BRE

information paper

Preventing hot water scalding in bathrooms: using TMVs

IP 14/03

Hot bath water is responsible for the highest number of fatal and severe scald injuries in the home. Young and old are most at risk because their skin is thinner and less tolerant to high water temperatures. There is no legal requirement to limit water delivery temperatures in homes, but The Guidance to the Water Supply (Water Fittings) Regulations 1999 recommends the use of thermostatic mixing valves in schools, public buildings and other public facilities. Schemes for housing built by housing associations have been revised recently. The Housing Corporation's Scheme Development Standards recommend thermostatically controlled supplies to bath taps in all housing, but consider it essential for showers and all hot water taps in housing for the elderly.
This IP explains how to reduce the risk of scalding and contains technical guidance on the selection, installation and maintenance of products to provide hot water at temperatures to minimise scalding risks to users of baths, basins and showers.

The problem

Hot bath water is responsible for the highest number of fatal and severe scald injuries in the home. Every year around 20 people die as a result of scalds caused by hot bath water and a further 570 suffer serious scald injuries.

Young children and older people are most at risk from bath water scalds because their skin is thinner and therefore less tolerant to higher water temperatures than that of other age groups. As a result, they sustain scalds more quickly, at lower water temperatures and often with a greater depth of burn.

Over three-quarters of severe scalds are suffered by children under five years of age, and almost three-quarters of the fatalities are people aged 65 and over – *see Table right*.

People with a reduced ability to perceive risk or react to hazardous situations – for example those with mental or physical disabilities – are also at greater risk of injury.

Average yearly numbers of bath scalds by severity and age group in UK 1992 – 1996

	Injury severity	
Age (years)	**Serious**	**Fatal**
Under 5	437	2.3
5 – 10	46	0
11 – 17	25	0
18 – 64	25	3.5
65 and above	41	15.2
All ages	574	21

Sambrook Research International, 1999

Deprivation increases the likelihood of a child suffering severe scald injuries. Research indicates that children from the poorest families are more likely to be admitted to hospital with scald injuries and with more severe scald injuries than children from wealthier homes (Hippisley-Cox et al, 2002).

The Child Accident Prevention Trust's project on preventing scalds is funded through the Department of Trade and Industry's Modernisation Fund

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Severe scalds in seconds

The degree of scalding depends on the temperature and volume of hot water, and the length of time the body is exposed to it. However, it can take only seconds for a severe scald to occur. Research (Waller et al, 1993) indicates that: *As the temperature of the water increases above 50°C, the duration of exposure needed to suffer third-degree burns decreases rapidly. Healthy adult skin requires 30 seconds of exposure to water at 54°C – 55°C before third-degree burning occurs, but only 5 seconds at 60°C and less than one second at 70°C. However, the skin of children and the elderly is even more sensitive to extreme temperatures*.

The impact of severe scalds

Severe scalds can result in long-term disability and disfigurement, and can be among the most distressing and painful injuries a child can receive. Apart from many years of surgery and hospital treatment, a child may also endure a lifetime of scarring, prolonged psychological trauma, social alienation and educational difficulties. Scalds can also have long-term repercussions for children's families and are very costly for the health service.

Case study

A two-year old boy fell into a bath of scalding hot water, sustaining massive burns to his body. By the age of seven, he had over 100 operations, 15 of them life-saving. He faces many more years of painful skin grafts until he stops growing. As he requires regular hospital treatment, and is sometimes confined to a wheelchair, his mother has been unable to take up training opportunities or return to work. The projected cost of treating his injuries is £250,000.

There are 570 serious bath water scald injuries in the UK every year, with projected treatment costs running into tens of millions of pounds.

Preventing bath water scalds

Parents can minimise the risk of scalding by closely supervising bath-time, so that a child has no opportunity to turn on the hot tap while their parent is distracted. However, the most effective safety measure is the installation of a thermostatic control device to regulate the bath water outlet temperature to reduce the risk of severe scalding. For deprived families, cost is the barrier and only the social housing provider can afford to introduce this.

Housing sector developments

The Housing Corporation has recognised the need for an effective solution to the hazard of scalding within social housing. The revised *Scheme Development Standards*, issued in April 2003, included a new recommendation for general needs housing under item 1.2.1.33a – that hot water taps to baths should have a thermostatically controlled supply.

Under item 1.2.1.59, housing for the elderly, the statement is classed as an 'essential' item and has a broader application which indicates that all hot water taps should have a thermostatically controlled supply.

The *Scheme Development Standards* set out the Corporation's requirements and recommendations for all housing projects that receive Social Housing Grants. The revised standards apply to all schemes subject to audit after 31 March 2003.

Legionella

Legionella bacteria can cause various illnesses in humans with and without pneumonia known as *Legionellosis*. Non-fatal illnesses without pneumonia include Pontiac fever and Lochgoilhead fever, but the potentially fatal form is Legionnaire's disease.

The reason for storing and distributing water at high temperatures is to prevent the proliferation of legionella. At temperatures between 32°C and 41°C, legionella bacteria multiply; legionella bacteria maintained at normal human body temperature of 37°C have been found to be the most virulent.

Legionella bacteria are killed progressively at temperatures above 46°C. For example, at sustained temperatures around 50°C, legionella will be killed within hours but at sustained temperatures around 60°C this is reduced to minutes. The actual time taken for all the legionella to die depends upon the level of contamination.

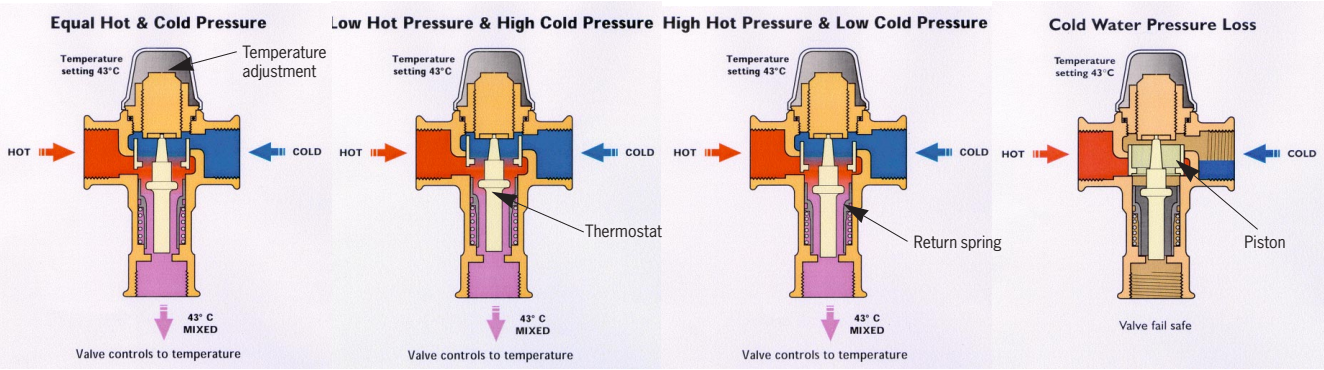
Further details about legionella bacteria, and the recommendations for its control, are in the current HSE Approved Code of Practice and Guidance Document L8.

Control of water temperatures

Temperature is the preferred method of controlling legionella bacteria. It is recommended that cold water is stored below 20°C and that cold taps supply water below 20°C within two minutes.

For hot water, the requirement is to store the water at 60°C or above and ensure that the hot outlet can supply water at or above 50°C within one minute. (Larger buildings usually have a recirculating hot water loop; such systems should return the water at 50°C or above.) These hot water delivery temperatures may be useful in some applications but they are too high for bathrooms. For appliances within bathrooms, the discharge temperatures should be between 37°C and 46°C from the outlets.

An effective way of achieving these objectives is to store and distribute water at high temperatures and use thermostatic mixing valves (TMVs) at, or very close to, the point of use to reduce outlet temperatures.



Thermostatic mixing valves

Thermostatically controlled products are available to control accurately the temperature of water for showering, bathing and hand-washing. These valves also maintain the pre-set temperatures even if the water pressure varies when other appliances are used. Installed and maintained correctly, they can significantly reduce the risk of scalding in the home.

Function

Hot and cold water entering the valve is mixed to a temperature pre-selected by the user or installer. This is achieved automatically by a thermally sensitive mechanism within the valve that proportions the amount of hot and cold water entering to produce the required blend. The mechanism then automatically compensates for any variations in supply pressures or temperatures to maintain the pre-selected temperature. In the event of cold water supply failure, the thermostatic mixing mechanism will automatically shut down the flow to prevent discharge of dangerously hot water – see figures above.

Main components

Thermostat A temperature sensitive element which expands or contracts depending on the temperature of the water surrounding it. When the thermostat senses a temperature change, it moves a piston which changes the proportion of hot and cold water being mixed in the valve. This movement enables the valve to remain stable and to shut down in case of cold or hot water failure.

Piston Usually connected to the thermostat, the piston moves back and forth over the cold and hot ports of the valve, changing the proportion of hot and cold water entering the valve depending on the temperature of the water.

Return spring When the thermostat expands it moves the piston under its own energy and compresses the return spring; when the thermostat is chilled, the thermostat contracts and the return spring pushes the piston back.

Temperature adjustment Most thermostatic mixing valves have a separate temperature adjustment (usually beneath a lock shield cover). Typically, this can be adjusted to change the position of the piston and therefore the proportion of hot and cold water entering the valve.

TMV product certification scheme

Care must be taken to select thermostatic mixing valves that are suitable for their intended use and provide adequate protection from scalding. To ensure that valves meet this requirement, independent third-party certification BuildCert TMV schemes have been established.

The recently introduced BuildCert TMV2 Scheme ensures that valves for domestic properties meet the requirements of BS EN 1111 and/or BS EN 1287 as well as the additional requirements of the BuildCert TMV2 Scheme. Valves conforming to these Standards can maintain temperature stability at all times and will shut down safely in case of cold water failure to protect the user from scalding.

If a thermostatic mixing valve complies with the requirements of D 08 (a National Health Service (NHS) specification), BuildCert TMV3 approval is granted. BuildCert TMV3 approved valves can be used in mixed water installations where the user is a less able member of the household who might not be able to react to a sudden change in water temperature. In all cases, a risk assessment should be carried out to establish the requirements of the individuals of the household and its effect upon the risk of scalding by hot water. The correct BuildCert TMV2 or TMV3 approved valve can then be selected for the desired application: bath, bidet, shower or washbasin.

Risk assessment

Known as the duty of care, it is the responsibility of the person in charge of the property to ensure that all necessary steps are taken to prevent people using the home or facility from being injured. In all environments, domestic, commercial or institutional, a risk assessment should be carried out to establish how susceptible people are to the dangers of scalding. When a person has taken all reasonable steps to ensure the safety of those people living and working in the environment, they will have discharged their duty of care. The correct valve can then be chosen for the application and to protect against the established level of risk.

Thermostatic mixer valve application table

Suggested best practice is for TMVs to be installed in all buildings even if there are no specific recommendations or requirements. The only exception to this would be if a risk assessment has concluded that TMV control is unnecessary.

In some building types, legislation and guidance stipulates certain types of valve and installations. The table on page 4 summarises the current situation. However, in all cases the relevant authority or controlling body should be consulted for the particular building.

Environment	Appliance	Is a TMV : required by legislation or authoritative guidance?	Is a TMV : recommended by legislation or authoritative guidance?	Is a TMV : suggested best practice?	Valve type?	Reference documents
Private dwelling	Bath			yes	TMV2	
	Basin			yes	TMV2	
	Shower			yes	TMV2	
Housing association dwelling	Bath		yes		TMV2	Housing Corp Standard (1.2.1.33a)
	Basin			yes	TMV2	
	Shower			yes	TMV2	
Housing association dwelling for the elderly	Bath	yes			TMV2	Housing Corp Standard (1.2.1.58 and (1.2.1.59)
	Basin	yes			TMV2	
	Shower	yes			TMV2	
Hotel	Bath			yes	TMV2	Guidance to the Water Regulations (G18.5)
	Basin			yes	TMV2	
	Shower			yes	TMV2	
NHS nursing home	Bath		yes		TMV3	NHS Health Guidance Note, Care Standards Act 2000, Care Homes Regulation 2001, DO8
	Basin		yes		TMV3	
	Shower		yes		TMV3	
					TMV3	
Private nursing home	Bath		yes		TMV3	Guidance to the Water Regulations (G18.6), Care Standards Act 2000, Care Homes Regulations 2001, HSE Care Homes Guidance
	Basin		yes		TMV3	
	Shower		yes		TMV3	
Young persons' care home	Bath	yes			TMV3	DoH National Minimum Standards Children's homes Regulations, Care Standards Act 2000, Care Homes Regulations 2001, HSE Care Homes Guidance
	Basin	yes			TMV3	
	Shower	yes			TMV3	
Schools, including nursery	Basin		yes		TMV2	Building Bulletin 87, 2nd edition, The School Premises Regulations/ National minimum care Standards Section 25.8
	Shower	yes			TMV2	
	Bath	yes, but 43°C max			TMV2	
Schools for the severely disabled including nursery	Basin		yes		TMV3	Building Bulletin 87 2nd edition, The School Premises Regulations, if residential, Care Standards Act
	Shower	yes			TMV3	
	Bath	yes, but 43°C max			TMV3	
NHS hospital	Bath	yes			TMV3	NHS Health Guidance Note, DO8
	Basin	yes			TMV3	
	Shower	yes			TMV3	
Private hospital	Bath		yes		TMV3	Guidance to the Water Regulations (G18.6)
	Basin		yes		TMV3	
	Shower		yes		TMV3	

Housing Corp Standard Housing Corporation, Scheme Development Standards, 5th Edition, Housing Corporation 2003.

DO8 Model engineering specifications D 08 Thermostatic mixing valves (healthcare premises), NHS Estates, 1997.

Building Bulletin 87 2nd edition School Building and Design Unit Department for Education and Skills. Building Bulletin 87 2nd edition, Guidelines for environmental design in schools. DfES 2003, London.

Guidance to the Water Regulations Department for Environment, Food & Rural Affairs, *Water Supply (Water Fittings) Regulations 1999 Guidance Document relating to Schedule 1: Fluid Categories and Schedule 2: Requirements For Water Fittings*. DEFRA 1999, London.

DoH National Minimum Standards Children's homes Regulations Department of Health, National Minimum Standards Children's homes Regulations

National minimum care Standards Section 25.8

NHS Health Guidance Note National Health Service Guidance note, Safe hot water and surface temperatures

HSE Care Homes Guidance Health and Safety Executive, Health and Safety in care homes, HSG 220, HSE 2001.

Care Standards Act 2000

Care Homes Regulations 2001

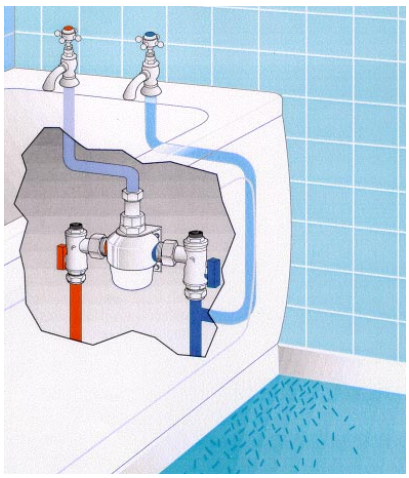
Children's Home Regulations 2001

Common applications

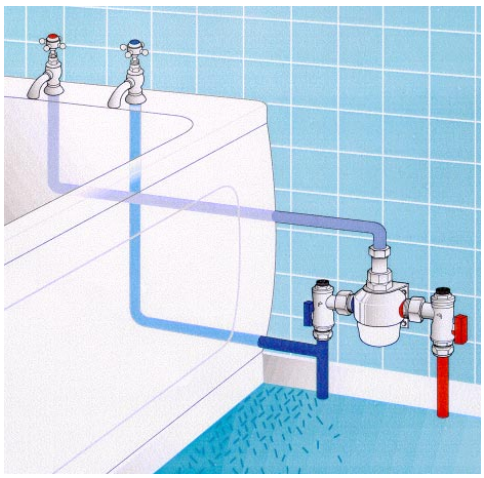
Baths

The bath has the highest number of reported fatal/serious scalding incidents. Safe water temperatures are essential. Most accidents occur with the young, elderly or infirm either getting into baths that are initially too hot, or in topping up with hot water.

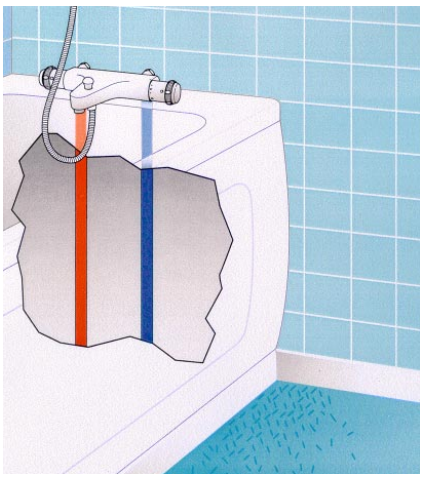
Thermostatic mixing valves can control hot water at a pre-selected maximum temperature, typically 44°C but maximum 46°C, which allows for heat loss in metal baths. Temperature adjustment to suit individual preference is still possible. Some types of thermostatic mixing valves can be installed with existing conventional taps, others can replace existing taps – see figures below.



Pillar taps and concealed under-bath TMV



Pillar taps with exposed under-bath TMV



Integrated bath and shower TMV tap

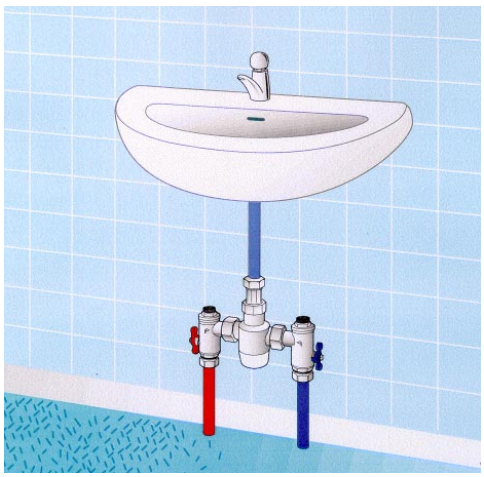
Basins

When washing, people may put their hands directly into running water without waiting for the maximum water temperature to be reached. When the hot water reaches full temperature, scalding can occur without warning. As with bathing, the young, elderly and infirm are most at risk, but scalding can happen to anyone.

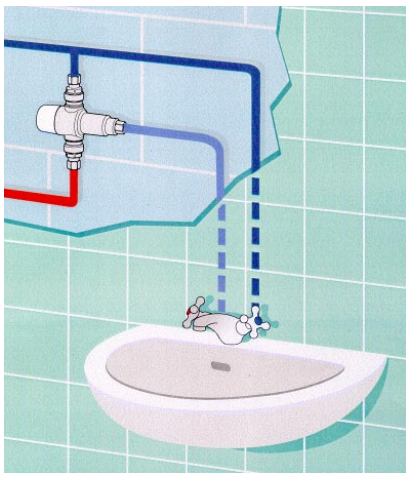
An under-basin thermostatic mixing valve should be used to control the hot water at each outlet to a pre-selected temperature, typically 41°C. The figures below show some applications.

Other options for basin water temperature control which meet the the TMV2 and TMV3 standard not shown include:

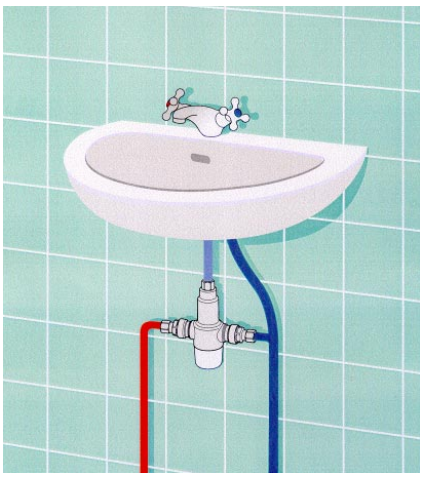
- Sequential thermostatic mixing valve with a single control (off – cold – mixed).
- Thermostatic mixing valve with separate integral controls for flow and temperature adjustment.
- Sequential thermostatic tap with a single control (off – cold – mixed).
- Dual-control thermostatic tap with separate integral controls for flow and temperature adjustment.



Single tap with pre-set mixed temperature from exposed under-basin TMV



Dual-control tap with an accessible concealed under basin TMV



Dual-control tap with exposed under-basin TMV

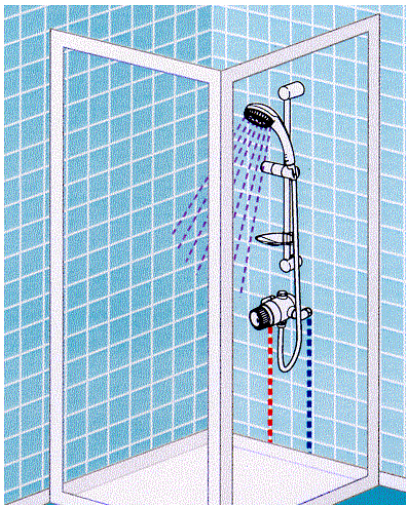
Shower controls

Showering with water that is too hot can cause scalding. Any sudden changes in temperature, whether hotter or colder, can also lead to injury through shock, slips and falls.

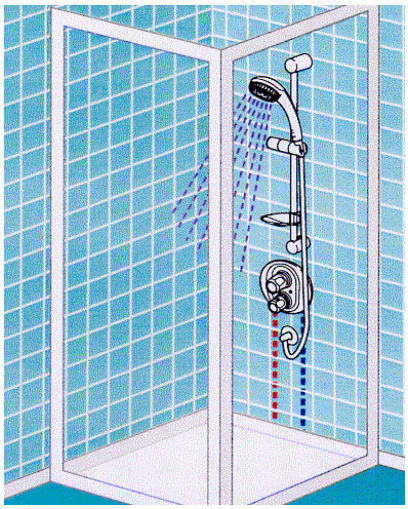
With thermostatic shower valves, users can set their preferred showering temperature. The valve then responds to changes in water pressure or temperature to maintain the selected temperature. In the event of loss of either hot or cold water supply, the thermostatic shower valve provides automatic shut down to reduce the risk of scalding.

Some shower valves have push-buttons with which the user can over-ride the factory-set maximum up to almost the full hot water temperature. The potential risk of such devices must be taken into account during the risk assessment and valve selection. The BuildCert TMV scheme recommends that thermostatic shower mixing valves be limited to delivering water at a temperature of 39°C – 43°C.

Another option for shower water temperature control which meets the requirements is a manual shower valve with an under-basin TMV to control its hot supply.



Single-control sequential shower TMV



Dual-control TMV

Manual shower valve with an under-basin TMV

Maximum outlet temperatures

The BuildCert TMV scheme recommends the following maximum hot water temperatures for use in all premises:
46°C for bath fill but see notes below;
41°C for showers;
41°C for washbasins;
38°C for bidets.
Temperatures should never exceed 46°C.

Notes:
46°C is the maximum temperature for water from the bath hot tap, having regard in particular for the margin of error inherent in TMV2 valves and temperature loss in metal baths, especially in cold bathrooms. It is not a safe bathing temperature for adults or children. The British Burns Association recommends 37 to 37.5°C as a comfortable bathing temperature for children.
In premises covered by the Care Standards Act 2000, the maximum water outlet temperature is 43°C.

Installation, commissioning, maintenance

Installing, commissioning and testing in-situ valves is very important. Unless these procedures are carried out to the manufacturer's instructions and to all the relevant standards, the protection given by TMVs cannot be guaranteed.

Installation

Before installing the thermostatic valve, ensure that its specification is appropriate: for example, flowrates, pressures and water temperatures must be within the limits stated by the manufacturer.

Most valves can be installed in any orientation provided the hot and cold supplies are connected to the appropriate inlets. Since the valves contain temperature sensitive components, soldering near the main valve body must be avoided.

TMV2 thermostatic mixing valves must be tested once a year to check their performance has not changed from the time of installation. To facilitate these tests, isolating valves must be installed on the hot and cold supplies leading up to the valve. The isolating valves and the thermostatic mixing valve itself must be fitted in such a way that testing and, if required servicing, can be carried out without major renovation works.

Depending on the design, each TMV will have different space requirements for installation. Owing to required

flowrates, a valve approved for low pressure may be significantly larger than one approved for high pressure; this is particularly true for baths owing to the high flowrates required. Check the information supplied with the TMV for space requirements.

Position TMV and isolating valves: here ...	but not here ...
Inside a vanity unit	Under floorboards
Behind a bath panel	In vanity kickspaces
Behind a pedestal	Behind tiled walls or other permanent enclosures
In an accessible service duct	In inaccessible ceiling voids and lofts

It is strongly recommended that full-bore strainers are installed on the hot and cold inlets to prevent debris entering the valve and causing damage to the internal components. As with isolating valves and TMVs, strainers should be located with easy access for servicing. Some TMVs incorporate isolating valves and full-bore strainers in their design.

Each outlet should be fitted with its own TMV with pipework from the valve no longer than 2 m. The length limit is part of the current guidance on the prevention and control of legionella. In addition, the length of any spur to a TMV, from a hot water recirculation system, should not exceed 5 m.

Although it may be physically possible to use one TMV to control the temperature of the hot water supply to all the appliances in an enclosed space, such as a bathroom, this is not recommended because :

- pipework runs from the TMV to the outlets would probably exceed the 2 m limit;
- the TMV2 guidance gives maximum temperatures for each appliance; for a bath, it is 46°C and for a basin 41°C; if one TMV is used to supply both, either the bath would be too cold or the basin too hot.

Commissioning TMVs

First, check the following:

- The designation of the thermostatic mixing valve matches the application.
- The supply pressures are within the valve's operating range.
- The supply temperatures are within the valve's operating range.
- Isolating valves and strainers are provided

If all these conditions are met, adjust the temperature setting according to the manufacturer's instructions.

How to test operating temperatures

- Take temperature readings at the normal flowrate after allowing about a minute for the system to stabilise.
- The sensing part of the thermometer probe must be fully submerged in the water that is to be tested.
- Any TMV that has been adjusted or serviced must be recommissioned and re-tested in accordance with the manufacturer's instructions.

Maintaining the TMV

TMV2 valves should be tested annually against the original performance results using the following performance checks:

- Measure the mixed water temperature.
- Carry out the cold failsafe shut-off test by isolating the cold water supply to the TMV. Wait for five seconds; if water is still flowing, check that the temperature is below 46°C.
- If there is no significant change to the set outlet temperature (2°C or less change from the original settings) and the failsafe shut-off is functioning, the valve is working correctly and no further service work is required.

If the outlet water temperature has drifted from its set point by more than 2°C or if the failsafe function does not work, a full service and recommissioning of the valve is required; see the manufacturer's instructions on servicing the TMV.

Maximum/minimum inlet temperature

To function at their optimum, thermostatic mixing valves require that the temperature of the hot water supplied to the valve is higher than the set mixed water outlet temperature; (check the manufacturer's specification for the exact temperature difference). This is to ensure that the valve will shut down the hot supply if the cold water were to fail.

Maximum/minimum working pressure

Most TMVs are designed and tested for use with high and low pressure water supplies and will have been third-party tested to ensure compliance with the BuildCert TMV2 scheme. A TMV that is approved for low pressure can be used where dynamic pressures are in the range of 0.2 to 1 bar; one that is approved for high pressures can be used where dynamic pressures are in the range of 1 to 5 bar, and a valve which is approved for both high and low pressures can be used for high and low pressures in the range of 0.2 to 5 bar. Use the table below to select the correct valve.

Supply pressure		Correct valve
Cold water	Hot water	
Low (0.1-1 bar)	Low (0.1-1 bar)	EN 1287 (LP)
Low (0.1-1 bar)	High (0.5- 5 bar)	EN 1287 (LP)
High (0.5- 5 bar)	Low (0.1-1 bar)	EN 1287 (LP)
High (0.5- 5 bar)	High (0.5- 5 bar)	EN 1111 (HP)

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BS 6700 : 1997 Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages.

BS EN 1111: 1999 Sanitary tapware – thermostatic mixing valves PN10 – General technical specification

BS EN 1287: 1999 Sanitary tapware- Low pressure thermostatic mixing valves – General technical specifications

Further reading

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01495 236 260
www.wrc-nsf.com

Child Accident Prevention Trust (CAPT)
18-20 Farringdon Lane, London, EC1R 3HA
020 7608 3828
www.capt.org.uk

Institute of Plumbing (IoP)
64 Station Lane, Hornchurch, Essex. RM12 6NB
01708 472 791
www.plumbers.org.uk

Thermostatic Mixing Valve Association (TMVA)
Westminster Tower, 3 Albert Embankment, London SE1 7SL
020 7793 3008
www.tmva.org.uk

child accident prevention trust

Thermostatic Mixing Valve Manufacturers Association

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