

## Section 7 – F/602/2884

# Understand and apply domestic hot water system installation and maintenance techniques



## F/602/2884 - Understand and apply domestic hot water system installation and maintenance techniques

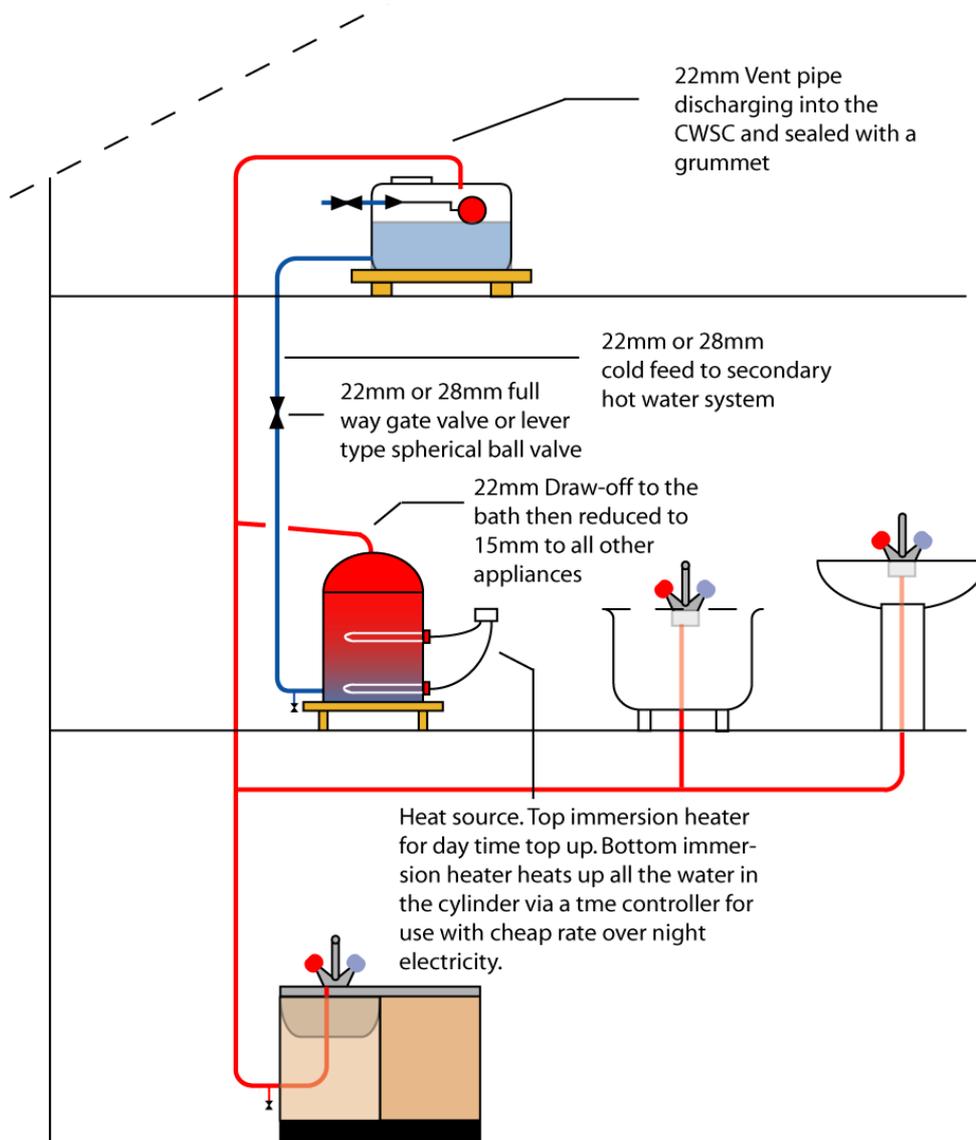
This combination unit provides learning in the installation, maintenance, decommissioning and soundness testing of a basic range of hot water system/component types in dwellings and industrial/commercial properties (of similar size and scope to domestic dwellings). The unit covers systems in building up to 3 storey's in height with pipework up to 28mm diameter. Upon completion the learner will:

- LO1.** Know the types of hot water system and their layout requirements
- LO2.** Know the site preparation techniques for hot water systems and components
- LO3.** Be able to apply site preparation techniques for hot water systems and components
- LO4.** Know the installation requirements of hot water systems and components
- LO5.** Be able to install hot water systems and components
- LO6.** Know the service and maintenance requirements of hot water systems and components
- LO7.** Be able to service and maintain hot water systems and components
- LO8.** Know the decommissioning requirements of hot water systems and components
- LO9.** Be able to decommission hot water systems and components
- LO10.** Know the inspection and soundness testing requirements of hot water systems and components
- LO11.** Be able to inspect and soundness test hot water systems and components.

**Learning Outcomes highlighted in Red indicate that these are covered by practical tasks from the learner practical portfolio.**

# Learning Outcome 1

## Know the types of hot water system and their layout requirements



There are fourteen Assessment Criteria in Learning Outcome 1:

- AC1.1.** Identify the type of hot water system from layout diagrams
- AC1.2.** State the factors that need to be considered when the type of hot water system is selected for use in a building
- AC1.3.** Identify the working principles of hot water system components
- AC1.4.** State the typical pipe sizes used in centralised open vented hot water systems in dwellings.
- AC1.5.** State the system layout features for the open vent and cold feed pipes of primary and secondary open vented hot water circuits.
- AC1.6.** State the connection requirements for feed and expansion cisterns into open vented primary hot water circuits.
- AC1.7.** State the system layout features for plastic feed and expansion cisterns:
- AC1.8.** Identify the type and typical sizes of open vented storage cylinder used in hot water systems in dwellings
- AC1.9.** State the system layout features for hot water heaters
- AC1.10.** State the typical pipe sizes used with mains fed instantaneous hot water heaters and open vented point of use water heaters in dwellings.
- AC1.11.** Identify the need for temperature control of hot water systems
- AC1.12.** State the factors that can lead to backflow from hot water outlets and equipment in dwellings.
- AC1.13.** Identify the standard backflow prevention devices that are used in hot water systems in dwellings supplying water to appliances
- AC1.14.** State the system layout features for the installation of hot water components

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## Before we begin.....

The theory behind hot water systems will contain terminology that will be unfamiliar to you. Understanding the terminology is key to understanding hot water installations, so, before we investigate hot water systems, let us first look at some of the key phrases that you will come across as you work through this section.

### Terminology

#### Centralised hot water systems

#### Localised hot water systems

### Meaning

A centralised hot water system that supplies every hot water outlet from a hot water vessel, heater or boiler usually sited in a central position in the property.

A localised hot water system that supplies hot water to a single appliance, such as a kitchen sink in an office or factory and is usually sited near to where the hot water is needed. They are only used for small amounts of hot water.

### Open Vented systems

An open vented system contains a vent pipe that is permanently open to the atmosphere. This means that the water in the system can never exceed 100°C. They are fed with water from a cold feed cistern (see Unit 05 Cold Water installations).

### Unvented systems

An unvented hot water system does not contain a vent pipe. These systems are supplied with water directly from the mains supply.

### Instantaneous hot water systems

Instantaneous hot water systems heat the water instantly as it is required when a tap is turned on. There is no hot water storage. These can be both localised and centralised multipoint

### Storage hot water systems

Storage hot water systems store an amount of hot water in a central location for distribution to all hot water outlets and taps. They can be both open vented systems and unvented systems.

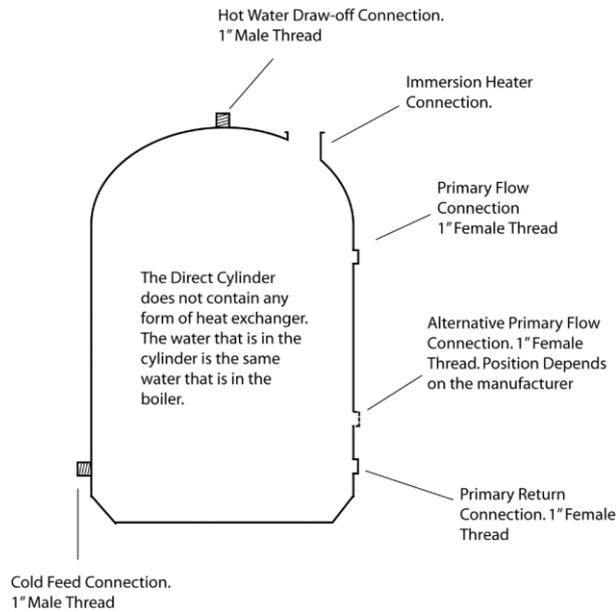
## AC1.1 Identify the type of hot water system from layout diagrams

There are a number of hot water systems in use in the UK. Some of these are open vented systems that remain open to the atmosphere and some provide instantaneous hot water through combination boilers and multipoint water heaters. The differences between each system will become apparent as we work through the system layouts. We will look at:

- Direct systems
  - Containing a back boiler
  - Containing a hot water immersion heater
- In-direct systems
  - Single feed, self-venting systems
  - Double feed systems with a hot water heating coil
- Thermal store
- Instantaneous hot water heaters
  - Single point (point of use) heaters
  - Multipoint heaters
- Combination (Combi) boilers

### Open Vented Direct hot water storage systems

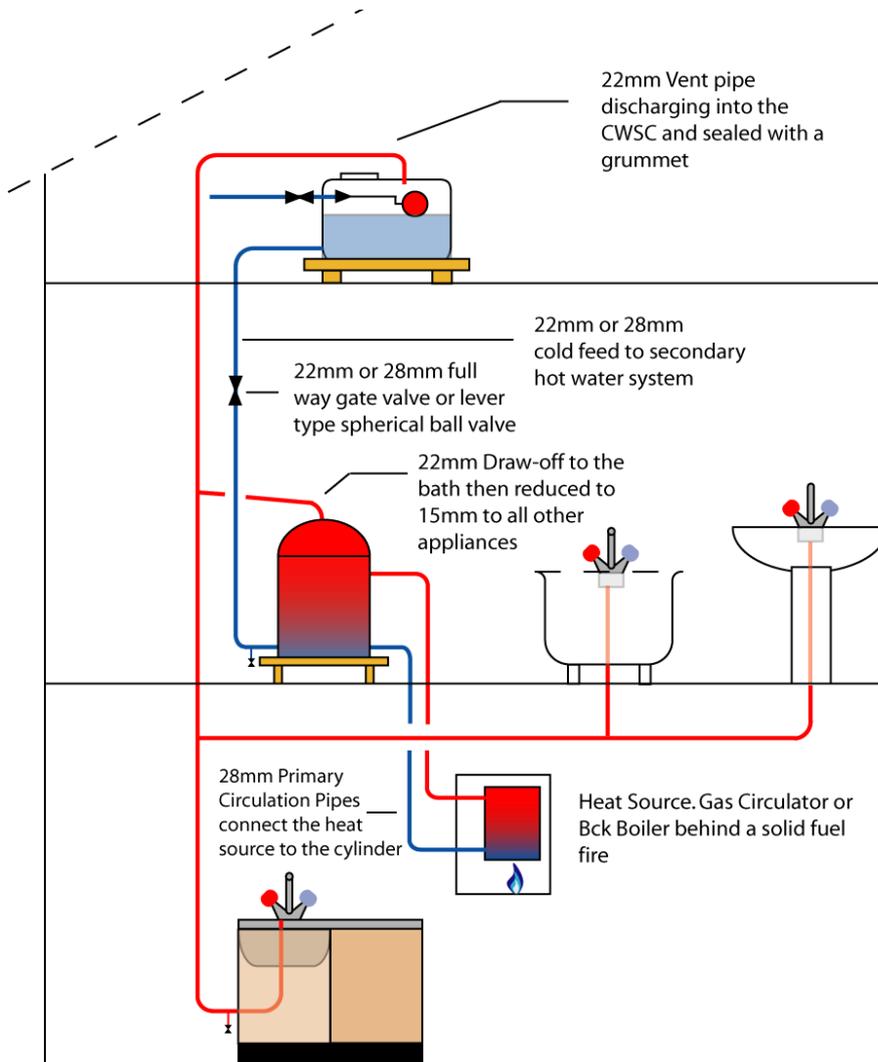
Direct open vented hot water storage systems are named after the type of hot water storage cylinders that the systems use. They use a direct-type hot water storage cylinder, which is heated either by **a)** a small hot water only boiler, or **b)** an electric immersion heater



The direct cylinder

The direct hot water storage cylinder does not contain a heat exchanger. The water is heated directly by either the hot water only boiler or an electric immersion heater. This type of cylinder is NOT suitable for use on central heating systems. The connections to the cylinder are usually male-type threads for the cold feed pipe and the hot water draw-off connections and female-type threads for the primary flow and primary return connections. A drawing of the hot water storage cylinder is shown left.

### Direct system hot water storage system with small hot water only boiler



Direct hot water storage system with small water boiler

Here, the water is heated by a hot water only boiler. These can either be a small gas fired boiler called a 'circulator' designed to heat the water directly or the water can be heated by a small back boiler situated behind a solid fuel fire. However, back boilers do not conform to Building Regulations Document L: Conservation of fuel and power, and should not be fitted on new installations as they cannot be adequately temperature controlled and are susceptible to boiling.

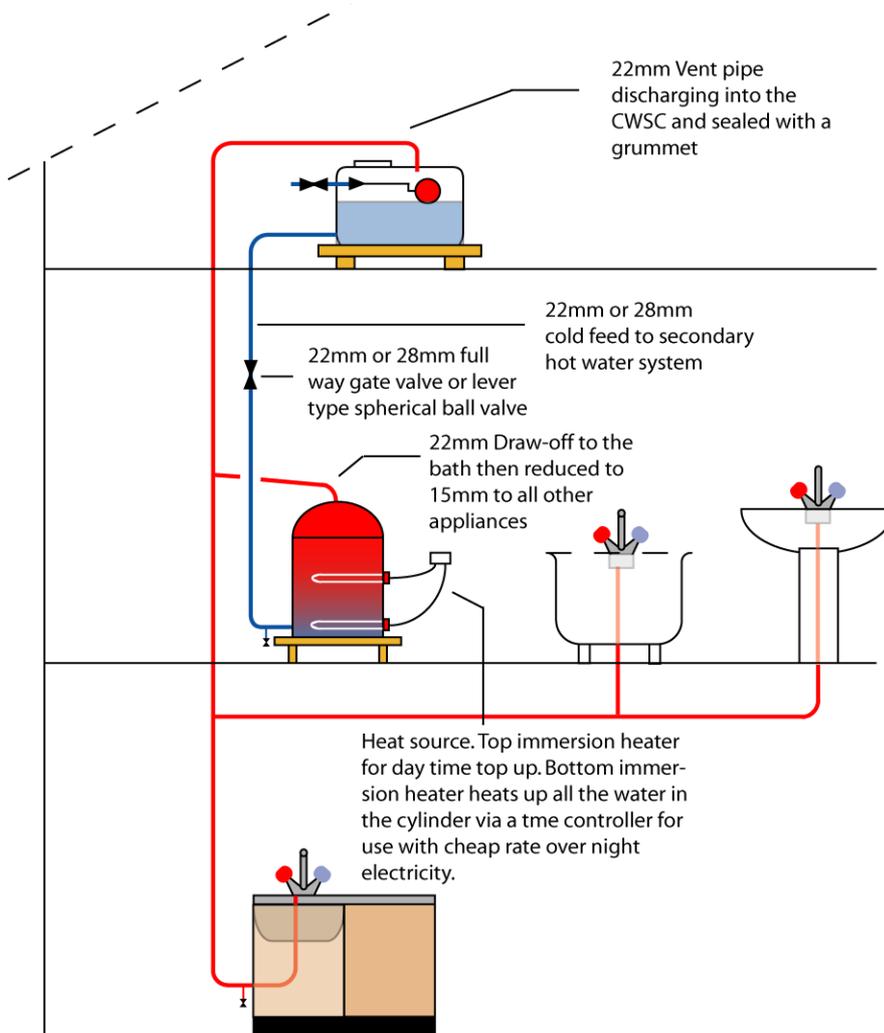
Because the water in the cylinder is in direct contact with the heat source, any boiler that is installed must NOT be made of a material that is likely to rust or contaminate the domestic hot water supply. This is to prevent dirty or rusty water being

drawn from any hot outlet or tap. Suitable materials are:

- Copper,
- Bronze, or;
- Stainless steel

The hot water circulates from the heat source via gravity using the principle of convection (see Unit 03: Scientific Principles). The heated water in the boiler rises through the primary flow connection, heating the water before cooling and returning to the boiler through the primary return pipe. In this way, the water in the storage cylinder heats up to the required temperature. However, the cylinder does not heat up uniformly. The hottest top part of the cylinder is around 10°C hotter than the bottom. This is called 'stratification' and is necessary in hot water storage vessels to maintain good circulation.

The primary flow and return pipework should be of 28mm size to ensure good circulation. An Open Vented Direct hot water storage system using a gas fired circulator is shown on page 482:



## b) Direct system hot water storage system with electric immersion heater

These systems use a 3KW immersion heater to heat the water instead of a hot water only boiler. Many existing systems are fitted with a single top entry immersion heater but modern systems utilise two smaller 300mm immersion heaters installed on the side of the storage cylinder. The top immersion heater only heats the top third of the cylinder for daytime hot water top up, whilst the bottom cylinder heats up the entire cylinder. The immersion heaters are time controlled to take advantage of cheaper over-night electricity.

*The direct hot water storage system with immersion heaters*

The temperature settings on the immersion heaters should be limited to no more than 55-60°C.

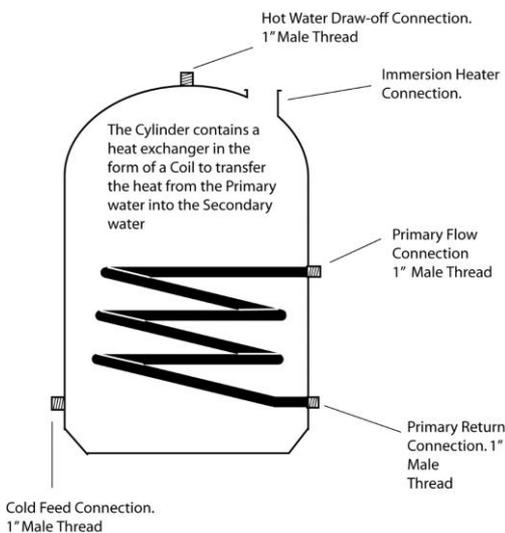
## Open Vented Indirect hot water storage systems

Again, like the Direct systems, Open Vented Indirect Hot Water Storage systems are named after the hot water storage cylinders that are fitted to the system. There are two very different systems using two equally different storage cylinders. These are:

- a) The Open Vented Double Feed Indirect Hot Water System incorporating an Indirect Double Feed Hot Water Storage Cylinder, and;
- b) The Open Vented Single Feed (self-venting) Indirect Hot Water System incorporating an Indirect Single Feed (Prismatic) Hot Water Storage Cylinder

Indirect hot water storage cylinders, outwardly, look very similar to Direct types. The difference between the cylinders is internal. Indirect Hot Water Storage Cylinders contain a heat exchanger to transfer the heat into the water. Indirect Cylinders can be used with central heating systems and it is the central heating boiler that is the primary heat source for the system. The heat exchanger in the storage cylinder separates the domestic hot water that we use at taps and outlets (known as secondary hot water) from the primary heating water from the boiler.

### a) The Open Vented Double Feed Indirect Hot Water System incorporating an Indirect Double Feed Hot Water Storage Cylinder



This system utilises a double feed indirect hot water storage cylinder shown in the diagram.

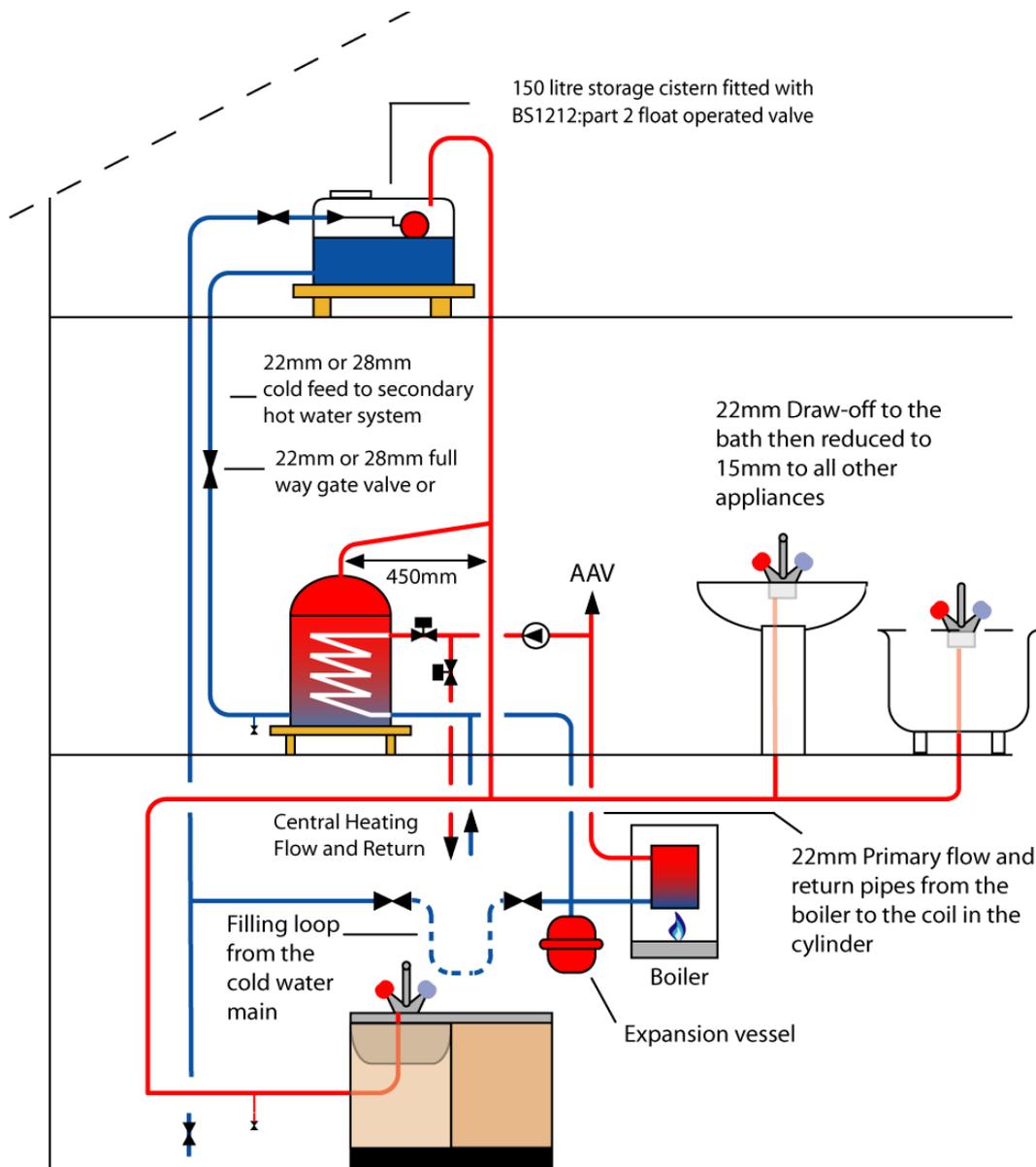
The coil, which is made from copper tube (stainless steel storage cylinders with stainless steel coils are also available), is the primary heat exchanger for the hot water supply. This type of hot water storage cylinder is suitable for use with central heating systems. It is called indirect because the water is heated indirectly by the primary water in the boiler via the heat exchanger.

The double feed indirect system has two cisterns. A large cold feed cistern that supplies the cold water to the hot water system via the cold feed pipe and a smaller feed and expansion cistern to supply water to the boiler, hot water heat exchanger and central heating system. Here the hot water circulates via the primary flow and return pipes, with the aid of a circulating pump or without a circulating pump through gravity (see Unit 003 Scientific Principles). The system is shown in the drawing below.

The Double Feed Indirect Hot Water Storage Cylinder allows the use of central heating boilers that use differing metals, such as copper and aluminium. There is no risk of rusty or contaminated water reaching any of the hot water outlets because the water in the cylinder is separate from the water in the heating system.

*The double feed indirect hot water storage cylinder*

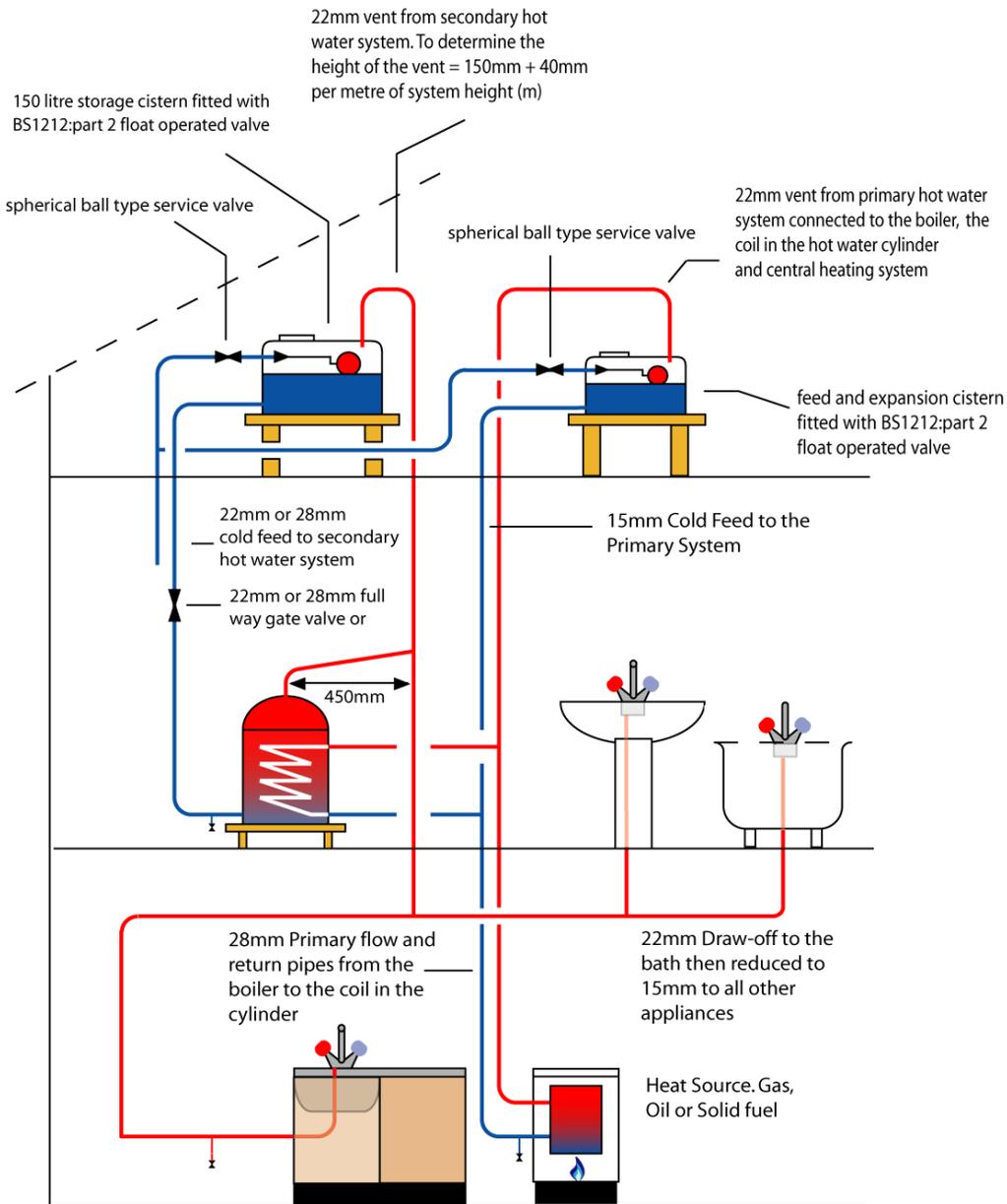
The system is designed so that the water in the central heating system is not changed once the system is full. Some water is lost through evaporation.



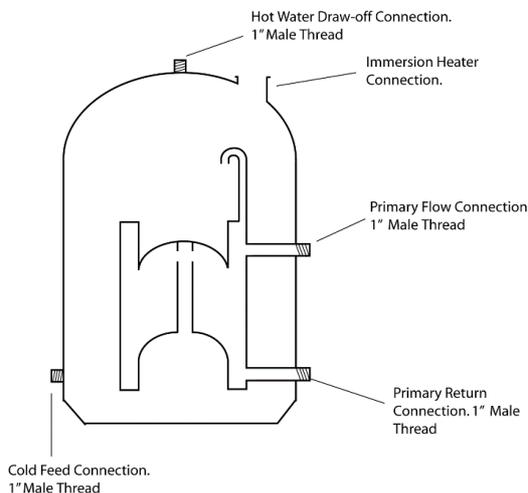
*The indirect hot water system with pumped primary circulation*

The secondary hot water that is drawn through the hot water outlets is heated by the coil through conduction (see Scientific Principles) as the water in the cylinder is in contact with the coil heat exchanger. It is the coil that heats the water.

The feed and expansion cistern feeds the primary part of the system and must be large enough to accommodate any expansion of water when the water is heated. Modern systems use a sealed central heating system which eliminates the need for a feed and expansion cistern, the system being filled via a filling loop and the expansion of water being accommodated in an expansion vessel (see drawing left). This updated system does not rely on gravity circulation to heat the water. Instead, the water is circulated through the coil by means of a circulating pump.



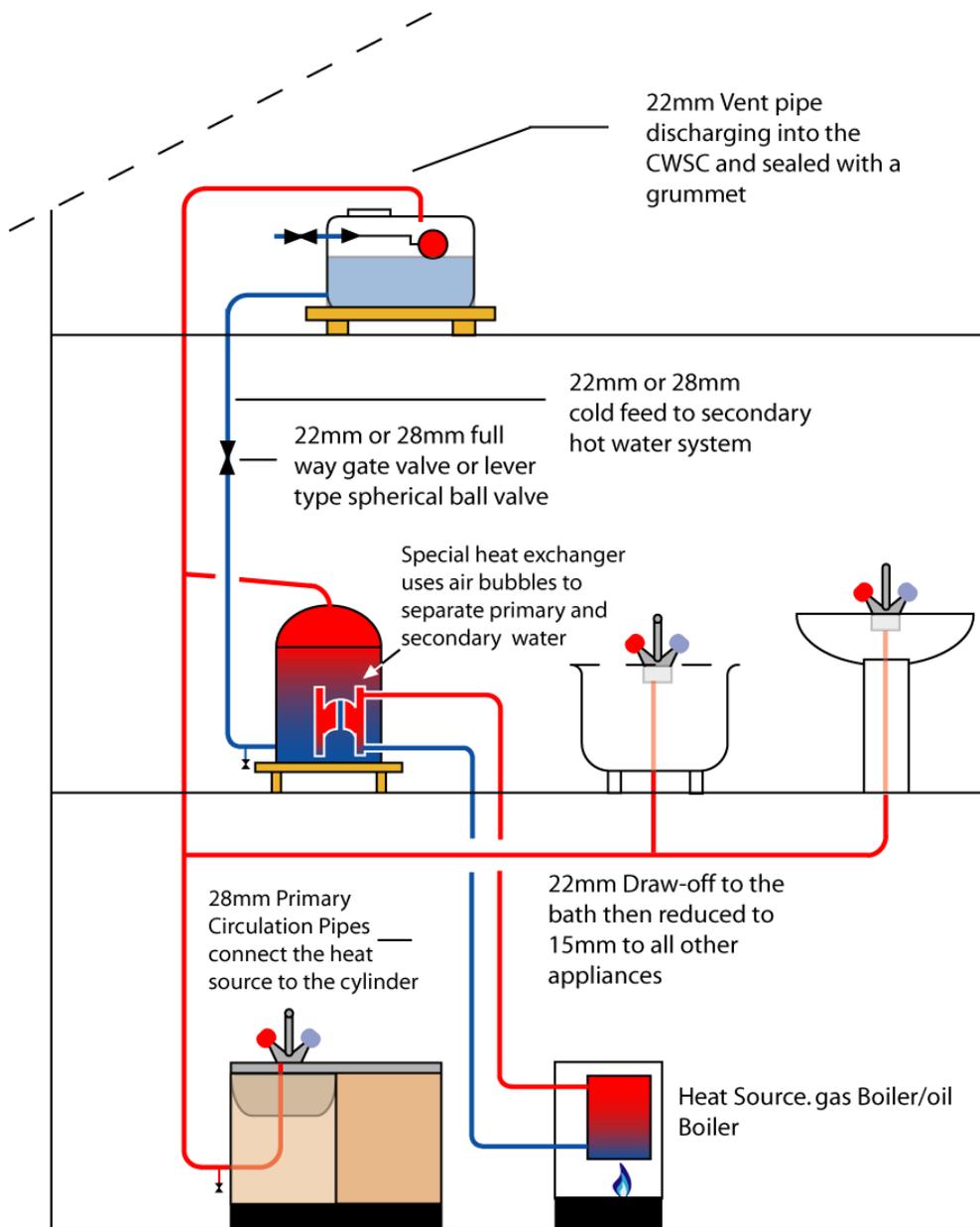
*The indirect hot water system with gravity primary circulation*



*The single feed self venting indirect hot water cylinder*

b) The Open Vented Single Feed (self-venting) Indirect Hot Water System incorporating an Indirect Single Feed (Primatic) Hot Water Storage Cylinder.

The Single Feed system incorporates a storage cylinder with a special heat exchanger that uses air entrapment to separate the secondary water from the primary (heating) water.



*The indirect, single feed hot water system*

Because the cylinder only requires a single cold feed, it is installed in the same way as a direct hot water storage vessel. There is no need to install a second (feed and expansion) cistern. When the system is filled with water, the secondary water is separated from the primary water by two bubbles of air that form at the top and bottom of the heat exchanger. It is these two pockets of air that prevent the two systems from mixing. The full system is shown left.

Occasionally, the air bubbles rupture causing the primary water and secondary water to mix. When this happens, dirty

water can be seen at the hot water outlets. This often occurs if the heating system is too big for the cylinder heat exchanger. The excessive expansion of water when it is heated forces the bubbles downwards into the secondary water, eventually causing the bubbles to burst. If the bubbles rupture, the system should be left to cool down. The air bubbles will then reform naturally allowing the water to be heated again.

Building Regulation Document L: Conservation of fuel and power **no longer allows this system to be installed and you will only** come across it during routine maintenance and replacement of the boiler or the hot water storage cylinder. The hot water circuit is gravity only. Pumped circulation through the heat exchanger is not possible as this would destroy the air bubbles at the heart of the system.

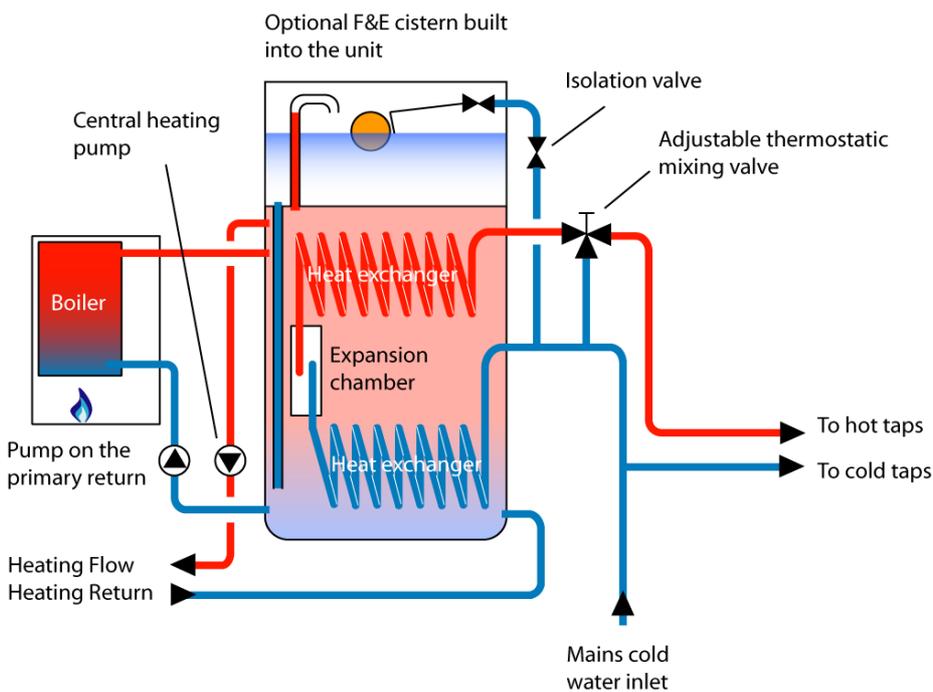
## Instantaneous hot water heaters

Instantaneous water heaters do not contain any stored hot water. They heat the water directly from the cold

supply as and when it is needed. There are several different types:

- a) Thermal stores
- b) Instantaneous multipoint water heaters
- c) Combination (combi) boilers
- d) Single point (point of use) heaters

## a) Thermal stores



Thermal stores (also known as water jacketed tube heaters) are centralised instantaneous multipoint water heaters that work by passing water direct from the cold water main through a series of heat exchangers. These heat exchangers are completely surrounded by water at around 80°C inside a large hot water vessel that is directly heated by a boiler. They look very similar to indirect hot water storage cylinders but actually work in reverse. Water from the

*A thermal store also known as a water jacketed tube heater*

mains cold supply enters the thermal store, passing through the first heat exchanger where the water is warmed. After passing through the expansion chamber, the water flows through the second heat exchanger where it is heated to full hot water temperature. Because hot water should not exceed a temperature of 60 – 65°C, the water is blended with cold water through an adjustable thermostatic blending valve on the outlet of the thermal store.

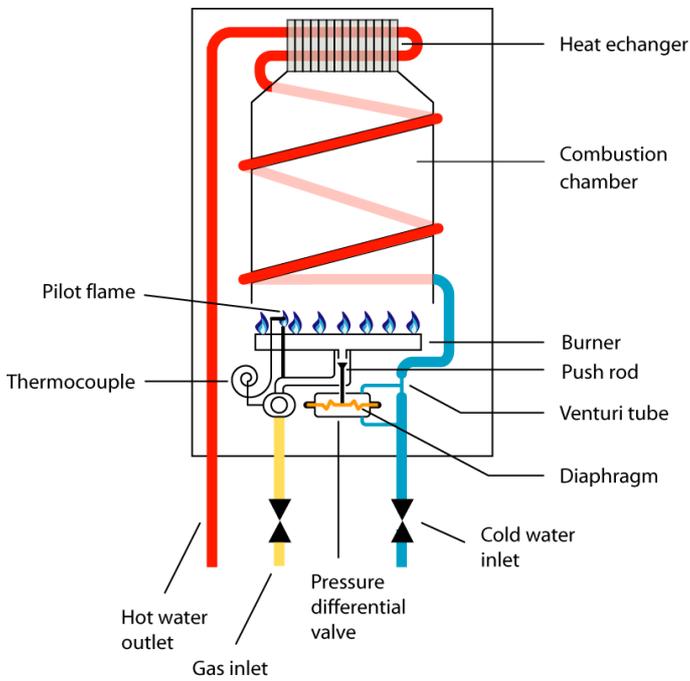
The water in the hot water vessel is completely separate from the domestic hot water and is heated by a boiler. The system can be used for properties with central heating systems.

## b) Gas-fired Instantaneous multipoint water heaters

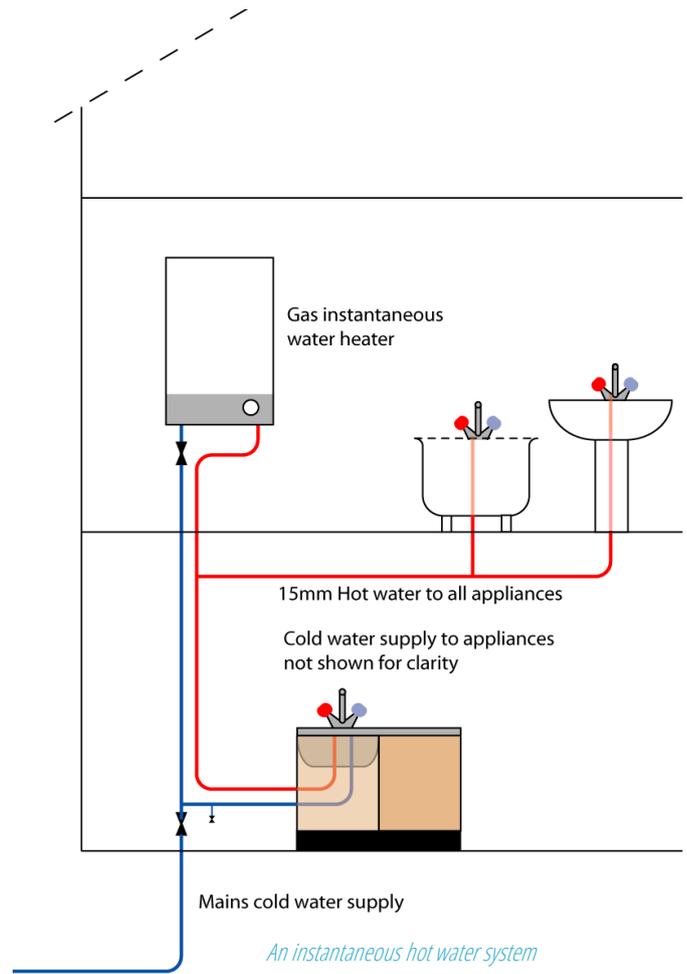
Fired by gas, instantaneous multipoint water heaters use the principle of pressure difference. When a tap is opened, the movement of water through a venturi tube creates a difference in pressure over a rubber diaphragm inside the pressure differential valve. The difference in pressure flexes the diaphragm inside the valve and this opens a gas valve. The gas passes through to the gas burner where it is ignited by either a pilot light or piezo ignitor. The water is then heated. When the tap is closed, the pressure across the pressure differential valve equalises and a spring in the valve closes the valve, shutting off the flow of gas.

Instantaneous gas water heaters can provide enough hot water for a small domestic dwelling but the hot taps should only be used one at a time as these hot water heaters cannot generate enough flow rate to supply two open hot taps simultaneously.

Electric-type multipoint water heaters are also available.



*A gas fired instantaneous water heater*

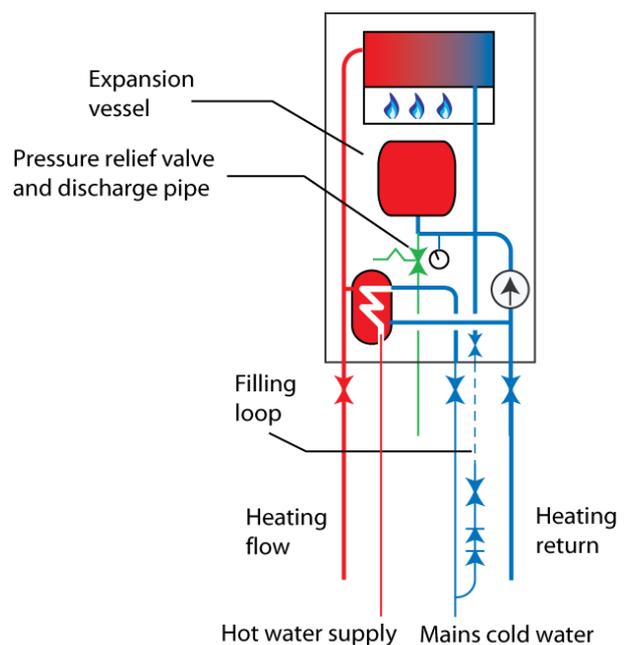


### c) Combination (combi) boilers

Combination boilers are fast becoming one of the main sources of hot water supply in small to medium sized dwellings in the UK. They combine hot water supply and central heating in a single appliance that can be sited virtually anywhere in the property.

‘Combi’ boilers use the same principle as thermal stores by heating the water through a water-to-water heat exchanger. Known as a ‘plate heat exchanger’, the heat exchanger can alternate the flow of water through a diverter valve to heat either the hot water instantaneously or the central heating system. They are hot water priority appliances, which means that if the central heating is on and a hot tap is opened, all energy created by the appliance will be transferred into generating hot water supply to the open tap.

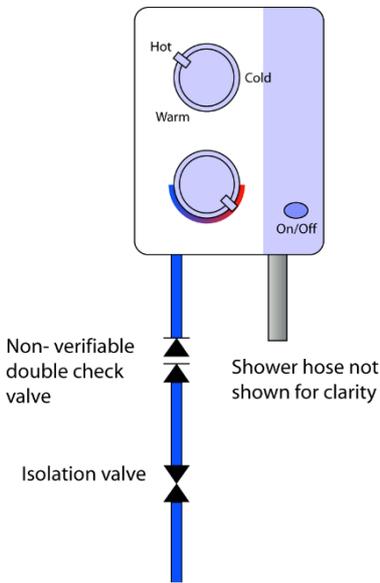
There are many different types of combination boilers available ranging from 24kW to 50kW in output. Some



*A combination boiler*

combis even have a small amount of hot water storage (less than 15 litres), which means hot water is delivered quickly to the hot taps. They are fitted in the same way as multipoint instantaneous hot water heaters.

### d) Single point (point of use) heaters



An electric shower

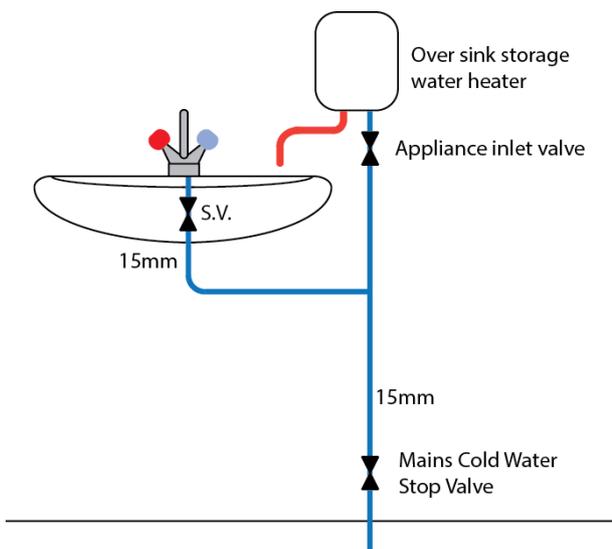
Localised hot water systems are installed in places where connection to the main source of hot water is difficult or impractical. They are often referred to as point of use heaters. They are usually installed over or under the appliance that they are serving with the water being discharged usually from a swivel spout for over sink types. They can be fuelled by either gas or electricity and are usually inlet controlled, meaning that the water is turned on as it enters the heater. Some storage type single point heaters are outlet controlled. There are two specific types:

- a) Instantaneous single point water heaters
- b) Storage single point water heaters.

#### Instantaneous single point water heaters

These provide instant hot water to a single appliance and are usually fuelled by electricity. There are two basic types:

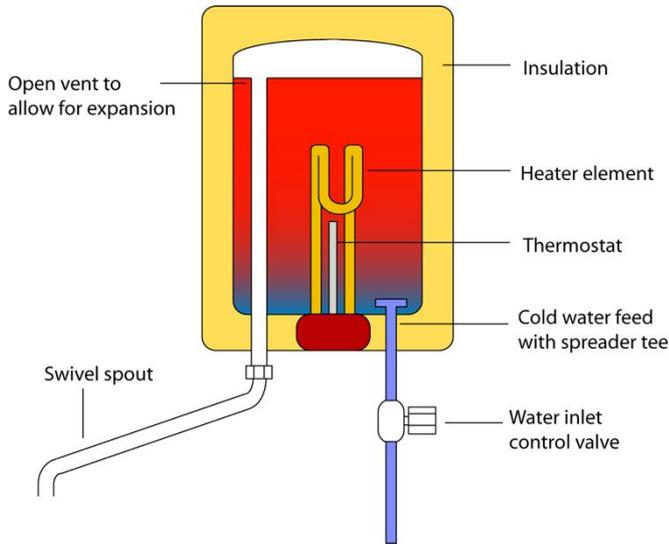
- o Hand wash type – small water heaters, usually around 3kW output, that are fitted over a single washbasin. They are inlet controlled. The temperature of the water depends on the flowrate through the heater. The faster the flowrate, the cooler the water. Flow rates are generally poor but adequate for hand washing.
- o Electric showers – outputs up to 12Kw, many electric showers feature sophisticated microchip technology allowing temperature stabilisation at low and high flow rates. Electric showers feature a low pressure cut-out to guard against scalding if the pressure or flow rate suddenly drop. Flow of water is controlled by an electrically operated solenoid valve that operates when the electricity supply is on to the heater.



A point of use water heater

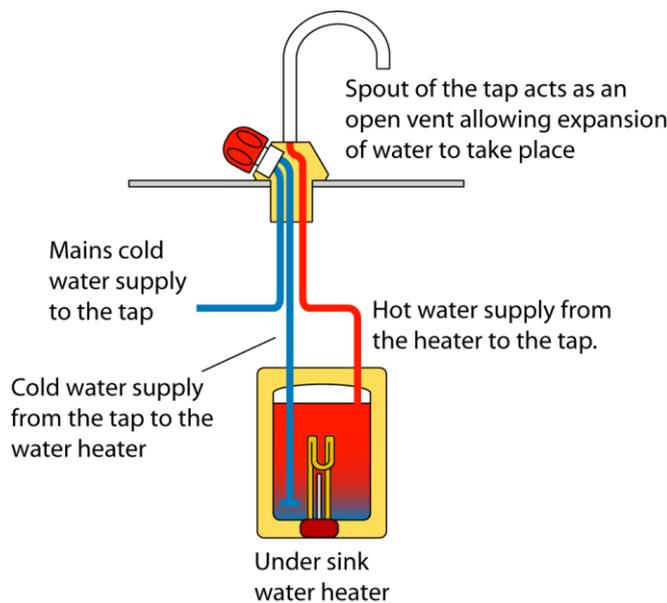
#### Storage single point water heaters

Storage point of use heaters are small water heaters that store a small amount of hot water, usually of less than 15 litres capacity, for use at a single appliance or small range of appliances. They can be either outlet or inlet controlled depending on the type. There are 3 basic types:



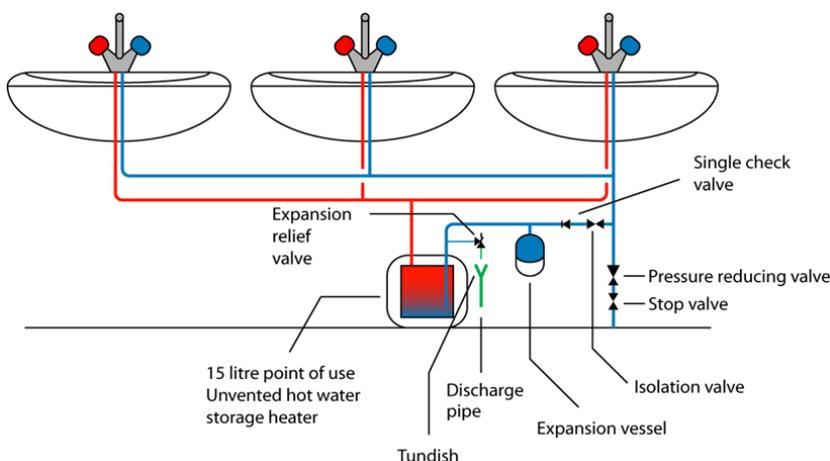
The over sink storage water heater

1 Over sink point of use storage water heaters – usually inlet controlled, these have a swivel spout to direct the water to where it is needed. One unusual feature of this type of heater is their tendency to drip water from the spout. This only occurs when the water is being heated and stops when the water has reached its set temperature. It is a safety feature because the spout acts as a vent and releases the expanded water when it is heated. It prevents the heater from being over-pressurised due to the water heating up and expanding. These heaters MUST be inlet controlled to allow the outlet to vent out the expanded water.



The under sink storage water heater

2 Under sink point of use storage water heaters – Similar to the over sink type but fitted below the appliance rather than above it. They can be sited in cupboards below kitchen sinks in offices and factories and small dwellings. These are inlet controlled through a special tap that allows the heater to be vented through the tap spout (see the diagram left).



The unvented under sink storage water heater

3 Unvented under sink point of use storage water heaters – These are fitted directly to the mains cold supply pipework and deliver hot water at or near to mains cold water pressure. They store less than 15 litres of hot water so are not subject to the Building Regulations enforcement. The expansion of water that occurs can be taken up within the pipework providing the size of the pipework is sufficient to accommodate it. If not, then a small expansion vessel must be fitted (see the diagram left).

Like larger Unvented Hot Water Storage Units, these small unvented

storage heaters require certain controls both safety and functional:

- A pressure reducing valve to limit the water pressure to the water heater.
- A single check valve to prevent hot water from expanding back through the cold water supply as this would constitute contamination of the cold water supply.
- An expansion vessel to allow water to expand within the system without causing creating excessive pressure problems.
- An expansion relief valve to protect the heater in the event of expansion vessel failure and excessive pressure.
- Discharge pipework to remove any water, which may be very hot, away from the location of the heater.

**Note: Unvented hot water storage systems are covered at Level 3**

## AC1.2 State the factors that need to be considered when the type of hot water system is selected for use in a building

When choosing a hot water system, there are certain factors that must be considered:

### Quantity and usage of hot water required

The amount of hot water is based on the number of people living at the property. The more people there are, the more hot water will be needed.

### Distance of outlet from hot water source

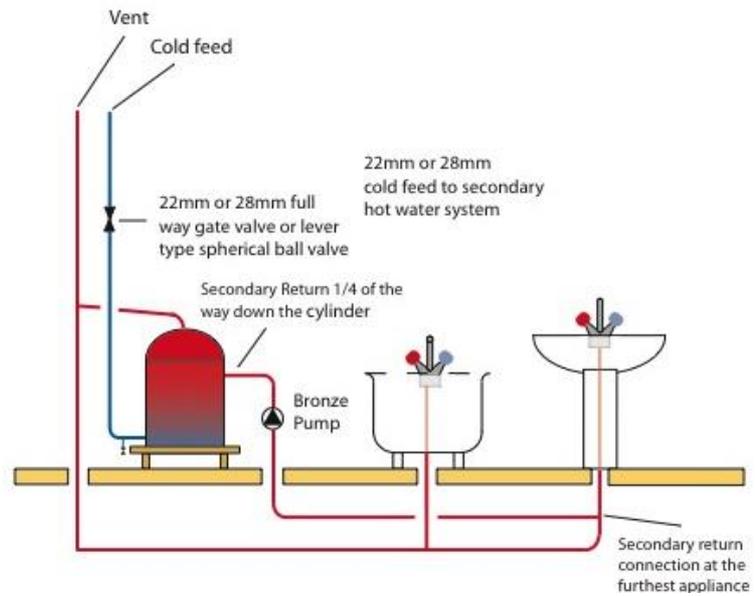
The Water Supply (water fittings) Regulations gives a maximum distance that hot water pipework can be run without the need for a secondary return pipe work system. The longer the distance from the hot water source to the tap, the greater is the risk of wastage of water simply because the water in the run of pipe is cold and therefore of no use in hot water system and in most cases, the occupier will simply run this to drain while they wait for the hot water to arrive. In these cases, only systems that can incorporate a secondary return pipe work system should be considered. That excludes most systems that supply instantaneous hot water. This subject continues in the next heading.

### Need for a secondary circulation system

When a hot tap is turned on, there is a certain amount of cold water that is always drawn off before the hot water arrives at the tap. This is called a dead leg. If the hot water takes longer than 30 seconds to reach the tap, then a secondary circulation system is required to circulate the hot water from the source to the tap and back again.

Secondary circulation is required if the length of the hot water draw-off to the taps exceeds the distances shown in the table below:

Maximum recommended lengths of un-insulated hot water pipes	
Outside diameter of pipe mm	Maximum length m
12	20
Over 12 up to and including 22	12
Over 22 up to and including 28	8
Over 28	3



Secondary circulation



A bronze pump

The secondary circulation system uses a bronze bodied pump positioned on the secondary return pipe, close to the cylinder to circulate the water to the cylinder. The secondary circulation connection is usually positioned about  $\frac{1}{3}$  of the way down from the top of the cylinder. Only a bronze bodied pump must be used to prevent rusty water being drawn from the hot taps.

## The types of fuel used

With hot water storage systems, it is often the case that more than one fuel can be used to heat the hot water. For instance, the main source might be a gas or oil fired boiler, that also incorporates a central heating system. This is often supplemented by an electric immersion heater(s) for use in the summer months when heating is not required. Instantaneous systems do not have this capability and so choice of fuel is limited.

## The number of hot water outlets

Another important point to consider because the more outlets there are, the better the flow rate needed. Again, this may exclude combination boilers or instantaneous multipoint heaters simply because they cannot supply the flow rate required by the system.

## Installation and maintenance costs

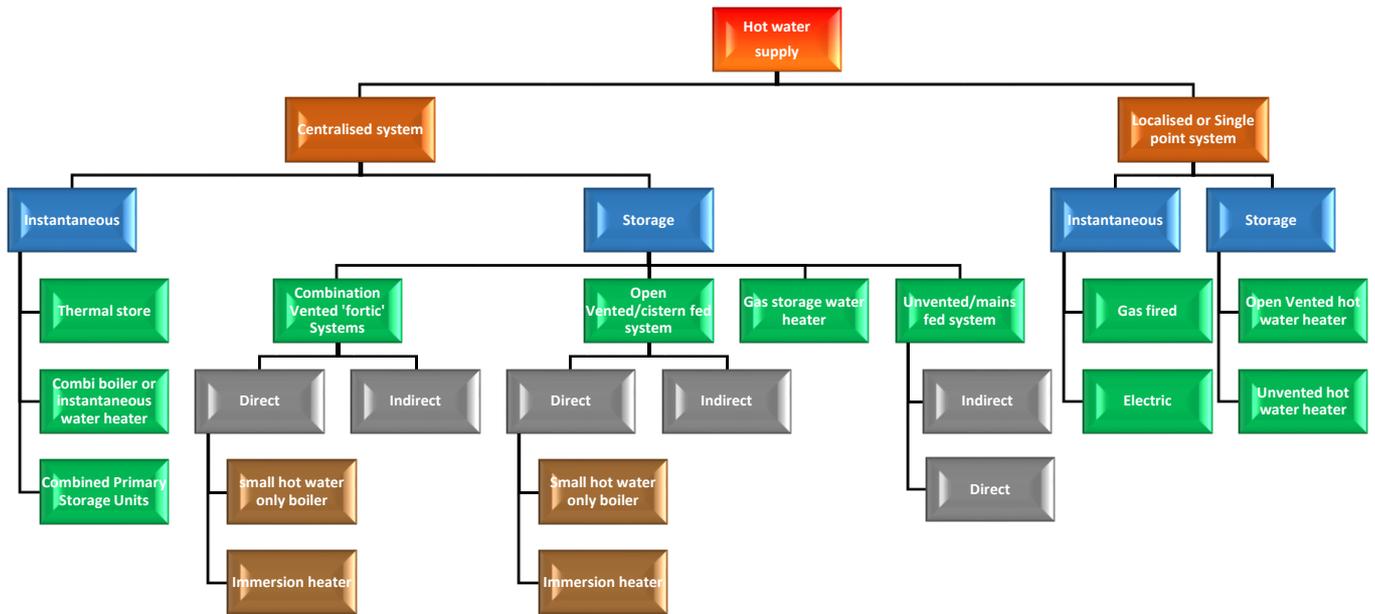
There are several questions here:

1. What is the initial cost of the appliances and materials?
2. How much will it cost to install them?
3. Will the system meet the requirements of the specification?
4. What are the long term running and maintenance costs?

These four questions need to be balanced against the system design to see which system offers the best cost effectiveness while meeting the customer’s requirements.

### Running costs and fuel efficiency

Some new systems, such as solar hot water supply, offer a 60% saving on running costs over a 12 month period, but this has to be balanced against the initial high cost of the solar collector and special storage cylinder. The development of more fuel efficient gas and oil boilers have also helped in the regard.



## AC1.3 Identify the working principles of hot water system components

Most of the appliances and components mentioned in this section, such as taps and valves, FoVs, showers, and backflow protection were covered in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques.**

### Feed and expansion cisterns

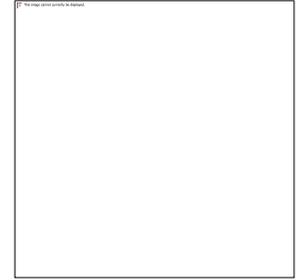
These small cisterns that are designed for use with vented hot water heating systems. They supply cold feed water to a heating system, and accommodates any expansion of the water due to the water being heated. The cistern must be large enough accommodate any expanded water and must be sized accordingly. See Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques.**

### Cold water feed cisterns

Cold feed cisterns are designed to feed cold water, via the cold feed pipe, to an open vent hot water storage system. See Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques.**

## Directly heated storage cylinders

The direct-type hot water storage cylinder is heated either by a small hot water only boiler, or an electric immersion heater. The direct hot water storage cylinder does not contain any form of heat exchanger. The water is heated directly by either the hot water only boiler or an electric immersion heater. This type of cylinder is NOT suitable for use on central heating systems.



## Indirectly heated storage cylinders:

### Single feed cylinder

Better known as the Single Feed, self-venting cylinder or 'primatic', incorporates a storage cylinder with a special heat exchanger that uses air entrapment to separate the secondary water from the primary (heating) water. They are no longer fitted due to problems with efficiency and corrosion but still may be fitted in some older properties.

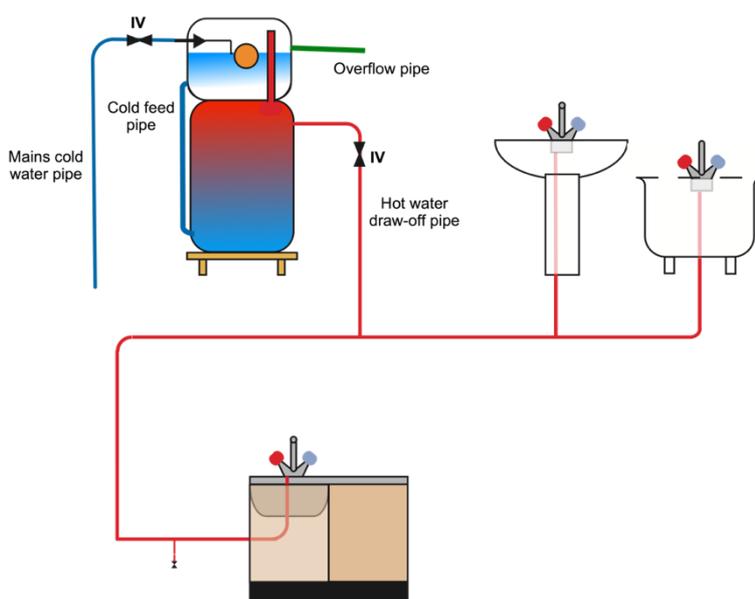
### Double feed cylinder

This cylinder contains a coil-type heat exchanger

The coil, which is made from copper tube (stainless steel storage cylinders with stainless steel coils are also available), is the primary heat exchanger for the hot water supply. This type of hot water storage cylinder is suitable for use with central heating systems. It is called indirect because the water is heated indirectly by the primary water in the boiler via the heat exchanger.



### Combination cylinder



Not to be confused with combination boilers, the combination cylinder combines the hot water storage cylinder with the cold water feed cistern. They are used where space is limited and eliminate the need to install a cold water feed cistern in the roof space. The cistern has an integrated vent pipe and cold feed pipe to vent the cylinder and feed the cylinder with water. They are available in direct and



double feed indirect type configurations

## Instantaneous water heaters:

### Mains fed multipoint heaters

These can either be gas-fired or run by electricity. They heat the water instantly as it is drawn from the cold water main. As the water flows when a tap is opened, it is passed over a heat exchanger (gas) or heating element (electric), which heats the water before it is delivered to the tap. The model shown in photograph (right) is an electrically operated model.



### Mains fed combination boilers

Combination boilers combine hot water supply and central heating in a single appliance that can be sited virtually anywhere in the property.

'Combi' boilers use the same principle as thermal stores by heating the water through a water-to-water heat exchanger. Known as a 'plate heat exchanger', the heat exchanger can alternate the flow of water through a diverter valve to heat either the hot water instantaneously or the central heating system. They are hot water priority appliances, which means that if the central heating is on and a hot tap is opened, all energy created by the appliance will be transferred into generating hot water supply to the open tap.



### Mains fed point of use water heaters

These provide instant hot water to a single appliance and are usually fuelled by electricity. There are two basic types:

- Hand wash type – small water heaters, usually around 3kW output, that are fitted over a single washbasin. They are inlet controlled. The temperature of the water depends on the flowrate through the heater. The faster the flowrate, the cooler the water. Flow rates are generally poor but adequate for hand washing.
- Electric showers – outputs up to 12Kw, many electric showers feature sophisticated microchip technology allowing the stabilisation of the temperature at low and high flow rates. Electric showers feature a low pressure cut-out to guard against scalding if the pressure or flow rate suddenly drop. Flow of water is controlled by an electrically operated solenoid valve that operates when the electricity supply is on to the heater.



### Thermostatic Mixing Valves (TMV)

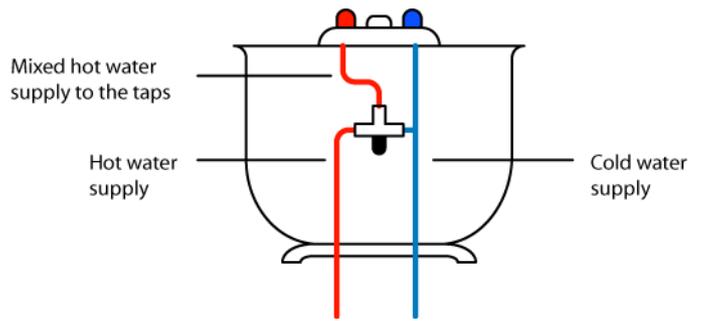


The maximum temperature of stored hot water is 60°C. However, water at a temperature of 51°C can cause serious burns to a child if the skin is exposed for 2 minutes. Because of this, Document G limits the temperature of hot water supplied to baths in domestic properties to 48 °C and all properties

where the public have access, such as schools, hospitals, nursing homes etc, under the Care Standards Act 2000 require that the temperature of water delivered to ALL hot outlets at 43°C., except where food preparation is carried.

This is controlled by a Thermostatic Mixing Valve.

A TMV mixes water from the hot and cold supplies to a temperature that is safe to use. The length of pipe from the TMV to the tap should be kept as short as possible.



*A typical TMV installation*

## AC1.4 State the typical pipe sizes used in centralised open vented hot water systems in dwellings

Hot water storage systems contain two circuits:

- The primary circuit – this circuit heats the water in the storage vessel
- The secondary circuit – this circuit delivers the water to the outlets

### The Primary circuit

The primary circuit connects the hot water storage vessel to the boiler. It consists of a primary flow pipe and a primary return pipe.

**Note:** In the drawings below, the mains cold water supply to the cistern have not been shown for clarity

#### The Pumped Primary circuit

In the pumped primary circuit, the water is pumped from the boiler to the cylinder and back again. As can be seen, the heating circuit is also taken from the primary circuit. Both the hot water storage vessel are controlled by motorised valve(s) (not shown). The position of the open vent and cold feed pipes are vitally important and must follow a simple rule – Vent/Cold feed/Pump or VCP (easily remembered as **V**ery **C**orrect **P**rocedure!). As a general rule, the pipe sizes for domestic properties are:

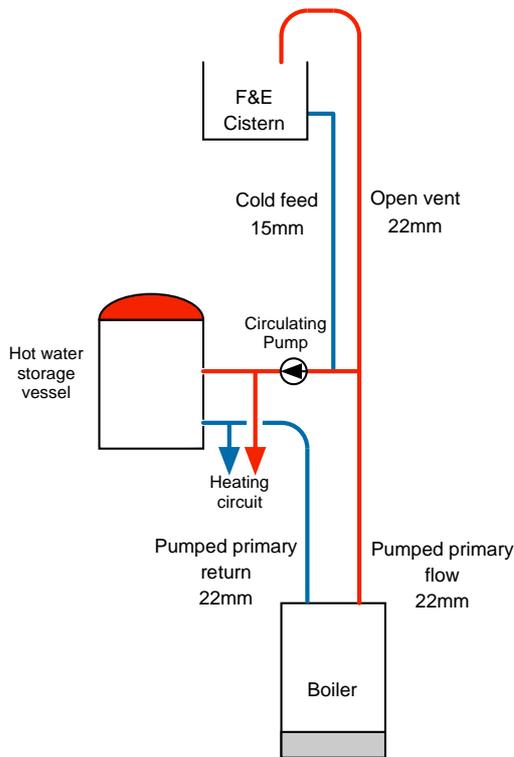
- 22mm for the primary flow and open vent.
- 22mm for the primary return
- 15mm for the cold feed pipe.

#### The Gravity Primary circuit

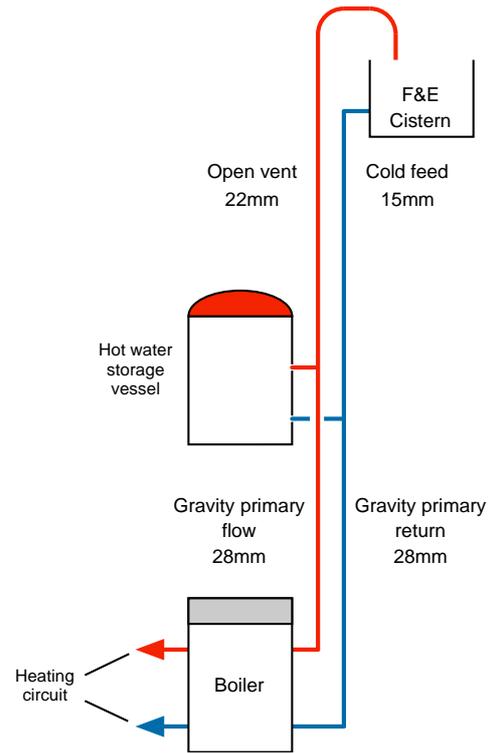
The gravity primary circuit is usually found in older systems. The hot water circulates via gravity circulation (see Unit J/602/2496 - understand how to apply scientific principles within MES). The heating circuit is a separate circuit. As a general rule, the pipe sizes for domestic properties are:

- 28mm for the primary flow
- 28mm for the primary return
- 22mm for the open vent.
- 15mm for the cold feed pipe.

The F&E cistern, open vent and cold feed can be replaced by an expansion vessel and filling loop in sealed systems.

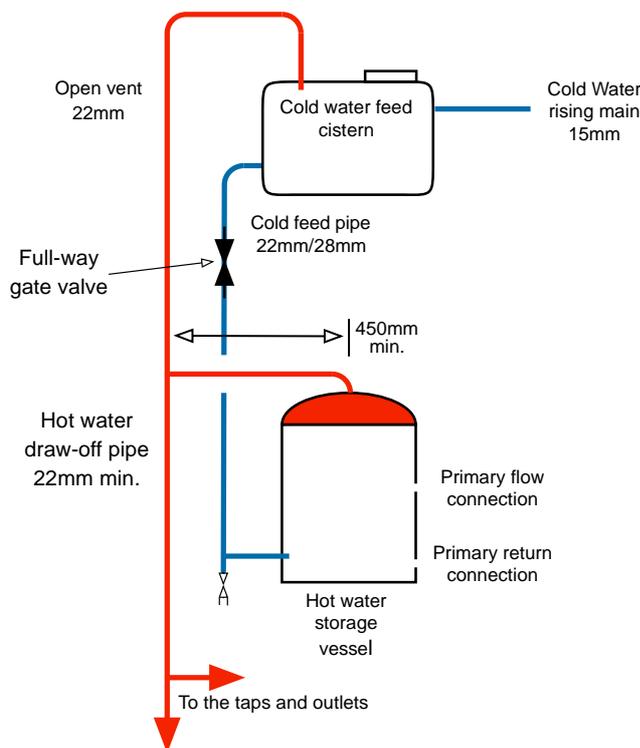


*Pumped primary circuit*



*Gravity primary circuit*

### The secondary circuit



The vent pipe should terminate over the inside of the cistern but not below the

The secondary circuit connects the hot water storage vessel to the taps. It is the method by which the hot water is delivered to the outlets. It consists of:

- **The cold feed pipe** – this pipe connects the cold feed cistern to the hot water storage vessel. It should have a full-way gate valve installed so that the hot water may be isolated without the need to drain the whole cistern and hot water storage vessel. Pipe sizes are generally 22mm/28mm depending on the number of outlets served.
- **The open vent pipe** – the vent pipe keeps the system at atmospheric pressure preventing the temperature from exceeding 100°C. It also allows the heated water to expand back into the

water line. The minimum pipe size of the vent pipe is 22mm. The vent pipe MUST NOT contain any form of isolation/gate valve.

- **The hot water draw-off pipe** – this pipe connects the hot water storage vessel to the taps and outlets. It should be connected to the top of the hot water vessel. It should rise slowly to the point where it connects to the vent pipe. The minimum distance between the centre hot water storage vessel and the vent pipe/draw-off intersection must be 450mm. This is to prevent parasitic or one-pipe circulation in the vent pipe, which creates heat loss from the hot water in the vessel. It is generally accepted that, because the system is a low pressure system, the bath should be connected in 22mm pipe directly from the hot water storage vessel. All other outlets can be connected in 15mm pipe, except when manufacturer's instructions state otherwise.

## AC1.5 State the system layout features for the open vent and cold feed pipes of primary and secondary open vented hot water circuits.

This subject is covered in AC1.4 State the typical pipe sizes used in centralised open vented hot water systems in dwellings. Please refer to AC1.4

## AC1.6 State the connection requirements for feed and expansion cisterns into open vented primary hot water circuits.

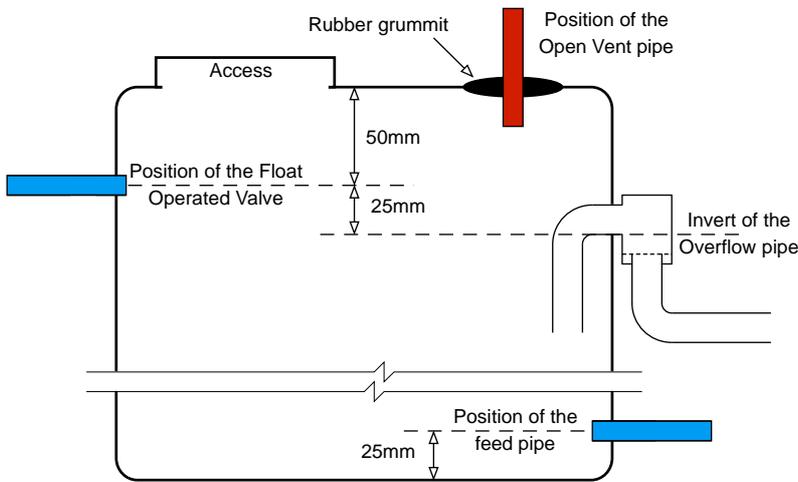
This subject is covered in AC1.4 State the typical pipe sizes used in centralised open vented hot water systems in dwellings. Please refer to AC1.4

## AC1.7 State the system layout features for plastic feed and expansion cisterns

### Typical Feed and Expansion cistern sizes for small dwellings

The size of the Feed and expansion cistern will depend on the water volume of the heating system installed. This is because the cistern acts not only as a water feed for the system but also the point where the heated water can expand into. Water expands by 4% when it is heated and the more water the system contains, the greater the expansion of water will be. However, it is generally accepted that a 10 litre cistern will be adequate for small/medium domestic dwellings.

## Warning pipe (overflow) arrangements, Inlet/outlet position, Position of float operated valve and Position of cistern vent



Drawing not to scale

Further information on cisterns can be found in this book in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**

### Service valve requirements

A service valve should be fitted on the rising main as close to the FoV as practicable but there should be **NO** isolation or service valve fitted on the cold feed pipe as this could be accidentally isolated leading to starvation of water due to evaporation of water from the F&E cistern.

### Cistern base support requirements.

The cistern should be well supported across the whole of its base to prevent deformation of the plastic cistern. See Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques.**

Size	Capacity
900mm x 350mm	74 litres
900mm x 400mm	98 litres
1050mm x 400mm	116 litres
900mm x 450mm	120litres
1050mm x 450mm	144 litres
1200mm x 450mm	166 litres
1500mm x 450mm	210 litres

AC1.8 Identify the type and typical sizes of open vented storage cylinder used in hot water systems in dwellings

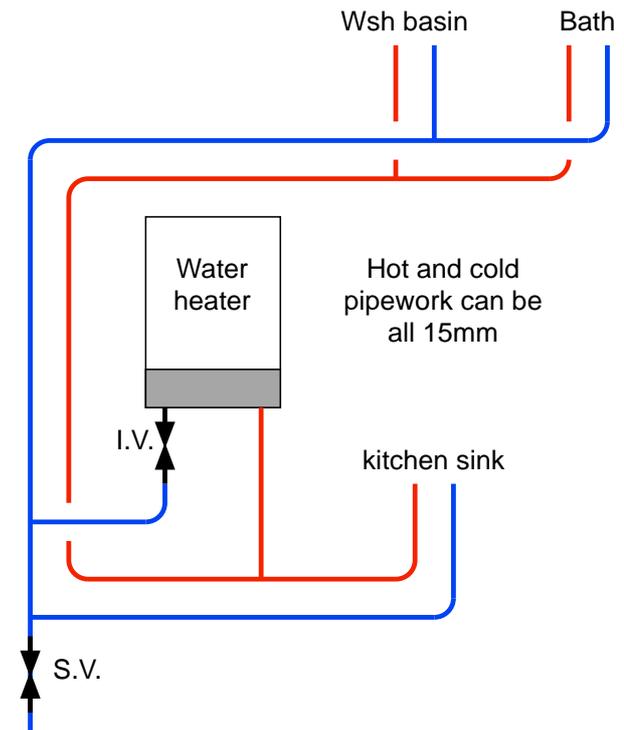
Open vented hot water storage cylinders are available in a wide range of sizes and capacities. Common sizes are shown in the table left.

Cylinders can also be manufactured to bespoke sizes and capacities for unusual installation situations.

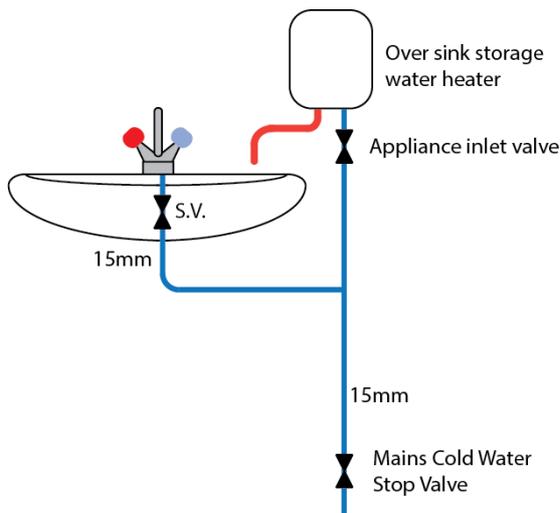
## AC1.9 State the system layout features for hot water heaters

Multipoint, instantaneous water heater systems are the simplest of all systems to install. Typically, the pipework size into and out of the water heater is 15mm because the hot and cold supplies are both fed from the mains cold water supply. This means that the system also can be installed in 15mm in its entirety. Combination boilers can also be installed in this way for the hot and cold water supplies. The heating installation, however, is typically installed in 22mm to and from the boiler itself.

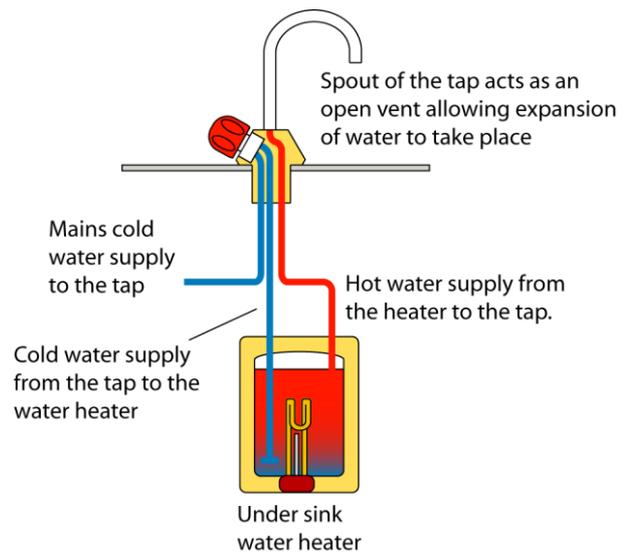
Open vented and instantaneous point of use water heaters are also usually supplied via a 15mm mains fed cold water supply. See diagrams below:



Hot water heater system layout



Oversink heater installation



Under sink heater installation

## AC1.10 State the typical pipe sizes used with mains fed instantaneous hot water heaters and open vented point of use water heaters in dwellings.

Please refer to AC1.9 above

## AC1.11 Identify the need for temperature control of hot water systems

Hot water systems must not exceed 100°C. At this point, water turns to steam often with disastrous consequences. The maximum operating temperature for hot water systems is 60 – 65°C but even at this temperature the risk of serious burns is ever present. Water at 51°C will cause serious burns to a child if the skin is exposed to it for a mere 5 seconds. Because of this, some form of temperature control for hot water systems is of vital importance. However, with stored hot water, the risk of legionella becomes greater and temperatures below 55 – 60°C, a legionella risk, however small, exists. There are many ways by which temperature control can be achieved. Temperature control should consist of:

- A thermostat set to the desired temperature – 55°C to 60°C is optimum.
- A second thermostat, called a high limit thermostat (or energy cut out) set to operate should the maximum temperature be exceeded. This is known as a second tier of control.

Below is a table of how this can be achieved.

Hot water storage systems containing an immersion heater.



*Immersion heater and thermostat*

Immersion heaters have a double thermostat. The control thermostat is set to the desired temperature of 55°C to 60°C, whilst the second energy cut-out thermostat is set to 85°C. However, most energy cut-out temperatures can be altered and should be set to at least 15°C above the control thermostat setting.

Thermostats are available in re-settable and non-re-settable types. Non-re-settable thermostats must be replaced if the high limit energy cut-out activates.

Hot water storage systems using gravity or pumped primary circulation.

Open vented Double feed indirect cylinders with gravity or pumped primary circulation must be fitted with a minimum of a cylinder thermostat and a motorised zone valve which closes when the water temperature in the cylinder reaches a pre-set level.



*A two-port zone valve and cylinder thermostat*

**Water heaters and combination boilers** These have a manually adjustable thermostat to control the temperature of the hot water. Typical water temperatures are around 40°C. because the water is heated instantaneously, the risk of legionella diminishes considerably.

**Open vented cylinders with no high limit thermostat** Open vented cylinders with no high limit thermostat can be fitted with a temperature relief valve. This spring operated valve is set to open automatically at a set temperature to release water safely via a tundish and discharge pipework to outside the property.

## AC1.12 State the factors that can lead to backflow from hot water outlets and equipment in dwellings

Hot water is classed as fluid category 2, which states that:

*Fluid category 2 is water that is fluid category 1 but otherwise impaired by taste, colour, odour or temperature.*

It is the last factor – *temperature* – that is of concern here.

In most hot water systems, the risk originates from mixer valves, such as shower valves and TMVs and mixer taps on appliances such as kitchen sinks, baths, bidets and wash basins. Problems of this sort are easily overcome by the use of Type EA/EB single check valves, which are designed to prevent the hot water from back flowing through the tap/valve and back into the cold water system. Further problems are also eliminated by ensuring that the pressures within hot and cold systems are equal. However, the use of single check valves is vital to guard against sudden cold water main pressure loss as this is where most backflow associated problems originate from.

### Back syphonage

Other backflow situations in the form of back syphonage may occur with appliances that have a shower hose attachment. If the shower hose is submerged in a bath of water, then this constitutes a fluid category 3 risk, as the water may, in a back syphonage occurrence, be sucked backwards through the shower and down into the mains cold water supply, possibly contaminating the water back as far as the trunk mains in the road.

To prevent this, there are several precautions that can be taken:

- The shower hose can be secured with a retaining ring prohibiting the shower head from being submerged in water.
- A Type EC/ED double check valve installed on the mains cold water inlet to the shower.

## AC1.13 Identify the standard backflow prevention devices that are used in hot water systems in dwellings supplying water to appliances

Please see AC1.12 above.

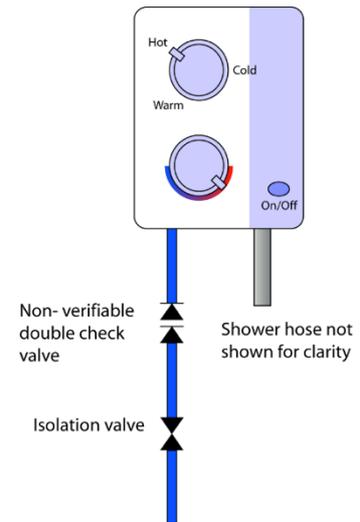
## AC1.14 State the system layout features for the installation of hot water components

### Instantaneous electric showers

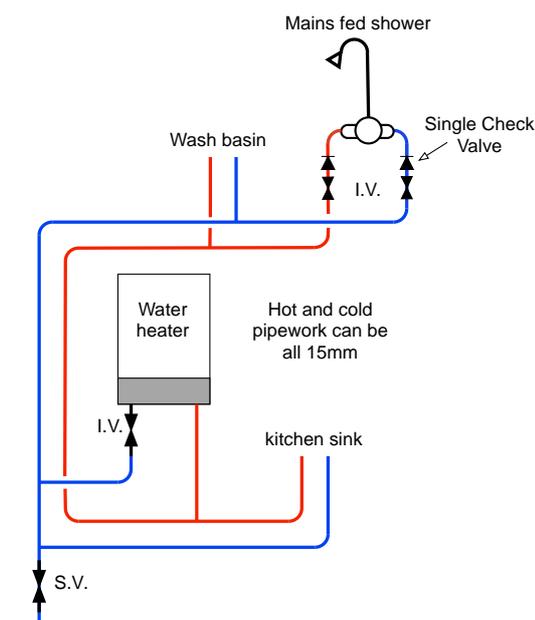
There are many different electric showers on the market, ranging from 8kW to 11kW inputs. The cold water supply is usually 15mm. direct from the cold water main, although there are some low pressure models available. A hose retaining ring should be fitted, especially when installing the unit over a bath, to prevent the hose from being able to be submerged in the bath water. A double check valve can also be fitted as an alternative. All units should have an isolation valve for maintenance and repair.

The size of electrical cable and the size of the RCD circuit breaker will be determined by two important factors:

1. The distance of the unit from the consumer unit.
2. The input rating of the unit



*The installation of an electric shower*



*Layout of a mains fed shower*

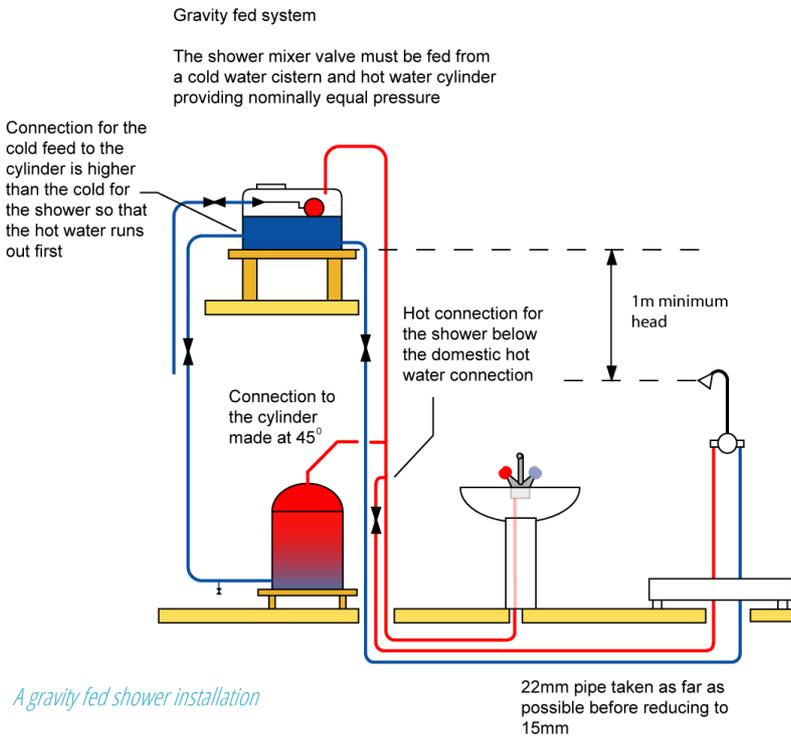
### Mains fed showers

Mains fed showers are thermostatic mixing valves, often referred to as pressure compensating shower valves. As mentioned in **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, there two types:

- Sequential control
- Dual control

Connection to the hot and cold supplies is a fairly straightforward operation but it should be remembered that, because it is a cross-connection between hot and cold supplies, Type EA/EB single check valves must be fitted to prevent backflow situations.

# Gravity fed showers

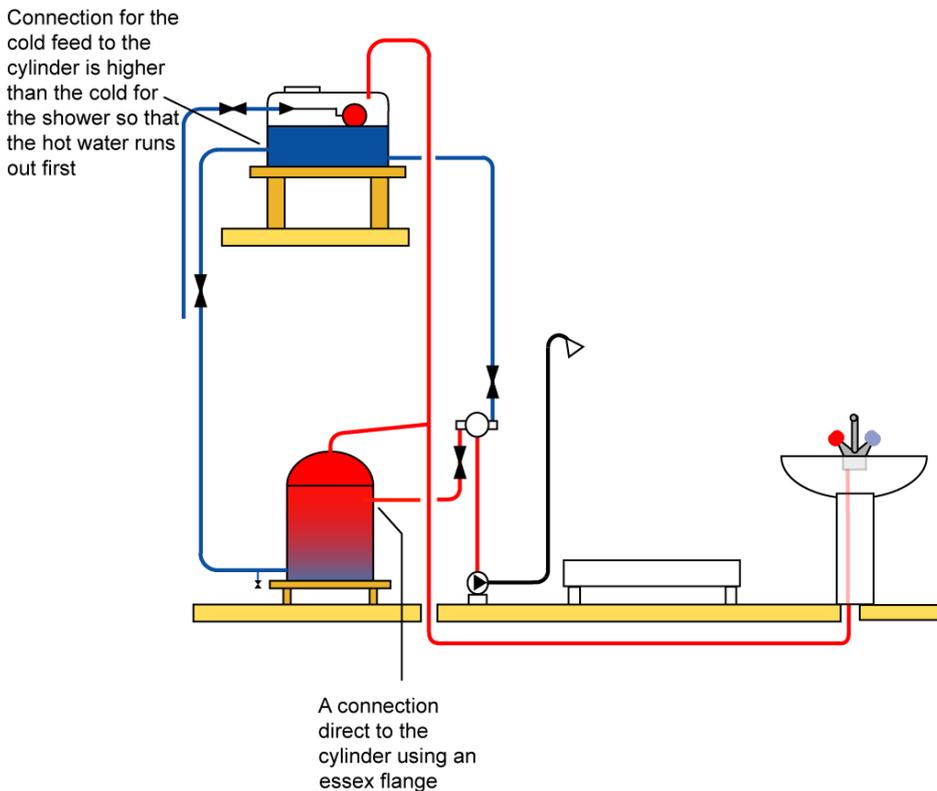


A gravity fed shower installation

The diagram left shows a typical shower mixing valve using cistern fed hot and cold water supplies. Since both hot and cold are cistern fed, the pressures are equal. The system is ideal for both thermostatic and non-thermostatic mixing valves and, since both hot and cold arise from the same cistern fed source, single check valves are not required. It should be remembered though that because non-thermostatic valves are not thermostatically controlled, the water will become cooler the longer the shower is used.

To give an adequate showering pressure, the distance from the bottom of the cistern to the shower head must be at least 1m

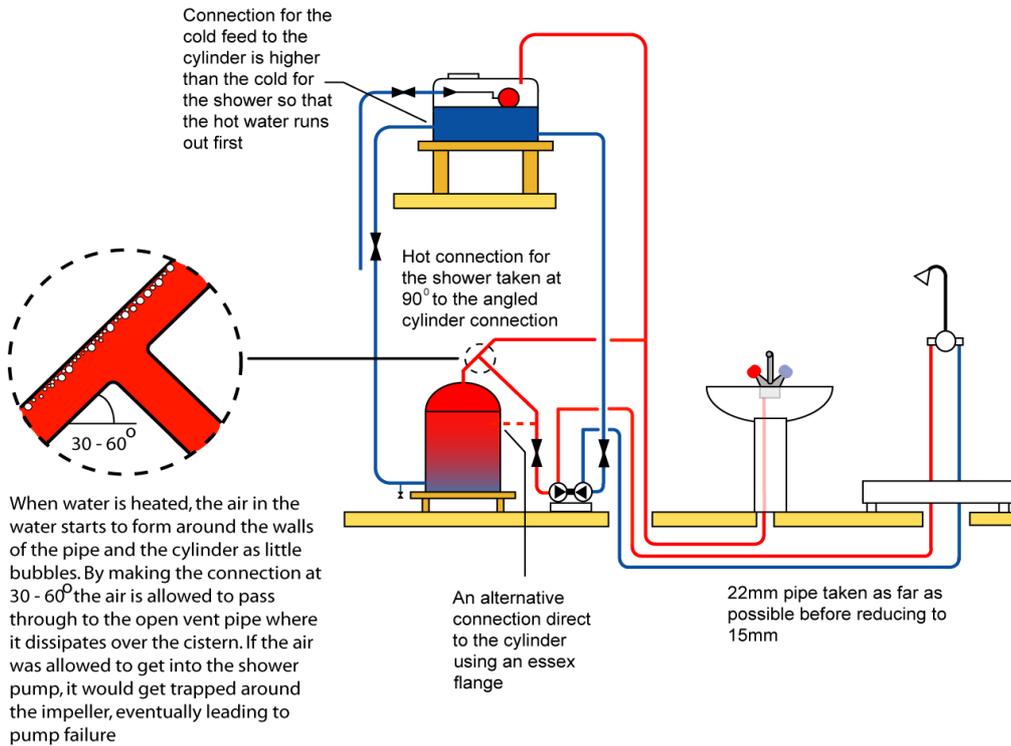
# Gravity fed showers with single impeller boosting pump



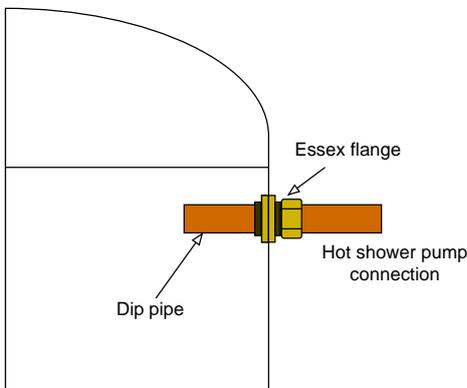
Shower installation with a single impeller shower pump

An example of a single impeller boosting pump was shown in **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**. These installations are designed to boost the mixed water *after* it has left the mixing valve. They are usually installed where the pipework and the valve are concealed and are ideal for the drench-type large fixed shower heads.

## Gravity fed showers with twin impeller boosting pump



*Shower installation with a twin impeller shower pump*



*An Essex flange*

An example of a twin impeller boosting pump was shown in **H/602/2697** - **Understand and apply domestic cold water system installation and maintenance techniques.**

This is probably the most difficult of all shower valve installations. The pump increases the pressures and flowrates of both hot and cold supplies to the shower valve.

Here, it is mixed to the correct temperature before flowing to the shower head.

Care must be taken when connecting the boosting pump to the cylinder as shower pumps are known to fail very quickly if air gets trapped inside the pump. There are two ways of connecting the hot connection from pump to cylinder:

1. This method involves installing the hot water draw-off at an angle of between 30° and 60° (45° is optimum) (see drawing) with the hot water connection to the pump made at an angle of 90°. This method allows any air in the system to flow upwards through to the vent pipe and away from the shower pump.
2. The second method involves making a dedicated connection to the cylinder ¼ of the way down from the top dome using an Essex flange with a dip pipe. With this method, the hot water to the pump is taken directly from the hot water storage vessel, by-passing the cylinder wall and extracting the water from the body of water in the storage vessel itself.

## Thermostatic mixing valves

The installation of TMVs was covered in AC1.3 of this unit.

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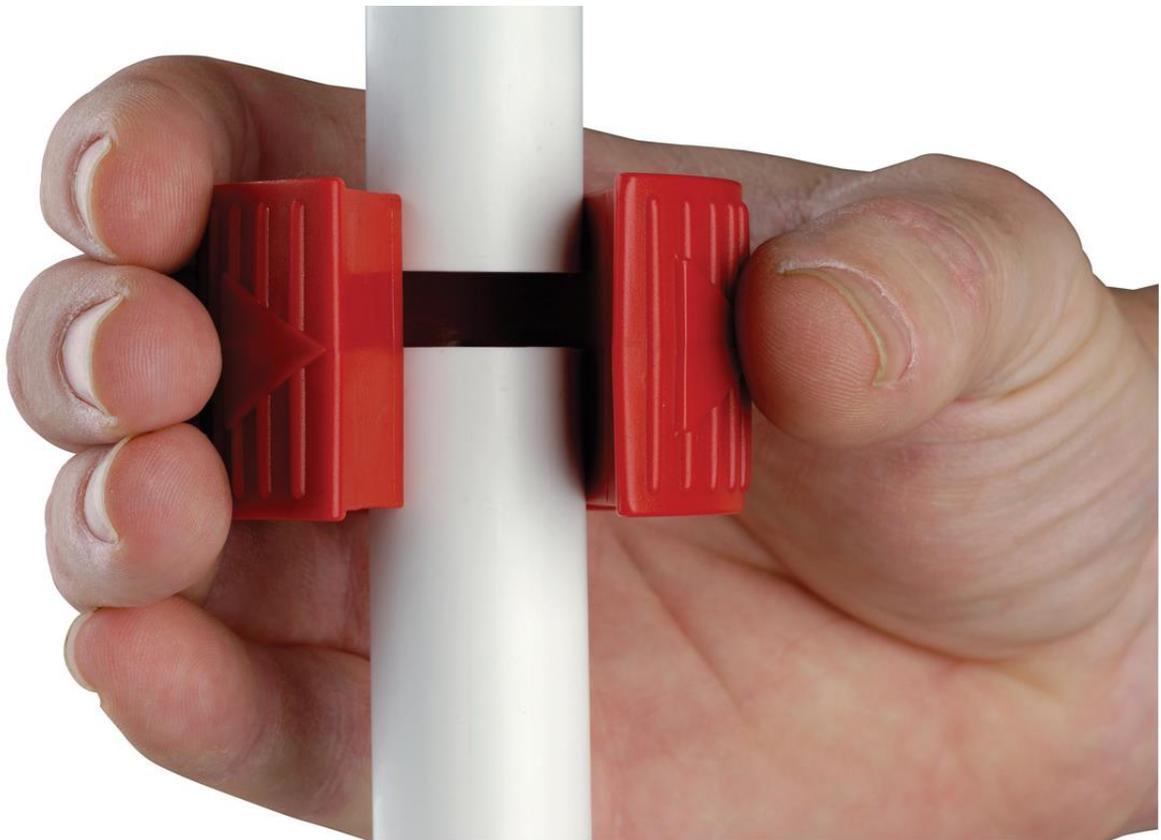
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## Learning Outcome 2

Know the site preparation techniques for hot water systems and components



There are five Assessment Criteria in Learning Outcome 2:

- AC2.1.** Identify the sources of information required when undertaking work on hot water systems
- AC2.2.** Identify the preparatory work required to be undertaken to the building fabric in order to install, decommission or maintain hot water systems and components.
- AC2.3.** Identify the protection measures required to the building fabric or customer property, during and on completion of work on hot water systems and components.
- AC2.4.** Identify the pipework materials and fittings required to complete work on hot water systems.
- AC2.5.** State the range of hand and power tools required to complete work on hot water systems and components.

Much of the information in Learning Outcome 2 has previously been covered in detail in other Units and specifically in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, and where possible, you will be directed to the relevant headings and Assessment Criteria within those units.

---

## AC2.1 Identify the sources of information required when undertaking work on hot water systems

### Regulations

The Regulations required when designing, installing and maintaining hot water systems are almost the same as for the installation of cold water systems. As such, they are covered in detail in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**. Where there are differences, they are listed below:

- The Water Supply (water fittings) Regulations 1999: Hot water supply is covered in Section 8 of Schedule 2 of the Water Supply (Water Fittings) Regulations.
- The Private Water Supply Regulations 2016
- Building Regulations Approved Document G - Sanitation, hot water safety and water efficiency 2010 – 2015 edition with 2016 amendments
- In 2010 the Building Regulations were updated and amended. Approved Document G - Sanitation, hot water safety and water efficiency was extended to bring new areas under the control of the Building Regulations, most notably, the installation of systems and water efficiency:
  - **G3 – Hot Water Supply and Systems:** Enhanced and amended provisions on hot water supply and safety, applying safety provisions to all types of hot water systems and a new provision on scalding prevention.
- The Gas (installation and use) Regulations 1998
- The IET (18<sup>th</sup> Edition) (BS7671:2008) Wiring Regulations

## The British Standards

### British Standards BSEN806:2012 Pts 1 to 5

BSEN806: Specifications for installations inside buildings conveying water for human consumption

- **BSEN806 – 1: 2000. General.** This document specifies potable water installation requirements and gives recommendations on the following aspects of hot and cold water installations:
  - Design
  - Installation
  - Alteration
  - Testing
  - Maintenance and operation.
  - Part 1 of BSEN806 also covers the pipework installation from the point of entry when the property is supplied with water from a private water source.
- **BSEN806 – 2: 2005. Design.** This document provides technical information so that the following points may be achieved from the design and installation:
  - Appropriate pressures and flowrates
  - Water quality at the tap is not contaminated or affected by the location or environment
  - The system avoids wastage of water and leakage.
  - The system is efficient, convenient, reliable and safe.
  - The system has a reasonable working life span.
- **BSEN806 – 3: 2006. Pipe sizing. Simplified method.** This document describes the simplified method for pipesizing drinking water standard installations as defined in section 4.2. However, the document does not engage in pipesizing for domestic firefighting systems.
- **BSEN806 – 4:2010. Installation.** Specifies the requirements of water installations within buildings and gives recommendations for their correct installation. It also covers pipework outside buildings but within the premises as outlined in BSEN806 – 1:2000. It applies to new, altered and repaired installations.
- **BSEN806 – 5:2012. Operation and maintenance.** This document takes the form of a practice specification. It specifies the requirements for the correct operation and maintenance of potable water supply installations within buildings and for pipework outside building but within premises in accordance with BSEN806 – 1:2000.

BSEN806 Parts 1 to 5 completely supersede BS6700 in all aspects of hot and cold water supply. **BS 8558: 2015 Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages** - complementary guidance to BS EN 806, now becomes the lead document for potable water supply in premises.

- [BS 8558: 2015 Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages - complementary guidance to BS EN 806](#)

BS8558 was developed primarily to provide complimentary guidance to BSEN806 Pts 1 to 5. Together, this complete suite of British Standards provides recommendations into best practice for the design, installation, testing, operation, maintenance and alteration of hot and cold water systems for domestic buildings.

BS8558 bridges the gap between BSEN806 and its predecessor BS6700 and provides UK guidelines for, not just plumbers, but the water supply industry as a whole.

- [PD 855468:2015 Guide to the flushing and disinfection of services supplying water for domestic use within buildings and their curtilages](#)

Flushing and disinfection of systems used to be part of BS8558:2011. However, the latest version of BS8558:2015 excludes flushing and disinfection. Instead, flushing and disinfection of systems is now a separate document PD 855468:2015.

PD 855468:2015 provides guidance on the cleaning, flushing and disinfection of cold water systems to control microbiological growth and the removal of debris. This includes guidance on:

- Deployment of the correct tools and personnel
- The use of the correct disinfectants
- How to respond if a microbiological problem is identified
- Keeping records of cleaning and disinfection

This new document applies to systems supplying water to domestic purposes within buildings and their curtilages, and includes water used in food preparation.

## Manufacturer technical instructions

The manufacturer's instructions are probably the most important document to read and consult when installing, servicing and maintaining appliances, components and equipment, because they instruct us on the best methods to use whilst keeping to current legislation and regulations. In some cases, it may appear that these instructions contradict the regulations. This occurs because regulations and codes of practice are only updated periodically, whereas manufacturers are constantly reviewing and updating their literature in line with modifications and current good practice. Where a conflict exists, manufacturer's literature should always be followed. If not:

- The warranty of the equipment may be void.
- Regulations may be inadvertently broken
- The installation may be dangerous.

## AC2.2 Identify the preparatory work required to be undertaken to the building fabric in order to install, decommission or maintain hot water systems and components

This topic was covered in Unit **D/602/2682 - Understand and carry out site preparation, and pipework fabrication techniques for domestic plumbing and heating systems**, Learning Outcome 3, AC3.1: Define the typical range of activities to be carried out when working on plumbing and heating systems and AC3.8: State the work methods for preparing building construction features for installation work

## AC2.3 Identify the protection measures required to the building fabric or customer property, during and on completion of work on hot water systems and components

This topic was covered in Unit **D/602/2682 - Understand and carry out site preparation, and pipework fabrication techniques for domestic plumbing and heating systems**, Learning Outcome 3, AC3.4: Identify how to protect the building fabric or customer property before the work commences.

## AC2.4 Identify the pipework materials and fittings required to complete work on hot water systems

This topic was covered in Unit **D/602/2682 - Understand and carry out site preparation, and pipework fabrication techniques for domestic plumbing and heating systems**, Learning Outcome 2, in the following Assessment Criteria:

- AC2.1.** Identify pipe work materials used in domestic plumbing and heating work
- AC2.2.** State the range of typical pipe material sizes available for use in dwellings.
- AC2.3.** State the acceptable methods of jointing new hot and cold water pipe to existing lead pipe work.
- AC2.4.** Identify the general fitting types used in dwellings.

## AC2.5 State the range of hand and power tools required to complete work on hot water systems and components

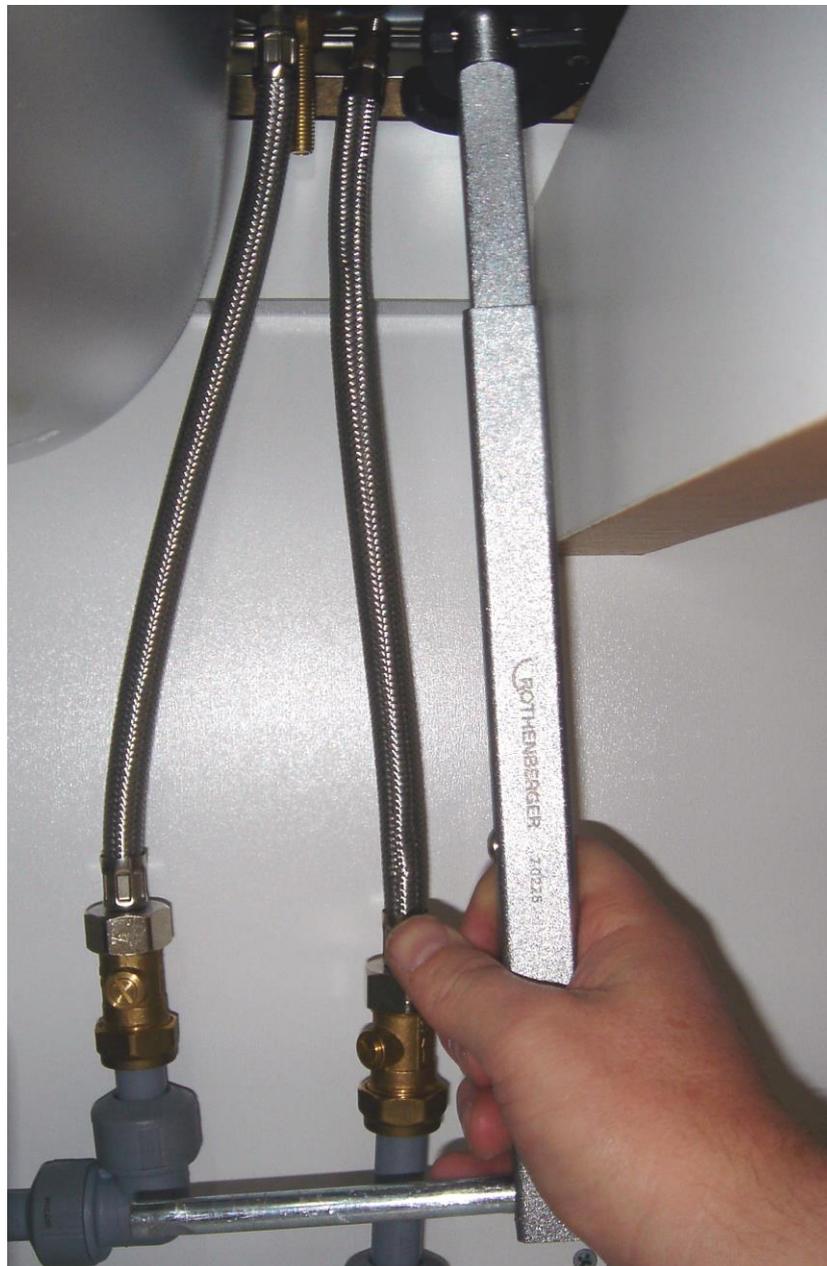
This topic was covered in Unit **D/602/2682 - Understand and carry out site preparation, and pipework**

**fabrication techniques for domestic plumbing and heating systems**, Learning Outcome 1, in the following Assessment Criteria:

- AC1.1.** State the purpose of hand and power tools used to carry out work on plumbing and heating systems.
- AC1.2.** Identify the different types of hand and power tools used to carry out work on plumbing and heating systems.

## Learning Outcome 4

Know the installation requirements of hot water systems and components



There are eleven Assessment Criteria in this Learning Outcome:

- AC4.1.** State how to take readings of hot water supply pressure and flow rate
- AC4.2.** State the positioning and fixing requirements of hot water pipework and components
- AC4.3.** Identify how expansion and contraction may be catered for in hot water pipework containing plastics and copper
- AC4.4.** State how to select clips and brackets appropriate to the hot water system pipework and the industry recommended spacings
- AC4.5.** State the positioning requirements of components in hot water systems
- AC4.6.** Identify how to measure, mark out and drill plastic storage cisterns to receive pipework connections
- AC4.7.** Identify how to make pipework connections to storage cisterns
- AC4.8.** Identify how to make pipework connections to open vented hot water storage cylinders
- AC4.9.** State how to position, fix and connect new hot water pipework to outlets and supply sources
- AC4.10.** Identify suitable methods of making new pipework connections into existing hot water system pipework
- AC4.11.** Identify the insulation requirements of hot water system components

Much of the information in Learning Outcome 4 has previously been covered in detail in other Units and specifically in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, and where possible, you will be directed to the relevant headings and Assessment Criteria within those units.

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## AC4.1 State how to take readings of hot water supply pressure and flow rate

**Pressure and Flow rate** The methods and equipment required to take flow rate and pressure readings were discussed in detail in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 5, AC5.1 State how to take readings of the incoming water supply pressure and flow rate. Please refer to AC5.1.

**Temperature** Taking temperature readings of the hot water is important to ensure that the system installed is reaching and maintaining an adequate and safe temperature to guard against scalding and legionella bacteria formation. This can be done in a number of ways:

- By the use of manual thermometers
- By the use of digital thermometers
- By the use of infrared thermometers

Examples of these are shown below:



*Examples of thermometers: left to right: A digital thermometer, an infrared thermometer*

## AC4.2 State the positioning and fixing requirements of hot water pipework and components

The positioning and fixing of pipework and components was discussed in detail in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 5, AC5.6 State the positioning and fixing requirements for cold water system pipework and components:

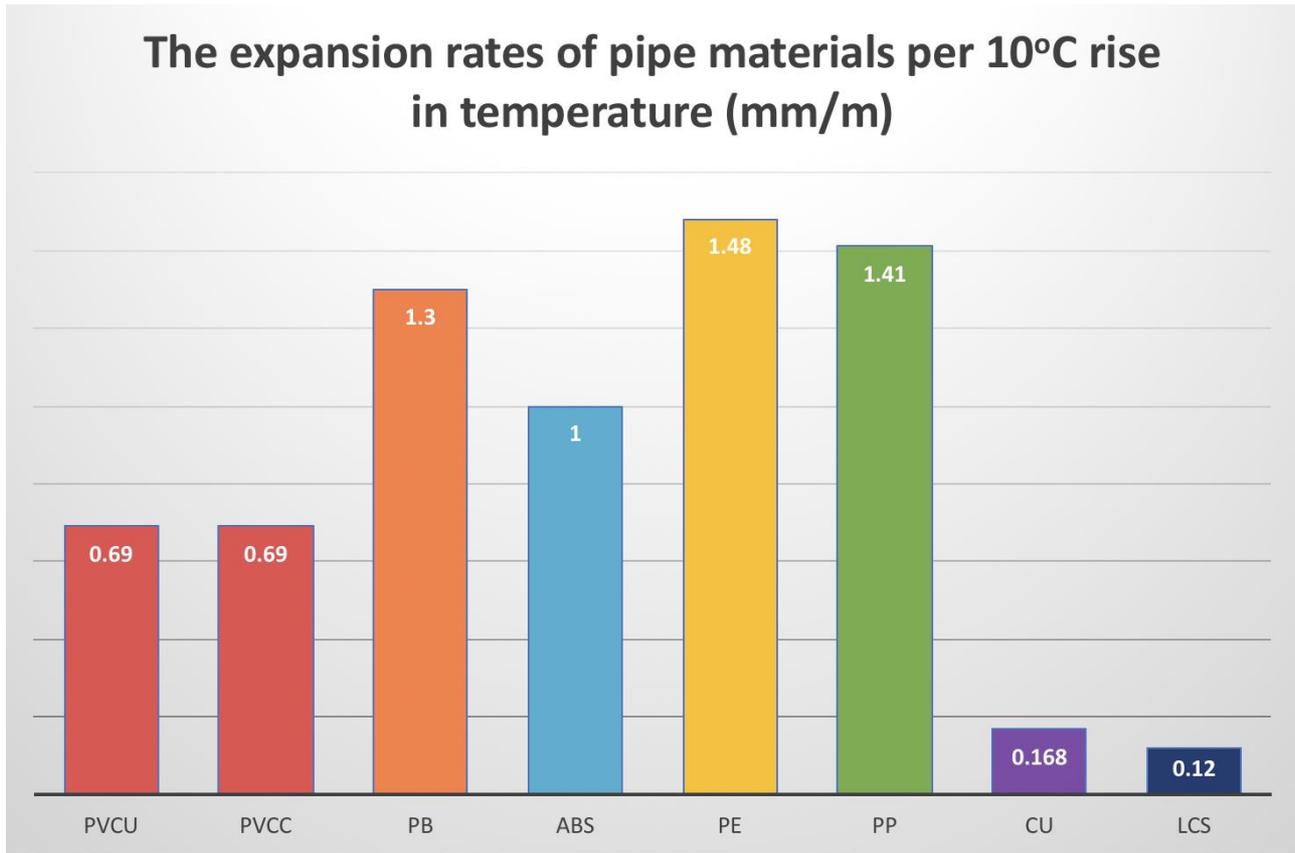
- a) In suspended timber floors
- b) In solid floors
- c) Embedded in walls
- d) In areas of the building subject to frost
- e) That may be exposed to warming.

Please refer to Learning Outcome 5, AC5.6 of Unit **H/602/2697**.

## AC4.3 Identify how expansion and contraction may be catered for in hot water pipework containing plastics and copper

It is a fact that both copper pipe and plastic pipe expand when they get hot. However, plastic pipes expand and contract more than any metallic pipe. Usually it is recommended that the issue of expansion of pipework be considered during the design stage.

Plastic pipe should always be allowed expand and contract freely or problems can occur, such as unsightly and unwieldy snaking pipework and stress on joints. If expansion is not catered for it can cause compression within the pipework, causing buckling and deformation. At the other end of the scale, it can cause tension loads, which could result in the pipe snapping or joints being pulled apart.



It is important to realise that different materials expand at different rates. The chart shows the different expansion rates of the common pipe materials found in modern plumbing systems. Two of the most common materials found in hot and cold pipe work are plastic and have the largest expansion rates of all, these being Polyethylene (PE) and polybutylene (PB).

For hot and cold water systems installed in PB, the PB expands/contracts by 1.3 mm/m per 10C change in temperature. If the ambient temperature is 10°C and the working temperature is 60°C, the expansion on an installed length of 10m PB pipe would be about 65 mm. Compare this to the same system installed in copper tube where the expansion rate is 0.168mm/m per 10°C rise and the expansion calculates to 8.5mm over a 10m length.

The most cost effective way of accommodating expansion is by using the flexibility of the pipework material by designing in changes of direction. The direction of pipe movement is controlled by using anchor points at key positions in the pipework. Where there are no changes of direction, such as long straight runs, then loops in the pipework can be made using machine ends (for metallic pipes) or fittings such as elbows.

In some cases, where loops and changes of direction cannot be used, due to the building design, then linear expansion devices such as expansion bellows or flexible hoses (for small diameter pipework) can be used. These need to be inspected at regular intervals and so must be accessible. With flexible hoses, it is important to ensure that they are not twisted during installation in order to maintain their effectiveness.

## AC4.4 State how to select clips and brackets appropriate to the hot water system pipework and the industry recommended spacings

The types of clips and clip spacings were dealt with in Unit **D/602/2682 Understand and carry out site preparation, and pipework fabrication techniques for domestic plumbing and heating systems**, LO5, AC5.4 Identify clip and bracket types for domestic plumbing and heating work.

## AC4.5 State the positioning requirements of components in hot water systems

As with all components and appliances, the installation requirements and restrictions can be found in the manufacturer's installation literature and these should be followed to ensure that the components are installed correctly and to the enforcing regulations and recommendations of the British Standards.

### Water Heaters/storage cylinders

The installation of water heaters is subject to the instructions given in the manufacturers installation data.

Hot water storage cylinders should be installed in a central position, usually in an airing cupboard. They should be mounted on a flat level base and raised slightly off the floor. The base should be capable of taking the weight of the vessel and the water it contains. The base should be slightly larger than the cylinder base. It should be positioned to give access to the primary flow and return connections and also the cold feed connection. A drain-off valve should be installed at the lowest point of the cold feed to enable draining, if required.

### Cisterns – hot water feed cisterns and feed and expansion cisterns

The installation of cold water cisterns was covered in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, LO2, AC2.8 State the system layout features for protected plastic storage cisterns.

### Drain valves

Drain off valves should be fitted at low points on the system to enable the complete draining of the pipework and components. A drain-off valve should be fitted on the cold feed pipe to the hot water storage vessel as low down as possible as the pipework enters the storage vessel.

### Service valves

Service valves are required to enable systems to be isolated for de-commissioning, maintenance and repair. A service valve must be installed on the mains cold water feed to any cisterns. This is a requirement of the

Water Supply (water fittings) Regulations 1999 and a gate valve must be installed on the cold feed pipe to the hot water storage vessel. The gate valve should be positioned above the hot water storage vessel.

## Thermostatic mixing valves

The installation and positioning of thermostatic mixing valves was covered and detailed earlier in this Unit in LO1, **AC1.3 Identify the working principles of hot water system components.**

## Showers – gravity fed mixer, mains fed mixer and instantaneous electric

The installation of shower mixing valves is subject to the instructions given in the manufacturers installation data. Most shower valves follow a similar installation/positioning pattern but the instructions give the specific details and requirements.

The electrical connections to electric showers should be made by a competent electrician.

## AC4.6 Identify how to measure, mark out and drill plastic storage cisterns to receive pipework connections

The marking and drilling of cisterns was discussed in detail in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 5, AC5.4 Identify how to measure, mark out and drill plastic storage cisterns to receive pipework connections.

## AC4.7 Identify how to make pipework connections to storage cisterns

Making connections to cisterns was discussed in detail in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 5, AC5.5 Identify how to make pipework connections to storage cisterns.

## AC4.8 Identify how to make pipework connections to open vented hot water storage cylinders

Hot water storage cylinder connections are usually as follows:

<b>Cold feed connection</b>	1" male or female thread depending on the manufacturer.	Connections made by a 1" boiler union (female thread) or a 1" x 28mm adapter (male thread)
<b>Hot water draw-off connection</b>	1" male or female thread depending on the manufacturer.	Connections made by a 1" boiler union (female thread) or a 1" x 28mm adapter (male thread)

<b>Primary flow and return connections</b>	1" male thread	Connections made by a 1" boiler union (female thread)
--	----------------	---



*A 28mm female straight boiler union*



*A 28mm x 1" male thread adapter*

## AC4.9 State how to position, fix and connect new hot water pipework to outlets and supply sources

Positioning and fixing pipework was discussed in detail in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 5, AC5.8 Identify how to position, fix and connect new cold water pipework to outlets.

Items not discussed in LO5, AC5.8 are discussed below.

### Hot water storage cylinder

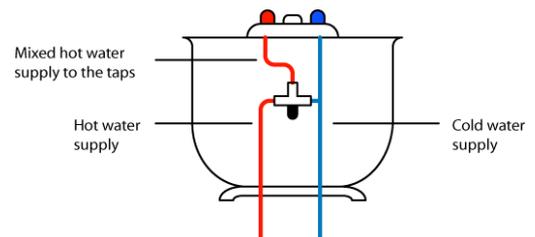
Hot water storage cylinders are usually sited in a central area of the property to ensure that the pipe runs to the hot outlets are not too long as this could lead to dead legs and the need for secondary circulation.

Connections to hot water storage vessels should be accessible and a drain-off should be fitted at the lowest point of the cold feed pipe. A gate valve for hot water isolation should be positioned on the cold feed pipe below the feed cistern but above the storage cylinder.

The hot water draw-off pipe should rise slowly to the vent pipe with a minimum distance of 450mm from the centre of the hot water storage cylinder to the vent/distribution pipe. Connections to Hot water cylinders should be made as stated in AC4.8 above.

### Thermostatic mixing valve

A Thermostatic Mixing Valve (TMV) mixes water from the hot and cold supplies to a temperature that is safe to use. The length of pipe from the TMV to the tap should be kept as short as possible. They are generally connected to the pipework via compression fittings supplied with the TMV.



## AC4.10 Identify suitable methods of making new pipework connections into existing hot water system pipework

This subject was discussed in depth in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 5, AC5.9 Identify suitable methods of making new pipe work connections into existing cold water system pipework.

## AC4.11 Identify the insulation requirements of hot water system components

### Hot water pipework insulation requirements

The insulation of pipework was discussed in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 5, AC5.10 Identify the insulation requirements of cold water system components. However, to prevent heat loss from hot water pipework the following recommendations should be observed:

- Primary circulation pipes for heating and hot water circuits should be insulated wherever they pass outside the heated living space or through voids, which communicate with and are ventilated from unheated spaces.
- Domestic hot water circuits primary circulation pipes are to be insulated throughout their length, subject only to practical constraints imposed by the need to penetrate joists and other structural elements.
- All pipes connected to hot water storage vessels, including vent pipe, to be insulated for at least 1 metre from their connection to the cylinder or insulated up to the point where they become concealed.
- If secondary circulation is used, all pipes kept hot by that circulation should be insulated along its entire length

Pipe diameter (mm)	Min. Insulation thickness (mm)
8mm	20mm
15mm	26mm
22mm	29mm
28mm	31mm

### Hot water storage cylinder insulation requirements

Hot Water Storage Cylinders are sprayed with polyurethane insulation foam at the factory. The thickness is dictated by the Building Regulations Document L: Conservation of Heat and Power, which states that Hot water storage cylinders in new build properties must have 50mm thickness of insulation and Hot water storage cylinders in existing properties need only 35mm of insulation.

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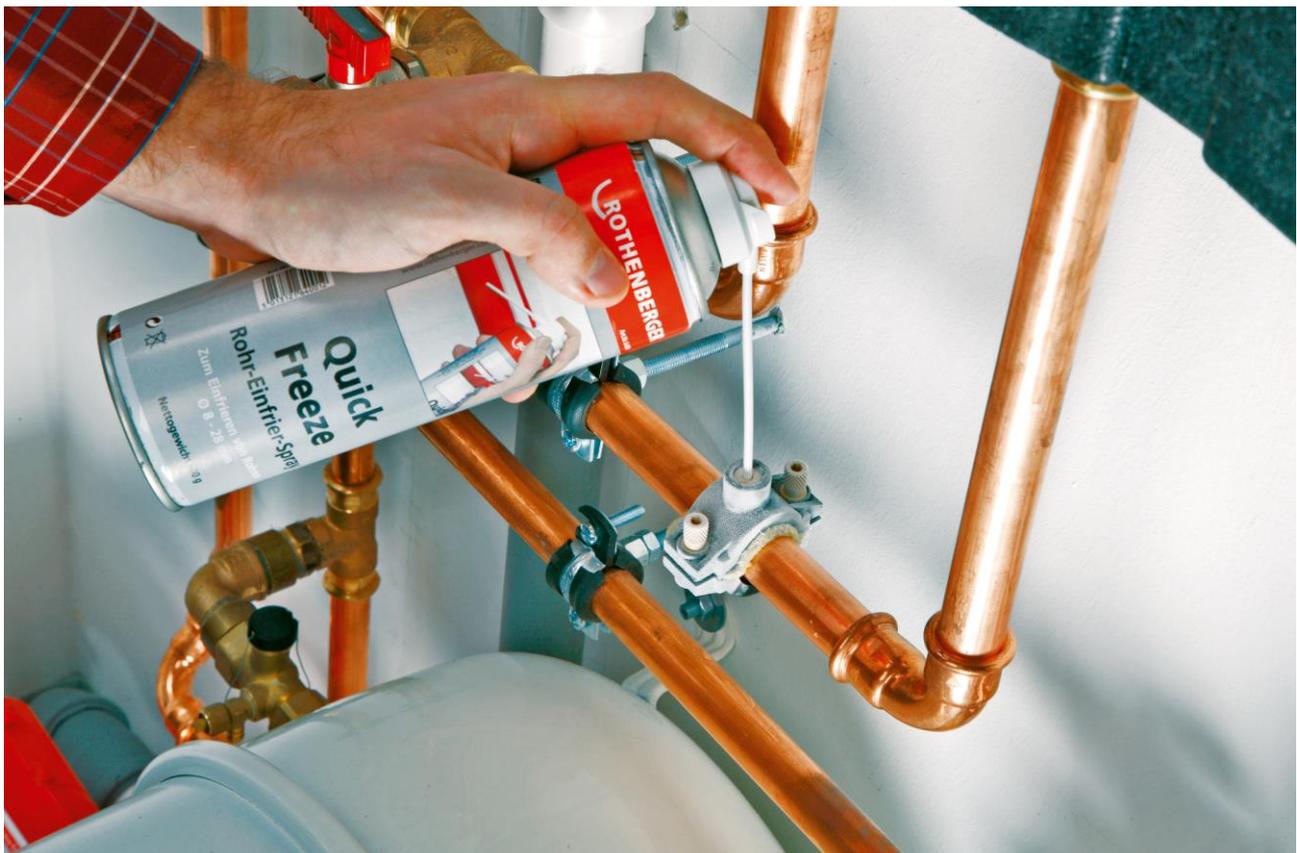
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## Learning Outcome 6

Know the service and maintenance requirements of hot water systems and components



There are four Assessment Criteria to this Learning Outcome:

- AC6.1.** Identify how to use manufacturer instructions and job maintenance schedules to establish the periodic servicing requirements of system components
- AC6.2.** Identify how to carry out routine checks on hot water components and pipework as part of a periodic maintenance programme
- AC6.3.** State the procedures for dealing with defects in hot water components and pipework
- AC6.4.** Identify the types of information to be provided on a maintenance record for hot water systems

As with other Learning Outcomes and Assessment Criteria in the Unit, much of the information required has previously been discussed in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques** and where this occurs you will be directed to the appropriate Assessment Criteria within the cold water unit. However, in many instances, further information specific to hot water systems is required and this will appear in the appropriate Assessment Criteria.

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## AC6.1 Identify how to use manufacturer instructions and job maintenance schedules to establish the periodic servicing requirements of system components

The use of manufacturer's instructions was discussed in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 7, AC7.1 Identify how to use manufacturer instructions and job maintenance schedules to establish the periodic servicing requirements of cold water system components.

## AC6.2 Identify how to carry out routine checks on hot water components and pipework as part of a periodic maintenance programme

The method of carrying out checks on pipework and components was discussed in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 7, AC7.2 Identify how to carry out routine checks on cold water system components as part of a periodic maintenance programme.

There are, however, components that require periodic maintenance that are specific to hot water systems and these will be discussed in turn.

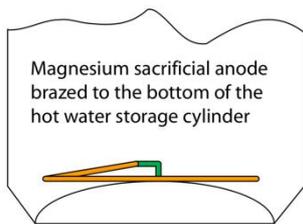
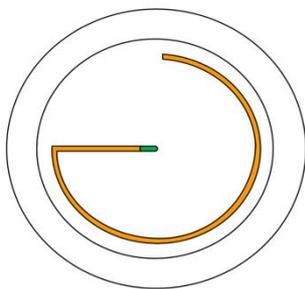
## Condition of hot water cylinder/heater and storage cisterns

### The hot water storage vessel/cylinder

The type of water in the UK varies with the different regions. As we have already discovered, water can be either hard or soft. Fresh, oxygenated water, when introduced in to a hot water storage vessel, especially in hard water areas, can accelerate electrolytic corrosion.

But why hard water areas?

Hard water contains a high parts per million (ppm) of calcium and magnesium carbonate, which allows the water to have high electrical conductivity (soft water has low electrical conductivity) and it is the high conductivity that allows electrolytic corrosion to occur rapidly. This usually manifests itself as calcium



deposits that settle in the bottom of the storage vessel. It creates blockages in pipework and attacks brass fittings, making them brittle. It can also effect the flow rate through heat exchangers, making the heating of the water slow.

Effective protection from electrolytic corrosion comes in the form of a sacrificial anode.

A sacrificial anode is a rod or small coil of magnesium that is placed into cylinder. Instead of the electrolytic corrosion attacking the hot water storage cylinder, it attacks the anode instead gradually eating it away, thereby protecting the cylinder from corrosion.

Some storage cylinders are manufactured with the anode in place, attached to the bottom, while others have to have the anode inserted by dropping a rod of magnesium in through the hot water draw-off

connection.

When inspecting hot water storage cylinders and heat exchanger of water heaters, check for:

- Signs of a white 'growth-like' corrosion on fittings and welded/brazed seams.
- Signs of leakage and damp patches.
- Deterioration in flow-rate. This could indicate that corrosion or lime-scale could be blocking either the feed pipe or the hot water draw-off.
- Sluggishness in the time taken to heat the water. Again this could indicate lime-scale in the primary flow or return pipes.
- The sound of 'kettling' (also known as localised boiling) when water heaters/boilers are turned on. This could also occur when an immersion heater is used.

### Hot water heaters

Gas-fired multipoint hot water heaters should be serviced every year by a GASSAFE registered operative.

Servicing should be carried out to the manufacturer's instructions and a check made on the flue gas emissions to ensure that they are within the manufacturer's tolerances. This ensures that complete combustion is taking place and the correct CO<sub>2</sub> emissions are present at the flue outlet. The operative will also check for:

- Signs of leakage and corrosion.
- Correct flow rates and time taken to heat the water.
- Correct temperatures
- The correct operation of all safety controls.

## Effective operation of thermostatic control devices

### Thermostatic Mixing Valves and Showers

Thermostatic Mixing Valves and showers rely on either a wax capsule or a bi-metallic coil to obtain and maintain the correct temperature precisely and continuously. If either of these two components should break down, then the required temperatures will not be achieved. In some situations, such as hospitals, nursing homes and care homes the correct temperature of the hot water is a matter of health and safety.

To ensure their continued service, check for:

- The correct temperature across a range of temperatures using a digital or infra-red thermometer.
- Correct flow rate.
- Any signs of corrosion or leakage.
- Any adjustments that may be required. This can only be completed by the use of the manufacturer's instructions.

### Electrical thermostats and motorised zone valves

These are usually found on the primary system of any hot water installation. They control the temperature of the hot water stored in the hot water storage cylinder by controlling the flow of water to the heat exchanger/coil. Simply put, the hot water cylinder thermostat senses when the temperature has been reached and disconnects the circuit to the motorised valve, which then closes. By doing this, circulation to the heat exchanger/coil is prevented, thus controlling the temperature of the stored water inside the hot water vessel. The temperature of the stored water should not exceed 60°C, so check that:

- The cylinder thermostat works correctly across a range of temperatures by adjusting the temperature control and observing the operation of the motorised valve.
- For any signs of leakage or corrosion.
- All electrical connections are secure and no bare wiring is present.
- The correct temperature has been set and that the system shuts down at this temperature.

## AC6.3 State the procedures for dealing with defects in hot water components and pipework

For the most part, the procedures for dealing with defects was adequately covered in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 7, AC7.3 State the procedures for dealing with defects in cold water components and pipework. However, there some components that are unique to hot water systems and these will be discussed here.

### Hot water storage cylinder/ heater failure

#### Hot water storage cylinder failure

Hot water cylinders generally fail in two quite different areas:

- a. Leakage of the cylinder, usually from a brazed or welded seam due to electrolytic corrosion. Easily detectable because water will show in the area where the hot water vessel is installed.
- b. Failure of the heat exchanger/coil allowing black central heating water into the domestic hot water system. Again, this is usually caused by electrolytic corrosion of the hot water coil and it is not easily detectable. It usually appears as an overflow running from either the cold feed cistern or the feed and expansion cistern (whichever cistern is the lowest). First impressions will be that the FoV has failed but the overflow will continue to run even after this has been replaced/repaired. This is because water is passing from the hot water system through the hole in the coil and backfilling the Feed and expansion cistern, raising the level of the water to the overflow, which then starts to run.

Either of these failures will require the replacement of the hot water storage cylinder. Always remember the following points when replacing hot water storage cylinders:

- Keep the customer informed as to the problems found.
- Correctly isolate the services (water, gas and electricity) and post notices that they are not to be turned on.
- Drain the entire contents of the hot water storage cylinder and the cold feed cistern in the roof space and turn on all hot taps.
- Drain the heating system to remove the water from the heat exchanger coil. If the cylinder is in an upstairs airing cupboard, then only the top half of the system will need to be drained.
- Disconnect the immersion heater by first isolating the electric switched fuse spur and removing the fuse. Always ensure that the electrical supply is dead before disconnecting any electrical services.
- Remove any external cylinder thermostats.
- Loosen and disconnect the cold feed pipe, the hot water draw-off pipe and both primary flow and return pipes and carefully remove the cylinder.
- Ensure that the new hot water storage cylinder is dressed with any new fittings required and install the immersion heater.

- Place the cylinder in to the correct position and reconnect all pipework, making alterations where necessary.
- Ensure all fittings are tight before turning on the water.
- Refilling the system is best done in two halves
  - **First System fill – the hot water storage cylinder:** Close off any open drain valves and turn off all open hot taps and outlets.
  - Isolate the gate valve on the cold feed pipe and turn on the isolation valve to cold feed cistern FoV. Allow this to fill completely before turning on the gate valve on the cold feed. This will ensure that the cylinder fills in one go and will ensure that airlocks do not become a problem.
  - Turn on the gate valve on the cold feed pipe and fill the cylinder. While this is filling, check the connections to the cylinder to ensure that there are no leaks.
  - Place a hand on the hot water draw-off pipe. When the cylinder is full, it will suddenly go cold as the cold water surges through the system.
  - Now, visit every hot tap and draw water through them, clearing any air.
  - Let the cistern fill again until the FoV shuts off and let the system stand for a few minutes.
  - Check the pipework again for leaks.
  - **Second system fill – the heating system:** close all radiator air valves.
  - Manually open any motorised zone valves.
  - Close off any open drain valves.
  - Open the service valve to the Feed and expansion cistern FoV (or filling loop if the heating system is a sealed system type) and fill the heating system, bleeding any radiators of air.
  - Ensure that the heat exchanger/coil is full of water.
  - Check for leaks.
  - Now, carefully reposition any cylinder thermostats and reconnect the electrical connections to the immersion heater by following safe electrical procedures and the manufacturer's instructions.
  - Once you are confident that all water and electrical connections have been made and are safe, then turn on the services and commission the system.
  - Once the hot water in the storage cylinder is hot, run the hot taps and check hot water temperatures and flow rates.

## Hot water heater failure

Failure of hot water heaters often means that these have to be replaced. Replacement of under and over sink point of use heaters is a fairly simple operation that can be completed easily and quickly by following the manufacturer's instructions. On no account should you attempt to replace any gas instantaneous water heaters as these can only be replaced by GAS SAFE registered engineers.

## Leakage or ineffective operation of Mixer showers and Thermostatic mixing valves

### Mixer showers

Mixer showers often leak through spindles and other moving parts because the water tight seals have

become worn. In most cases, the manufacturer will provide, at a cost, a seal pack and a set of instructions to reseal all moving parts within the shower body itself. It must be remembered that ALL sealing washers provided must be replaced even if the washer being removed seems to be working perfectly. Use any lubrication provided to ensure that the moving parts move freely and thoroughly test in all temperature and flow rate configurations once the repairs have been completed.

In the event that the whole shower valve requires replacement, most shower valves have a centre-to-centre measurement of 147mm between the hot and cold connections and all showers have the same arrangement of hot/left, cold/right when viewed from the back of the valve. Replacement is usually via compression fittings on the hot/cold connections. Manufacturer's instructions should be followed.

### Thermostatic Mixer Valves (including thermostatic mixer showers)

These are fairly simple to repair since the thermostatic mixing control within the valve comes as a like-for-like cartridge that is simply replaced within the valve. Manufacturer's instructions must be followed.

Before replacing the cartridge, it may be a good idea to check the manufacturer's instructions for any diagnostic procedures that may indicate either lack of flow rate or pressure. These can be followed first to ensure that it is a replacement cartridge that is needed. This may include:

- Temperature check of the hot and cold water.
- Flow rate of the hot and the cold supply

## AC6.4 Identify the types of information to be provided on a maintenance record for hot water systems.

For hot water systems, it is advisable to keep a record of all maintenance and repairs for future reference. The types of information noted should be:

- The name of the maintenance engineer
- The date and time the maintenance/repairs were carried out
- The type of hot water system being maintained
- The type of maintenance/repairs undertaken
- Their location
- The materials/components or replacement parts used
- The location of manufacturer's instructions/maintenance data.
- The flow rates and pressures of outlets, taps and components
- The temperature of the hot water for scalding safety and legionella protection
- Any corrosion witnessed and where.

## Learning Outcome 8

Know the decommissioning requirements of hot water systems and components



**Hot Water System turned off.  
Plumber working on the system  
Do not turn on!**

There are five Assessment Criteria to this Learning Outcome:

- AC8.1.** Identify the working methods that reduce the time periods during which hot water systems need to be isolated.
- AC8.2.** State the information that needs to be provided to other persons before decommissioning work takes place.
- AC8.3.** State how to temporarily decommission hot water system components and connecting pipework systems.
- AC8.4.** Identify the work sequences for permanently decommissioning hot water components and pipework systems.
- AC8.5.** Identify the methods used during the decommissioning process to prevent the end-user from operating hot water system components

## AC8.1 Identify the working methods that reduce the time periods during which hot water systems need to be isolated

## AC8.2 State the information that needs to be provided to other persons before decommissioning work takes place

There are instances where hot water systems must be temporarily de-commissioned to allow essential works, such as repairs and servicing, to be conducted. The impact of isolation means that some parts, and in a worst-case scenario, all of the system will need to be isolated. Also, ensure that all electrical components, heaters, thermostats, motorised valves etc. are correctly isolated before work begins.

There are methods we can employ to lessen the impact of isolation on the customer:

- 1)** Do as much preparation beforehand as possible. If, for instance, you are connecting an extension to the hot water system or replacing an appliance or component, make the final connection to the water system the last operation, so that the water is off the minimum amount of time.
- 2)** Be frank with the customer and tell them how long the system will be off. Point out that this is an estimated time and the water will be turned back on as soon as is possible.
- 3)** Tell the customer which parts of the system you will be working on.
- 4)** Ask the customer to collect water for drinks in saucepans and jugs and water for ablutions in a bucket. They may not be needed but at least the customer will have some water for those essential things.

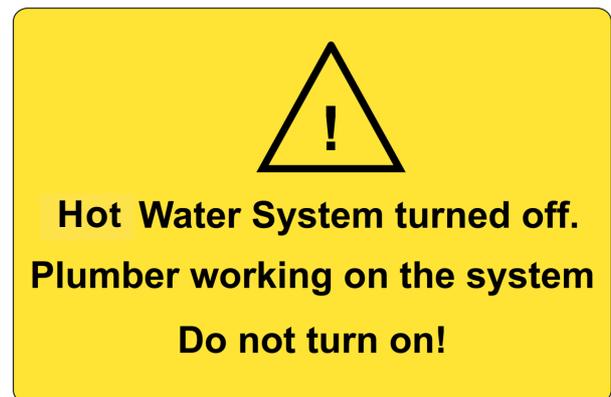
Isolating water supplies can be very annoying and inconvenient to a customer but most cases you will find that the customer is very understanding of the situation.

## AC8.3 State how to temporarily decommission hot water system components and connecting pipework systems

This is where a water system or part of a water system is isolated and drained down so that work may be performed on it. Once the work is completed, the water will be turned on and the system put back into operation.

The customer must be the focus when isolating water supplies. Water is vital for the day-to-day running of a household. Therefore, keeping them informed of the sequence of operations allows them to make informed choices about bathing, clothes washing, food preparation etc. Below is a suggested sequence of events:

- 1) Inform the customer that the water supply is going to be isolated and inform them as to how long the supply is expected to be off.
- 2) Suggest that they might like to collect some water for drinking etc.
- 3) Ensure that those appliances that are using or may be using water supply are turned off. Ask the customer not to turn on any clothes or dish washing machines. Ensure that the electrics to any combination boilers are turned off. This is to ensure that the boiler does not fire up while the water is off. It is purely precautionary.
- 4) Place a warning notice at the point of isolation warning other people that the supply is turned off and is not to be turned back on.
- 5) Isolate the system or part of the system that is being worked on.
- 6) Drain the system of water at the nearest drain point.



## AC8.4 Identify the work sequences for permanently decommissioning hot water system components and connecting pipework systems

Unlike temporary de-commissioning, permanent de-commissioning of a system literally means that the system will not be re-instated. In most instances, this will mean the complete removal of all pipework and appliances. The pipework should be cut back to the nearest live connection and capped to prevent stagnation of the water supply:

- 1) Isolate the water supply at the point where the system is to be decommissioned. For hot water systems, this will usually be the mains cold water isolation valve connected to the Float Operated Valve to the storage/feed cistern in the roof space.
- 2) Open all hot taps and let the water run until the water stops.

- 3) Completely drain the hot water cylinder at the drain-off and the cold feed pipe.
- 4) Isolate and disconnect any electrical controls, such as immersion heaters and thermostats.
- 5) Remove all appliances and storage vessels and carefully remove the pipework and clips.
- 6) Cut the pipework back to the stop valve or nearest live connection and cap the pipe off.
- 7) If necessary, a notice can be left by the stop valve informing that the system has been permanently de-commissioned and is not to be turned on.

## AC8.5 Identify the methods used during the decommissioning process to prevent the end-user from operating hot water system components

This subject was covered in depth in AC8.1 to AC8.4. Please see above.

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BPEC's End-point Assessment Organisation (EPAO) are approved by the Education and Skills Funding Agency (ESFA) and are included on the Register of End-point Assessment Organisations (RoEPAO).

Through our expertise and specialism in Plumbing, Heating & Gas Engineering you can be sure you are getting an impartial service you can trust.



# Learning Outcome 10

Know the inspection and soundness testing requirements of hot water systems and components



There are five Assessment Criteria to this Learning Outcome:

- AC10.1.** State the checks to be carried out during a visual inspection of a hot water system to confirm that it is ready to be filled with water.
- AC10.2.** State how to fill hot water pipework with water at normal operating pressure and check for leakage.
- AC10.3.** Identify how to carry out a soundness test to industry requirements on hot water systems pipework and components.
- AC10.4.** State the flushing procedure for hot water systems and components.
- AC10.5.** Identify the actions that must be taken when inspection and testing reveals defects in hot water systems

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## AC10.1 State the checks to be carried out during a visual inspection of a hot water system to confirm that it is ready to be filled with water

The checks to be carried out on hot water systems are almost identical to the checks carried out on cold water systems and these were covered in Unit **H/602/2697 - Understand and apply domestic cold water system installation and maintenance techniques**, Learning Outcome 11, AC11.1 State the checks to be carried out during a visual inspection of a cold water system to confirm that it is ready to be filled with water. However, there are some additional checks that should be made when dealing with hot water systems:

- Check that all open ends have been capped and/or all valves have been isolated.
- Check that all taps and outlets have been turned off and any drain valves are closed.
- Isolate any service valves and gate valves.
- Check all visible joints to ensure that they have been properly made. Check that capillary joints have been wiped clean of any excess flux as this can cause corrosion in later life.
- Check that enough pipe clips have been installed and that the pipework is secure.
- Check that tap connectors and compression fittings are tight.
- Ensure that any automatic air valves are open.
- Ensure that a provisional fill level has been set in any cold water cisterns fitted.
- Check that all cisterns have been fitted correctly and are well supported.
- Check that cistern lids are left in place.
- Check that the hot water storage vessel well supported and stable.
- If the immersion heater in the hot water storage cylinder has been connected to the electric switched fuse spur, ensure that it is isolated and the fuse has been removed
- Ensure any electrical components are isolated, i.e. motorised zone valve, cylinder thermostat, shower pump, secondary circulation pump etc.

## AC10.2 State how to fill hot water pipework with water at normal operating pressure and check for leakage

After the system has been inspected as detailed in **AC10.1**, the following method can be used for filling the system with water. Remember, for a test to be trouble free, there must be a method of releasing any air that collects in the system. Isolation valves are a good idea to enable this.

Testing is best done in stages or by zones:

- 1) Isolate the gate valve on the cold feed pipe and turn on the isolation valve to cold feed cistern FoV. Allow this to fill completely before turning on the gate valve on the cold feed. This will ensure that the cylinder fills in one go and will ensure that airlocks do not become a problem.
- 2) Turn on the gate valve on the cold feed pipe and fill the cylinder. While this is filling, check the connections to the cylinder to ensure that there are no leaks.
- 3) Place a hand on the hot water draw-off pipe. When the cylinder is full, it will suddenly go cold as the cold water surges through the system.
- 4) Now, visit every hot tap and draw water through them, clearing any air and checking for leaks.
- 5) Let the cistern fill again until the FoV shuts off and let the system stand for a few minutes.
- 6) Check the pipework again for leaks.

## AC10.3 Identify how to carry out a soundness test to industry requirements on hot water systems pipework and components

The testing requirements of water systems was covered in detail in **D/602/2682** - Understand and carry out site preparation, and pipework fabrication techniques for domestic plumbing and heating systems

**Learning Outcome 9:** Know the inspection and soundness testing requirements of domestic plumbing and heating pipework

**AC9.2 State how to carry out a soundness test on domestic plumbing and heating pipework**

## AC10.4 State the flushing procedure for hot water systems and components

The importance of flushing hot water systems cannot be overstated. Hot water is susceptible to legionella bacteria and flushing a system helps to remove any dirt or swarf that may encourage legionella growth. Flushing water systems should be done initially with fresh clean water drawn from the water undertaker's mains cold water supply. All pipework and components should be flushed through, including the cold water feed cistern and the hot water storage vessel and it is advisable that the latter be drained completely after flushing to remove any build-up of dirt or swarf that has found its way into the storage cylinder/vessel.

The following method is a basic flushing sequence that assumes that the system has already been filled in accordance with the procedure stated in AC10.2 State how to fill hot water pipework with water at normal operating pressure and check for leakage:

- 1) Visit each terminal fitting, valve and tap individually and turn on.
- 2) Flush the system through until the water runs clear and then let it run for 20 – 30 seconds.
- 3) Once all taps have been flushed with cold water, let the cold feed cistern fill until the float operated valve shuts off.
- 4) Check the immersion heater and set the temperature to 55 – 60°C at the thermostat. Replace the immersion heater cover.
- 5) Replace the fuse into the immersion heater switched fuse spur (checking that it is a 13amp fuse) and switch on the switched fuse spur.
- 6) Run the system up to the correct temperature.
- 7) Visit each tap in turn and draw off hot water through the tap.
- 8) Re-check for leaks.
- 9) Isolate the immersion heater switched fused spur and any other electrical circuits that have been energised.
- 10) Turn off the service valve to the cold feed cistern.
- 11) Open all hot taps and run off all the water until it stops flowing.
- 12) Place a hose pipe on the cold feed pipe drain off valve and completely empty the hot water storage cylinder. This will ensure that any debris in the cylinder is flushed through to the drain.
- 13) Turn off the drain off valve and cold feed pipe gate valve.
- 14) Turn off all hot taps and outlets.
- 15) Re-fill the system as previously stated and check for leaks.

## AC10.5 Identify the actions that must be taken when inspection and testing reveal defects in hot water systems

Faults that are immediately obvious during inspection will require rectifying before testing takes place. Problems such as loose pipework and general lack of fixings are easily fixed. Some initial problems, such as inadequate support for cisterns and cylinders, may take longer to remedy.

Problems that arise during initial testing are generally centred around leakage that will require fixing as a matter of urgency.

There may also be problems that arise during the commissioning stage, such as failure to meet the requirements of the specification, lack of flow rate or pressure or unsatisfactory performance of fitted components and appliances. Where problems of this nature occur, then the system designer must be informed, and a remedy sought as a matter of urgency. In these cases, reference to manufacturers data should be made.

Occasionally, problems occur with faulty components and appliances, such as faulty shower pumps, mixer valves etc. when these are found, the manufacturer should be contacted immediately. In some instances,

the manufacturer may want to visit the job to ensure that the component has been fitted correctly before taking any action. Often, though, they will ask you to return it to the place of purchase and ask for an exchange unit. Remember: Keep the customer informed.