ABCB

PLUMBING CODE DEVELOPMENT RESEARCH REPORT

Warm Water Systems

2015

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1 Introduction

This report contains the findings of a review of available material on the design, installation and maintenance of warm water systems. It was developed as part of the Australian Building Codes Board (ABCB) Plumbing Code Development Research Project.

As explained in more detail further into the report, warm water systems are heated water supply systems installed in situations where otherwise acceptable heated water delivery temperatures are considered too high for building occupants who may have an increased susceptibility to scalding. Although system design can be similar to circulatory systems that are used to distribute heated water at higher temperatures for more general use, the differences are in the delivery temperature of the water and the additional management and maintenance processes necessary for the control of bacterial growth.

Currently, there are no prescriptive solutions available under the Plumbing Code of Australia (PCA) for the design, installation and management of warm water systems. Such systems are designed specifically for individual projects, some using manufactured proprietary systems, all based on hydraulic and mechanical design principles, and in accordance with specific requirements of jurisdictional health regulatory authorities.

1.1 About this report

The report contains a range of information drawn from existing material on warm water systems, including regulatory requirements, State and Territory based advisory information and National Construction Code (NCC) provisions relevant to these areas.

The information was gathered through a review of known publications and State and Territory regulatory documents and manufacturer's literature regarding products specific to warm water.

Information sourced for this document has been structured in a format similar to one that a designer would follow in the development of a warm water system, i.e. design, installation and maintenance. The report, however, should not be considered to be a complete reference on the design and installation of such systems.

The report includes numerous examples of warm water systems and accompanying figures to assist in understanding the broad range of options currently available in public material. The figures have been developed to reflect those found in the source material but redrawn in a consistent format for ease of comprehension. The definitions of certain terms, abbreviations and symbols used in figures are set out in Appendix D.

1.2 About the Australian Building Codes Board

The Australian Building Codes Board (ABCB) is a Council of Australian Government (COAG) standards writing body that is responsible for the National Construction Code (NCC) which comprises the Building Code of Australia (BCA) and the Plumbing Code of Australia (PCA). It is a joint initiative of all three levels of government in Australia and was established by an Intergovernmental agreement (IGA) signed by the Commonwealth, States and Territories.

The ABCB addresses issues relating to safety, health, amenity and sustainability in the design and performance of buildings through the National Construction Code (NCC) Series, and the development of effective regulatory systems and appropriate non-regulatory solutions.

The three volumes of the NCC are drafted in a performance format allowing a choice of Deemed-to-Satisfy Provisions or flexibility to develop Alternative Solutions based on existing or new innovative building, plumbing and drainage products, systems and designs.

2 Warm water systems

Warm water systems distribute water to outlets used for personal hygiene purposes such as showers, basins and baths, at a reduced temperature, to minimise the risk of scalding. They shouldn't be confused with the 'heated water system' typically installed in all, or most, buildings, including circulatory heated water systems that are designed to distribute heated water at higher temperatures, although there are numerous similarities.

According to New South Wales Health, in their publications (Part A - Approval specification for operational testing of thermostatic mixing valves for use in non domestic buildings in New South Wales, 2014) and (Part B - Approval specification for operational testing of warm water generating systems not incorporating thermostatic mixing valves for use in non domestic buildings in New South Wales, 2014) warm water systems deliver heated water at temperatures of between 40.5°C and 43.5°C. This is lower than that usually provided for personal hygiene purposes, which is a maximum of 45°C in certain high scald risk situations and 50°C more generally. Although many of the systems discussed in this report could also be used for higher temperatures, the focus in this case is on warm water systems utilising lower temperatures only.

Warm water systems are commonly used in hospitals, health care buildings and aged care facilities but they can also be installed in a large range of buildings, including residential apartment blocks, accommodation buildings such as hotels and even hairdressing salons. There are two main types of warm water systems; reticulated and centralised circulatory.

As noted above, these systems are generally installed to reduce the likelihood of scalding, but the reduced temperature can also introduce other risks such as microbial growth. Water within a certain temperature range promotes the development of potentially pathogenic microorganisms, including Legionella, if systems are not designed, installed, managed and maintained with this in mind.

The information provided in this report predominantly focuses on those building types mentioned above but, depending on the need, it could also be relevant to other building types, although this would be considered rare due to cost implications and ongoing maintenance requirements.

There are a number of factors to take into consideration when undertaking any work on a warm water system such as system design, installation configurations, ongoing maintenance and State and Territory Regulations; these will all be covered through the report with jurisdictional Regulations, Codes and guidelines listed in Appendix A. No local government specific requirements have been identified through this review.

3 Design

There are many different pipework configurations and heating variants used in the design of warm water systems, with many of these also used for general purpose heated water installations. Some systems distribute heated water to thermostatic mixing valves (TMV) which are installed within the sanitary facility it serves. In these, untempered branches can serve other fixtures not intended for personal hygiene purposes thus not requiring temperature control, such as kitchen sinks or laundry troughs. Other systems distribute water at the desired temperature, circulated around the building and usually incorporate a means of system disinfection.

The design of a warm water system will be affected by many things such as building type, use and layout, heating plant energy source and location and State and Territory plumbing, building and health regulations. One necessity and general requirement found in the majority of regulations covering these systems is the need to incorporate in the design a means of disinfecting and draining the system.

3.1 Types of warm water systems

There are generally two types of warm water systems, *'reticulated'* and *'centralised circulatory'*. These are described in the following sections with associated figures to assist in their explanation. A glossary of the symbols is provided at Figure 19 and abbreviations used at the figures is in Appendix C.1.

There are also proprietary systems available from a number of different manufacturers, these system incorporate a number of components into a pre-packaged set up for warm water temperature control. These will not be discussed in this report.

3.1.1 Reticulated Systems

A reticulated system is where heated water is distributed to one or more sanitary facilities with water temperature regulated via a thermostatic mixing valve. This system is primarily used where there are a small number of fixtures within the property and the water heater is in close proximity to the outlets. For reticulated systems where the temperature of the water is to be maintained within the pipework heat trace wires can be installed. Simplified versions of reticulated systems are captured in 3.1.1 for a One pipe reticulated system and 3.1.1.2 for a Reticulated system incorporating heat trace cables

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3.1.1.1 One pipe reticulated system

A single pipe system that distributes heated water to outlets or temperature control devices; typical examples are shown at Figure 1 and Figure 2. This system is primarily used in small installations where the water heater can be located in close proximity to the outlets.

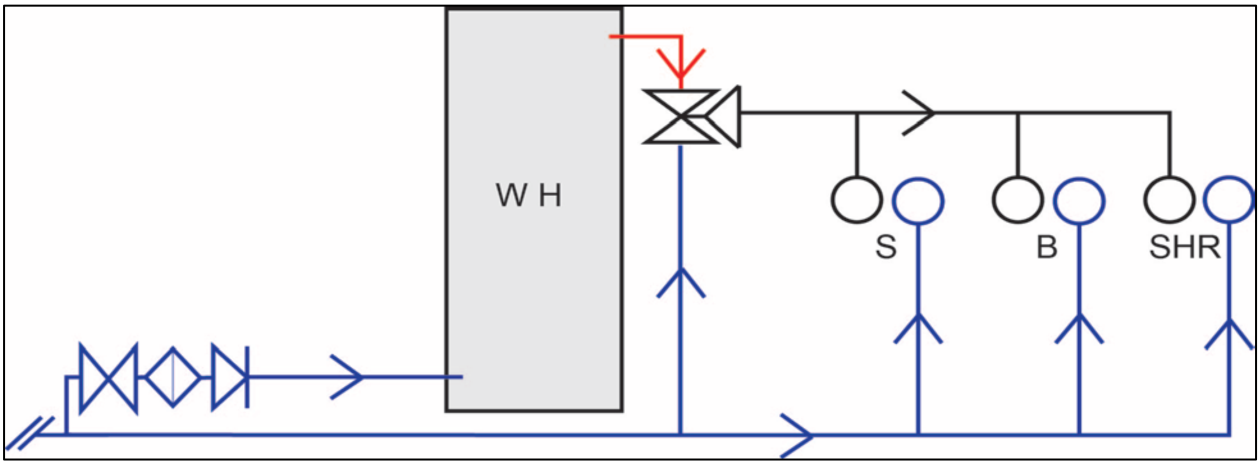

Figure 1: Typical example of a fully tempered reticulated warm water system.

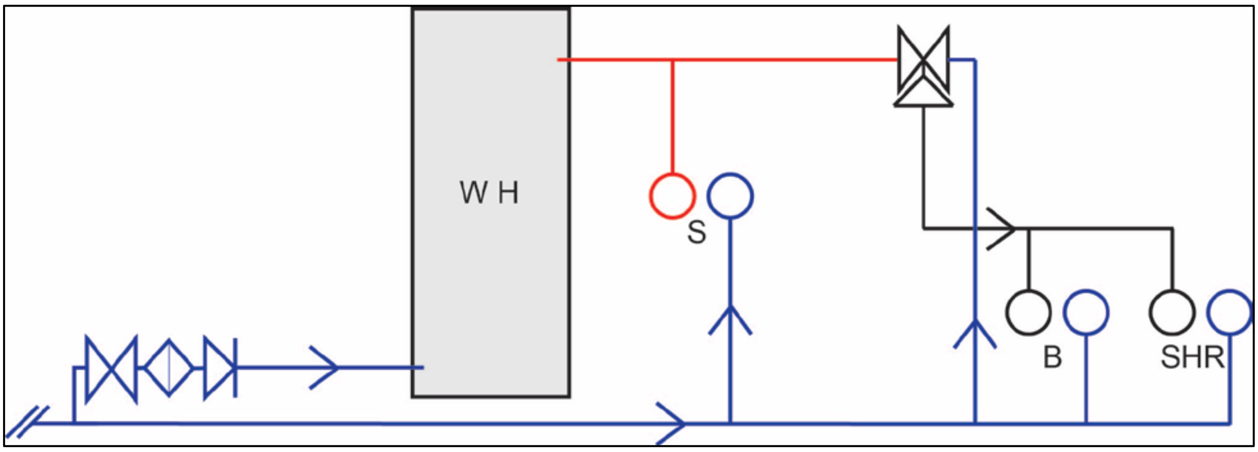

Figure 2: Typical example of a partially tempered reticulated warm water system.

3.1.1.2 Reticulated system incorporating heat trace cables

This is a reticulated system where the water temperature is controlled through thermostatic mixing valves and is distributed throughout a building with the temperature maintained throughout the pipework by a heat trace cable, an example is shown at Figure 3. Pipework with heat trace cabling installed should be permanently labelled at regular intervals to alert practitioners to its presence. Mechanical protection such as metal cladding should also be installed and effectively bonded to an earthing conductor when utilising this type of system. A risk assessment should be undertaken when determining if a heat trace system is suitable.

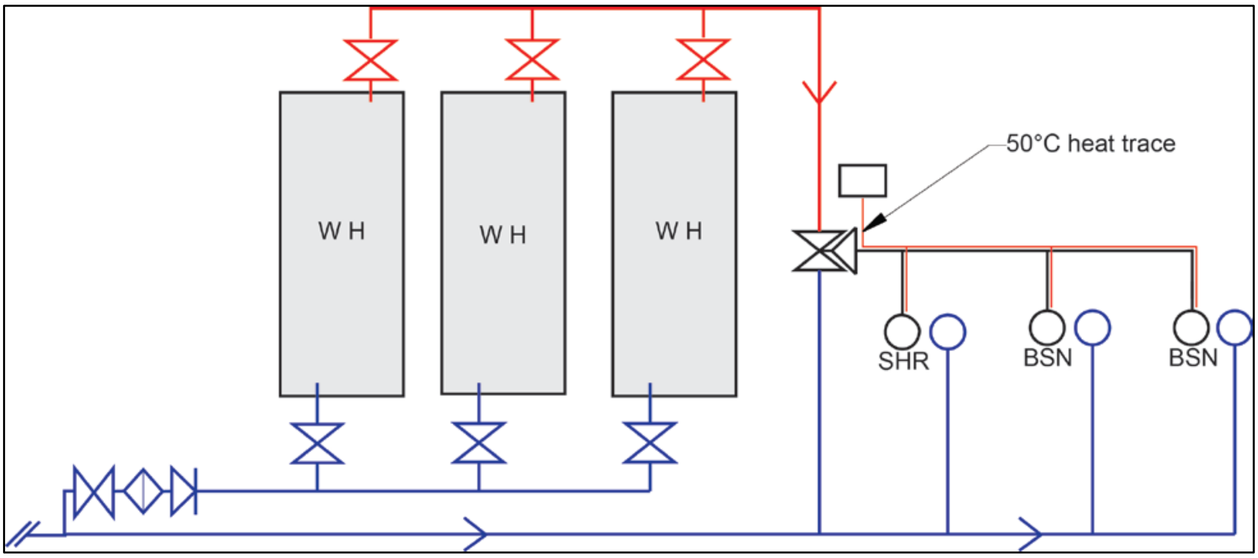

Figure 3: Typical example of a reticulated warm water system incorporating heat trace wire.

3.1.2 Centralised Circulatory Systems

A centralised circulatory system maintains a constant temperature by drawing heated water through the system via a pump or pump set, see Figure 4. The water temperature is controlled by either:

- a temperature control device, such as a thermostatic mixing valve; or
- through a temperature sensor.

Thermostatic mixing valve.

Where water is blended as it passes through the thermostatic mixing valve to the required temperature, the valve also provides a failsafe function causing a thermal shutdown if there is any disruption to the cold or heated water supplies. An example is shown at Figure 4. Reducing the water temperature as close as possible to the outlet also reduces the risk of bacteria growth within the system by maintaing a higher temperature.

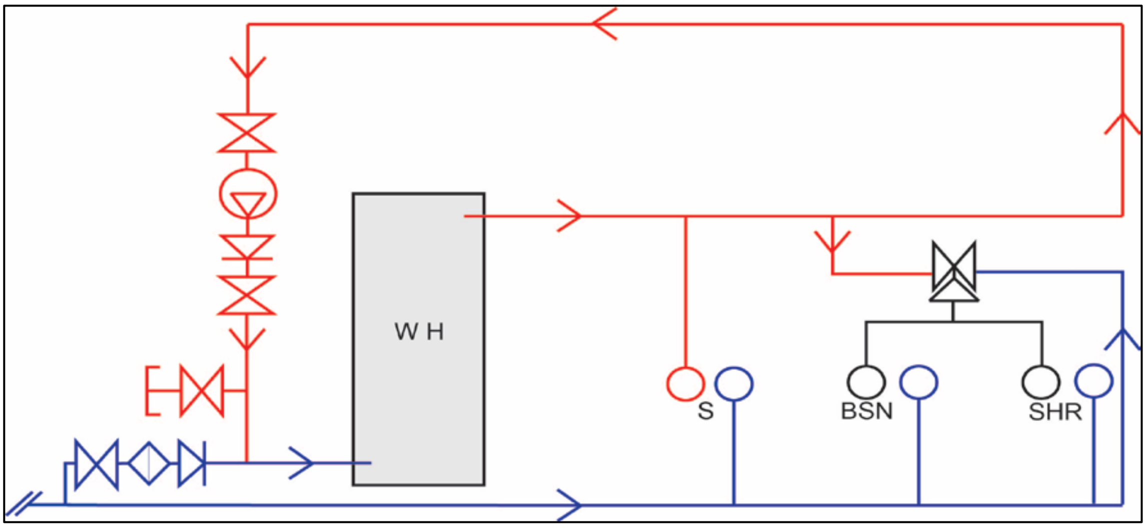

Figure 4: Typical example of a circulating warm water system controlled by a TMV.

Temperature sensors.

Where the water temperature is digitally monitored and adjusted automatically through a modulating valve or water heater burner. One example is through the use of a continuous flow water heater, as shown at Figure 5, and another is through the use of a modulating valve, as shown at Figure 6. These systems can also incorporate ultra violet sterilisation to maintain disinfection of the warm water.

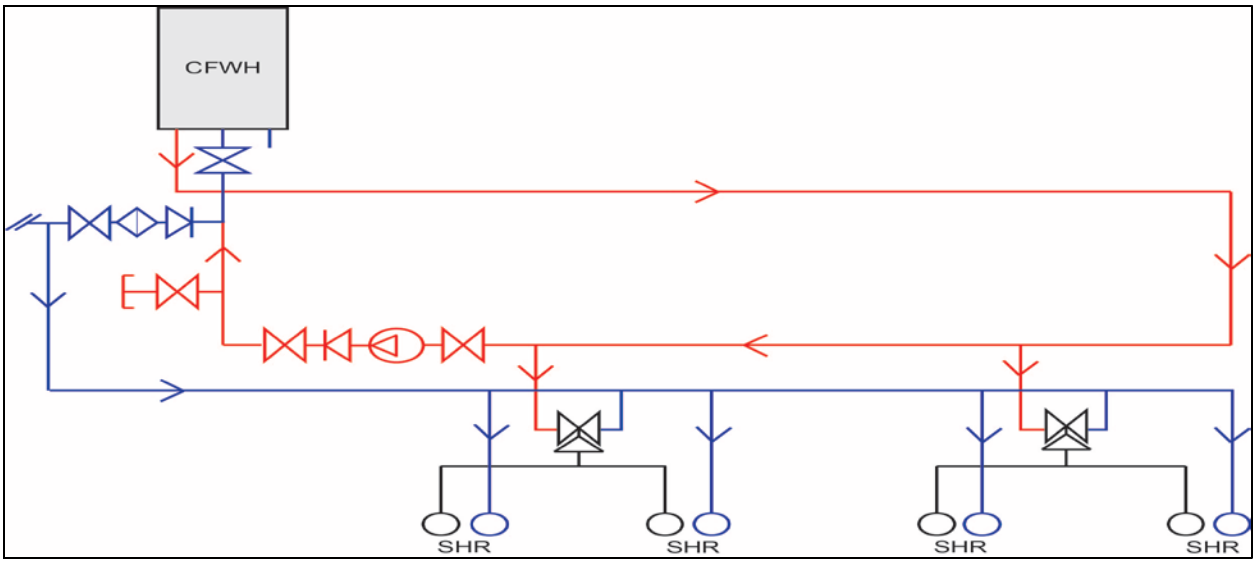

Figure 5: Typical example of a circulating warm water system controlled by a continuous flow water heater.

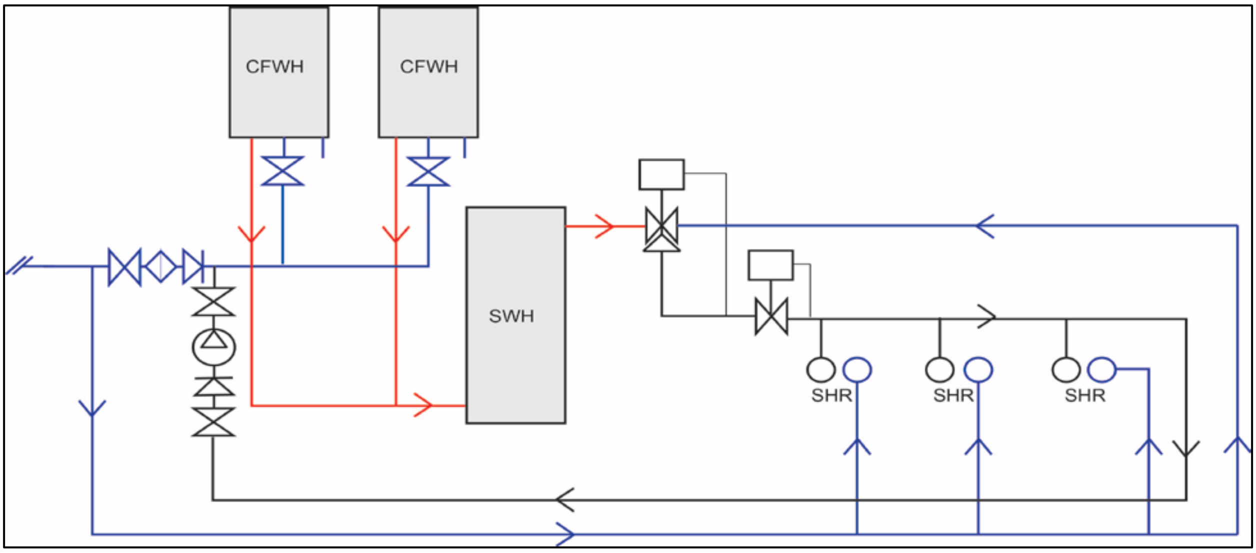

Figure 6: Typical example of a circulating warm water system controlled by a modulation valve with a temperature sensor.

In addition to those typical central circulatory systems shown at Figure 4, Figure 5 and Figure 6 there are several other common configurations, which are explained in more detail in the following sections.

3.1.2.1 Single pipe circulating system

Single pipe circulating systems are primarily used within commercial buildings and high rise apartments where a centralised heating plant is used; however the number of outlets being served by this type of system is limited by the size of the heating plant. These systems incorporate a pump or pump set to circulate heated water throughout the circuit back to the heating plant; this is shown at Figure 7 using a single water heater.

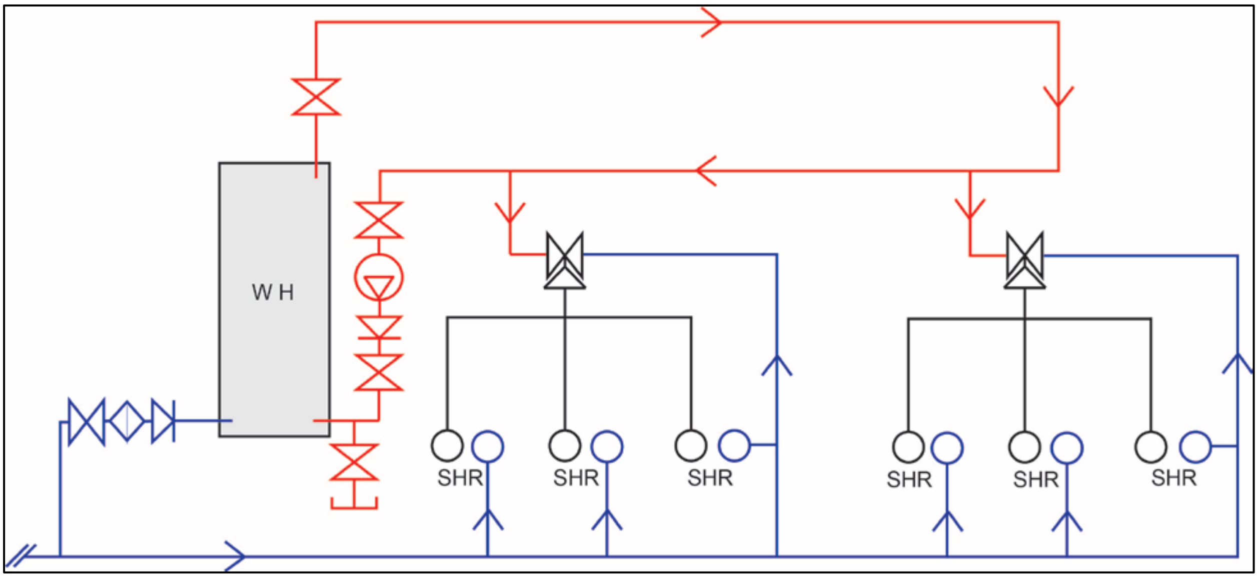

Figure 7: Typical example of a single pipe circulating system.

More complex single pipe systems can incorporate multiple continuous flow water heaters, as shown at Figure 8, or they can be controlled by a modulating valve through a bank of water heaters, as shown at Figure *9*.

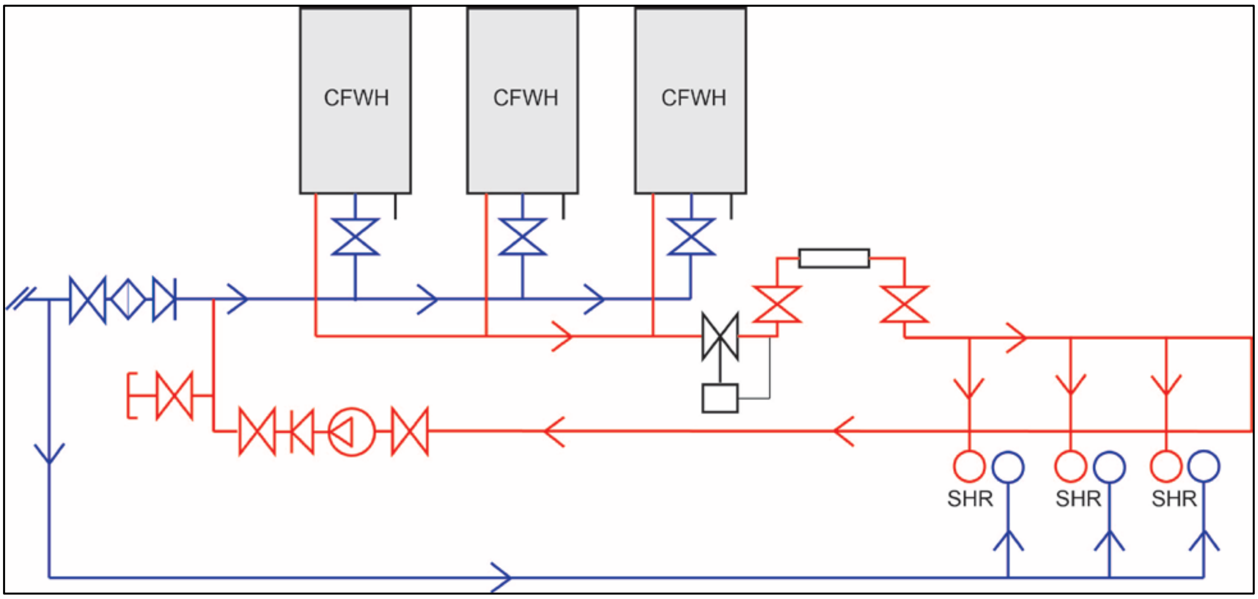

Figure 8: Typical example of a single pipe warm water circulating system controlled by a bank of continuous flow water heaters.

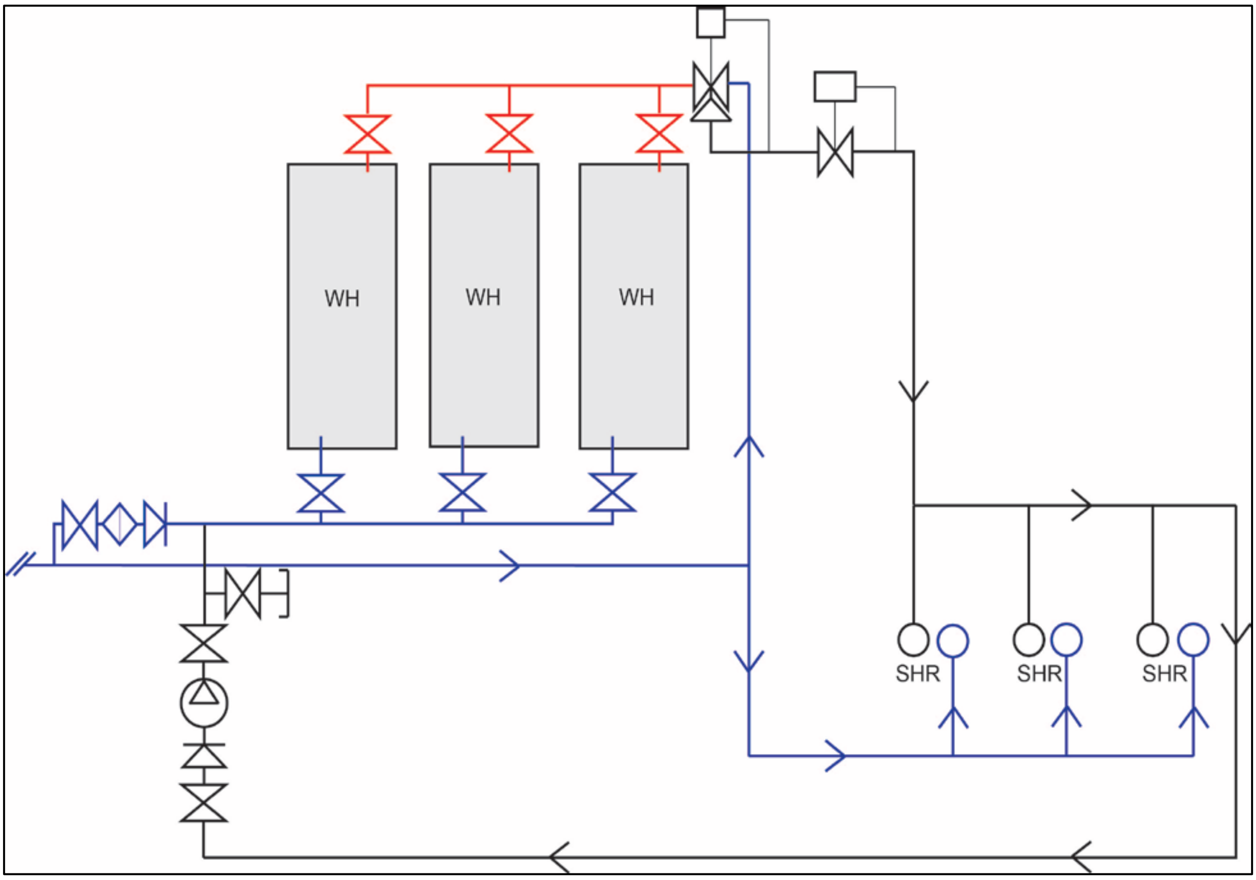

Figure 9: Typical example of a single pipe warm water circulating system controlled by a modulating valve through a bank of water heaters.

3.1.2.2 Primary flow and return heated water system

The primary flow and return system is fundamentally the same system as a single pipe circulating system around the building however it usually incorporates additional heated water storage and is circulated through heating plant on a secondary circuit rather than heating the water within the storage containers. Some examples of different scenarios are shown at Figure 10, Figure 11 and Figure 12.

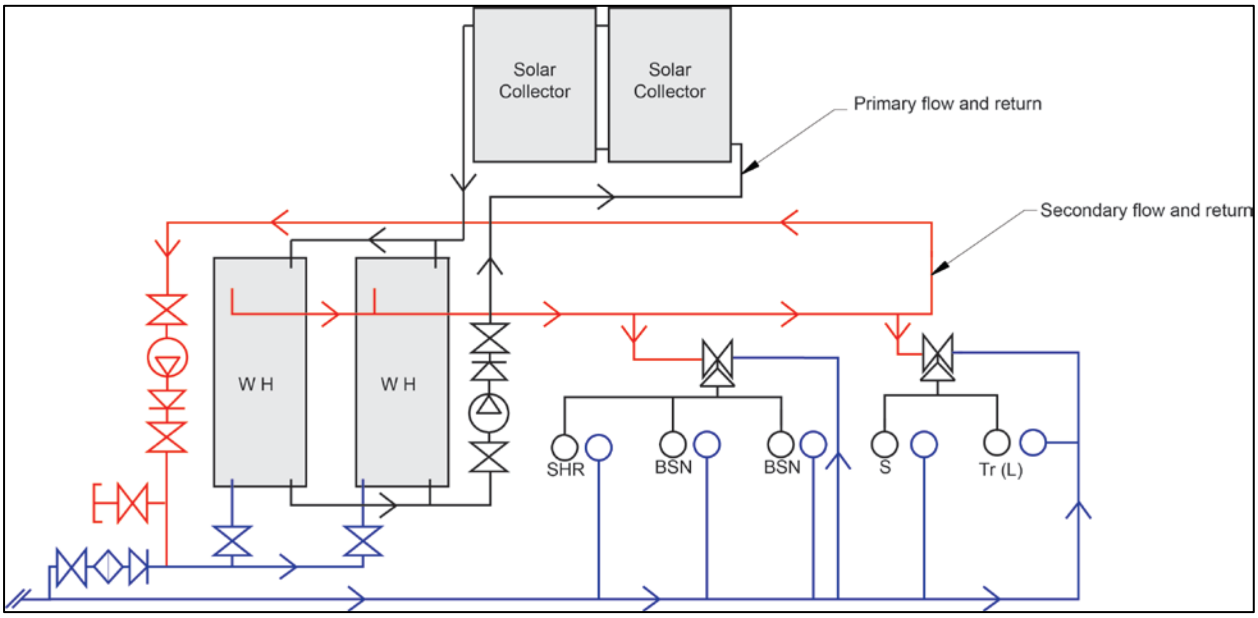

Figure 10: Typical example of a primary flow and return solar system.

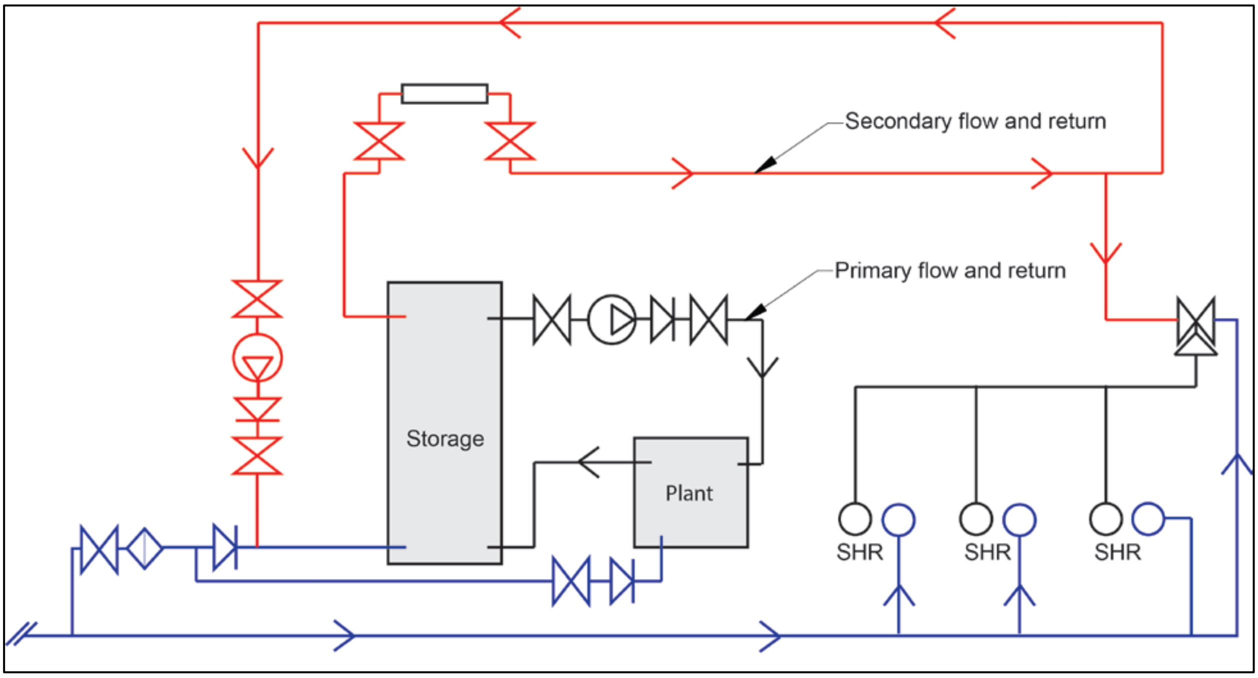

Figure 11: Typical example of a primary flow and return system through a boiler.

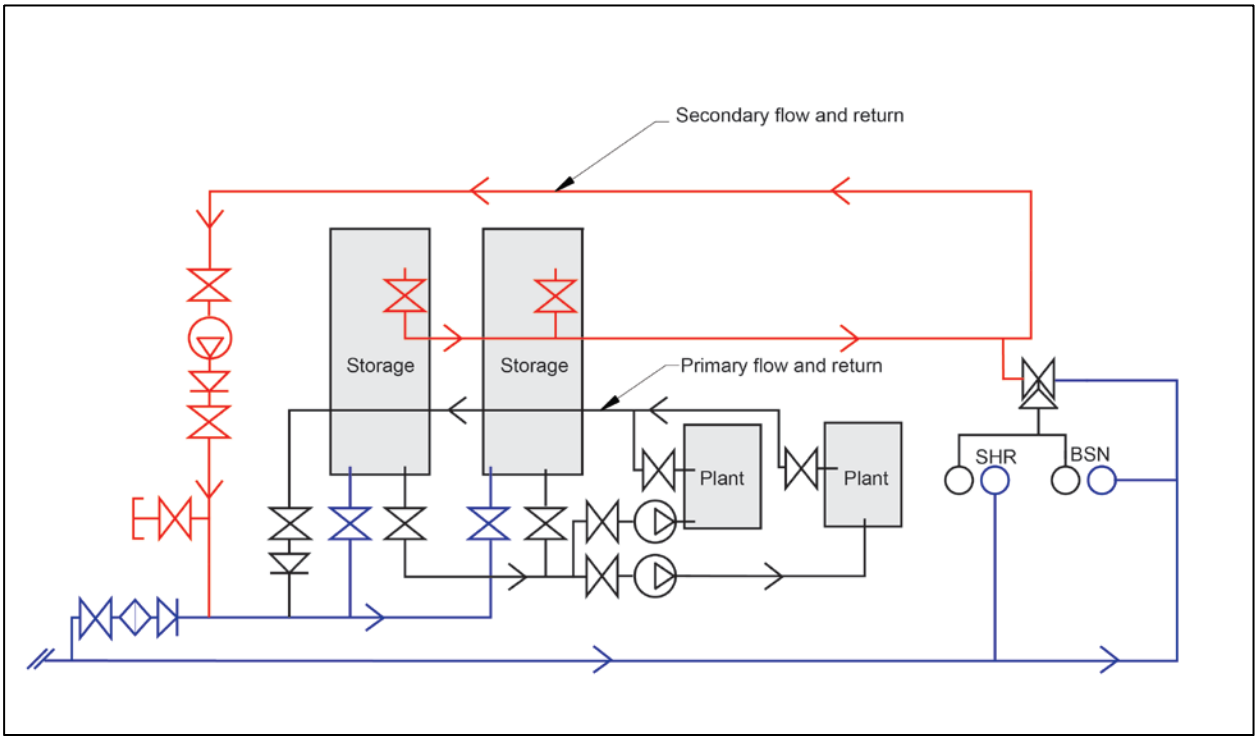

Figure 12: Typical example of a primary flow and return system through heating plant.

3.1.2.3 Heated water flow and return system

The flow and return heated water system is designed to service a large number of outlets across many levels of a building or commercial property. To ensure that the flow rate is equal across all return line branches balancing valves are used before returning the heated water to the plant. The pump or pump set can be installed at either the flow or return pipes.This is shown with pumps on the return line at Figure 13, and with pumps installed on the flow line, shown at Figure 14. The return pipe usually has a 3°C to 5°C[1] reduction in temperature due to the length of the circulatory system. Flow and return systems utilise thermostatic mixing valves within close proximity to outlets reducing the amount of tempered water pipework.

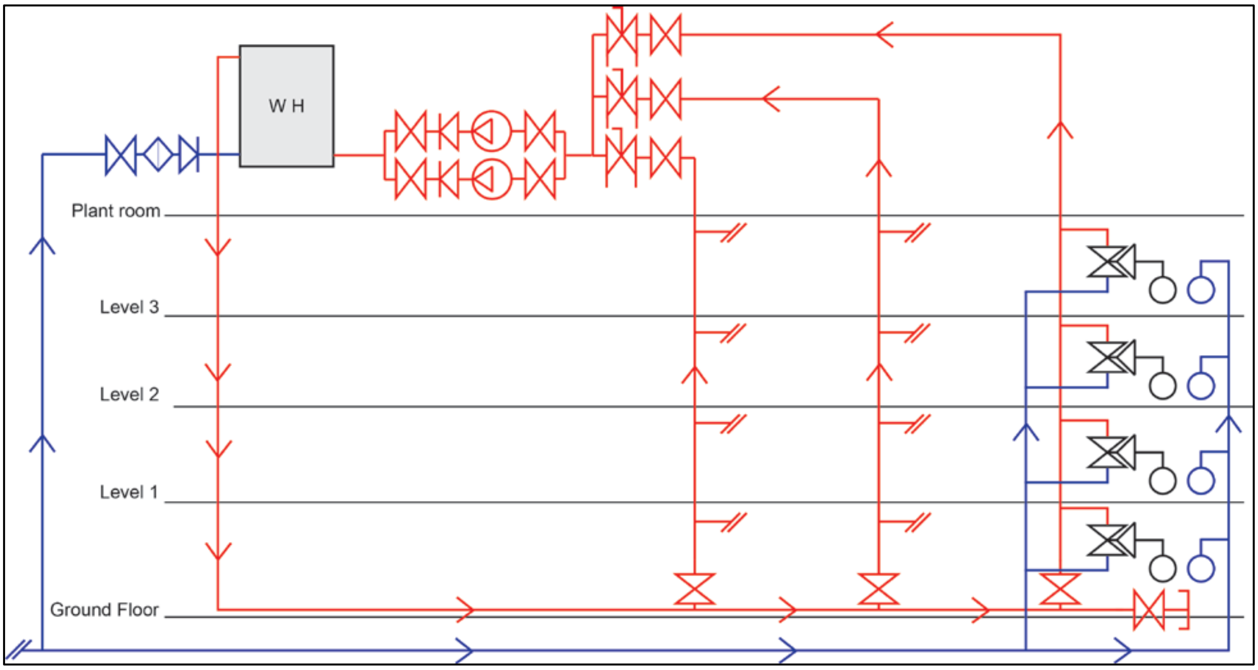

Figure 13: Typical example of heated water flow and return system with pumps on return line

[1] (Hydraulic Services Design Guide, 1st Edition April 2014)

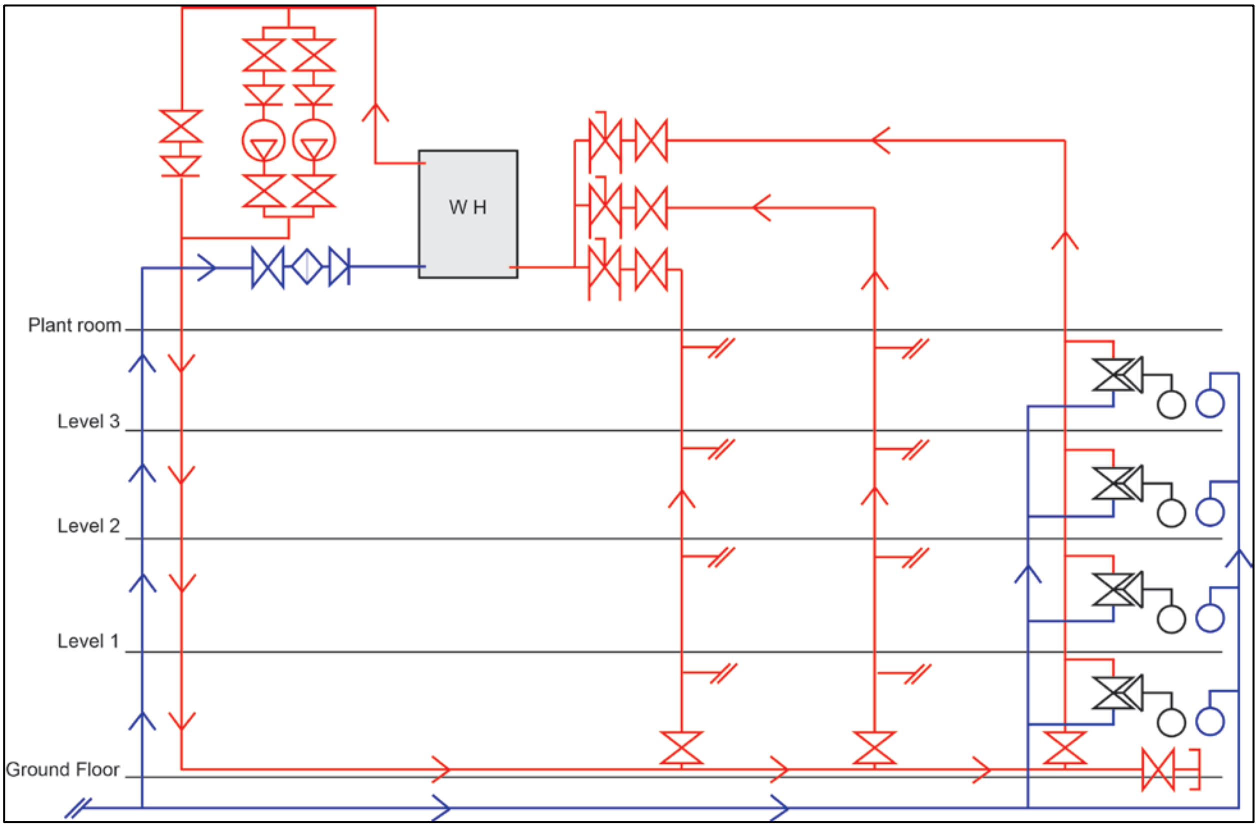

Figure 14: Typical example of heated water flow and return system with pumps on flow line.

3.1.2.4 Two pipe – Direct return system

Two pipe direct return systems comprise of two main pipe rings; one delivers the heated water to each level of the building, the other returns the heated water to the plant, as shown at Figure 15. These systems are designed to limit the length of any branches from the circulatory line to a recommended 6 – 8 meters[2].

Bubbles formed when the water is heated within the plant equipment can cause an airlock in the system. To prevent this the circuit extends the return pipework to the highest floor and an air relief valve is installed at the highest point to expel any air prior to returning to the heating plant by a pump or pump set. Similar to a typical flow and return system, these systems utilise thermostatic mixing valves within close proximity to outlets, reducing the amount of tempered water pipework.

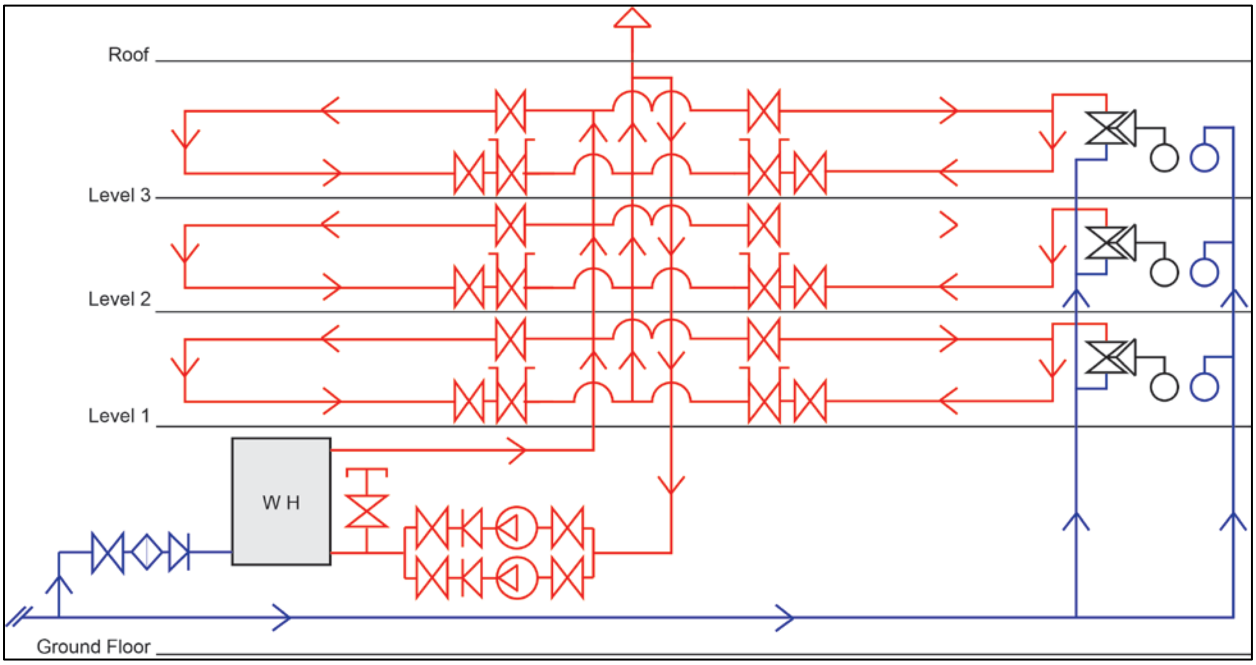

Figure 15: Typical example of a two pipe – Direct return system.

[2] (Hydraulic Services Design Guide, 1st Edition April 2014)

3.1.2.5 Two pipe – Reverse return system

The two pipe reverse return system is also a two pipe heated water system incorporating two main pipe rings. It is designed to have an even flow to all branches or levels of the system by having equal flow and return pipe lengths. This is achieved by having the first branch off the flow line to the secondary ring of the circuit also being the last to be returned to the return line. Balancing valves (see Figure 19), as shown at Figure 16, are still recommended for this type of system to ensure a consistent water flow**.** These systems also utilise thermostatic mixing valves within close proximity to outlets, reducing the amount of tempered water pipework.

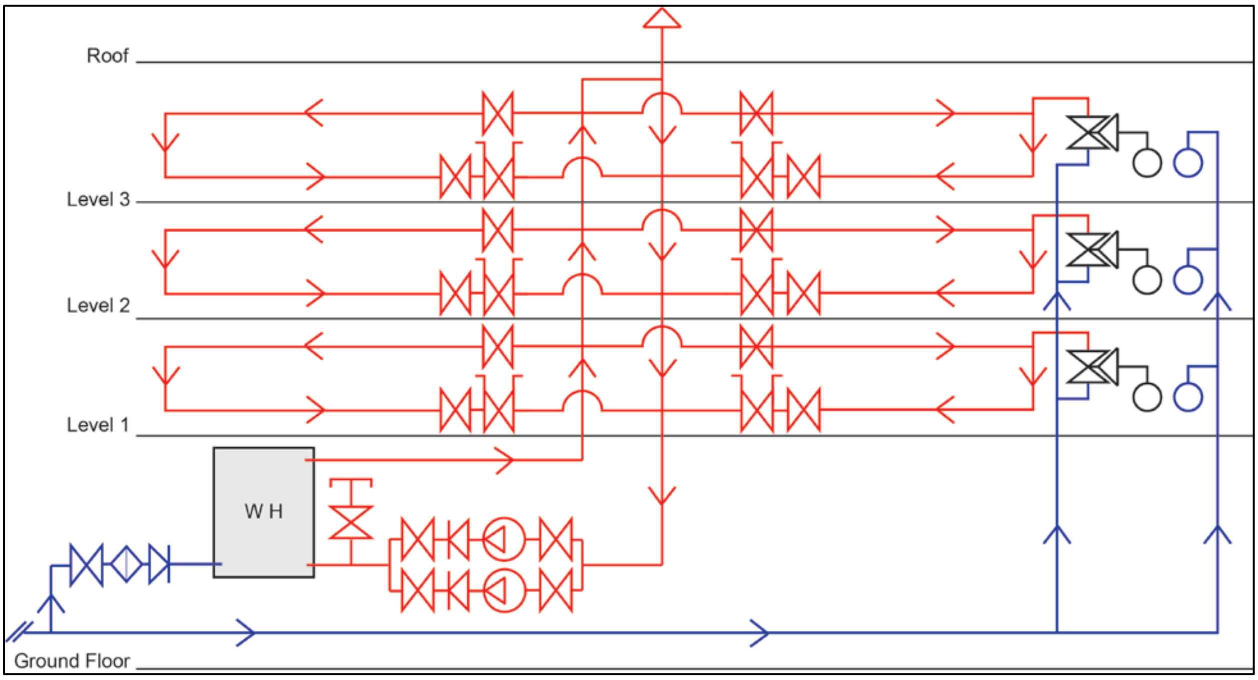

Figure 16: Typical example of a two pipe – Reverse return system.

4 Installation

All heated water services must be installed in accordance with the Plumbing Code of Australia (PCA), however, the PCA and the referenced installation standard (AS/NZS 3500 Plumbing and Drainage - Part 4: Heated Water Services, 2003) are silent on specific provisions for the installation of warm water systems.

This section discusses some of the main components and areas specific to warm water systems, such as:

- pipework;
- heating plant;
- thermostatic mixing valves;
- circulation and pumping; and
- temperatures.

4.1 Pipework

Careful consideration should be given to the layout of pipework. Pipework installation for any system will always be affected by building design, service access and ducts, heating plant location, etc. When designing and installing pipework systems, thermal loss is of critical importance as the efficient operation of a warm water system can be severely compromised if poorly managed. Excessive ‘dead water’ draw-off (i.e. where it is necessary to drain cooled water from the supply pipe prior to delivery of heated water) can result in unnecessary water and energy wastage.

4.1.1 Insulation

Where pipework is not insulated there may be limited heat loss along the length of the branch when in use, however, insulation of the pipework branch lines will extend the time it takes for the heated water to reduce to ambient temperature. The amount of insulation a product offers is measured by its R-Value. This is a term used for the thermal resistance of a component which is calculated by dividing its thickness by its thermal conductivity.

4.1.2 Dead legs in branch lines

Where an infrequently used fixture is located at the end of a branch, water can cool around that fixture, heightening the risk of bacterial growth. This can create what is known as a ‘dead leg’. This risk can be reduced by having the most frequently used fixture the furthest from the mixing valve and branches from this main line to other fixtures kept as short as possible. An example is shown at Figure 17. Branch lengths from the warm water system should be kept to a minimum to limit the distance of pipework to infrequently used taps and fixtures. A branch length of less than 10 metres[3] is generally acceptable, or another way to measure it is to limit the time taken for heated water to reach the outlet of no more than 30 seconds[4].

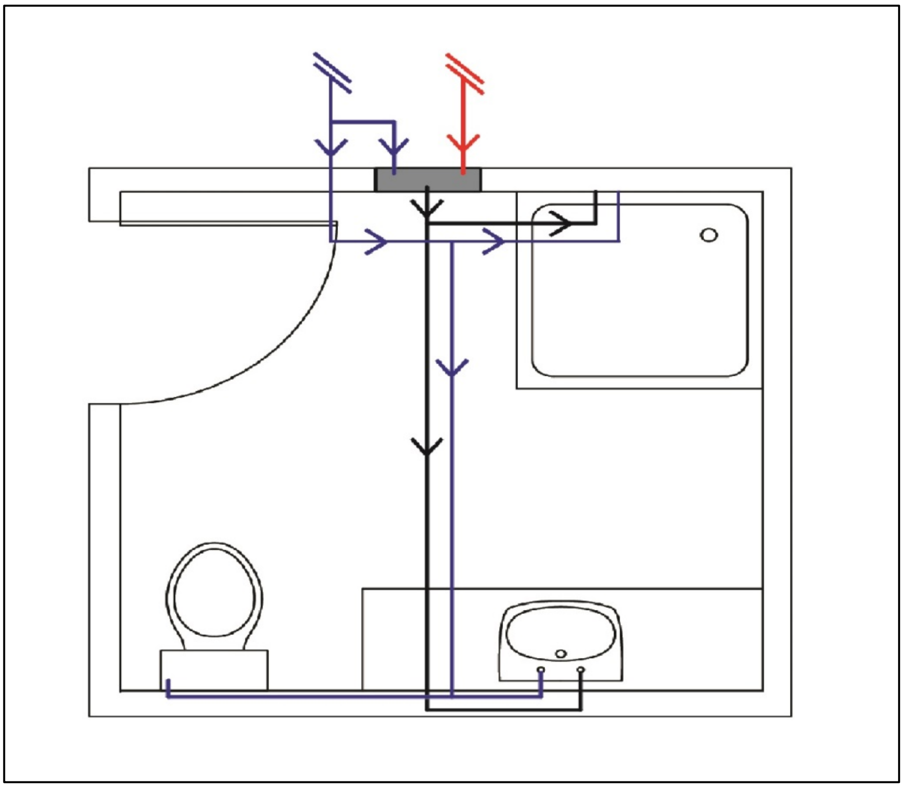

Figure 17: Typical bathroom pipework layout

The following calculation methods can be used as a means of determining the time it takes for heated water to reach the outlet and the quantity of water that is discarded.[5]

[3] (Policy Directive: Water - Requirements for the Provision of Cold and Heated Water, Jan 2005)
[4] (Hydraulic Services Design Guide, 1st Edition April 2014)
[5] (CPCPWT4013A Commission and Maintain Heated Water Temperature Control Devices, 2012)

4.1.2.1 Capacity of fluid

To calculate the capacity of fluid within a 5 metre branch of 25mm DI pipe Equation 1 can be used.

Equation 1

$$C = \frac{\pi}{4}\, x\, d_i{}^2 x\, l$$

C = Capacity (mm³)

π = 3.14 ($\frac{\pi}{4}$ =0.78)

d_i = internal diameter of pipe (mm)

l = length of pipe (mm)

Example:

C= (3.14/4) x 25² (mm pipe) x 5,000

= 0.78 x 625 x 5000

= 0.78 x 3,125,000

= 2,437,500mm³

4.1.2.2 mm³ to mL

To convert mm³ to mL Equation 2 can be used.

Equation 2

$$mL = \frac{mm^3}{1000}$$

Example:

mL=2,437,500/1,000

= 2437.5mL

4.1.2.3 mL to L

To convert millilitres (mL) to litres (L) and identify the amount of water wasted, Equation 3 can be used.

Equation 3

$$Litres = \frac{mL}{1000}$$

Example:

Litres = 2,437.5 / 1,000

= *2.44 litres*

4.1.2.4 Estimation of time delay

Once the amount of water wasted has been established Equation 4 can be used to gain an estimation of the time delay.

Equation 4	
$t = \frac{C}{F}$ t = Time delay - Amount of time for heated water to reach the outlet (m). C = Capacity (litres). F = Flowrate of tap (litres/min)	**Example:** For a branch of 25mm pipe and extending 5 meters with an outlet flowrate of 9L/m: $= \frac{2.44}{9}$ = 0.27 minutes

4.2 Heating Plant

This report does not go into detail regarding water heating plant[6] as there is limited detail specific to warm water systems; however, there are many different types of heated water plant available for warm water systems. The major technology types include:

- gas continuous flow (instantaneous);
- gas storage;
- large gas boilers;
- electric storage;
- heat pump;
- solar; and
- combinations of the above mentioned.

The selection is determined by a number of factors including:

- the type and layout of the building;
- the usage pattern;
- the source of energy;
- the location of the plant;
- the initial plant cost and the ongoing operational costs;
- thermostatic mixing valve requirements, where used;
- circulation; and
- temperature needs.

[6] (Hydraulic Services Design Guide, 1st Edition April 2014)

4.3 Thermostatic Mixing Valves

Thermostatic mixing valves (TMV's) are devices that ensure the delivery of heated water at a specified temperature to an outlet by mixing the heated and cold water supplies.

4.3.1 Operation

The temperature of water in a TMV is regulated within the valve by an actuating device which expands and contracts to the mixed water temperature to adjust the flow of heated water. When installing thermostatic mixing valves, the distance from the valve to the outlet being served should be taken into consideration and the valve calibrated to account for any temperature loss.

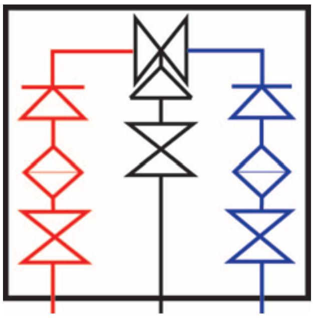

Figure 18: Integral components of a thermostatic mixing valve

The function of a TMV ensures the delivery of heated water at a specified temperature. A TMV usually contains non-return valves, line strainers and a means of isolation of both cold and heated water inlets as an integral part of the device. This provides a means of testing the thermal shutdown of the device. Thermal shutdown occurs if there is a loss of cold water supply but the heated water is still available, the valve will shut off the supply until the cold water supply is reinstated. For this reason TMV's are commonly used within hospitals, schools and aged care facilities with a requirement for annual testing to reduce the risk of scalding by enabling the valves to be monitored to ensure the correct operation of the device.

4.3.2 Installation

When installing a TMV it is important to take into consideration the pressure drop created by the device and that the pressure differential between the heated and cold water supply is limited to within 10% for both static (not in operation) and dynamic (in operation) pressures[7]. A minimum pipe length of 1 metre is recommended from the TMV to the first outlet to reduce the effect of a possible heat spike and help minimise

[7] (CPCPWT4013A Commission and Maintain Heated Water Temperature Control Devices, 2012)

any temperature increase should the fail safe function of the valve be initiated. The length of pipe installed will assist in dissipating the heated water.

A maximum branch pipe length of 10 metres is recommended from the flow and return line of a circulatory system or the temperature control device of a reticulated system to the fixture outlet to ensure heat loss and microbial growth is minimised, unless a heat trace system is used to maintain system temperature.

It is important to correctly size thermostatic mixing valves. Larger sized mixing valves should only be used where there is low inlet pressures or large draw offs at the outlet.[8]

When one TMV is serving multiple fixtures across separate bathrooms simultaneous fixture use can cause some imbalance and variation in the temperature and heated water pressure being supplied. The TMV must be able to tolerate pressure variations caused by simultaneous fixture use without warm water departing from the allowable temperature range. This must be assessed during commissioning.[9]

4.3.3 Installation considerations

The operating pressure of both heated and cold water supplies at the inlet to a TMV needs to be nominally equal to or within 10% imbalance, this will prevent any variations in temperature at the outlets. Pressure variance may be more prevalent where one TMV is servicing a number of outlets. Pressure reducing or limiting valves may be necessary to achieve nominally equal inlet pressures.

TMV's should not be installed in parallel on the same warm water line as this could affect the temperature control and fail safe operations of the valve.[10]

4.4 Circulation

Circulatory systems are commonly used in the design of warm water systems to reduce the time taken for the heated water to reach the outlet (see Equation 4). This is achieved by circulating heated water through the system and returning cooler water to the heating plant using a pump or pump set, usually installed on the cooler return line.

Pumping equipment should contain a means of disconnection to enable pump maintenance and a non-return valve, installed as an integral part of the pump assembly, to reduce hydraulic load.

[8] (Code of Practice for Thermostatic Mixing Valves in Health Care Facilities, 1990)
[9] (Code of Practice for Thermostatic Mixing Valves in Health Care Facilities, 1990)
[10] (Code of Practice for Thermostatic Mixing Valves in Health Care Facilities, 1990)

Correct pump selection is critical as they must have sufficient design pressure and flow rate for the system. Incorrect pump selection can cause excessive energy consumption and an under-sized pump may result in heating plant operating at a much higher and fluctuating temperature whereas an oversized pump may result in excessive water velocities[11].

Practitioners also need to consider the potential for erosion of heated water piping systems. One cause is through excessive velocities of heated water, where air bubbles and/or suspended solids through turbulent areas of pipework, such as bends, can erode pipework prematurely and can also cause excessive pipework noise within a building.[12]

It is common practice to install a pump set of multiple pumps rather than a single large pump, pumps can then be set to a schedule and in the event of a failure an alarm can be raised and the other pump utilised[13].

Generally a circulating pump is selected based on the following criteria:[14]

- static pressure available at the cold water main connection;
- length of service loop pipe;
- friction loss in the loop piping;
- pump head loss through the system;
- demand of the fixtures attached to the system in terms of minimum working pressures and flow rates;
- appropriate corrosion resistant materials; and
- temperature of the water intended to be circulated.

Circulation of heated water can be continuous or pumps can be regulated by:[15]

- pre-programed timers;
- manual operation such as initiation buttons;
- motion sensors; or
- thermostatic controls.

[11] (Hydraulic Services Design Guide, 1st Edition April 2014)
[12] (Hydraulic Services Design Guide, 1st Edition April 2014)
[13] (Hydraulic Services Design Guide, 1st Edition April 2014)
[14] (Hydraulic Services Design Guide, 1st Edition April 2014)
[15] (Background Research Project - Consideration of hot water circulators for inclusion in the WELS Scheme, 2008)

4.4.1 Installation considerations

The minimum flow rate for most continuous flow water heaters is between 2 to 3 L/min. If water circulates throughout the system at a lower flowrate it is possible that the booster will not ignite[16].

4.5 Temperature

There two main risks associated with water temperature; bacteria growth and scalding[17]. Heated water stored at temperatures too low can promote the growth of disease causing bacteria and temperatures delivered too high can increase the risk of scalding, especially for users who may have a delayed reaction time such as the elderly or infirm or those with thinner skin thicknesses such as children.[18]

4.5.1 Scalding

Scalding or epidermal necrosis from heated water is a risk for all users should a warm water system fail or be incorrectly installed; however, this risk is far greater for people who are more vulnerable, such as those with a disability, the elderly and children, who may have a reduced reaction time and thinner skin thickness. The higher the water temperature the shorter the exposure time necessary to cause serious scalding. Indicative data on the risk of scalding is shown in Appendix D. Research conducted by Feldman states that at a temperature of 54°C children can burn in about one fourth the time of an adult[19].

[16] (Reference Guide - Commercial Hot Water)
[17] (HB 263: Heated Water Systems, 2004)
[18] (NSW Code of Practice for the Control of Legionnaires' Disease, 2004) and (Studies of thermal injury II. The relative importance of time and surface temperature in the causation of cutaneous burns, 1947).
[19] (Paediatrics Vol. 71, 1983)

4.5.2 Water temperature classifications

The temperatures given below[20] can be used to provide guidance for the classification of cold, warm and heated water temperatures within a piping network, see Table 1[21].

Water Temperature (°C)	0 - 25	25 - 50	50 - 70	70 - 90
Water	Cold	Warm	Hot	High temperature heated water

Table 1: Water temperature classifications guide

Table 2 below defines the temperature coding for fixtures. These colours are used to identify the water temperature at the outlet of a fixture. This can be achieved through the indicator lettering on the tapware or the colour of the tap handle. [22]

Water Temperature (°C)	< 38	38 – 43.5	> 43.5
Indicator Colour	Blue	Yellow	Red

Table 2: Water temperature indicator guide

4.5.3 Legionellosis

Legionellosis is an illness caused by Legionella pneumophila and other related Legionella bacteria. The severity of legionellosis varies from mild febrile illness (Pontiac fever) to a potentially fatal form of pneumonia (Legionnaires' disease). These legionella associated illnesses can affect anyone, but some are more susceptible than others due to age, illness, immunosuppression or other risk factors, such as smoking[23].

The presence of Legionella pneumophila bacteria to some degree is common in most water systems; however, the bacteria thrive in lower temperatures (see Table 3). The concentration level of Legionella pneumophila bacteria required to cause infection is unknown[24].

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[20] (Technical Solution Sheet 6.11, 2014)
[21] (HB 263 Heated Water Systems , 2004) and (Policy Directive: Water - Requirements for the Provision of Cold and Heated Water, Jan 2005).
[22] (Policy Directive. Water - Requirements for the provision of cold and heated water, Feb 2015)
[23] (Legionella and the prevention of legionellosis, 2007)
[24] (Legionella and the prevention of legionellosis, 2007)

Legionnaires' disease is developed when Legionella pneumophila is present within airborne droplets of water and inhaled, typically infecting the lungs. To assist in the removal of potentially contaminated airborne droplets, adequate mechanical exhausting of shower areas should be provided to extract any airborne moisture which may be contaminated with bacteria.[25]

Temperature	Effect on Legionella bacteria
70°C	Destroyed almost instantly
60°C	Destroyed within 2 minutes
50°C	Destroyed within 80 - 124 minutes
37°C - 42°C	Greatest reproduction rate
20°C - 37°C	Increase of reproduction rate
20°C and under	No increase

Table 3: Temperature effects on Legionella bacteria[26]

In high risk areas of hospitals, such as organ transplant centres and intensive care units, water from the outlet should be free of Legionella (no colonies detectable in 1 Litre of water). Outbreaks of legionellosis generally cause a high level of morbidity and mortality in the people exposed; therefore, the suspicion of an outbreak event should warrant immediate action with health authorities being alerted.

[25] (Code of Practice Prevention and control of Legionnaires' disease, 2010)
[26] (Legionella and the prevention of legionellosis, 2007)

5 Maintenance

Because of the inherent risks associated with warm water, Legionella specifically, all systems need to be suitably designed, installed and carefully monitored. An on-going monitoring system and water quality maintenance regime needs to be introduced. The aim of these steps is to avoid conditions that may allow bacteria such as legionella to multiply.

Maintenance routines may differ from site to site depending on installation; however, it is important to have processes in place such as:

- regular inspections, monitoring and recording of:
  - pressure of cold water;
  - flowrate of cold water;
  - pressure of warm water;
  - temperature of warm water;
  - flowrate of warm water;
  - temperature of cold water where the flow rate of cold water is to be calculated rather than measured; and
  - the time taken for the warm water to reach the prescribed operating temperature in degrees Celsius (°C);
- water sampling and testing;
- chlorination and/or thermal disinfection;
- UV operation;
- temperature;
- valve servicing, including:
  - testing of non-return valves;
  - cleaning of line strainers;
  - testing of temperature control devices; and
  - testing of thermal shut-off;
- flushing of the dead legs on fixtures which are infrequently used; and
- review of maintenance procedures and risk assessments.

The maintenance and disinfection of warm water systems are legal requirements in some jurisdictions. See Table 5 for relevant information in each jurisdiction.

When maintenance of a warm water system is being carried out, contamination of adjoining areas and the ambient environment by aerosols, dust, particulate matter or effluent must be minimised and it must be ensured that public access to the area in which the maintenance is being carried out is prevented.[27]

Details of any repairs, replacement parts or any other work carried out on the warm water system should be detailed in a maintenance service report and it is recommended that the site manager or building owner be made aware of any work conducted.[28]

5.1 Risk Management

A risk management approach to Legionella management, such as that undertaken in Victoria[29], requires that reasonable steps be taken to manage the risks of Legionella. Risk assessments are undertaken and risk management plans are developed as part of this process. In assessing the risks associated with warm water systems, it is important to undertake the following:

- Determine the potential for people to be exposed to respirable sized droplets.
- Identify dead legs including those created by unused or infrequently used outlets.
- Develop a water sampling strategy and commence regular sampling for bacteria, specifically Legionella.
- Develop a clear procedure should the presence of Legionella bacteria be detected.
- Undertake a site audit to locate, gather and document basic information about each warm water system.

The risk assessment should determine whether existing control measures are sufficient and operate effectively. If they are not sufficient, additional measures should be identified and introduced.

5.2 Testing and maintenance of thermostatic mixing valves

All thermostatic mixing valves should be tested and serviced to ensure adequate operation. For some jurisdictions such as the Australian Capital Territory, Northern Territory and Queensland, thermostatic mixing valve installation, replacement and maintenance is required to be undertaken by an appropriately licenced plumber; this should be assessed prior to undertaking any testing.

AS 4032.3:2004 states that in the absence of a risk assessment, field testing shall be carried out at intervals of no more than 12 months for thermostatic mixing valves.

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[27] (NSW Code of Practice for the Control of Legionnaires' Disease, 2004)
[28] (Policy Directive. Water - Requirements for the provision of cold and heated water, Feb 2015)
[29] (Technical Solution Sheet 6.11, 2014)

The minimum activity during testing includes the following:[30]

- Strainer cleanliness.
- Non-return valve operation.
- Discharge temperature measured at the nearest outlet to the valve for high and low flow.[31]
- Cold water shut-off operation (thermal shut off).
- Hot water shut-off operation (cold shock test).
- Isolation valve test.
- Replacement and lubrication of dynamic ‘o’ rings and seals at intervals not exceeding 5 years from commissioning or such shorter intervals indicated by the manufacturer.

The following is reported:[32]

- The model, manufacturer and identification of the valve.
- Location of the valve.
- Temperatures recorded during test.
- Details of tests, maintenance and parts replaced.
- Reference to this test method.

State and Territory requirements for testing are included in Table 4. References to Standards within Table 4 are that of the source document.

[30] (AS 4032 Water supply - Valves for the control of heated water supply temperatures Part 3: Requirements for field-testing, maintenance or replacement of thermostatic mixing valves, tempering valves and end-of-line temperature control devices, 2004)

[31] (Part A - Approval specification for operational testing of thermostatic mixing valves for use in non domestic buildings in New South Wales, 2014)

[32] (AS 4032 Water supply - Valves for the control of heated water supply temperatures Part 3: Requirements for field-testing, maintenance or replacement of thermostatic mixing valves, tempering valves and end-of-line temperature control devices, 2004)

State / Territory	Testing Requirements	Source
ACT	No information found.	NA
NSW	The Public Health Act, the Public Health Regulation 2000 and the NSW Code of Practice for Thermostatic Mixing Valves in Health Care Facilities, AS 4032.3 as well as any manufacturers published instructions shall be followed in regards to the system design, installation, commissioning, operation, maintenance / service and site management of all warm water and hot water supply systems.	(Policy Directive. Water - Requirements for the provision of cold and heated water, Feb 2015)
NT	No information found.	NA
QLD	No information found.	NA
SA	Temperature controlling devices such as thermostatic mixing valves or tempering valves should be regularly serviced in accordance with the manufacturer's instructions and AS 4032 and, in any case, at least every 12 months.	(Guidelines for the Control of Legionella, 2013)
TAS	The owner of a warm water system that uses thermostatic mixing devices must ensure that the warm water system is maintained in accordance with the requirements of AS/NZS 4032:1998.	(Guidelines for the Control of Legionella in Regulated Systems , 2012)
VIC	It is a requirement of AS/NZS 3500.4 that thermostatic mixing valves "be inspected periodically to ensure proper operation". The Victorian Building Authority recommends that thermostatic mixing valves are inspected and serviced annually in accordance with AS 4032.3.	(Technical Solution Sheet 6.11, 2014)
WA	Temperature control devices require routine maintenance and performance testing. Information on maintenance can be found in AS 4032.2.	(Technical Note - Water temperature, 2010)

Table 4: State and Territory testing requirements

To assess the amount of heated water used by a thermostatic mixing valve, Equation 5 can be used. This calculation will assist in the determination of storage requirements for heated water services. For example; with temperatures of 20°C cold, 45°C tempered and 70°C heated the percentage proportions are 50/50 between cold and heated[33].

Using the example shown in Equation 5, where the TMV is serving 2 showers each with a flow at the outlet of 9 litres per minute, the temperatures recorded are:

Cold = 20
Tempered = 45
Heated = 80

Equation 5

$HV\% = 100 \text{ x } (M - C) \div (H - C)$ HV% = the percentage of heated water used in the mix M = the temperature of the tempered water H = the temperature of the heated water C = the temperature of the cold water	**Example:** How to find the split percentages of flow use: HV% = 100 x (Tempered – Cold) ÷ (Heated - Cold) HV% = 100 x (45 – 20) ÷ (80 - 20) = 42% This means that the 42% of the water being supplied to the outlet is from the heated water supply.

To convert from litres per minute to litres per second, Equation 6 can be used.

Equation 6

$l/sec = \frac{l/min}{60}$	**Example**: 18 L/min ÷ 60 = 0.3 L/Sec

To convert to litres per second to litres per minute Equation 7 can be used.

[33] (CPCPWT4013A Commission and Maintain Heated Water Temperature Control Devices, 2012)

Equation 7

$$l/min = l/sec \ x \ 60$$

Example:
0.3 L/sec x 60 = 18 L/min

5.2.1 Testing procedures for thermostatic mixing valves

The following procedures produced by NSW Health apply to the testing of TMV's to ensure they are functioning accurately.

5.2.1.1 Thermal shut off Test[34]

The following should be measured and recorded during this test:

- thermal shut-off reaction time; and
- the maximum temperature of the discharge water during this period.

Steps:

1) Close the isolating valve in the cold water supply line to the TMV quickly, to completely stop or isolate the flow of cold water. This action should cause the TMV to rapidly respond and provide a quick, thermal shut off operation.
2) Measure the time elapsed between the complete shut-off of the cold water isolation valve to the cessation in flow of water discharged from the warm water outlet. The thermal shut off time should not exceed 4 seconds.
3) Keep the cold water supply line isolating valve shut.
4) Any water subsequently produced by the TMV should not exceed the maximum permissible temperature limit.
5) For a period of 30 minutes the temperature of the discharge water should be kept under constant visual observation.
6) At intervals of 5 minutes, the temperature of any water still being emitted from the outlet should be recorded during this period.
7) The maximum accumulated flow of any leakage water should not exceed 20 litres.
8) Open the cold water supply isolation valve quickly and measure and record the following:

[34] (Part A - Approval specification for operational testing of thermostatic mixing valves for use in non domestic buildings in New South Wales, 2014)

- The time taken for the TMV to be reactivated and produce stable warm water at the outlet. The elapsed time should not exceed 10 seconds and the discharge water temperatures not exceed the maximum permissible temperature limit.
- Warm water produced at the outlet should be between 40.5°C and 43.5°C.

5.2.1.2 *Cold Shock Test*[35]

The following should be measured and recorded during this test:

- the reaction time; and
- the accumulated flow of water emitted from the mixing valve during the reaction time or thirty seconds, whichever is the lesser time.

Steps:

1) Close the isolation valve in the hot water supply line to the TMV quickly so as to completely stop or isolate the flow of heated water.
2) Measure the reaction time from the time of complete shut-off of hot water to the complete cessation of output or a significant reduction of output of water discharged from the warm water outlet.
3) This action should cause the TMV to rapidly respond and provide either a complete cessation of output or a significant reduction of output within a reaction time of 4 seconds.

5.3 Flushing, disinfection and decontamination

Risks associated with Legionella growth within warm water systems can be managed in a number of ways such as flushing, disinfection and decontamination.

5.3.1 Flushing

Routine flushing of fittings and branches is recommended, especially for fixtures and appliances with minimum use, as Legionella bacteria can be found in shower roses, taps, spouts etc.[36]

Any outlet that has not been used for more than 7 days should be flushed[37] at full flow until the operating temperature of the system has been reached.

[35] (Part A - Approval specification for operational testing of thermostatic mixing valves for use in non domestic buildings in New South Wales, 2014)
[36] (Hydraulic Services Design Guide, 1st Edition April 2014)
[37] (Guidelines for the Control of Legionella, 2013)

5.3.2 Disinfection

Preventative maintenance such as system disinfection is essential for the minimisation of the risk of Legionella bacterial growth within warm water systems.

This can be done continuously or periodically at monthly intervals and achieved through:[38]

- Ultra violet disinfection.
- Continuous chlorination.
- Continuous monochloramine disinfection.
- Copper/silver ionisation.
- Ozone.
- Heat (above 60°C).

Other equipment that is recommended to monitor and control disinfection includes:[39]

- Compact Oxidation-Reduction Potential (ORP) controller and industrial ORP probe.
- Diaphragm metering pump (up to 1600 kPa).
- Frequent maintenance regimes for the calibration of pumps and probes and refill of chemical disinfectant supplies.

ORP probes and sensors are useful as they measure the amount of dissolved oxygen. The more contaminants there are in the water results in less dissolved oxygen because the organics are consuming the oxygen and therefore the lower the ORP level. The higher the ORP level the more ability the water has to destroy foreign contaminants such as microbes or carbon based contaminants.

5.3.3 Decontamination

Based on State and Territory health authority publications the two most common methods of system decontamination recommended are:

- pasteurisation (heat); and
- chlorination.

Pasteurisation (heat).

Firstly ensuring that there is no scalding risk to occupants, warm water services should then be heated to a minimum of 70°C[40] for a period of not less than one hour as a

[38] (Fighting Legionella: Lessons from more than 100 hospitals and healthcare facilities)
[39] (Fighting Legionella: Lessons from more than 100 hospitals and healthcare facilities)

means of system disinfection. This can be done by increasing the temperature of the system then flushing at full flow for a minimum of 5 minutes at each individual fixture or simultaneously flushing fixtures connected to the branch. Temperature should be confirmed by digital thermometer and recorded. This process should be undertaken monthly[41].

Chlorination.

Drain any sludge from the bottom of the warm water storage system. Ensure there is a non-return valve fitted to prevent any contamination of the cold water supply. Add chlorine with a dosage of approximately 10mg/L[42] within the storage system[43] and at least 7mg/L measured at all outlets and a ph. of between 7.0 and 7.6[44]. Each outlet should be flushed at full flow for a minimum of 5 minutes[45].

The different methods and requirements for disinfection in each State and Territory are identified in Table 5.

State/Territory	Method of disinfection	Source
ACT	Warm water storage systems must be disinfected by one of the following methods: A. Heat disinfection at 70°C flushing each outlet in turn for two minutes. B. Chlorine disinfection with free chlorine residual of not less than 7mg/L at one outlet, preferably the furthest point downstream.	(Cooling Towers, Evaporative Condensers and Warm Water Storage Systems (Specilised Systems) Code of Practice, 2005)

40 (Guidelines for the Control of Legionella in Regulated Systems , 2012) and (Cooling Towers, Evaporative Condensers and Warm Water Storage Systems (Specilised Systems) Code of Practice, 2005)
41 (Code of Practice Prevention and control of Legionnaires' disease, 2010)
42 (Cooling Towers, Evaporative Condensers and Warm Water Storage Systems (Specilised Systems) Code of Practice, 2005)
43 (Guidelines for the Control of Legionella in Regulated Systems , 2012)
44 (Cooling Towers, Evaporative Condensers and Warm Water Storage Systems (Specilised Systems) Code of Practice, 2005)
45 (Guidelines for the Control of Legionella in Regulated Systems , 2012)

State/Territory	Method of disinfection	Source
NSW	Dose the warm water storage tank with sodium hypochlorite to maintain a free chlorine residual of 5 – 10mg/L for at least 30 minutes.	(NSW Code of Practice for the Control of Legionnaires' Disease, 2004)
NT	No information found.	NA
QLD	No information found.	NA
SA	Warm water systems must be completely flushed at least 6 monthly with water of not less than 70°C for 5 minutes (or an equivalent temperature/time combination) or be treated with chlorine to provide a minimum free chlorine residual of 1 mg/L at all outlets.	(Guidelines for the Control of Legionella, 2013)
TAS	Heat decontamination of 70°C for a period of one hour or chlorine decontamination of a free chlorine residual in waster of not less than 7mg/L at the outlet at the furthest point from the warm water storage system.	(Guidelines for the Control of Legionella in Regulated Systems , 2012)
VIC	No information found.	NA
WA	Warm water services should be heated to at least 60°C once each month for a period of one hour. Minimum maintenance – heated and cold water systems: clean and disinfection of system at least annually.	(Code of Practice Prevention and control of Legionnaires' disease, 2010)

Table 5: Methods of disinfection

5.3.4 Water testing and sampling

Sampling of warm water systems should be undertaken during the following stages:[46]

- initial commissioning of the system;
- if any components are modified;
- if the system has not been in operation for longer than one month; and

[46] (Cooling Towers, Evaporative Condensers and Warm Water Storage Systems (Specilised Systems) Code of Practice, 2005) and (Code of Practice Prevention and control of Legionnaires' disease, 2010).

- six monthly intervals throughout the operation of the system.

A sample of the water within a warm water system should be taken from various outlets throughout the building, especially those which may not be used frequently.[47] If a water sample shows a result of 10 or more Legionella colony forming units per millilitre (cfu/mL) the system should be flushed and disinfected and an additional sample be taken from the same point approximately 3 days after the initial test to ensure system disinfection. Table 6 identifies the water sampling requirements in each State and Territory. Table 7 can be used as a guide for strategies should legionella be detected within a system.

State / Territory	Water sampling requirements	Source
ACT	Water sampling of a warm water storage system must be undertaken at start up and then every month for six months to demonstrate that the disinfection process controls Legionella bacteria. Sampling must also be undertaken if the process of disinfection is modified or if an authorised officer directs that sampling is to be undertaken.	(Cooling Towers, Evaporative Condensers and Warm Water Storage Systems (Specilised Systems) Code of Practice, 2005)
NSW	The frequency of monitoring should be determined by the record of the performance of the individual systems. Once efficient systems and procedures have been established, regular monitoring may be reduced to less frequent intervals.	(NSW Code of Practice for the Control of Legionnaires' Disease, 2004)
NT	No information found.	NA
QLD	No information found.	NA
SA	The relevant authority must, at least once in every 12 months arrange for a NATA accredited laboratory to conduct microbiological testing, in accordance with AS/NZS 3896 of at least 2 samples of water taken from each warm water system, to determine the presence and number of colony forming units of Legionella in the water.	(South Australian Public Health (Legionella) Regulations, 2013)

[47] (Cooling Towers, Evaporative Condensers and Warm Water Storage Systems (Specilised Systems) Code of Practice, 2005)

State / Territory	Water sampling requirements	Source
TAS	Every six months, and at such other times as directed by an authorised officer, a representative sample of water is taken from the warm water system and tested in an accredited laboratory for the presence of Legionella.	(Guidelines for the Control of Legionella in Regulated Systems , 2012)
VIC	Regulations no longer require testing warm water systems periodically for Legionella; it is recommended that all 'high risk' facilities undertake a water sampling program as part of a risk management approach.	(Public Health and Wellbeing Act 2008: News Bulletin - Information for aged care, health services, health service establishments, registered funded agencies, correctional services and commercial vehicle washes, 2010)
WA	Legionella testing is also useful as part of an: • Investigation of an outbreak; • Validation of effectiveness of control measures; and • Verification of the effectiveness of decontamination.	(Code of Practice Prevention and control of Legionnaires' disease, 2010)

Table 6: Water sampling requirements

For State and Territory Regulations that may specify requirements for sampling frequencies see Appendix A.

In high risk areas of hospitals such as organ transplant centres and intensive care units, water should be free of Legionella bacteria (0 colonies detectable in 1 litre of water)[48] as these patients have weaker immune systems and are more susceptible to developing the disease.

[48] (Legionella and the prevention of legionellosis, 2007)

Test results (CFU/mL) detected:	Control strategy
0 - 10	Effective maintenance practices. System under control. Maintain current monitoring and treatment program.
10 - 100	Maintenance practices may not be satisfactory. Rectify. Monitor and perform follow up testing.
100 - 1,000	Potentially hazardous situation. Immediate disinfection (alternative or higher dose biocide than usual). Review control strategy. Re-test water and assess if further remedial action is necessary.
≥ 1,000	Serious situation. Immediate disinfection (halogen based biocide recommended). Review control strategy. Re-test water and assess if further remedial action is necessary.

Table 7: Control strategies for the presence of legionella[49]

Where Legionella is detected it is recommended that action be taken immediately and the operation and maintenance program for the system be reviewed

It is a requirement that testing of water samples for Legionella bacteria be performed at a National Association of Testing Authority (NATA) registered laboratory in the Australian Capital Territory, New South Wales, South Australia and Tasmania.

[49] (Code of Practice Prevention and control of Legionnaires' disease, 2010) and (NSW Code of Practice for the Control of Legionnaires' Disease, 2004).

5.3.5 Documentation

All maintenance actions, inspection observations, operating and maintenance manuals should be stored on-site and include:[50]

- as-installed drawings of equipment and systems;
- commissioning and cleaning procedures;
- operating and shut down procedures;
- dates and details of equipment and nature of servicing;
- all appliance, tapware, valve, component and fixture documentation; and
- results of all tests.

In some jurisdictions such as New South Wales, warm water system operation and maintenance inspection checklists are provided from the health department, see Appendix A.

[50] (Policy Directive. Water - Requirements for the provision of cold and heated water, Feb 2015) and (Code of Practice Prevention and control of Legionnaires' disease, 2010).

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Appendix A Legislation, Regulations and Guidelines

Each State, Territory and Australian Government has differing legislation relating to the design, installation and maintenance of warm water systems. Relevant legislation and other documentation has been listed to provide guidance, however it should be noted that this may not be complete; as such it is recommended that the relevant authority be contacted where further information is required.

A.1 Australian Capital Territory

- Planning and Development Act 2007
- Public Health Act 1997
- The Cooling Towers, Evaporative Condensers and Warm Water Storage Systems (Specialised Systems) Code of Practice 2005. (Public Health Act 1997).

For further information see:

- Legislation - www.legislation.act.gov.au
- Plumbing - www.planning.act.gov.au
- Health - www.health.act.gov.au

A.2 New South Wales

- Microbial Sampling - Warm Water Systems Including Thermostatic Mixing Valves
  - Notification of installed water cooling system or warm water system.
- NSW Code of Practice for the Control of Legionnaires' Disease 2004
- NSW Health
- Part A - Approval specification for operational testing of thermostatic mixing valves for use in non-domestic buildings in New South Wales.
- Part B - Approval specification for operational testing of warm water generating systems not incorporating thermostatic mixing valves for use in non domestic buildings in New South Wales.
- Plumbing and Drainage Act 2011
- Plumbing and Drainage Regulation 2012
- Public Health (Microbial Control) Regulation 2000
- Public Health Act 2010
- Public Health Regulation 2012
- Public Health Regulation 2012 – Part 2 Legionella Control
  - Warm Water System – Installation inspection Checklist
  - Warm Water System – Maintenance inspection Checklist
- Policy Directive Water - Requirements for the Provision of cold and Heated Water Jan 2015
- Policy Directive Water - Requirements for the Provision of cold and Heated Water Feb 2015

For further information see:

- Legislation - www.legislation.nsw.gov.au
- Plumbing - www.fairtrading.nsw.gov.au
- Health - www.health.nsw.gov.au

A.3 Northern Territory

- Building Act 2015
- Building Regulations 2014
- Health Services Act 2014
- Health Services Regulations 2014
- Public and Environment Health Regulations 2014
- Public and Environmental Health Act 2014
- Public Health Fact Sheet No. 407 Legionaries' Disease

For further information see:

- Legislation - www.nt.gov.au
- Plumbing - www.plumberslicensing.nt.gov.au
- Health - www.health.nt.gov.au

A.4 Queensland

- Design Guidelines for Queensland Residential Aged Care Facilities
- Guidelines for Managing Microbial Water Quality in Health Facilities 2013
- Health infrastructure requirements, Volume 1
- Legionnaires disease – reducing the risk in the home (Queensland Government – Department of Health)
- Public Health Act 2005

For further information see:

- Legislation - www.legislation.qld.gov.au
- Plumbing - www.hpw.qld.gov.au
- Health - www.health.qld.gov.au

A.5 South Australia

- Guidelines for the Control of Legionella in Manufactured Water Systems in South Australia 2013
- Public Health (Legionella) Regulations 2013
- Public Health Fact Sheet #303 Is my heated water system captured under the legionella regulations?
- Public Health Fact Sheet #304 Decontamination of high risk manufactured water systems
- South Australian Public Health Act 2011

For further information see:

- Legislation - www.legislation.sa.gov.au
- Plumbing - www.sa.gov.au
- Health - www.health.sa.gov.au

A.6 Tasmania

- Guidelines for Notification of Notifiable Diseases, Human Pathogenic Organisms and Contaminants 2010
- Guidelines for the Control of Legionella in Regulated Systems 2012. (Public Health Act 1997)
- Public Health Act 1997

For further information see:

- Legislation - www.thelaw.tas.gov.au
- Plumbing - www.justice.tas.gov.au
- Health - www.dhhs.tas.gov.au

A.7 Victoria

- Building Act 1993
- Building Regulations 2006.
- Health (legionella) Regulations 2001
- Plumbing Regulations 2008
- Public Health and Wellbeing Act 2008
- Public Health and Wellbeing Act 2008 – News Bulletin – Information for aged care, health services, health service establishments, registered funded agencies, correctional services and commercial vehicle washes
- Public Health and Wellbeing Regulations 2009
- Technical Solution Sheet 6.01 6: Hot Water Plumbing – Achieving Hot Water Delivery Temperatures/Dead Ends
- Technical Solution Sheet 6.03 6: Hot Water Plumbing – Heat Trace Cables in Warm Water and Hot Water Systems (Victorian Building Authority, 2014)
- Technical Solution Sheet 6.11 6: Hot Water Plumbing – Warm Water Systems

For further information see:

- Legislation - www.legislation.vic.gov.au
- Plumbing - www.vba.vic.gov.au
- Health - www.health.vic.gov.au

A.8 Western Australia

- Code of practice Prevention and control of Legionnaires' disease 2010. (Occupational Safety and Health Act 1984 & Mines Safety Act 1994).
- Health (Air-handling and Water Systems) Regulations 1994
- Health Act 1911
- Occupational Safety and Health Act 1984
- Technical Note – Water Temperature

For further information see:

- Legislation - www.slp.wa.gov.au
- Plumbing - www.commerce.wa.gov.au
- Health - ww2.health.wa.gov.au

Appendix B Relevant NCC Provisions

Provisions within the National Construction Code which may be relevant to warm water systems.

B.1 Volume Three – The Plumbing Code of Australia

The PCA sets out the requirements for the design, installation, replacement, repair, alteration, and maintenance of any part of a heated water service of a property that is connected to the drinking water supply, from the point of connection to the points of discharge.

Relevant Provisions include, but may not be limited to Part B2 Heated Water Services.

The Objectives and Functional Statements may be used as an aid to interpretation.

Objective - BO2

The Objective of this Part is to –

(a) Safeguard people from illness, injury or loss (including loss of amenity) due to the failure of a heated water installation; and
(b) Ensure that a heated water installation (including an installation provided for use by people with a disability) is suitable; and
(c) Conserve water; and
(d) Safeguard the environment; and
(e) Reduce greenhouse gas emissions; and
(f) Safeguard public and private infrastructure; and
(g) Ensure that a heated water installation is designed and is capable of being maintained so that throughout its serviceable life it will continue to satisfy Objectives (a) to (f).

Functional Statements

BF2.1
Sanitary fixtures, sanitary appliances and supply outlets provided with heated water must have a safe and adequate piped heated water supply.

BF2.2

The heated water supply must be conveyed through plumbing installations in a way that –

(a) minimises any adverse impact on building occupants, the Network Utility Operator's infrastructure, property and the environment; and
(b) facilitates the conservation of water.

BF2.3

To reduce greenhouse gas emissions, to the degree necessary, a heated water service is to -

(a) be capable of efficiently using energy; and
(b) obtain its heating energy from –
  i. a low greenhouse gas intensity energy source; or
  ii. an on-site renewable energy source; or
  iii. another process of reclaimed energy.

Performance Requirement

A Plumbing or Drainage Solution will comply with the PCA if it satisfies the Performance Requirements.

BP2.1 Heated water service supply

Installations intended to supply heated water for human consumption, food preparation, food utensil washing or personal hygiene must be connected to a drinking water supply.

BP2.2 Heated water temperatures

Heated water supplied by a new heated water service must be delivered to fixtures and appliances used primarily for personal hygiene at a temperature which reduces the likelihood of scalding.

BP2.3 Heated water service installation

A heated water service must be designed, constructed and installed in such a manner as to –

(a) avoid the likelihood of contamination of drinking water within both the on-site installation and the supply; and
(b) provided heated water to fixtures and appliances at flow rates and temperatures which are adequate for the correct functioning of those fixtures and appliances under normal conditions and in a manner that does not create undue noise; and
(c) avoid the likelihood of leakage or failure, including uncontrolled discharges; and
(d) * * * * *

(e) allow adequate access for maintenance of mechanical components and operational controls; and
(f) allow the system, appliances and backflow prevention devices to be isolated for testing and maintenance, where required.

BP2.4 Pressure Vessels

Pressure vessels used for producing and/or storing heated water must be provided with safety devices which –

(a) relieve excessive pressure during both normal and abnormal conditions; and
(b) limit temperatures to avoid the likelihood of flash steam production in the event of rupture.

BP2.5 Heated water storage

Heated water must be stored and delivered under conditions which avoid the likelihood of the growth of Legionella bacteria.

BP2.6 People with a disability

Where heated water is supplied in facilities provided for people with a disability, supply taps or other operational controls must be accessible and adequate for their use.

BP2.7 Materials and Products

Materials and products used in heated water services must meet the requirements of Part A2.

BP2.8 Heated water service energy and water efficiency

A heated water service, including any associated distribution system and components must, to the degree necessary –

(a) have features that facilitate the efficient use of energy appropriate to –
   i. the heated water service and its usage; and
   ii. the geographic location of the building; and
   iii. the location of the heated water service; and
   iv. the energy source; and

(b) Obtain heating energy from –
   i. a source that has a greenhouse gas intensity that does not exceed 100g CO_2 –e/MJ of thermal energy load; or
   ii. an on-site renewable energy source; or
   iii. another process as reclaimed energy; and

(c) Have features that facilitate the efficient use of water.

Appendix C Notations, abbreviations, terms, definitions and symbols.

For the purpose of this document the following notations, abbreviations, terms, definitions and symbols are included for reference.

C.1 Notations and abbreviations

°C – degrees Celsius

ABCB – Australian Building Codes Board

AS – Australian Standards

B – Basin

BCA – Building Code of Australia

Bth – Bath

cfu – Colony-forming unit

cfu/mL - Colony forming units per millilitre

CFWH – Continuous flow water heater

Di – Internal diameter

m – Meters

mg – Milligrams

mg/L - Milligrams per litre

mL – Millilitre

mm – Millimetres

NCC – National Construction Code

ORP - Oxidation-Reduction Potential

PCA – Plumbing Code of Australia

pH – The term used to describe the hydrogen ion concentration in water, pH 7 is neutral

Shr – Shower

SWH – Storage water heater

TCD – Temperature Control Device

TMV - Thermostatic mixing valve

Tr.(L) – Laundry trough

TV – Tempering Valve

UV – Ultraviolet

W.H – Water Heater

μg/L - Micrograms per litre

C.2 Terms and definitions

For the purpose of this report the following terms and definitions are applied.

Aged care building - A Class 9c building for residential accommodation of aged persons who, due to varying degrees of incapacity associated with the ageing process, are provided with personal care services and 24 hour staff assistance to evacuate the building during an emergency.

Auxiliary water heater - A secondary water heating device having a coil or container fitted to cooking or heating equipment or a flue assembly, fuelled by an uncontrolled heat source and used to supplement a primary water heater or system.

Boiler - A vented water heater designed to provide boiling or near boiling water.

Circulating system (solar) - A system in which the heat transfer fluid circulates between the collector and storage vessel or heat exchanger, during operating periods (by means of a pump or fan by natural convection).

Continuous flow water heater (instantaneous) - An unvented water heater in which the heat energy is applied only while the water flows to an outlet.

Dead leg - A length of water-filled pipe where there is little or no flow.

Dead water - The cold water drawn off before hot water commences to discharge from a heated water outlet.

Developed length - The total length along the centre-line of a pipe and fittings including all bends.

Direct system - A heated water service in which the water supplied to the daw-off points is heated by a primary source of heat such as solid fuel, gas, electricity or oil.

Dynamic pressure - The pressure in pipework under flow conditions.

Expansion control valve - A pressure activated valve that opens in response to an increase in pressure caused by the expansion of water during the normal heating cycle of the water heater and which is designed for the installation on the cold water supply to the water heater.

Head - The total energy possessed by a unit weight of fluid due to its elevation, pressure and velocity. It is expressed as a height in metres of fluid.

Heated water reticulation - Other than the actual water heater, all parts of the installation and all equipment and materials necessary to provide a supply of heated water at the specified outlets.

Heated water service - All parts of the installation including the water heater and all equipment and materials necessary to provide a supply of heated water at the specified outlets.

Indirect system - A heated water service in which the water supplied to the draw–off points is heated by means of a water calorifier.

Isolating valve - Any valve for the purpose of isolating part of a water system from the remainder.

Legionnaires' disease - The most severe and common form of pneumonia caused by Legionella pneumophila. Symptoms are nonspecific; however the disease has rapid onset and can be fatal.

Legionellosis - Generic term used to describe infections caused by Legionella pneumophila, which can range in severity from a mild, febrile illness (Pontiac Fever) to a rapid and potentially fatal pneumonia (Legionnaires' disease).

Manifold - A pipe assembly comprising headers and branch pipes for interconnecting a number of appliances so as to combine their output.

Mechanical mixing valve - A mixing valve of the non-thermostatic type, which controls the temperature from the mixed water outlet.

Mixing valve - A valve in which separate supplies of hot water and cold water are mixed together, either automatically, to give a desired temperature from the mixed water outlet.

Non-return valve - A valve to prevent reverse flow from the downstream section of a pipe to the section of pipe upstream of the valve.

ORP probe - A device used to measure very small voltages generated with a probe placed in ozonated water

Pre-heater water heater - A water heater not containing a means of supplementary heating and installed to preheat the cold water supply prior to its entry into any other type of household water heater.

Pressure limiting valve - A valve that limits the outlet pressure to a set pressure, within specified limits only, at the inlet pressures above the set pressure.

Pressure ratio valve - A valve that automatically reduces the outlet pressure to a specified ratio of its inlet pressure.

Pressure reducing valve - A valve that automatically reduces the pressure to below a predetermined value on the downstream side of the valve.

Pressure relief valve - A spring loaded or weight loaded valve for automatically controlling the build-up of excessive pressure in pipework or fittings by means of a discharge to atmosphere.

Primary circuit flow and return - Pipes that respectively convey water from the source of heat to the storage vessel and from the storage vessel back to the source of heat.

Pump - A mechanical device generally driven by a prime mover and used for raising fluids from a lower to a higher level or for circulating fluid in a pipework system.

R – Value (m^2.K/W) - The thermal resistance of a component calculated by dividing its thinness by its thermal conductivity.

Residential - A building that contains one or more sole occupancy units.

Return pipe - A pipe in a primary heated water system, in which water moves back to the boiler, or a pipe in a secondary heated water system in which water moves back to the heated water storage vessel.

Sanitary facility - A bathroom or alike containing multiple plumbing fixtures.

Secondary circuit flow and return pipe - Pipes that respectively convey heated water from and return it to the storage vessel and from which heated water may be drawn off.

Sole occupancy unit - A room or other part of a building for occupation by one owner, lessee, tenant, or other occupier to the exclusion of any other owner, lessee, tenant or other occupier.

Storage water heater - A water heater that incorporates a thermally insulated container in which the water is heated and stored for subsequent use.

Supplementary water heater - An additional appliance or device supplying water heated by a controlled heat source and used to supplement a primary water heater or system.

Temperature Control Device - Either a tempering valve or a thermostatic mixing valve.

Temperature –pressure-relief (TPR) valve - A spring loaded automatic valve limiting the pressure and temperature by means of discharge and designed for installation on the heated side of a storage water heater.

Temperature relief valve - A temperature-actuated valve that automatically discharges fluid at a specified set temperature. It is fitted to a water heater to prevent the temperature in the container exceeding a predetermined temperature, in the event that energy input controls fail to function.

Tempering valve - A mixing valve that is temperature actuated and is used to temper a heated water supply with cold water to provide heated water at a lower temperature.

Thermal shut off - A term used to describe the function of a warm water generator in promptly and automatically either shutting off or significantly reducing the flow of water, should either:

(a) The cold water supply to the warm water generator be inadequate or be interrupted; or
(b) There is a malfunction of the product that is covered by the operation and maintenance manual for the product.

Thermostatic mixing valve (TMV) - A mixing valve which the temperature of the water from the mixed water outlet is automatically controlled by a thermostatic element/sensor to a preselected temperature that is suitable for direct contact with the skin.

Warm Water - Potable water within the temperature range of 40.5°C to 43.5°C as measured at an ablution outlet fixture.

Warm Water Generator - A standard commercial product other than a thermostatic mixing valve, that is suitable for the intended purpose and can automatically generate warm water from cold water and also control the temperature of the warm water.

Working pressure - The maximum internal pressure that can be sustained by a pipeline component for its estimated useful life, under the anticipated working conditions.

C.3 Symbols

The valve Symbols within Figure 19 represent valves commonly used in heated and warm water systems and are used throughout the figures within this report.

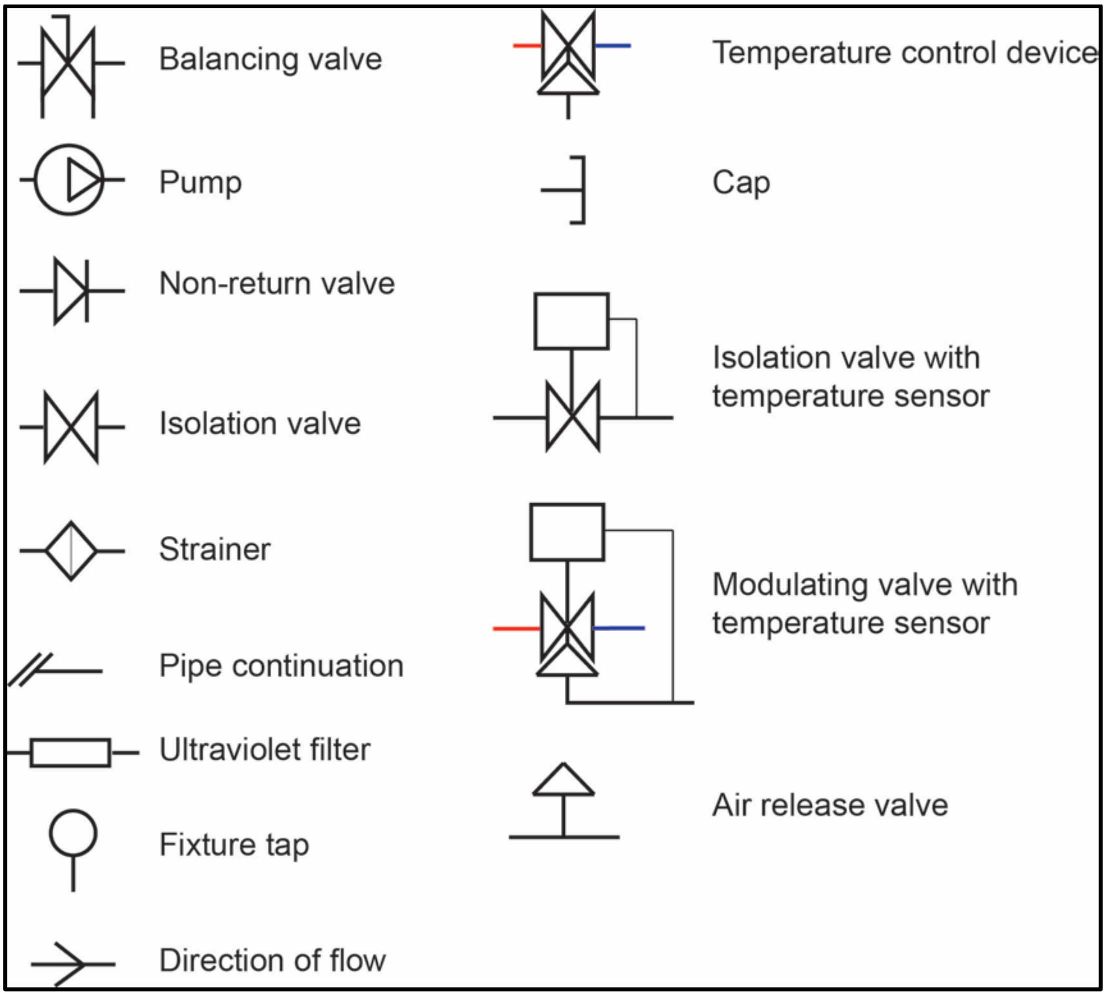

Figure 19: Legend of symbols

Appendix D Rate of scalding

The indicative rate of scalding shown in Table 8 has been used to develop Figure 20 to show the variations in scalding times between adults[51] and children[52].

Temperature °C	*Adults*	*Children (0 – 5 years)*
45	6 hours	6 hours
50	5 minutes	5 minutes
51	3 minutes	3 minutes
52	1.5 minutes	1.5 minutes
53	1 minute	1 minute
54	35 seconds	10 seconds
55	30 Seconds	-
56	16 seconds	-
57	14 seconds	4 seconds
58	10 seconds	-
59	7 seconds	-
60	5 seconds	1 seconds
65	2 seconds	0.5 seconds
70	1 second	-

Table 8: Indicative rate of scalding

[51] (Studies of thermal injury II. The relative importance of time and surface temperature in the causation of cutaneous burns, 1947)
[52] (Paediatrics Vol. 71, 1983)

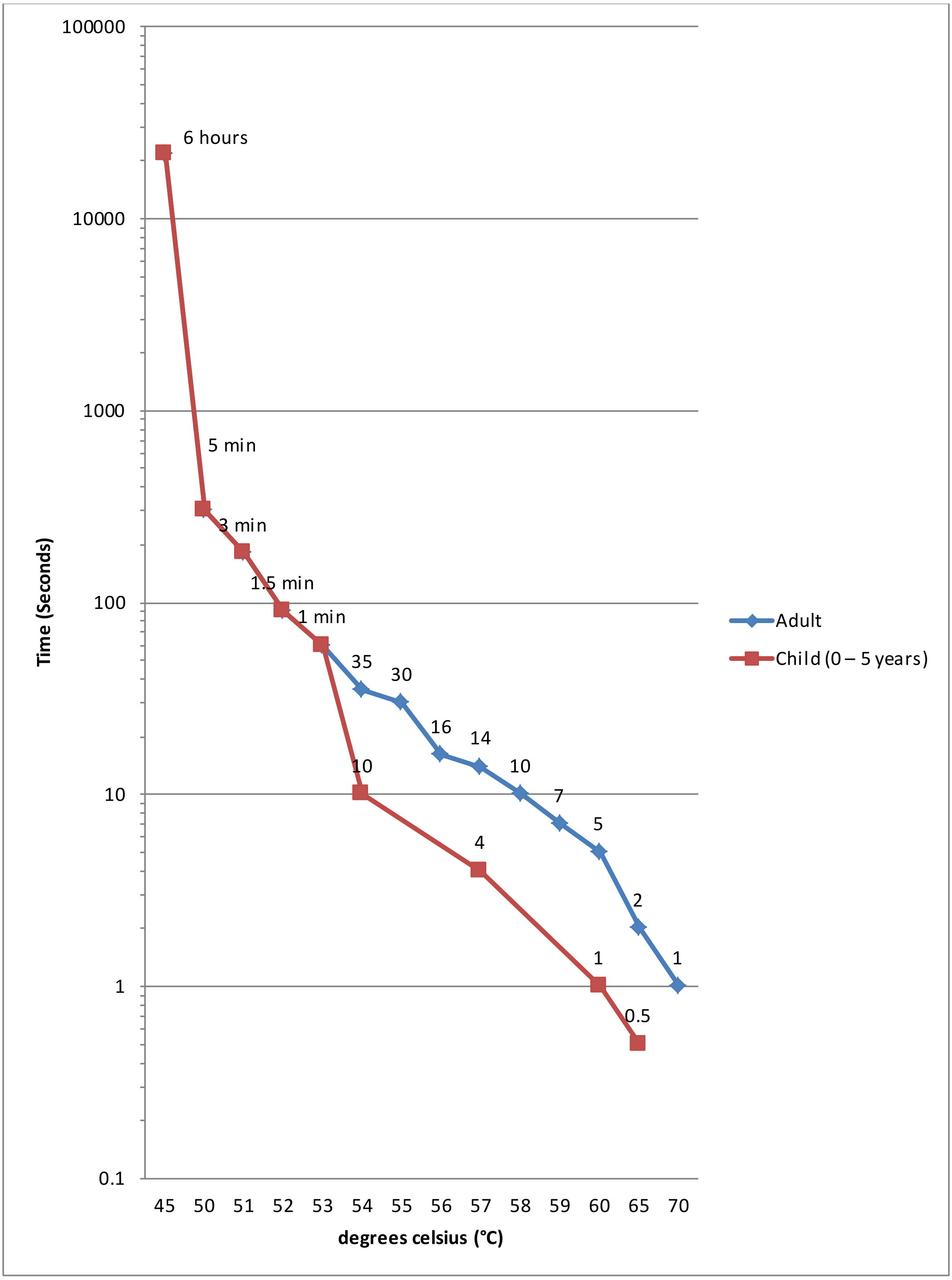

Figure 20: Rate of scalding