UNIT 303

Understand and apply domestic hot water system installation, commissioning, service and maintenance techniques

This unit provides learning in application of design techniques, installation and use of specialist components; maintenance, diagnostics and rectification of faults and commissioning procedures, along with the backflow protection in plumbing systems to comply with current legislation and regulations. The unit covers open vented and un-vented systems in multi-story dwellings.

There are ten Learning Outcomes for this unit. Hot water is a complex subject so the unit is separated into subject headings. The Learning Outcomes and the assessment criteria will be listed at the head of each section. There are 76 Guided Learning Hours recommended for this unit. The learner will:

1. Know the types of hot water system and their layout requirements.
2. Know the uses of specialist components in hot water systems.
3. Know the design techniques for hot water systems.
4. Be able to apply design techniques for hot water systems.
5. Know the installation requirements of hot water systems and components.
6. Be able to install hot water systems and components.
7. Know the fault diagnosis and rectification procedures for hot water systems and components.
8. Be able to diagnose and rectify faults in hot water systems and components.
9. Know the commissioning requirements of hot water systems and components.
10. Be able to commission hot water systems and components.

Factors affecting hot water type selection (LO1, LO3)

There are three assessment criteria for these Learning Outcomes:

1 Define the factors which affect the selection of hot water systems for single occupancy dwellings.
2 State the criteria used when selecting hot water system and component types:
   - customers needs
   - building layout and features
   - suitability of system
   - energy efficiency
   - environmental impact.
3 Compare the types of hot water supply systems used in dwellings:
   - centralised systems:
     - unvented hot water systems
     - open vented hot water systems.
   - localised systems:
     - unvented point of use heaters
     - instantaneous heaters.

The types of hot water supply systems used in dwellings

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Outcome 1 PowerPoints

The type of system we choose will depend on the following points:

- **The size of the property and the distance from the outlets** – The Water Supply (water fittings) Regulation stipulates the maximum distance that a hot water supply pipe may run without constituting wastage of water. This is because of the amount of cold water that is drawn off before hot water arrives at the taps. This 'dead', cold water must be limited. Large properties may exceed the maximum distances for hot water deadlegs, which excludes some hot water systems. In these cases, only systems that can incorporate secondary circulation should be considered.
- **The number of occupants and the amount of hot water required** – Larger households will, obviously, require more hot water, which can be supplied in a number of ways, ie an instantaneous water heater giving unlimited hot water amounts or a large hot water storage cylinder, but other factors must also be considered before a decision is made.

- **The number of hot water outlets** – Again, an important point as this may automatically exclude such appliances as combi boilers and instantaneous heaters because, although classed as multipoint heaters, only one outlet at a time may be opened satisfactorily, where as other types of hot water system may allow multiple open taps with good flow rate.
- **The type(s) of fuel to be used** – With most storage hot water systems, multiple fuels may be used in one system, i.e. utilising gas, oil or solid fuel as the main fuel source with an electrical alternative (immersion heater) as back-up or for summer use. Multipoint heaters do not have this capability and so fuel type usage is very limited.
- **Installation and maintenance costs** – Again, a very important point because of the size of the system, initial cost of the appliance and materials. Add to this the installation costs and any maintenance costs over the lifetime of the system.
- **Running costs and energy efficiency** – New, more efficient methods of heating water are being developed constantly. Perhaps the most important recent development is that of solar hot water heating, which can, theoretically, offer a 60% saving on domestic hot water heating costs, despite its initial costly installation. The development of fuel-efficient condensing oil and gas boilers and storage cylinders with fast heat recovery times have also helped in terms of energy efficiency.

Choosing the right hot water system

When points 1 to 6 are considered, the choice of hot water system should be quite a straightforward affair. Certain dwellings almost dictate the system that should be fitted. For example, it would be foolhardy to install a combi boiler in a dwelling with three bathrooms, a kitchen, utility room and downstairs washroom. The hot water demand would be more than the boiler could cope with. Overall, the main considerations that must be taken into account are the type and number of appliances and their pattern and frequency of use. Knowing this will indicate the correct choice of system to install and the customer can then be advised accordingly.

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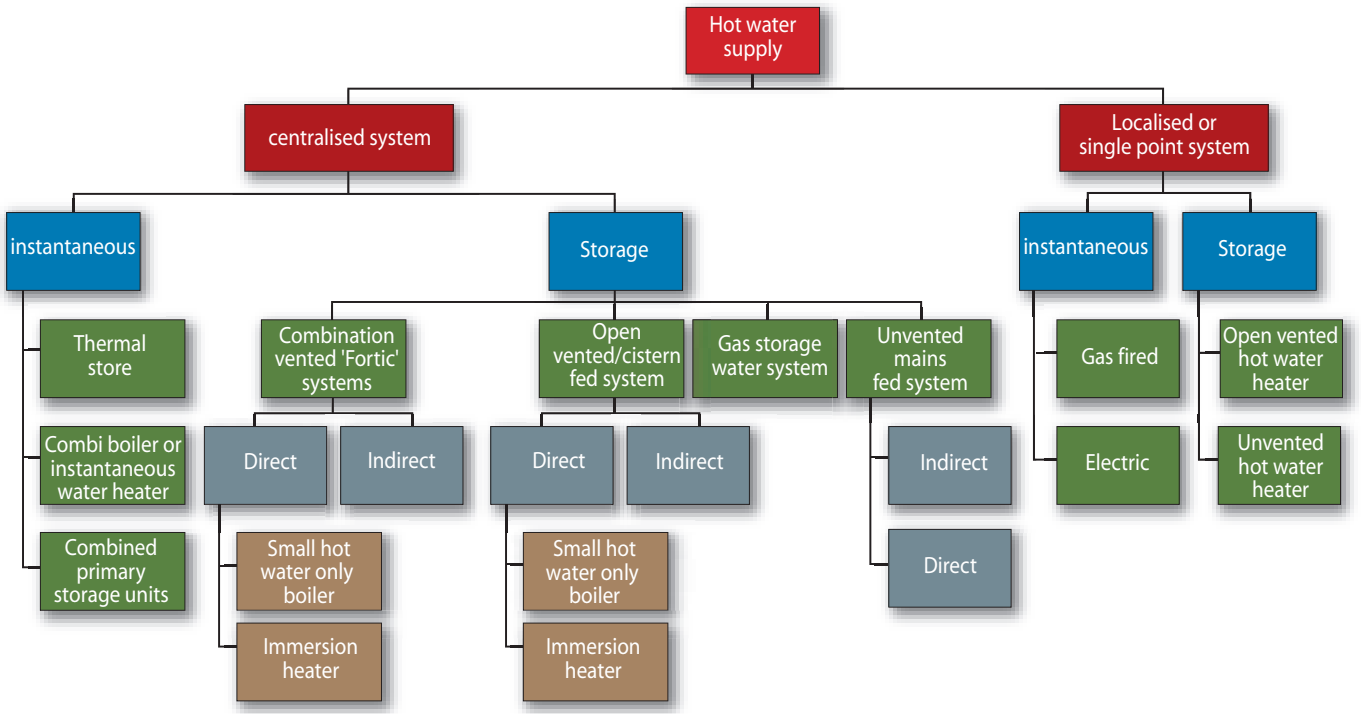
Handout 1

Hot water system types



Types of hot water system

As you can see from the drop chart above, hot water systems can be divided into two categories. These are:

- **centralised systems** – Where hot water is delivered from a central point to all hot water outlets in the dwelling. The water may be heated by a boiler or an immersion heater.
- **localised systems** – Often called single point or point of use systems. With these systems, the hot water is delivered by a small water heater at the point where it is needed.

Centralised systems

Centralised systems are those where the source of hot water supply is sited centrally in the property for distribution to all of the hot water outlets. They are usually installed in medium to large domestic dwellings such as a three bedroomed house. These can be further divided into two types:

Centralised hot water storage systems are divided into:

- **open vented systems** – Those hot water storage systems that are fed from a cistern in the roof space and contain a vent pipe that is open to the atmosphere.

- **unvented systems** – Those hot water storage systems that are fed directly from the cold water main and utilise an expansion vessel or an internal air bubble to allow for expansion.

Centralised instantaneous hot water systems can be divided into:

- **gas fired instantaneous multi-point hot water heaters** – Those heaters that heat the water instantaneously
- **gas or oil fired combination boilers** – Operate in a similar fashion to instantaneous hot water heaters but also have a central heating capability.
- **thermal stores** – Sometimes referred to as water jacketed tube heaters.
- **gas or oil fired combined primary storage units** – Again, these are very similar in operation to the thermal store.

Open vented hot water storage systems

In an open vented hot water storage system, water is heated, generally by a boiler or an immersion heater, and stored in a hot water storage vessel sited in a central location in the property, usually in the airing cupboard. Open vented systems contain a vent pipe, which remains open to the atmosphere ensuring that the hot water cannot exceed 100°C. The vent pipe acts as a safety relief should the system become overheated. It must be sited over the cold feed cistern in the roof space.

The cylinder is fed with water from the cold feed cistern. The capacity of the cistern will depend upon the capacity of the hot water storage vessel and BS 6700 recommends that the capacity of the cistern feeding cold water to a hot water storage vessel must be at least equal to that of the hot water storage vessel. Here are some important points to note about open vented hot water systems:

- The open vent pipe must not be smaller than 22mm pipe and must terminate over the cold feed cistern.
- The open vent pipe must not be taken directly from the top of the hot water storage vessel.
- The hot water draw-off pipe should rise slowly from the top of the cylinder to the open vent pipe and incorporate at least 450mm of pipe between the storage cylinder and its connection point to the open vent. This is to prevent parasitic circulation (also known as one pipe circulation) from occurring.

- The cold feed pipe should be sized in accordance with BS 6700. The cold feed is the main path for expansion of water to take place within the cylinder when the water is heated. The heated water from the cylinder expands up the cold feed pipe, raising the water level in the cold feed cistern.
- The cistern should be placed as high as possible to ensure good supply pressure. The higher the cistern, the greater the pressure at the taps. Poor pressure can be increased by raising the height of the cistern.
- All pipes should be laid with a slight fall (except the hot water draw off) to prevent air locks within the system.
- The cold feed pipe from the storage cistern must only feed the hot water storage cylinder.
- A drain off valve should be fitted at the lowest point of the cold feed pipe.

As we discovered at Level 2, there are two types of open vented hot water storage systems. These are:

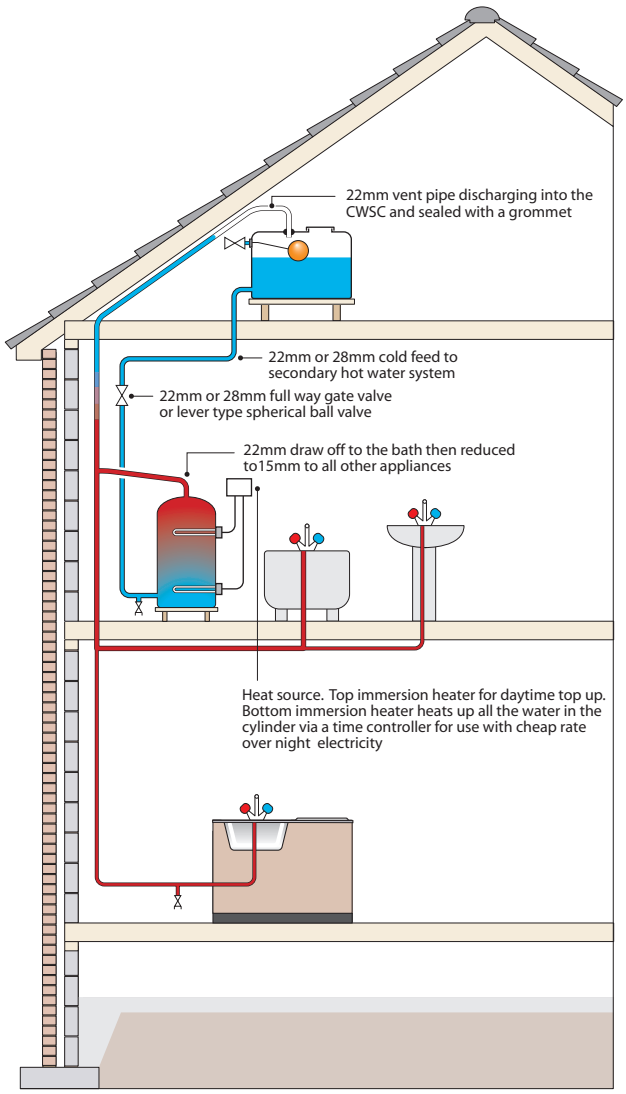
- the direct system
- the indirect system.

Direct open vented hot water storage systems

The direct open vented hot water storage system uses a direct type hot water storage cylinder. The direct cylinder contains no form of heat exchanger so is not suitable for use with central heating systems. The connections for the cold feed and draw-off are usually male thread connections with the primary flow and return connections are female thread. They are usually heated by either one or two immersion heaters, depending on the cylinder type, or they may be heated by a gas fired hot water circulator. Existing installations may also use a back boiler placed behind a solid fuel fire. Because the water in the boiler comes directly from the hot water storage cylinder, the boiler must be made of a material that does not rust. This is to prevent rusty water being drawn off at the taps. Suitable boiler materials are:

- copper
- stainless steel
- bronze.

A typical direct system using immersion heaters is shown below.



Direct open vented hot water storage system

Indirect open vented hot water storage system

The indirect system uses an indirect-type hot water storage cylinder, which contains some form of heat exchanger to heat the secondary water. There are two distinct types:

- the double feed indirect hot water storage cylinder
- the single feed, self venting indirect hot water storage cylinder.

The heat exchanger contains primary water and so is classified as part of the central heating system to the dwelling.

Open Vented indirect (double feed type) hot water storage systems

This is probably the most common of all hot water delivery systems installed in domestic properties. It uses a double feed indirect hot water storage cylinder, which contains a heat exchanger, at the heart of the system. The heat exchanger within the cylinder is usually a copper coil but, in older type cylinders it can also take the form of a smaller cylinder called an annular. It is called indirect simply because the secondary water in the cylinder is heated indirectly by the primary water via the heat exchanger.

In a double feed indirect system two cisterns are used – a large cistern for the domestic hot water and a smaller one for the heating. It is now general practice to install indirect cylinders in preference to direct types, even if the indirect flow and return are capped off.

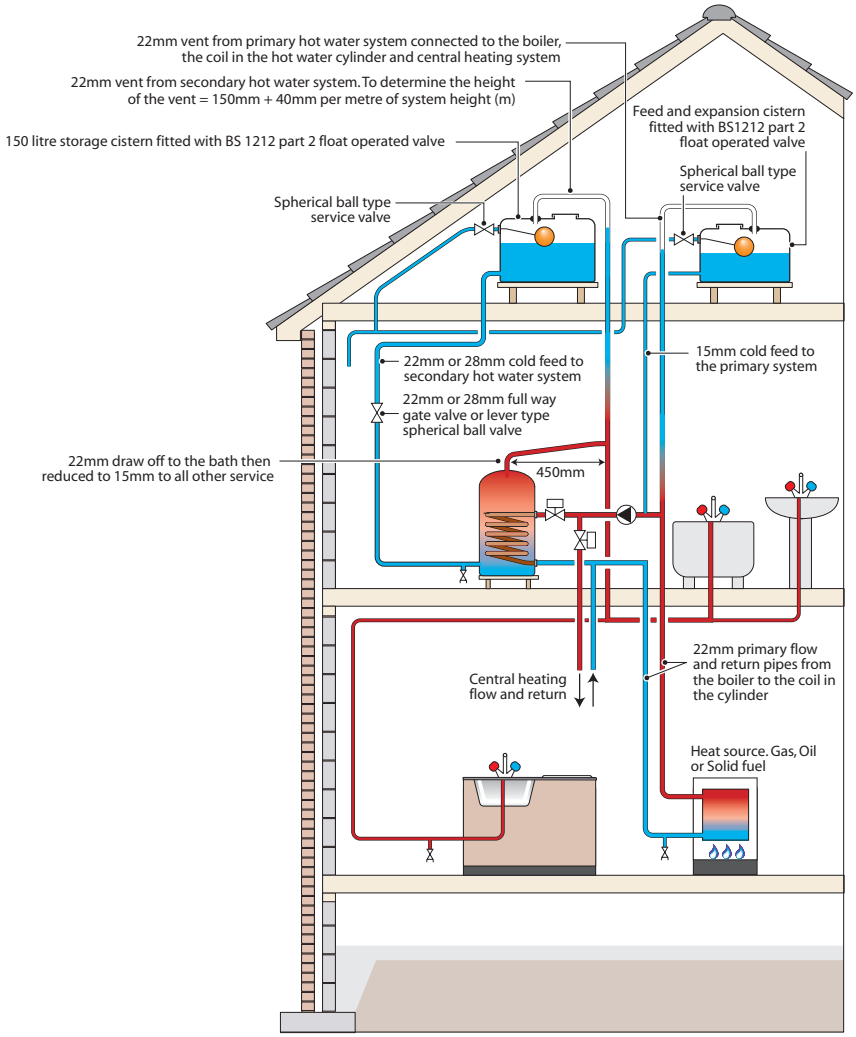
The double feed indirect hot water storage cylinder allows the use of boilers and central heating systems that contain a variety of metals, such as steel and aluminium, because the water in the cylinder is totally separate from the water in the heat exchanger. This means that there is no risk of dirty or rusty water being drawn off at the taps. The system is designed in such a way that the water in the boiler and primary pipework is hardly ever changed, the only loss of water being in the feed and expansion cistern through evaporation.

The secondary water is that which is drawn from hot water storage cylinder to supply the hot taps. It is heated by conduction as the water in the cylinder is in contact with the heat exchanger.

A feed and expansion cistern feeds the primary part of the system, and this must be large enough to accommodate the expansion of the water in the system when it is heated. The vent pipe from the primary system must terminate over the feed and expansion cistern. An alternative method would be to use a sealed heating system, which is fed with water from the cold water main via a filling loop. Expansion of water is accommodated in an expansion vessel.

Hot water storage cylinders must conform to BS 1566, which specifies the minimum heating surface area of the heat exchanger.

A typical open vented indirect (double feed type) hot water storage system utilising fully pumped primary circulation is shown below.



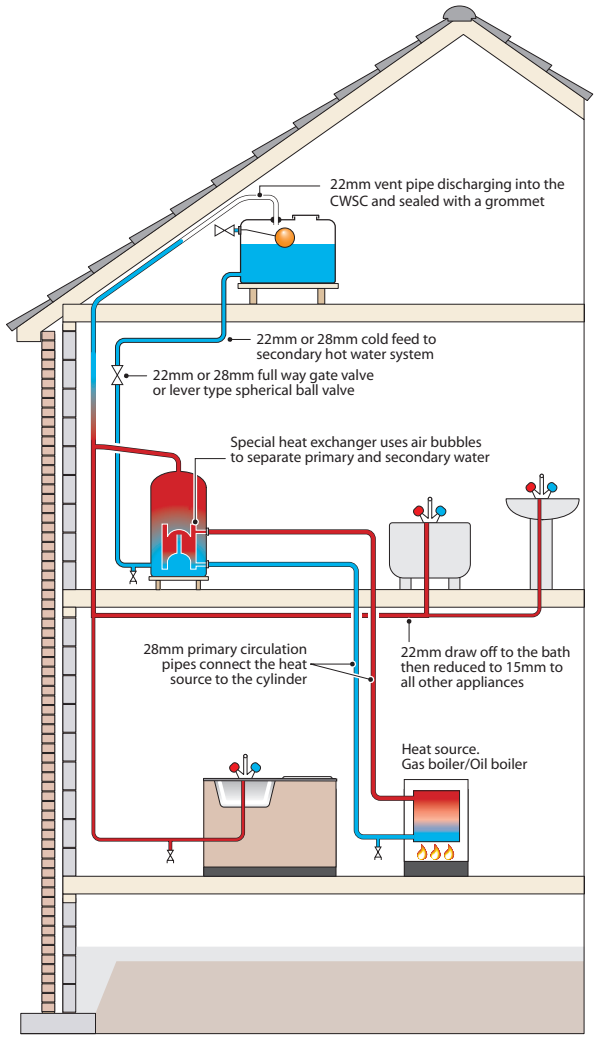
Indirect open vented (double feed type) hot water storage system

Open vented indirect (single feed, self-venting type) hot water storage systems

This system uses a single feed, self-venting indirect cylinder, often referred to by its trade name – the 'primatic' cylinder. It contains a special heat exchanger, which uses air entrapment to separate the primary water from the secondary water.

It is fitted in the same way as a direct system, with only one cold feed cistern in the roof space but, unlike the direct system, it allows a boiler and central heating to be installed. It does not require a separate feed and expansion cistern. The heat exchanger works in such a way that the primary and secondary water are separated by a bubble of air that collects in the heat exchanger, preventing the waters from mixing. According to the Domestic Building Services Compliance Guide, these cylinders are no longer allowed for new or replacement cylinders. A 'double feed' type cylinder must be used on all replacement installations.

A typical open vented indirect (single feed, self-venting type) hot water storage system utilising gravity circulation is shown below.



Indirect open vented single feed self-venting hot water storage system

KEY POINT

On no account must central heating inhibitors be used in the primary water if a single feed cylinder is installed as this would cause contamination of the water if the air bubbles were to rupture.

Unvented hot water storage systems

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Handout 2

An unvented hot water storage system is simply a sealed system of pipework and components that is supplied with water above atmospheric pressure. The system does not require the use of a feed cistern. Instead, it is fed with water directly from a water undertaker's mains supply or with water supplied by a booster pump and a cold water accumulator if the mains pressure is low.

An unvented hot water system differs from open vented types because there is no vent pipe. Expansion of water due to the water being heated is accommodated either in an external expansion vessel or an expansion bubble within the storage cylinder. The system also requires other mechanical safety devices for the safe control of the expansion of water and to ensure that the water within the storage cylinder does not exceed 100°C. There are two categories of centralised unvented hot water storage systems:

- directly fired/heated storage systems
- indirectly fired/heated storage systems.

These will be discussed later in the unit.

Comparisons between open vented and unvented hot water storage systems

There are important differences between these two types of systems. Table 1 compares the two storage systems.

Table 1: Comparisons between vented and unvented storage hot water systems

Advantages	Disadvantages
Open vented systems	
Storage is available to meet the demands at peak times	Space needed for both the hot water storage vessel and the cold water storage
Low noise levels	Risk of freezing
Always open to the atmosphere	Increased risk of contamination
Water temperature can never exceed 100°C	Low pressure and often poor flow rate
Reserve of water available if the mains supply is interrupted	Outlet fittings can be limited because of the low pressure
Low maintenance	
Low Installation costs	
Unvented systems	
Higher pressure and flow rates at all outlets, giving a larger choice of outlet fittings	No back up of water should the water supply be isolated
Balanced pressures at both hot and cold taps	If the cold water supply suffers from low pressure or flow rate, the system will not operate satisfactorily
Low risk of contamination	
The hot water storage vessel can be sited almost anywhere in the property, making it a suitable choice for houses and flats alike	There is the need for discharge pipes that will be able to accept very hot water and there will be restrictions on their length
The risk from frost damage is reduced	A high level of maintenance is required
Less space required because cold water storage is not needed	Higher risk of noise in the system pipework
Installation is quicker as less pipework is required	Initial cost of the unvented hot water storage vessel is high
Smaller diameter pipework may be used in some circumstances	

Gas fired instantaneous multi-point hot water heaters

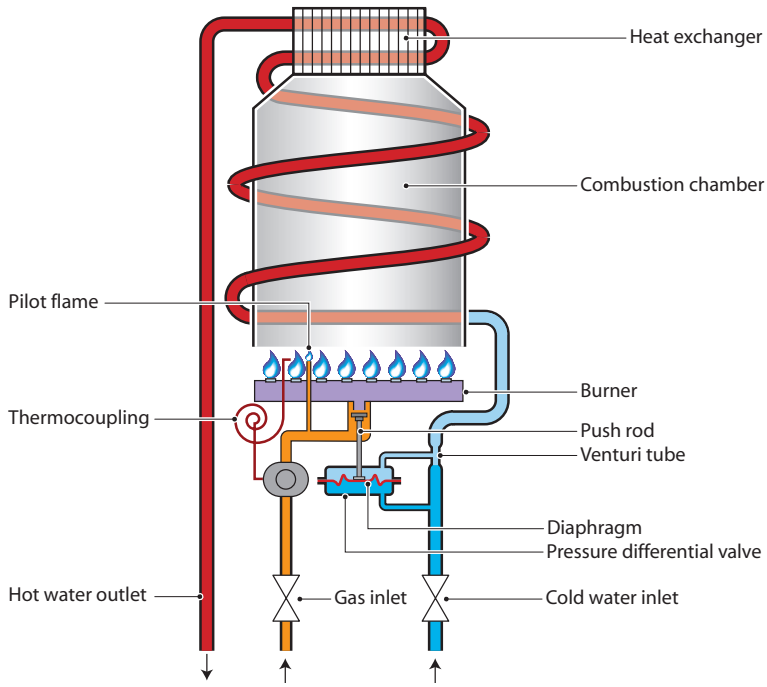
With this type of hot water heater, cold water is taken from the water undertaker's main and heated in a heat exchanger as demand requires before being distributed to the outlets. As long as the tap is running, hot water will be delivered to the taps. There is no limit to the amount of hot water that can be delivered. There is no storage capacity.

KEY POINT

Bernoulli's principle states that when a pipe is suddenly reduced in size, the velocity of the water increases but the pressure decreases. The principle can also work in reverse. If a pipe suddenly increases in size, then the velocity will decrease but the pressure will increase slightly.

Expansion of water as a result of being heated is accommodated by back pressure within the cold water main. However, if this is not adequate or the cold water system contains pressure-reducing valves or check valves, then an expansion vessel must be fitted.

The heater works on Bernoulli's principle by using a venturi tube to create a pressure differential across the gas valve when the cold water is flowing into the heater.



Gas instantaneous hot water heater

Gas or oil fired combination boilers

Combi boilers are dual function appliances. They provide instantaneous hot water and central heating within the same appliance. In normal working mode, combination boilers are central heating appliances, supplying a proportion of their available heat capacity to heat the central heating water. When a hot tap is opened, a diverter valve diverts the boiler water around a second heat exchanger, which heats cold water from the water undertaker's cold water mains to supply instantaneous hot water at the hot taps. In this mode, the entire heat output is used to heat the water. Temperature control is electronic and this automatically adjusts the burner to suit the output required. Typical flow rates are around 9 litres per minute (35°C temperature rise). Some combination boilers

Assessment checklist

What you now know (Learning Outcome)	What you can do (Assessment criteria)	Where this is found (Page numbers)
1. Know the types of hot water system and their layout requirements	1.1 Compare the types of hot water supply systems used in dwellings:	192–194
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	• unvented hot water systems	197
	• open vented hot water systems	195–197
	■ localised systems:	204
	• unvented point of use heaters	204
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	1.2 Identify hot water system pipework layout features for dwellings:	219–222
	■ centralised unvented hot water systems	219–222
	■ larger systems requiring a secondary circulation system.	219–222
	1.3 Confirm the recommended design temperatures within hot water systems:	228–233
	■ hot water storage vessel	228–233
	■ hot water outflow	228–233
	■ secondary return	228–233
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	• gas or oil fired	224–225
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What you now know (Learning Outcome)	What you can do (Assessment criteria)	Where this is found (Page numbers)
1. *(continued)*	1.6 Define the function of components in unvented hot water systems:	236
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	• control thermostat	237
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	■ methods of balancing circuits.	252–255
	1.9 State how trace heating can be used as an alternative to a secondary circulation system.	255–261
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	■ infrared operated taps	97
	■ concussive taps	98–99
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What you now know (Learning Outcome)	What you can do (Assessment criteria)	Where this is found (Page numbers)
2. *(continued)*	2.2 Evaluate the use of components in hot water systems to overcome temperature and pressure effects caused by the installation of backflow prevention devices.	97–111
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	3.2 State the criteria used when selecting hot water system and component types:	113–116
	■ customers needs	113–116
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	■ suitability of system	113–116
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	■ verbal and written feedback from the customer.	113–116
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What you now know (Learning Outcome)	What you can do (Assessment criteria)	Where this is found (Page numbers)
7. *(continued)*	7.6 Specify methods of safely isolating hot water systems or components to prevent them being brought into operation before the work has been fully completed.	285
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	8.2 Isolate hot water systems or components to prevent them being brought into operation before the work has been fully completed.	285
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	9.4 Identify how to conduct a soundness test on hot water systems:	292
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