Fluid Mechanics and Hydraulic Analysis

Report about

WATER HAMMER

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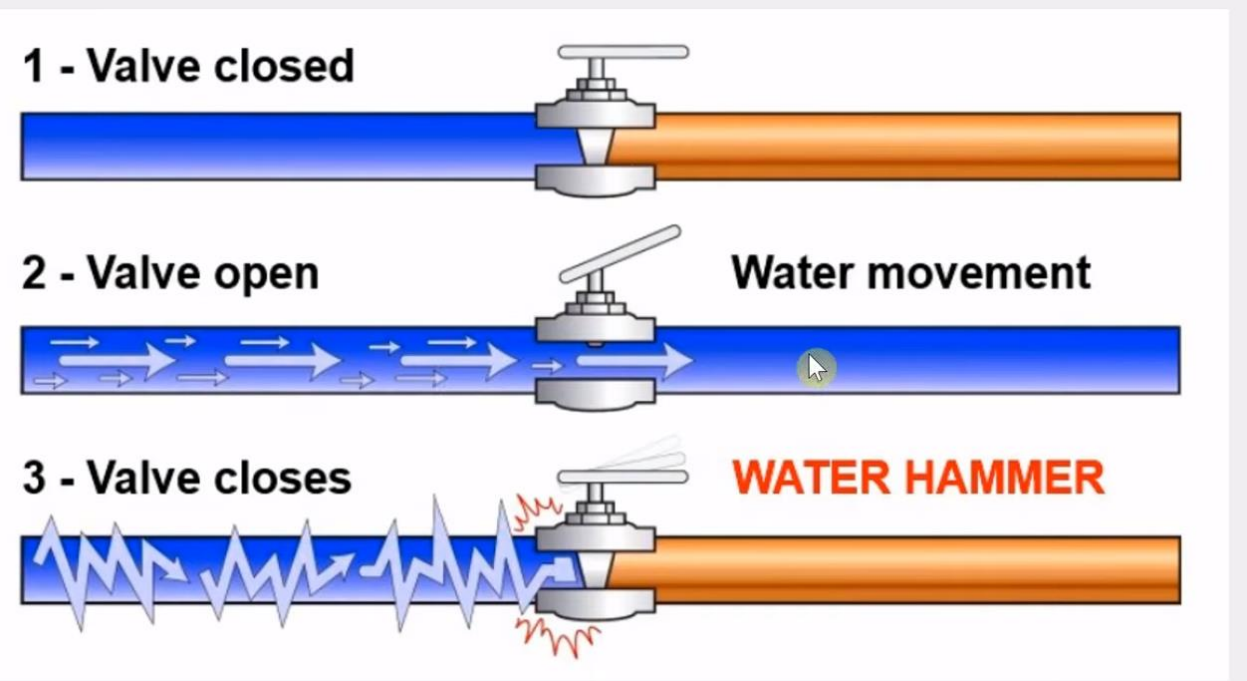
٣٠/٠٧/٢٠٢٤

Definition of Water Hummer: Hydraulic Shock and Fluid Hummer

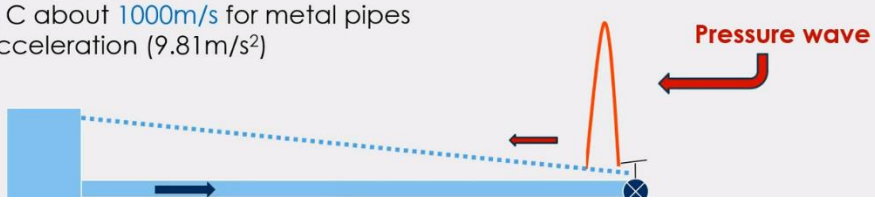
Definition:

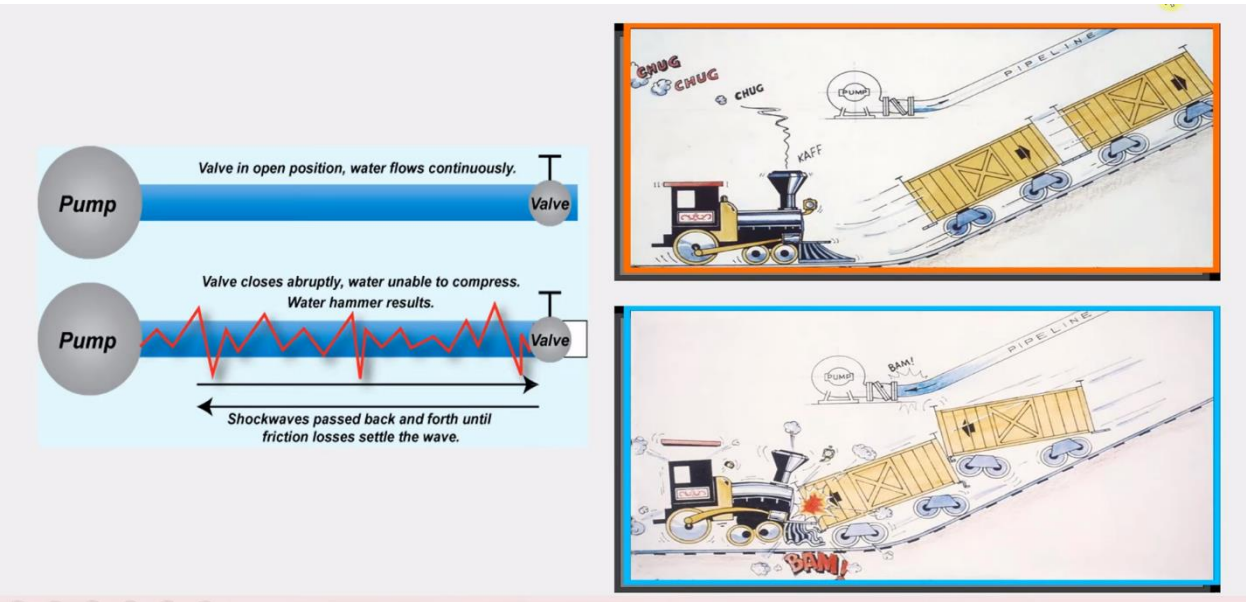
A water Hummer (WH) is a Pressure Surge or wave caused when a fluid (liquid or Gas) in motion is forced to stop or Change Direction suddenly.



$$\Delta H = (c/g)\,\Delta V$$ Joukowsky's Equation

ΔH	is change in pressure head in meters
ΔV	is change in velocity (m/s)
C	is wave speed. C about 1000m/s for metal pipes
G	gravitational acceleration (9.81m/s^2)





Causes of Water Hummer:

Water Hummer Can Happen When:

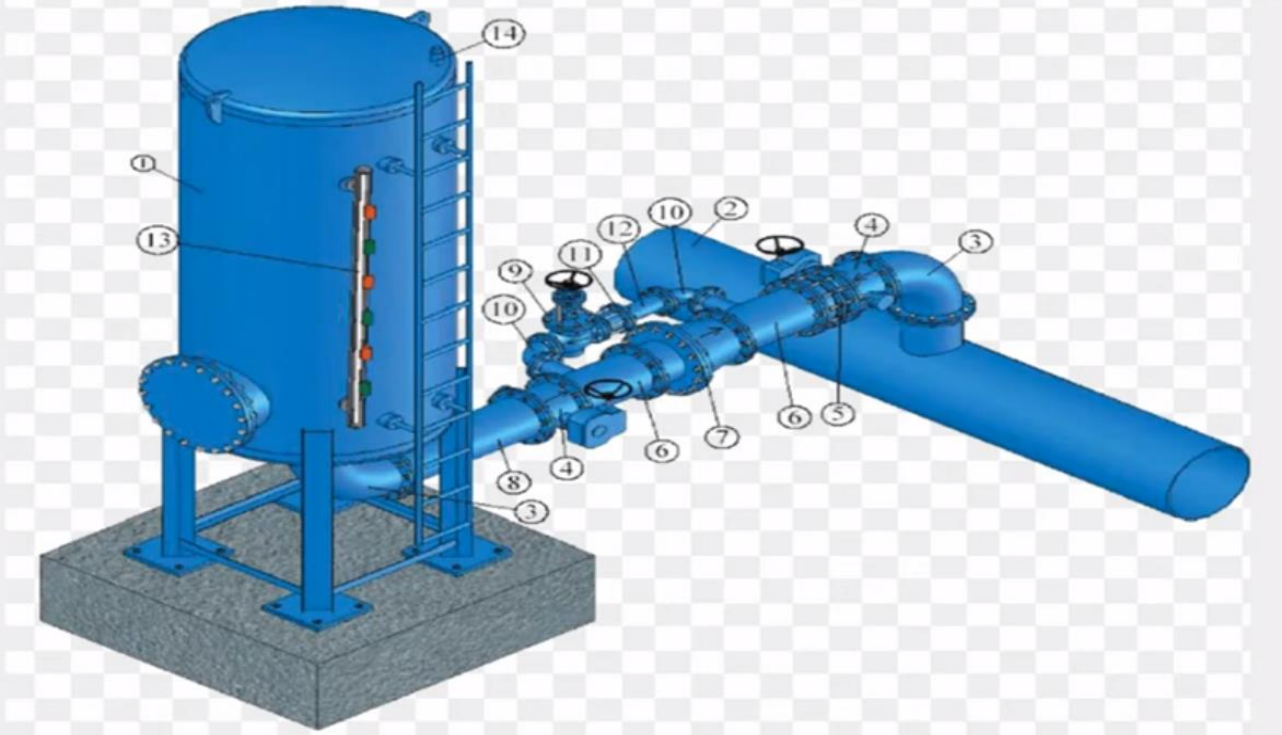
- The Pipe is Suddenly Closed at the Outlet (down Stream)
- Valve Suddenly Closes along the flow.
- An upstream valve in a pipe closes suddenly.
- Common appliances like washing machines, and automatic flushing toilets, when they suddenly get shut off from water flow.
- Pump Failure and check valve slam (due to sudden deceleration, a check valve may slam shut Rapidly.
- Pump Trip
- Pump Shutdown
- Pump Startup
- Valve Closing
- Valve Opening

- Check Valve Slam/closing
- Rapid change in demand
- Rapid change in reservoir level
- Rapid change in tank level
- Pipe break
- Hydrant opening
- Hydrant Closing
- Flushing Operation
- Air Valve Slam /Closing
- Change Velocity

Indications:

The Indications of the Occurrence of Water Hummer are

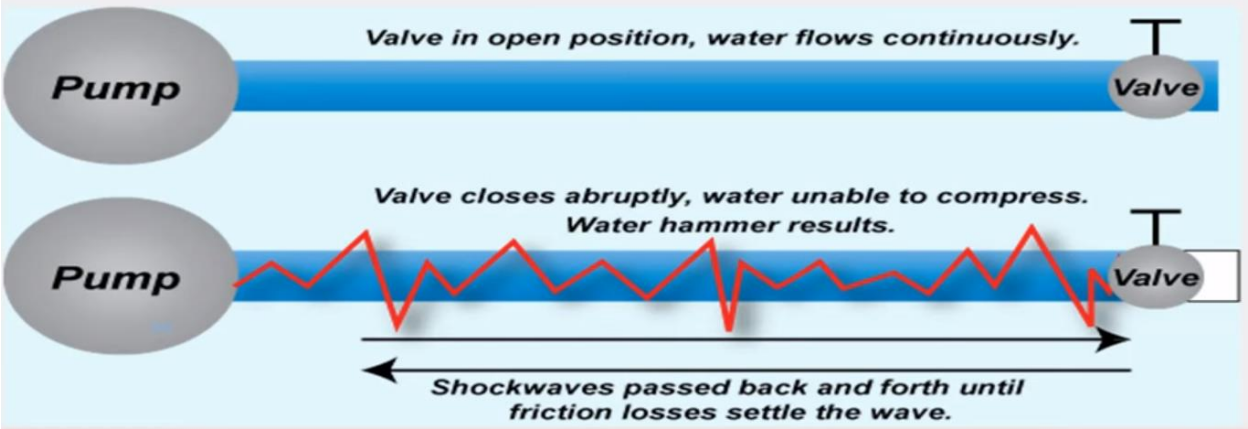
- May be Head as a loud bang.
- Repetitive Banging (as the shock wave travels back and forth in the plumbing system)
- Sudden knock sound continuing repeatedly as the water surge moves backward.



No.	Part Name	Properties	No.	Part Name	Properties
1	Surge Tank	V , PN	8	Flanged Pipe	DN_1, PN
2	Pipe Line	DN	9	Globe Valve For Control	DN_2, PN
3	Flanged Elbow	DN_1, PN	10	Flanged Elbow	DN_2, PN
4	Flanged Butterfly Valve	DN_1, PN	11	Dismantling Joint	DN_2, PN
5	Dismantling Joint	DN_1, PN	12	Flanged Pipe	DN_2, PN
6	Flanged Tee	DN_1 X DN_1 X DN_2 , PN	13	Magnetic Level Gage	---
7	Check Vales, lifting Type	DN_1, PN	14	Surge Relief Valves	---

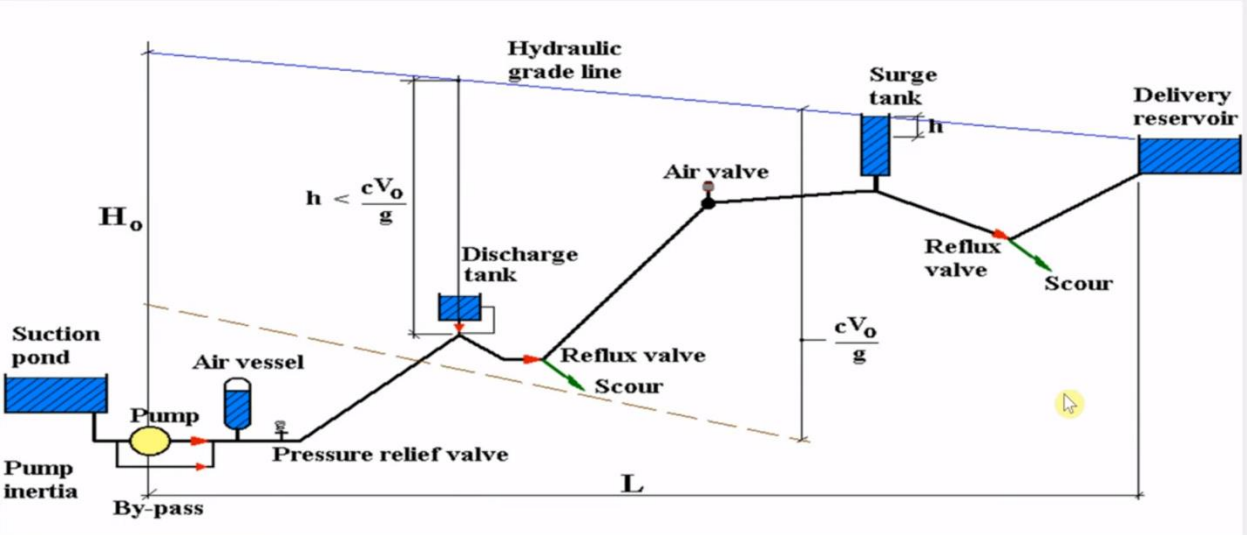
INTRODUCTION:

In any pumping or gravity lines, the rapid start-up or shut down of flow can result in a phenomenon called water Hummer, which can cause serious damage to pipe components such as pumps and valves resulting in costly repairs, downtime, and loss of water. Uncontrolled start-up and shutdown of pumps and isolating or controlling valves that close too quickly are the most common causes of these water hummer events.



Protection Methods Against Water Hummer:

- Surge Tank (open – close- bladder)
- Air valves (Release – Intake)
- Relief Valves (Pressure – Anticipator)
- Check Valve (non-return valve NRV- Reflux valve)
- Control Valves.



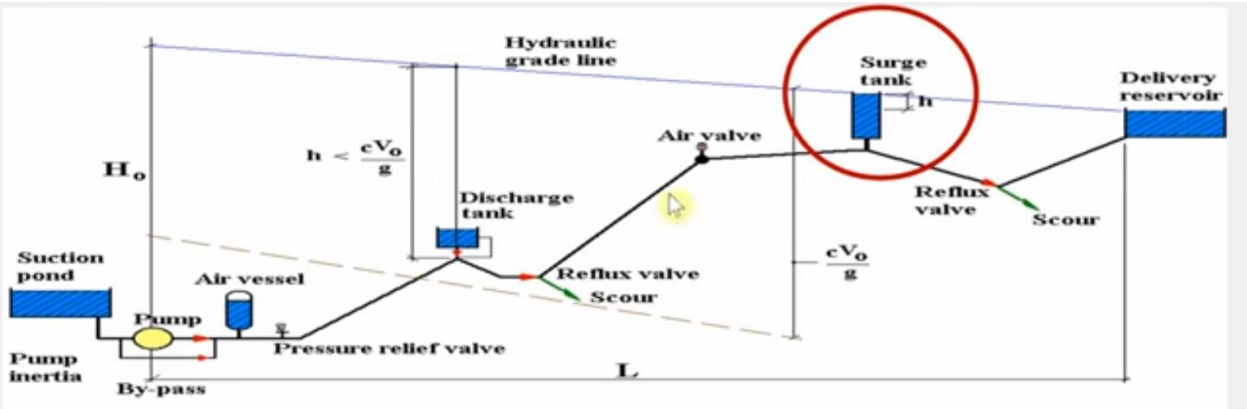
١. Surge Tank (open – close- bladder):

Surge Tanks have become very popular as surge protection devices, they allow the injection of water into a pipeline at points where low pressure is formed due to:

- Pump trip
- Electrical failure
- Rapid Valve Closure

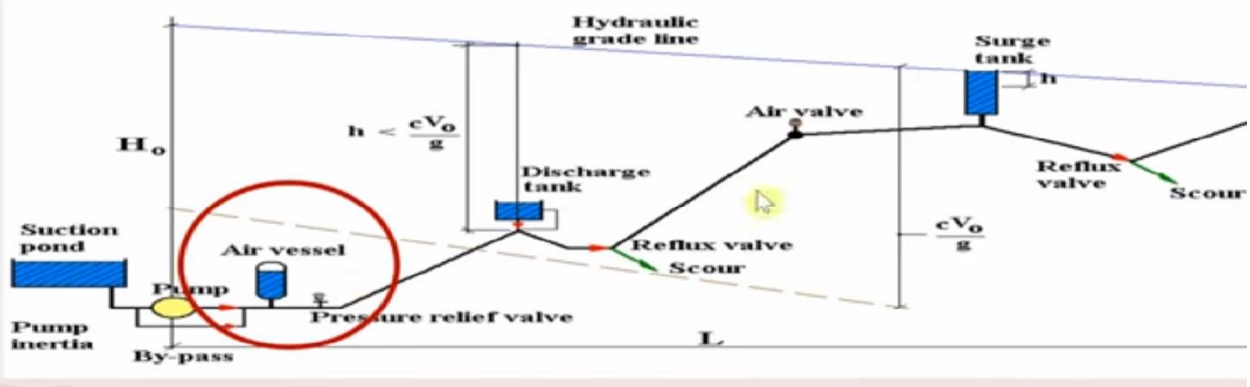
➢ Open Surge Tank:

These are normally concrete or steel structures with problems of maintenance and remote locations.

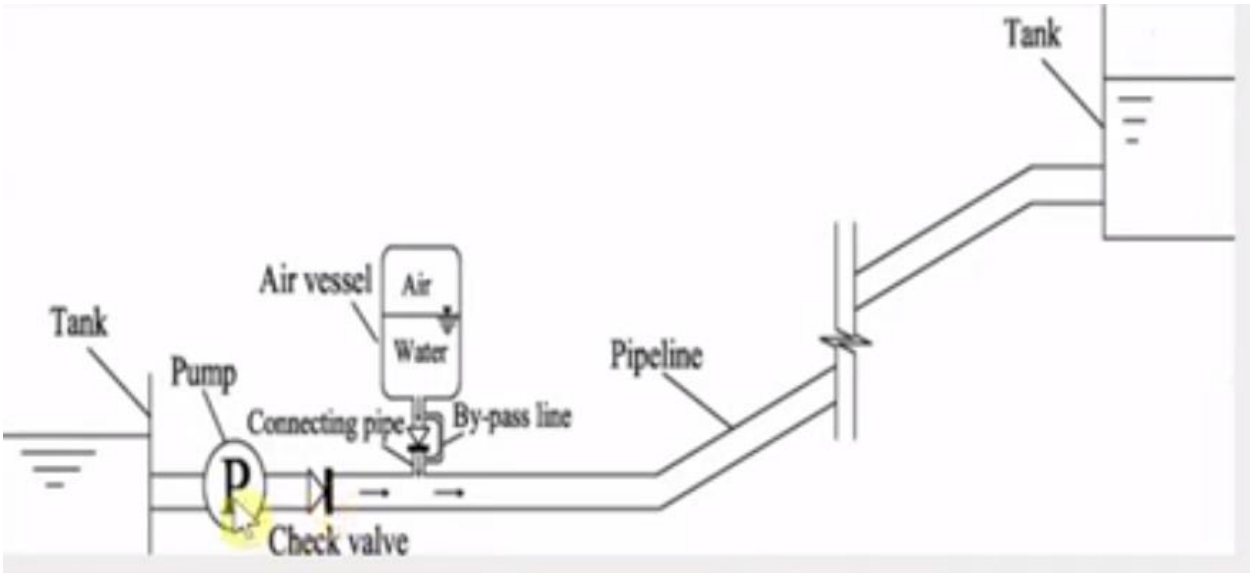


➢ Close Surge Tank:

This requires an installed compressor and instrumentation with high maintenance to ensure continued correct operation

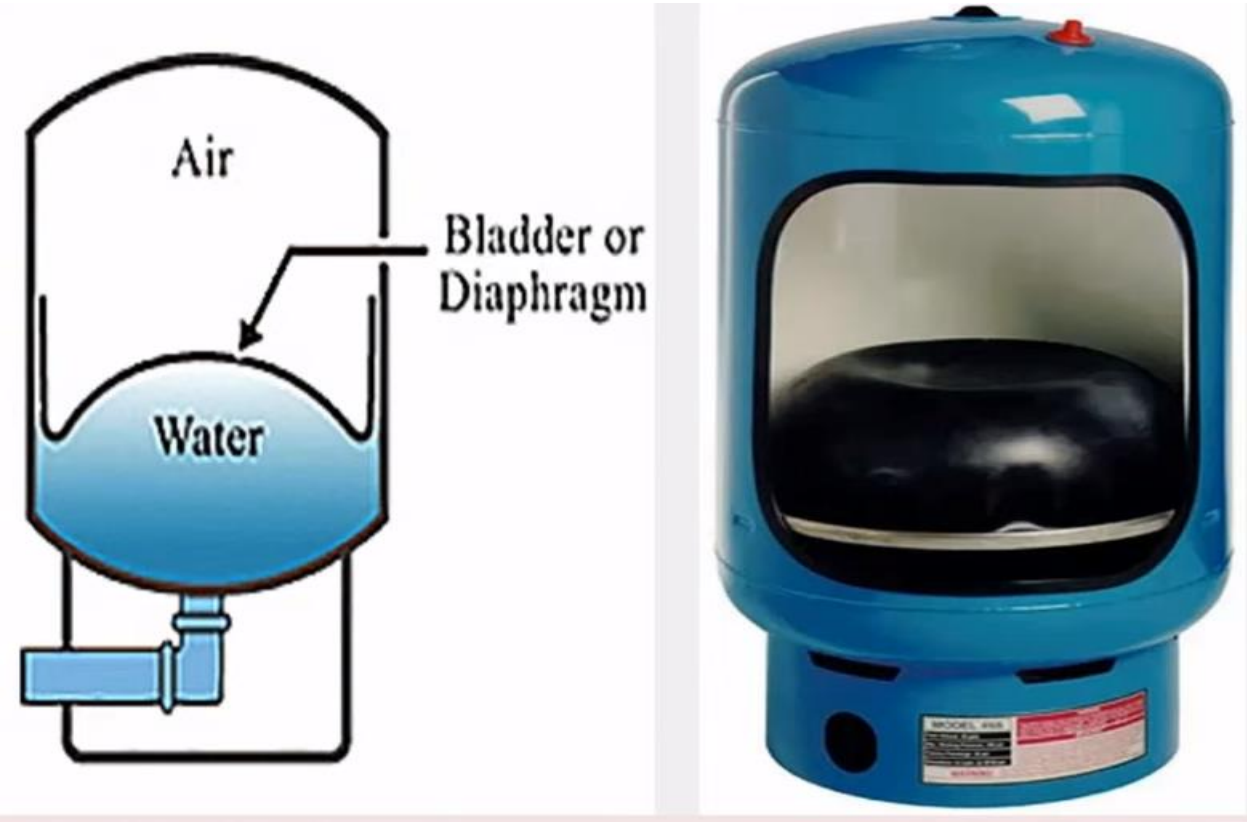


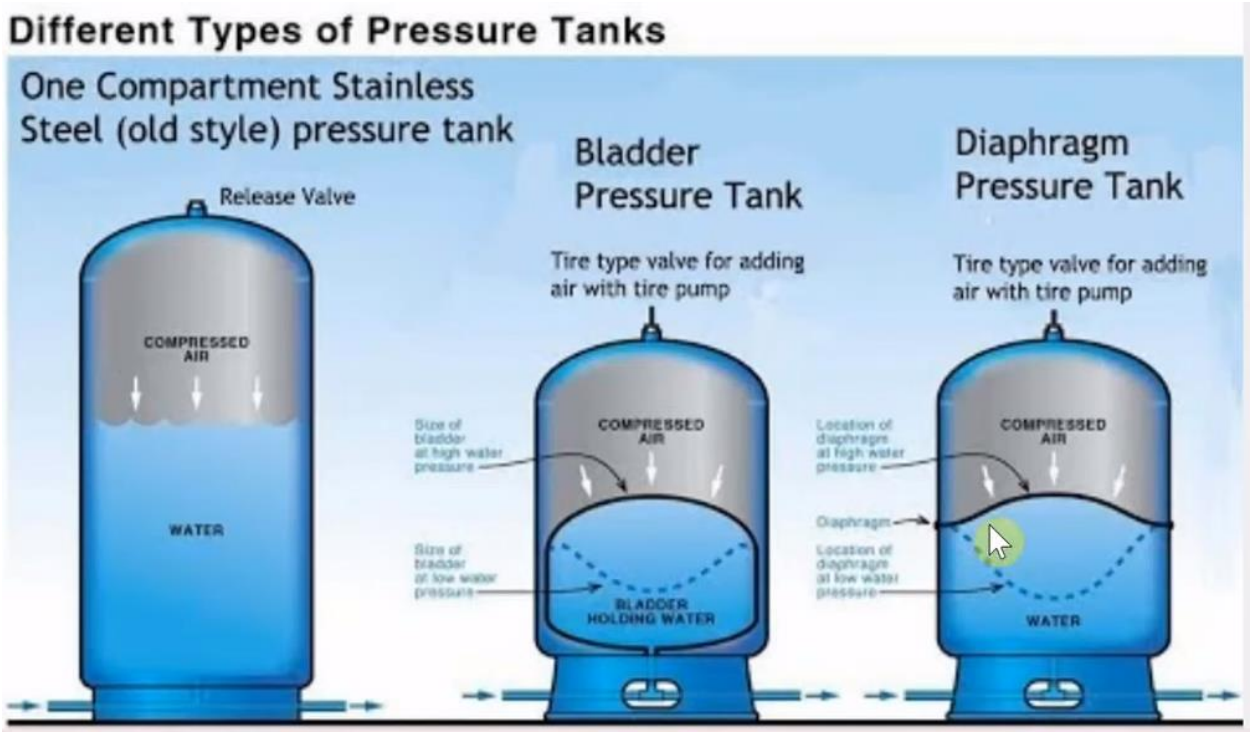
Close Surge Tank (Air Vessel):



- Bladder Surge Tank

  These are by far the most suitable solution as they have a rubble bladder interface between the water and air and do not suffer from high maintenance costs





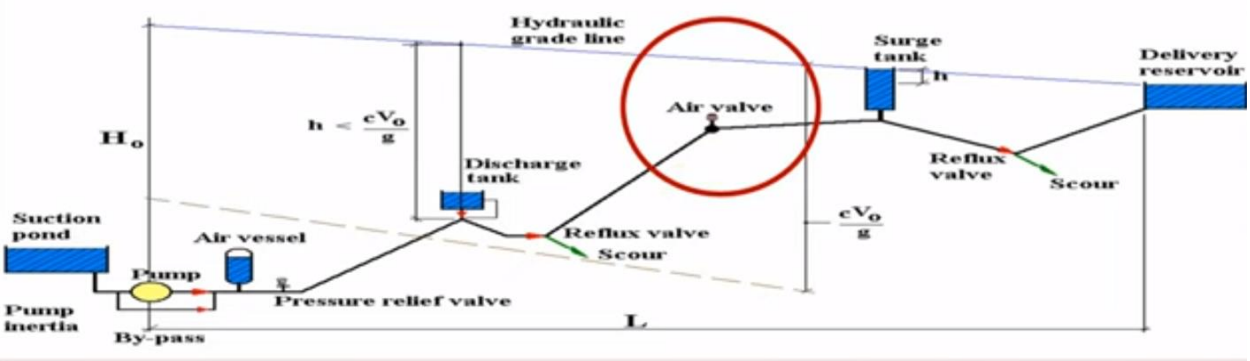
٢. Air Valves (Release / Intake):

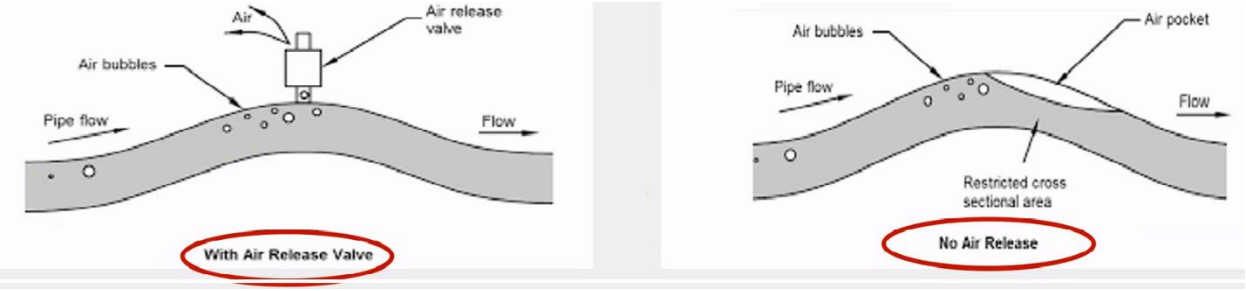
Air enters pipelines from various sources:

- Air intake from pump stations.
- Release of dissolved air due to pressure and temperature changes.
- Discharge of air due to filling of empty pipes.

➢ Air Release / Intake Valves:

Remove The accumulated air from the pipelines by air release valves placed at points where air naturally accumulated. the same air valve is used as the intake of outside air in case of negative pressure.

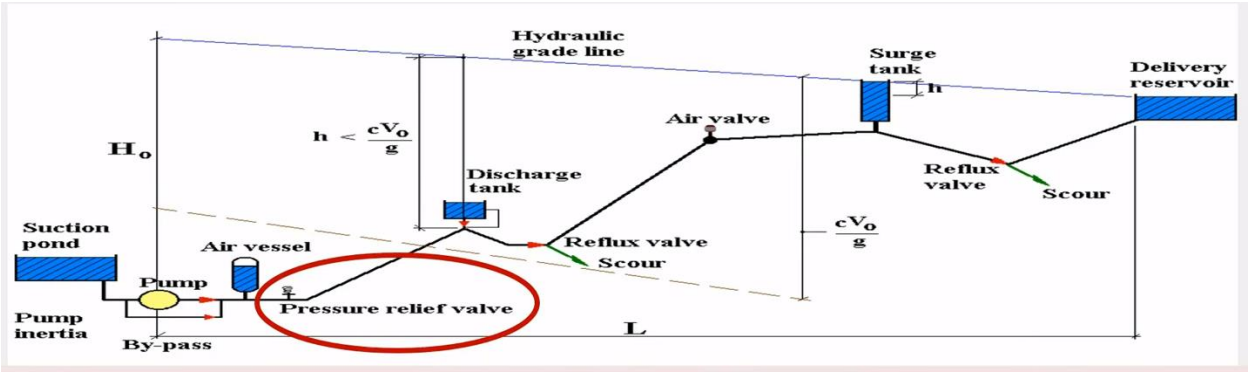


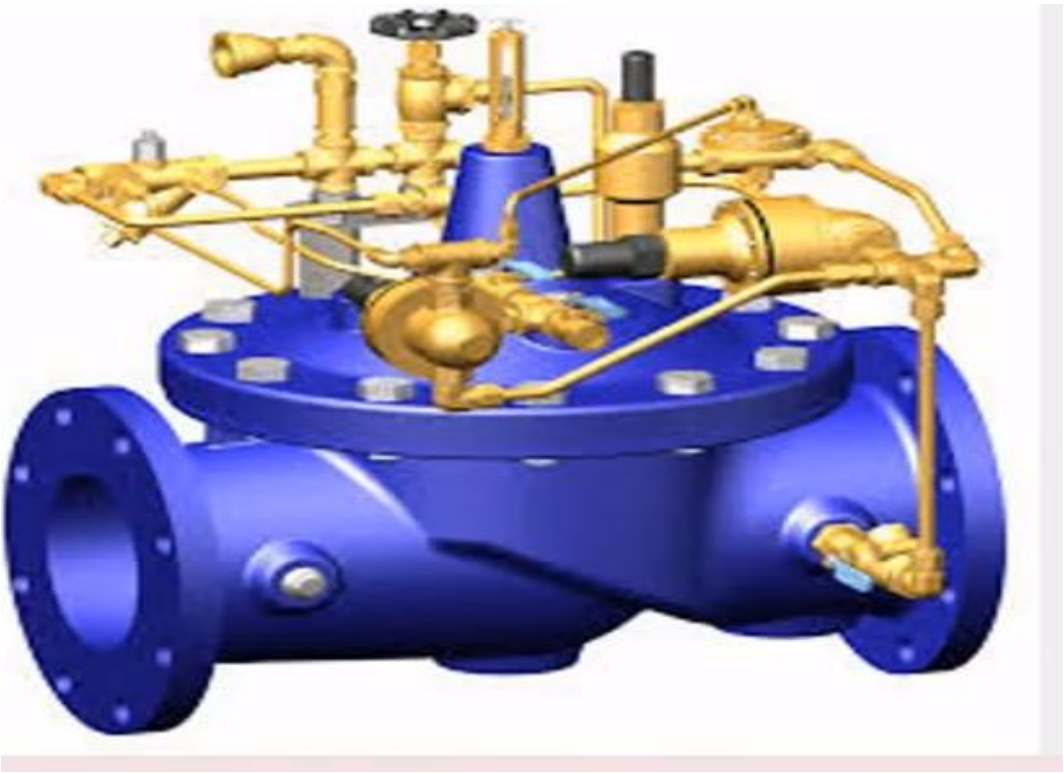


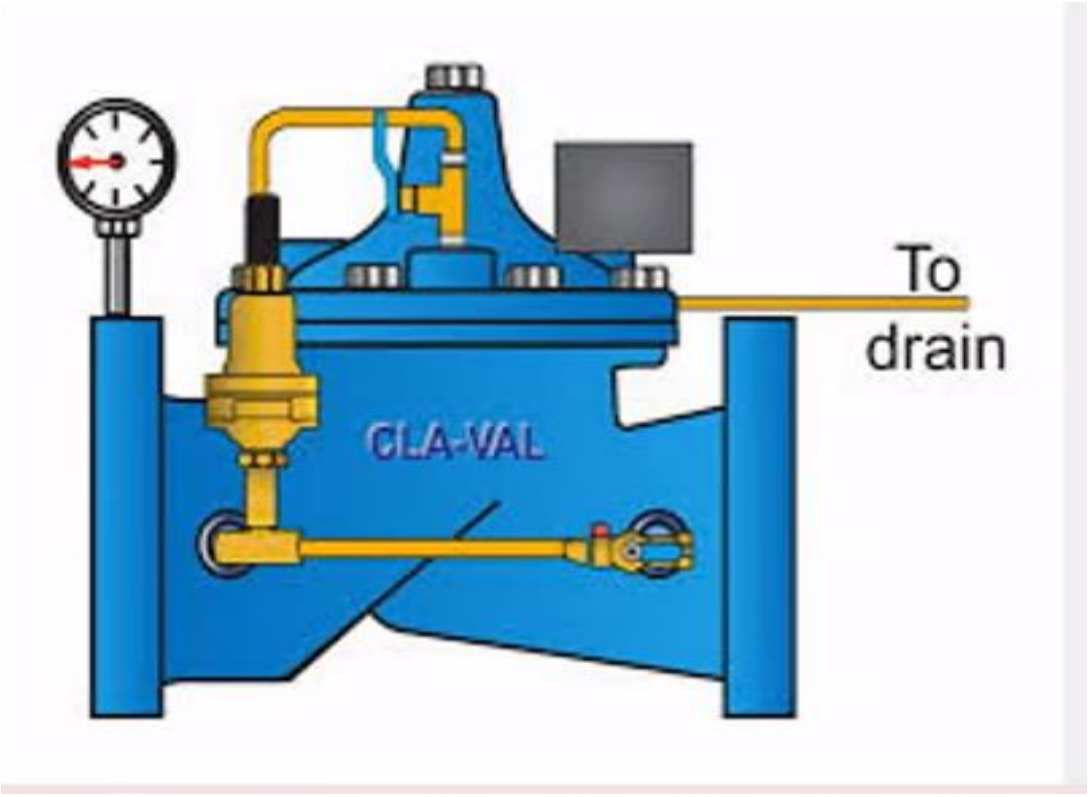
٣. Relief Valves (Pressure / Anticipator):

- Pressure/ Anticipator Relive Valves

  These valves are available in different formats to remove high pressure/ low pressure caused by water hummer from the pipeline.



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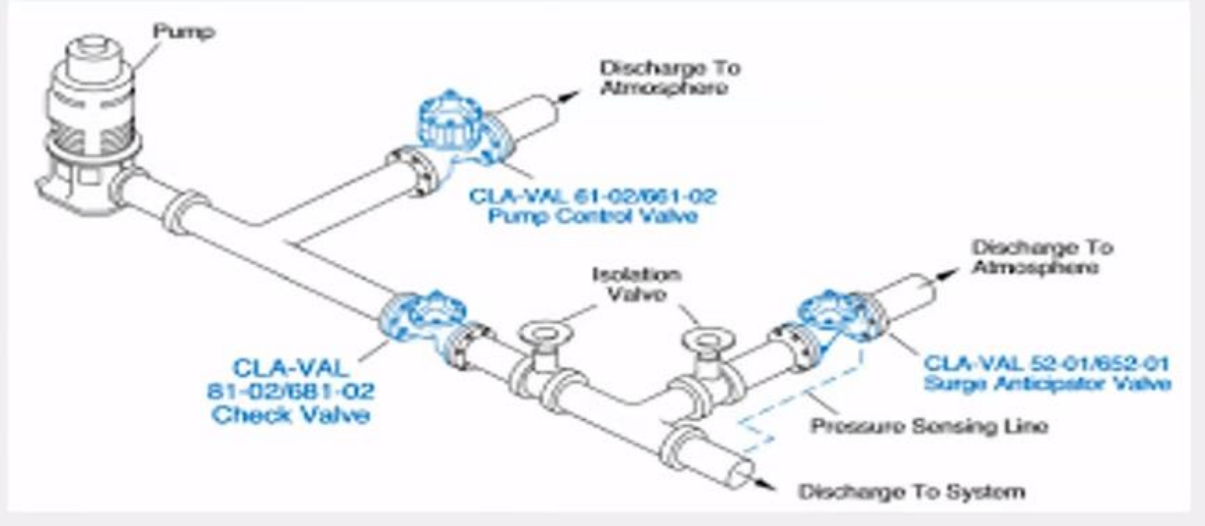
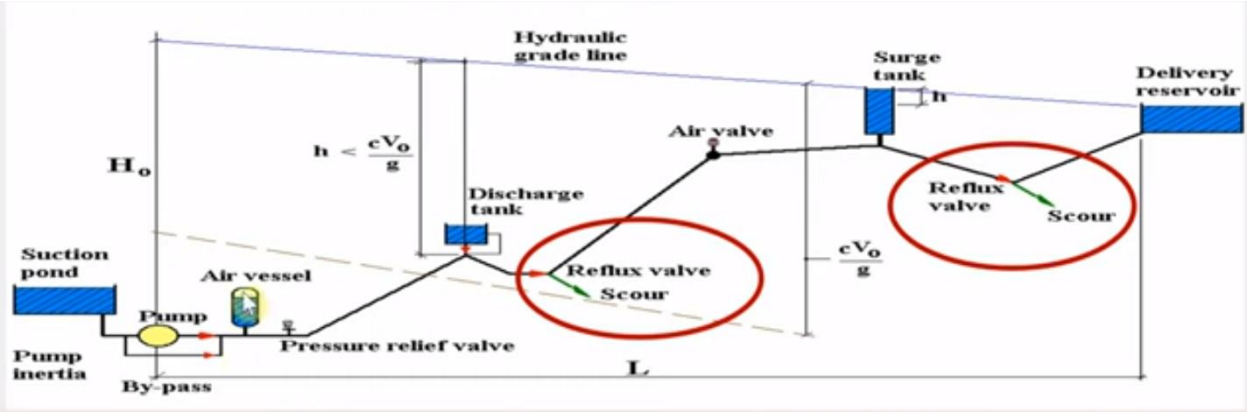


٤. Check Valve (Non-Return Valve NRV / Reflux Valve):

- Check Valve:

Check Valves are generally installed on pump delivery to prevent the return when the pump is stopped



٥. Control Valves:

In most pumping systems it's advisable to start and stop the pump in a controlled fashion to ensure that

- The acceleration and deceleration are achieved gradually to reduce the effects of the water hammer.

- The pump does not operate outside its efficient design parameters.
- Pump cavitation is avoided.

Conclusion and Recommendation:

١-All methods as mentioned can serve water hummer protection purposes.

٢-No way to Use NRV only to prevent the water hummer effect.

٣-There is no way to use ONE method only to prevent the water hummer effect.

٤-Good Analyses = Good Design = Less Running Cost.

Reference:

١- **Water Hummer Practical Solutions** by B. B. Sharp (Author), D. B. Sharp in ٢٠١١

٢- **Water Hammer: Problems and Solutions by** Hodder Arnold (July ١, ١٩٨١)

٣- **Hydraulics of Pipe Lines (Classic Reprint) Hardcover by** W. F. Durand in ٢٠١٨

٤- **Water Hammer: Its Cause, Magnitude, Prevention by** Oscar G. Goldman in ٢٠١٠.