Large Diameter Copper Tubes
for Industrial & Commercial Heating Applications

COPPER DEVELOPMENT ASSOCIATION
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1. Introduction

The aim of this publication is to create awareness amongst architects, designers and specifiers of the uses of copper and copper alloys in commercial and industrial heating systems using tube sizes of 28mm to 159mm outside diameter.

Good corrosion resistance and compatibility with a wide range of fluids makes copper and its alloys suitable materials for use in heating systems. The high thermal conductivity of copper makes it ideal for use in heat exchange applications. Good machinability of copper alloys and the range of forming processes result in the production of close tolerance, high strength, wear and corrosion resistant valve bodies, flanges and fittings. The inherent strength of copper tubes, together with their relatively low wall thickness, leads to a high water carrying capacity compared to other materials.

The ease of fabrication of copper tube and the jointing methods available simplifies the manufacture and installation of the heating system and generally results in improved cost effectiveness of systems when compared to other materials.

This cost effectiveness, resulting from the intrinsic properties of the metal and the proven working lifetime of the material, has been enhanced over recent years by the increased availability of copper throughout the world, together with developments in jointing technology.

2. Copper Tubes

The copper used in the manufacture of tubes is phosphorus deoxidized copper Cu-DHP, CR024A in accordance with BS EN 1976. The minimum copper content is defined as 99.90% Cu and the residual phosphorus content as 0.015 to 0.040%. Its density is 8.9 g/cm^3, melting point 1083ºC and its coefficient of linear expansion is 16.8 x 10^{-6} per ºC (between 20º and 100ºC).

Generally, large-size copper tubes used in a conventional heating system are to BS EN 1057, in the half-hard (R250) condition. Tubes to BS EN 1057 R290 (hard drawn) can also be used, but because such tubes are hard drawn they cannot be bent without local annealing, and specialised bending equipment.

Large diameter copper tubes in the U.K. are generally supplied in 3m and 6m half-hard (R250) straight lengths and the standard outside diameters are compatible with a wide range of fittings.

'Kitemarked' products are an acceptable way of identifying quality products, this is also the case with copper tube. Only tubes manufactured by a firm licensed under the BSI scheme are permitted to carry the 'Kitemark'. BS EN 1057 requires detailed marking of the tubes of sizes 10mm up to and including 54 mm diameter at intervals of not more than 600 mm with at least the following information:

EN 1057

- outside diameter x wall thickness
- identification for half hard temper (R250) by 'HH'
- manufacturer's identification mark
- date of production: year and quarter (I or IV) or year and month (1 to 12)

The specification also that tube sizes less than 10mm diameter and those greater than 54mm diameter shall be similarly marked at both ends.

Table 1: Dimensions, mechanical properties and working pressures for half-hard copper tube, BS EN 1057 R250 ***(formerly known as Table X)***

Size of tube mm	Nominal thickness mm	Tensile strength minimum N/mm^2	Elongation on 5.65 So minimum %	Maximum working pressure(1) bar(2)
28	0.9	250	30	40
35	1.2	250	30	42
42	1.2	250	30	35
54	1.2	250	30	27
66.7	1.2	250	30	20
76.1	1.5	250	30	24
108	1.5	250	30	17
133	1.5	250	30	14
159	2.0	250	30	15

Note: (1) based on material in half hard condition at 65ºC **(2)** 1 bar = 0.1 N/mm^2 = 10^{5}N/m^2

Table 2: Dimensions, mechanical properties and working pressures for thick walled half-hard copper tube, BS EN 1057 R250 ***(formerly known as Table Y).***

Size of tube mm	Nominal thickness mm	Tensile strength minimum N/mm²	Elongation on 5.65 So minimum %	Maximum working pressure (1) bar (2)
28	1.2	250	20	55
35	1.5	250	20	54
42	1.5	250	20	45
54	2.0	250	20	47
66.7	2.0	250	20	37
76.1	2.0	250	20	33
108	2.5	250	20	29

Note: (1) based on material in half hard condition at 65ºC **(2)** 1 bar = 0.1 N/mm^2 = $10^5 N/m^2$

Hard tubes

Table 3: Dimensions, mechanical properties and working pressures for hard copper tube, BS EN 1057 R290.

Size of tube mm	Nominal thickness mm	Tensile strength minimum N/mm²	Elongation on 5.65 So minimum %	Maximum working pressure (1) bar (2)
35	1.0	290	3	36
42	1.0	290	3	30
54	1.0	290	3	23
66.7	1.2	290	3	22
76.1	1.5	290	3	24
108	1.5	290	3	17
133	1.5	290	3	14
159	2.0	290	3	15

Note: (1) based on material in hard condition at 65ºC **(2)** 1 bar = 0.1 N/mm^2 = $10^5 N/m^2$

Advice on the availability of the larger sizes of tube should be sought from the manufacturer.

The maximum working pressures at temperatures up to 65ºC are calculated in accordance with the following formula:

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

Where P = maximum working pressure (bar)
F = design stress (N/mm^2)
t = minimum wall thickness (mm)
D = maximum outside diameter (mm)

For annealed, R220, condition F = 46 N/mm^2.
For half hard, R250, condition F = 60 N/mm^2.
For hard, R290, condition F = 72.5 N/mm^2.

- If tubes in the hard and half hard condition are annealed, e.g. during brazing or hard soldering, the stress value quoted above for condition annealed should be used for calculating working pressures.
- Copper tubes are suitable in some circumstances for use up to a maximum temperature of 200ºC, but for pressure calculations a stress value appropriate to the particular temperature should be used, see Table 4.

Table 4 Stress values for working temperatures in excess of 65ºC

Temperature ºC	110	150	175	200
Max. admissable stress for annealed, R220, condition, N/mm²	40	34	26	18

Copper tube is available in larger sizes typically 219.1mm diameter and 267mm diameter.

3. Hangers and Expansion

Hangers

The number of hangers and supports for a pipework system depends upon the weight and rigidity of the tube. The lightweight of copper and the rigidity of the tubes mean that relatively few hangers are required. The following spacings for hangers on pipe runs should be observed:

Table 5: Spacing of hangers for large diameter copper tube

Size of pipe (OD) mm	Maximum spacing vertical runs mm	Maximum spacing horizontal runs mm
28	2.4	1.8
35	3.0	2.4
42	3.0	2.4
54	3.0	2.7
66.7	3.6	3.0
76.1	3.6	3.0
108	3.6	3.0
133	3.6	3.0
159	4.2	3.6

Expansion

The coefficient of linear expansion of copper is 16.8 x 10^{-6} per ºC and hence a 10m length of copper tube, irrespective of its size, wall thickness or temper, will increase in length by 10mm when heated through 60ºC. Pipes installed on hot water services must be free to accommodate this expansion, otherwise stresses will build up in the pipework, which may lead to joints being pulled apart and/or tubes fracturing. Clearly the magnitude and frequency of such changes in length will determine the life of the joint or failure of the tube.

In the case of copper tube in domestic hot water and heating installations the 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 10m, are encountered, allowance for expansion should be made.

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.

Short stubs to and from radiators, connected to relatively long straight runs should also be avoided. This can usually be achieved by introducing an expansion loop, thereby increasing the length of pipework fixed between the flow/return legs and the radiator connection. However, expansion accommodation techniques such as the use of loops and horseshoes may not be sufficient to accommodate large amounts of expansions and in such cases the use of expansion bellows or gland type expansion joints may be necessary.

4. Pressure Losses and Flow Rate

Assuming good design practice and installation the maximum recommended flow velocities of oxygenated water at different temperatures are as follows:

Table 6

Degree C	10	50	70	90
flow m/s	2.0	1.5	1.3	1.0

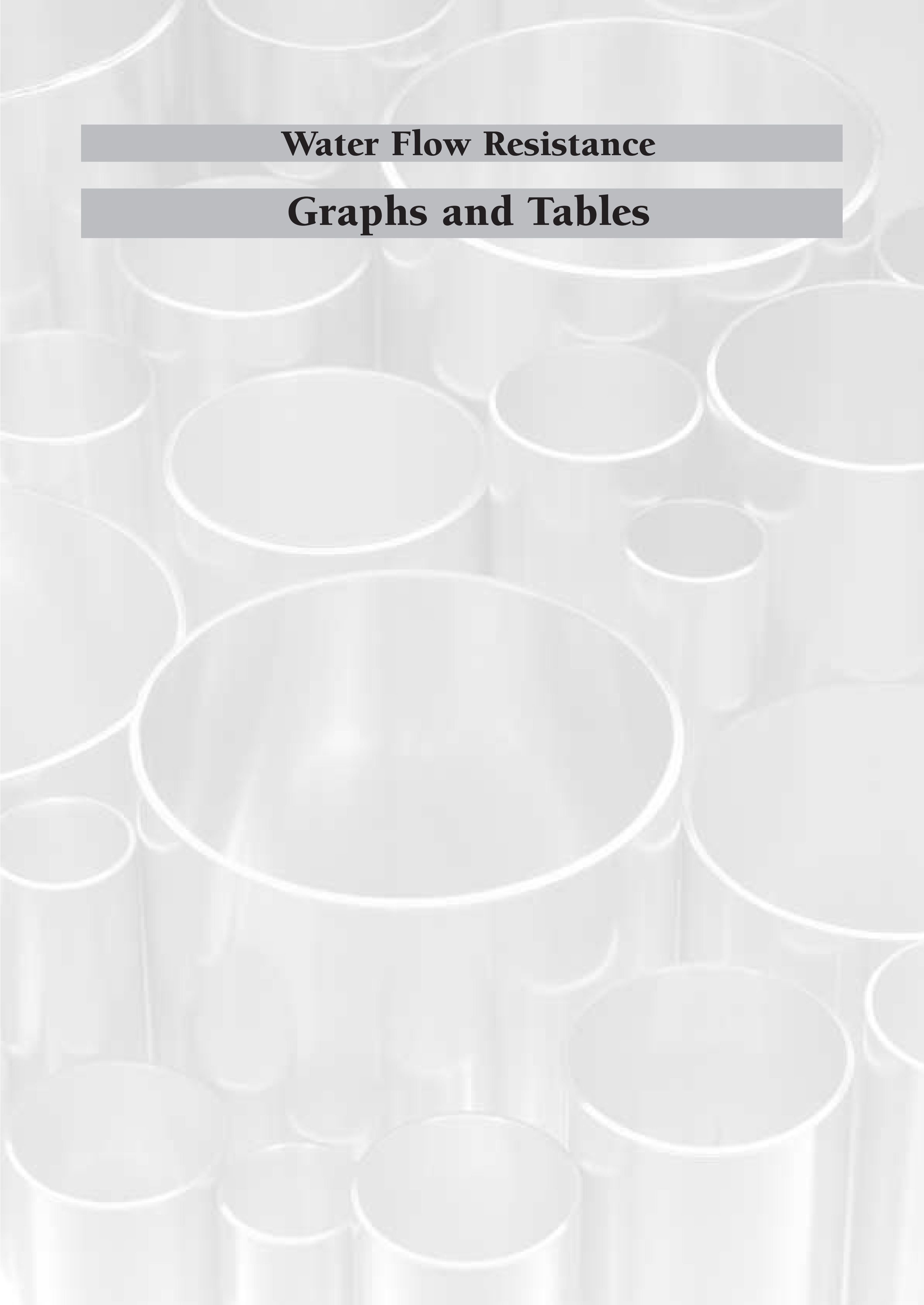
Flow velocities should be between 0.5m per second, below which any suspended matter may settle out, and the maximum values given in the table, above which erosion/corrosion and/or cavitation may occur.

In deoxygenated hot water flow velocity is restricted only by system constraints.

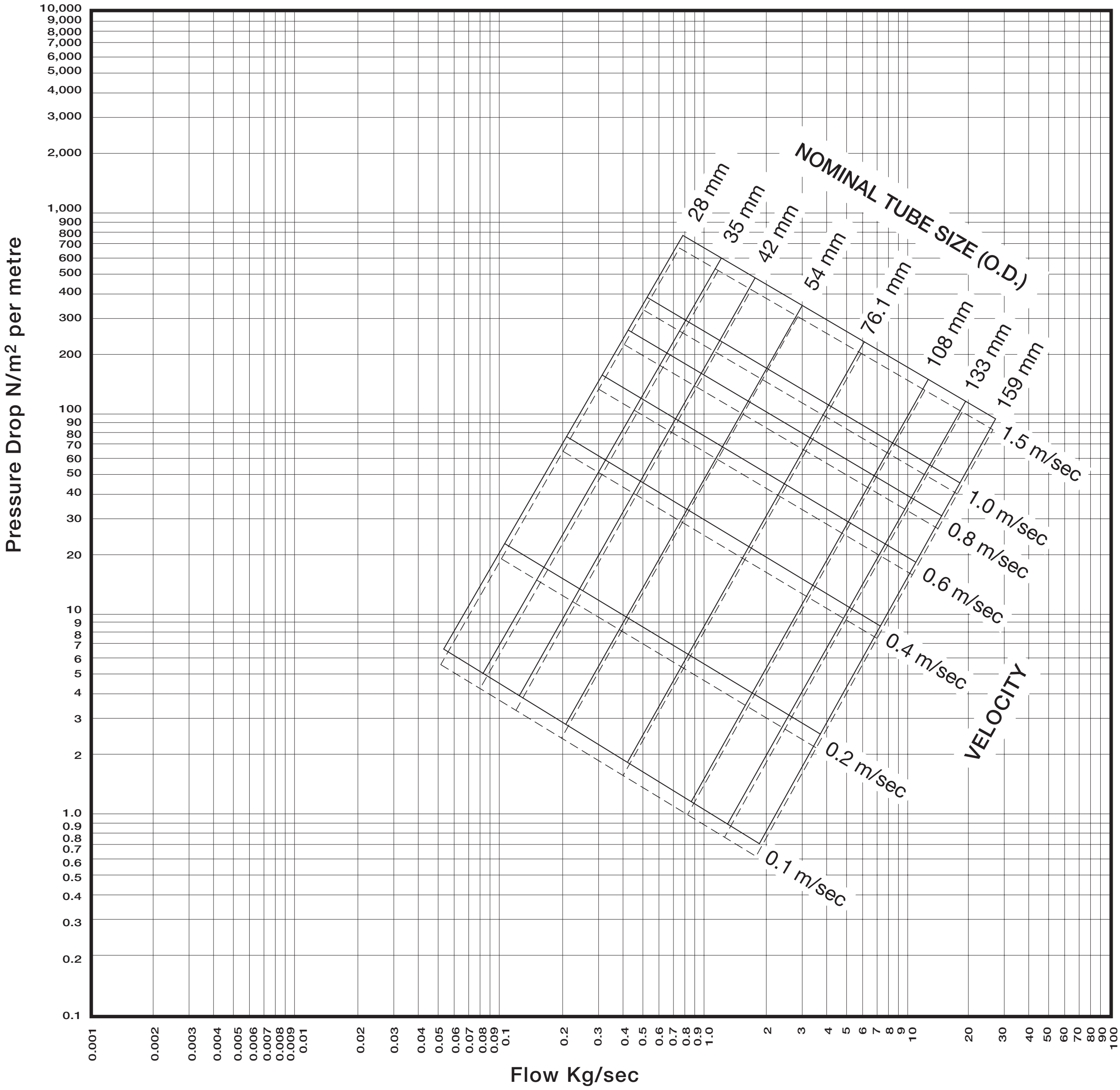
The size of the tube should therefore be selected according to the conditions. Charts for calculating the flow rate, velocity and pressure loss for each tube size are given in Sections 5, 6 and 7.

Water Flow Resistance

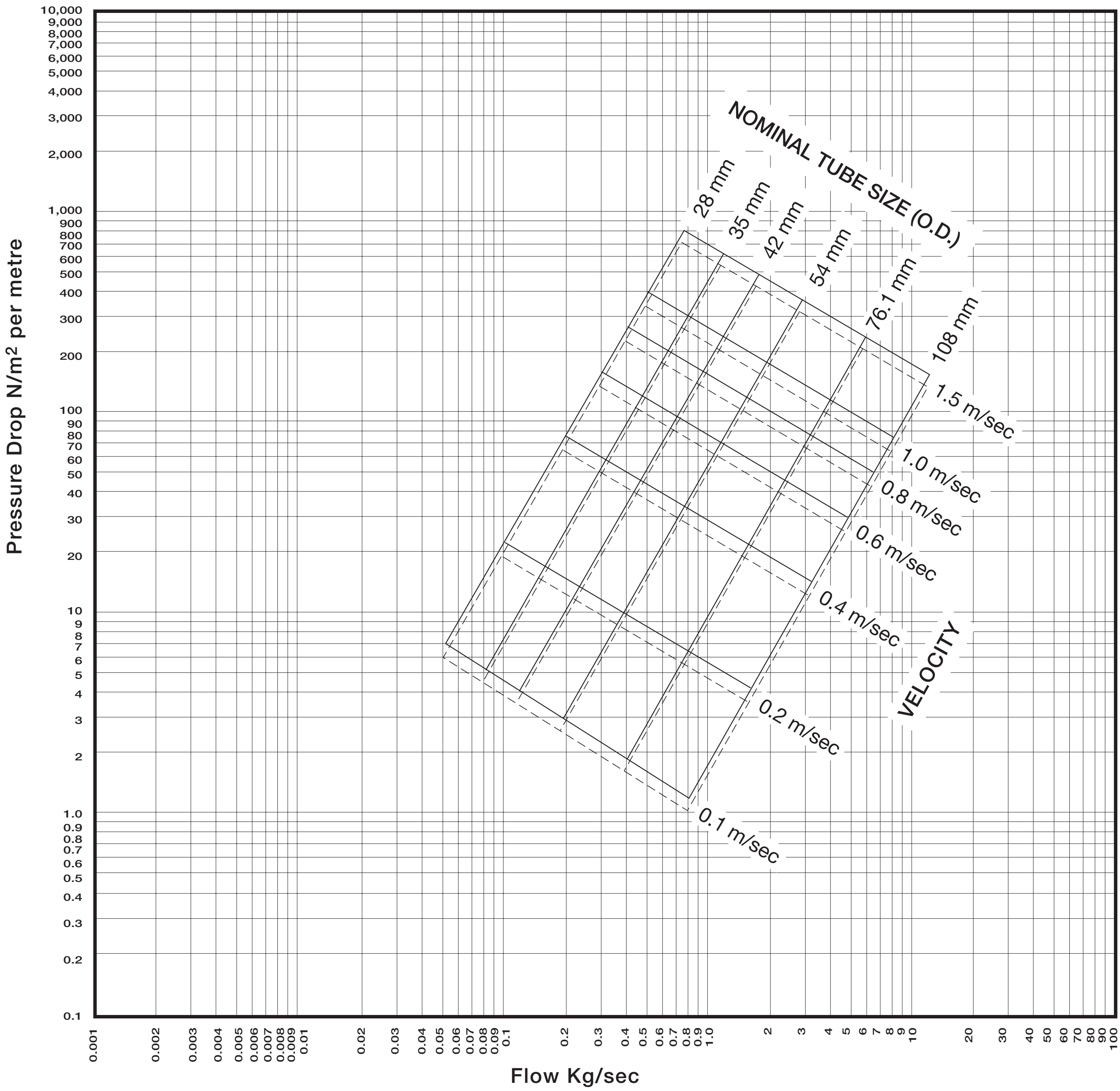
Graphs and Tables



5. Water Flow Resistance Through R250 and R290 Copper Tube to BS EN 1057



6. Water Flow Resistance Through R250 Thick Walled Copper Tube to BS EN 1057



7. Water Flow Resistance through Compression and Capillary Fittings used with Copper Tube to BS EN 1057.

Nominal Size (mm)	Water Temp. (ºC)	Tee (compression or capillary)			Reducing Tee (compression or capillary)		Pitcher Tee (compression)			Pitcher Tee (capillary)			Elbow (compression)	Elbow (capillary)
					D1/D2 = 2	D1/D2 = 3								
WATER FLOW RESISTANCE THROUGH R250 AND R290 COPPER TUBE TO BS EN 1057														
28	15.5	0.010	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	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	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	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	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	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	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	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	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	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	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	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	0.61	9.4	7.9	10.0	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	0.77	11.0	9.4	12.0	7.8	0.77	5.3	7.1	0.95	4.7	7.1	5.8	5.5
	115.0	0.78	12.0	10.0	13.0	8.4	0.84	5.7	7.6	1.0	4.9	7.6	6.3	6.0
159	15.5	0.83	12.0	10.0	13.0	8.4	0.80	5.6	7.6	1.0	5.0	7.6	5.9	5.9
	65.0	0.97	14.0	12.0	14.0	9.6	0.97	6.3	8.6	1.2	5.8	8.6	6.7	6.7
	115.0	0.98	15.0	12.0	16.0	10.0	1.0	6.7	9.3	1.2	6.1	9.2	7.2	7.2
WATER FLOW RESISTANCE THROUGH R250 THICK WALLED COPPER TUBE TO BS EN 1057														
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	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	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	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	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	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	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	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	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	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	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	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	0.61	9.4	7.9	10.0	6.5	0.67	4.6	6.0	0.80	3.7	6.0	5.2	4.7

Nominal Size (mm)	Water Temp. (ºC)	Twin Elbow (compression)		Twin Elbow (capillary)		Bend (comp. or cap.)	Return Bend (compression)		Return Bend (capillary)	Reducer (compression or capillary) D1/D2 = 2	Reducer (compression or capillary) D1/D2 = 3	Angle Valve	Gate Valve	Stop-cock
WATER FLOW RESISTANCE THROUGH R250 AND R290 COPPER TUBE TO BS EN 1057														
	15.5	0.52	0.58	0.81	0.68	0.48	0.58	1.5	0.58	0.29	0.27	4.5	0.52	8.6
28	65.0	0.64	0.70	0.95	0.83	0.58	0.67	1.7	0.67	0.34	0.31	5.5	0.61	10.0
	115.0	0.68	0.75	1.0	0.90	0.63	0.73	1.9	0.73	0.35	0.31	5.7	0.68	11.0
	15.5	0.69	0.76	1.0	0.85	0.60	0.69	1.9	0.69	0.38	0.35	6.0	0.69	11.0
35	65.0	0.80	0.86	1.2	1.0	0.71	0.80	2.2	0.80	0.45	0.42	6.8	0.77	13.0
	115.0	0.87	0.96	1.3	1.1	0.80	0.85	2.5	0.85	0.48	0.44	7.6	0.87	14.0
	15.5	0.88	0.95	1.3	1.0	0.75	0.85	2.4	0.85	0.49	0.46	7.5	0.91	14.0
42	65.0	1.0	1.1	1.5	1.2	0.89	1.0	2.8	1.0	0.55	0.52	8.9	1.0	16.0
	115.0	1.1	1.2	1.6	1.3	1.0	1.1	3.2	1.0	0.58	0.55	9.6	1.2	18.0
	15.5	1.3	1.4	1.8	1.4	1.1	1.1	3.4	1.3	0.77	0.64	11.0	1.3	20.0
54	65.0	1.5	1.6	2.1	1.6	1.2	1.3	3.9	1.4	0.87	0.72	12.0	1.5	22.0
	115.0	1.5	1.7	2.2	1.7	1.3	1.3	4.3	1.4	0.87	0.71	13.0	1.6	25.0
	15.5	1.8	1.8	2.6	1.7	1.5	1.5	4.9	1.6	1.0	0.93	16.0	1.9	29.0
76.1	65.0	2.2	2.4	3.1	2.4	1.8	1.8	6.0	1.9	1.2	1.0	19.0	2.4	34.0
	115.0	2.3	2.5	3.2	2.5	1.9	1.9	6.6	2.0	1.2	1.2	20.0	2.5	37.0
	15.5	2.9	3.2	4.1	3.2	2.2	2.1	7.9	2.2	1.6	1.5	25.0	3.0	45.0
108	65.0	3.3	3.7	4.6	3.7	2.5	2.4	9.2	2.6	1.8	1.7	29.0	3.5	52.0
	115.0	3.5	3.8	4.9	3.8	2.7	2.5	10.0	2.7	1.9	1.8	31.0	3.7	56.0
	15.5	3.6	3.9	4.9	3.9	2.6	2.6	9.7	2.6	1.9	1.8	30.0	3.7	55.0
133	65.0	4.3	4.7	5.8	4.7	3.2	3.1	11.0	3.1	2.3	2.2	37.0	4.5	67.0
	115.0	4.5	4.9	6.3	4.8	3.4	3.1	13.0	3.0	2.4	2.3	40.0	4.8	72.0
	15.5	4.6	5.0	6.2	5.1	3.4	3.4	13.0	3.4	2.5	2.4	40.0	4.8	71.0
159	65.0	5.3	5.8	7.1	5.8	3.8	3.8	14.0	3.8	2.9	2.7	45.0	5.5	82.0
	115.0	5.5	6.1	7.5	5.9	4.0	3.8	16.0	3.8	3.0	2.8	49.0	5.9	89.0
WATER FLOW RESISTANCE THROUGH R250 THICK WALLED COPPER TUBE TO BS EN 1057														
	15.5	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
28	65.0	0.62	0.68	0.92	0.80	0.56	0.65	1.7	0.65	0.33	0.30	5.3	0.59	10.0
	115.0	0.66	0.73	1.0	0.88	0.61	0.71	1.9	0.71	0.34	0.31	5.6	0.66	11.0
	15.5	0.69	0.76	1.0	0.85	0.60	0.69	1.9	0.69	0.38	0.35	6.0	0.69	11.0
35	65.0	0.80	0.86	1.2	1.0	0.71	0.80	2.2	0.80	0.45	0.42	6.8	0.77	13.0
	115.0	0.87	0.96	1.3	1.1	0.80	0.85	2.5	0.85	0.48	0.44	7.6	0.87	14.0
	15.5	0.87	0.94	1.3	1.0	0.74	0.84	2.4	0.84	0.48	0.45	7.4	0.90	14.0
42	65.0	1.0	1.1	1.5	1.2	0.87	0.96	2.7	0.96	0.54	0.51	8.7	1.0	16.0
	115.0	1.1	1.2	1.6	1.3	0.97	1.1	3.2	1.0	0.57	0.54	9.5	1.2	18.0
	15.5	1.2	1.4	1.8	1.4	1.0	1.1	3.4	1.2	0.75	0.63	11.0	1.3	19.0
54	65.0	1.5	1.6	2.1	1.6	1.2	1.3	3.9	1.4	0.87	0.72	12.0	1.5	22.0
	115.0	1.5	1.7	2.2	1.7	1.3	1.3	4.3	1.4	0.87	0.71	13.0	1.6	25.0
	15.5	1.8	1.8	2.6	1.7	1.5	1.5	4.9	1.6	1.0	0.93	16.0	1.9	29.0
76.1	65.0	2.2	2.4	3.1	2.4	1.8	1.8	6.0	1.9	1.2	1.0	19.0	2.4	34.0
	115.0	2.3	2.5	3.2	2.5	1.9	1.9	6.6	2.0	1.2	1.2	20.0	2.5	37.0
	15.5	2.9	3.2	4.1	3.2	2.2	2.1	7.9	2.2	1.6	1.5	25.0	3.0	45.0
108	65.0	3.3	3.7	4.6	3.7	2.5	2.4	9.2	2.6	1.8	1.7	29.0	3.5	52.0
	115.0	3.5	3.8	4.9	3.8	2.7	2.5	10.0	2.7	1.9	1.8	31.0	3.7	56.0

A major factor in reducing pressure losses and achieving smooth flow characteristics is the design of fittings that do not restrict the cross-section of the bore, as far as possible restrictions to flow should be avoided. The resistance to flow of the fittings and valves must be taken into consideration when designing a system. The simplest method to use is to equate each fitting type, valve type and bend with an equivalent length of straight pipe of the appropriate diameter.

8. Valves, Fittings and Jointing Techniques

A range of copper alloy materials may be used in the manufacture of valves for heating and hot water systems. These valves should meet the requirements of the relevant British or European Standards.

Copper tubes can be joined in a number of different ways; capillary joints, using brazing (hard soldering) and soft soldering techniques, compression joints, push-fit or press-fit. The fittings in these cases are manufactured from gunmetal, brass (including dezincification resistant brass) and wrought copper. Capillary and compression fittings are manufactured to the requirements of BS EN 1254. Standards are currently being developed for push-fit and press fittings. In some cases it may prove necessary to use flanges and bolting.

Capillary fittings, as described in BS EN 1254 Part 1, utilize the force of capillary action to ensure that molten solder is drawn into the gap between the tube wall and the fitting. The strength of the joint is invariably stronger than the tube itself. In order to achieve proper capillary flow the gap between the tube and the fitting surfaces must be within certain specified limits.

There are two types of capillary fittings; integral solder ring and end-feed fittings.

Integral solder ring fittings have a 'ring' of solder inserted into each socket during manufacture. This solder is the correct amount to ensure a good joint.
End-feed fittings require the use of solder wire. In these cases care has to be taken to ensure that the correct amount of solder is used, as too much solder is wasteful and too little will leave a poor joint.

Brazing, or hard or silver soldering, is suited to those applications where higher temperatures and pressures than can be tolerated by soft soldered joints may be encountered. Brazed joints are made in a similar way to soft soldered joints. However, it should be noted that the temperatures involved result in local annealing of the tubing and therefore system design calculations should take this into consideration (see pressure calculation section 2).

Compression fittings are available in two types, as defined in BS EN 1254 Part 2, up to 67mm in size. Each type of fitting is designed for a specific application.

Type 'A' non-manipulative fittings do not require any manipulation of the tube end prior to installation. The joint is made by tightening a compression nut on to the body of the fitting that compresses a ring on to the outside of the tube making a watertight seal. This type of fitting can be used on hard (R290) and half-hard (R250) tube.
Type 'B' manipulative compression fittings require the end of the tube to be flared, cupped or belled with a special forming tool. The formed end of the tube is compressed against a corresponding section of the fitting, or a loose thimble, when the correspondingly shaped compression nut is tightened. Manipulative compression fittings are not suitable for hard tubes and annealed tubes must be carefully de-burred and re-rounded before the tube end is formed.

Push-fit fittings are new, reliable and versatile. As the tube is inserted into the fitting in several types it passes through a release collar and then a stainless steel grip ring. The grip ring has a series of teeth that open out and grip on to 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. In some push-fit fittings the position of the 'O' ring and grip ring are reversed. Fittings are available in sizes up to 54mm.

Most of these fittings can be disconnected, and the operation is as simple as forming the joint. Pressure is applied to the release collar in the mouth of the fitting, using a special disconnecting tool, which splays the teeth of the grip ring. Thus the tube is freed from the fitting. Other types require a securing cap to be unscrewed.

Press fittings are another new type of fitting requiring a special compression tool. The tube is fully inserted into the fitting until it reaches the tube stop. A mechanical means is then employed to compress the fitting on to the tube to create a secure and reliable joint. During this operation the 'O' ring seal is also compressed between the wall of the fitting and the tube. This type of joint is quick and effective requiring no spanners or flame but does require the special tool. Fittings are available in sizes up to 108mm.

9. Bending

For tubes up to 54mm OD portable bending machines are suitable but for tubes over 54mm OD fixed power benders are the most suitable method.
See section 10 on Prefabrication.

Most bending machines work on the principle that the tube is bent between matched formers and back guides that support the OD of the tube thereby eliminating the risk of collapse of the tube wall. The point at which the bending pressure is exerted must be maintained at the correct distance in front of the point of support of the former.

Correct bend formation will avoid the creation of wrinkled, kinked or flattened bends which may adversely affect flow conditions and possibly induce fatigue cracking or impingement attack (cavitation).

The use of adjustable bending machines, which permit the pressure on the back guide to be adjusted, ensure perfect bends every time, providing that the root (inside) bending radius is not less than 3 times the outside diameter of the tube.

10. Prefabrication

Whilst copper systems are easy and quick to install there are situations where prefabrication can be advantageous. One such case is in large multi-occupancy buildings where the large number of units needed make it economical to design and prefabricate a special unit for that particular building. Another case is for buildings of unusual design that may pose pipework installation problems that can be overcome by one-off prefabrications in the ideal conditions afforded by the workshop.

In each case the fact that bending, jointing and assembly are done in the ideal conditions of the workshop instead of the problematic conditions that may be encountered on site represents one of the main benefits of prefabrication.

Prefabrication allows the designer a chance to view the pipework before installation, and to make any necessary adjustments. The availability of fittings need not hamper work progress as bends and branches can easily be incorporated into the design, virtually no scrap is produced and potential of theft of material is all but eliminated.

The attributes of copper make it ideal for pre-fabrication work in that it is suitable for any type of building service application.

11. DZR Brass

Copper alloys are the preferred materials for valves in water distribution systems because of their high strength, corrosion resistance and compatibility with the working fluid.

In some areas of the UK the water supply is aggressive to duplex brass and will leach the zinc leaving behind a mass of porous copper, a form of corrosion known as dezincification. In such cases dezincification resistant brass should be used for the valves. However, in any situation where there is doubt concerning the quality or type of water, the local water supplier should be consulted.

Dezincification resistant brass, DZR, is specified in BS EN 12164, BS EN 12165, BS EN 12167 and BS EN 12168. The alloy designation is CW602N (formerly CZ 132) and the composition is selected to give the hot malleability of conventional brass to aid manufacture and to ensure that after a suitable heat treatment the material will satisfy the requirements of a dezincification resistance test.

DZR brass can be soldered satisfactorily but should not be heated to temperatures in excess of 550ºC otherwise the corrosion resistance properties of the material will be affected, i.e. dezincification resistance.

12. Corrosion in Heating Systems

If a heating system is designed, installed and operated correctly it is unlikely that there will be any problems with corrosion of its components.

In most wet heating systems the components are manufactured from a number of different metals. Any problems that occur in mixed metal systems are usually the result of poor circuit design and rarely the fault of the materials themselves.

Normal water supplies contain a certain amount of dissolved oxygen that increases the corrosion potential of the water. In a heating circuit this is normally quickly used up in forming protective scales and the oxygen in the incoming water is driven off at the boiler.

Air finding its way into the system through incorrect design, installation or operating practices will lead to leaks and other corrosion problems.

In the event of continual oxygen replenishment of the system water the following problems may occur:

- 1) Restricted water circulation - corrosion of steel components, eg radiators, will result in the build up of orange/brown iron oxide (haematite) powder in the bottom of the radiators or collection of nitrogen or hydrogen in the top of the radiators both of which can restrict the water circulation and heat output.

- 2) Bimetallic corrosion (galvanic corrosion) - two dissimilar metals in contact in oxygenated water constitute a galvanic cell in which the more noble metal, copper, is the cathode and the less noble, e.g. steel, aluminium, the anode, which tends to dissolve (corrode).

When cold, fresh water passes through pipework no undue damage will occur if the iron or steel is installed upstream of the copper. It should be noted that galvanic corrosion will not take place in the absence of an electrolyte (e.g. fresh water containing dissolved oxygen).

The use of excessive amounts of flux during capillary jointing may result in localized corrosion that can eventually penetrate tubes or other components (e.g. radiators) in the form of pinholes. Recommendations made in manufacturers' literature and in standards such as BS6700, governing the use of flux and removal of flux residues should therefore be followed.

Table 7: Galvanic series of metals and alloys

Corroded end: anodic – least noble
Zinc
Aluminium-magnesium alloys
99% aluminium
Aluminium-copper alloys
Steel or iron
Cast iron
Stainless steel (active)
Lead-tin solders
Lead
Tin
Nickel (active)
Brasses
Copper
Bronzes
Copper-nickel alloys
Silver solder
Nickel (passive)
Silver
Graphite
Gold
Protected end: cathodic – most noble

14. Legionella in Heating Systems

The bacterium legionella pneumophila may be present in all water systems. A number of measures have been recommended to prevent the multiplication of the bacteria. Two well-known factors which decrease the rate of multiplication of legionella pneumophila are elevated temperature (greater than 46ºC) and the dosing of water systems with free chlorine.

A lesser known factor is that copper itself is an extremely effective biocide. Indeed, it has been shown that copper is the only commonly used plumbing material which actually decreases the number of bacteria, including legionellae, growing on its surface compared to neutral glass.

Temperature
The optimum temperature for the multiplication of the bacteria in the laboratory is around 37ºC. At higher temperatures the rate of multiplication of legionellae in the laboratory decreases and at 46ºC it falls to zero. Bacteria will survive at higher temperature but the survival time decreases from a matter of hours at 50ºC to minutes at 60ºC and practically zero at 70ºC. For these reasons there is no viable legionellae in heating systems using water at operating temperatures of 80ºC. However, in the case of domestic hot water distribution systems, it is recommended that water be heated in calorifiers to 60ºC and then distributed at 50ºC.

Chlorine
Any residual free chlorine in the supply water disappears on heating and therefore protection against legionella is to a large extent dependent on temperature control and material of construction. System cleanliness is also important in that it is known that sediments, sludges and scale can act as a habitat and source of nutrients for legionella. Where necessary disinfection, with carefully controlled and monitored doses of chlorine may be required. In such situations particular attention should be paid to concentration and dwell time of disinfection solutions. Pipework systems should also be immediately and thoroughly flushed after disinfection that in any event should be carried out under the supervision of an appropriately qualified expert.

Material of construction
Research by the Public Health Laboratory Service has shown that copper is the only common plumbing material which consistently reduces bacterial growth in a variety of naturally occurring waters over a range of temperatures.

Viable organisms that have survived heating to temperatures in excess of 50ºC will be discouraged from multiplying downstream in copper systems but not other materials.

It should be recognized that unsuitable materials may provide conditions for growth or even a source of nutrients for bacteria. Copper consistently suppresses the formation of bacteria biofilms and legionella pneumophila.

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