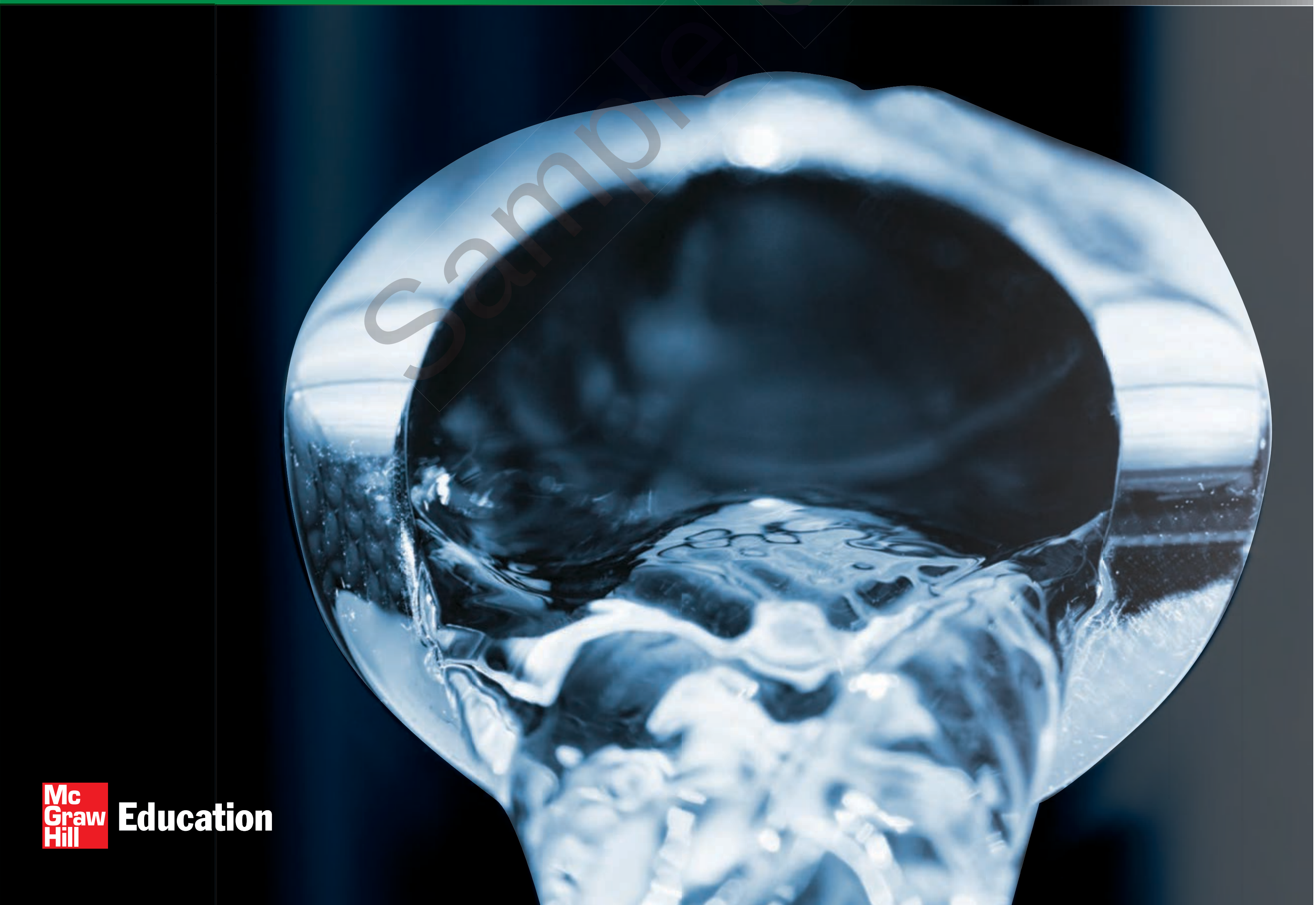
Rob Kavanagh, Peter Miles
R.J. Puffett, L.J. Hossack

3rd Edition

Water

Plumbing Services Series



McGraw Hill Education

Plumbing Services Series

Water

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Contents

PART 3 WATER SYSTEMS

Preface

This text provides an overview of how we deal with the sources, treatment and control of water. First we look at the common water collection and treatment methods and the processes associated with these, and then explore alternative methods of water supply, such as might be used where a municipal facility is not available.

The text progresses through the entire process, from collecting water from the hydrological cycle to its storage transmission and distribution, the valves and controls required, hot water treatment, and water supply to rural areas, including a chapter on pumps and pumping. The treatment and collection of rainwater on-site is also discussed and, as with most things, it varies from area to area. Your local manufacturers are a great resource in this respect. They have already done the groundwork regarding authority requirements in order to provide products that meet their needs.

The final chapters deal with insulation and noise transmission with water systems. The basis for the regulatory information in this text has been the standard AS/NZS3500 which is applicable to most areas and adopted by most authorities.

New to this edition

This latest edition is an update of the earlier editions prepared by Bob Puffet and Len Hossack and brings the text into the twenty-first century, although it must be said that many concepts and principles are timeless. As already stated, the basis is AS/NZS3500, and as such, the references to items such as 'locations, 'sizing' or 'testing' have been sourced from this document. Many of the figures from previous editions have been recreated as they still apply to today's requirements, and photographs have been added to further illustrate and support the text.

So what is new? Even though 'it still flows downhill', how it gets there is changing, with new materials such as polyethylene becoming more popular and pumping arrangements becoming more progressive. We researched the latest products and we cover sustainable practices, such as rainwater harvesting, solar heating and embodied energy.

This book is intended to be a guide to supplement your on-the-job experience. Given the limitations on what could be covered, we have repeatedly recommended that you check with your relevant local authorities as to their specific requirements in plumbing and water supply, as these do vary. Enjoy the text!

Rob Kavanagh and Peter Miles

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About the authors

Bob Puffett

After serving as the Head of School of Plumbing and Sheetmetal in NSW, Bob Puffett went on to be Director of Staff, Principal and Assistant Director General, TAFE. Bob was made a Member of the Order of Australia (AM) for his contribution to Technical Education as Director of the Sydney Institute of Technology. Following his 'retirement' Bob became National Chairman of Worldskills Australia. He now serves on local community organisations and is a Board member of a NSW plumbing training organisation.

Len Hossack

Len Hossack is a former Head of School of Plumbing, South Australian Department of Technical and Further Education and has been actively involved in his local community and with the plumbing industry in South Australia for many years.

Robert Kavanagh

Robert Kavanagh contributed most of the chapters in this edition of *Water*. Robert currently holds the position of Training Co-ordinator at the Plumbing Industry Association of South Australia. Robert has been a VET plumbing teacher since 1987 and is a qualified Master Plumber with a lifetime of plumbing experience, having entered the industry at the age of 17.

Robert's qualifications include the Advanced Certificate in Plumbing, a Bachelor of Teaching in Adult Education, Certificate IV in Workplace Education and Certificate IV in Training and Assessment. He was responsible for introducing a Certificate I in Plumbing to high schools throughout Adelaide in partnership with the Department of Education and Children's Services (DECS). He is also the author of *Basic Skills* in the Plumbing Services Series.

Apart from his extensive plumbing experience, Robert has also been teaching sailing for many years at North Haven in South Australia. After many years of sailing and study he gained his Master V Certificate in Maritime, which allowed him to gain a position as Second Officer on the sailing ship the *One and All*, sailing in Australian waters.

Peter Miles

Peter Miles contributed chapters 2 and 7 *(apart from Testing and Commissioning of Hot Water Systems, which was written by Robert Kavanagh)*. Peter is currently Head Teacher of Plumbing at North Sydney TAFE and has been teaching since 1988. He entered the plumbing industry at the age of 15, as the trend at the time for those wanting a trade was to leave in Year 10 and enter the workforce, and later moved into the teaching profession after being inspired and encouraged by several of his teachers.

After qualifying as a Licensed Plumber by completing his trade and post trade qualifications at Gosford TAFE, Peter was awarded the Kembla Scholarship in Adelaide for his efforts. His educational qualifications include a Diploma of Teaching, Bachelor of Teaching in Adult Education, and Masters of Teaching in Adult Education. He is also the co-author of *Gasfitting* in the Plumbing Services Series.

Peter's interests centre on his family and church, and on surfing, when he can find the time.

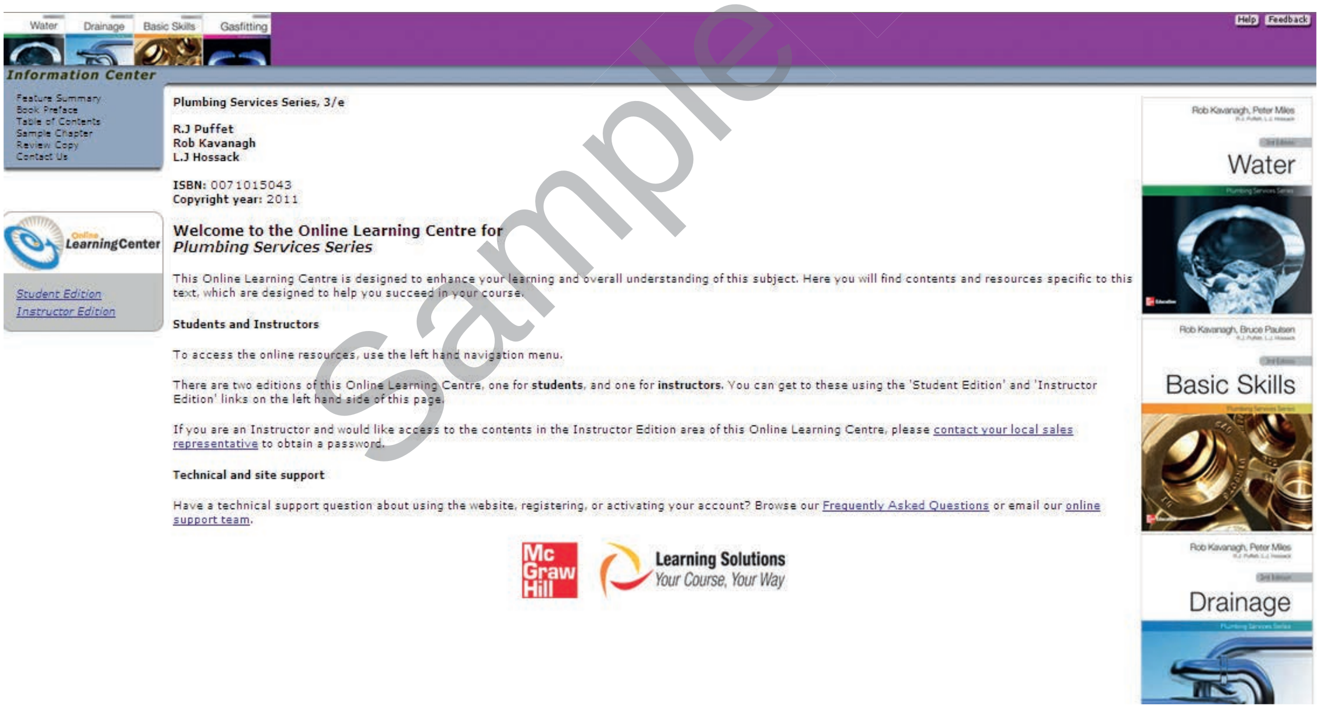
E-student/E-instructor

Online Learning Centre

www.mhhe.com/au/plumbing

The Online Learning Centre (OLC) that accompanies this text is an integrated online product that will assist you in getting the most from your course, providing a powerful learning experience beyond the printed page.

The OLC contains premium online resources. Students can access it by registering the code located at the front of this text. Instructors have access to an additional instructor-specific resource area.



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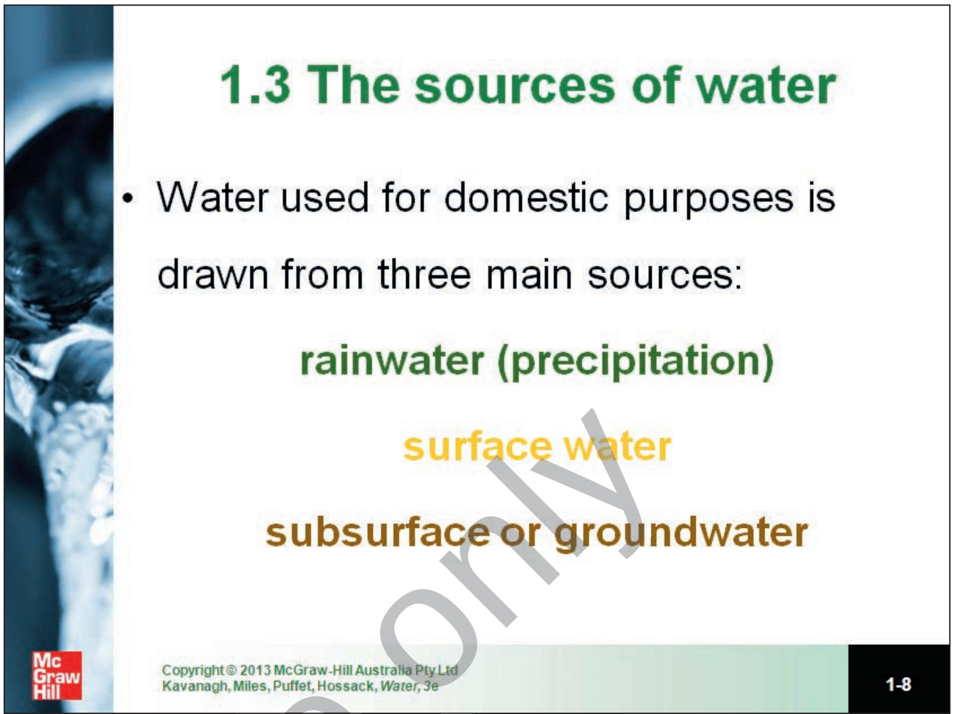
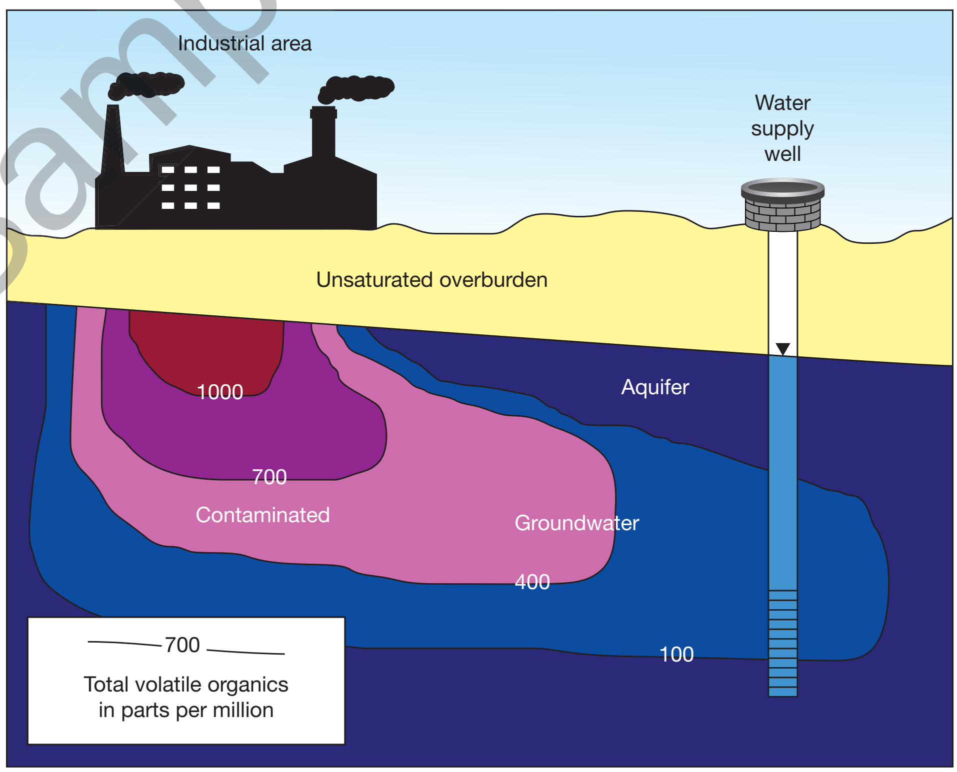
A set of PowerPoint slides accompanies each chapter and features items that provide a lecture outline, plus key figures and tables from the text.



Art Library

All the illustrations from the text are provided in a convenient ready-to-use format.



Solutions Manual

The solutions manual contains worked solutions to the chapter exercises provided at the back of the book.

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CHAPTER **THREE**

Water services and meters

LEARNING OBJECTIVES

In this chapter you will learn about:

- **3.1 Water Services Association of Australia (WSAA)**
- **3.2 safety in excavating water mains**
- **3.3 drilling and tapping**
- **3.4 installing service pipes under roads**
- **3.5 materials for water services**
- **3.6 types of water meters.**

INTRODUCTION

The 'service' is that part of the water supply system conveying water from the authority's main to the metering device, generally located inside the boundary of the consumer's property. The responsibility for laying the service pipe varies from state to state. In some areas, it is the responsibility of the water supply authority to tap the main and lay the service, while in other states opening of roads and the excavation of trenches ready to receive the service pipe is the plumber's responsibility.

WATER SERVICES ASSOCIATION OF AUSTRALIA (WSAA)

Water and sewage services in Australia are vital not only to people and households but also to industry and commercial enterprises and are provided by government-regulated water utilities. The Water Services Association of Australia (WSAA) is the peak industry body that brings together and supports this Australian urban water industry. Members provide water and sewage services to more than 16 million Australians. They also provide services to many of Australia's largest industries and commercial enterprises.

As the peak body representing the nation's urban water industry, WSAA acts on behalf of all members, providing a strong, national voice for the sector and taking a leading role in influencing urban water policy development. The WSAA regularly assesses and reports on the performance of the industry to help support members in their engagement with customers, stakeholders and the community. To implement the WSAA requirements, each state and territory also has supplementary documentation for their installation requirements.

Payment of fees

Before starting work on the laying of the service it is usually necessary to pay fees to both the water supply authority and local government authority. The fees payable to the water supply authority are intended to cover the tapping of the main, initial and subsequent inspections (which are required when carrying out all water supply work) and, in some instances, the supply of the service control valve and fittings.

The fees payable to the local government authority are intended to cover site inspections and restoration of road and footpath surfaces should these areas be damaged during the excavation and laying of the water service. In new subdivisions where roads are surfaced, and kerbing and guttering is provided, the underground mains are already laid, to prevent disturbance of the existing structures.

The opening of roads and footpaths is prohibited in some areas. Where these restrictions apply, a service conduit is supplied so that the water service may be laid without disturbing the road surface. The position of the conduit is usually marked on the kerb or by the use of coloured pegs, and notification signs are placed in prominent positions in the area (Figure 3.1).

FIG 3.1 Prominent signs are erected directly above conduits

LOCATING THE MAIN

Information about the position of water mains in relation to other underground services, such as gas mains, underground power cables and telephone cables, may be obtained from the relevant authority when fees are paid. In many cities, and especially on main roads, underground services are allocated fixed positions under footpaths and roadways. These positions are agreed upon by the various regulatory authorities. Details can be obtained by telephoning Dial Before You Dig (DBYD). Care must, of course, be exercised by the plumber during excavation.

NOTE: Prior to the commencement of any works, the contractor/licensed plumber is required to obtain the location of all services from Dial Before You Dig (DBYD) by telephoning 1100 or applying through selected outlets or online.

MATERIALS

Ductile iron cement-lined pipe (DICL)

Where DICL pipe is required for water main applications it will be detailed on the approved design drawings. Ductile iron pipe that is manufactured in accordance with the current AS/NZS 2280: 1999 uses a K(*n*) value to describe the class of pipe, for example, K9. The pipe uses a rubber ring jointing system and is internally lined with a cement mortar as specified in AS/NZS 2280. For example, SA Water has nominated class K9 for all reticulation applications with an operating pressure of less than PN16.

Polyethylene pipe

Polyethylene pipe has become one of the most widely used of all plastic systems within the water supply industry. Its advantages are its corrosion resistance, light weight and ease of installation. Long lengths are used for directional drilling and in country regions where long runs are required. A detectable underground warning tape is to be laid on top of the embedded pipe, which is a requirement of the Water Supply Construction Manual (WSCM).

Jointing methods for polyethylene pipe include the following:

- butt welding, which provides homogenous jpin ts and is essential to ensure adequate weld strength; must be carried out by a suitably skilled and /or certi ed operator
- mechanical compression
- electrofusion welding, using electrofusion couplings requiring a controlled electrical input from a welding machine.

Other important characteristics of polyethylene are its high flow capacity, high impact strength and weather resistance. The pipe is stabilised against ultraviolet light degradation by the inclusion of carbon black in the raw material, making it suitable for situations where it will be exposed to direct sunlight.

PVC-U

PVC-U (unplasticised polyvinyl chloride) accounts for a large proportion of plastic pipe installations. This is due to its excellent chemical resistance and broad range of operating pressures, ease of handling and installation, material strength and outstanding flow characteristics. PVC-U is manufactured in Australia, conforming to AS/NZS 1477: 1999.

PVC-O

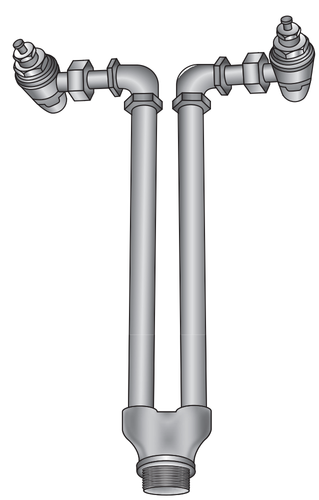
PVC-O pipes are used for medium- and high-pressure water pipe systems for potable water supply, firefighting mains, recycled water, irrigation and pumping systems. It is suitable for these purposes because of the molecular orientation manufacturing process, which strengthens the pipe to prevent cracking due to scratches. PVC-O pipes are able to absorb excessive pressure caused by water hammer. The pipes are recyclable as they can be ground up and reprocessed for use in the manufacture of other plastic products.

Existing service connections (steel and cast iron mains)

When a service control valve is to be connected to an existing steel or cast iron mains, the main is usually drilled and tapped by the water supply authority, or selected subcontractors on behalf of the authority, and the service control valve is attached. In the majority of states the most common tapping size is 25 mm BSP thread. When the service diameter exceeds 25 mm, two drillings are required, connected by a breeching piece to the service pipe (Figure 3.2).

When a service is required that exceeds 65 mm in diameter, the main is cut and a special flanged tee is used

FIG 3.2 Breeching piece



to which the control valve is attached. This work is carried out by the authority in the majority of cases.

Gibault elongated joints

These fittings are designed for use on repairs to steel or cast iron mains. They are similar to the standard repair joint except that the centre section is elongated to accommodate the tapped boss. They provide the added advantage of being able to receive a larger service than would be possible by directly tapping the main (Figure 3.3).

FIG 3.3 Gibault joint

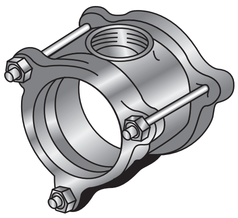
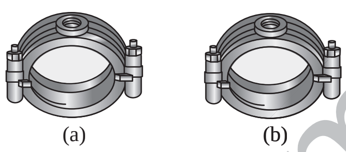


FIG 3.4 Cast iron tapping band used to connect a water service to a PVC-U main: (a) single, (b) double



Service connections (PVC-U mains)

When a service is to be connected to a PVC-U main, a cast iron tapping band is used (Figure 3.4). This is manufactured in two halves, fitted with neoprene or rubber seals, and bolted together. The connecting bosses are threaded to receive the service control valve and may be attached to the main while it is under pressure using a specially adapted drilling machine.

EXCAVATING THE MAIN

Every state and territory will have a Road Management Act that outlines the responsibilities for conducting works on roads and traffic management, and executing a duty of care. An example of this is the Victorian *Road Management Act 2004* which contains the 'Code of Practice, Worksite Safety—Traffic Management'.

It is always the contractor's responsibility to ensure that the safety and welfare of both plumbers and the public are considered. This is especially the case where excavations are carried out on private property or in a public street. It is also the plumber's responsibility to supply and erect adequate warning signs, barricades and, where necessary, covering for all excavations. Where an excavation is to be left open overnight, adequate lighting must be provided.

Where an excavation is to be undertaken on a public roadway, special care should be taken to ensure the safety of both the workers and the traffic. Figures 3.5 and 3.6 show examples of the minimum safety requirements when excavating a trench in a public thoroughfare.

Road markings should be positioned to prevent confusion. Approaching traffic is to be guided gradually to either side of excavations in the centre of the road, or around those at the edge of the road. The positioning of a protective vehicle is most important, as it provides a last line of defence for

FIG 3.5 An example of the minimum safety requirements for: (a) a trench in the centre of a road, (b) a trench near the edge of a road

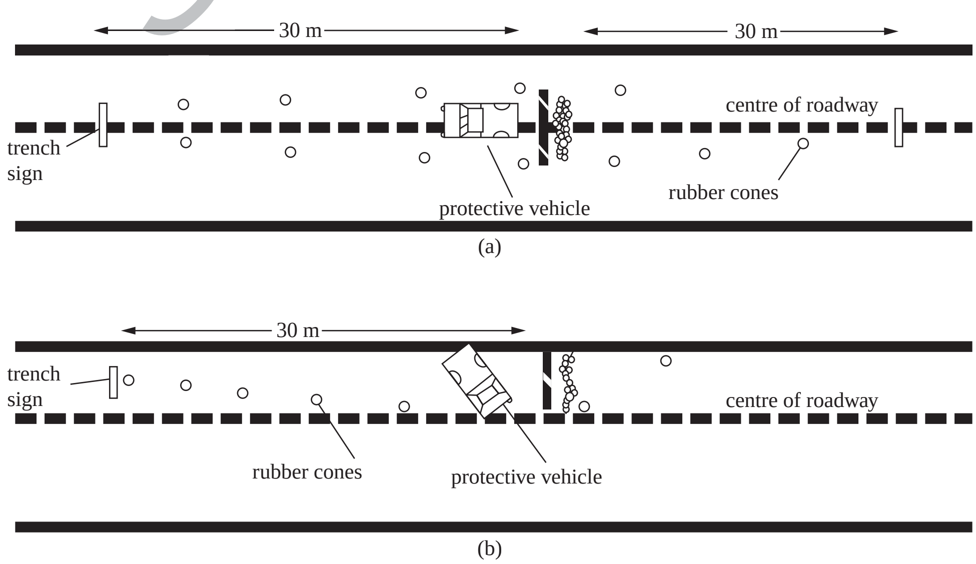
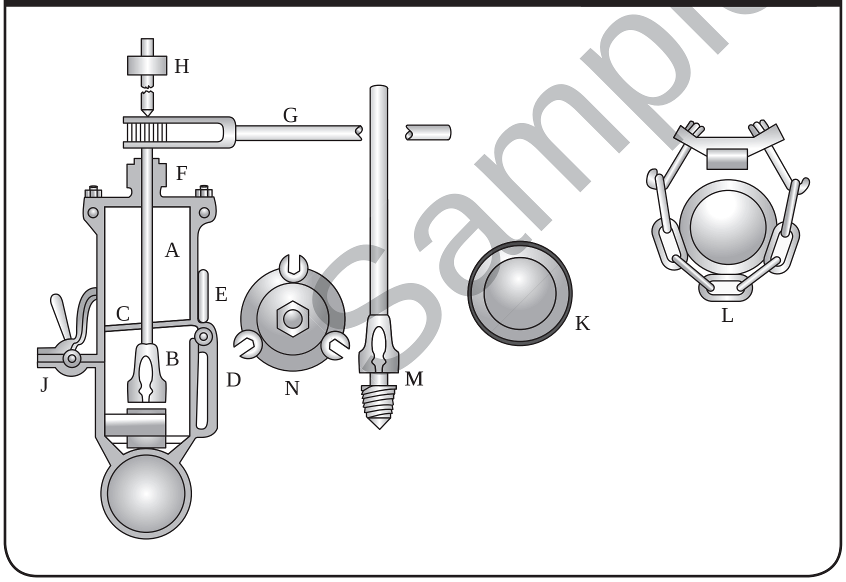


FIG 3.6 An example of traffic control

FIG 3.7 Main tapping machine



The main components of a mains tapping machine are:

A. chamber
B. chamber
C. watertight ap
D. bypass
E. valve
F. packing gland
G. ratchet handle
H. supporting frame
J. drain valve
K. sealing gasket
L. tensioning chains
M. tool spindle and holder
N. retaining ange.

workers should the driver of a vehicle fail to observe the warning signs.

DRILLING AND TAPPING CAST IRON MAINS (UNDER PRESSURE)

Drilling and tapping cast iron mains under pressure has distinct advantages over the drilling and tapping of mains with the water turned off, even though the equipment required is more complicated to use and takes a little longer. When the pressure in the main is reduced, as is the case when the water is turned off, small, previously unnoticed leaks become entry points for dirty or polluted water. When the main is turned off, ball-type hydrant valves in which the internal pressure of the water holds the ball seal in position drop open, allowing entry of polluted water into the main. Air may also enter the main at this time, causing inconvenience to consumers and accelerating internal corrosion of the main.

Figure 3.7 shows a mains-tapping machine used for drilling and tapping mains under pressure. The machine consists of two chambers, A and B, separated by a watertight flap, C. The two chambers are also fitted with a bypass, D, controlled by a valve, E, which enables the pressure in both chambers to be equalised.

Positioning the service control valve

There are four factors that influence the position of the service control valve:

- the position of the main and the material from which it is constructed
- the type of service control valve used (must be approved by the water control authority)
- the position of the service conduit (if provided)
- the position of the meter (the meter should be located at 90 degrees to the main).

PROCEDURE FOR TAPPING MAINS UNDER PRESSURE

1. Locate and excavate the main, making sure that there is ample room in the excavation in relation to its depth.
2. Mark the desired position on the main using a centre punch or diamond point chisel (Figure 3.8(a)).
3. Place the sealing gasket in position, with the starting mark centralised (Figure 3.8(b)).
4. Attach the machine to the main using the tensioning chains, taking care that the machine is located squarely on the sealing gasket (Figure 3.8(c)).
5. Place the tapping tool in the tool holder and x the retaining ange and spindle to the machine (Figure 3.8(d)).
6. Proceed to drill and tap the hole in the main (Figure 3.8(e)).
7. After the hole has been drilled and tapped to the required depth, remove the spindle and replace the tapping tool with the main control valve or ferrule (Figure 3.8(f)).
8. Replace the retaining ange and spindle to which the main control tap is attached. Screw the control tap into the main (Figure 3.8(g)).
9. Remove the machine from the main and give the control tap a nal tighten (Figure 3.8(h)).

Most water authorities will not permit the tapping of mains within a specified distance of a collar or fitting: it is vital to check requirements with the authority prior to tapping.

DRILLING AND TAPPING CAST IRON MAINS (WATER TURNED OFF)

The equipment required for drilling and tapping mains when the water is turned off is much simpler than that required for under-pressure tapping. However, the advantages of tapping under pressure are lost when the water is turned off.

SEPARATION OF SERVICES

Separation from above and below ground electrical supply cables, consumer gas pipes, water mains and underground obstructions are clearly defined in AS/NZS 3500.1.

FIG 3.8 Main tapping

LAYING THE SERVICE

NOTE: The service should be laid in a straight line from the main to the meter position and always at 90 degrees to the main. This positioning is standardised so that the service pipe may be located easily at a later date.

As previously mentioned, service conduits are sometimes provided where the service pipe is required to pass under roads. This is the exception rather than the rule and usually occurs only in newly built areas where roads are sealed and kerbs and gutters are already installed. In situations where a service is to be laid across a road and a service conduit is not provided, an alternative method must be found to locate the service pipe in the desired position.

There are four accepted methods of installing service pipes under roads. They are:

1 excavating
2 driving
3 jet ting
4 boring.

Excavating

NOTE: Prior to the commencement of any works, the contractor/licensed plumber is required to obtain the location of all services from Dial Before You Dig (DBYD) by telephoning 1100 or applying through selected outlets or online.

Excavating is only suitable where an unsealed road has to be crossed or it is known that the composition of the ground through which the service has to pass contains a high percentage of rock. Main roads authorities and local councils seldom permit the excavation of tar-sealed or concrete roads for the laying of services, unless other methods have been tried and have proven unsatisfactory. If permission has been granted by an authority to open a sealed or unsealed road, the excavation should be carried out in two sections so that traffic flow is not completely disrupted. The usual safety precautions, as shown in Figure 3.5 must be observed.

Driving

Driving is a rather primitive method of forcing the service pipe under the road surface, and the degree of success depends on the type of fill used to form the road base. If rock is used as a road base, the chance of successfully driving the service pipe is remote as even the smallest piece of rock may cause the driving point to deflect from the desired line.

The equipment required consists of a driving point, driving rods and a striking head, assembled as in Figure 3.9. Rod guides are also used to retain the driving rod in the desired position and to correct alignment. After the main has been excavated, a trench is dug on the opposite side of the road at 90 degrees to the main, of sufficient length to accommodate the driving rod, and at a depth that will give the required cover to the service pipe.

The rod guides are then driven into the bed of the trench, aligned and levelled, and the driving rod assembled in the guides. To drive the rod under the road, the striking head is struck with a sledgehammer. After one length of rod has been driven up to the second rod guide, the striking head is removed and another length of rod attached to the previous length. This procedure is repeated until the driving point breaks through at the main excavation (see Figure 3.10).

When driving is complete, the rod is removed using a puller of the type shown in Figure 3.11. To prevent the hole from collapsing during or after withdrawal of the rod, the service pipe should be inserted from the water main side as the driving rod is withdrawn.

Jetting

Jetting can only be employed where the filling beneath the road consists of sandy or loamy soils. The equipment required is similar to that used for driving except that the jetting point is fitted with holes to allow the water to flow under pressure and erode away the soil, and the service pipe itself may be used to convey the water to the jetting point.

Water supply authorities and local councils are not in favour of this method as it wastes large quantities of water, and in loose sand and soils it is likely to create excessive

FIG 3.9 Driving equipment used for boring under narrow sections, such as culverts, footpaths, existing drains

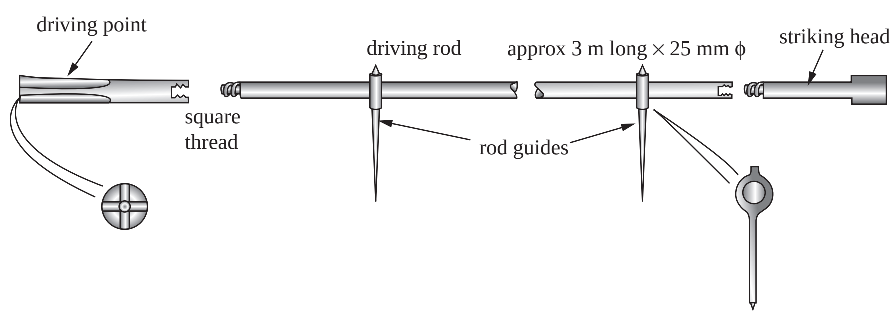


FIG 3.10 Driving under a roadway

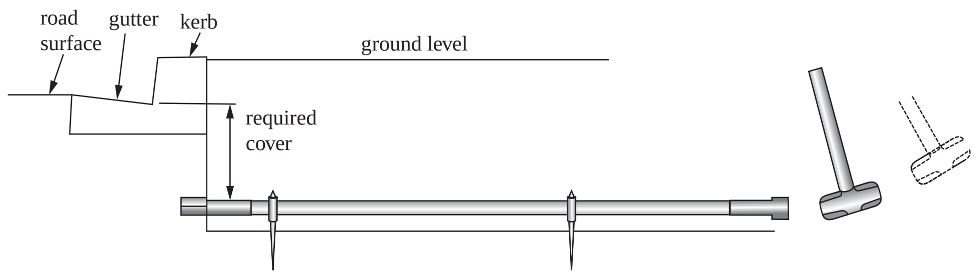
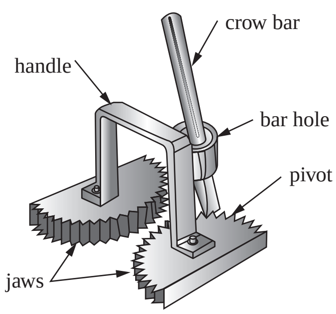


FIG 3.11 Pipe puller—as the crowbar is moved backwards, the jaw grips the rod to remove it from the bored hole



erosion which may cause the road surface to subside under heavy traffic or vibration. It is necessary to have the main drilled and tapped and the service control valve fitted prior to the laying of the service pipe.

Boring

The boring method of installing services beneath surfaced roads is by far the most commonly used, even though it has some distinct disadvantages in comparison to other methods. The main disadvantage is the inability of the operator to determine the difference between the various materials used for underground services. This often results in holes being bored through underground conduits conveying potentially dangerous substances such as electricity and gas. For this reason, extreme care should be exercised during the boring operation and the precise location of other underground services in the immediate vicinity must be known before boring commences.

Operation

After the water main has been excavated, a trench on the opposite side of the road is dug to the required depth to receive the boring cradle. The bed of the trench is levelled and the boring cradle positioned and anchored. The hydraulic pump motor is started, and the hydraulic motor rotates the boring rod and auger to penetrate for a distance equal to one length of the boring rod. Service pipes of varying diameters may be installed using this method, by increasing the diameter of the auger.

Electrical safety as stated in AS/NZS 3500.1:2003

Safety precautions need to be observed when cutting into pipework or disconnecting water meters, fittings and devices on pipework. There have been fatalities and injuries that have been attributed to water services carrying an electrical current.

Where existing metallic service pipework is to be replaced in part or in its entirety by plastic pipe or other non-metallic fittings or couplings, the work should not commence until the earthing requirements have been checked by an electrical contractor and modified if necessary. Close attention to the requirements of AS/NZS 3500.1 and the local water authority is of the utmost importance.

MATERIALS FOR DOMESTIC WATER METER SERVICES

Domestic water services are generally laid using copper or metric polyethylene pipes and fittings in diameters from 20 mm to 40 mm. Copper tubes must be in accordance with national standards, as must polyethylene pipes. Fittings used on these materials must also comply with the relevant standards.

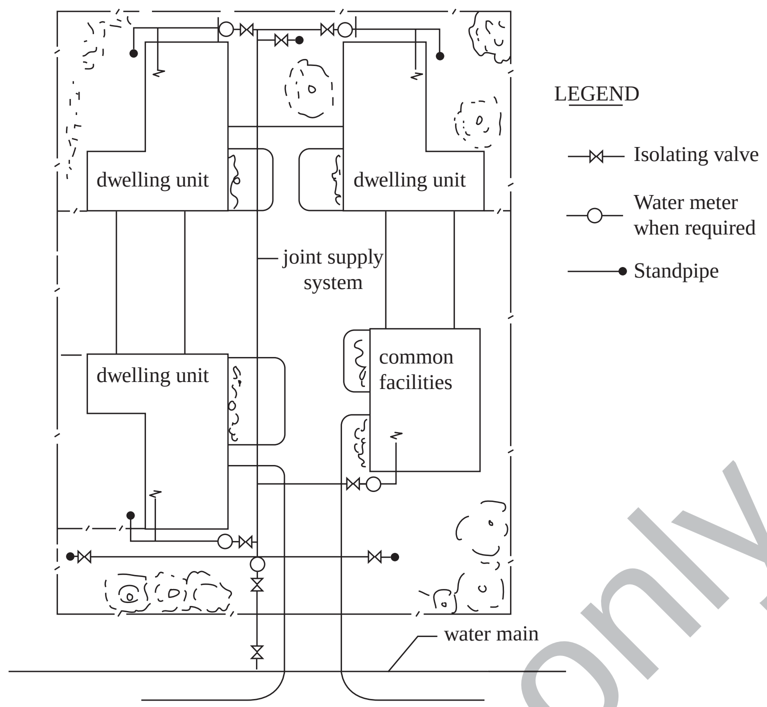
Copper and copper alloy pipes and fittings are not normally susceptible to external corrosion. However, external corrosion may occur when these materials are laid through filled ground containing ashes, salt (sodium chloride) or magnesite (magnesium oxychloride). Where the laying of pipes in these areas is unavoidable, pipes should be wrapped or coated externally with a suitable material capable of resisting the attack of these substances.

In unsewered areas, the contents of sullage pits and effluent absorption trenches may also accelerate external corrosion. Pipes in these areas should also be treated against external attack.

Metric polyethylene pipe

Polyethylene pipe is made from flexible PE80B medium density polyethylene material. It is highly cost effective and flexible for easier handling. With high-impact capabilities and UV resistance, it is manufactured to AS/NZS 4129.

FIG 3.12 Joint water supply system



Water service controls

All water supply services must be fitted with a service control valve, which is installed in the main at the point of connection with the service. The valve must be of an approved type acceptable to the water supply authority and suitable for installation below ground. Valves designed for this purpose are usually of a loose valve screw-down pattern, with the valve head securely attached to the body to prevent accidental removal of the head while the valve is under pressure.

Joint water supply controls

A 'joint water supply' is a term used for any privately owned water supply pipe that serves two or more dwelling units. Each dwelling unit and common facility used by the occupants of all units must be supplied by a separate branch from the joint supply pipe, and each must have its own isolating valve, positioned so that they can be isolated without affecting the water supply to other units or common facilities (Figure 3.12).

When this type of installation is required, an isolating valve of the loose screw-down pattern is installed in an accessible position as close to the property alignment as possible and fitted in such a way that all branch connections from the joint supply can be isolated from the water main.

WATER METERS

As a general rule, all domestic water supply installations must be fitted with a meter to record the quantity of water passing through to the consumer. They are usually installed within the property alignment in an accessible but protected position.

Selection of water meters

The selection of the size and type of water meter will be dependent on the required flow rates nominated by the applicant and the intended use of the development. All water meters used by a water corporation for billing purposes are to be of an approved type supplied by the water corporation. There are two basic types of meter in common use: volumetric and turbine.

Volumetric

The volumetric meter is a positive displacement type meter, also referred to as a piston meter. The meter incorporates a small bucket or piston with a known volume. The water flows through one orifice and fills the bucket, which then rotates and lets the water flow out through a second orifice. The number of buckets of water is converted to a total volume by the counter gearing.

VOLUMETRIC METER

Advantages:

- robust design brass body
- excellent low flow accuracy
- suitable for installation in any orientation
- suitable for water temperatures to 30 °C
- evacuated and sealed counter ensures clear reading.

Applications

Applications for volumetric metres include households and smaller commercial installations, leakage detection, and measuring flow into break tanks.

NOTE: This type of meter is generally susceptible to wear in poor water quality areas. However, the new style of volumetric meter offers superior wear resistance. High-grade engineering plastic is incorporated with the internal components, and processed using a unique moulding technique.

Turbine

With a turbine water meter, the water enters the meter body and is directed to a chamber around the measuring insert. The water then flows to the turbine via multiple passages spaced at intervals around the circumference of the insert. These passages form the 'multiple' jets of water that act to rotate the turbine. This rotation is transferred to the counter dials via the counter gearing.

TURBINE

Advantages:

- robust fully brass body and headring
- wet dial counter ensures clear reading
- direct drive from turbine to counter
- uniform accuracy over the whole of the meter life
- multi-jet configuration ensures even bearing wear
- suitable for water temperatures up to 50 °C
- excellent resistance to the impurities in water
- silent operation.

Applications

Turbine meters are used for general purpose metering (for small households and medium-sized commercial properties), and industrial installations where robust construction is required.

NOTE: Multi-jet turbine meters are typical of the meters used throughout Europe and many parts of the world. The multi-jet design is renowned for its long life and its resistance to the effects of poor water quality. To achieve their stated accuracy, multi-jet meters must be installed horizontally.

Water meter reading

Turbine meters differ from volumetric meters not only in the measuring principle they utilise but also in the way they display their measured volume. Volumetric meters typically have a single row of digits to display the reading. The first four digits are in black and represent whole cubic metres. The final four digits are in red and represent the fractions of a cubic metre.

Turbine meters use a combination of in-line digits and clock dials to show the volume of water that has been measured. The inline digits are in black and show the whole cubic metres. The clock dials have read points that indicate the fractions of a cubic metre.

Installation

Water meters must be installed level, approximately 75 mm above ground (Figure 3.13). The position selected for the meter should be within the property alignment and accessible at all times for reading and maintenance.

Where meters are installed in driveways and may be subjected to vehicular damage, they may be recessed into walls or surrounded by a suitable guard to prevent damage. Under normal circumstances meters should not be installed below ground. However, in areas where the temperature may drop to below freezing, the meters may be installed below ground, subject to special approval, in a properly constructed and drained box (Figure 3.14).

Meter controls

Every meter is required to have a control valve fitted at the inlet. This control is of the loose valve screw-down pattern and incorporates a 'T' head or similar suitable for hand operation. Some authorities allow for a right-handed, lockable ball valve to be installed, providing the minimum backflow requirements are met.

On installations that involve excessive lengths of outlet pipework from the meter, or on multi-storey installations, an additional control valve may be fitted at the outlet of the

FIG 3.13 Water meter installed above ground

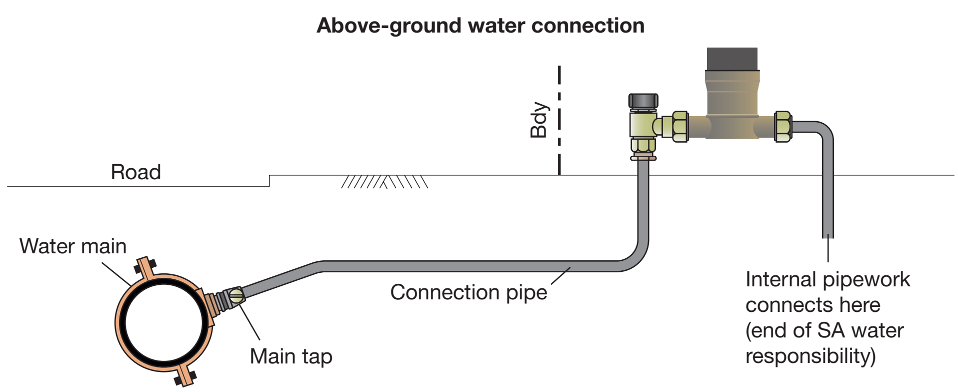


FIG 3.14 Meter installed in box

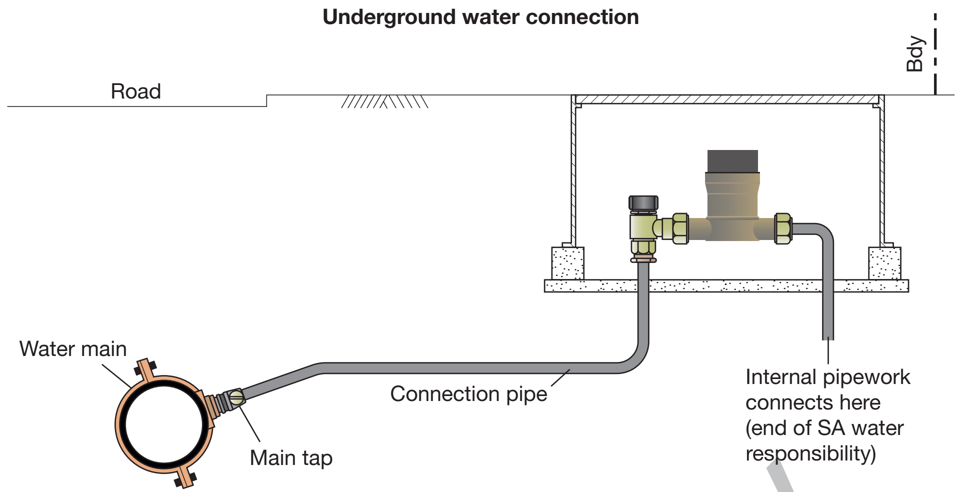


FIG 3.15(a) Installed water meters

FIG 3.15(b) Installed water meters

meter. If the meter is disconnected, this valve prevents the backflow of water contained in the pipework which could create a hazardous situation.

Back ow prevention

Some states and territories require all new connections and redevelopments to have an appropriate backflow prevention device fitted at the outlet of the main water meter (containment protection) in accordance with plumbing regulations incorporating the Plumbing Code of Australia.

If the risk category of a non-residential development is unknown at time of application, the water corporation may require the installation of a high-hazard backflow prevention device. For single residential properties, a low-hazard dual check valve may be required to be installed at the outlet of the water meter (Figures 3.15 (a and b)).

NOTE: Where the installation of an appropriate zone or individual hazard backflow prevention device is necessary in accordance with the provisions of AS/NZS 3500.1:2003, the relevant water corporation may require, as a minimum, the same level of protection installed as a containment backflow prevention device at the outlet of the property main water meter.

Where above-ground rainwater tanks are installed to provide toilet flushing, and it is intended to interconnect the reticulated drinking water supply system from the relevant water authority, an appropriate containment backflow prevention device will be required at the outlet of the main water meter to the property. In such cases, as a minimum, the device is to be a watermark approved, dual check valve.

SUSTAINABLE PLUMBING: RECYCLED WATER

Recycled water is water taken from any waste stream and treated to a high standard so it can be used for a new activity. Recycled water can refer to fully treated effluent from sewage treatment plants.

Recycled water is a secure alternative water source that, when treated as required, is fit for a range of purposes, such as:

- agricultural irrigation
- industrial processing such as for cooling
- municipal uses such as watering parks and gardens
- domestic uses such as toilet flushing, car washing and garden watering.

As an example, an extensive system of pipes and aqueducts distributes water from Melbourne's water storage reservoirs to the retail water companies and their customers.

National guidelines, such as Australian guidelines for water recycling, require the water to be 'fit for the intended purpose'. Environmental factors, such as salinity and nutrient levels, also need to be considered to ensure recycled water is suitable for the intended use.

Upgrades to sewage treatment plants have improved the quality of recycled water and made it suitable for a wider range of uses. Water companies, in conjunction with water industry partners and the government, are continuing to develop programs to support recycled water to be used by farmers, industry, local councils and households.

NOTE: It is important to match the quality of recycled water to its intended use.

FOR STUDENT RESEARCH

Investigate and report on approved materials (not those covered in this text) for water services in your area. Include in your report any specific requirements for these materials.

Australian Standards

AS/NZS 3500.1 Plumbing and drainage—Water services

AS 3565 Meters for water supply

AS/NZS 2845 Water supply—Backflow prevention devices

AS/NZS 1477 PVC pipes and fittings for pressure applications

AS/NZS 2032 Installation of PVC pipe systems

AS/NZS 4441 PVC-O pipes for pressure applications

AS/NZS 4765 Modified PVC (PVC-M) pipes for pressure applications

CHAPTER **SIX**

Insulation and noise transmission

LEARNING OBJECTIVES

In this chapter you will learn about:

- **6.1 thermal insulation**
- **6.2 types of insulating materials**
- **6.3 noise transmission in pipework**
- **6.4 how water hammer arrestors work**
- **6.5 water hammer causes and remedies.**

INTRODUCTION

Attention must be given in any plumbing system to minimising the heat losses through radiation and conduction caused by exposed surfaces such as hot pipes, storage vessels and boilers. To prevent heat loss some form of heat-resisting insulating material, commonly called 'lagging', is needed. A short definition of 'thermal insulation' is that it is 'a material applied to surfaces in order to reduce the amount of heat emitted by the pipes and boilers'. Heat loss occurs when there is a difference in temperature between exposed pipework and the surrounding air. The efficiency of an insulation material depends upon the number of air spaces existing within the material, its durability and resistance to change by heat.

INSULATION MATERIALS

A large number of insulating materials are in common use throughout the plumbing industry. Each material is designed for specific applications and care should be taken to ensure that the material selected is suitable for both the temperature range expected and the location (Figure 6.1). It is important to remember that some insulating material becomes ineffective when wet, so care should be taken when installing external lagging to protect it from weather and physical damage.

Some common types of insulating materials and their applications are:

1. microcellular PVC (hot and cold copper piping, chilled water)
2. aluminium foil and metal sheathed mineral wood (hot piping)
3. EPDM rubber– thylene propylene diene monomer (M-class) rubber (exposed solar hot piping, steam lines up to 150 °C)
4. reflective foil laminate and metal sheathed styrene foam (cold piping)
5. reflective foil laminate and metal sheathed isocyanurate foam (cold piping)
6. reflective foil laminate and metal sheathed mineral wool (cold piping)
7. high-density polyethylene-encased and galvanised-steel encased rigid polyurethane foam (hot and cold piping)
8. high-density polyethylene-encased rigid foamed glass (hot and cold piping)
9. reflective foil laminate sheathed foamed glass (hot and cold piping).

SUSTAINABLE PLUMBING: INSULATION SOLUTIONS

The growth of high-density living, residential apartments, hotels, motels, aged care buildings, townhouses and other attached buildings, has resulted in an increased demand for noise abatement methods and materials which will allow for a better quality living environment. The construction industry is now requiring sustainable insulation solutions to protect both the built environment and the natural environment. The changing regulations and requirements set out by the Building Code of Australia (BCA) regarding energy efficiency and acoustic insulation solutions must be achieved by manufacturing products that meet the highest thermal, acoustic and fire safety performance levels.

FIG 6.1 Insulation to solar close-coupled units needs to be weather resistant and withstand high temperatures (possibly up to 99 °C)

Some other materials that have been used in the past for insulating pipework and that may be encountered during maintenance are:

1. hair felt
2. cork (sheet and granulated)
3. magnesia
4. rock wool
5. asbestos.

NOTE: Care should be exercised. Do not handle asbestos materials as inhaled dust particles may present a health risk.

TRANSMISSION OF NOISE IN HOT AND COLD WATER SYSTEMS

Sanitary fittings associated with hot and cold water systems need to be conveniently placed in any building but should not be obtrusive. Water services are potential sources of noise and the planning and installation of the services should therefore be carefully carried out to avoid the production and transmission of noise.

Sound is louder and travels much faster in water than in air; a noise transmitted through the air may be inaudible from a certain distance but quite audible if transmitted the same distance through a water service. Noises in water services, however, vary in kind and intensity. Some noises are caused by:

- water being disturbed as it ows through pipes and ttings
- peculiarities in the moving parts of taps and valves
- the behaviour of water at the discharge point.

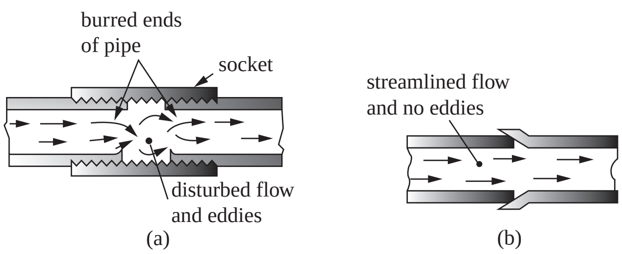
Disturbance through pipes

Noise can be transmitted by the pipes themselves in larger residential buildings such as home units (Figure 6.2). Plumbers may signal to one another by tapping on the pipe

FIG 6.2 The BCA requires waste pipes to be acoustically insulated, especially where they pass over habitable areas

with a metal tool. Probably the most common and obvious noise in water services is the 'singing' or 'humming' noise caused as water passes through the pipe. All internal pipe surfaces tend to cause friction, which forms eddies in the flow, and it is the eddying of the water that causes this noise. The noise can also be intensified by a number of factors such as roughness of the internal pipe surface, a large number of joints, an acute change of direction and the velocity of the flow (Figures 6.3 and 6.4).

FIG 6.3 Joint in drawn copper tube: (a) disturbed flow, (b) streamlined flow



Moving parts of valves and taps

High-pitched humming or screaming noises can be caused by a jumper valve spinning in a screwed-down valve or tap. This is caused by the water passing over the serrated face and edges of a worn tap washer. The loose stem of the jumper valve within the spindle produces the noise. It can usually be cured by replacing the worn washer.

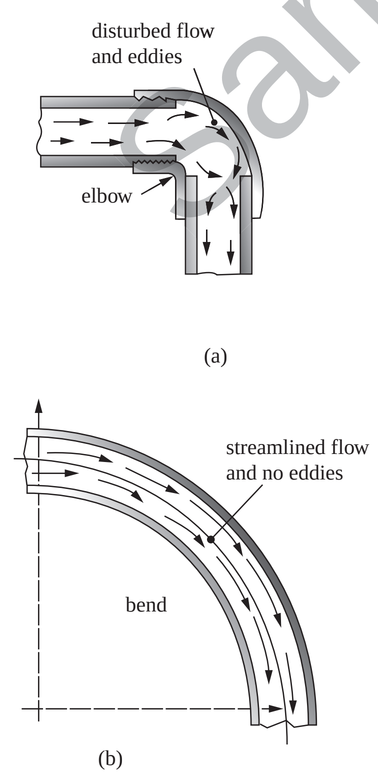
Chattering noises can also be caused by loose parts such as jumpers in screwed-down taps and valves, and lever

REDUCING NOISE IN PIPES

The following precautions should be taken to reduce or prevent the cause of friction noise in pipelines.

1. Use pipe that has a smooth internal surface. The internal mirror nish of drawn copper pipe is preferred to that of the rougher internal nish of galvanised mild steel.
2. Unnecessary ȷ̇in ts should be avoided– lan the ȷ̇b to overcome this problem. Ream any cut ends of tube with the appropriate tool to allow a full bore and smooth end. Where a tting is necessary to make a ȷ̇ int, give preference to a tting that is the same bore as that of the tube to which it is to be tted.
3. Any changes in direction should be made by bend if practicable. It is generally accepted that if the radius of a bend is not less than ve times the diameter of the pipe, the velocity of the ow will not be reduced. The smaller the reduction in velocity, the smaller will be the resulting noise-causing eddies.
4. It is essential to consider the velocity of the ow in planning a pipeline;all t he pipes should be large enough to ensure that when water is drawn off, the rate of ow is within the capacity of the pipe. Unfortunately, this is not always given suf cient consideration by many plumbers who may, in picking up an individual tting that is too small, dramatically reduce the pipe size in the interests of economy.

FIG 6.4 (a) Disturbed flow in elbow, (b) streamlined flow in bend



arms and pistons in ball valves; parts of the taps and valves become worn causing them to loosen. To remedy this situation either the worn parts are built up by the addition of new metal or the offending part or valve is replaced.

Behaviour of water at the discharge point

A common noise in water pipelines is the screaming caused by water flowing through a restricted orifice or opening smaller than the bore of the pipe through which the bulk of the water is flowing. The greater the pressure, the greater will be the flow through the orifice in a given time, which increases the noise.

Ball float valves, because of their design, are a common cause of this noise. In most ball float valves the size of the valve orifice is less than that of the pipe supplying the valve; the shape of the piston chamber and ball float valve outlet may also restrict the flow. The noise frequently increases in volume before the valve orifice is closed, when the flow of water is restricted by the face of the piston as it approaches the valve orifice. To eliminate or reduce this noise, close the stop valve controlling the ball float valve sufficiently to reduce the noise. At the same time allow sufficient water to flow through to the ball float valve at a reasonable rate.

WATER HAMMER

Water hammer may be defined as a noise resembling a succession of hammer-like blows on a water service pipe. It is a shock wave that may be felt and heard. For all practical purposes water may be considered to be incompressible when travelling at high speed. If suddenly arrested, by the closing of a valve or tap, a great force is exerted; the pressure is increased above the flow pressure by approximately 350 Pa for each 300 mm/s of sudden decrease in water flow. For example, if a water flow of 3 metres is suddenly arrested, it produces a maximum water hammer pressure of 3500 Pa or 3.5 kPa. The principle of the hydraulic ram is based on the action of water hammer.

Water hammer occurs frequently; the shock may be transmitted throughout a water service and through the main supply to other services such as a hot water service. The high pressures that develop may cause damage because the increase in pressure results in tension stresses being increased on both the pipes and fittings, which may burst as a result. The added strain from this increase is put on all valves and taps in the service. A decreasing 'pulsating' effect may also be set up in the water; this can be felt and heard, and may become a nuisance to the occupiers of the premises.

The intensity of water hammer is influenced by three main factors:

1 Loose pipes causing a drumming effect as they vibrate against the walls or foundations, especially a wooden bearer foundation or metal-clad wall.

2 Closing the tap or valve too fast. This increases the intensity of the hammer.

3 Pressure in the service. The higher the pressure in the service, the more severe will be the hammer.

Locating a water hammer

The most common sources of water hammer are:

1 Spring-loaded taps. These are not commonly used on most domestic services, but could be installed, for example, as a bubbler for children. These snap close unless they are of the non-concussive type.

2 Rubber washers on taps and valves of the hemispherical type. These are usually composed of rubber, sold with the jumper part for the repair of a screw-down tap or valve. This type of washer not only closes the orifice suddenly but also presses down into the tap or valve orifice, transmitting additional thrust to the water in the service after the orifice is closed.

3 Ball float valves. These are not a major cause of water hammer, because they normally close slowly, but they may set up a secondary hammer after the valve has been forced open by the initial hammer and the ball-float has been caused to bounce.

4 Plug cocks or low-pressure taps. These are not normally used on high-pressure services, because there is no method of preventing back feed into the main supply, and this is prohibited by most statutory authorities. These plug cocks or low-pressure taps, however, are sometimes installed inadvertently by the owners of premises, and the sudden stop to the flow of water causes water hammer.

5 Sharp changes in direction, which can set up **turbulence in flow.** When the water flow on the outlet side is stopped suddenly, the water entering the inlet side of the bend hits against the water that is stationary.

6 Incorrect clipping or support for pipework

Removal of a persistent water hammer

Should the remedies recommended above or the cost of rearranging the installation be too expensive or unwarranted, a water hammer arrestor should be installed as near to the tap or valve causing the water hammer as practicable. To understand the principles of water hammer arrestors, we can look at how an air chamber works.

REMEDIES FOR WATER HAMMER

1. Fit spring-loaded taps with a flow-control valve, which is a non-concussive spring-loaded valve designed to close slowly to avoid causing water hammer.
2. Replace unsuitable tap washers with flat fibre or neoprene washers.
3. Decrease the supply of water to ball float valves
4. Replace low-pressure taps with high-pressure taps of the loose-valve type, to bring the service into line with the regulations (most statutory authorities prohibit the use of plug cocks on high-pressure services).
5. Rearrange the water service layout to replace sharp changes of direction—it may be expensive, but necessary. Use easy radius bends on all water services to reduce the risk of water hammer.
6. Increase the number or type of pipe supports.
7. Ensure accurate pipe sizing to limit the velocity to 3 metres/second.
8. Maintain a maximum of 500 kPa pressure.

Principles of an air chamber

The air chamber needs to be strongly constructed—standard pipe fittings are often used and are perfectly airtight. Provision must also be made for draining the air vessel for the purpose of replacing the air that becomes absorbed by water.

When the bulk of the air in the chamber is absorbed the water will be heard again; when this stage is reached it is necessary to replenish the air in the chamber. The air may be renewed by draining the service of water and allowing air to enter through an adjacent valve or a special valve in the vessel itself. This valve needs to be in an accessible position or the renewal of the air may be neglected. Figure 6.5 shows various types of air vessels.

The problem of noise or water hammer in water services is not a simple one. A noise may be caused in one

FIG 6.5 Air vessels available for different applications

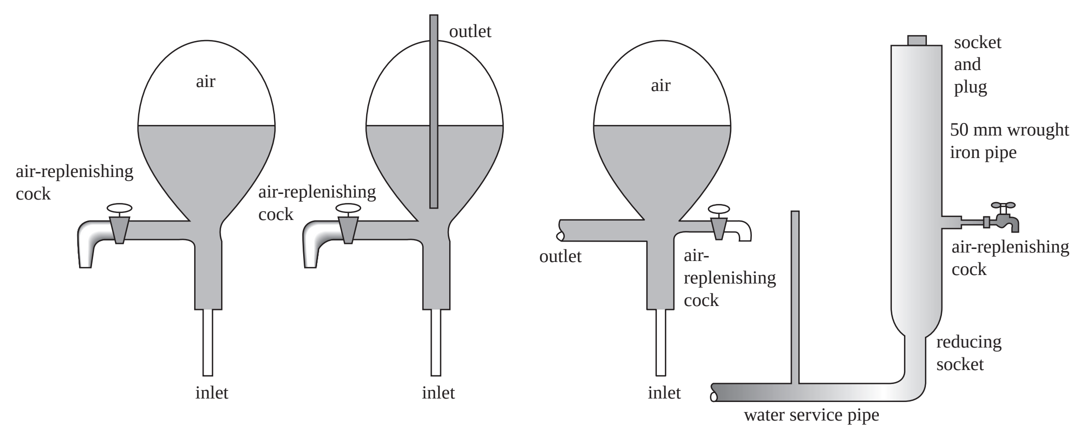


FIG 6.6 (a) and (b) Examples of modern water hammer arrestors

(a) (b)

place and yet be transmitted a considerable distance; the noise may not necessarily be caused by the valve or tap that is first opened. Finding the source of the noise or hammer can be time consuming and thus expensive.

Modern water hammer arrestor

Modern water hammer arrestors work on the principle of compressing air to absorb the induced pressure wave. The arrestor is placed at 90 degrees to the water flow, just upstream from the offending device. When the device closes, the pressure wave begins to move back along the pipe. As it reaches the arrestor the force acts against a piston, which in turn pushes against a charge of air that is compressed, dissipating the wave energy and nullifying the hammer effects (Figure 6.6).

FOR STUDENT RESEARCH

1. With the assistance of your supervisor, investigate and document any signs of water hammer within your school campus.
2. Investigate and document the approved methods of disposal of asbestos products in your area. List the state or local authorities responsible for these.

Australian Standards

AS/NZS 3500.1 Plumbing and drainage—Water services

AS/NZS 3500.4 Plumbing and drainage—Heated water services

AS 1530.3 Methods for fire tests on building materials, components and structures

AS/NZS 4859.1 2002 Materials for the thermal insulation of buildings

AS/NZS 2712 Solar and heat pump water heaters—Design and construction