Hot Water Systems

Domestic hot water
&
Space Heating

Arrow Valves

Agenda

Fluid Categories – risk classification - *New UK standards*
A Brief History – *Pioneers*
Domestic Hot Water –
System Types – *Vented, Un-Vented*
LTHW-MTHW-HTHW –
Expansion –
Pressure & Temperature –
Backflow – *How the heating system will contribute*
Corrosion & Sludge -
Chemical Dosing –
Safety
Controls

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Water Regulations Guidance

The **legal** UK Water Regulations include -

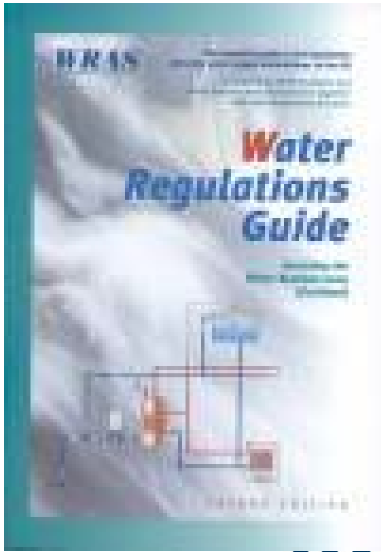
The Water Supply (Water Fittings) Regulations – Statutory Instruments 1148

Schedule 1 – Fluid Categories

Schedule 2 – Requirements for Water Fittings

Guidance is produced by DETR (DEFRA) and WRAS "Water Regulations Advisory Scheme"

The "Water Regulations Guide" contains all the Regulations and Guidance *(Replaces Water Supply Byelaws Guide)*



Schedule 1 – Fluid Category Risk Comparison

Previous UK Classification	European/New UK Classification	Backflow Prevention Examples (Used in Building Services)
Class 1 Schedule A Risk	European Fluid Category 5	Air Gap – AA AB Pipe Interrupter - DC
Class 2 Schedule B Risk	European Fluid Category 4	RPZ – BA Non-House Heating Systems
	European Fluid Category 3	Double Check – ED Heating Systems in a House
Class 3 Schedule C Risk	European Fluid Category 2	Single Check – EB Hot Water
Wholesome Water →	European Fluid Category 1	No Protection Required (Except whole site, at times)

A Brief History of Hot Water Systems

Hot water has long since been associated with cooking, washing, heating, cleaning and so on. Man has sort many ways of heating water, from natural geysers to the simple pot on top of an open fire

The Roman Empire was synonymous with warm baths and warm water and this could be considered as the first step towards water heating

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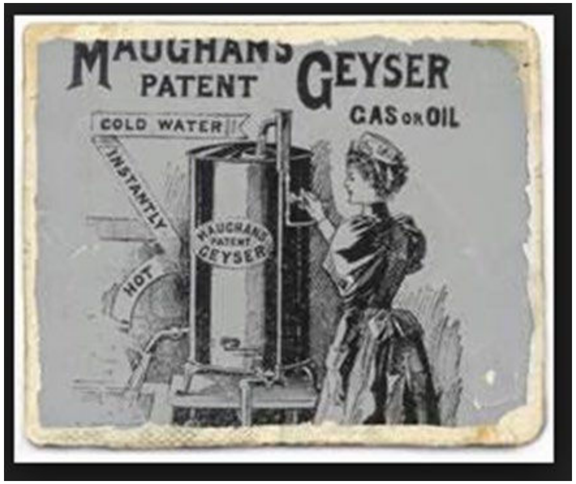
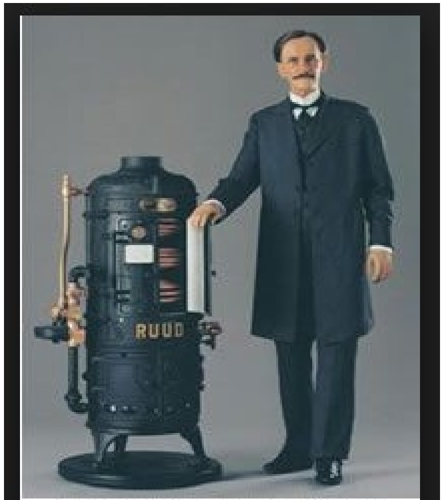
Maughan and Ruud

Benjamin Waddy Maughan, invented the first water heater that didn’t use solid fuel in 1868, it consisted of a series or wires heated via hot gasses from a separate burner that produced hot water, it had no vent and was considered extremely dangerous!





Edwin Ruud, inventor of the automatic storage water heater in 1898, founded the company that is now known as Rheem

Following on from this Edwin Rudd used the idea to invent the Rudd hot water heater and founded his company, a company that still exits today (Rheem) Many different designs of heaters were developed around the turn of the century, including electric and solar and have essentially evolved in to the units we know today.

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Sources of Heat

Moving forward a few years and the process hasn't changed much, we still use a source of energy to provide the heat source (Solid Fuel, Gas, Electricity, Solar, Renewable, Ground source heat pumps, and naturally occurring geysers) but we are far more concerned with efficiency and safety in the production of hot water than before.

- Electricity
- Gas
- Solid Fuel
- Solar
- Ground Source Heat Pumps
- Renewable
- Naturally Occurring Geysers
- CHP (Combined Heat and Power)

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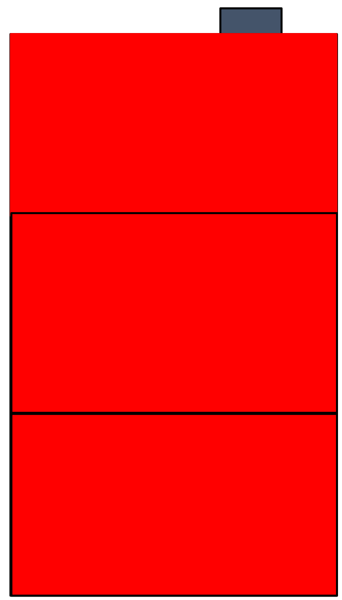
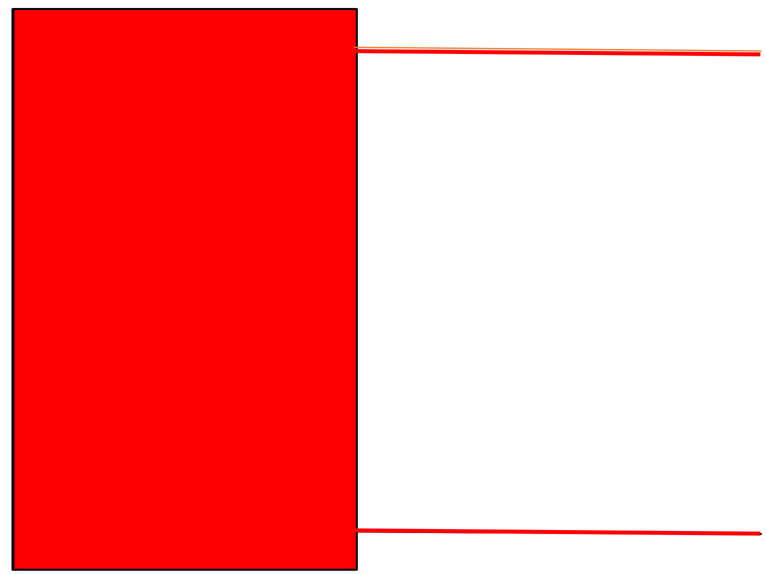
DHW and Storage (Cylinders)

The Maughan and Rudd systems produced domestic hot water, the conventional way to heat and store hot water is via a hot water cylinder, an external or internal heat source heats up a body of water that is drawn off for use.

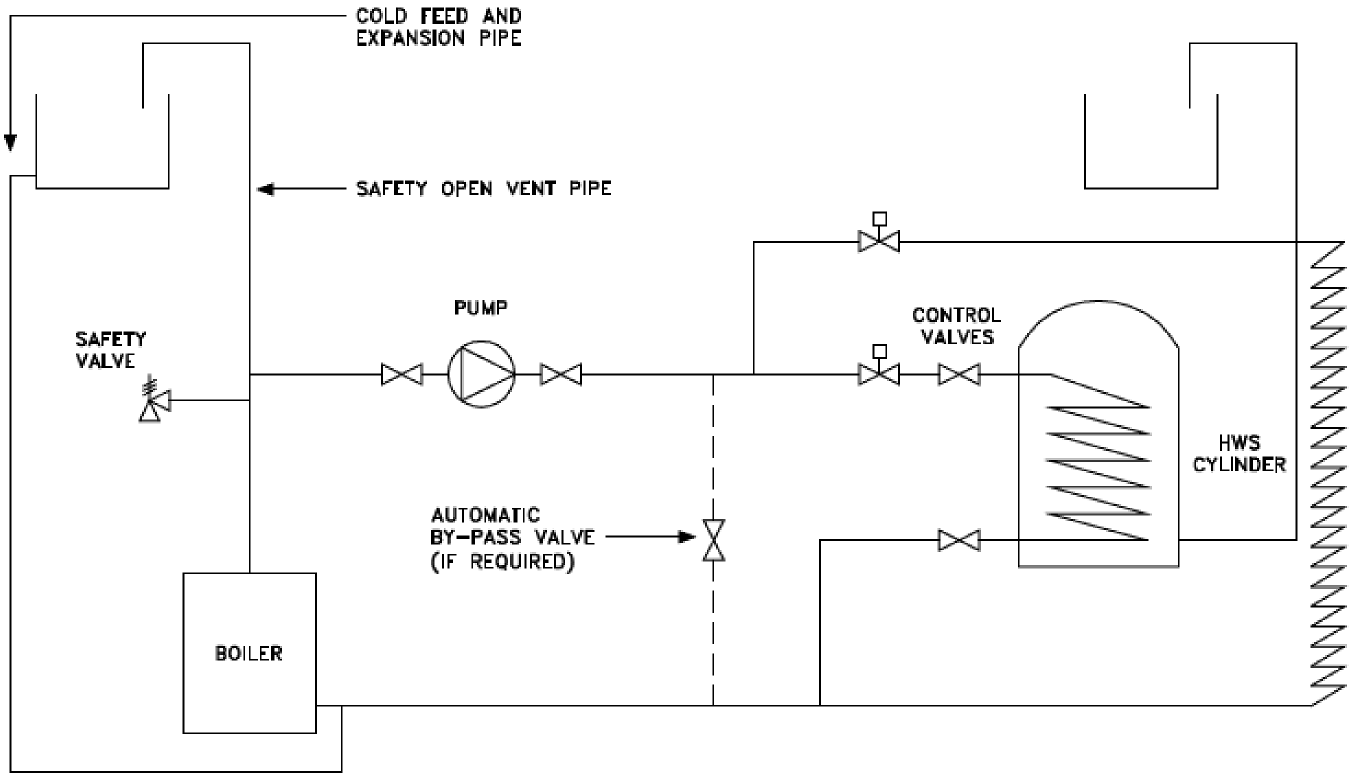
A Cylinder that uses an internal heat source is a Direct Cylinder, A Cylinder that used an external heat source is an indirect Cylinder, or Calorifier.





Open Vented Systems

An open vented system is a heating system that is open to the atmosphere and would have a cold-water cistern mounted above the cylinder, as water is drawn off, water refills the tank under gravity, this then defines the water pressure for the whole system, the height from the tank to the outlet of the taps = “Head” = pressure. This would work for both direct and indirect water cylinders.

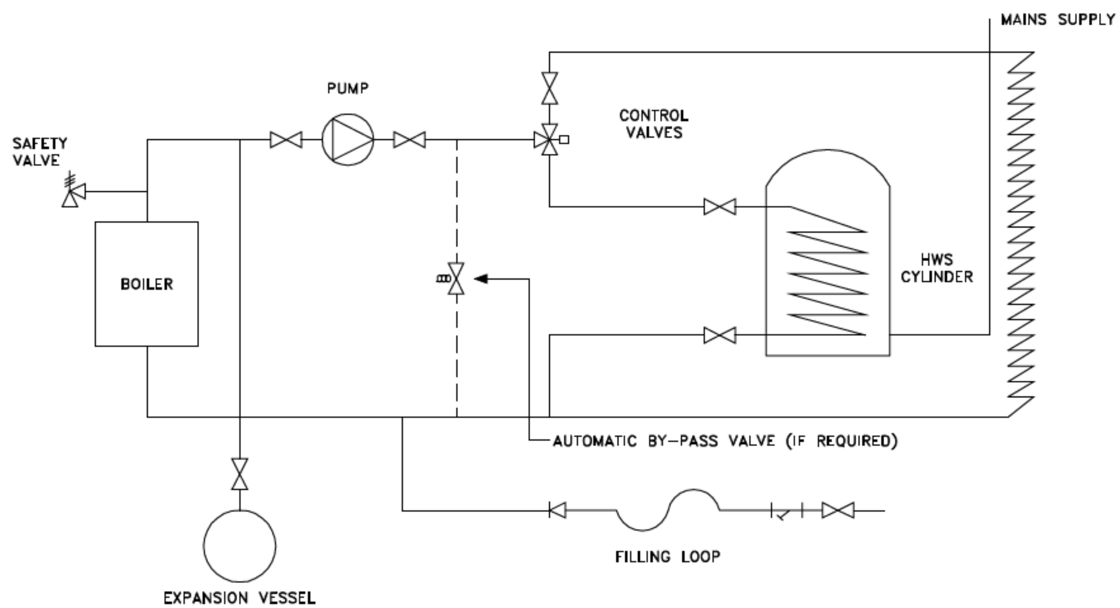


Open Vented Downsides

An open vented system is typically used in older heating systems and cannot get to high pressures. It can allow pollutants to enter the system water. Feed and expansion tanks will require periodic cleaning and enable oxygen to enter the system that can contribute to corrosion. The pipe work run from the tank location to the plant room can sometimes be arduous and will need insulating to protect against freezing.

Sealed Systems

A sealed system does not have the header tanks in the circuit, the cylinder would be fed direct from the mains and heated accordingly, the primary circuit again would be fed from the mains water supply, if water was lost via evaporation or small leaks then the primary circuit would need to be topped up, again from the mains water supply. To cope with expansion of the water as the temperature increases, we must install an expansion vessel to deal with this. The vented circuit has backflow built in by merit of the air gap in the expansion tank, the sealed system needs additional devices to prevent backflow from the primary circuit into the mains water supply.



Benefits of Sealed Systems

Sealed systems take up less space, assist with system cleanliness, improve water quality and reduce oxygen ingress.

Sealed systems have the benefit of all equipment - pressurisation units and expansion vessels - being located in the boiler room, making service and maintenance access simpler.

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Space Heating

Space heating is simply the process of transferring heat from a heat source into living quarters (Space). With a water based system this can be accomplished in various ways.

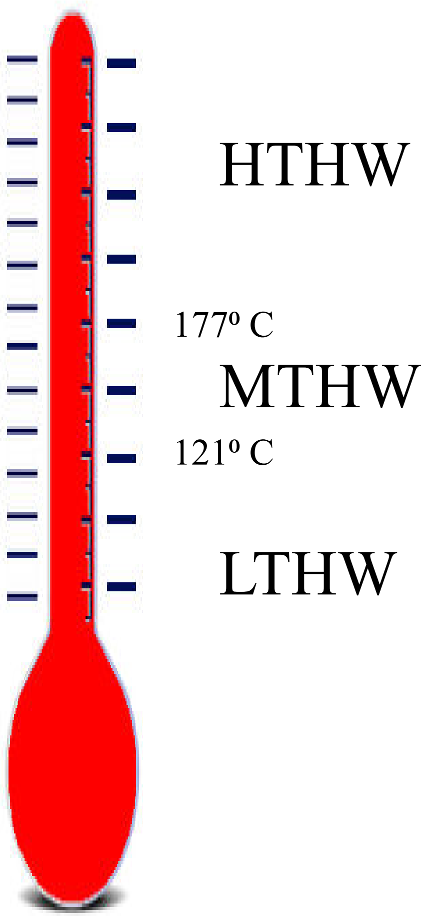
Radiators

Fan Coil Units

Underfloor Heating

Thermal Skirting

LTHW MTHW HTHW



- LTHW systems are typically associated with space heating in homes, residential buildings and local distribution of district heating systems.
- MTHW systems are used in large hot water systems, like district heating and in systems processes where the process requires higher temperatures than an LTHW system.
- HTHW used in large distribution systems and process applications.

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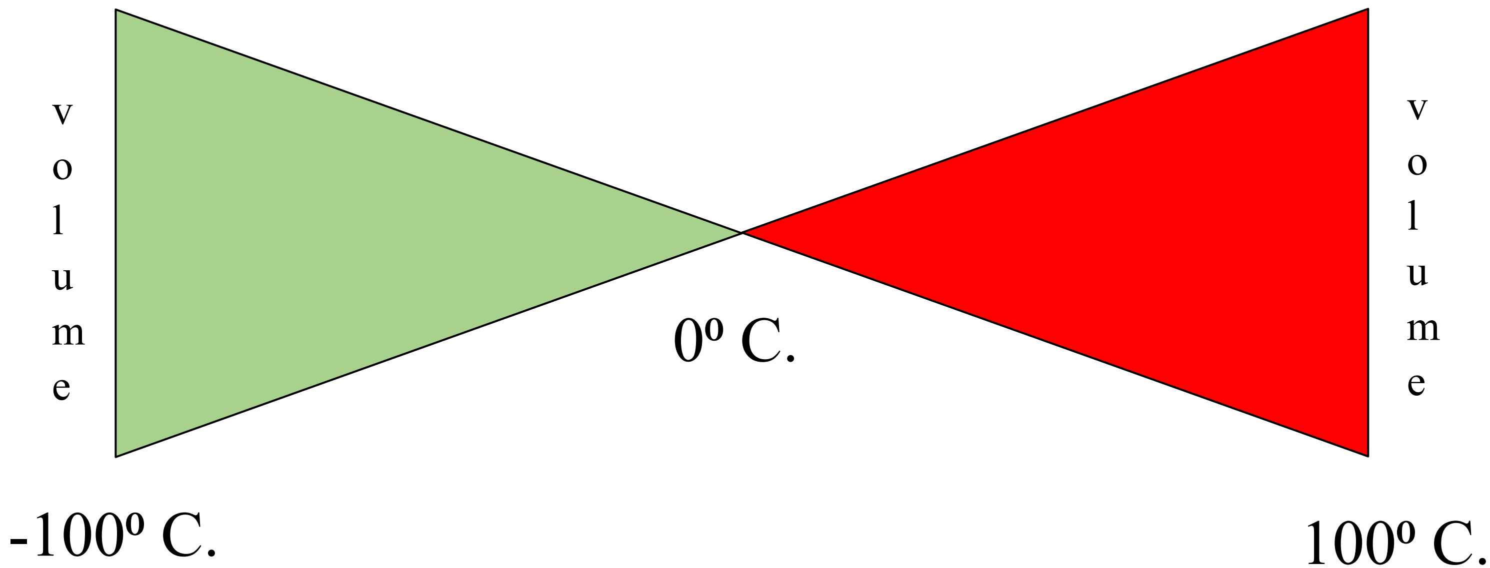
Water Properties



Water has unique properties over other fluids in that it both expands when it is frozen and when it boils. Water boils at 100ºC at 1 bar (Sea level) On Mount Everest it would boil at 71ºC, in a vacuum it would in theory evaporate immediately. The purpose of this example is to show how the effect of pressure can change the thermal heat capacity of water and thus allow us to continue to use water at temperatures above 100ºC. simply by containing the pressure that the heated water is generating. For example, water at 25 bar will boil at 225ºC. What we must consider however is that 1 liter of water is equivalent to 1600 liters of steam.

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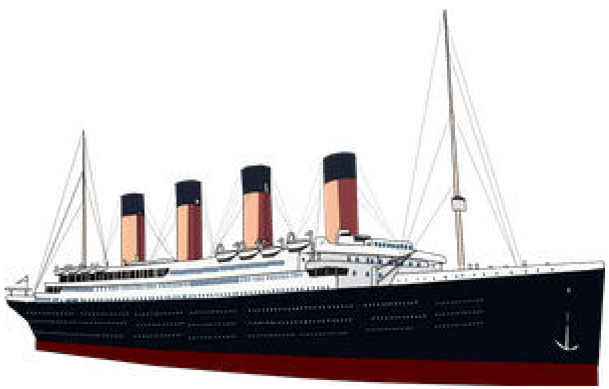
Water Expansion

We need to understand that water will expand with the application of heat even before it reaches the point of evaporation, and we must take this into account in our system.

In a sealed system, the expansion of water must be compensated for, this is normally achieved with an expansion vessel. Expansion vessels are pre-charged with air that pushes down on a diaphragm, in turn water enters the vessel on the other side of the diaphragm and compresses the air as the water expands.



Expansion Vessel Sizing

Number of boilers (same output kW)		3	*e.g. 1, 2 or 3 assuming same output*
Boiler (output per boiler)	kW	100	*1 kW = 3412 Btu/h, 1000 Btu/h = 0.293 kW*
Assumed system content factor	litres/kW	12	*Usually 10 - 14. Assume 12 if not advised otherwise*
Or enter known system volume	litres		*Leave blank if unknown - "assumed" will be used*
Max. static head above vessel	m	20	
Flow temperature	°C	80	*Normally 82 or BS7074 use system highest temperatur*
Return temperature	°C	60	*Normally 71 or BS7074 use system highest temperatur*
High cut-out switch set at	bar	4.0	*Typically 2.9 bar for static heads up to 20 m*
			must be at least 0.2 bar below safety relief valve.
Total boiler output (one system)	kW	300	*Calculated as No.boiler x kW each*
Volume assumed	litres	3600	*Total kW x assumed system content factor*
Volume used for calculation	litres	3600	
Mean temperature	°C	70.0	*Mean average of flow and return. Normally 77*
Expansion coefficient		0.0187	*Automatically calculated according to mean temp.*
Final working pressure (see later)	bar	3.70	*0.3 bar margin below safety valve*
Low cut out switch	bar	0.5	*0.5 bar falling min.*
Cold fill pressure (switch on)	bar	**2.2**	*0.8 bar min. 0.2 bar more than static to assist venting*
Cold fill pressure (switch off)	bar	2.5	*Switch differential typically 0.3 bar*
Vessel pre-charge air pressure	bar	**2.2**	*Normally same as cold fill switch-on*
Acceptance factor		0.2553	*Automatically calculated*
Result - Vessel capacity	litres	276	*With 5% margin - i.e 5% bigger to allow for errors*
Result - Vessel capacity rounded up	litres	300	*This is the next largest available size*
Vessel product code		**EVUP40MP300V**	*Model EVUP is 10 bar rated - also horizontal available*
Vessel Valve product code		**BV40FP300DT**	*This includes drain tap and wired locked valve*
Chosen Vessel capacity	litres		*Leave blank if using rounded up value above*
Capacity used for this calculation	litres	300	
Recalculated Vessel factor		0.2241	*Based on vessel capacity used as above*
Final working pressure	bar	**3.51**	*Assuming rounded up figure used as above*
Vessel max working pressure	bar	10.0	*Typ. 4 bar. At least 0.2 bar above high cut-out switch*
			and more than safety relief valve

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Hot Water / Heating Fluid Classifications

Our domestic hot water is Fluid category 2, its aesthetic quality has been changed (It's hot)
Table G6.1c: (The determination of Fluid Category 3) Cites an example of fluid category 3 as "Water in primary circuits and heating systems (with or without additives) in a house.
Table G6.1d: (The determination of fluid category 4)
"Primary circuits and central heating systems in other than a house"
As a definition is quite clear on the differences between the 2 classifications, therefore a double check valve would suffice as protection in a house, and an RPZ valve or suitable air gap would suffice in a non-house situation.

EB

ED

RPZ

AB

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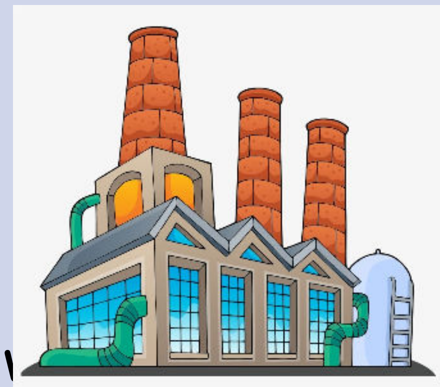
Filling Restrictions

The Water Regulations state a house is fluid category 3 and a non-house is fluid category 4 so how does this affect how we fill and top up the system…? **Schedule 2 Paragraph 15: G15 and G24.2**

A Filling loop with double check valve can be used to fill a system in a house provided it is removed after use, it can then be used as a temporary connection for top up. **(R24.2a G24.2)**

For all other Non-House systems we have to use a minimum fluid category 4 backflow prevention device in order to fill the system **CANNOT** use a traditional Filling loop. **(R24.2c G24.2)**

Backflow

Fluid Category 2	Fluid Category 3	Fluid Category 4
 (will affect the taste)	 Heating System	 Heating System

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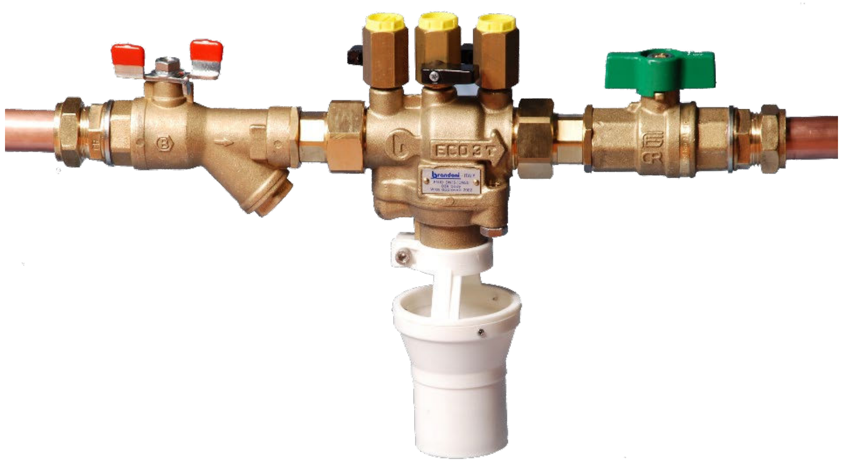
House Systems CA Device

We’ve discovered that in a system in a house you can use a filling loop as a temporary connection. The problem with this is that if the system does lose pressure there is every chance that the boiler will cut-out and the building is left without heating or DHW. A CA device allows a permanent connection that will top up the system as and when a pressure drop is detected.

R24.2b: WRAS.(2001).*Water Regulations Guide.* Cardiff: WRAS, 8.25.

Non-House Systems RPZ/AutoFill

Non-House systems are designated at fluid category 4, we have established that we need an RPZ valve or suitable air gap to provide the disconnection between the system and the mains water connection.



R24.2c: WRAS.(2001).*Water Regulations Guide.* Cardiff: WRAS, 8.25.

Midi Fill Digital

MFD, Is a fluid category 5 device that has a continuously rated pump for filling and pressurising heating systems. A pumped system benefits where there is low mains water pressure

The unit executes a weekly self test with BMS alerts prior to heating system shutdown – ideal for facilities dependent on reliable heating such as schools.

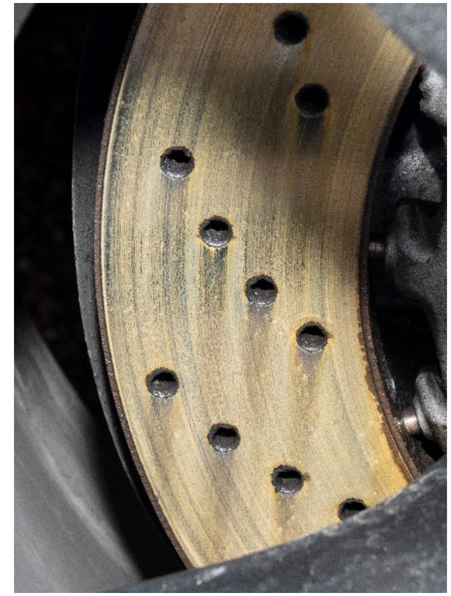
Features anti-seize pump and automatic daily pump pulse.

Integral water meter with excess filling alarms.

The lockable digital display enables adjustment of cold fill, high cut-out pressure and excess water consumption values

Corrosion and Sludge Build UP

In an earlier slide we saw that vented systems contributed to oxygen ingress and allowed pollutants to enter the system, closed systems are less susceptible to this, but the process of heating water and the fact the there is oxygen present initially, still contributes to scale build up sludge deposits.



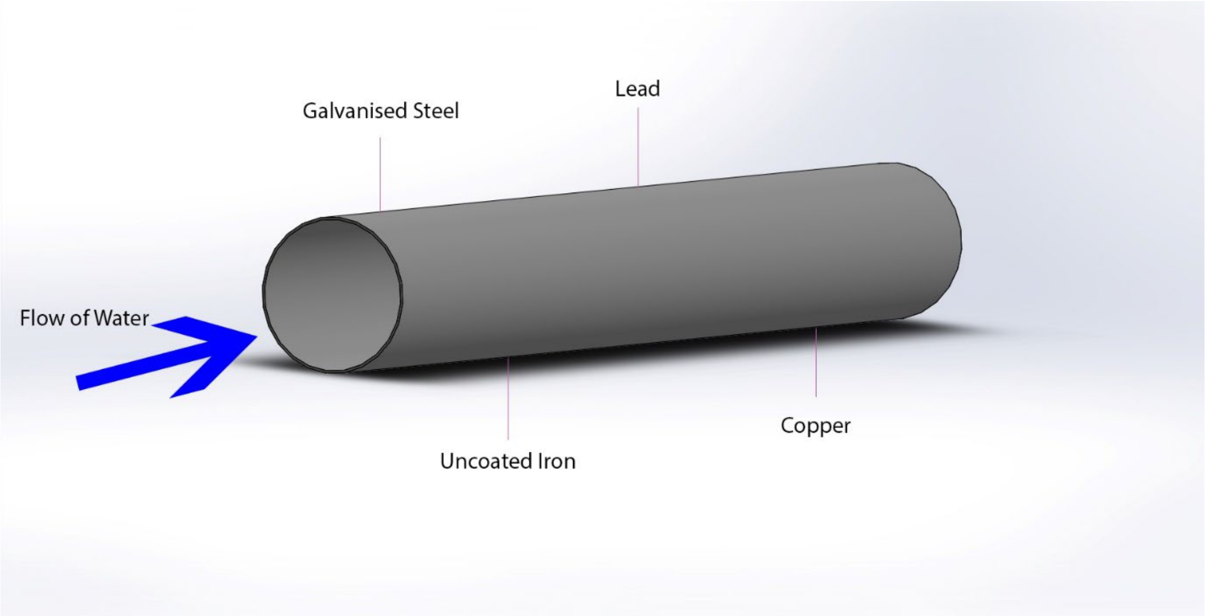
Flash Corrosion:
A brand new system is a series of empty tubes full of air, off which Oxygen is around 21%, when the system is initially filled our raw water will mix with the Oxygen and can cause flash corrosion - look at your brake discs in the morning!

Limescale:
Hard water areas are a result of calcium in the water, when water is heated the calcium will turn to Limescale and will begin coating the inside of pipes and fittings, a heating element or heat exchanger with 1.5mm of Limescale coating is 400 times less efficient!

Magnetite:
Magnetite forms when steel (Iron pipes, radiators) reacts in un-oxygenated water, and will coat internal pipework, and at the same time form a black ferritic sludge that blocks the system.

Galvanic Corrosion

Galvanic Corrosion:
This is where dissimilar metals react and corrode via electrolysis, this can happen with copper, steel, lead weld sites, scratches in metals etc. It’d important that we follow the correct procedure when connecting dissimilar metals or add insulating breaks



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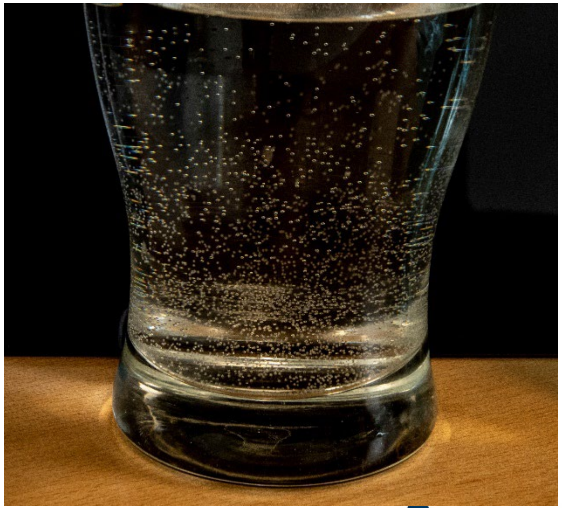
Dirt and Air

Dirt:
Foreign bodies introduced with the water supply or during the installation phase.

Air:
Despite our system being sealed and clever mechanisms to remove air, air can enter the system via pump glands, threaded joints, micro pores and re-start the chain reactions listed above.



Air and Dirt Removal

ADR546

ADR551

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Chemical Dosing

Safety Mechanisms

We mentioned earlier that water can expand 1600 times its original volume when it turns into steam, if pipework or cylinders were to fracture under this amount of pressure, the resulting damage is catastrophic and has the potential to level a home!

We need to prevent this from happening, from limiting the maximum heat input to the system to mechanisms that will release any excess pressure safely.

Domestic boilers, have essentially become combined units with the majority of the controls, pumps and valves built in. We may need to run a few external measuring devices for the hot water cylinder thermostat and wall thermostat, but otherwise the unit is self contained. Along with the controls the safety mechanisms are also built in with regards to electronic control, but we still need mechanical devices as back up.

Larger systems will require a control panel to link all of the individual items together, the complexity of the control panel can vary considerably, with Internal/external monitoring linking to BMS controls.

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Safety Mechanisms

Temperature:

Boilers will have limit switches that shutdown the fuel to the boiler if the temperature gets to high. With Biomass Heating, it's more complex, as it's not so easy to stop the fuel burning, additional controls will need to be fitted, thermal stores, buffer vessels are one way to cope with the rise in temperature, the same would be needed for a CHP system.

Pressure:

Again most modern domestic boilers will have an inbuilt pressure sensor that protects the system should the pressure exceed the set parameters of the boiler, the system will shut down until the system is either refilled, or cools down and then normalises.

Midi Break Wall mounted

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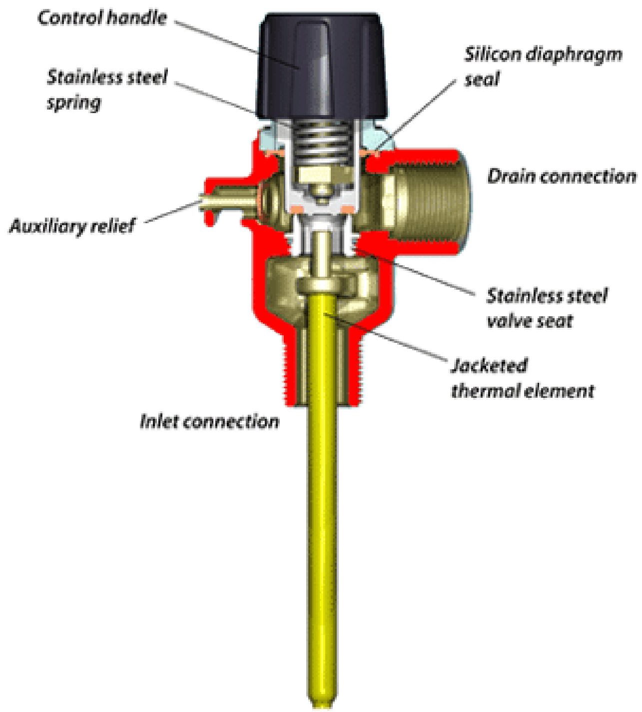
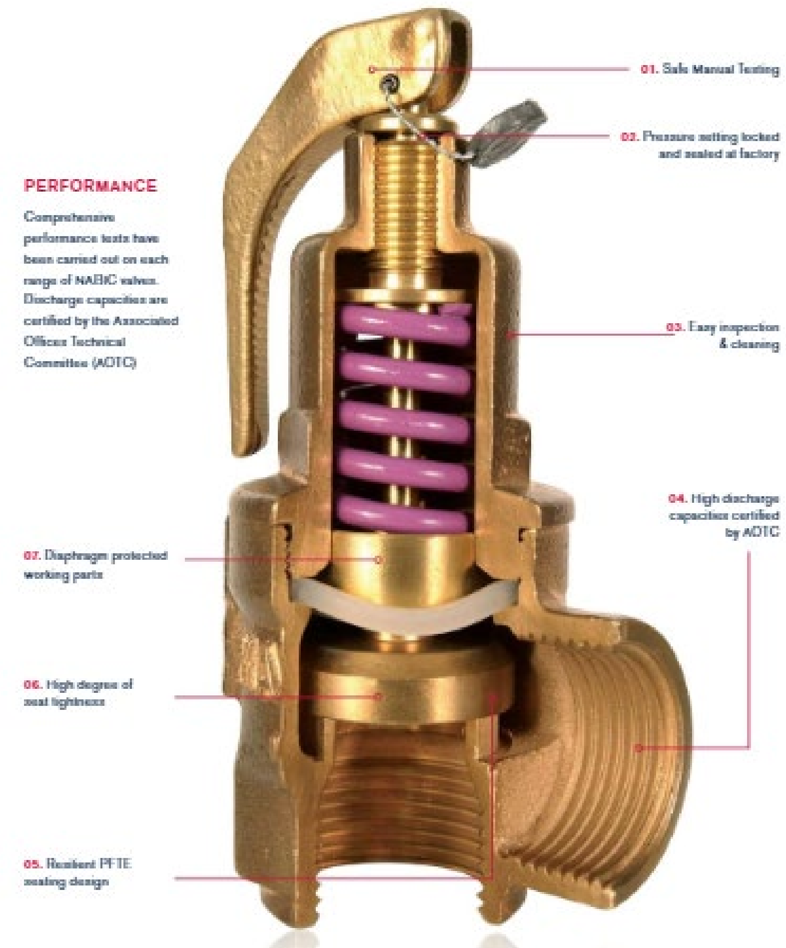
Temperature/Pressure Relief Direct Cylinders



In the event of electrical control devices failing, excess water pressure needs to be vented from the cylinder to reduce the risk of explosion from occurring.

Safety Valves



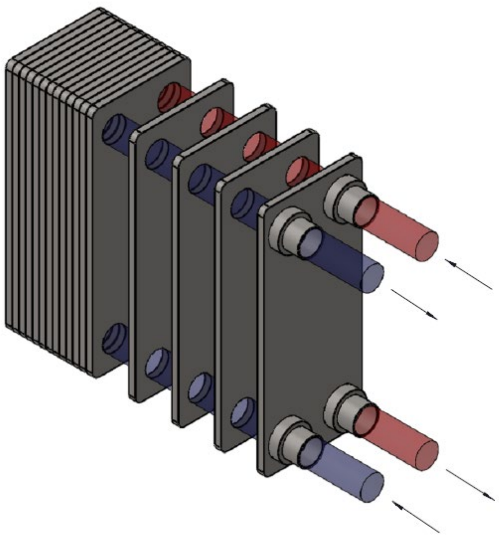
Safety Valves are designed specifically to deal with pressure in larger systems. Boilers and pressure systems designed to BS6759. require a safety valve to the same specification.

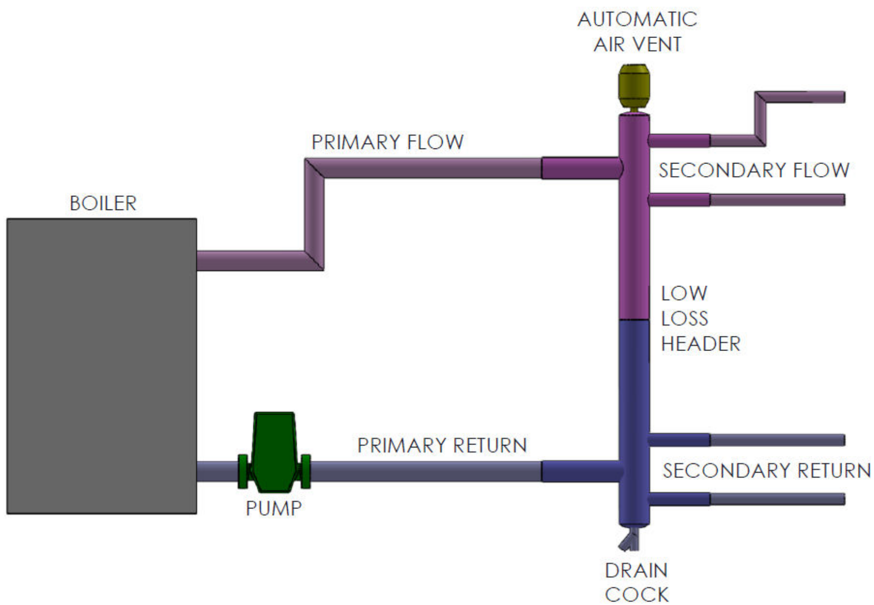
Safety valves require an adequate margin, between the set pressure of the safety relief valve and the normal working pressure of the system, the set pressure should normally be at least 10% above the system working pressure, with a minimum margin of 0.7 bar for water, and 0.35 bar for steam.

It's important that these valves are tested on a regular basis and it's recommended that they should be tested every 3 months.

Heat Transfer

Methods for transferring the heat from the boilers can vary; from large thermal stores, Plate heat exchangers, and Low loss headers. Low loss headers are used so that there is a hydraulic separation between boilers and heating circuits, regulating the flow rate and pressure, thus improving efficiency and performance. Low loss headers work very well with multiple boiler installations.



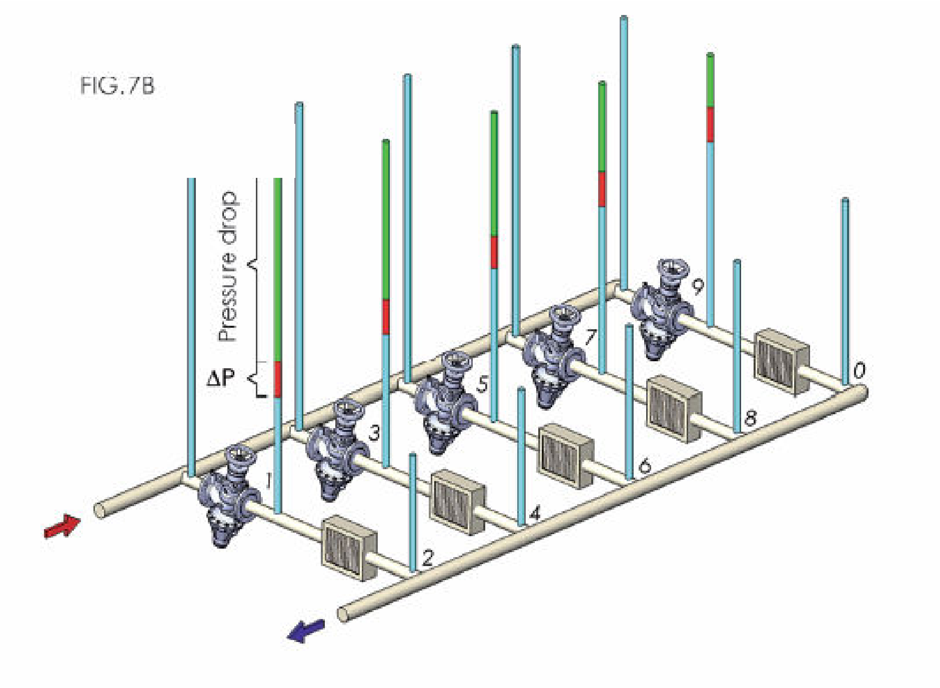


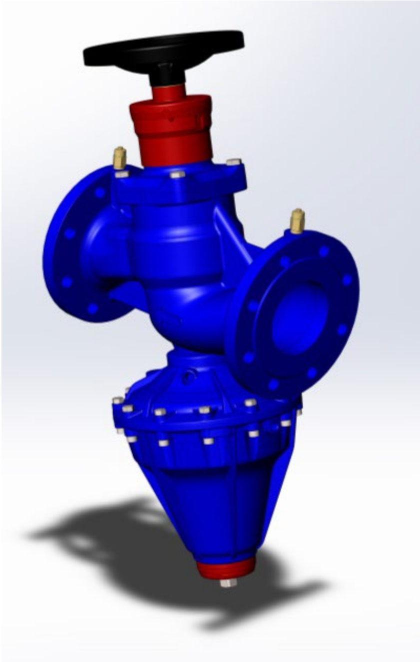
System Balancing

With efficiency being the drive behind modern systems, and our quest to reduce CO_2 emissions modern systems incorporate various devices to contribute to these savings.

Balancing valves: these are devices controlling differential pressure in heating systems, balancing flow in the main network or single risers and branches of the system, consequently temperature and pressure become balanced: Reduced noise, longer life for thermostatic control valves, energy saving, and greater environmental comfort.

FIG.7B





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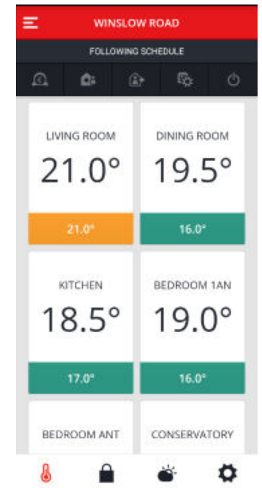
System Components and Controls

Circulation pumps are inverter controlled and reduce energy as less heat is required



Zone control, individual radiator thermostats all contribute to energy saving. (with a nice little phone app to boot!)

Underfloor heating runs at a cooler temperature than radiators, Distribution groups in the plant room act in a similar way to the low loss header and give variable temperatures for different types of personal space heating, therefore you can have a flow and return of 80º - 60º for radiators from one unit and 60º - 35º for underfloor heating from another.

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Water Regulations

As we can see our systems are designed to give comfort, efficiency and reliability. But it’s imperative that safety plays a key part, not just for the building but for the water network.

Pressurisation units incorporating the correct backflow prevention device will insure compliance with the water regulations and keep drinking water safe.

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Summary

The salient points of this presentation are –

- The Water Regulations Guide is the single most useful source of information.
- The local water company has the authority to enforce, inspect and risk assess.
- The Regulations apply to the whole building (if supplied by the water company)
- DHW, Conventionally stored in cylinders or instantaneous.
- System types, Vented or unvented
- Expansion - Control
- Hot water classification, DHW FC2, House FC3, Non House FC4
- Problems that lead to premature failure, Corrosion, Sludge, Air, Dirt.
- Chemical Dosing
- Safety Devices – Pressure, Temperature.
- Controls

The End

Thank You

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