Pressure Testing Piping Systems

Pressure testing of pipelines should normally be carried out using water. Only in exceptional circumstances should pneumatic pressure testing using compressed inert gas or air be used, and then only under carefully controlled conditions. The reason for this is because water is virtually incompressible (as are other liquids) and only a small quantity of energy needs to be introduced to increase the pressure significantly. Air, however, (like all gases) is compressible and, as a result, much more energy has to be put into the gas to raise its pressure. In fact, at the pressure ranges normally used for testing water-piping systems 200 times more energy is stored in compressed gas compared to water at the same pressure and volume. So, should a joint, pipe, or any other component fail under test pressure when using compressed gas, the energy can be released with deadly force! However, where water leakage would cause unacceptable damage to property, a pneumatic leak test (at say 5kPA - 20mbar) can be used first, followed by a hydraulic leak test.

Where water is unacceptable in the pipework, then a pneumatic leak test followed by a pneumatic pressure test could be carried out, but both employers and employees must be aware of their statutory duties with regard to the Health and Safety at Work Act. This requires employers to provide sufficient information, instruction, training, supervision and a safe working environment, and employees not to carry out the test in a way that endangers themselves or others.

Water regulation requirements for valves and testing

The UK Water Regulations require that every supply pipe or distributing pipe providing water to premises be fitted with a stopvalve, and that water supply systems shall be capable of being drained down and fitted with an adequate number of servicing valves and drain taps. A sufficient number of stopvalves are also needed for isolating parts of the pipework. Fitting these valves and drain taps will also facilitate hydraulic pressure testing.

The test requirement

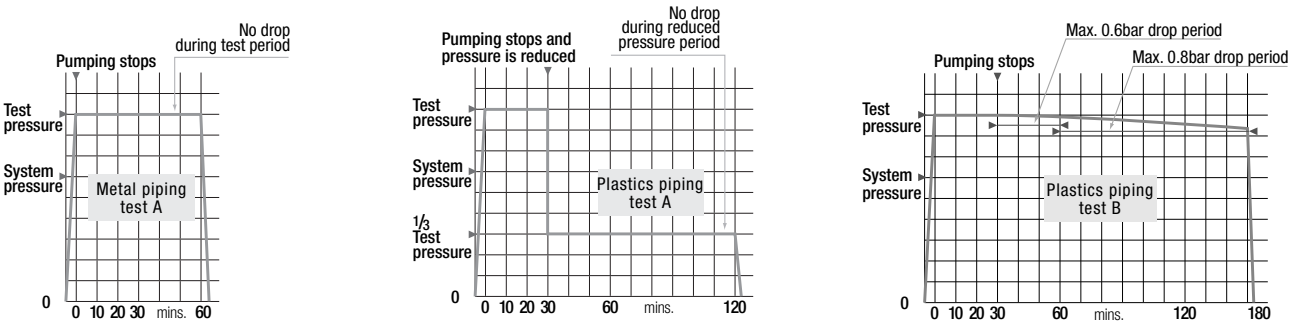
Water Regulation 12 requires that: "The water system shall be capable of withstanding an internal water pressure not less than 1 1/2 times the maximum pressure to which the installation or relevant part is designed to be subjected in operation."

So, for a water piping system that will operate at 3-bar the test pressure will be 3 x 1.5 = 4.5bar.

The regulation goes on to state that this requirement shall be deemed to be satisfied in the case of a water system that does ***NOT*** include a pipe made of plastics, where the whole system is subjected to the test pressure by pumping, after which the test continues for one hour without further pumping. The test is passed if the pressure in the system is maintained for one hour and there is no visible leakage throughout the test.

So the test on an all metal piping system is quite straightforward, simply carry out a risk assessment, prepare and

Figure 1 Graphs illustrating relationship between system pressure, test pressure and time, for metal and plastics water piping systems.



pressurise the system to 1 1/2 times the normal maximum pressure, stop pumping and wait for 1 hour to see if any pressure loss is indicated whilst checking the system for visible signs of leakage.

Where the system ***DOES*** contain plastics piping, two acceptable tests are described by the regulations: tests 'A' and 'B', but both are complex and time consuming.

In test 'A' the whole system is subjected to the test pressure by pumping for 30 minutes, after which the test continues for 90 minutes without further pumping; at the end of the 30 minutes pumping period the pressure is reduced to one third of the test pressure. Test 'A' is passed if the pressure does not drop below one third of the test pressure over the following 90 minutes and there is no visible leakage throughout the test.

In test 'B' the whole system is subjected to the test pressure by pumping for 30 minutes, after which the pressure is noted and the test continues for 150 minutes without further pumping. Test 'B' is passed if the drop in pressure is less than 0.6bar (60kPa) after the following 30 minutes, or 0.8bar (80kPa) after the following 150 minutes, and there is no visible leakage throughout the test. These tests are illustrated in ***Figure 1***.

Planning for the test

Before carrying out a pressure test a risk assessment must be carried out. This needs to consider hazards associated with stored energy, the possibility of blast and its effects, potential missile formation and brittle fracture. A safe system of work also needs to be established (this may require a permit-to-work system, training, use of written procedures, suitable venting arrangements, proper tools and equipment, safety restraints and personal protective equipment etc).

The following factors also need to be considered:

- Is the specified test appropriate for the service and the building environment?
- Will it be necessary to divide up vertical pipework to limit pressures in high-rise buildings?
- Will a water test leave pockets of un-drained water that might cause frost damage or corrosion later?
- Can the piping, or any in-line fittings and components (valves, bellows, tanks, cylinders, radiators etc) withstand the proposed test pressure? If not, these need to be blanked-off or removed and 'make-up' pieces of tube inserted.
- If a water leak occurs what damage might be caused, and could minor faults be checked by carrying out a leak test with air or inert gas at 5kPa (20mbar) before filling with water?
- Are sufficient people available to keep a progressive check for problems whilst filling the system?
- Can different services be inter-connected temporarily to enable simultaneous testing?
- How long will it take to fill the system using the water supply available, and what is the best time to start the test bearing in mind the duration and time needed to undertake the necessary preparations?

Test preparation

- Check that all high points have a tap or vent to facilitate removal of air during filling and that these are all closed.
- Blank, plug or seal any open ends and close all valves at the limits of the test section of the piping.
- Remove or blank off any vulnerable in-line fittings and components that may be damaged by the test pressure.
- Open any valves within the enclosed test section.
- Check that the test gauge is functioning correctly, has been calibrated and has the correct range. Attach the test pump, see ***Figure 2*** (fit a separate gauge if necessary, see ***Figure 3***) using suitable adaptor fittings.
- Check that a suitable hose is available for draining the system.

Hydraulic pressure test procedure

1. Start to fill the piping and then 'walk' the route of the piping under test, continuously visually checking for leaks and by listening for the sound of escaping air.

2. Release air from all the high points systematically through the system to completely fill it with water.

3. Once the system is full, raise the pressure to the test pressure and, if a plastics piping system, continue pumping for the specified period.

Figure 2 Typical hydraulic test pump

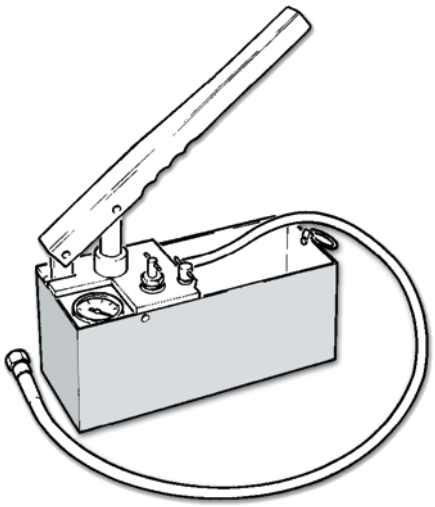
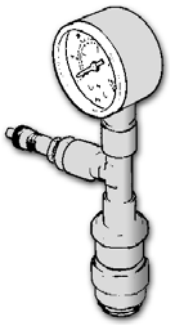


Figure 3 Typical pressure gauge



4. If the pressure falls, check that stopvalves are not letting by, then walk the system again for leaks.

5. Once the system is proven sound, have the test witnessed if necessary and obtain a signature on the test certificate.

6. After testing release the pressure. If necessary, ensure that any vents on cylinders, tanks, and pressure-vessels are opened to atmosphere ***BEFORE*** draining down and refitting vulnerable items.

If the system has to carry fluids other than water, it may be necessary to dry out the piping internally by passing hot air through it, (this can take some time to achieve).

Testing underground water mains

Underground water mains are jointed using a variety of methods including socket and spigot, push-fit and mechanical fittings. The forces that have to be contained within the piping can be considerable so, in addition to the above procedures, the following items are also recommended when pressure testing underground water mains:

- Install and test long mains in sections determined by agreement with the contractor.
- Pressure testing must *NOT* commence until anchor blocks and anti-snaking blocks are in position and the trench partially backfilled and rammed (leaving the joints exposed). This is to prevent any movement causing damage due to the pressure inside the piping. Strutting may also be necessary on blanked ends and branches.

Testing against valves is best avoided, but in any case check that the valves can withstand the test pressure, if necessary blanking off any valves that cannot.

Fill the main slowly and allow any air to escape before beginning to test, and pressurize slowly.

Once the main is proved sound, complete backfilling, then perform a final test and obtain a witness signature as necessary.

Pneumatic leak testing at low pressure followed by hydraulic pressure testing

Due to the inherent dangers associated with pneumatic testing using compressed air or inert gas, a responsible person must be in charge of this operation at all times. This person should direct the preparations and supervise the application of the test by working to a pre-prepared written plan based on the risk assessment. A written record of the test showing the system designed working pressure, the test pressure and duration should be kept and, at the conclusion of the test, this person must verify that the system is safely depressurised and ready for safe operation at the design working pressure.

Preparation

- Check that all high points have a tap or vent and that these are all closed.
- Blank, plug or seal any open ends and use valves to limit the test section of piping to about 50 metres in length for up to 50mm bore tube, (to limit the total stored energy).
- Remove or blank off any vulnerable in-line fittings and components that may be damaged by the test pressure.
- Check that the testing gauge is functioning correctly, has the correct range, has been calibrated if necessary and connect it to the system using suitable adaptor fittings.
- Check that all flexible connections between the compressed air supply (or pump) are securely fastened at both ends to prevent 'whipping' should one end become detached.
- If the compressed air or inert gas is at a higher pressure than is required for the test (maximum 0.5bar pressure) a pressure reducing valve, pressure gauge and pressure relief valve set to open at the test pressure should be fitted to the connecting pipework.
- If possible, the compressed air supply should be controlled outside the test area.

Pneumatic leak test procedure

1. Ensure that all rooms through which the piping passes are cleared of people, then pressurise the system to the leak test pressure (normally 20mbar, but a pressure of up to 0.5bar could be used).

2. Wait at least 10 minutes, checking the gauge for pressure drop, and if necessary 'walk' the route of the piping under test checking for leaks using leak detecting fluid.

3. Once the leak test is passed, release the air pressure slowly and then carry out the normal hydraulic test as previously described.

Pneumatic pressure testing

Because pneumatic pressure testing involves higher final pressures, it also involves higher risk, so this method must only be used when hydraulic testing is not practicable. No work should be carried out on the piping during the test.

Carry out the test preparations as for the pneumatic leak test, however ***if the compressed air supply cannot be controlled from outside the test area then the pipework in the test area should be protected (e.g. by use of sandbags) to limit damage if an explosive failure of the piping occurs!*** Then follow the low-pressure pneumatic leak test procedure as above. After completing the leak test, make sure that all the rooms through which the piping passes are cleared of all people, and gradually increase the air pressure in steps of about 0.5bar up to the required test pressure. Retain the test pressure for 30 minutes and have this pressure and time witnessed. Gradually reduce the pressure through a safe vent point clear of all people to 1.1 times the working pressure, hold this pressure for 30 minutes, then check for leaks (indic-ated by a further fall in pressure) and obtain witness signature on the test certificate. Once the test is complete, gradually release all pressure through a safe vent point clear of all people, refit any vulnerable components and seal the system ready for use.

For further information and guidance refer to HMSO publication GS4 Safety in Pressure Testing.

Brian Curry, May 2003.