assurance standards.	

British Standards Institution, 389 Chiswick High Road, London. W4 4AJ

Other references

S F White, G D Mays 'Water Supply Byelaws Guide'
Water Research Centre,
Water Byelaws Advisory Service, 660 Ajax Avenue,
Slough, Berks, SL1 4BG

The Building Regulations 1985
Approved Documents
G Hygiene
L Conservation of Fuel and Power
Department of the Environment and The Welsh Office
Her Majesty's Stationery Office

Guidance Note EH 48 'Legionnaires' Disease'
Environmental Hygiene Series 48 (January 1987)
Health and Safety Executive
Her Majesty's Stationery Office

Figures

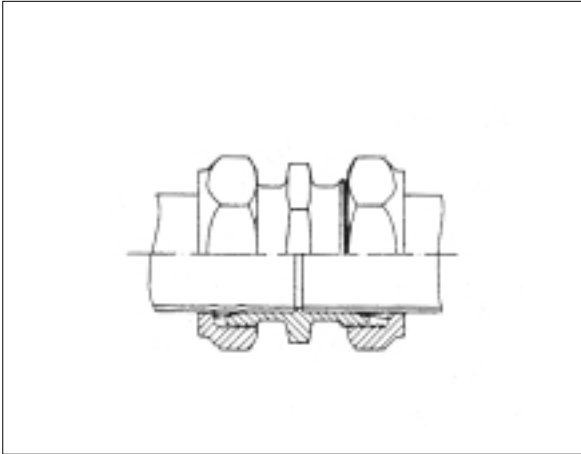


Figure 1 Compression fitting

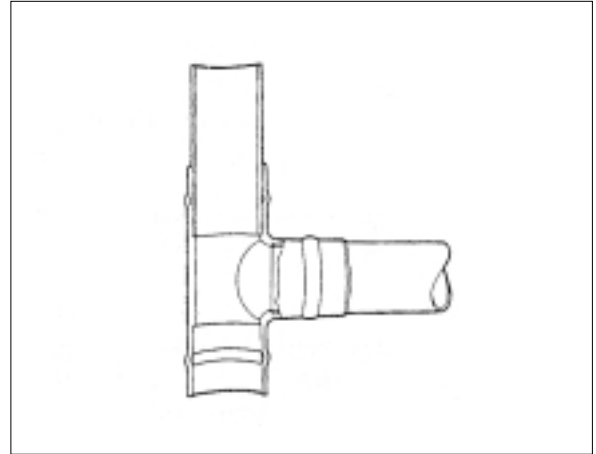


Figure 2 Integral solder ring capillary fitting

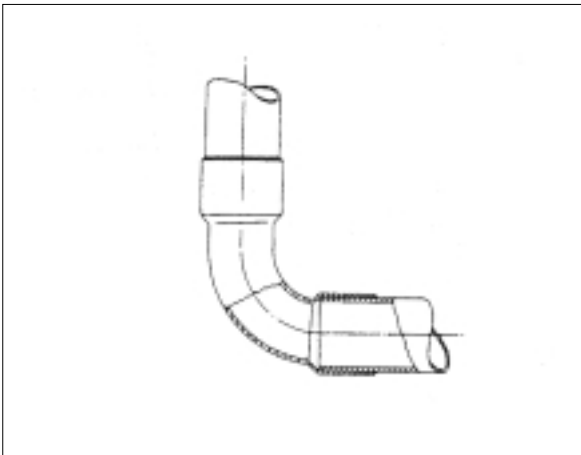


Figure 3 End feed capillary fitting

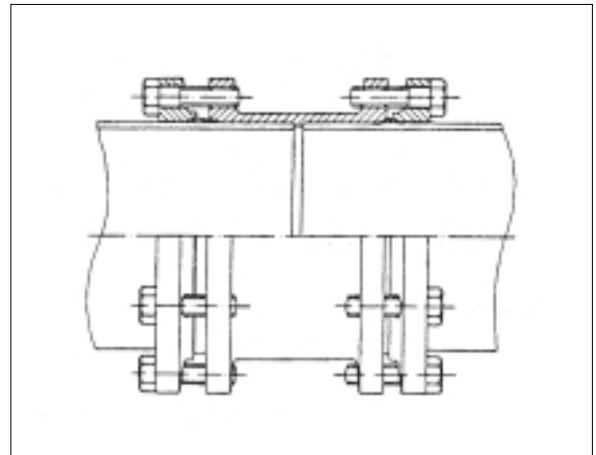


Figure 4 Large diameter compression fitting

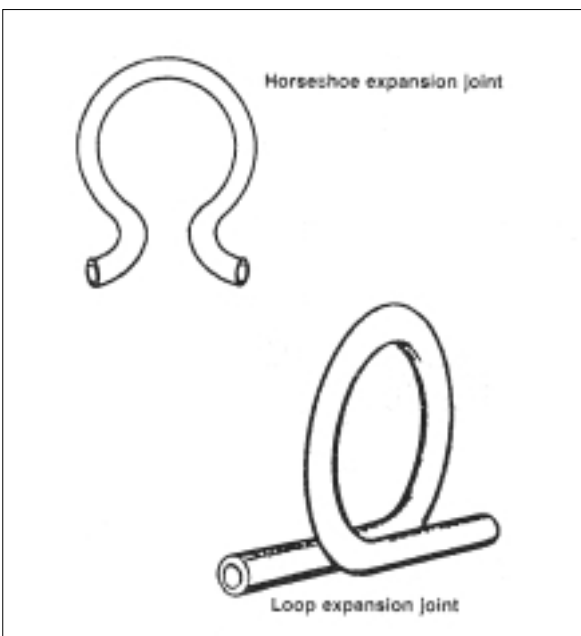


Figure 5 Horseshoe and loop expansion joints

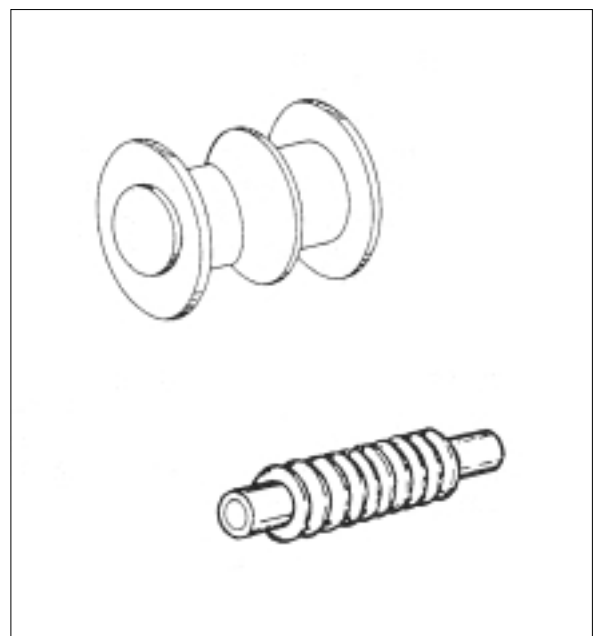


Figure 6 Bellows expansion joints

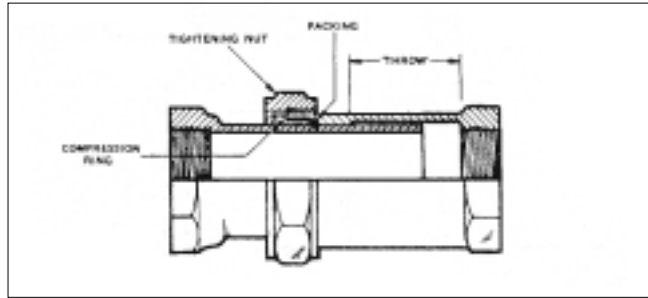


Figure 7 Gland type expansion joint

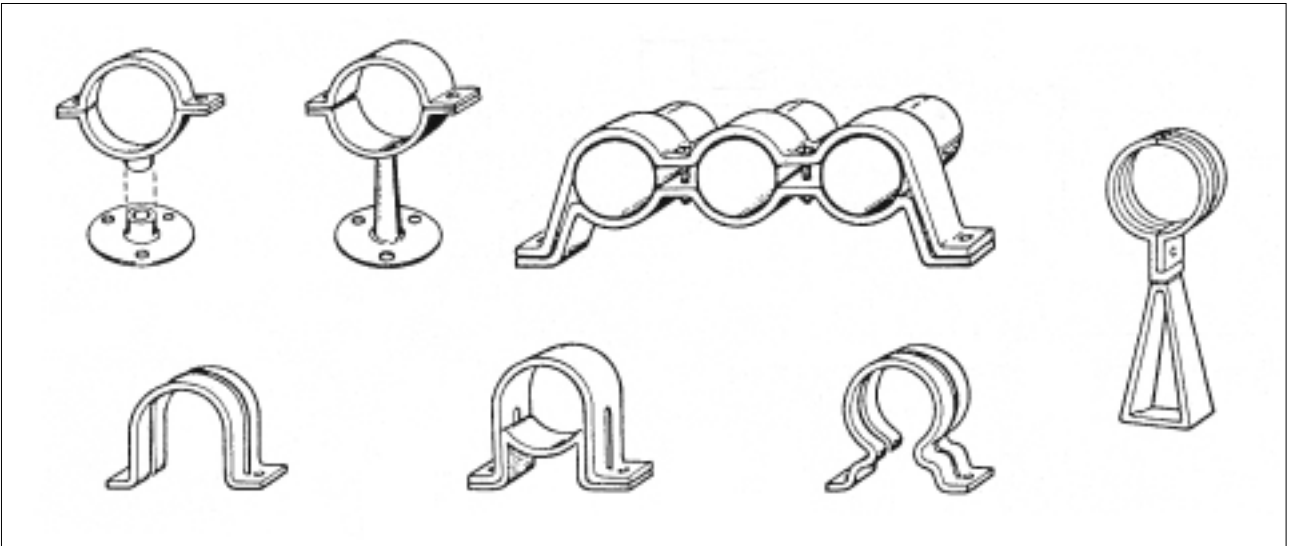


Figure 8 Fixings

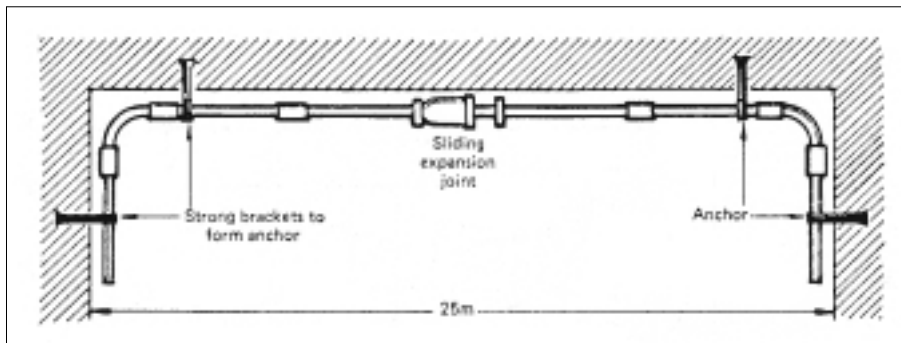


Figure 9 Method of fixing long lengths of pipework along a wall (Sliding expansion joint)

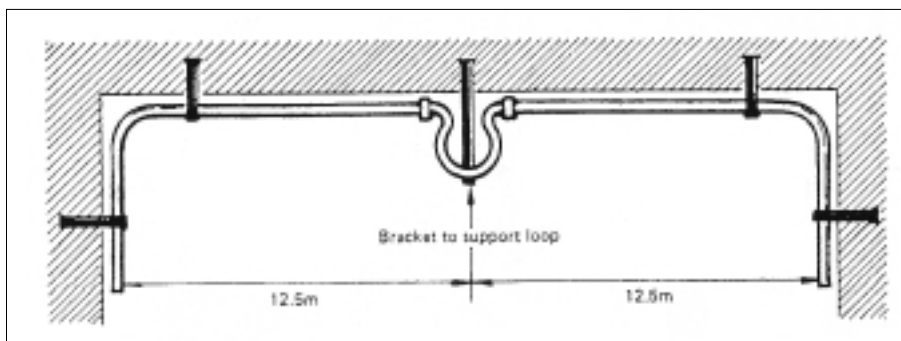


Figure 10 Method of fixing long lengths of pipework along a wall (Loop expansion joint)

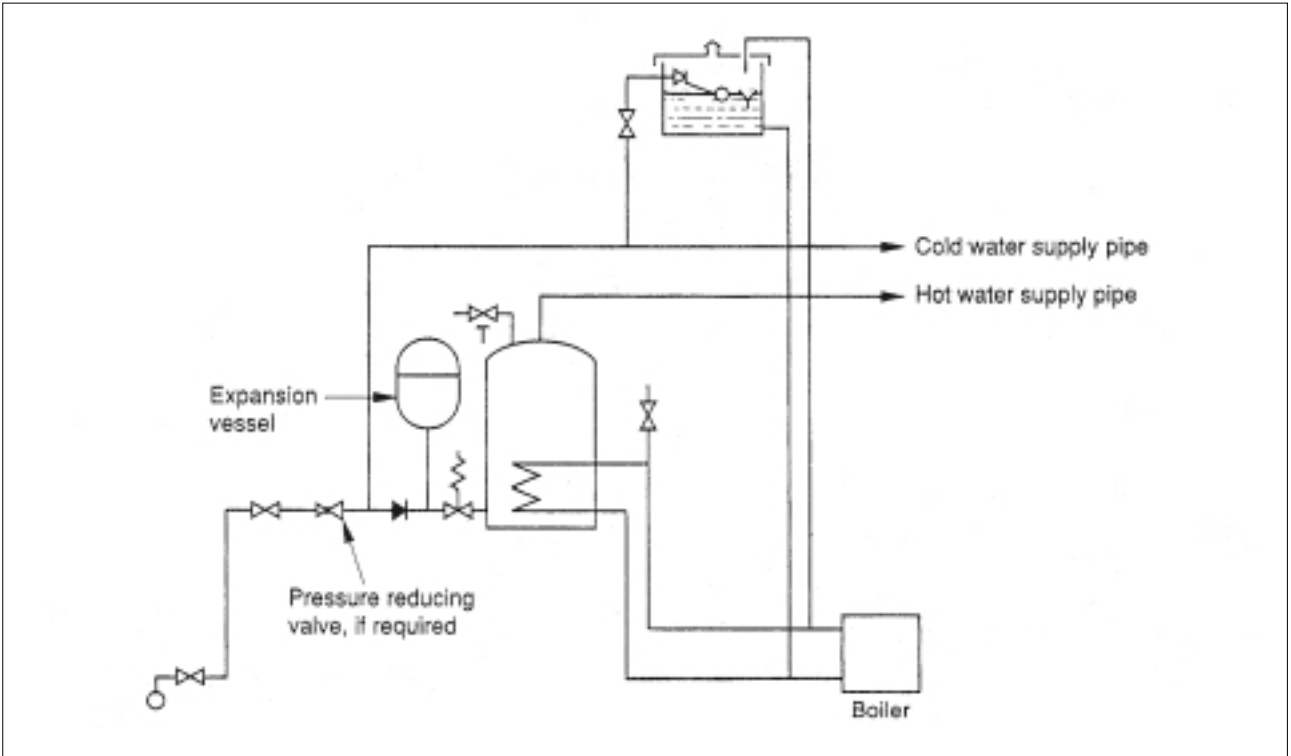


Figure 11 Indirect unvented (vented primary) system

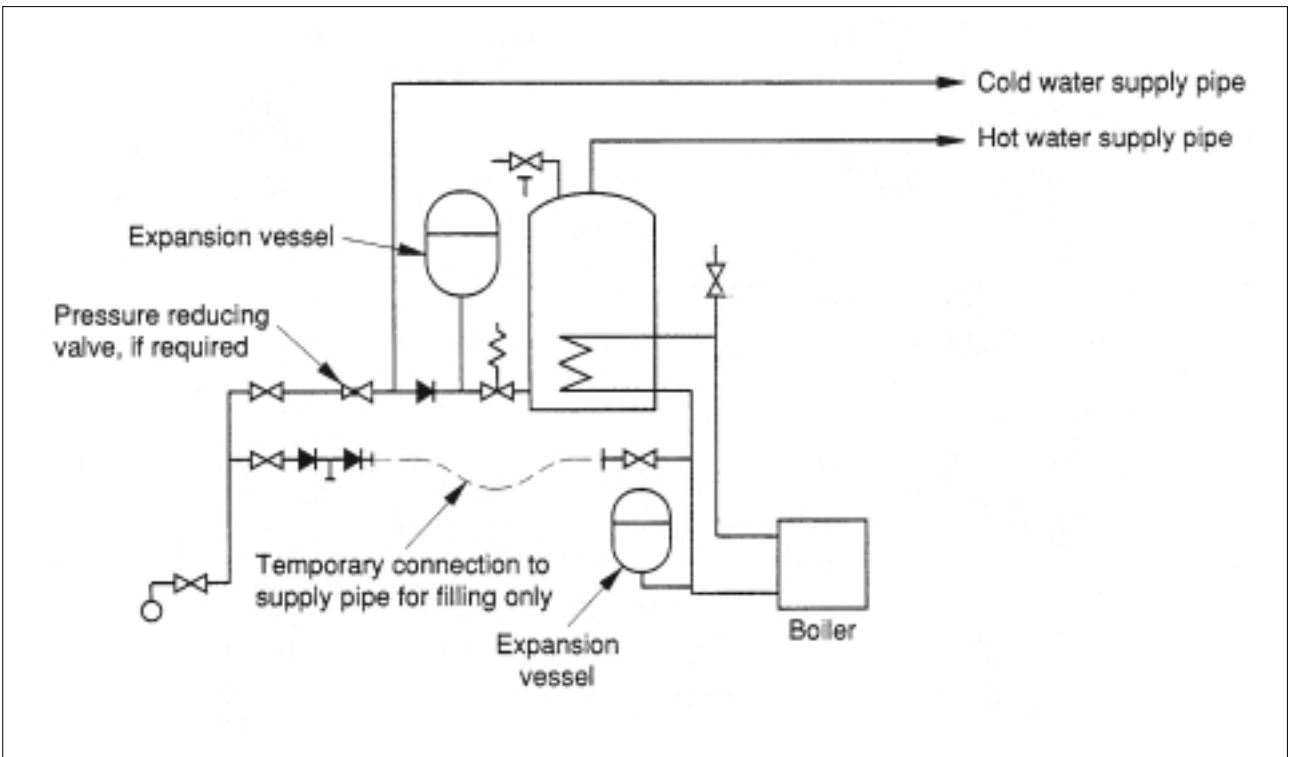


Figure 12 Indirect unvented (sealed primary) system

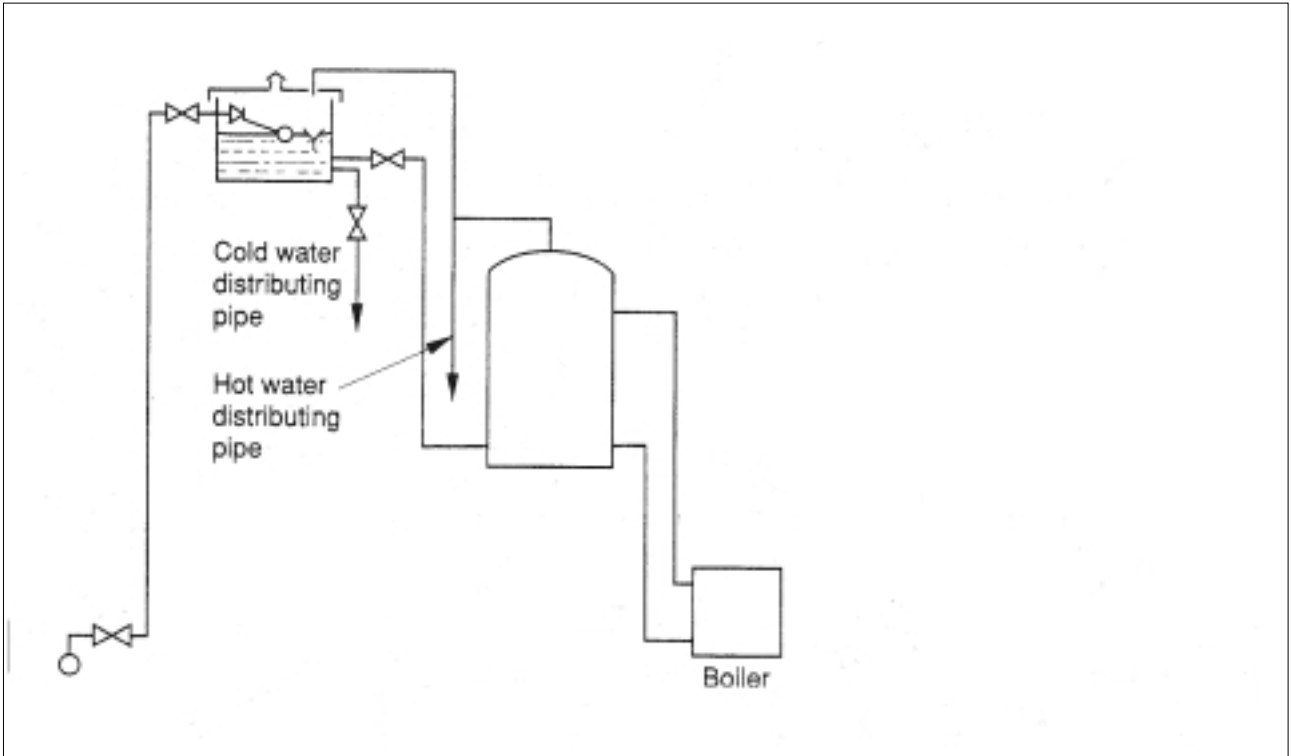


Figure 13 Direct (vented) system

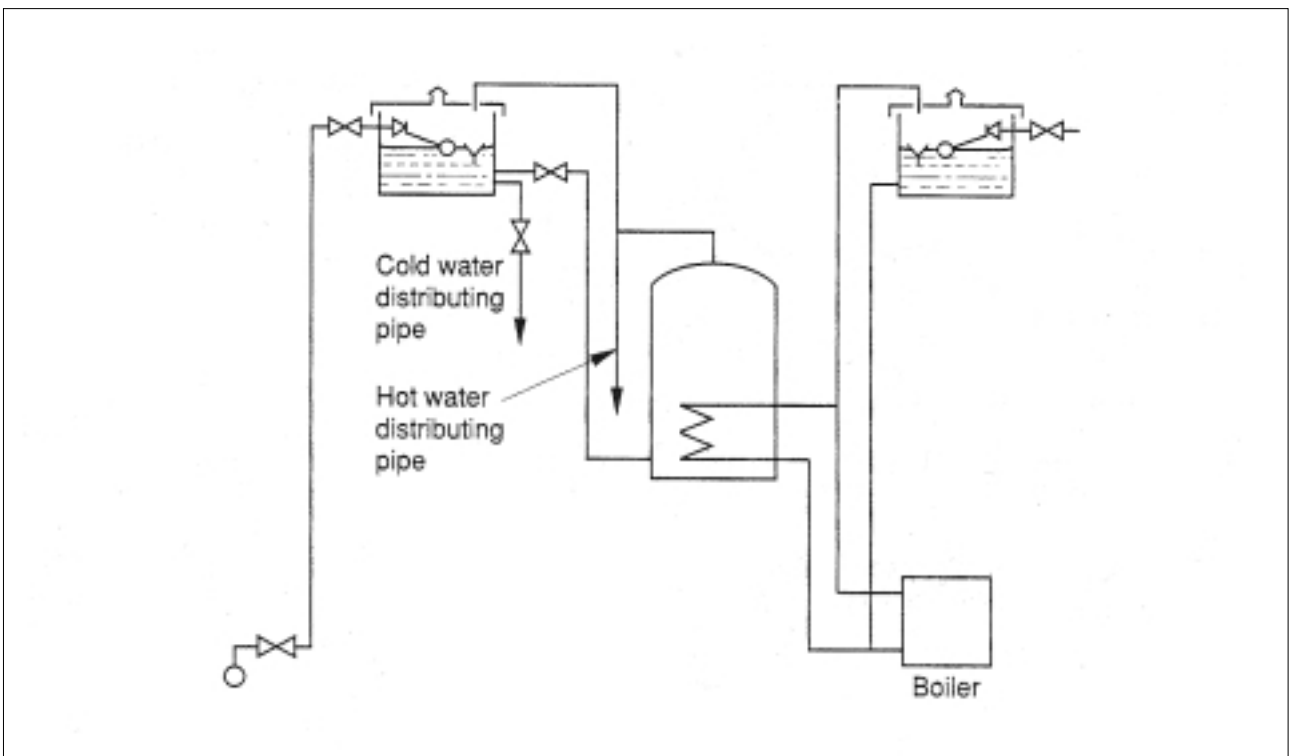


Figure 14 Indirect (vented) system

Notes

Notes



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www.brass.org

