Strength and Durability

Pull-out resistance

BS 7291: Part 2: 2001 provides a test procedure for assessing the pull-out strengths of pipes from fittings.

Hep$_2$O® pipes and fittings have been tested and offer resistances in excess of these requirements.

The levels required by BS 7291: 2001 are shown in Table 1.

Hydrostatic pressure resistance and life expectancy

The ability of a pipe to resist water pressure depends upon the tensile strength of the material, which varies with temperature.

Hep$_2$O® pipe has been tested to resist various pressures at various temperatures representing normal operating life cycles. Refer to Table 2.

Hep$_2$O® pipes and fittings conform to the long term hydrostatic strength tests as detailed in BS 7291: Part 1: 2001, Clause 6.3.

A life expectancy of not less than 50 years can be extrapolated from this data, and is based on the range of intermittent flow temperatures that these systems would normally experience, ranging between 12 bar 20°C and 6 bar 90°C.

Short exposure to temperatures up to 100°C resulting from thermostat/system malfunction will not cause failure, but may shorten the long term design life of the system.

Thermal cycling

Thermal cycling - the rise and fall in water temperature during normal operation - also induces different and additional stresses on pipes and joints.

Hep$_2$O® conforms to the requirements of a thermal cycling test schedule, to prove the strengths of a plumbing system, as detailed in BS 7291: Part 1: 2001. The schedule is set out in Table 3.

Effects of Fire

Flammability and burning

In common with most other organic polymers and materials used in the manufacturing and construction industries, polybutylene will burn. It is difficult to ignite, however, and is defined as combustible but not highly flammable.

Fire protection

Polybutylene pipe, less than 50mm in diameter, does not need to be sleeved in intumescent material when passing through a fire resistant wall.

Table 1 BS 7291: 2001 Pull-Out Force Requirements

Nominal outside pipe diameter	BS safe maximum pull-out force
10mm	380N *
15mm	705N *
22mm	1190N *
28mm	1960N *

*From BS 7291: Part 2: 2001, Table C1

Table 2 Operating Temperatures and Pressures

Safe pressures	Peak life cycle operating temperatures								Short malfunction at 100°C
	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	
Bar	12	11.5	11	10.5	9	8	7	6	3.5
psi	174	167	160	152	131	116	102	87	51
Head of water (m)	120	115	110	105	90	80	70	60	35

Table 3 Thermal Cycling

Hot water		Cold water		Min pressure			No. of cycles
Inlet temp	Duration	Inlet temp	Duration	Bar	psi	m/head	
83 ± 2°C	20 mins	15 ± 5°C	10 mins	3.5	88.2	60	5000
114 ± 2°C	20 mins	15 ± 5°C	10 mins	6	88.2	60	1000
105 ± 2°C	20 mins	15 ± 5°C	10 mins	3.5	88.2	60	5000

Flexibility

Modulus of elasticity

Modulus of elasticity is a measure of the ability of a material to cope with stresses.

The modulus of elasticity of polybutylene is 400-450N/mm^2. Compared to other materials, including other plastics, this value is very low. For example, for PVC it is 2410N/mm^2 and for copper 129800N/mm^2.

This means that polybutylene is not difficult to bend and expansion stresses are low. However, polybutylene is unusual in combining flexibility with toughness even at elevated temperatures and pressures, ensuring that **Hep$_2$O®** meets the demands of modern heating installations.

Manipulation of pipework

Hep$_2$O® pipe can be bent manually without heating for unsupported bends to a minimum radius of eight times the pipe's outside diameter. This removes the need to insert a 90° elbow fitting and results in a reduction in loss of head (i.e. a 15mm elbow equates to an extra 0.5m on the pipe run).

The durability of **Hep$_2$O®** pipe and its ability to stretch without damage, allows the minimum bend to be made cold, without causing 'kinking' on the inside, nor collapse on the outside of a bend. A reduction of the bore is thereby minimised. Refer to Figure 1 and Table 4.

Where support bends are needed for 15mm and 22mm outside diameter pipes, the use of a Cold Forming Bend Fixture (HX75) will give a radius of eight times the pipe diameter, again minimising the loss of head in a system. Refer to Figure 2 and Table 5.

Dependent on its diameter, pipe is available in coils of up to 100 metres (see Product Range section, page 12), which facilitates handling and transportation.

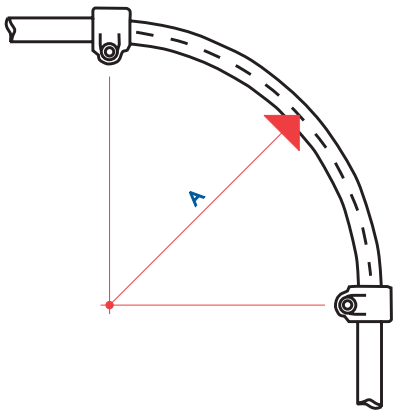

Figure 1
Minimum unsupported cold-bend radii

Table 4 Minimum Unsupported Cold-Bend Radii

Nominal dia (mm)	10	15	22	28
A (mm)	80	120	176	224

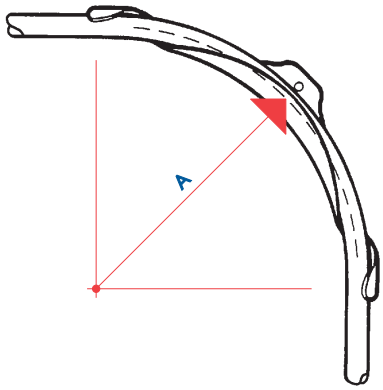

Figure 2
Cold form bend radii

Table 5 Cold Form Bend Radii

Nominal dia (mm)	15	22
A (mm)	120	176

Site handling is also made easier as this flexibility enables the pipe to be bent around corners and within confined spaces.

Hep$_2$O® pipes will not suffer fatigue stress damage through normal vibration.

Weight

Hep$_2$O® pipe is approximately $^1/_4$ the weight of copper pipe per metre as indicated in Table 6.

Table 6 Hep$_2$O® and Copper Pipe Weight Comparison

Nominal dia (mm)	10	15	22	28
	Weight (g/m)			
Hep$_2$O	41	75	126	210
Copper	183	281	534	683

Thermal expansion

Hep$_2$O® pipes expand when the temperature is raised.

The flexibility of the pipe means that the expansion is spread evenly along a pipe run eliminating damaging movement at a critical fixed point in the system.

When hot, the pipe's expansion creates undulations, though its former length is resumed after the temperature has dropped.

Exposed pipe runs should therefore be boxed in to avoid unsightly temporary distortion.

The coefficient of thermal expansion of polybutylene is 1.3 x 10^{-4}/m/°C. This means that the pipe expands by 1.3mm per metre of pipe for every 10°C temperature rise.

Example:

Calculate the amount of expansion of a 2.4 metre pipe installed at 20°C when running at 80°C.

0.00013 x 2400 x 60 = 18.72mm

Where the pipe is totally restrained in a concrete floor (e.g. as underfloor heating), the stresses are so low that they are absorbed by the material.

Thermal Characteristics

Thermal conductivity

The thermal conductivity (k) of polybutylene is 0.22W/mK which is low relative to copper. This property, coupled with the approximately 2mm thick pipe walls of **Hep$_2$O®**, means that:

- the pipe is safe to touch even when conveying water at 60°C.
- the pipe does not radiate heat quickly, and so will not cool quickly, thereby delivering hot water.

Melting point

The melting point of polybutylene is 125°C, and as a result, blow lamps must never be played on **Hep$_2$O®** pipes and fittings.

However, the Vicat softening point, at 116-117°C, is well above the boiling point of water and is also greater than the overheat control of gas and oil boilers (approximately 95°C).

Connections to boilers

Where boilers incorporate a copper heat exchanger and the connections are made outside the casing, **Hep$_2$O®** can be connected directly to the boiler via the compression nut, if this is located more than 350mm from the heat source. Typically, these boilers contain high limit cut-out thermostats and generally have a low water content. See page 51.

Special installation procedures only apply for solid fuel boilers, other cast iron heat exchange boilers, or where the first connection is made inside the boiler casing. In these instances, where the heat output may be uncontrolled, a 1 metre run of copper pipe should be used between the boiler and the start of the **Hep$_2$O®** system. See page 51.

All boiler connections should be made in accordance with the requirements of BS 5955: Part 8.

Solder joints

When soldering HX42/10 (a brass double spigot reducer in the Demountable range), ensure that the solder joint is completed first and has fully cooled before making the push-fit connection.

Freezing temperatures

Hep$_2$O® maintains its flexibility in temperatures down to -15°C. This property significantly reduces the likelihood of bursts, even at sub-zero temperatures, when the pipework has frozen and the water has expanded in volume by becoming ice.

Hep$_2$O® pipe accepts this expansion without fracturing, and resumes its original size after a thaw.

Thermal Insulation

Thermal diffusivity

Thermal diffusivity is the rate of heat diffusion throughout a material. The greater the value the greater the heat diffusion. The thermal diffusivity of a material depends on its thermal conductivity, density and specific heat.

Although **Hep$_2$O®** has a lower diffusivity than copper, its insulation requirements are the same as those of copper and should comply with BS 6700, BS 5422 and the Water Regulations.

Frost protection

The minimum thicknesses of insulation to delay freezing are given in Table 7.

Pipework that is potentially exposed to freezing conditions and therefore requires insulation would typically be found in the following areas:

- unheated roof spaces.
- unheated cellars.
- unheated outbuildings.
- near windows, airbricks, ventilators, etc.
- in chases or ducts formed in outside walls.

Central heating installations

Minimum thicknesses of insulation for central heating installations are given in Table 8. The figures are based on the temperature differential of 75°C hot face to 20°C ambient air.

Gas and oil fired domestic hot water installations

The recommended minimum thicknesses of insulation for domestic hot water pipework is given in Table 9. The figures are based on the temperature differential of 60°C hot face to 20°C ambient air.

Table 7 Frost Protection

	Indoor (k)			Outdoor (k)		
	0.035	0.04	0.055	0.035	0.04	0.055
Pipe diameter (mm)	Insulation (mm)			Insulation (mm)		
15	22	32	50	27	38	63
22	22	32	50	27	38	63
28	22	32	50	27	38	63

Table 8 Central Heating Installations Insulation Thicknesses

	0.04 (k)	0.55 (k)	0.07 (k)
Pipe diameter (mm)	Insulation (mm)		
15	19	25	25
22	25	25	25
28	25	25	25

Table 9 Gas & Oil Fired Domestic Hot Water Installations Insulation Thicknesses

	0.04 (k)	0.55 (k)	0.07 (k)
Pipe diameter (mm)	Insulation (mm)		
15	25	32	32
22	25	32	32
28	25	32	32

Corrosion and Chemical Effects

Corrosion and oxygen diffusion

Corrosion of metals is a hazard in installations, therefore it is essential that the water oxygen content is kept to an absolute minimum.

Oxygen will almost always be present in any system as it can enter through a variety of points, such as open header tanks, threaded joints, valves and pumps. However, **Hep$_2$O®** Barrier Pipe will ensure that oxygen ingress through the pipe wall is kept to a minimum.

All heating circuits, whatever the type of pipe used, should be protected by an inhibitor, and then any oxygen entering the system will have no adverse effects.

Hep$_2$O® pipe is unaffected by both acidic (soft) water or alkaline (hard) water, the most common reasons for copper pipe corrosion in all-metal pipework.

Contact with chemicals

Hep$_2$O® is not damaged by *short term* contact with other chemicals commonly found in a domestic environment. These chemicals include: paraffin, diesel oil, carbon tetrachloride, bleaches, detergents, turpentine, linseed oil, white spirit, water purification softeners, common adhesives, paints, varnishes, sealers, cement, quick lime.

High sustained concentrations of chlorine will have an adverse effect on all plastics pipe. However, such concentrations are not usually experienced within the UK water supply which are very low (less than 0.5 ppm). At these levels, under normal operating conditions there will be no adverse effect on the life expectancy of the **Hep$_2$O®** system. Short term chlorination for disinfection will not have an adverse effect on the system.

However, **Hep$_2$O®** should not be used in installations where sustained above average chlorine levels can be anticipated such as swimming pools.

If long term contact is suspected, the Hepworth Plumbing Products Technical Advisory Service should be consulted on 01709 856406.

Scale resistance

Hep$_2$O® pipe is unaffected by both acidic (soft) water or alkaline (hard) water, the most common reasons for copper pipe scale build-up in all-metal pipework.

In hard water areas, scale or fur build-up inside **Hep$_2$O®** pipes is resisted by the exceptionally smooth finish and cleanly abutting surfaces within joints. The bore of the pipework will therefore be maintained almost indefinitely, as the scale will not adhere to it.

Hep$_2$O® pipe and fittings have been tested by the Water Research Centre and have been found to comply with the requirements of the Water Regulations. The pipes and fittings will not waste nor impart taint, taste or odour to water.

Biological

Organic growth

Hep$_2$O® does not encourage the growth of micro-organisms, as listed in the Water Fittings and Materials Directory 0112066. Polybutylene satisfies the requirements of BS 6920.

Rodent attack

Hep$_2$O® does not specifically attract rodents. However, if the installation is in an area where there is a high risk of rodent attack, **Hep$_2$O®** like other piping and electrical cables should be ducted to ensure no damage can be caused.

Ultra-violet Light

External **Hep$_2$O®** installations must be adequately covered to avoid long exposure to sunlight.

Hep$_2$O® pipe is delivered in SmartPack™ protective wrapping that should not be opened until the pipe is ready for installation.

Opacity

Hep$_2$O® materials conform with the opacity requirements of BS 7291: Part 1: 2001, Clause 6.7, ensuring that insufficient light passes through the pipe walls to allow the growth of algae.

Acoustic

Problems with noise are frequently experienced with systems incorporating rigid pipes. **Hep$_2$O®** pipe does not transmit noise and with careful installation to reduce the source of noise to a minimum, **Hep$_2$O®** can be installed to run almost silently. For example:

- the flexible nature of **Hep$_2$O®** pipe prevents high contact forces between pipes and supports, significantly reducing the 'creaking' commonly associated with the thermal expansion of rigid pipes.
- noise can be caused by pipes knocking together or knocking on hard surfaces in close proximity. Unlike rigid pipes, the inherent elasticity of **Hep$_2$O®** cushions the impact causing less impact noise and absorbing vibrations, preventing the transmission of any sound along the pipes.
- similarly, noise from 'water hammer' resulting from abrupt stoppage of water flow (typically by closure of quarter turn valves, solenoids and reverberating ball valves) is normally absorbed by **Hep$_2$O®** and not transmitted along the pipes.
- noise generated by central heating pumps is rapidly absorbed by **Hep$_2$O®** pipes and can be significantly reduced when compared with rigid systems.

Electrical Safety

Hep$_2$O® piping does not conduct electricity.

However, if **Hep$_2$O®** forms a break in the continuity of metal pipework that is being used for earthing or bonding, then the break should be re-bonded to both sections of the existing pipe when cutting and after installation.

Main, supplementary and equipotential bonding

Installers should be aware of the main and supplementary bonding of electrical installations where plumbing is carried out with plastics piping.

1. This guidance is given on the basis that the following conditions apply. If they do not then the installation must be considered on an individual basis:

- the gas pipe to the boiler is metallic.
- the hot and cold water services are carried out in **Hep$_2$O®**.
- the central heating pipes are **Hep$_2$O®**.
- the waste pipes from the bath, hand basin, WC, bidet and kitchen sink are plastics.

2. There is no requirement to supplementary bond the following:

- the bath even if it is metal.
- the kitchen sink.
- central heating radiators.
- bathroom radiators and towel rails heated by a wet central heating system unless there is less than a 2 metre run of plastics pipe between them and the boiler, or between them and any metallic pipe from the boiler to which the radiator plastics pipe is connected.

3. There is no requirement in the above circumstances to bond a steel sink but it is not incorrect to bond a steel sink to the earth terminal of an adjacent socket.

4. If all the conditions in 1 apply then the following precautions must be undertaken.

Items to be mainbonded:

- the consumer's gas pipe at the service entry.
- any other services that are metallic, e.g. heating oil pipes.
- structural steel should be bonded to the main earth terminal.

Items to be supplementary bonded (in the bathroom):

- the earth terminal of the lighting point (rose, luminaire support coupling, luminaire).
- the earth terminal of the electric radiant heater (if any).
- the earth terminal of the electric shower water heater (if any).
- the earth terminal of any other appliance.

There is no need to connect the supplementary bonding conductor to the main earth bar.

Supplementary bonding in a bathroom when Hep$_2$O® and plastics soil and waste pipes have been installed

(Refer to Figure 3)

There is no requirement to supplementary bond:

- **Hep$_2$O®** pipes.
- plastic soil and waste pipes.
- visible copper pipes less than 0.5m long.
- metal taps.
- metal baths not connected to extraneous conductive parts (i.e. structural steelwork).

However, metal (Class 1) items of equipment in a bathroom or shower room (e.g. electric heaters, showers and luminaires) will require supplementary bonding if simultaneously accessible.

Supplementary bonds must be connected to the protective conductors of each circuit at the accessory point.

Supplementary bonding in a bathroom when metallic service pipes, soil pipes and waste pipes have been installed

(Refer to Figure 4)

Supplementary bonding will be a requirement for:

- all simultaneously accessible metal (Class 1) equipment (e.g. electric heaters and showers).
- central heating pipes.
- hot and cold water pipes.
- waste and soil pipes.

Pipe connections should be made with BS 951 clamps, complete with a 'safety electrical connection' label.

However, metal baths not connected to a metal building structure do not require supplementary bonding if all metal pipes connected to them have been bonded.

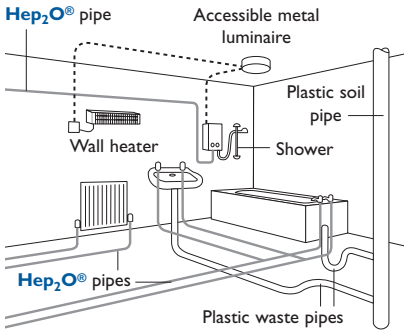

Figure 3

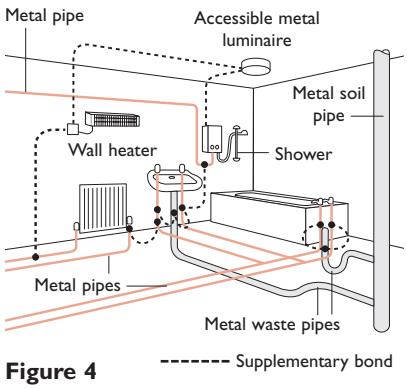

Figure 4