British Plastics Federation
PIPES GROUP

# Testing the lifetime of plastic piping systems for domestic applications

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Plastic pipes are widely used in the UK for hot and cold water supply for domestic purposes (in homes and other buildings with water and sanitary provisions) and heating installations. The service life of plastics is generally determined by a combination of three factors; temperature, stress (pressure) and aggressive chemicals. Members of the BPF Pipes Group undertake testing at the limits of these factors to confirm the suitability of piping products for water supply systems.

## Background

In the UK, the service conditions for standard domestic applications can be found in British Standard BS 7291 *'Thermoplastics pipe and fitting systems for hot and cold water for domestic purposes and heating installations in buildings'.* These service conditions are called 'Class S' and are as follows (Table 1 taken from BS 7291-1:2010 and any amendments).

| Application | Nominal system flow temperature $T_f$ (°C) | Maximum system service temperature $T_s$ (°C) | System malfunction temperature $T_m$ (°C) | System maximum working pressure (bar)[B] |
|---|---|---|---|---|
| Indirect cold water systems | 20 | 20 | - | 3½ |
| Direct mains-fed cold water systems | 20 | 20 | - | 12½ |
| Subsurface heating systems | 60 | 83 | 100 | 3½ |
| Vented hot water supply systems | 65 | 83 | 100 | 3½ |
| Unvented hot water supply systems including Instantaneous heaters and/or incorporating storage | 65 | 95 | 100 | 6 |
| Vented central heating systems and indirect hot water primary circuits | 82 | 95 | 100 | 3½ |
| Sealed central heating systems and indirect hot water primary circuits | 82 | 105 | 114 | 3 |

[A] Where a nominal working pressure does not comprise an integer value, the mantissa is expressed in a fractional format. This is done to reduce the possibility of misinterpretation or obscurity that could cause a system to be subjected to an excessive pressure.

[B] 1 bar = $10^5$ N/mm$^2$ = $10^5$ Pa

[C] Continuously operated re-circulating systems are excluded from these applications.

BS 7291 (in common with the European Standards for plastics piping systems for hot and cold water installations) includes many tests to demonstrate suitability for these applications. The tests are designed to replicate the conditions experienced by the pipe system in use at the limits of performance.

These include:

- **Confirmation of dimensions** – the first and most important characteristic of a plastic pipe is sufficient wall thickness to resist pressure at temperature. The dimensions of outside diameter and wall thickness are specified in BS 7291 and are measured on a routine basis by pipe manufacturers.

- **Long-term hydrostatic strength of pipes** – it is essential to confirm the performance of the pipe over its whole design life. Holding samples of pipe at raised pressures at various temperatures for long periods of time generates data on times to failure. Pipes at higher pressures will burst sooner than those at lower pressures. Statistical analysis of the times to failure allows a robust prediction of the maximum pressure resistance of the pipe at over 50 years or beyond.
- **Hydrostatic pressure resistance of assembled pipes and fittings** – the strength of the joint between a pipe and fitting is critical to the lifetime success of a system. Pressurising samples of pipes and fittings together for 1,000 hours at pressures well above the Class S rating will confirm joint strength.
- **Resistance to thermal cycling of assembled pipes and fittings** – the temperature fluctuations and rapid thermal expansion and contraction encountered by a domestic hot water system or central heating system can induce stress in the pipework. This has the potential to damage or age the plastics being used. Subjecting pipe samples to thermal cycle testing involves creating a closed loop system which is repeatedly cycled with cold and hot water over three consecutive stages for approximately 7½ months. The test demonstrates the resistance of the system to this fluctuating stress.
- **Resistance to cyclic pressure shock** – pressure shocks can be experienced in water systems due to the rapid closing of valves or shutting down of pumps. Testing samples of pipe at 93°C and subjecting them to a 9-bar pressure shock every two seconds (30 cycles per minute), repeated 10,000 times, will confirm the resistance of pipes to these rigorous pressure shock conditions.
- **Oxygen permeability (barrier pipe)** – like metals, plastics can suffer oxidation in the presence of high levels of oxygen. Plastic pipes can be tailored to provide a barrier layer to oxygen permeability. This test confirms that the barrier is effective. The level of oxygen in a closed loop recirculating system is measured at very sensitive levels to ensure it is sufficiently low to prevent oxidation of the pipe or other system components (e.g. iron radiators).

Other short-term tests are designed to give manufacturers confidence that their piping system continues to meet the requirements on a day-to-day basis. These are basic pressure tests (at raised temperatures) over a short timeframe.

## Factors in installation which can affect the lifetime of a plastics piping system

Members of the BPF Pipes Group provide technical assistance on the correct installation of their systems. This information will help installers and end users maintain a correctly functioning system over its design life.

Further assistance can also be found in Building Regulations and installation standards BS EN 806 '*Specification for installations inside buildings conveying water for human consumption*' and BS 8558 *'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'.*

## Advice from manufacturers

In summary, the main advice points relating to design, installation, testing and commissioning are these.

**DESIGN**

- Use the piping system in applications for which it is designed
- Use connectors (and pipe inserts) compatible with the pipe
- Consult pipe sizing guides to guarantee sufficient flow
- Do not exceed the specified temperatures and pressures for the application ("Class S" BS 7291-1)
- Design the system to expand and contract freely during heating and cooling cycles
- Design the system to accommodate hot water expansion
- Do not put mechanical strain on a piping system
- Carefully follow manufacturer's guidance when connecting to a boiler
- Protect from direct sunlight
- Do not bury pipe and fittings directly in concrete (except for underfloor heating pipe)

**INSTALLATION**

- Protect pipework during installation from damage such as scratching, chemical attack by unsuitable substances (e.g. solder flux) or heat (e.g. blow torches)
- Do not use components that are obviously damaged
- Protect the pipework during service from freezing, direct mechanical abuse or attack by rodents
- Comply with electrical continuity requirements
- Do not bend pipework excessively, twist joints or apply side load
- Correctly support the pipe (consult manufacturer instructions on clipping)

**TESTING AND COMMISSIONING**

- Ensure unvented hot water cylinders are functioning correctly
- Always pressure test systems before commissioning
- Always consider local disinfection requirements before commissioning