Chapter 8

Water Hammer

Water hammer is a shock wave generated in a pipeline caused by the flow of water stopping suddenly. Although in many cases water hammer is accompanied by a loud vibrating sound of knocking pipes, it can be present without such noise or obvious signs. Therefore, damage may be occurring to pipes and equipment without anyone's knowledge. Examples of damage that may be incurred, are:

a) Pipe fixings working loose.
b) Joints of fittings pulling apart.
c) Pipes fracturing from the constant vibration on the timber/steel frames.
d) Loose pipes generating vibrations through equipment.

It is possible for noises to be present in the pipes even when the water service is not being used. Not all noises in pipes are caused by, or are necessarily associated with water hammer. This chapter is concerned only with noise caused by water hammer as a result of water flowing through pipes at too high a velocity. The noise in pipes associated with water hammer can only occur when a tap or valve in the open position is closed quickly.

Water hammer, is the term used to define the destructive forces caused by the water supply being suddenly stopped. Water is a non-compressible liquid and when the velocity is terminated suddenly a large amount of energy is generated, with nowhere for it to disperse except along the pipe. A shock wave is created with a force up to eight times the existing water pressure. The shock wave bounces from one end of the pipe to the other and back. It takes only a fraction of a second for the shock wave to travel the length of the pipe many times, before it gradually slows and stops.

As previously stated, it is often the case that water hammer can occur without noise. Pipes without protection against water hammer, will to some extent be subject to the same damaging effects as if noise were present. There are simple tests that can be carried out to determine if water hammer is in fact present in a pipeline.

The recommended procedure for performing a test for water hammer is as follows:

a) Fit a pressure gauge to a garden hose tap or control valve on the supply pipe with the valve in the open position. Choose a fixture for the test, a washing machine, that has a quick action valve is a perfect selection.

b) With the washing machine valve closed and no movement of water in the pipe, the indicator on the pressure gauge will remain steady.

c) The washing machine is turned on and the inlet valve activated, allowing the machine to fill. When the machine reaches the appropriate level, the valve will snap closed. (Alternatively, opening and closing the kitchen sink tap quickly can achieve the same result).

d) If the indicator on the pressure gauge continues to flicker and not settle quickly after the washing machine valve (or kitchen tap) is closed, it is a clear indication that there is a shock wave passing along the pipe. If the pressure gauge indicator remains still, it demonstrates there is no water hammer present.

Note: It is the shock wave that causes damage to the pipes, fittings, valves and equipment, not the actual noise.

The Relationship Between Water Hammer and Noise

A number of factors determine whether noises will exist in some pipelines and not others. The greater the number of these factors present, the higher the chance of noise and the greater the noise level is likely to be.

Some of these factors include:

a) The hardness of the pipe material.
b) The length of the pipe.
c) The water pressure.
d) The velocity of water in the pipe.
e) The speed with which the valve is closed.

Contrary to popular belief, faulty taps and valves do not cause water hammer. The shock wave in the water pipe hitting the valve actually does the damage and creates the noise. The design of some taps and valves allows them to be closed in a quick action format, which increases the likelihood of the shock wave occurring. The quicker a tap or valve can be closed, the greater the shock wave in the pipe. The noise factor is created when the pressure of the shock wave becomes so great that the pipe vibrates and expands to attempt to absorb the force of the pressure.

Water Hammer is not restricted to residential and commercial buildings, it can also occur in large diameter industrial pipes. A 225 or 300mm valve closing quickly can have the same effect as closing a 20 or 25mm valve.

The Effect of Water Hammer on Pipes Made from Hard and Soft Materials

Case Study

To illustrate that water hammer is not confined only to pipe systems constructed from hard materials and that damage can occur without the knowledge of the homeowner, a test was carried out on two attached townhouses. One was constructed using copper tube for the hot and cold water services, the other with a soft plastic pipe, only the townhouse with the pipes made from the harder material experienced the water hammer noise. On completion both were tested in the same manner.

Before the actual test was carried out on the softer material, the builder was under the misapprehension that the soft plastic pipes were free of water hammer due to the absence of noise. This can provide the homeowner with a false sense of security as the townhouse with the soft plastic pipe did in fact have a water hammer problem, despite the lack of noise.

It could be suggested that by having noise present in the pipes made from the harder material allowed the problem to be identified and rectified before damage could occur. It is important to check for water hammer whether or not there is obvious evidence of noisy pipes.

To confirm the presence of water hammer, the water closet cistern was flushed while the kitchen tap was simultaneously turned on and off a number of times and left in the off position on completion, no noise was evident. What was clear was the water closet cistern filled with an uneven flow of water, stopping and starting until it appeared the cistern was filled. Just as the test was completed, the cistern allowed more water to enter before finally completing the fill cycle.

Regardless of the pipe being soft and there being no noise present, the shock wave was evident due to the uneven flow of water filling the cistern. As the shock wave settled, the cistern filled and the water hammer dissipated. The shock wave travelling through the softer pipe was causing damage to pipes in the townhouse wall cavities, as well as to the fittings, valves and equipment.

No pipe is immune from water hammer unless suitable precautions have been taken.

Noise that Suddenly Occurs in Pipes

Noises caused by water hammer are not always evident immediately after an installation and can occur in pipes long after the building has been occupied. Noises suddenly occurring in pipelines, for what appears to be no apparent reason, are a good indication of water hammer being present. In these cases the water hammer was never correctly accommodated during construction.

Alternatively, it is possible, in buildings which have been renovated or extended, that the problem can be traced to original construction, or that the pipework was altered from its original design.

The following factors may have an adverse effect on a building, causing noises in water pipes, that were not experienced previously:

a) Undersized pipes.
b) Pipes being extended, without protection against water hammer.
c) A bathroom or kitchen extension with quick closing taps.
d) Replacement of existing taps with lever-action quick closing taps.
e) Installation of additional control valves, which can affect the shock wave and cause new noise.
f) An existing control valve may suddenly develop noise. This is due to the shock wave constantly hitting the valve and eventually damaging it. Such a situation can be avoided by controlling water hammer in the first instance.
g) Old galvanized pipe being replaced with new copper pipe, causing an increase in the velocity.
h) A gravity feed hot water system being replaced with a mains pressure hot water system. The increased velocity may create a noise factor.
i) Pipes that have not been fixed correctly and securely may create noise.

Note: Even when the pipe is clipped correctly and securely, the shock wave can loosen the clips and a noise may become noticeable years after the installation. Clips nailed into pine timber studs are the most likely to be affected in this way.

j) The installation of a new washing machine or dishwasher, with flexible hoses from the tap to the machine, which are of a harder material than the original.
k) A new water meter incorporating a non-return valve.
l) A spa bath or shower being installed with the taps on one wall and the spout or shower rose on another wall, if using 15mm pipe. A reverse water hammer will be created. The extention pipe between the taps and the shower outlet must be 20mm.

Eliminating or Rectifying Water Hammer

Throughout this text the importance of water velocity, as it relates to pipe sizing has been emphasised. The larger the pipe diameter for a given flow of water, the lower the velocity. It has also been stated the water hammer shock wave is caused by high velocity water being brought to a sudden stop.

It logically follows that accurate sizing of pipes is vital to eliminating water hammer.

It is critical to take into account the occupancy of a building when calculating optimum water velocity and pipe sizing. The more people there are in a building, the greater the possible flow demand and the greater the possibility of the velocity increasing during peak periods.

Design criteria that will assist in the elimination of water hammer, are as follows:

a) A design flow of 1.2 m/s rather than 2.2 m/s will dramatically decrease the chances of water hammer occurring.
b) Fitting a pressure-limiting valve to provide a maximum of 35 m/h, 343 kPa or 3.4 bar.
c) Replacing faulty valves and tap washers is essential, however, this will not in itself eliminate the problem.
d) Installing a water hammer arrestor upstream of pipes that are inaccessible and where the fixings have worked loose. This eliminates the noise only, not the actual shock wave.
e) New washing machines, dishwashers or similar equipment must be fitted with a water hammer arrestor.
f) On existing equipment installations, replacing the hoses with flexible ones.
g) A pressure-limiting valve may be installed on the water service inlet adjacent to the water meter, or on individual equipment, such as the hot water system.
h) Where lever action taps or solenoid valves are installed, a water hammer arrestor should also be installed.

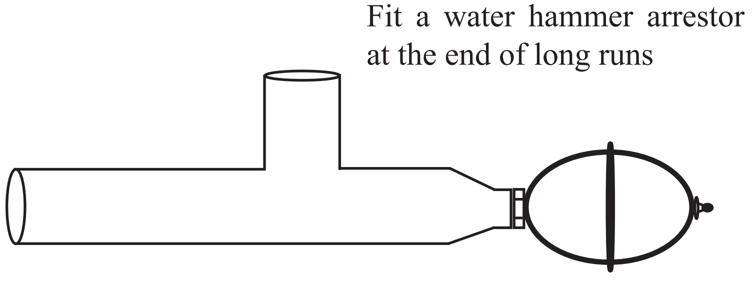

Figure 8-1 End of Line Water Hammer Arrestor

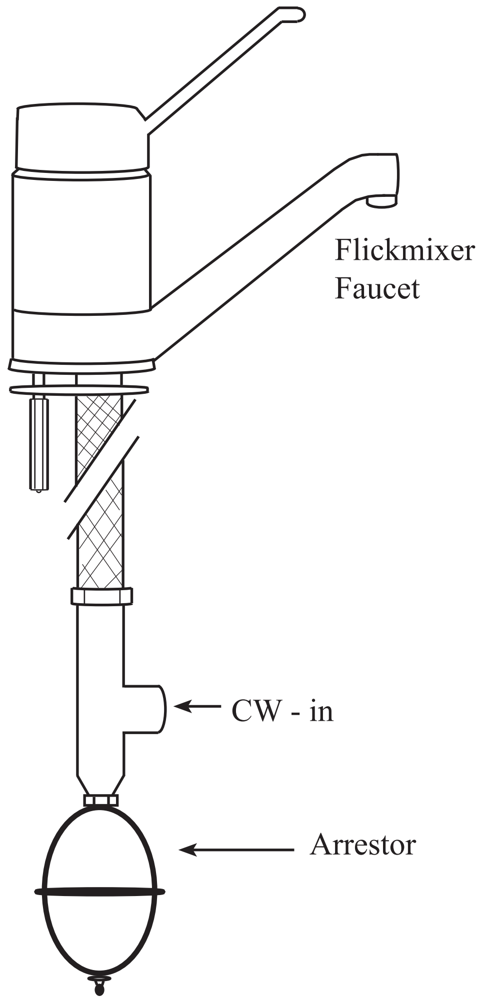

Figure 8-2 Flickmixer with Water Hammer Arrestor

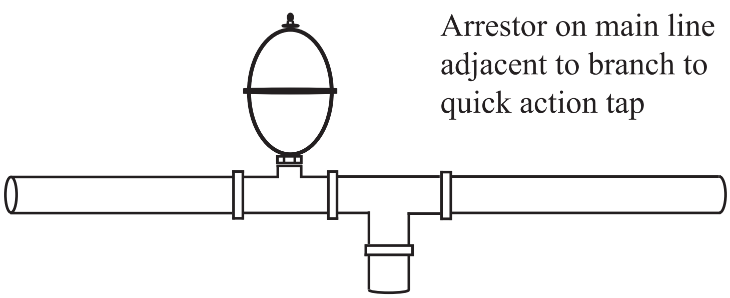

Figure 8-3 Water Hammer Arrestor Adjacent to Quick Action Tap

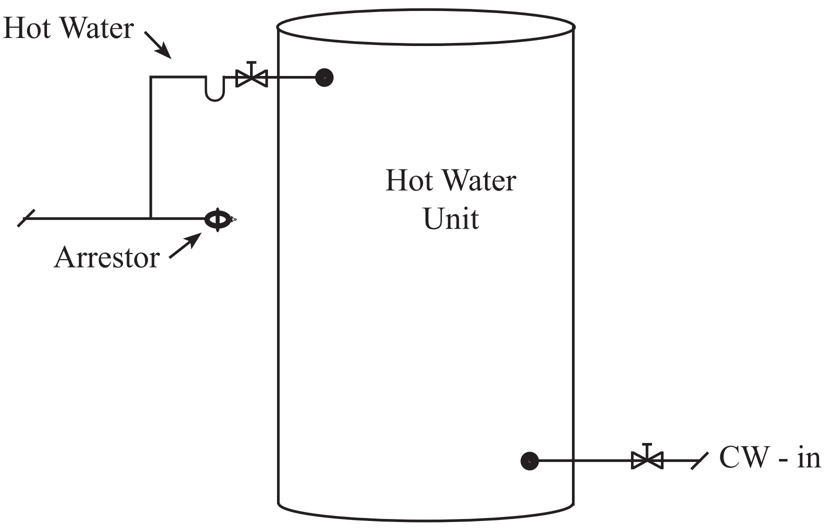

Figure 8-4 Hot Water Unit with Water Hammer Arrestor

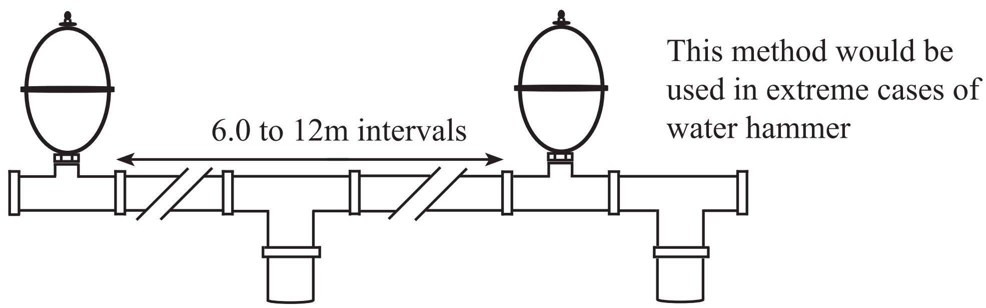

Figure 8-5 Water Hammer Arrestor on Main Line

Summary

1. Install one or more water hammer arrestors.
2. Install a pressure-limiting valve if the pressure exceeds 50 m/h, 490 kPa or 4.9 bar.

Note: It may be that the manufacturer of the hammer arrestor requires a pressure lower than 490 kPa. For example, some water hammer arrestors require that the water pressure not exceed 380 kPa. In such cases a pressure-limiting valve will definitely be required.

3. Clip pipes firmly and use screw fixings in preference to nails.
4. Fix all pipes at no greater than the specified distance for each type of pipe.
5. Install a ball valve at the meter if the meter incorporates a non-return valve.
6. Design pipe sizes and velocities as recommended in this text.
7. Pack silicon evenly around pipes where they pass through timber or steel studs.
8. Provide additional fixings, where the pipe is attached to the surface of a stud.
9. Stand-off clips are better suited to the elimination of water hammer.

Giving due consideration to water hammer at the design and installation stages of a project will have cost benefits for the property owner, who will avoid the inconvenience of rectification work at a later date. The prevention of noises, caused by water hammer will also result in a greater comfort for the end user.

Reverse Water Hammer

In cases where an outlet pipe has been connected to a tap or control valve and extended for a distance of one to two metres, 'reverse' water hammer may occur if the diameter of the extended pipe is too small.

While the aim of good design is to keep pipes as small as possible, the actual pipe between the tap and the outlet should be considered independently. If the shower rose is placed on a wall adjacent to the hot and cold taps, the pipe size must be increased to limit the possibility of reverse water hammer occurring. The same applies to an extended pipe from a control valve to a piece of mechanical equipment. The reverse water hammer is due to the high velocity and sudden surge in pressure, resulting from closing the tap or valve quickly. .

As the tap is closed, the water flow causes a vacuum immediately after the tap. The vacuum may suddenly reverse the water flow, causing a vibration and loud banging noise.

Figure 8-6 illustrates a shower rose, that has been placed on an adjacent wall to the taps, reverse water hammer may occur in this situation.

Solution

The pipework from the tap to the outlet should be increased from 15 to 20mm. On larger projects the pipe can be increased by one size.

Rectification

Pipes are often concealed behind walls and must be accessed in order to increase the pipe size from 15mm to the preferred 20mm.

Alternatively, a flow control valve may be fitted to limit the volume of water and reduce the velocity. Flow control inserts are available and can be fitted in the hot and cold water taps for this purpose. Showers are often designed for a velocity of 18 L/m, when in fact 9 L/m is adequate. The reduced flow rate will assist in rectifying the reverse water hammer.

The most important aspect of the rectification process is to reduce the velocity of the water.

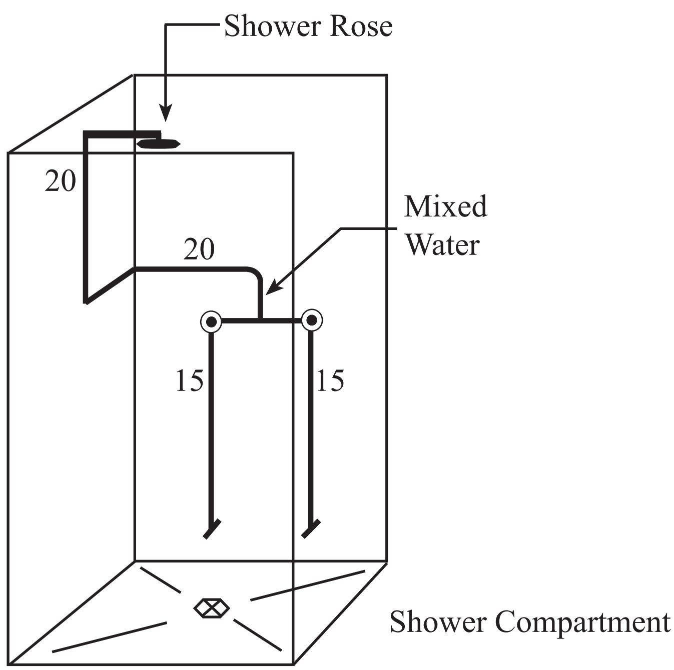

Figure 8-6 Illustration of a 20mm Pipe from the Combination to the Shower Rose