

# Waterhammer & Surge Tanks

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# What is a WATERHAMMER?

- Also known as Hydraulic Transient
- Occurs when there is a quick changes in pressure in a pipe
- It is a fluid shockwave that is caused by the fluid suddenly stopping and changing directions.

**Valve open - water flows**



**Valve rapidly closes - WATER HAMMER**



# What is a WATERHAMMER?

- Caused when a valve is closed quickly and the kinetic energy changes to potential energy
- The pressure in a pipe will change and create a wave which travels back and forth in the pipe until it comes to static pressure.
- This process occurs usually in under 1 second

# Things that alter the waterhammer

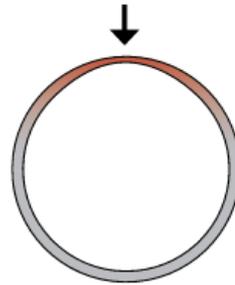
- Pipeline Profile
- Pipeline Length
- Moment of Inertia
- Pipe Material
- Pipe Dimensions
- Filling around the pipe

# Problems Caused By Waterhammer

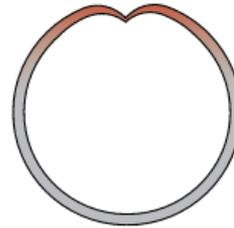
- Can pull pipe supports from mounts, rupture piping, and cause pipe whip
- Pipeline collapse from sub pressure or overpressure
- Pipeline collapse from column separation due to vapor pressure causing vacuums or cavitation in pipe
- Corrosion or erosion from cavitation implosion which can lead to upsurge, down surge, cracking or rupture of pipe
- Fatigue and external wear caused by frequent start and stop of the water flow

# Possible Failure Modes

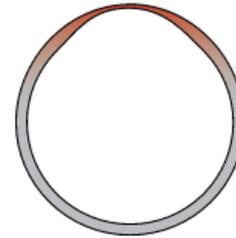
Different effects  
of a weakened  
section.



Weakened section



Downsurge



Upsurge



Cracking



Rupture

# Prevention:

- Active protection (needs additional power supply)
  - Variable frequency drives (VFD): an electric control that changes the impeller speed to control flow
  - Soft starters: low down flow when stopping pumps
  - Slow-closing valve: slowly decrease the flow of the fluid instead of closing the valve fast, long process for long pipes

# Prevention (cont'd):

- Passive Protection (operates without additional power supply)
  - Standard air chamber are connected to the pipes and filled with liquid and compressed air. When the pressure drops, the air is discharged into the pipe helping to slow down flow.
  - Bladder air chamber contains a bladder with compressed air and is airtight to prevent mixing with fluid
  - Surge tower is a tank containing water that connects to the pipe to reduce subpressures that occur in the pipes. It is open to the atmosphere and has potential energy stored in height. When the pipe stops the tower releases water into the pipe to balance out the low pressure.
  - Air inlet valves put where subpressurce can occur in pipe and the valves allow air to enter the pipe when the pressure falls. A release valve is present to prevent air pockets.

# The Sweden Pump Station (1930):

- A Sweden Pump station, with pumps from 1930, needed upgrading because of the frequent failures and unplanned stops which caused flooding. To fix the problem, an additional pipe was added and to prevent waterhammers, a feed pipe was added to connect the system to a lake that had check valves. If the pressure subpressure in the pipes, the lake water would be fed into the pipe, working as a surge tower.

## Another Swedish Pump:

- Another pump in Sweden was needed to be put in to bring cool water to a gas-fired plant. This pipe would be sensitive to waterhammers due to heat exchangers which are sensitive to pressure changes. To solve the waterhammer issue, a propeller pump was installed and the water was pumped into a surge tower to help with the pressure in the pipe. The tower ensured there was no fast changes in pressure.

# Surge Tank:

- An attachment to help with pressure changes in a system
- When pressure rises, it forces fluids upward which goes into the surge tank raising the water level instead of rising the pressure in the pipe
- If pressure drops in the system, the surge tank will let fluid into the system to bring the pressure up
- Usually used in hydro power plants

# Surge Tank Design:

- Depends on system it is attached to and what is needed to be accomplished for the system
- Contains sets of valves to control fluid flow
- May have emergency release valve to release pressure in emergency cases

# Function of Surge Tanks

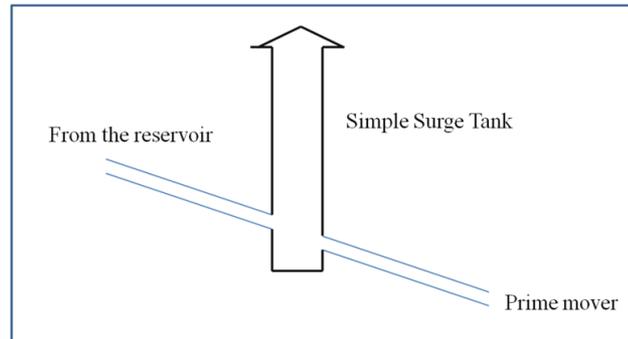
- A system that allows water to rise and fall in tank when the pressure in a system is too high or too low
- Acts as a storage for where water can be supplied in cases a valve is opened suddenly and prevents a turbine valve from collapsing due to negative pressure
- When a valve is closed, the water in the pipe has an inertia that reduces slowly which builds up pressure in the pipe
- Reduces intensity of waterhammering and can be neglected in the design of a tunnel
- Reduces distance between the free water level in reservoir and turbine
- Acts as a relief valve when pressure is very high in pipe
- Acts as a temporary reservoir and provides water to the turbine to pick up new load quickly and safely

# Dimensions and Location:

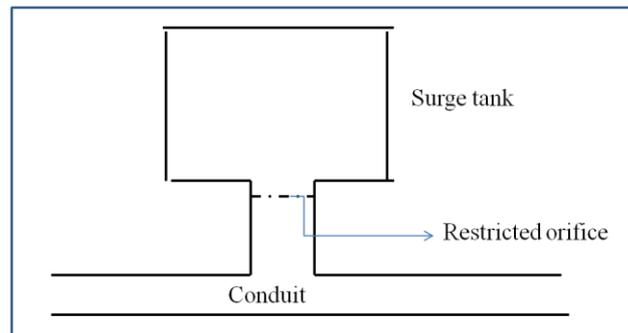
- Located as close to the power or pumping plants as possible
- At a high enough height to prevent overflow
- Bottom should be low enough so that the tank can be drained and admit air into the pipe
- Have a large enough cross sectional area to be stable

# Types of Surge Tanks

- Simple Surge Tank: Vertical pipe that supplies water to turbine generator

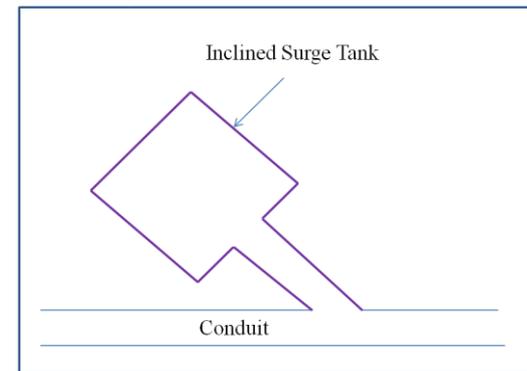


- Restricted orifice surge tank (throttle surge tank): contains a throttle and provides friction loss when water is flowing to and from tank which helps reduce the pressure

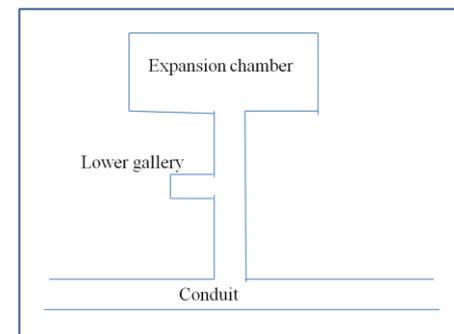


# Types (continues)

- Inclined Surge Tank: the effective water surface increases and a lower height works too, can also help reduce the diameter (not very well used)



- Gallery type surge tank: has expansion on top and bottom to reduce extreme pressures



# Examples:

- Found in pools as filters on the side near the surface
- Used for systems like radiators
- Fuel lines in vehicles

# Conclusion:

A waterhammer is a rapid pressure change in fluid in a pipe. It is caused by a valve rapidly shutting. It is detrimental to the pipe system, and can be mitigated to an extent.

A surge tank is a reservoir which water can rise and fall in to reduce pressure swing. By doing this, it helps reduce the negative effects of a waterhammer. It reduces the distance from a turbine to the fluid surface, while protecting high pressure rise upstream.

# Sources:

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