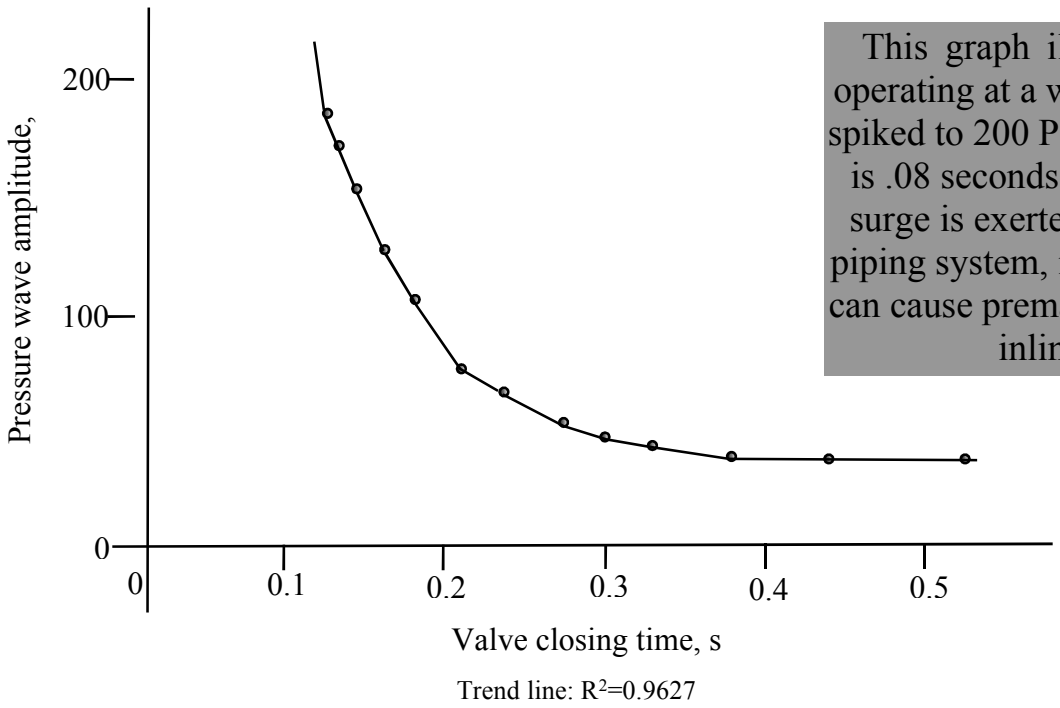
WHAT IS WATER HAMMER?

Water hammer is the term used to describe the destructive forces, pounding noises and vibration resulting from the high-pressure surges that develop in a piping system when the column of non-compressible water flowing through the pipe line is stopped abruptly. This water flow stoppage occurs when a valve in the piping system is shut off or when a column of water flows rapidly through an empty pipeline and meets a flow restriction caused by an inline restricting valve or orifice.

WHAT CAUSES WATER HAMMER?

The cause of water hammer pressure surges is well defined. Water flowing through a pipe has mass or weight (8.33 lbs / gallon) and when this mass is moving through a plumbing system the entire column of water has energy. That energy is equal to the mass of the water column times the flow velocity squared ($E=MV^2$). The total energy of this moving column of water must be absorbed by the plumbing system when the water column is brought to a stop.

The column of moving water can be equated to an automobile traveling at speed. To bring the vehicle to a controlled stop the brakes are applied until the energy of the moving vehicle is absorbed in a controlled way. Should the automobile hit a solid immovable object the vehicle's energy is absorbed in a violent, destructive crash. The same action occurs in a plumbing system – the faster the change in the speed of the water column (i.e. the faster an inline valve is closed), the more violent the stopping forces are. The graph below shows a typical pressure build-up in a plumbing system as a function of valve closure time. The quicker the valve is closed, the more excessive the resultant pressure spike or surge is going to be.



This graph illustrates that a system operating at a water pressure of 20 PSI is spiked to 200 PSI if the valve closure rate is .08 seconds. This excessive pressure surge is exerted on all components in a piping system, including the injector, and can cause premature failure or harm to all inline components.

HOW DO I PREVENT WATER HAMMER?

The severity of water hammer pressure surges is a function of the pipe size, length of pipe involved, flow rate through the pipe and the time it takes to close the valve. The most common causes of water hammer are the operation of quick closing, solenoid valves, pneumatic valves and even hand-operated ball valves.

To solve the pressure increase the actual formula is as follows.

$$P = \frac{0.070\ VL}{t} + P_I$$

V= Flow velocity **P_I**= Inlet pressure **L**= Upstream pipe length
P= Surge pressure **t**= Valve closing time

An automatic pressure increase calculator can be found online at
http://www.ajdesigner.com/phpwaterhammer/pressure_increase_equation.php

Solution 1: Replace quick closing shut-off valves with slow acting valves

If the valve opening and closing operations cannot be slowed down then a water hammer arrester, properly engineered for the specific system, must be installed for the protection of the injector and all the piping system components. One size arresters that fit all piping systems do not exist.

Solution 2: Install a properly sized and designed water hammer arrester

Each water hammer arrester will be custom designed by the manufacturer. The following measurements are helpful to have on hand.

Length of pipe
This is the affective pipe length of the branch line serving the hammering valve. This is where the energy is to be absorbed.

Flow pressure
This is the gauge pressure at the valve when the valve is on and the water is flowing.

Pipe size
Try to use the actual I.D. of the pipe if possible. The normal size of the pipe will be adequate, but the actual I.D. size will be more accurate.

Flow rate
This is the maximum flow rate that could occur in the piping system to be protected. Lower flow rates will also be protected.

Maximum allowable pressure
This may be represented in pounds per square inch gauge.

Source: *This information has been reproduced from an original document by Ed Grout of "Dosmatic Injectors" – 19 July 2000*