The Plumbers Handbook

Ninth Edition -
March 2016

International Copper Association Australia
Copper Alliance

All plumbing work should be performed by competent, accredited trades persons in accordance with current relevant Standards and specifications required by the authority within whose jurisdiction the work is to be performed.

To ensure an installed system will provide satisfactory performance and the expected life, Industry practitioners should refer to Australian Standard AS4809 and give careful consideration to all aspects of:

- design
- operating condition
- the internal and external environments
- use of approved materials

THE PLUMBERS HANDBOOK

NINTH EDITION

Produced by

The Australian Copper Tube Industry

International Copper Association Australia

Copper Alliance

Proudly Sponsored by

KEMBLA

MM KEMBLA QUALITY RELIABILITY SERVICE 100 YEARS

Foreward

The International Copper Association Australia, in conjunction with MM Kembla, is proud to issue the ninth edition of the Plumbers Handbook which is published as an industry aid at a time when marked changes are taking place with respect to installation practice and material specification. This revision reflects some of those changes.

In 2016, the Australian copper tube manufacturing reaches 100 years of operation. Over this remarkable period, the tube companies have developed flexible copper systems for domestic, residential, commercial and industrial piping applications. A national network of distributors, on a day to day basis, offers a total system of reliable quality tubes, fittings, components and accessories which are manufactured and marked in accordance with WaterMark Licences, as required by the Plumbing Code of Australia.

The inherent flexibility and reliability of copper offers specifiers, designers, building owners, installers and occupiers significant benefits for an array of piping services which include plumbing, drainage, gas, refrigeration, air conditioning, fire services, air, steam and medical installations. Copper piping products are readily available with no embargo on intermixing of pipe and fitting brands. Small outside diameters offer space savings whilst copper's light weight and ductility assists installers. The impermeability of copper prevents the ingress of external substances. This characteristic, combined with copper's health benefits and compliance with AS/NZS 4020, ensure drinking water is suitable for human consumption. Copper's potential for 100% recycling contributes to a clean environment. Importantly, in addition to these attributes, copper systems are cost effective.

This edition of the Plumbers Handbook is issued with the expectation that recipients will use the information to complement design and installation skills for copper piping systems that have been developed over many years and played an essential role in Australia's development, and maintaining the health of its people.

The International Copper Association Australia recognizes the contribution of its members in the revision of this book and thanks its originator MM Kembla for the privilege of adopting it as a Copper Industry publication.

Contents

Tube Specification and Size Ranges

MATERIAL		
Copper	Phosphorus Deoxidised Copper, High Residual Phosphorus, Alloy C 12200 Copper tubes and fittings are suitable for the conveyance of a drinking water as they comply with Australian Standard AS/NZS 4020.	
Size Range	**Outside Diameter (mm)** 4.76mm up to and incl. 254.0mm **Thickness (mm)** 0.31 mm up to and incl. 3.25mm	
STANDARD LENGTHS		
Straight	All Diameters:	6 metres
Coils	Diameters up to and incl. 7.94mm: Diameters over 7.94mm and up to 31.75mm:	30 metres 18 metres

Standards Applicable to Copper and Alloy Tubes

STANDARDS AND DESCRIPTION	
AS 1432	Copper Tubes for Plumbing, Gasfitting and Drainage Applications
AS 1572	Copper and Copper Alloys - Seamless Tubes for Engineering Purposes
AS/NZS 1571	Copper - Seamless Tubes for Air Conditioning and Refrigeration
AS 1569	Copper and Copper Alloys - Seamless Tubes for Heat Exchangers
AS 3795	Copper Alloy Tubes for Plumbing and Drainage Applications
AS 3688	Water supply and gas systems - Metallic fittings and end connectors
AS 4809	Copper pipe and fittings- Installation and commissioning

Other Relevant Standards

STANDARD	DESCRIPTION
AS/NZS 3500	National plumbing and drainage
AS 2419.1	Fire hydrant installations - Systems design, installation and commissioning
AS 2441	Installation of fire hose reels
AS 2118.1	Automatic fire sprinkler systems
AS 2118.2	Wall-wetting sprinklers (Drenchers)
AS 2118.3	Deluge sprinkler systems
AS 2118.4	Residential sprinkler systems
AS 2118.5	Domestic sprinkler systems
AS 2118.6	Combined sprinkler and hydrant
AS 2118.9	Piping support and installation
AS 2118.10	Approval documentation
AS 4118.1	Fire sprinkler systems
AS 4118.2.1	Piping - General
AS/NZS 4645.1	Gas Distribution Networks
AS 5601	Gas Installation Code
AS 2896	Medical gas systems - Installation and testing of non-flammable medical gas pipeline systems
AS 4041	Pressure Piping
AS/NZS 4020	Testing of products for use in contact with drinking water
AS 5200	Procedures for certification of plumbing and drainage products
NCC	National Construction Code consisting of the BCA and PCA
BCA	Building Code of Australia (Volumes 1 & 2 of the NCC)
PCA	Plumbing Code of Australia (Volume 3 of the NCC)

Copper Tube Properties

Phosphorus Deoxidised Copper High Residual Phosphorus

ALLOY C12200

CHEMICAL COMPOSITION	
Copper:	99.90% minimum
Phosphorus:	0.015% -0.040%
TUBE SPECIFICATIONS	
Recommended:	AS 1432
Related:	AS/NZS 1569, 1571,1572, EN1057, ASTM B75, 88 JISH3300, NZS 3501
PHYSICAL PROPERTIES	
Melting Point:	1083°C
Density:	8.94×10^3 kg/m^3 at 20°C
Thermal Expansion Coefficient:	17.7×10^{-6} per° K
Thermal Conductivity:	305-355 W/(m.K)
Specific Heat Capacity:	0.385 kJ/kg.K
Electrical Conductivity (annealed):	75-90% I.A.C.S.
Electrical Resistivity (annealed):	0.0192-0.0230 μΩ.m at 20°C
Modulus of Elasticity:	117 GPa
Modulus of Rigidity:	44 GPa

JOINTING PROPERTIES		FABRICATION PROPERTIES	
Soldering:	Excellent	Cold work:	Excellent
Brazing:	Excellent	Hot work:	Excellent
Welding:		Hot work temp:	750°C - 875°C
oxyacetylene:	Good		
carbon arc:	Good using alloy filler rods	Annealing range:	450°C - 600°C
gas shield arc:	Good		
coated metal arc:	Good using alloy filler rods		
resistance spot:	Not recommended		
resistance butt:	Not recommended		

SUITABILITY FOR SURFACE FINISHING BY	
Polishing:	Excellent
Plating:	Excellent
Machining:	Machinability rating (20)

TYPICAL MECHANICAL PROPERTIES

Tube temper	Annealed	Bendable	Hard drawn
Hardness (HV/5)	70max	80 - 100	100min
Yield 0.2% proof (MPa)	70	220	350
Ultimate tensile (MPa)	220	280	380
Elongation (% on 50mm)	55	20	5

Standard Copper Plumbing Tube Details

In recognition of meeting the stringent quality assurance requirements of the Plumbing Code of Australia and Standards Australia, the Australian copper tube manufacturers hold product certificates for tubes manufactured to comply with AS 1432.

The manufacturers are proud to display the WaterMark on copper plumbing tubes.

COPPER TUBE IDENTIFICATION

Copper tubes, manufactured to meet the requirements of AS 1432, are incised at 0.5m intervals along the tube with the manufacturer's trademark, the Australian Standard number, nominal size and thickness type e.g.

Trademark AS 1432 DN 15B

In addition, "Hard drawn" and "Bendable" copper tubes to AS 1432 are colour coded, with either a legend in the designated colour for the particular thickness Type or, the legend in black and a separate distinguishing colour mark along the length. The legend includes the manufacturer's trademark, "Australia" the country of origin, the WaterMark, the Australian Standard Number, the Conformance Assessment Body Licence number, nominal size, and thickness type and "BQ" to identify Bendable temper tubes e.g.

Trademark AS 1432 LIC.XXX DN 15B BQ

Four colours are used to represent the tube specification types:

Type A - Green **Type B - Blue**
Type C - Red **Type D - Black**

Tables listing the nominal sizes for the 4 types of tube in AS 1432 are shown on pages 13 to 15 inclusive.

It is noted that copper tubes are made from the one alloy and are of similar quality. The word "TYPES" refers to the 4 thickness categories with Type "A" being the thickest and Type "D" being the thinnest tube permitted for use by water authorities.

Copper Tubes for Plumbing, Gasfitting and Drainage Applications to Australian Standard 1432 – 2004

TYPE A			
Nom. Size	**Actual Tube Size Metric (mm)**	**Actual Tube Size Imperial**	***Safe Working Pressure (kPa)**
DN6	6.35 x 0.91	1/4” x 20g	11,320
DN8	7.94 x 0.91	5/16” x 20g	8,810
DN10	9.52 x 1.02	3/8” x 19g	8,350
DN15	12.70 x 1.02	1/2” x 19g	6,100
DN18	15.88 x 1.22	5/8” x 18g	5,750
DN20	19.05 x 1.42	3/4” x 17g	5,560
DN25	25.40 x 1.63	1” x 16g	4,750
DN32	31.75 x 1.63	1¼” x 16g	3,750
DN40	38.10 x 1.63	1½”x 16g	3,100
DN50	50.80 x 1.63	2” x 16g	2,310
DN65	63.50 x 1.63	2½” x 16g	1,840
DN80	76.20 x 2.03	3” x 14g	1,900
DN90	88.90 x 2.03	3½” x 14g	1,630
DN100	101.60 x 2.03	4” x 14g	1,500
DN125	127.00 x 2.03	5" x 14g	1,200
DN150	152.40 x 2.64	6” x 12g	1,300
DN200	203.20 x 2.64	8” x 12g	910

**Applicable up to 50°C. For safe working pressures at other temperatures refer Page 23.*

Copper Tubes for Plumbing, Gasfitting and Drainage Applications to Australian Standard 1432 – 2004

TYPE B			
Nom. Size	**Actual Tube Size Metric (mm)**	**Actual Tube Size Imperial**	***Safe Working Pressure (kPa)**
DN6	6.35 x 0.71	¼" x 22g	8,560
DN8	7.94 x 0.71	5/16" x 22g	6,700
DN10	9.52 x 0.91	3/8" x 20g	7,220
DN15	12.70 x 0.91	½" x 20g	5,290
DN18	15.88 x 1.02	5/8" x 19g	4,810
DN20	19.05 x 1.02	3/4" x 19g	3,970
DN25	25.40 x 1.22	1" x 18g	3,500
DN32	31.75 x 1.22	1¼" x 18g	2,780
DN40	38.10 x 1.22	1½"x 18g	2,300
DN50	50.80 x 1.22	2" x 18g	1,710
DN65	63.50 x 1.22	2½" x 18g	1,370
DN80	76.20 x 1.63	3" x 16g	1,520
DN90	88.90 x 1.63	3½" x 16g	1,300
DN100	101.60 x 1.63	4" x 16g	1,200
DN125	127.00 x 1.63	5" x 16g	960
DN150	152.40 x 2.03	6" x 14g	1,000
DN200	203.20 x 2.03	8" x 14g	720

**Applicable up to 50°C. For safe working pressures at other temperatures refer Page 23.*

Copper Tubes for Plumbing, Gasfitting and Drainage Applications to Australian Standard 1432 – 2004

TYPE C			
Nom. Size	Actual Tube Size Metric (mm)	Actual Tube Size Imperial	*Safe Working Pressure (kPa)
DN10	9.52 x 0.71	3/8" x 22g	5,520
DN15	12.70 x 0.71	½" x 22g	4,070
DN18	15.88 x 0.91	5/8" x 20g	4,180
DN20	19.05 x 0.91	3/4" x 20g	3,450
DN25	25.40 x 0.91	1 " x 20g	2,560

TYPE D			
Nom. Size	Actual Tube Size Metric (mm)	Actual Tube Size Imperial	*Safe Working Pressure (kPa)
DN32	31.75 x 0.91	1¼" x 20g	2,040
DN40	38.10 x 0.91	1½" x 20g	1,690
DN50	50.80 x 0.91	2" x 20g	1,260
DN65	63.50 x 0.91	2½" x 20g	1,010
DN80	76.20 x 1.22	3" x 18g	1,130
DN90	88.90 x 1.22	3½" x 18g	970
DN100	101.60 x 1.22	4" x 18g	890
DN125	127.00 x 1.42	5" x 17g	830
DN150	152.40 x 1.63	6" x 16g	800

**Applicable up to 50°C. For safe working pressures at other temperatures refer Page 23.*

Bendable Temper Tubing

In certain circumstances it may be desirable to use a straight tube that has improved bending characteristics compared to normal hard drawn temper tube. To fill this need, a selected size range of 6m straight length copper tubes is available in bendable temper.

These particular tubes are capable of being bent, without local annealing, to minimum centreline radii of 45mm, 60mm and 85mm for nominal sizes DN15, DN18 and DN20 respectively.

Bendable temper tubes are coded with the letters “BQ” to distinguish them from normal hard drawn tubes.

E.g. Trademark AUSTRALIA AS 1432 LIC. XXX DN 15B BQ

AVAILABLE SIZES	
DN15A	12.70 x 1.02mm
DN15B	12.70 x 0.91mm
DN15C	12.70 x 0.71mm
DN18B	15.88 x 1.02mm
DN18C	15.88 x 0.91mm
DN20B	19.05 x 1.02mm
DN20C	19.05 x 0.91mm

LARGE DIAMETER COPPER TUBES

Occasionally large diameter tubes, which are not included in the AS 1432 range, are specified for special applications. The following sizes are projections of the AS 1432 tables. Safe working pressures have been included for temperatures up to 50°C.

TYPE	A		B		C	
Nom. Size	**Nom. WT (mm)**	**SWP (kPa)**	**Nom. WT (mm)**	**SWP (kPa)**	**Nom. WT (mm)**	**SWP (kPa)**
DN200	-	-	-	-	1.63	595
DN250	3.25	905	2.64	730	2.03	580

Pre-Insulated Copper Tube

A comprehensive range of pre-insulated tubes is available with plastic sheathing for use in a variety of end use applications e.g. short run domestic hot water lines, burying in corrosive soils, laying under floors and concrete slabs (where approved), chasing into walls and masonry, pipework exposed to aggressive environments. The impermeable, tough, waterproof and chemically inert green insulation is clearly marked with the manufacturer's trademark, AUSTRALIA (the country of manufacture), the copper tube size in mm, the Australian Standard, the WaterMark Licence Number, the tube nominal size and thickness type e.g. Trademark COPPER TUBE IS 12.7 x 1.02mm AS 1432 LIC. XXX DN 15A.

The DN15, DN18 and DN20 copper tubes are covered with a micro cellular grooved insulation to minimise heat loss. Straight lengths in this size range are Bendable Temper. In relation to heat efficiency, it is important to adhere to the requirements of AS/NZS 3500.

Plastic insulation will soften at elevated temperatures and the product should not be used for installations operating continuously at temperatures above 75°C.

When lines are to be exposed to aggressive and moist environments or buried, all joints must be wrapped or otherwise protected to ensure that the entire pipeline covering is water tight. Each end must also be made water tight.

Where tubes are to be used in sizes above DN20 for the conveyance of hot water, it may be necessary to provide additional thickness of insulation to achieve acceptable heat losses - see page 48. Purpose designed insulation should be used where heat loss is critical.

In localities subject to freezing conditions, additional insulation may be required to prevent water freezing in exposed pipelines - page 48. On its own, the plastic, on pre-insulated tubes, will not prevent water freezing.

The plastic insulation is resistant to ultraviolet radiation and the product can be installed in situations where the pipes are in direct sunlight. No piping must be placed in direct contact with metal roofs.

It is to be noted that lagging consisting of hair felt or other fibrous material should be used only in dry, well-ventilated places. The use of such lagging in damp or confined, poorly ventilated environments is not recommended.

Recycled Water Tubes

Due to the decreasing availability of traditional drinking water supplies, there are locations in Australia where wastewater is being collected, treated and then recycled through separate distribution pipes to properties. For the purpose of differentiation between drinking water pipes and those used for recycled water, copper tubes are supplied with purple coloured plastic coating. Tubes in the range DN 15 to DN 100 are produced for recycled water piping. In addition to the normal identification marks, and in accordance with the requirements of AS/NZS 3500, these tubes are clearly marked along the length as: “RECYCLED OR RECLAIMED WATER - DO NOT DRINK”.

LP Gas Pipelines For Vehicle Engines

Rigid copper fuel supply piping that is subject to container pressure shall be in accordance with AS 1432 or AS 1572.

A minimum nominal thickness of 0.91 mm applies to DN10 copper tube or smaller, whilst for larger sizes the minimum nominal thickness is to be no less than 1.02mm.

Pre-insulated tube is used for this application to satisfy the requirements of Australian Standard AS 1425: “LP gas fuel systems for vehicle engines” which specifies that piping is to be protected throughout its exposed length.

It is recommended that reference be made to AS1425 to identify specific installation practice requirements.

Copper Tube For Refrigeration

An extensive range of copper tube is manufactured specifically to cater for the special requirements of refrigeration gas lines. These tubes comply with the required internal cleanness limits specified in AS/NZS1571: Copper-seamless tubes for air-conditioning and refrigeration.

Tubes are factory cleaned and supplied sealed to maintain the cleanness of the bore under normal conditions of handling and storage.

Standard stock sizes of AS/NZS 1571 tube are incised at approx. 0.5m intervals with the manufacturer’s trademark, the Australian Standard number and thickness of tube e.g. Trademark AS/NZS 1571 0.91. Non-stock sizes may be available on request.

It is important to select tubes with working pressures that exceed the maximum design working pressure of the system being installed. To accommodate high pressure refrigerants such as R410A, a special range of tubes is available. The tubes are recognized by rose/pink colour caps and external markings “R410A”. These tubes are highlighted in bold type in the Tables on pages 20 & 21. It is noteworthy that for intermediate temperatures between 50°C and 65°C, pressure ratings can be interpolated from the values in the table.

The joint Australian/New Zealand Standard AS/NZS 1677.2 addresses safety, design, construction, installation, testing, inspection, operation and maintenance of refrigeration systems. Important considerations are:

- The refrigerant must be compatible with copper. Ammonia is not compatible with copper.
- Tubes must be able to withstand the maximum working pressure of the system, based on the maximum operating temperature.
- Precautions should be taken, at the design stage, to accommodate movement due to thermal cycles.
- Liquid hammer may produce pressures in excess of those anticipated at the design stage. Undesirable pressures could cause failure of piping. Hence they should be avoided.

Medical Gas Tubes

Copper tubes are widely used for medical gas installations. Only appropriately qualified personnel are to be involved in the design and installation of medical gas systems. The Standard applicable to this work is AS/NZS 2896. It addresses safety, construction, testing, operation and maintenance of non-flammable medical gas pipeline systems using common gases but not those with special mixtures. The internal cleanness of piping and components is critical to the effective performance of medical gas lines. Factory sealed AS/NZS 1571 copper pipe is specified.

As with refrigeration piping, it is important to select pipes suitable for the temperatures and pressures in the system.

For positive pressure lines, as-drawn temper AS/NZS 1571 copper pipe is required but the thickness must not be less than specified for AS 1432 Type B pipes of equivalent diameter. Copper is also suitable for suction lines.

Special precautions are required when making joints in medical gas piping. During all heating and brazing operations, to prevent formation of oxide and scale, piping is to be purged with protective gas in accordance with the procedures specified in AS/NZS 2896. A 15% silver-copper-phosphorus filler metal is to be used for all brazing.

Copper Refrigeration Tube Chart 1

AS/NZS 1571 Copper tube for air conditioning, refrigeration and mechanical services.

ACTUAL TUBE SIZE					COPPER TUBE SAFE WORKING PRESSURES (kPa)	
Imperial (inch)		Metric (mm)		Nominal Tube Mass (kg/6m)	Service Temperature Range	
Outside Diameter	Wall Thickness	Outside Diameter	Wall Thickness		Up to 50° C	Over 50°C up to 65°C
3/16	0.028	4.76	0.71	0.48	12715	11410
1/4	0.028	6.35	0.71	0.68	9175	8235
1/4	**0.032**	**6.35**	**0.81**	**0.76**	**10635**	**9545**
1/4	**0.036**	**6.35**	**0.91**	**0.83**	**12140**	**10900**
5/16	**0.032**	**7.94**	**0.81**	**0.97**	**8290**	**7440**
5/16	**0.036**	**7.94**	**0.91**	**1.08**	**9430**	**8465**
3/8	0.028	9.52	0.71	1.05	5900	5295
3/8	**0.032**	**9.52**	**0.81**	**1.19**	**6800**	**6105**
3/8	**0.036**	**9.52**	**0.91**	**1.32**	**7720**	**6930**
1/2	0.028	12.70	0.71	1.44	4345	3900
1/2	**0.032**	**12.70**	**0.81**	**1.62**	**4995**	**4480**
1/2	**0.036**	**12.70**	**0.91**	**1.81**	**5655**	**5075**
5/8	0.032	15.88	0.81	2.06	3945	3540
5/8	0.036	15.88	0.91	2.30	4460	4000
5/8	**0.040**	**15.88**	**1.02**	**2.56**	**5030**	**4515**
3/4	0.035	19.05	0.89	2.72	3600	3230
3/4	0.040	19.05	1.02	3.10	4150	3725
3/4	**0.045**	**19.05**	**1.14**	**3.44**	**4670**	**4190**
7/8	0.036	22.22	0.91	3.27	3140	2815
7/8	0.048	22.22	1.22	4.32	4265	3825
7/8	**0.055**	**22.22**	**1.40**	**4.91**	**4930**	**4425**
7/8	**0.064**	**22.22**	**1.63**	**5.66**	**5795**	**5205**
1	0.036	25.40	0.91	3.76	2730	2450
1	0.048	25.40	1.22	4.97	3705	3325
1	**0.064**	**25.40**	**1.63**	**6.53**	**5025**	**4510**
1 1/8	0.036	28.58	0.91	4.25	2420	2170
1 1/8	0.048	28.58	1.22	5.63	3275	2940
1 1/8	0.064	28.58	1.63	7.41	4435	3980

*The sizes in **bold type** are **R410A Compatible**.*

Copper Refrigeration Tube Chart 2

AS/NZS 1571 Copper tube for air conditioning, refrigeration and mechanical services.

ACTUAL TUBE SIZE					COPPER TUBE SAFE WORKING PRESSURES (kPa)	
Imperial (inch)		Metric (mm)		Nominal Tube Mass (kg/6m)	Service Temperature Range	
Outside Diameter	Wall Thickness	Outside Diameter	Wall Thickness		Up to 50° C	Over 50°C up to 65°C
1 1/8	**0.072**	**28.58**	**1.83**	**8.25**	**5015**	**4500**
1 1/4	0.036	31.75	0.91	4.73	2170	1950
1 1/4	0.048	31.75	1.22	6.28	2935	2635
1 1/4	**0.080**	**31.75**	**2.03**	**10.17**	**5005**	**4495**
1 3/8	0.036	34.92	0.91	5.22	1970	1770
1 3/8	0.048	34.92	1.22	6.93	2660	2390
1 3/8	**0.080**	**34.92**	**2.03**	**11.26**	**4525**	**4065**
1 1/2	0.048	38.10	1.22	7.59	2435	2185
1 1/2	**0.090**	**38.10**	**2.29**	**13.83**	**4690**	**4210**
1 5/8	0.036	41.28	0.91	6.19	1660	1490
1 5/8	0.048	41.28	1.22	8.24	2240	2010
1 5/8	**0.095**	**41.28**	**2.41**	**15.79**	**4550**	**4080**
2	0.048	50.80	1.22	10.20	1810	1625
2 1/8	0.036	53.98	0.91	8.14	1265	1135
2 1/8	0.048	53.98	1.22	10.85	1705	1530
2 1/8	0.064	53.98	1.63	14.39	2290	2055
2 5/8	0.048	66.68	1.22	13.46	1375	1230
2 5/8	0.064	66.68	1.63	17.88	1845	1655
2 5/8	0.080	66.68	2.03	22.13	2310	2075
3	0.064	76.20	1.63	20.49	1610	1445
4	0.064	101.60	1.63	27.47	1200	1080
4 1/8	0.110	104.78	2.79	47.98	2015	1805

*The sizes in **bold type** are **R410A Compatible**.*

Note: Safe working pressures have been based on tube minimum thickness and the annealed temper design tensile stress values specified in Australian Standard AS 4041 - “Pressure Piping”. The calculations allow for softening when tubes are brazed or heated. The test pressure for copper piping installations shall not exceed 1.5 times the safe working pressure of the copper tube. Tubes with increased wall thickness have been included in the table to address high working pressures associated with new generation refrigerants with different pressure requirements. Operating pressures for specific refrigerants should be obtained from refrigerant suppliers. When designing and installing refrigerant piping, reference should be made to current local regulations and the joint Australian/New Zealand Standard AS/NZS 1677 “Refrigerating Systems”.

Steam Lines

Lightweight, ductility, ease of installation and corrosion resistance are some of the attributes which make copper worthy of consideration for steam lines. When designing steam lines it is necessary to:

- Refer to the requirements of AS 4041
- Select tubes which will withstand the maximum operating pressures and temperatures of the system. Safe working pressures and temperatures for tubes are addressed on page 23.
- Avoid steam hammer which could produce undesirable pressure surges.
- Ensure provision is made to accommodate thermal expansion.
- Take precautions to eliminate vibration from the piping.
- Tubes should be no thinner than those specified in AS 1432 for Type B sizes.
- Copper tube may not be suitable when steam is contaminated with chemicals and where high velocities could be involved

SATURATED STEAM PRESSURES (ABSOLUTE)					
kPa	**°C**	**kPa**	**°C**	**kPa**	**°C**
10	45.8	90	96.7	800	170.4
20	60.1	100	99.6	900	175.4
30	69.1	200	120.2	1000	179.9
40	75.9	300	133.6	1100	184.1
50	81.3	400	143.6	1200	188.0
60	85.9	500	151.9	1300	191.6
70	90.0	600	158.8	1400	195.1
80	93.5	700	165.0	1500	198.3

Air Lines

Corrosion resistance and ease of installation make copper an attractive alternative to steel piping for air lines. In comparison to plastics, copper resists damage, will not burn or evolve toxic gases and offers maximum scope for modification with minimum interruption to the service.

At both the design and installation stages, attention should be given to selecting the appropriate tube for the maximum operating pressures and temperatures. Accommodation should be made for expansion, avoidance of vibration and hammer which might result from the operation of fast-acting solenoids.

Safe Working Pressure Calculations For Copper Tubes

The safe working pressures for copper tubes at temperatures up to 50°C are shown on pages 13 to 15. Values for elevated temperatures may be calculated by multiplying Psw figures at 50°C by the appropriate temperature factor, T. For sizes outside AS 1432, values for other tubes may be calculated by the following formula. Calculations are based on annealed tube to allow for softening at brazed joints.

$$P_{SW} = \frac{2000 \times S_D \times t_{min}}{D - t_{min}}$$

Where

P_{SW} = Safe Working Pressure (kPa)
t_{min} = minimum wall thickness (mm)
D = Outside Diameter (mm)
S_D = Maximum allowable design tensile stress for annealed tube (see below)
T = Temperature factor

Values for **S_D** for various temperature ranges were taken from AS 4041, Pressure Piping Code.

Design strengths at intermediate temperatures may be obtained by linear interpolation.

TEMPERATURE RANGE (°C)	MAXIMUM ALLOWABLE DESIGN TENSILE STRESS (S_D) (MPa)	T
up to 50	41	1.00
over 50-75	34	0.83
over 75-125	33	0.80
over 125-150	32	0.78
over 150-175	28	0.68
over 175-200	21	0.51

The testing pressures for copper plumbing installations should not exceed 1.5 times the safe working pressure.

Note: 1kPa = 0.145 psi
100kPa = 1 bar

AS1432 Copper Tubes Approximate Mass Per Length

AS1432 COPPER TUBES APPROXIMATE MASS PER LENGTH (kg) #							
Nom. Size	TYPE A		TYPE B		TYPE C		TYPE D
	Coils 18m	Straights 6m	Coils 18m	Straights 6m	Coils 18m	Straights 6m	Straights 6m
DN6	4.17*	0.83	-	0.68	-	-	-
DN8	5.39*	1.08	-	0.87	-	-	-
DN10	-	1.46	3.96	1.32	-	1.05	-
DN15	6.03	2.01	5.43	1.81	-	1.44	-
DN18	-	3.02	7.67	2.56	6.89	2.30	-
DN20	12.66	4.22	9.30	3.10	8.35	2.78	-
DN25	19.60	6.53	14.92	4.97	-	3.76	-
DN32	24.83	8.28	-	6.28	-	-	4.73
DN40	-	10.02	-	7.59	-	-	5.71
DN50	-	13.51	-	10.20	-	-	7.65
DN65	-	17.00	-	12.81	-	-	9.60
DN80	-	25.39	-	20.49	-	-	15.42
DN90	-	29.73	-	23.98	-	-	18.04
DN100	-	34.08	-	27.47	-	-	20.65
DN125	-	42.77	-	34.45	-	-	30.07
DN150	-	66.66	-	51.47	-	-	41.43
DN200	-	89.27	-	68.85	-	-	55.40†
DN250	-	137.40†	-	111.88†	-	-	86.24†

 # Based on maximum mean outside diameter and standard thickness.

** 30 metre length coil.*

† Projected AS 1432 large sizes – see page 16.

Tube Mass Calculation Formula

$$M = (OD - t) \times t \times Y$$

Where

M	=	Tube mass per metre (kg/metre)
OD	=	Outside diameter (mm)
t	=	Thickness (mm)
Y	=	Constant

MATERIAL CONSTANT – Y

Copper	0.0281
70/30 Brass	0.0268

Fitting Specification and Size Ranges

A full range of copper and copper alloy fittings is readily available for use in both pressure and non-pressure applications. Copper capillary pressure fittings, which are marked AS 3688, complement the safe working pressures of AS 1432 Type B copper tubes of similar nominal diameter.

In addition to capillary fittings, plumbers have a wide choice for making copper piping joints. The options include dezincification resistant (DR) copper alloy compression and non-pressure fittings as well as push-fit, press-fit and roll grooved fittings. All fittings comply with and are marked in accordance with relevant Australian Standards and certified to the WaterMark requirements.

SIZE RANGES CHART

TYPE	SPECIFICATION	COPPER	BRASS
Capillary fittings	AS 3688	DN 15-250	-
DN High pressure Bends, tees	AS 3688	DN 32-250	-
3D long radius bends	AS 3688	DN 15-250	-
Reducers	AS 3688	DN 15 x 10 250 x 200	DN 40 x 32 100 x 80
Roll grooved fittings	AS 3688	DN 50-DN 150	-
Compression fittings	AS 3688	-	DN 10-20
SWV fittings	AS 3517	DN 32-250	DN 32-100
Expansion joints	AS 3517	DN 32-150	DN 32-100
Traps, gullies & fittings	AS 1589	DN 32-100	DN 32-100
Pan collars	AS 1589	DN 100 & 100 x 80	DN 100 & 100 x 80
Press-fit fittings	AS 3688	DN15-100	-
Push-fit fittings	AS 3688	DN15-25	-

Standards Applicable to Copper and Copper Alloy Fittings

AS 1589 Copper and copper alloy waste fittings

AS 3517 Capillary fittings of copper and copper alloy for non pressure sanitary plumbing applications

AS 3688 Water Supply and Gas Systems – Metallic fittings and end connectors

MP 52 Manual of authorization procedures for plumbing and drainage products

Jointing Methods

Copper tubes can be easily joined using compression fittings, capillary fittings with either soft solders or silver brazing alloys, push-fit and press-fit fittings or by ‘fittingless’ plumbing techniques using silver brazing alloys.

When joining the ends of pipes of different diameters, a reduction fitting shall be used. It is unacceptable to crimp the larger tube and fill the cavity. In order to ensure high quality, leak proof joints are made, the following precautions should be taken:

COMPRESSION JOINTS

Compression fittings are available in various forms, i.e. olive, flared and croxed types. It is important:

> Tube ends should be square and de-burred.

> Flaring, swaging and croxing tools should be well maintained and free from scores or damage.

> Care must be taken to avoid twisting or distortion of tube by not over-tightening.

> Tube shall not be crimped or grooved.

SOFT SOLDERED CAPILLARY FITTINGS

> Soft soldered fittings are to be of the long engagement type complying with AS 3688.

> Tube ends must be square, de-burred and thoroughly cleaned.

> Flux should be applied uniformly around the tube surface and residues removed immediately the joint has cooled.

> Fluxes containing ammonium compounds, amines or its derivatives must not be used.

> Uniform heating should be applied to joints and overheating avoided.

> The joint should be made in such a way that globules of solder are not retained on the inside or outside surfaces of the tube.

> A solder containing not more than 0.1% lead must be used. Compositions of some suitable ‘lead-free’ soft solders are given below:

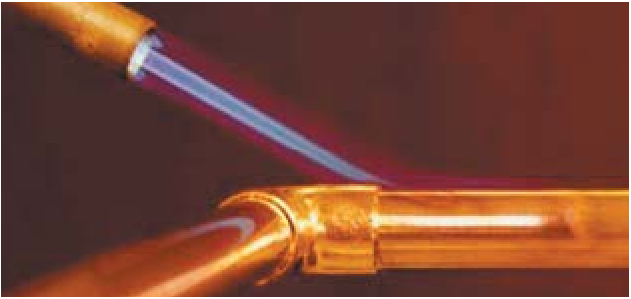
LEAD FREE SOFT SOLDERS			
% Tin	**% Silver**	**% Antimony**	**% Copper**
96.5	3.5	-	-
95	-	5	-
99	-	-	1
95.5	0.5	-	4

• Soft solders are not to be used with annealed coiled copper tube.

• The chemical composition of water in some areas may preclude the use of soft soldered joints. Check with the local Authority

SILVER BRAZED JOINTS

> Tube ends are to be square, de-burred and thoroughly clean.
> Fully engage the tube and fitting or expanded end of mating tube.
> Tube and joint are to be well supported.
> Apply heat in a uniform manner to the tube and joint area until bright red.
> Brush the filler metal rod into the shoulder of the fitting. It should melt on contact and flow by capillary action around the joint.
> Maintain a cherry red colour until joint penetration is complete.
> Avoid overheating and the formation of filler metal globules inside and outside the joint.
> When the joint is complete, either allow to cool in air or, if necessary, quench in water or with a damp cloth.
> The silver brazing filler metal must contain a minimum of 1.8% silver and maximum 0.05% cadmium.
> Flux is not necessary for copper-to-copper joints when a silver-phosphorus copper filler metal is used but must be used for brass fittings and pipes.
> When flux is used, it should be applied uniformly and sparingly.
> Residues must be removed immediately the joint has cooled.
> Flux should be non-aggressive and water soluble. It must not contain ammonium compounds, amines or its derivatives.
> In fabricated fittings, branches are not to penetrate main lines where flow conditions apply.
> During the brazing process, surrounding combustible structures must be protected from heat by using a heat shield.
> Filler rod ends should be disposed of thoughtfully.



COLOUR IDENTIFICATION OF SILVER BRAZING ALLOYS IN ACCORDANCE WITH AS1167

SILVER-COPPER-PHOSPHORUS ALLOYS FOR FLUX-FREE BRAZING OF COPPER			
Colour Identification	**Alloy Classification**	**Silver Content %**	**Melting Range °C**
Canary [Yellow]	B2	2	645-704
Silver	B3	5	645-740
Tan [Brown]	B4	15	645-700

SILVER-COPPER-ZINC ALLOYS [CADMIUM-FREE] FOR INTERMEDIATE TEMPERATURE BRAZING			
Colour Identification	**Alloy Classification**	**Silver Content %**	**Melting Range °C**
Pink	A3	50	688-744
Gold	A8	40 + 2% Ni	660-780

EXPANDED JOINTS

Tubes of the same diameter may be joined end-to-end by expanding the end of one length with a purpose-built expansion tool to form a socket into which the mating tube is inserted, prior to brazing.

When making expanded joints:

- Tube ends must be cut square and internal burrs removed.
- Prior to expansion, the tube ends should be softened [annealed] uniformly to a dull red colour using a heating torch, then cooled.
- Use only purpose-built expansion tools that have been maintained in good working order.

BRANCH FORMING

This practice reduces the need for fittings and the number of brazed joints. It is ideal for pre-fabrication, retrofit projects and where piping modifications are required during construction.

Hand and electric forming tools are available for rapid production of branches up to DN50. When using tools, follow the manufacturer's instructions. Tools may be available to make branches larger than DN50 or alternatively large branches for pressure piping and angled junctions in sanitary plumbing pipes may be manually formed by:

> Cutting an undersized oval hole in the main tube.
> For tee connections at 90°, the dimension of the larger diameter of the oval hole should be equal to the diameter of the branch tube less allowance for an overlap, which will form a collar not less than 4 times the main tube thickness, once the socket has been formed.
> With entries at 45° or greater, the diameter measurement is taken from the angular cut branch tube, making similar allowances for socket overlap.
> Heat the surface around the hole to a dull red colour and cool with a wet cloth.
> Insert a dressing pin into the oval hole then carefully and evenly form the socket to accept the branch tube. The pin can be manipulated by either hand or use of a mallet.
> If required, heat can be applied to soften metal around the hole during dressing out. Copper must not be over-heated past dull red, whereas brass is not to be worked in the 250°C -550°C range to avoid embrittlement.
> The inserted branch must not penetrate or obstruct the main pipe bore.
> Branch formed joints must be silver brazed.

ROLL GROOVED JOINTS

Roll-grooved joints have been in use since 1925. A roll-grooved system has been developed for Australian Standard DN50-DN150 copper tube diameters. Special copper tools are available to produce joints as are pre-grooved tees, elbows and reducing fittings.

When installing roll-grooved tube, refer to the special system installation instructions. Some precautions are:

> Cut the pipe square. It must be free from distortion and de-burred.
> Groove the pipe with the appropriate Australian copper grooving tool. Steel grooving roll sets must never be used.
> Ensure the gasket landing is smooth and clean.

> Measure the accuracy of the groove against the specification.
> Check pipe is not out of round.
> Apply lubricant to inside and outside of gasket.
> Slide gasket onto the end of one pipe.
> Bring pipe ends together and slide gasket into place between grooves.
> Undo one bolt on the coupling and place coupling over gasket.
> Make sure that the coupling sits squarely in the grooves.
> Tighten bolts.
> Only Australian size couplings are to be used.

Never disassemble joints unless they have been depressurized.

PUSH FIT JOINTS

Various types of push-on fittings are approved for copper piping. It is important when using such fittings that:

> The fitting manufacturer's installation instructions are followed.
> Tube ends are cut square and both the external and internal surface of tube ends are deburred to prevent damage of "O" rings.
> A tube cutter must be used to cut annealed temper (soft) tube
> Avoid flats and scratches on and near the engagement ends
> The depth of insertion is critical. Use a depth gauge.

Push fit fittings can be disassembled for reuse providing the appropriate tools are used and the fittings components are free from damage. These fittings can also be rotated for ease of alignment but care must be taken to fix the pipe work to the wall or studs.

> Unless stated to the contrary, this type of fitting is not for gas applications or compressed air. They are not to be used adjacent to solar heating panels or on piping with uncontrolled temperature in excess of 90°C.

PRESS-FIT JOINTS

Press-fit copper fittings offer an ultra-fast, efficient method of joining AS 1432 Type A and B copper piping. Assembled press-fit systems provide secure, permanent, non-detachable joints without the need for flame, glue or separate collars. The fittings maintain the full flow bore of piping. Significant time saving can be achieved by temporarily assembling all pipes and fittings in a layout. The pressing tool can then be used to seal all joints in an efficient manner by working from one end of the layout to the other. It is important to note that fittings for water applications are colour coded green whilst those for gas piping are coded yellow. Refer to pages 32 and 33 for more detailed information.

Copper Press-Fit fittings

Copper Press-fit systems are a relatively new mechanical cold jointing system in Australia using specially constructed fittings designed to form joints by compressing a fitting onto copper tube using hydraulic press tools.

An extensive range of DN15-100 size press-fittings are now available in Australia manufactured in accordance with Australian Standard AS 3688 and AS 4020, Watermark certified and suitable for use with hard, half hard and annealed copper tube to Australian Standard AS 1432 Type A & B tube. A range of special light weight press tools are also available with jaw profiles specifically designed for pressing AS 3688 press-fittings.

DN15-50 sized fittings generally contain an elastomeric O-ring sealing element, and DN65-100 sized fittings can also contain a metal gripping ring to assist in creating a tight connection. The sealing elements protect the joint's integrity, reinforcing it to guarantee the seal is secure and leak-tight. Most fittings are suitable for pressures up to 1600 kPa.

Different fittings are available for use in Water, Gas and High Temperature applications. The O-ring sealing element material differs for each of these applications and is generally identified by O-ring colour, product markings or packaging. The O-ring material used is generally as follows:

- Water – EPDM (Black O-ring)
- Gas – HNBR (Yellow O-ring)
- High Temperature – FKM (Red O-ring)

Due to the O-ring material used, Gas and Water fittings are not interchangeable. Gas fittings contain O-rings designed for gas, oil and chemical resistance that is not suitable for use in drinking or potable water.

For suitability of a fitting for particular applications or mediums, or compatibility with a press tool, contact the fittings supplier or manufacturer for details.

There are numerous benefits to using copper press-fit systems over traditional joining methods:

- Considerably faster installation time than brazing
- Easier joining method than brazing
- No need to drain water out of the system during installation
- No flame is present for use in areas where flames are not permitted
- Not hot work permits required

Installation should always be in accordance with relevant installation standards as well as product installation instructions.

PRESS-FIT – PERFECTING YOUR PRESS INSTALLATION INSTRUCTIONS

ACTION	WHY?
1. Deburr the inside and outside of all tube.	This is critical for press fitting connections, as any burrs on the tube can damage the O-ring and cause failure of your connection. It also minimises turbulence and pressure loss.
2. Mark the insertion depth on your tube by lining up the fitting side by side with the tube. When the fitting is inserted onto the tube, the outer edge of the fitting must line up with the marking.	Correct insertion depths are fundamental to a perfect press. Incorrectly inserted tube can lead to failure of your connection.
3. Ensure you have the correct fitting for the application. Do not swap O-rings between fittings	Not all O-rings are suitable for all applications, choosing the correct fitting is critical to the integrity of your press connection. Refer to product literature or contact your supplier for application suitability. Swapping O-rings can increase the risk of damaging the O-ring and may also void product warranties.
4. Ensure O-rings are present and in good condition.	Missing or damaged O-rings will lead to a failed connection. The O-ring is integral to a complete press connection.
5. Ensure the inside press jaw profile is free of debris, excessive grease or damage. Jaws should be cleaned after every use.	Any debris, grease or damage on a jaws inside profile can lead to damage to the fitting upon pressing.
6. When closing the press jaw onto the fitting, ensure the jaw is straight and the raised bump in the fitting rests inside the grooved profile of the jaw.	A misalignment of the jaw and fitting can lead to a failed press connection. Jaw and fitting should always be aligned prior to activating the press.
7. Visually inspect all fittings to ensure the press has been completed.	An incomplete press will lead to a leak in your connection. Pressed fittings will display indents on the fitting and no gap between the fitting and tube.

Accessories

A vast range of copper and copper alloy plumbing assemblies and accessories, is available for completion of copper piping systems. The products include:

- > Combinations & Breeching Pieces
- > Prefabricated Assemblies
- > Annealed & Chrome Plated Copper
- > Tube
- > Bathroom Accessories
- > Exposed Combinations
- > Laundry Arms
- > Pipe Clips & Saddles
- > Recess Combinations
- > Recess Tees
- > Shower Arms
- > Spouts
- > Water Meter Assemblies
- > Assemblies tapped for water saving devices
- > Washing Machine Combinations & Adaptors
- > Fire Sprinkler Droppers

Corrosion Protection Systems for Pipe and Fittings

Under most normal operating conditions, copper and brass tubes will resist serious corrosion – see pages 70 & 71 for corrosion information. However, special precautions need to be taken to protect pipelines that will be buried in aggressive soils and those exposed to corrosive atmospheres. Petrolatum coatings can be used for the protection of:

> Either bare piping or bends and joints in pre-insulated lines

> Complete unprotected pipelines

Petrolatum tape is a non woven bonded synthetic fabric, fully impregnated and coated with neutral petrolatum based compounds and inert fillers. Petrolatum tape is chemically inert and does not polymerise or oxidise and therefore retains its water resistance and dielectric properties over an indefinite period.

Prior to the application of the tape, the surface should be cleaned and coated with petrolatum priming paste. This primer is used to displace surface moisture to passivate surface oxides and to fill small irregularities.

A petrolatum mastic compound is available to improve the contour of flanges, bolts, valves and other irregular shapes prior to applying tape. While applying petrolatum tape, smooth the tape surface by hand to eliminate air bubbles and to ensure intimate contact and lap seals.

COVERAGE ESTIMATES / 100M			
Pipe Diameter	**Petrolatum Priming Paste (kg)**	**Petrolatum Tape (rolls)***	**Recommended Tape Width (mm)**
DN20	1.7	40	50
DN25	2.1	50	50
DN32	2.7	42	75
DN40	3.0	47	75
DN50	3.8	59	75
DN80	5.6	65	100
DN100	7.2	84	100
DN150	10.6	83	150
DN200	13.8	107	150

**Allowance for 55% overlap*

Note: An overlap of 55% is generally recommended, however a minimum 20mm overlap may be used on pipes DN150 and larger.

Water Supply Piping Design

Copper tube is renowned for its satisfactory performance in plumbing systems. However, when occasional problems have occurred, subsequent investigations revealed that, in general, failures were either associated with system design or an aggressive operating environment. At the design stage, all aspects of the piping system's internal and external service conditions must be considered if failures are to be avoided.

WATER COMPOSITION

Long term performance of copper water pipes is dependent on the establishment of a natural, protective, internal surface film. The quality of some waters may preclude the development of protective films. Untreated waters where transient conditions exist, and those with no buffering capacity, are both potential contributors to the non-development or degradation of desirable internal films in copper pipes.

Low pH of water, less than 7, can contribute to the internal deterioration of water mains and service pipes. Linings on cement-lined mains may be attacked and calcium carbonate can be deposited on copper piping, initiating corrosion cells. The potential for cuprosolvency increases as water pH decreases below 7. In acidic water, there is likelihood of small traces of copper dissolving into the water.

Elevated pH water is now also suspected of being a contributor to blue water due to microbiological activity. In the Australian Drinking Water guidelines, it is stated that, "New concrete tanks and cement-mortar lined pipes can significantly increase pH….". The effectiveness of some chlorination treatments may be diminished in high pH waters and result in deterioration of the waters microbiological quality.

In AS 4809, the Copper Pipe Installation and Commissioning Standard, it is stated: "The service life of copper pipe installations may be compromised if used to convey water that falls outside the range nominated by the Australian Drinking Water Guidelines (ADWG) particularly in terms of pH, alkalinity, chloride, sulphate and residual disinfectant".

The composition of untreated supplies and bore waters should be examined to ensure compatibility with copper prior to installation of piping. Untreated tank water may not be compatible with copper due to the lack of stability and potential microbiological variability.

Note: Guidance on the types, causes and control measures of internal corrosion of copper pipes in drinking water is given in the **Hydraulic Services Design Guide** - Chapter 6, available for free download at www.copper.com.au

ANTIMICROBIAL BENEFITS OF COPPER

A study by KIWA, the Dutch water quality research institute, has shown that using copper pipes reduces the growth and proliferation of the bacterium responsible for Legionnaire's disease.

The study simulated the domestic use of different hot water distribution systems for just under a year and analysed the proliferation of Legionella pneumophila, responsible for 90% of cases of Legionnaire's disease.

The experiments showed that the Legionella concentration in water conveyed by copper pipes was 10 times less than the level for cross-linked polyethylene pipes (PEX).

Copper's bacteriostatic and mechanical properties explain why it is used in many current applications, from piping, coins, door handles, cooking utensils and medical equipment.

Other recent studies carried out by different microbiology research centres have also shed light on copper's positive role in combating Listeria, E.coli 0151 and staphylococci – three other highly pathogenic bacteria.

The results of the KIWA study were published in the Netherlands in the May and June 2003 issues of the Journal Intech and in the 30 May issue of the Journal H2O.

WATER MAINS

It is important to examine the layout and condition of the water mains which will service the building. Properties with extensive distribution systems should not be connected to the end of a large water main as accumulated sedimentary matter may settle on pipes and develop into corrosion cells. Ring mains are essential. In situations where there is a low draw off rate from the mains a flushing facility may be necessary.

DEAD LEGS

All pipe systems should be free from sections in which potable water may remain stagnant for long periods. Particular attention must be given to pipeline design in laboratories, the location of drinking fountains, domestic bar sink taps, en-suites, ice making machines etc. Where possible, such fixtures should be connected with short lengths to main flow lines or, if such is impractical, be connected close to downstream regularly used water services.

Pipe Sizing

Pipe sizing is critical. Pipes must not be oversized as low velocities, less than 0.5m/sec, may allow undesirable suspended solids in the water to deposit on pipes. Excessive velocities will cause turbulence and may destroy protective films.

All piping should be accurately sized to ensure acceptable flow rates to fixtures and appliances without exceeding maximum velocity limits. Information required for sizing calculations include:

1. Minimum and maximum pressure available at the main.
2. Minimum and maximum pressure requirements for outlets to fixtures and appliances.
3. AS/NZS 3500.1 specifies a minimum pressure of 50kPa at the most disadvantaged fixture and a maximum static pressure of 500kPa at any outlet.
4. Head losses through tubes and fittings.
5. Static head losses.
6. Accurate pipe sizing may require full hydraulic calculations.

More information on this subject is contained in the following publications:

1. AS/NZS 3500 - Australian National Plumbing and Drainage Part 1 - Water Supply: available from Standards Australia
2. Selection and Sizing of Copper Tubes for Water Piping Systems: available from the Institute of Plumbing Australia.
3. Pipe Sizing for Building Services by Paul Funnell.

Flow Rates at Fixtures or Appliances

The flow rates from taps, valves and to cisterns should not be less than the values given below:

FIXTURE / APPLIANCE	FLOW RATE (L/s)
Water Closet	0.10
Bath	0.30
Basin	0.10
Spray Tap	0.03
Shower	0.10
Sink (standard tap)	0.12
Sink (aerated tap)	0.10
Laundry Tub	0.12
Washing Machine	0.20
Hot Water System	0.20
Hose Tap (DN20)	0.30
Hose Tap (DN15)	0.20

Recommended Water Velocities

SECTION OF WATER SERVICE INSTALLATION	ACCEPTABLE VELOCITY (M/S)
1. Pipelines at mains pressure	1.0 to 3.0
2. Pipelines from storage tanks serving: - the next two floors - below the next two floors	 0.1 to 0.5 1.0 to 1.5
3. Pipelines (pumped supply): - suction pipelines - delivery pipelines	 1.2 to 2.0 1.5 to 3.0
4. Pipelines for Recirculated Heated Water	0.5 to 1.2

Exclusive of fire services, the recommended maximum water velocity in piping shall be 3 m/s.

These velocities relate to acceptable sound levels of moving water containing entrained air and the minimization of the effects of erosion. Erosion in water tubing results from the impingement of rapidly moving water, sometimes containing air bubbles or suspended solids, and can result in the complete penetration of the tube wall. The problem of impingement is more noticeable at sharp changes in direction (bends, tees) where localised turbulence can lead to high water velocities.

Irregularities in the pipe bore due to dents, misalignment, distortion at bends, solder globules, etc, can lead to erosion damage downstream.

Pressure Loss and Flow Data for Copper Pipes and Fittings Calculation Formulae

The following formulae may be used in conjunction with the table on page 41.

CAPACITY

How many litres of water in 65 metres of DN80A tube.

CAPACITY (C) = L x N

L = tube length in metres
N = calculation factor for DN80A

$$\mathbf{C} = \mathbf{L \times N}$$
$$= 65 \times 4.087$$
$$= 265.7 \text{ litres}$$

To determine the overall mass of a pipe filled with water, add the appropriate value from the table on page 24.

VELOCITY

Determine the velocity of water in a DN20B tube with 0.25 litres/sec flow rate.

VELOCITY (V) = $\mathbf{\frac{Q}{N}}$

Q = Flow rate in litres/sec.
N = Calculation factor for DN20B

$$\mathbf{V} = \mathbf{\frac{Q}{N}} = \mathbf{\frac{0.25}{0.227}}$$
$$= 1.10 \text{ metres / sec}$$

FLOWRATE

Calculate the flow rate in a DN15B tube with 1.5 metre/sec water flowing.

FLOWRATE (Q) = V x N

V = velocity in metres/sec.
N = calculation factor for DN15B

$$\mathbf{Q} = \mathbf{V \times N}$$
$$= 1.5 \times 0.093$$
$$= 0.14 \text{ litres/sec}$$

FRICTION LOSS

Find the friction loss in a DN100B tube with water at 15°C flowing at 18 litres/sec.

FRICTION LOSS (H) = $\mathbf{F_{15} \times Q^{1.8}}$

$\mathbf{F_{15}}$ = calculation factor for DN100B at 15°C.

Q = flow rate in litre/sec

$$\mathbf{H} = \mathbf{F_{15}} \times \mathbf{Q^{1.8}}$$
$$= 0.0268 \times 181.8$$
$$= 4.87 \text{ metres/100 metres}$$

Note: 1kPa = 0.102 metres head

$$\therefore \text{ Pressure loss } = \frac{4.87}{0.102}$$
$$= 47.7 \text{ kPa/100m}$$

ALLOWANCE FOR FITTINGS

Losses associated with fittings can be determined by using the Equivalent Length of Tube Method. Equivalent length values for some fittings are shown in the Fittings Loss Factors Table on page 42.

The values in the Table were taken from "Pipe Sizing for Building Services" by Paul Funnell.

Water Flow Rates

CALCULATION FACTORS FOR WATER FLOW RATES IN AS1432 COPPER TUBE						
Type	Nom. Size D N	CALCULATION FACTORS				
		N (Capacity) L/M	CONSTANTS FOR FRICTION LOSS BASED ON WATER TEMPERATURE			
			F at 4°C	F at 15°C	F at 60°C	F at 82°C
Type A	6	0.016	73970	69390	58230	55000
	8	0.029	17460	16380	13740	12980
	10	0.044	6660	6250	5245	4955
	15	0.089	1215	1140	958	905
	18	0.142	400	375	315	297
	20	0.206	162.7	152.6	128.1	121
	25	0.385	36.43	34.18	28.68	27.09
	32	0.637	10.86	10.19	8.549	8.074
	40	0.953	4.134	3.8723	3.254	3.074
	50	1.775	0.9299	0.8723	0.7321	0.6914
	65	2.850	0.2985	0.2800	0.2350	0.2219
	80	4.087	0.1256	0.1178	0.09890	0.09341
	90	5.653	0.05768	0.05411	0.04541	0.04289
	100	7.472	0.02953	0.02770	0.02325	0.02196
	125	11.871	0.009723	0.009121	0.007654	0.007229
	150	16.999	0.004107	0.003853	0.003233	0.003054
	200	30.766	0.000989	0.000928	0.000778	0.000736
Type B	6	0.019	49280	46230	38795	36640
	8	0.033	12880	12085	10140	9575
	10	0.047	5797	5438	4563	4310
	15	0.093	1103	1035	868	820
	18	0.150	347.4	325.9	273.5	258.3
	20	0.227	129.1	121.1	101.6	95.99
	25	0.414	30.6	28.7	24.1	22.7
	32	0.675	9.48	8.89	7.46	7.05
	40	0.999	3.7	3.47	2.91	2.75
	50	1.837	0.857	0.804	0.674	0.637
	65	2.928	0.28	0.262	0.22	0.208
	80	4.179	0.119	0.112	0.0938	0.0888
	90	5.760	0.0551	0.0517	0.0434	0.041
	100	7.595	0.0284	0.0268	0.0224	0.0211
	125	12.026	0.00942	0.00884	0.00742	0.00701
	150	17.283	0.00395	0.0037	0.00311	0.00293
	200	31.146	0.00096	0.0009	0.00076	0.000714
Type C	10	0.052	4546	4264	3579	3380
	15	0.100	927	870	730	690
	18	0.155	322	302	254	240
	20	0.233	121	114	95.6	90.3
	25	0.437	26.9	25.3	21.2	20.0
Type D	32	0.704	8.57	8.04	6.75	6.37
	40	1.034	3.40	3.19	2.68	2.53
	50	1.884	0.806	0.756	0.634	0.599
	65	2.988	0.268	0.25	0.211	0.198
	80	4.273	0.113	0.106	0.0889	0.084
	90	5.871	0.0527	0.0494	0.0415	0.0392
	100	7.723	0.0273	0.0256	0.0215	0.0203
	125	12.107	0.00927	0.0087	0.0073	0.0069
	150	17.469	0.00385	0.00361	0.00303	0.00286

Fitting Loss Factors

FITTING TYPE	DIAMETER									
	DN150	DN20	DN25	DN32	DN40	DN50	DN65	DN80	DN100	DN150
	EQUIVALENT LENGTHS (m)									
ELBOW	0.50	1.08	1.40	1.80	2.20	2.90	3.50	4.50	6.00	8.50
BEND 90° Long Radius	0.22	0.48	0.62	0.79	0.97	1.28	1.54	1.98	2.64	3.74
TEES Branch	0.91	2.25	2.65	3.00	3.30	4.00	4.30	4.95	6.60	9.35
TEES Flow	0.55	1.35	1.59	1.80	1.98	2.40	2.58	2.97	3.96	5.61
REDUCERS	0.40	0.51	0.66	0.85	1.03	1.36	1.65	2.12	2.85	4.00

Pressure Loss Factors for Type B Copper Tubes

FLOW RATE L/s	TUBE SIZE DN10B			TUBE SIZE DN15B			TUBE SIZE DN18B		
	VELOCITY m/s	HEAD LOSS		VELOCITY m/s	HEAD LOSS		VELOCITY m/s	HEAD LOSS	
		15°C kPa/m	60°C kPa/m		15°C kPa/m	60°C kPa/m		15°C kPa/m	60°C kPa/m
0.05	1.06	2.43	2.04	0.54	.046	0.39	0.33	0.15	0.12
0.06	1.28	3.37	2.83	0.65	0.64	0.54	0.40	0.20	0.17
0.07	1.49	4.45	3.73	0.75	0.85	0.71	0.47	0.27	0.22
0.08	1.70	5.65	4.74	0.86	1.08	0.90	0.53	0.34	0.28
0.09	1.91	6.99	5.87	0.97	1.33	1.12	0.60	0.42	0.35
0.10	2.13	8.45	7.09	1.08	1.61	1.35	0.67	0.51	0.42
0.12	2.55	11.73	9.84	1.29	2.23	1.87	0.80	0.70	0.59
0.14	2.98	15.48	12.99	1.51	2.95	2.47	0.93	0.93	0.78
0.16	-	-	-	1.72	3.75	3.14	1.07	1.18	0.99
0.18	-	-	-	1.94	4.63	3.89	1.20	1.46	1.22
0.20	-	-	-	2.15	5.60	4.70	1.33	1.76	1.48
0.22	-	-	-	2.37	6.65	5.58	1.47	2.09	1.76
0.24	-	-	-	2.58	7.78	6.52	1.60	2.45	2.05
0.26	-	-	-	2.80	8.89	7.53	1.73	2.83	2.37
0.28	-	-	-	3.01	10.26	8.61	1.87	3.23	2.71
0.30	-	-	-	-	-	-	2.00	3.66	3.07
0.32	-	-	-	-	-	-	2.13	4.11	3.45
0.34	-	-	-	-	-	-	2.27	4.58	3.85
0.36	-	-	-	-	-	-	2.40	5.08	4.26
0.38	-	-	-	-	-	-	2.53	5.60	4.70
0.40	-	-	-	-	-	-	2.67	6.14	5.15
0.42	-	-	-	-	-	-	2.80	6.70	5.63
0.44	-	-	-	-	-	-	2.93	7.29	6.12
0.46	-	-	-	-	-	-	3.07	7.90	6.63

FLOW RATE L/s	TUBE SIZE DN20			TUBE SIZE DN25			TUBE SIZE DN32		
	VELOCITY m/s	HEAD LOSS		VELOCITY m/s	HEAD LOSS		VELOCITY m/s	HEAD LOSS	
		15°C kPa/m	60°C kPa/m		15°C kPa/m	60°C kPa/m		15°C kPa/m	60°C kPa/m
0.10	0.44	0.19	0.16	0.24	0.04	0.04	-	-	-
0.15	0.66	0.39	0.33	0.36	0.09	0.08	0.22	0.03	0.02
0.20	0.88	0.66	0.55	0.48	0.16	0.13	0.30	0.05	0.04
0.25	1.10	0.98	0.82	0.60	0.23	0.19	0.37	0.07	0.06
0.30	1.32	1.36	1.14	0.72	0.32	0.27	0.44	0.10	0.08
0.35	1.54	1.79	1.51	0.85	0.43	0.36	0.52	0.13	0.11
0.40	1.76	2.28	1.91	0.97	0.54	0.45	0.59	0.17	0.14
0.45	1.98	2.82	2.37	1.09	0.67	0.56	0.67	0.21	0.17
0.50	2.20	3.41	2.86	1.21	0.81	0.67	0.74	0.25	0.21
0.55	2.42	4.05	3.40	1.33	0.96	0.79	0.81	0.30	0.25
0.60	2.64	4.73	3.97	1.45	1.12	0.93	0.89	0.35	0.29
0.65	2.86	5.47	4.59	1.57	1.30	1.07	0.96	0.40	0.34
0.70	3.08	6.25	5.24	1.69	1.48	1.24	1.04	0.46	0.38
0.75	-	-	-	1.81	1.68	1.41	1.11	0.52	0.44
0.80	-	-	-	1.93	1.88	1.56	1.19	0.58	0.49
0.85	-	-	-	2.05	2.10	1.76	1.26	0.65	0.55
0.90	-	-	-	2.17	2.33	1.95	1.33	0.72	0.61
0.95	-	-	-	2.29	2.57	2.15	1.41	0.79	0.67
1.00	-	-	-	2.42	2.81	2.36	1.48	0.87	0.73
1.20	-	-	-	2.90	3.91	3.28	1.78	1.21	1.02
1.40	-	-	-	-	-	-	2.07	1.60	1.34
1.60	-	-	-	-	-	-	2.37	2.03	1.70
1.80	-	-	-	-	-	-	2.67	2.51	2.11
2.00	-	-	-	-	-	-	2.96	3.04	2.55

Pressure Loss Factors for Type B Copper Tubes

FLOW RATE L/s	TUBE SIZE DN40			TUBE SIZE DN50			TUBE SIZE DN65		
	VELOCITY m/s	HEAD LOSS		VELOCITY m/s	HEAD LOSS		VELOCITY m/s	HEAD LOSS	
		15°C kPa/m	60°C kPa/m		15°C kPa/m	60°C kPa/m		15°C kPa/m	60°C kPa/m
0.2	0.20	0.06	0.02	-	-	-	-	-	-
0.4	0.40	0.07	0.05	-	-	-	-	-	-
0.6	0.60	0.14	0.11	0.33	0.03	0.03	-	-	-
0.8	0.80	0.23	0.19	0.44	0.05	0.04	-	-	-
1.0	1.00	0.34	0.29	0.54	0.08	0.07	0.34	0.03	0.02
1.2	1.20	0.47	0.40	0.65	0.11	0.09	0.41	0.04	0.03
1.4	1.40	0.62	0.52	0.76	0.14	0.12	0.48	0.05	0.04
1.6	1.60	0.79	0.66	0.87	0.18	0.15	0.55	0.06	0.05
1.8	1.80	0.98	0.82	0.98	0.23	0.18	0.61	0.07	0.06
2.0	2.00	1.18	0.99	1.09	0.27	0.23	0.68	0.09	0.08
2.2	2.20	1.41	1.18	1.20	0.33	0.27	0.75	0.11	0.09
2.4	2.40	1.64	1.38	1.31	0.38	0.32	0.82	0.12	0.10
2.6	2.60	1.90	1.59	1.42	0.44	0.37	0.89	0.14	0.12
2.8	2.80	2.17	1.82	1.52	0.50	0.42	0.96	0.16	0.14
3.0	3.00	2.46	2.06	1.63	0.56	0.48	1.02	0.19	0.16
3.5	-	-	-	1.91	0.75	0.63	1.20	0.24	0.21
4.0	-	-	-	2.18	0.96	0.80	1.37	0.31	0.26
4.5	-	-	-	2.45	1.18	0.99	1.54	0.39	0.32
5.0	-	-	-	2.72	1.43	1.20	1.71	0.47	0.39
5.5	-	-	-	2.99	1.70	1.42	1.88	0.55	0.46
6.0	-	-	-	-	-	-	2.05	0.65	0.54
6.5	-	-	-	-	-	-	2.22	0.75	0.63
7.0	-	-	-	-	-	-	2.39	0.85	0.72
7.5	-	-	-	-	-	-	2.56	0.97	0.81
8.0	-	-	-	-	-	-	2.73	1.09	0.91
8.5	-	-	-	-	-	-	2.90	1.21	1.02

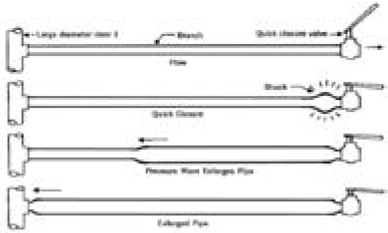
FLOW RATE L/s	TUBE SIZE DN80			TUBE SIZE DN90			TUBE SIZE DN100		
	VELOCITY m/s	HEAD LOSS		VELOCITY m/s	HEAD LOSS		VELOCITY m/s	HEAD LOSS	
		15°C kPa/m	60°C kPa/m		15°C kPa/m	60°C kPa/m		15°C kPa/m	60°C kPa/m
1.0	0.24	0.01	0.01	-	-	-	-	-	-
2.0	0.48	0.04	0.03	0.35	0.02	0.01	-	-	-
3.0	0.72	0.08	0.07	0.52	0.04	0.03	0.39	0.02	0.02
4.0	0.96	0.13	0.11	0.69	0.06	0.05	0.53	0.03	0.03
5.0	1.20	0.20	0.17	0.89	0.09	0.08	0.66	0.05	0.04
6.0	1.44	0.28	0.23	1.04	0.13	0.11	0.79	0.07	0.05
7.0	1.68	0.36	0.31	1.22	0.17	0.14	0.92	0.09	0.07
8.0	1.91	0.46	0.39	1.39	0.21	0.18	1.05	0.11	0.09
9.0	2.15	0.57	0.48	1.56	0.26	0.22	1.18	0.14	0.11
10.0	2.39	0.69	0.58	1.74	0.32	0.27	1.32	0.17	0.14
11.0	2.63	0.82	0.69	1.91	0.38	0.32	1.45	0.20	0.16
12.0	2.87	0.96	0.81	2.08	0.44	0.37	1.58	0.23	0.19
13.0	3.11	1.21	0.93	2.26	0.51	0.43	1.71	0.27	0.22
14.0	-	-	-	2.43	0.59	0.49	1.84	0.30	0.25
15.0	-	-	-	2.60	0.66	0.56	1.97	0.34	0.29
16.0	-	-	-	2.78	0.75	0.62	2.11	0.39	0.32
17.0	-	-	-	2.95	0.83	0.70	2.34	0.43	0.36
18.0	-	-	-	-	-	-	2.37	0.48	0.43
19.0	-	-	-	-	-	-	2.50	0.53	0.44
20.0	-	-	-	-	-	-	2.63	0.58	0.48
20.5	-	-	-	-	-	-	2.70	0.60	0.50
21.0	-	-	-	-	-	-	2.76	0.63	0.53
21.5	-	-	-	-	-	-	2.83	0.66	0.56
22.0	-	-	-	-	-	-	2.90	0.69	0.57
22.0	-	-	-	-	-	-	2.96	0.71	0.60
23.0	-	-	-	-	-	-	3.03	0.74	0.62

Pressure Loss Factors for Type B Copper Tubes

FLOW RATE L/s	TUBE SIZE DN125			TUBE SIZE DN150			TUBE SIZE DN200		
	VELOCITY m/s	HEAD LOSS		VELOCITY m/s	HEAD LOSS		VELOCITY m/s	HEAD LOSS	
		15°C kPa/m	60°C kPa/m		15°C kPa/m	60°C kPa/m		15°C kPa/m	60°C kPa/m
5.0	0.42	0.02	0.01	-	-	-	-	-	-
7.5	0.62	0.03	0.03	-	-	-	-	-	-
10.0	0.83	0.05	0.05	0.58	0.02	0.02	-	-	-
12.5	1.04	0.08	0.07	0.72	0.03	0.03	-	-	-
15.0	1.25	0.11	0.10	0.87	0.05	0.04	0.48	0.01	0.01
17.5	1.46	0.15	0.13	1.01	0.06	0.05	0.56	0.02	0.01
20.0	1.66	0.19	0.16	1.16	0.08	0.07	0.64	0.02	0.02
22.5	1.87	0.24	0.20	1.30	0.10	0.08	0.72	0.02	0.02
25.0	2.08	0.28	0.24	1.45	0.12	0.10	0.80	0.03	0.02
27.5	2.29	0.34	0.28	1.59	0.14	0.12	0.88	0.03	0.03
30.0	2.49	0.40	0.33	1.74	0.17	0.14	0.96	0.04	0.03
32.5	2.70	0.46	0.38	1.88	0.19	0.16	1.04	0.05	0.04
35.0	2.91	0.52	0.44	2.03	0.22	0.18	1.12	0.05	0.04
37.5	3.12	0.59	0.50	2.17	0.25	0.21	1.20	0.06	0.05
40.0	-	-	-	2.31	0.28	0.23	1.28	0.07	0.06
42.5	-	-	-	2.46	0.31	0.26	1.36	0.08	0.06
45.0	-	-	-	2.60	0.34	0.29	1.44	0.08	0.07
47.5	-	-	-	2.75	0.38	0.32	1.53	0.09	0.08
50.0	-	-	-	2.89	0.42	0.35	1.61	0.10	0.09
55.0	-	-	-	3.18	0.49	0.41	1.77	0.12	0.10
60.0	-	-	-	-	-	-	1.93	0.14	0.12
65.0	-	-	-	-	-	-	2.09	0.16	0.14
70.0	-	-	-	-	-	-	2.25	0.18	0.16
75.0	-	-	-	-	-	-	2.41	0.21	0.18
80.0	-	-	-	-	-	-	2.57	0.23	0.20

Water Hammer

Hydraulic shock in pipelines is commonly referred to as water hammer. However, water hammer is only one result of the harmful effects created by hydraulic shock. Hydraulic shock occurs when fluid flowing through a pipe is subjected to a sudden, rapid change in velocity. The pressure wave generated travels back and forth within the piping until the energy is dissipated.



When the tubes are not adequately secured or supported, or the tube runs are particularly long, these rebounding pressure waves cause the tubes to vibrate and hit against the supporting structure causing the noise referred to as water hammer. The noise is objectionable but not, in itself, inherently dangerous. Noise may not be as noticeable in plastic pipes but damaging shock stresses are still imposed on pipes and fittings. Hydraulic shock can cause damage to joints, taps, valves, meters and even to the pipeline itself. Water hammer effects can be generated by foot action taps, clothes and dishwashing machine solenoid valves, quick acting quarter turn taps and pumps. Tube should be fixed in position securely at the spacings shown in the table on page 47 to minimise noise associated with hydraulic shock. Water hammer effects may be minimised by reducing the velocity of the water flow in the tubes, reducing the inlet pressure of the water in the system, closing manually operated taps slowly and by fitting slow acting solenoid valves.

In certain cases it may be necessary to fit a water hammer arrestor as close as possible to the source of the problem. These devices are available from plumbing merchants.

Additional information on this subject is outline in the “Water Hammer Book” produced by the International Copper Association Australia and attached to the middle of this publication. A Copper Industry is available if assistance is required to resolve persistent existing water hammer problems. Contact numbers are on the back of this booklet.

A PDF version of the Water Hammer Book can be viewed or downloaded from the ICA Australia - www.copper.com.au

Pipe Spacing

The following MAXIMUM FIXING distances apply to horizontal and vertical runs of copper piping for water supply:

NOMINAL Size	MAXIMUM Fixing (m)	NOMINAL Size	MAXIMUM Fixing (m)
DN15	1.5	DN65	3.0
DN18	1.5	DN80	3.0
DN20	1.5	DN90	3.0
DN25	2.0	DN100	3.0
DN32	2.5	DN125	3.0
DN40	2.5	DN150	3.0
DN50	3.0		

Copper Tubes Exposed to Freezing Conditions

Freezing of water within the tube can result in bursting and precautions should be taken to prevent direct exposure of piping to these conditions. When the ambient air temperature regularly falls below freezing, all piping located outside buildings should be buried to a minimum depth of 300mm. Any exposed sections should be covered with a continuous waterproof insulation. In very cold climates, it will be necessary to provide additional insulation over the normal pre-insulated tubes. Piping within the building may also freeze up if it is located in positions which are difficult to keep warm. These areas would include: on the outside of roof or wall insulation batts, unheated roof spaces, unheated cellars, locations near windows, ventilators or external doors where cold drafts occur, and any location in direct contact with cold surfaces such as metal roofs, metal framework or external metal cladding. Tubes installed in any of these locations should be insulated to minimise the possibility of water freezing.

Where it is unavoidable to install copper tubes on metal roofs, special care must be taken to insulate the pipeline to prevent bi-metallic corrosion. It is recommended brackets be used to lift the tube off the roof and the entire pipeline be covered with a waterproof insulation which will withstand the anticipated environmental conditions. Factory pre-insulated tubes will not provide adequate protection to prevent water freezing in exposed pipes.

The suggested minimum thickness of the insulation required to minimise freezing problems is given on page 48. It should be noted that the presence of insulation will not prevent water freezing if the conditions are particularly severe over an extended period of time. In situations where the building is not in use over the winter months, and no heating of the inside area is maintained, it may be necessary to completely drain the pipes to prevent damage by water freezing.

Minimum Thickness for Thermal Insulation to Prevent Freezing

FITTING TYPE	THERMAL CONDUCTIVITY OF INSULATING MATERIAL (W/m.K)				
	0.03	0.04	0.05	0.06	0.07
	Minimum Thickness Required (mm)				
DN15	9	14	20	29	40
DN18	6	9	12	15	20
DN20	4	6	8	10	12
DN25	3	4	5	6	8
DN32	2	3	4	5	6

These insulation thicknesses were calculated, using the formulae given in BS 5422, to just prevent freezing of water initially at 15°C if exposed to an ambient temperature of -5°C for a period of 8 hours. If temperatures fall below -5°C or freezing conditions extend for periods of longer than 8 hours, additional thickness of insulation may be necessary.

It is important to note that water will freeze first in small diameter pipelines.

Thermal Conductivity of Insulating Materials

EXAMPLE OF MATERIAL	THERMAL CONDUCTIVITY (W/m.K)
Rockwool or fibreglass sectional pipe insulation (prefabricated sections)	0.032
Rockwool or fibreglass loose fill or blanket material	0.032-0.045
Foamed nitrile rubber	0.040
Loose vermiculite (exfoliated)	0.06-0.07
Flexible foamed plastic	0.070-0.075

Heated Water Piping Insulation

AS/NZS 3500.4 must be referred to regarding the exact requirements for insulation of heated water piping. Difference climatic areas require different thicknesses of insulation to ensure that the required energy efficiency measures are met.

In general, all circulating heated water piping, all exposed heated water piping and all heated water piping that is buried or within a conduit encased within a concrete slab must be insulated.

The minimum thickness of good quality insulation such as a closed-cell polymer insulation, is 13mm. A thicker layer will be required with some insulating materials and when the pipe work is installed in cold and alpine areas. The NCC describe the climatic zones within Australia and AS/NZS 3500.4 states the required insulation thickness for different materials.

Installation Practice – Safety Precautions

ELECTRICAL EARTHING

Plumbing must not be used for earthing, however in some older buildings it was a common practice and the following precautions should always be followed.

Do not break, cut or remove sections of metallic water tubing used as an earth electrode for an electrical installation or remove a water meter before suitable precautions have been taken to ensure that it is safe to do so and minimise the risk of electric shock.

The main switch or switches on the premises shall be switched off and a tag reading 'DANGER DO NOT SWITCH ON' attached over the switch.

A bridging conductor, fitted with suitable clamps and having a current rating of not less than 70A, shall be connected across the intended gap.

The pipe shall be cleaned to bare metal where the clamps are to be connected. The electrical bridge shall not be broken or removed until all work on the water service is completed and continuity of the metallic service pipe is restored.

Where any existing metallic service pipe is to be replaced in part or in its entirety by plastics pipe or other non-metallic fittings or couplings, the work shall not commence until the earthing requirements have been checked by an electrical contractor and modified, if necessary.

ROOF AND TRENCH WORK

Special care must be taken by a plumber engaged in roof or trench work. Before commencing such work, it is imperative that the job be planned carefully with specific attention given to worker safety. All trench and roof work must be performed in accordance with safe practice and requirements specified by the regulatory authority.

PROXIMITY OF WATER PIPES TO OTHER SERVICES

Above and below ground water services shall be installed so that no potential safety hazard is created when in close proximity to other services. Access should be provided for maintenance and modifications to piping. Detailed information is outlined in AS/NZS 3500.1.

Plumbing Precautions

INSTALLATION AND DESIGN

If the life expectancy of a copper system is to be maximised, it must be designed correctly and installed by professional, trained personnel using established practices. Reference should be made to the Plumbing Code of Australia; AS 4809 the Copper Piping Installation and Commissioning and the International Copper Association Australia; Hydraulic Services Design Guide, a pdf form of which can be viewed or downloaded from www.copper.com.au.

Care is to be taken to ensure piping is free from damage and distortion. Bends are to be of uniform radius and joints made without internal obtrusions. Also:

> Fluxes must be flushed from pipes and fittings. It is unnecessary to use flux for copper to copper joints if silver-copper-phosphorus filler rods are used.
> Overheating is to be avoided.
> Pipes are to be clamped securely within specified spacing limits.
> Potential sources of vibration are to be eliminated to avoid noise and possible premature failure due to fatigue. Water hammer is an area of concern see pg 46.
> Forces due to expansion and contraction must be calculated and accommodated in the design.

CLEANING

Piping must be flushed regularly with clean compatible water during installation and prior to commissioning of the building. If water is allowed to stagnate, deposits may interfere with the formation of protective films on copper – refer to AS 4809.

SUPPLY TANKS

Tanks should be flushed on a routine basis to prevent sludge build-up and subsequent pollution of water services. Protective coatings on lined tanks must be inspected regularly for deterioration.

EARTH RODS

Plumbing pipes must not be used as an earthing rod. Electrical earths must be installed properly if associated corrosion problems are to be avoided. Earth rod connection clamps must be clean, secure and positioned correctly. The use of electrical isolation fittings at water main tappings has reduced currents flowing from mains into properties and vice versa.

PROTECTION OF POTABLE WATER SUPPLIES

All water supply systems shall be designed, installed and maintained so as to prevent contaminants from being introduced into the potable water

Only potable water shall be supplied to plumbing fixtures for drinking, bathing, culinary use or the processing of food, medical or pharmaceutical products. Backflow prevention devices are used to prevent contamination of potable water supply. Special references to hazard ratings and the requirements for use of backflow prevention devices are outlined in AS/NZS 3500.1.

Concealment Of Copper Water Services

In order to provide accessibility for maintenance, it is recommended that all hot and cold lines be concealed, wherever possible, within areas such as walls, cornices, pelmets, cupboards, skirtings or ducts.

As a matter of principle, it is not recommended that service lines be cast into or buried under reinforced concrete slabs.

Reference should be made to the specific regulations and codes of practice laid down by the local responsible authority when any tubes are to be concealed. Particular attention should be given to requirements specified in the Australian Standard AS/NZS 3500.

The following general information is provided for guidance when tubes are to be concealed in relatively inaccessible locations.

TUBES IN WALLS

Copper water services located in walls shall not be less than Type C. In timber framework, holes are to be accurately sized to firmly locate fully lagged pipe. Alternatively, neutral cure silicon sealant is to be used to completely fill the annular space and secure unlagged pipes.

Holes drilled in metal frames are to be accurately sized to accommodate lagged pipes, suitable grommets or sleeves compatible with copper. There should be no direct contact between pipes and framework or restriction of movement.

TUBES IN CHASES, DUCTS OR CONDUITS

All tubes should be lagged with an impermeable flexible material. Pipelines should be clipped and held in place in chases with easily removable mortar. Ducts must have removable covers. Proper provision should be made for expansion of hot water lines. Care should be taken to prevent damage to the tube.

TUBES UNDER CONCRETE

Pipelines laid under concrete should be no thinner than Type B. Joints should be kept to a minimum and made using approved silver brazing alloy. Tubes are to be protected from ingress of moisture by either lagging or placement in a water-tight conduit. The ends of the conduit or lagging should be sealed water-tight. Where tube penetrates a slab it is to be lagged with a minimum thickness of 6mm flexible water-tight lagging. Soft soldered joints are not permitted. All joints are to be kept to a minimum but it is preferable to have no joints beneath concrete slabs.

TUBES IN CONCRETE

When there is no suitable alternative to embedding tubes in concrete walls or floors, they should be located in chases or ducts with removable covers. All tubing should be no thinner than Type B and covered over its complete length with an impermeable flexible plastic material. Tubes should not extend through any expansion joint in the concrete. Proper provision should be made for expansion of the concealed tubes and the connecting tubes outside the concrete structure.

Note: Pre-insulated tube is an impermeable flexible material for use in concealed piping.

TUBING BELOW GROUND

Water supply tubes laid below ground shall have a minimum cover as follows:

- In PUBLIC AREAS 450mm covering is required for unpaved, paved or road surfaces whilst 300mm depth is required for solid rock.
- In PRIVATE PROPERTY a 300mm cover applies to areas subject to vehicular traffic, 75mm under houses or concrete slabs and 225mm for all other locations.

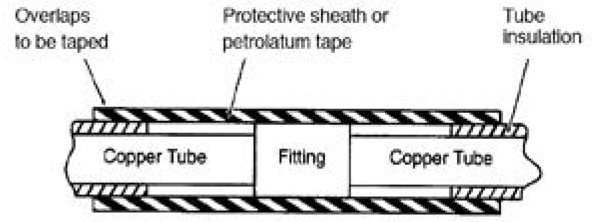
Copper and copper alloy tubes and fittings should not be used unless suitably protected against external corrosion such as where they might be in contact with such materials as:

Ash, sodium chloride [salt], magnesite, ammonia and its compounds or derivatives, nitrates, nitrites, mercury salts, foundry sands, animal excreta urine or any other identified or potential aggressive environment.

In such cases tube and joints should be continuously protected by a tough waterproof covering. Pre-insulated tube is ideally suited to these adverse environments provided joints are adequately protected and ends sealed. Unprotected tubes should not be laid in or allowed to cross rubble drains or similar waste disposal systems.

Protection For Joints

Where piping is lagged for protection against corrosion, it is important that all joints in the lagging are sealed to prevent ingress of moisture and aggressive substances. The use of a taped section cut from pre-insulated tubing, is often a simple, effective option.



Heat shrink sleeving could be used to protect straight joints in larger diameter installations where pre-insulated tube has been used. Petrolatum products are recommended when covering tees, bends and other bulky fittings in large diameter lines.

Installation of Hot Water Lines

The operating conditions for hot water lines differ in many respects from those for cold water, and consideration of the important differences will help avoid failures from incorrect pipeline design or unsatisfactory installation techniques. Reference should be made to the current requirements for Energy Efficiency in AS/NZS 3500 Parts 4 & 5.

With copper installations, two of the important factors to be considered are:

1. Movement of the tubes due to expansion and contraction. On occasions, due to incorrect design, longitudinal expansion and contraction results in a repeated alternating stress concentrating in the tube and ultimate failure by corrosion fatigue.

2. Corrosion rates increase with increasing temperature and care needs to be taken that the maximum water velocity is not exceeded and that the pipe work is protected from aggressive environments.

During planning, special attention should be given to location of fittings, bends, ends of runs, branch joints, and to those areas where heat from brazing or soldering has softened the tube causing a localised loss in strength. The stressing produced from expansion effects usually concentrates in these regions and these are the most likely sites for corrosion fatigue failures.

To minimise the effect of localised stressing, it is necessary to make sufficient allowance for the free movement of the tube. This implies not only a loose fit between the tube and its surroundings, but also that adequate allowance is made for the increase in length resulting from thermal expansion.

The amount of longitudinal movement depends on the length of the run and the expected temperature change. Minimum practical values can be obtained from Table 1.

TABLE 1

TUBE LENGTH (metres)	**ALLOWANCE FOR LENGTH INCREASE [mm]**						
	Temperature Increase °C						
	40	**50**	**60**	**70**	**80**	**90**	**100**
Up to 3	3	3	4	4	5	5	6
Over 3 to 5	4	5	6	7	8	8	9
Over 5 to 9	7	8	10	12	13	15	16
Over 9 to 12	9	11	13	15	17	20	22
Over 12 to 15	11	14	16	19	22	24	27
Over 15 to 20	15	18	22	25	29	32	36
Over 20 to 25	18	23	27	31	36	40	45

Table based on the formula:

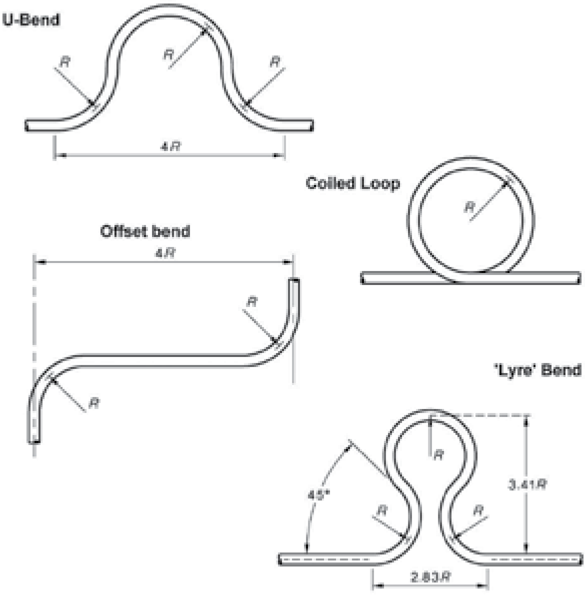
Expansion [mm] = tube length (m) x temperature rise (°C) x 0.0177

A useful "rule of thumb" for normal hot water lines is to allow for 1 mm expansion for every 1 metre of straight run.

The effects of expansion and contraction may be minimised by installing tubes in ducts or clear space and this should be done wherever possible.

Expansion loops, bellows or bends may also be used for larger installations that have relatively long runs and for tubes of large diameters or in situations where significantly large temperature differences occur repeatedly.

The following diagrams show standard dimensional loops and offsets with suitable radii being given in Table 2 on the following page.



Expansion loops and offsets must be placed horizontally to avoid forming air locks at the top of the loops and to ensure proper circulation of the water. It is preferable to locate the bend or loop as close to the mid point of the straight run as possible.

EXPANSION (mm)	RADII FOR EXPANSION LOOPS AND BENDS 'R' (mm)									
	Nominal Tube Size									
	DN15	DN20	DN25	DN40	DN50	DN65	DN80	DN90	DN100	DN125
10	180	210	250	320	350	400	430	470	510	560
15	220	270	290	370	410	440	500	540	600	650
20	250	300	380	430	510	560	620	670	710	790
25	300	350	400	500	550	630	680	730	810	910
30	320	370	430	530	610	660	740	780	840	950
40	340	430	490	620	720	770	870	920	1000	1130
50	400	480	550	680	780	880	1000	1050	1150	1300
60	450	530	630	760	880	960	1060	1160	1260	1350
70	460	560	660	790	910	1020	1130	1220	1320	1450
80	510	610	710	860	990	1120	1220	1320	1410	1530
90	610	640	740	920	1020	1150	1250	1350	1430	1550
100	680	760	840	990	1120	1190	1340	1420	1470	1570

TABLE 2

** For pipe sizes DN18 and DN32 the next larger pipe is used.*

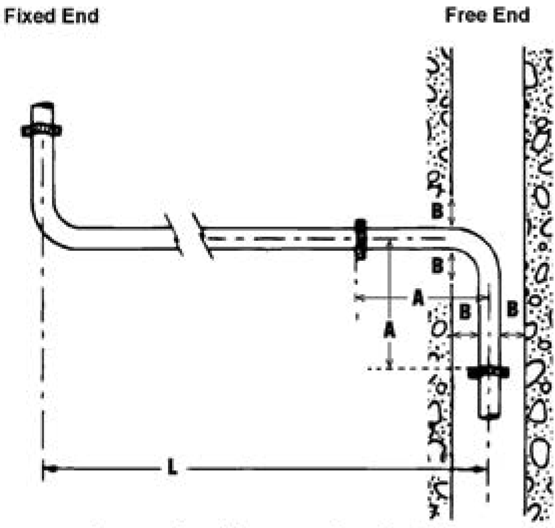
Provision for expansion must be considered when designing tube runs and fixing points by allowing freedom of movement at bends, branches and offsets. Allowance for expansion should incorporate:

I. A clear space to permit movement - refer Table 3 [B]

II. Sufficient free length of tubing around the bend or along the branch to prevent over-stressing the tube - refer table 3 [A].

TABLE 3

L (run length) m	**A** (Free length) Min. mm	**B** (for 60°C temp rise) Min. mm
Up to 4.5	600	5
Over 4.5 to 9	900	10
Over 9 to 18	1200	20



Expansion allowance for offsets.

Fatigue cracks have sometimes occurred at bends in hot water lines where the tube passes from one structure to another, e.g. from a concrete floor up into a wall.

To reduce stressing of the tube in this region, the bend radius should be as large as possible. These cracks usually occur on the sides of the bend where the tube is oval and result from flexing of the wall of the tube at these points.

Additional precautions should be taken to ensure that hot water lines are not damaged by flattening or twisting as these faults can act as stress concentrators and lead to failure by fatigue.

Copper and Brass Tubes for Sanitary Plumbing

It is well known that copper and brass tubes offer significant advantages to designers of sanitary plumbing systems. Some attributes are the material's light weight, ease of installation, flexibility, space saving capacity, corrosion resistance and ability to be prefabricated.

Nevertheless, careful attention must be given to material selection and installation practice if a system is to perform satisfactorily. The complete internal and external operating environment is to be considered when selecting pipeline materials. Corrosive discharge liquids or aggressive surrounds could reduce the life of a system.

MATERIAL LIMITATIONS

Copper Pipes and Fittings

- Pipes and fittings shall not be used for urinal discharges only, but may be permitted where the flow is diluted by discharges from regularly used upstream fixtures. They shall not be used in conjunction with grease arrestors.
- Type B pipes shall not be field bent beyond a 10 degree offset angle.
- Type D pipes shall be used in straight lengths only and shall not be offset by bending.
- Type D pipes shall not be used for sanitary drainage below ground.
- Bends and junctions at the base of stacks up to 9m in height shall be formed from no thinner than Type B pipe.
- For stacks greater than 9m in height, bends and junctions at the base are to be cast or hot pressed copper alloy.

Brass Pipes and Fittings

- Pipes shall only be used in the as-supplied 1/2 hard temper.
- Pipes shall not be bent, offset or misaligned.
- Pipes shall not be used with compression fittings.
- No fitting other than a junction shall be fabricated in the field.
- Local annealing is only permitted where necessary for making joints.

It is important to note that some cleaning chemicals have contributed to the corrosion of metal pipes. Both copper and brass may be affected by some undiluted discharges from commercial dishwashers, glass washers and bar sinks.

Pipe Support

Vertical and graded pipes are to be supported at maximum intervals of 3 metres. Pipes are not to be supported or spaced by means of brazing or welding short sections of material to the surface of each pipe.

All brackets are to be lined with an inert, non-abrasive material where they contact pipes. Other than at expansion joints, the brackets shall, when fully tightened, permit tube to move longitudinally. Brackets are to clamp expansion joints securely and prevent their movement.

Expansion Joints

STACKS

Where a stack passes through more than 2 floors, whether above its base or above any offset bend, expansion joints are to be fixed:

> At the base of the stack or in the vertical pipe above an offset bend.

> At alternate floor levels where the stack is unrestrained or at each floor level except the top floor when the stack is restrained or is subject to hot discharges.

> The expansion joint at any intermediate floor is to be placed immediately above the junction of the highest discharge pipe connected to the floor concerned.

GRADED DISCHARGE PIPES

An expansion joint is to be installed as close as practicable to the stack in any restrained, graded discharge pipe exceeding 6 metres in length.

BED PAN SANITISER AND WASHER

An expansion joint is to be installed at each floor in any soil stack, soil vent and steam relief vent pipe connected to a bed pan sanitizer and washer supplied with steam.

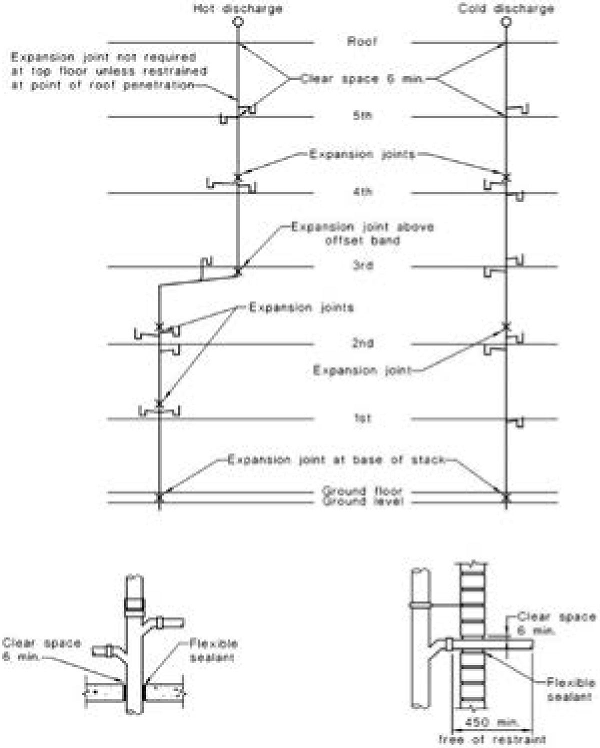
Freedom From Restraint

A pipe is considered to be unrestrained provided that:

> No restraint on longitudinal movement occurs where it passes through walls or floors. A 6mm annular space is to be provided and the space may be filled with an approved flexible sealant (see page 60).

> No restraint on movement shall occur on any branch discharge pipe for a distance of 450mm from its junction with a stack.

Where the discharge pipe penetrates any floor or wall within such distance, a 6mm annular space is to be provided. The space may be filled with an approved flexible sealant.



(b) Freedom from restraint

NOTE: Vents omitted for clarity.

DIMENSIONS IN MILLIMETRES

EXPANSION JOINTS IN COPPER AND COPPER-ALLOY STACK

Copied from AS/NZS 3500.2

Penetration Sealants

The installation of pipes through fire rated members is critical. Particular attention is needed where pipes penetrate various adjoining fire rated compartments. In the event of a fire, flames must be restricted from passing from one compartment to another at points where pipes penetrate.

Special installation techniques have been developed, tested and certified to satisfy PCA requirements for copper and brass pipes. Specific caulking compounds are available to close off pipe penetrations and provide a fire rated seal. Sealant suppliers will assist in the identification of product suitable for specific fire rating requirements.

Pipe Grade Conversions

PIPE GRADE CONVERSION CHART			
Percentage %	**Ratio** (gradient)	**Percentage %**	**Ratio** (gradient)
20.00	1 in 5	1.10	1 in 90
6.65	1 in 15	1.00	1 in 100
5.00	1 in 20	0.85	1 in 120
3.35	1 in 30	0.70	1 in 140
2.50	1 in 40	0.65	1 in 150
2.00	1 in 50	0.60	1 in 160
1.65	1 in 60	0.50	1 in 200
1.45	1 in 70	0.40	1 in 250
1.25	1 in 80	0.35	1 in 300

Copper Tube for Fire Services

Copper tube is permitted to be used in fire hydrant, hose reel and automatic sprinkler systems. However, limitations apply. When considering piping for these applications, it is important that:

> Design and installation is performed by competent, accredited personnel.

> Reference is made to current relevant Standards, some of which are listed on page 9.

> The local regulatory authority approves of the work to be performed and materials to be used.

FIRE HYDRANT SYSTEMS

In accordance with AS2419.1, copper pipes used above or below ground in hydrant systems are required to comply with AS1432 Types A or B or AS1572 where thicker tube is necessary. Tube shall have a test pressure of 1700kPa, or 1.5 times the highest working pressure, whichever is the greater.

Soft soldered joints are not permitted.

Copper is prohibited to be used in above ground situations in non-fire sprinklered buildings unless protected using materials that will provide a FRL of not less than -/60/60 or be located in a floor or ceiling system that achieves a resistance to the incipient spread of fire of not less than 60 minutes.

FIRE SPRINKLER SYSTEMS

Copper is permitted to be used in wet fire sprinkler systems only as defined in AS2118.1 for hazard classifications up to OH3 Special, AS2118.4 [Residential] and AS2118.5 [Domestic]. Copper pipes are an ideal option for Domestic combined and independent systems – see the latest edition of AS 2118 Part 5.

> Tube shall be to AS1432 and minimum Type B. Thickness may be to Type A depending on applicable test pressures as outlined on page 69.

> Capillary and compression fittings to AS3688 are permitted to be used.

> Joints may be brazed with minimum 1.8% silver-copper-phosphorus filler metal.

> Soft soldered joints, where approved, are permitted for residential and domestic systems as well as light and ordinary hazard 1 occupancies when piping is concealed in ceilings or void spaces.

> Copper may be bent to a minimum radius of 6 diameters for sizes DN50 or smaller and 5 diameters for larger sizes.

Copper for Gas Piping

Copper is approved for fuel gas piping in AS 5601 - Gas Installation Code. It is suitable for conveyance of Town Gas, Natural Gas, and Liquefied Petroleum Gas in the vapour phase, Tempered Liquefied Petroleum Gas and Simulated Natural Gas:

> AS1432 Type A or B tube is required for pressures up to and including 200kPa.

> Copper is not permitted in the ground beneath a building at pressures above 7kPa unless protected with either a manufactured plastic coat or a proprietary wrapping acceptable to the authority. Where pipe is coated, the entire length is to be protected and made water-tight, including ends.

> Permissible joints are: flared copper alloy compression, capillary, press-fit, expanded sockets and formed branches [in hard tube only].

> Soft soldered joints and olive type fittings are not permitted.

> When copper alloy [brass] fittings are to be buried in the ground, they must be DR or effectively protected against corrosion.

The use of Copper tube and fittings for main to meter applications is allowed in most circumstances. There are restrictions on the allowable joining methods and reference should be made to your local network provider, AS/NZS 4645.1 Gas Distribution Networks and AS 4809 Copper pipe and fittings – Installation and Commissioning.

Protection During Building Construction

Care is to be taken to ensure that water service pipes are not damaged during normal building activities. Concealed piping is to be maintained under normal water pressure while subsequent building operations are being carried out which could cause damage to the pipes. The service must be flushed with clean water at regular intervals until the building is occupied. Disinfection treatment may be necessary – refer to AS 4809.

Bending Copper Tubes

GENERAL CONSIDERATIONS

The making of good bends in copper tube requires care and skill. One essential requirement is that the material must have sufficient ductility for it to deform into the shape of the bend without seriously weakening the tube wall or giving rise to undesirable distortion or fractures.

Distortion and fractures are usually caused by: bending tool wear, excessive tube hardness or lack of proper bending techniques.

Good bends are produced with a smooth action of the bender without jerks or relative movement between bender and tube.

Annealed temper tube is desirable for hand bending since it can be worked with the least amount of strain, and is more suited to the small radiused bends used in plumbing installations.

When using hand bending tools, the presence of oil or grease in the groove or on the tube, can lead to excessive wrinkling on the inside of the bend. A similar fault can result if the groove has been excessively worn. Kinking can occur if the wiper shoe is not positioned correctly at the start of bending.

ANNEALING (SOFTENING) FOR BENDING

Heating for too long, or at too high a temperature, causes excessive grain growth with little or no additional softening. It results in coarsening of the grains and can cause an undesirable "orange peel" surface to develop during bending. In the worst case, it can lead to rupture of the metal.

The typical range for annealing Copper and 70/30 DR Brass is 450°-600°C. This temperature range is distinguished by the heated metal changing to a "dull red" colour.

Annealing Procedures

These can vary from large-scale furnace annealing, to the use of a gas torch where only localised annealing is required. Where torches are used, care must be taken to avoid concentrating the heat on one spot or heating for an excessive time. The annealing of thin-wall tube should be approached with extreme care as incorrect procedures can result in burning of the metal or loss of thickness due to oxidation. If undesirable grain growth is to be avoided, an accurate estimation of temperature is important. Furnace annealing normally utilises pyrometers for this purpose, but with torch annealing the use of temperature-sensitive crayons is recommended.

The Effects Of Time On Annealing

The time at temperature can vary from just a few minutes to 1/4 hour or more. To achieve a fine grain size, it is best to anneal at lower temperatures and correspondingly increase the "soak" time. Optimum properties can best be obtained by experimentation.

Cooling After Annealing

Copper and 70/30 DR Brass tubes may be cooled by either quenching in water or allowing to cool naturally in air.

Surface Cleaning (Pickling)

Any scale or other oxide products that develop on the surface of copper and brass tubes when heating in air may be removed by immersion in appropriate acid solutions.

STRESS RELIEF AFTER BENDING

When tubes are bent cold, the metal is usually left in a state of internal stress.

These residual stresses may cause some metals to crack when they are exposed to certain agents such as ammonia, mercury, or liquid solder. The stresses can also cause a loss of shape that may be important if, for example, the bent tube has to be brazed to form part of a fabricated assembly. If the tube is required to operate under onerous conditions, or if there is any doubt about the need for such treatment, then it is always advisable to stress relieve.

Stress relief is not normally required with copper, but is essential for 70/30 DR Brass. Treatment consists of heating in the temperature range 300°-360°C, and holding for a time sufficient to reduce the internal stresses to a safe level. 10-15 minutes should be an adequate soak time for all tubes. An undue increase in temperature or soak time is liable to produce a slight softening of the metal. There is no need for stress relief if the tubes have been bent hot and cooled naturally, or if the tubes are to be annealed soon after bending.

If there is any doubt about the adequacy of stress relieving treatment, or a need to test for susceptibility to stress corrosion cracking, then this can be done by means of stress corrosion test. Details of this test are given in Australian Standard AS 2136 and British Standard International Standard BS ISO 6957.

COLD BENDING

Provided correct tempers and tube thickness are chosen, copper and 70/30 DR Brass can be bent cold.

The single, most important requirement in cold bending is that the material should be sufficiently ductile. Typical elongation values for copper and 70/30 DR Brass are given on page 67.

Due to elastic recovery of the metal, some small allowance may be necessary for springback when accurate alignments are required.

There is always a tendency for the outside wall to flatten, and if this becomes objectionable, it may be overcome by the use of internal support in the form of a mandrel, suitable filler material or by the use of bending springs.

HOT BENDING

Most metals can be bent hot providing there is adequate internal support by mandrels or suitable fillers to prevent distortion.

Large diameter tubes, principally those with thick walls, require mechanical means for bending and are therefore commonly bent hot as this reduces the load required to effect the bend.

Hot cracking from embrittling agents or unsuitable fillers may occur and examples of these are some low melting point alloys containing bismuth and cadmium, and sodium hyposulphite (hypo) filler.

Ordinary phosphorus deoxidised copper tubing (C12200) as used for plumbing, may be bent hot, but very high temperatures and prolonged heating should be avoided as excessive oxidation and grain growth can occur. In extreme cases this can lead to a loss of grain boundary cohesion causing the metal to crack during bending.

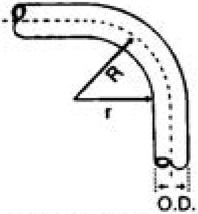
Copper tube may be bent hot in the range 700°-800°C, but excessive heating times should be avoided. 70/30 DR brass tube may be hot bent in the range 725°-825°C, but temperatures of 250°-550°C should be avoided as the material is susceptible to hot-short cracking in this temperature range.

TUBE BENDING CALCULATIONS

The minimum bend radius to which a tube can be bent depends on the amount of ‘stretch’ the outside wall of the bend will withstand without causing undue distortion or fracturing. Good ductility is thus an essential requirement. Other significant factors are tube material, diameter, wall thickness, and the type of bending equipment employed.

There is relatively little difference in the bending characteristics of copper and brass although power requirements necessary to form bends will increase as alloy strengths increase.

It is general practice when designating minimum bend radii, to refer to the dimension of the centreline of the bend in the case of round tubes and to the inside of the bend in the case of square or rectangular tubes.



R (Centre Line Radius) = r + 1/2 OD
r is the inside bend radius

The following formula, which takes into account the tube's ductility, may be used as a rough guide for determining minimum bend radii:

$$\mathbf{R} = \frac{\textbf{tube diameter (O.D. in mm) x 50}}{\mathbf{E}}$$

Where **R** = minimum centre line radius and **E** = % elongation in 50mm.

Typical Elongation Values (**E**)

COPPER	Soft - 55 Hard - 10
70/30 DR BRASS	Soft - 65 Hard - 15

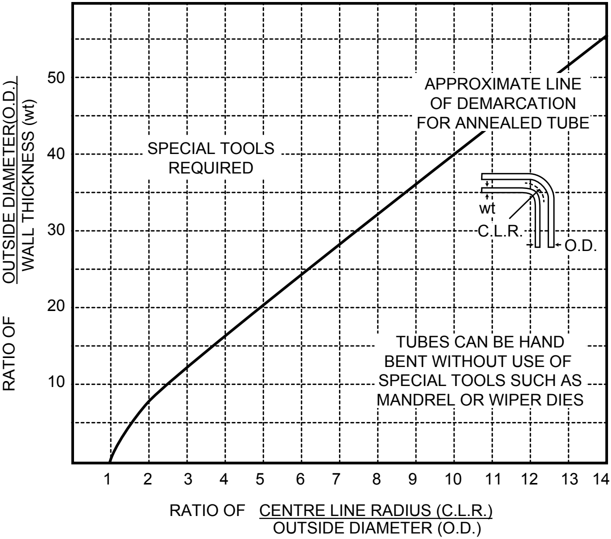
Example: determine the minimum bend radius of a 50.8mm outside diameter soft copper tube.

$$\textbf{Min. bend radius (R)} = \frac{\mathbf{50.8 \times 50}}{\mathbf{55}} = \frac{\mathbf{2450}}{\mathbf{55}} = \mathbf{46.18mm}$$

No minimum radii are available for hot bending. Buckling can be reduced by peening the inside of the bend. The more difficult bends are done slowly. Hot bending can result in some metals cracking and details of this have been given in the section on hot bending.

For making a given bend there is no precise demarcation as to whether tools are necessary, but guidance on their use may be obtained from the following chart.

BENDING WITHOUT TOOLS



TEMPURATURES BY COLOUR

APPEARANCE	APPROX. TEMP °C
Lowest red heat visible in the dark	335
Red hot in the dark	400-500
Faint red	516
Dark red	650-700
Brilliant red	800
Cherry red	900
Bright cherry red	1000

Test Pressures

Australian Standards for various systems specify that the piping is to be tested to the following pressures. It is strongly recommended that installed piping be tested prior to burial or concealment. Adherence to this procedure will facilitate the location and repair of any leak exposed by the pressure test.

SYSTEM	PRESSURE	AUSTRALIAN STANDARD
Cold Water	1500kPa for 30 minutes minimum	AS/NZS 3500.1
Hot Water (excluding storage container or hot water heater)	1500kPa for 30 minutes minimum	AS/NZS 3500.4
Sanitary Plumbing	Hydrostatic test to flood level or air pressure test at 30kPa for 3 minutes minimum	AS/NZS 3500.2
Gas Piping - specific practice is outlined in AS 5601 - only applies for test pressures not exceeding 400kPa	a) New piping before appliances are connected or repaired/altered system with appliances isolated: - pressurise to 7kPa or twice operating pressure, whichever is greater. - no loss of pressure during an isolation period of 5 minutes after stabilisation plus an additional 5 minutes for every 30 litres [0.03m^3] of pipe volume. b) New piping or repaired/altered systems with appliances connected: - pressurise to operating pressure. - test period as for 'a'.	AS 5601
Fire Hydrant	Not less than 1700kPa for a period of 2 hours or 1 .5 times the highest working pressure whichever is the greater.	AS 2419.1
Fire Hose Reel	1500kPa for not less than 30 minutes.	AS/NZS 3500.1
Fire Sprinkler		
- Domestic	Not less than 1500kPa.	AS 2118.5
- Residential	Not less than 1500kPa.	AS 2118.4
- AS 2118	1.4MPa for a period of 2 hours or 400kPa in excess of the maximum static working pressure, whichever is the greater.	AS 2118
- Wall-wetting (drencher)	1.4MPa for a period of 2 hours or 400kPa in excess of the maximum static working pressure, whichever is the greater.	AS 2118.2

Corrosion Rating of Copper and 70/30 DR BRASS

ENVIRONMENT	COPPER	70/30 DR BRASS
Acetone	A	A
Acids:		
- Chromic	D	D
- Citric	A	C
- Hydrochloric	C	D
- Nitric	D	D
- Phosphoric	B	D
- Sulphuric	C	D
- Tanic	A	B
- Tartaric	A	C
Alcohols	A	A
Aniline dyes	C	C
Animal/excreta and decomposed undiluted urine	D	C
Ashes	D	D
Asphalt	A	A
Atmosphere:		
- Industrial	A	B
- Marine	B	B
- Rural	A	B
Beer	A	B
Benzene, Benzol	A	A
Bleaching Powder	B	D
Brines	B	D
Carbon tetrachloride (m)	B	D
Fruit juices	B	D
Fuel oil	A	B
Gases:		
- Acetylene	D	D
- Ammonia (m)	D	D
- Bromine (m)	C	D
- Butane	A	A
- Carbon Dioxide (m)	B	C
- Carbon Monoxide	A	A
- Chlorine (m)	C	D
- Freon	A	A
- Hydrogen	A	A
- Hydrogen Sulphide (m)	D	C
- Methane	A	A
- Natural Gas	B	A
- Nitrogen	A	A
- Oxygen	A	A
- Propane	A	A
- Steam	A	C
- Sulphur Dioxide (m)	B	D

Corrosion Rating of Copper and 70/30 DR BRASS (Cont...)

ENVIRONMENT	COPPER	70/30 DR BRASS
Gasoline	A	A
Kerosene	A	A
Lacquers	A	A
Magnesite	D	D
Mercury and Salts	D	D
Silver salts	D	D
Sodium Chloride	B	D
Sodium Hypochlorite	C	D
Sugar solution	A	B
Trichlorethylene [dry]	A	A
Trichlorethylene [m]	B	C
Varnish - solvents	A	A
Water:		
- Carbonated	B	C
- Potable	A	B
- Sea water	B	C
- Mine water	C	D
- Soapy	A	B
- Sewage	A	C

RATINGS

A Excellent - Under most conditions.

B Good - May be considered in place of ‘A’ when some other property governs use.

C Fair - May only have limited life.

D Poor - Not recommended.

Note:

> [m] moist

> Both materials unsuitable for use with ammonia, ammonium compounds and amines.

> Tinning may be required if used in contact with food products.

> Some cleaning chemicals have contributed to the corrosion of metal pipes. Both copper and brass may be affected by some undiluted discharges from commercial dishwashers, glass washers and bar sinks.

More information of the Corrosion Rates of other material and for particular circumstances can be obtained by contacting the ICAA on the numbers shown on

Index

The information in this publication has been assembled for guidance only. Care has been taken to ensure accuracy, but no liability can be accepted for any consequences that may arise as a result of its application.

All plumbing work should be performed by competent, accredited tradespersons in accordance with current relevant Standards and specifications required by the authority within whose jurisdiction the work is to be performed.

To ensure an installed system will provide satisfactory performance and the expected life, Industry practitioners should refer to Australian Standard AS4809 and give careful consideration to all aspects of:

- design
- operating condition
- the internal and external environments
- use of approved materials

Cu International Copper Association Australia
Copper Alliance

Australian Office

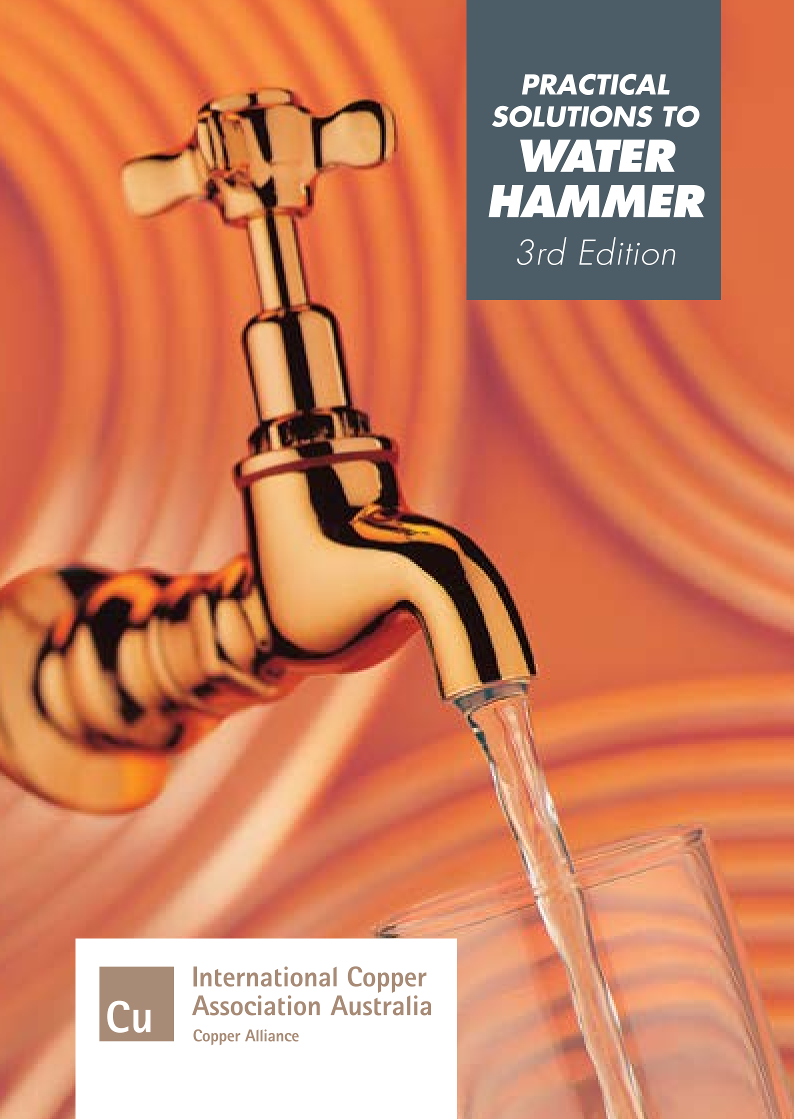
Suite 1, Level 7, Westfield Towers
100 William Street, Sydney NSW 2011
Tel: (+612) 9380 2000
Fax: (+612) 9380 2666
www.copper.com.au
www.smartwiredhouse.com.au
www.antimicrobialcopper.com

Proudly Supported by:

MM Kembla
Gloucester Boulevarde
PO Box 21 Port Kembla 2505
Phone: (+612) 4223 5300
Fax: (+612) 4223 5111
www.kembla.com.au

KEMBLA

MM KEMBLA QUALITY RELIABILITY SERVICE 100 YEARS



PRACTICAL SOLUTIONS TO WATER HAMMER

3rd Edition

International Copper Association Australia

Copper Alliance

PREFACE

Since the first "Water Hammer Booklet" was launched in July 1998, many calls have been received from plumbers, engineers and builders on water hammer noise.

In helping to resolve these problems there has been an increased understanding of the causes of water hammer in its many forms, in both metallic and non-metallic systems.

Version 3 of this booklet has been released to share this knowledge with the Plumbing Industry.

The installation of air chambers and the reduction of water pressure below 500 kPa (as per AS/NZS 3500 requirements) was found to eliminate water hammer noise in virtually all instances.

This book is issued as a tool to assist in the design and installation of copper piping systems. In the event problems are experienced, do not hesitate to contact the International Copper Association Australia (ICAA) on 02 9380 2000.

John Fennell
Chief Executive Officer
International Copper Association Australia Ltd

INDEX

1. INTRODUCTION

The following water hammer information was developed by the International Copper Association Australia Ltd, with technical support from various experts. Copper Tube member companies Crane Copper Tube and MM Kembla support the work, which offers solutions to what are in general isolated cases of water hammer that often would have been avoided if consideration had been given to the system design and pressures at the planning stage.

Some homes are subjected to water hammer in plumbing of both metallic and plastic pipes. A great deal of damage occurs, not only to the pipes themselves, but also to expensive appliances, tapware and fittings.

To prevent potential damage, the shock waves related to water hammer need to be eliminated.

- **SHOCK WAVES** will impose undesirable stress on piping and appliances unless controlled and can exist with or without noise.
- **NOISE** which is auditory, alerts property owners to water hammer problems. Without the noise there will be no indication of a problem until damage is caused, or worse, a home is flooded by a burst appliance hose, pipe or fitting.
- **COPPER PLUMBING** acts to alert home owners that shock waves are occurring in their plumbing system.

If all water hammer is to be prevented, it would be advisable to install a hammer suppression device at each automatic appliance solenoid and quick closing valve. To control costs, eliminate noise and minimise the impact of shock waves, a fabricated air chamber may be installed as an alternative, as suggested on pages **a10** and **a11**. Air chambers have some disadvantages, which are explained on page **a13**.

2. MORE FACTS ABOUT WATER HAMMER

- Water hammer will occur with or without noise.
- When a quick closing lever tap or solenoid valve closes it can produce a shock wave of up to 3000 kPa and more.
- Tests show that if a quick closing valve is closed when only trickle of water is coming from it, the shock wave is still around 2000 kPa.
- AS/NZS 3500 states that to disconnect the water meter, taps, appliances and other fixtures that may be damaged when testing the water service at 1500 kPa. Then consider the damage being caused at 3000 kPa every time a quick closing valve is closed.
- The harder the pipe material the greater the noise but it is not the noise causing damage it is the shock waves.
- Pipe work and fixtures can be damaged with or with out noise if water hammer is not controlled. The noise provides a warning, therefore, any potential damage can be eliminated.
- All water services, which contain a quick closing valve, should be fitted with a hammer suppression device as recommended by AS/NZS 3500.
- To prevent damage the following recommendations should be followed for copper and plastic installations.

Note: A hammer suppression device refers to a Hammer Arrester and an Air Chamber.

3. STEPS IN PREVENTING WATER HAMMER

- If the water pressure is above 500 kPa always install a 500 kPa pressure - reducing valve at the water meter. This will eliminate the need for a pressure-limiting valve at the hot water system and this does not increase the cost.
- Clip all pipes as per AS/NZS 3500.
- Preferably use stand off clips.
- If the pipe runs along a stud install extra clips.
- Always install at least one hammer suppression device on the cold supply and one on the hot supply in the location stated on page a10.
- Use ball valves in place of loose jumper valves where possible. (E.g. at the meter when the meter is fitted with a non-return valve).
- Install loose jumper valves at a lever tap only when required by the contract or a local regulation (the stop taps are not required by AS/NZS 3500).
- If a loose jumper valve must be installed, use a spring-loaded washer.
- When penetrating a stud, ensure the silicon is evenly distributed around the pipe.
- If a non-return valve is required prior to the dishwasher, install it as far away as possible from the dishwasher. (E.g. at the hot water system if on hot water or at the meter)'

4. STEPS TO LOCATE WATER HAMMER (NEW HOUSE)

- When installing the roughin, install it as per the directions on the previous page STEPS IN PREVENTING WATER HAMMER.
- On completion of a roughin, install a ball cock and pressure gauge on the line and close it off quickly. This will indicate if and where a hammer problem exists.
- If the installation has been installed as per the STEPS IN PREVENTING WATER HAMMER, the problems are likely to be insufficient clips, faulty valves or incorrect positioning of valves.
- As stated before, if a pressure-limiting valve is required at the dishwasher, it should be placed as far away as possible to allow the connection of the hammer suppression device to be installed between the dishwasher and the valve. When the valve is placed close to the dishwasher the shock waves will hit the valve at around 3000kPa causing damage to the valve. This is why sometimes a plumber may get a call back in about 2 to 12 months with a noise being generated by the pressure limiting valve.

5. STEPS TO LOCATE WATER HAMMER (EXISTING HOUSE)

- Has a new dishwasher or washing machine been installed? A new machine may create a noise where it did not exist before.
- Check for faulty valves. The most common valves to be damaged by shock waves are pressure-limiting valves to dishwashers and valves to hot water systems, in particular solar hot water systems.
- Once the valves have been replaced, it is good practice to install hammer suppression devices whether the pipe work is copper or plastic, to prevent damage to the new valves.
- Check for faulty washers and replace them.
- Stop taps that remain open should have spring-loaded washers installed or preferably be ball valves.
- Check the clips on pipe work. Shock waves can loosen the clips.
- If water hammer noise is occurring when a tap is not being used, it could possibly be generated from the house next door. This occurs when the tappings to the two properties are close together.
- In this case, the neighbor's problem needs to be rectified or the washer in the main stop tap needs to be replaced. A hammer suppression device fitted to the water service down stream as far as possible works in most cases.
- Check the water pressure and install a 500kPa pressure-limiting valve if necessary.
- If a noise appears that did not exist before, it is almost certain that damage has occurred by shock waves.

6. COMMON CAUSES OF WATER HAMMER

The following are some examples of water hammer problems that have occurred and rectification solutions:-

(Problem) Two months after installation a hammer noise occurred at the kitchen sink.

(Solution) Shock waves damaged the pressure-limiting valve installed at the dishwasher. The valve was repositioned at the hot water outlet of the hot water system and air chambers installed. In one case there was an air chamber installed but the shock wave had to pass through the valve before it was controlled by the air chamber.

(Problem) A plumber had pinned the washers to all washing machines in a block of units and installed a hammer arrester near the pump at the entry to the building. Water hammer noise still existed.

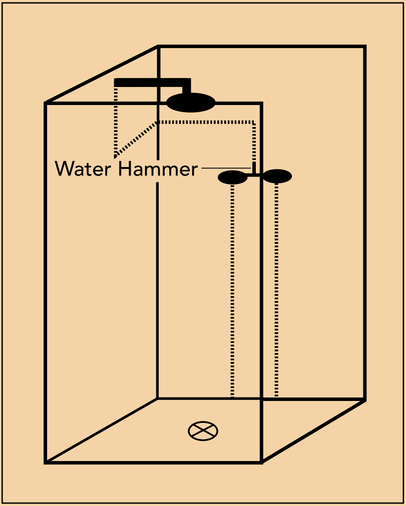
(Solution) Spring-loaded washers were installed on the stop taps to each laundry. This solved the problem of the noise but a hammer suppression device on each line would control the shock waves and extend the life of the washing machine hoses and solenoid valves.

Common causes

- Hammer suppression devices installed in the wrong position.
- Hammer suppression device not installed and excessive pressure in the line.
- Loose pipes and faulty valves some times caused by shock waves.

7. REVERSE WATER HAMMER

This is when water hammer occurs between the tap and the outlet when there is an extended distance of pipe work.
For example, when the pipe to a shower rose is extended to install the rose on another wall to the taps.



Solutions:

- Install a hammer suppression device as close as possible to the taps on the outlet side.
- And/or reduce water pressure to 350kPa.
- And/or limit the volume of water to the rose.

8. VELOCITY NOISE

The common causes of velocity noises are;

- Excessive pressure.
- Restrictions in the pipe work.
- Diameter of pipe too small (not installed as per AS/NZS 3500)

The following steps can be taken to reduce velocity noise;

- Reduce the pressure to no more than 500kPa AS/NZS 3500. 1 states the velocity shall not exceed 3.0 m/s therefor a DN15 pipe is not permitted to deliver more than 16.7 L/min. If more than16.7L/min is being delivered at the outlet of a DN15 pipe then the velocity is above 3m/sec, (40.9L/min for DN20). AS/NZS 3500. 1 also notes that the maximum pressure should not exceed 500kPa at any outlet.
- Use a pipe cutter in good condition and cut the pipe without using excessive force.
- If the pipe cutter blade is damaged or worn or the cut is performed to quickly, an excessive burr will occur on the pipe restricting the flow. This will generate a noise as the water passes this restriction. (AS/NZS3500. 1 states the burr formed in cutting any pipe shall be removed)
- Use pipe benders where ever possible.

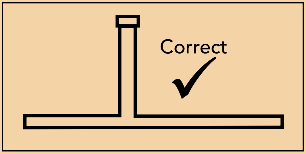
If a velocity noise occurs mainly due to restrictions in the pipe, then the installation of a 350kPa pressure limiting valve will in most cases reduce the noise to an acceptable level.

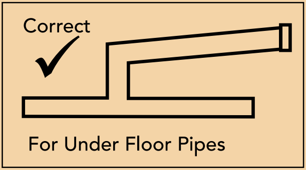
9. POSITIONING OF VALVES TO PREVENT DAMAGE

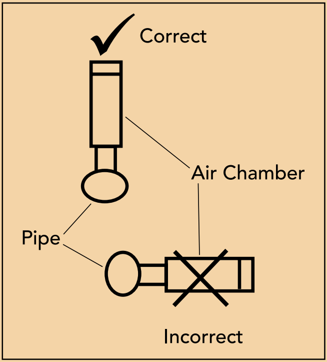
- Shock waves cause damage to valves. This damage initially does not prevent the valve from working but may create extensive water hammer noise.
- If a 500kPa pressure-limiting valve is installed at the meter, there is no need to install one at the hot water system or the dishwasher if it is connected to the cold water supply.
- If the dishwasher is connected to the hot water and the manufacturer requires the installation of a pressure-limiting valve,install the valve near the hot water system rather than the dishwasher.
- Valves to solar hot water systems can also be damaged by water hammer and create excessive noise.
- When valves are installed, install the valves (that are not part of the appliance or regulations require them to be installed at the appliance) as far away as possible from the appliance. E.g. pressure limiting valve for a dishwasher.
- Install an air suppression device between the valve/s and the appliance/ quick closing valve.

10. SIZE OF AIR CHAMBER

- A minimum tube size of DN 20 should be used for the air chamber on DN 20 and DN 15 pipes.
- The recommended length is 1.5m. If this proves difficult to install, the length may be reduced to no less than 1m.
- To reduce the length less than 1m, the diameter needs to be increased.
- Always connect the air chamber vertically on the water line. (see diagrams)

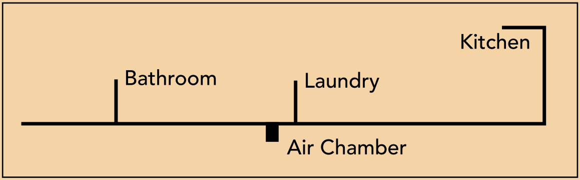


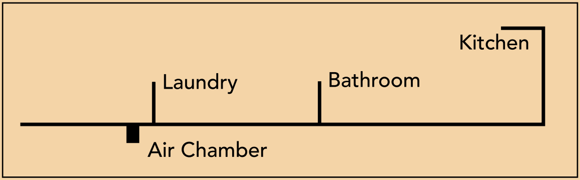




11. POSITION OF AIR CHAMBER

- One air chamber should be installed on the cold water and one on the hot water of an average house.
- In a block of units each unit needs to have air chambers installed.
- The best position for an air chamber, when only one is being installed, is on the main line (of the hot and cold lines) immediately downstream of the first branch to a quick closing valve or washing machine.
- The following examples are when the bathroom does not contain quick closing valves and the kitchen has a lever tap.





12. DAMAGE THAT HAS OCCURRED DUE TO WATER HAMMER

Metallic pipe installations.

- Excessive noise.
- Damaged valves.
- Creation of noisy valves.
- Clips loosening.

Plastic piping (the type of damage may be different for different types of pipe).

- Ruptured pipe.
- Vibration of pipe when not clipped.
- Damaged valves.
- Creation of noisy valves.
- Joints loosening and resulting in leaks.
- Clips breaking.

The installation of hammer suppression devices, whenever a quick closing valve or solenoid is installed, will extend the life of valves, fittings and appliances such as washing machines and dishwashers.

Note: There does not need to be a noise to create damage to the installation. Whenever a quick closing valve or solenoid is installed, it is only a matter of time before damage occurs unless the shock waves are controlled in both metallic and plastic piping.

13. PREFERRED DEVICES THAT WILL HELP TO ELIMINATE WATER HAMMER

- **Hammer suppression devices.**
  Hammer suppression devices include the following;
  a) Hammer arresters.
  (advantage) long lasting, some have a life time guarantee if installed as per manufacturers specifications.
  (disadvantage) greater cost
  b) Air chambers.
  (advantage) cheaper cost.
  (disadvantage) will progressively lose air and gradually become ineffective therefor they will need to be recharged with air at least every three years. This can be achieved when the water is turned off and the pipe drained to change a tap washer. The air chamber will not permanently eliminate all shock waves but will initially eliminate the noise and limit the impact on pipes, fittings and fixtures.
- **Soft closing lever taps.**
- **Ball valves** where possible in locations where taps remain in the on position.
- **Spring loaded washers** in other locations where taps remain in the on position.
- **500kPa pressure limiting valve.**

14. COPPER INDUSTRY HELPLINE

If you have been unable to resolve the water hammer problem after reference to this book, we have a service to assist by phone, fax or email.

By Phone

Call the International Copper Association Australia (ICAA) on
(02) 9380 2000

By Email

Email: **ica.australia@copperalliance.asia**

By Fax

Fax number: (02) 9380 2666

Please fax or email through a diagram of the premises indicating the following;

- All pipe work, hot and cold.
- Measurements (approximately)
- Source of the noise
- Water pressure.
- HWS location.
- Water meter location.
- Location of quick closing valves.
- Location of any additional valves (e.g. PLV at dishwasher)

International Copper Association Australia
Copper Alliance

www.copper.com.au