Technical surge Session

Hydraulic Transient and Surge Protection Devices

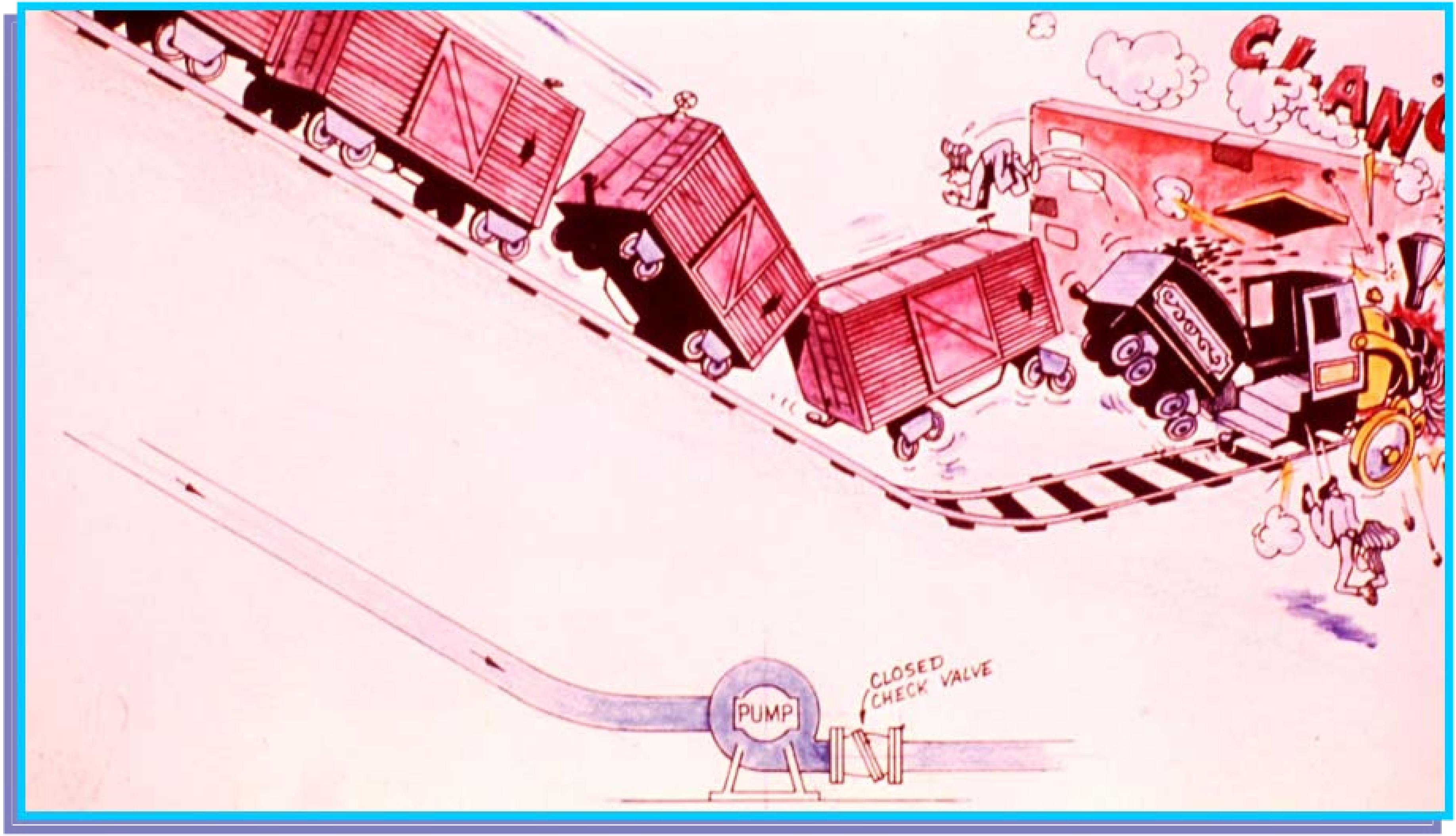
Gwenn A. PHALEMPIN

What Causes Pressure Surges?

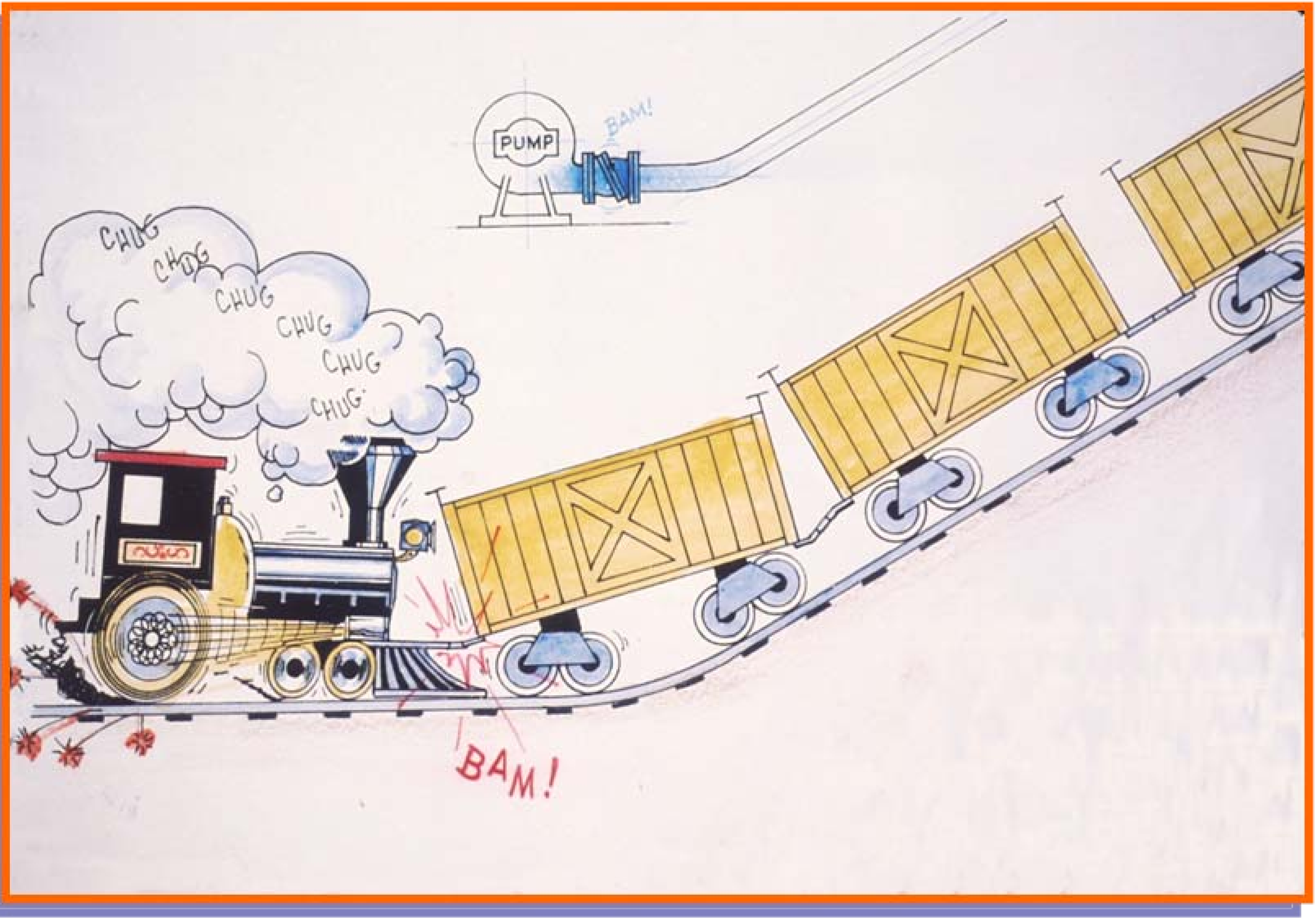
- Rapid Change in flow rate caused by:
  - Valves (Opening, closing)
  - Pumps (Start-up, stop, power failure)
  - Check Valve (Slamming)
  - Air/Vac Combinations (Air slam)

WORST CASE ANALYSED: Power Failure at Max Flow

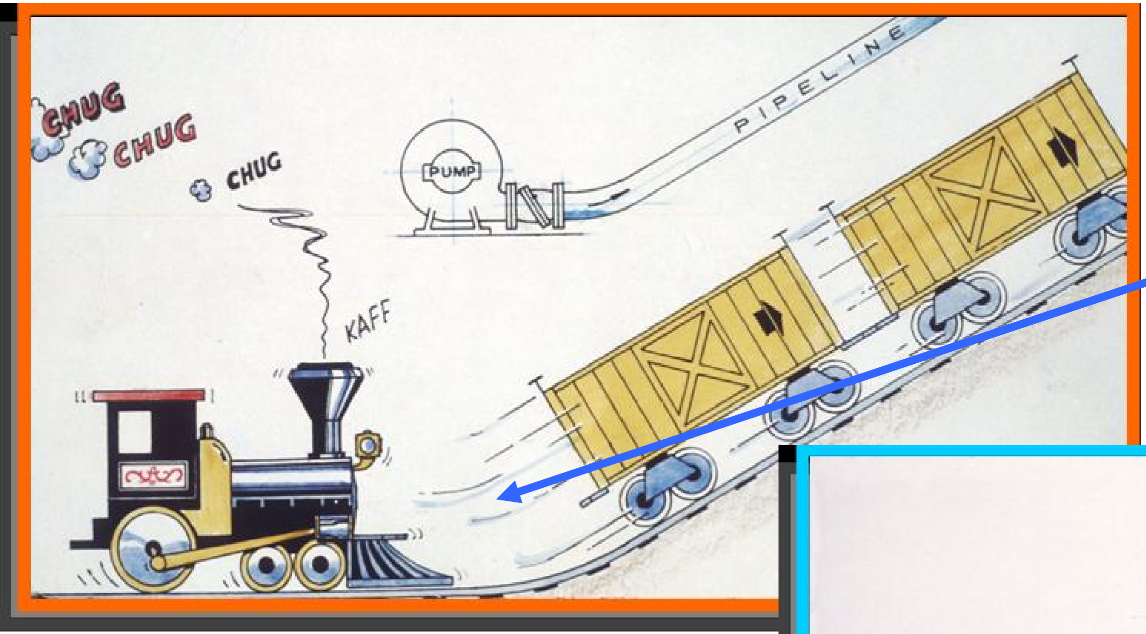
What happens when a valve shuts off?



What happens when a pump starts?



What happens when a pump stops?



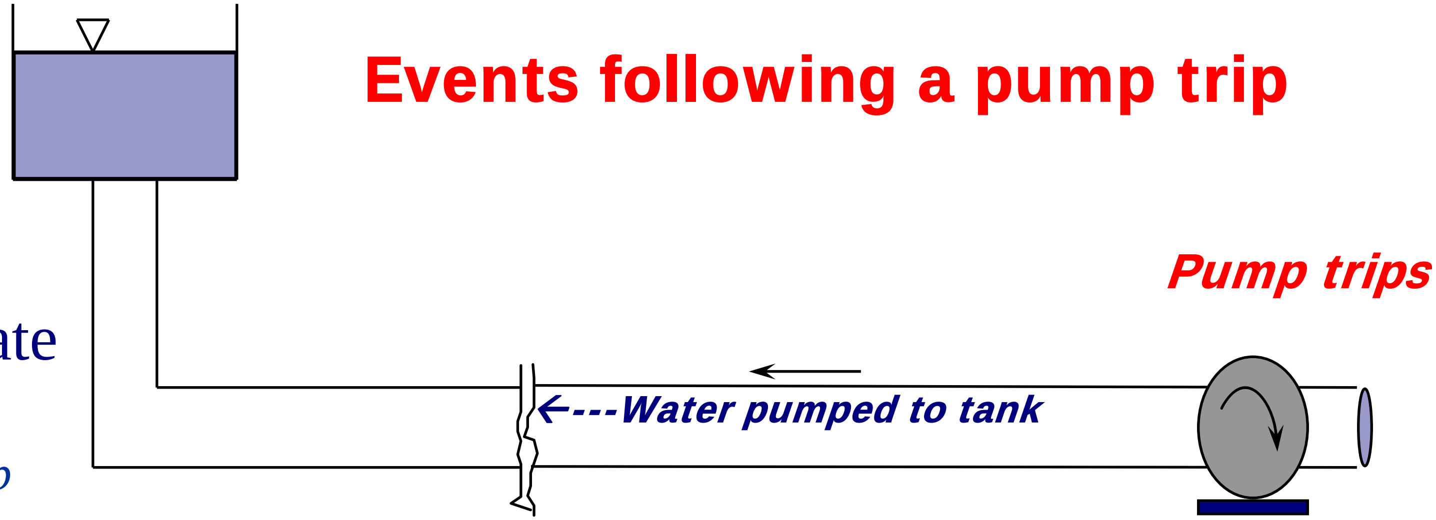
Low Pressure

High Pressure

What happens when a pump stops or a valve closes rapidly?

- UPSREAM:
  - Pressure rises
- DOWNSTREAM
  - Pressure drops
  - Water Column Separation
    - CAVITATION: (Vapor pocket created: -14.5 psi)
  - Flow reverses => water column rejoins.
  - Vapor pocket collapse, high pressure spikes.

Events following a pump trip



Steady state

Pump trip

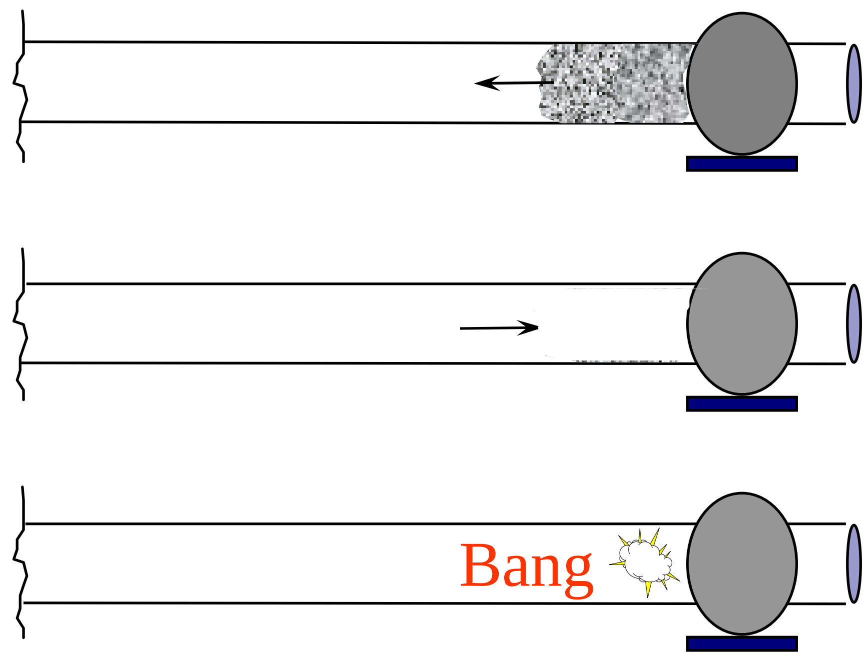
Formation of vapor cavity

Growth of vapor cavity

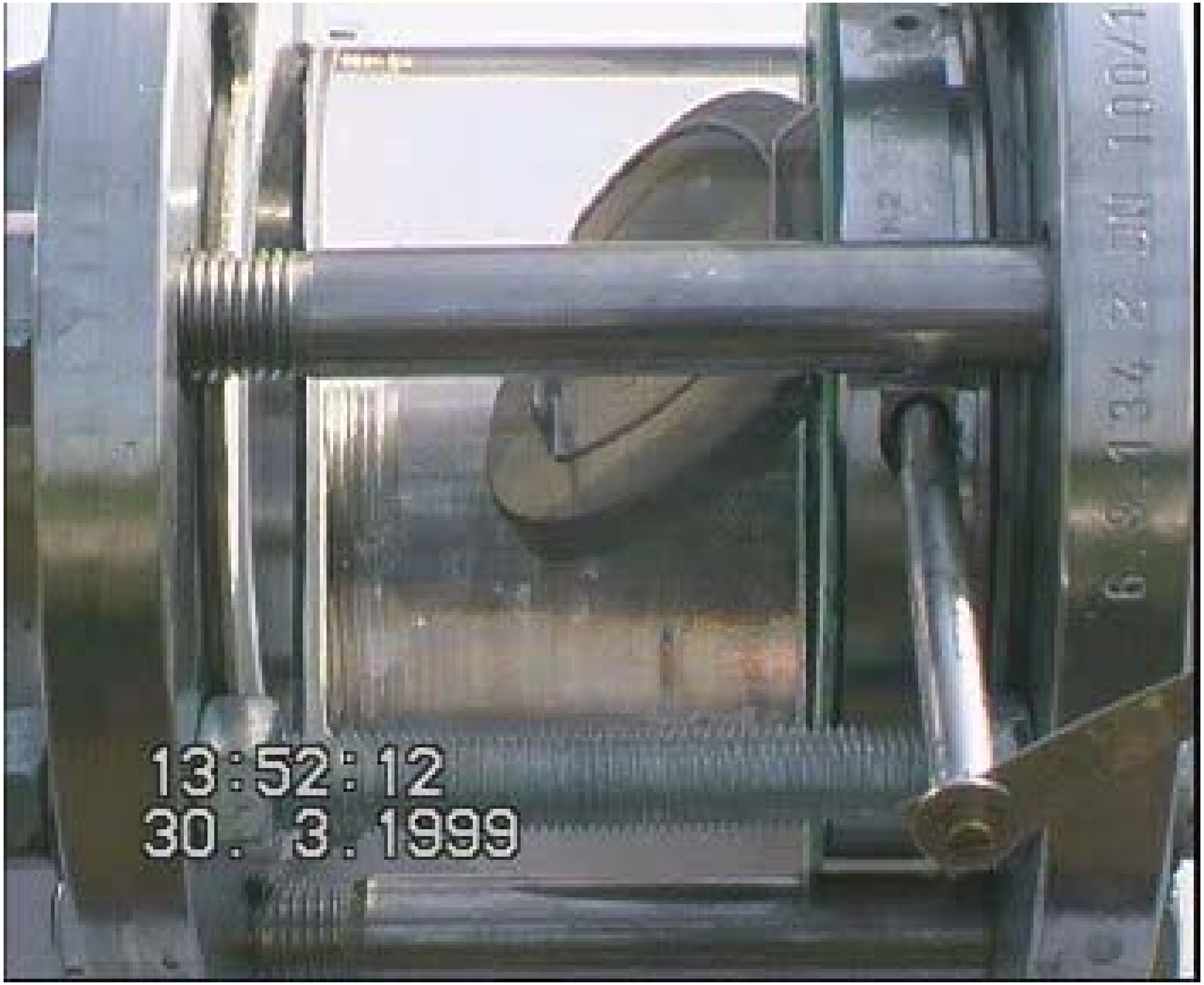
Flow reversal

Vapor cavity collapses

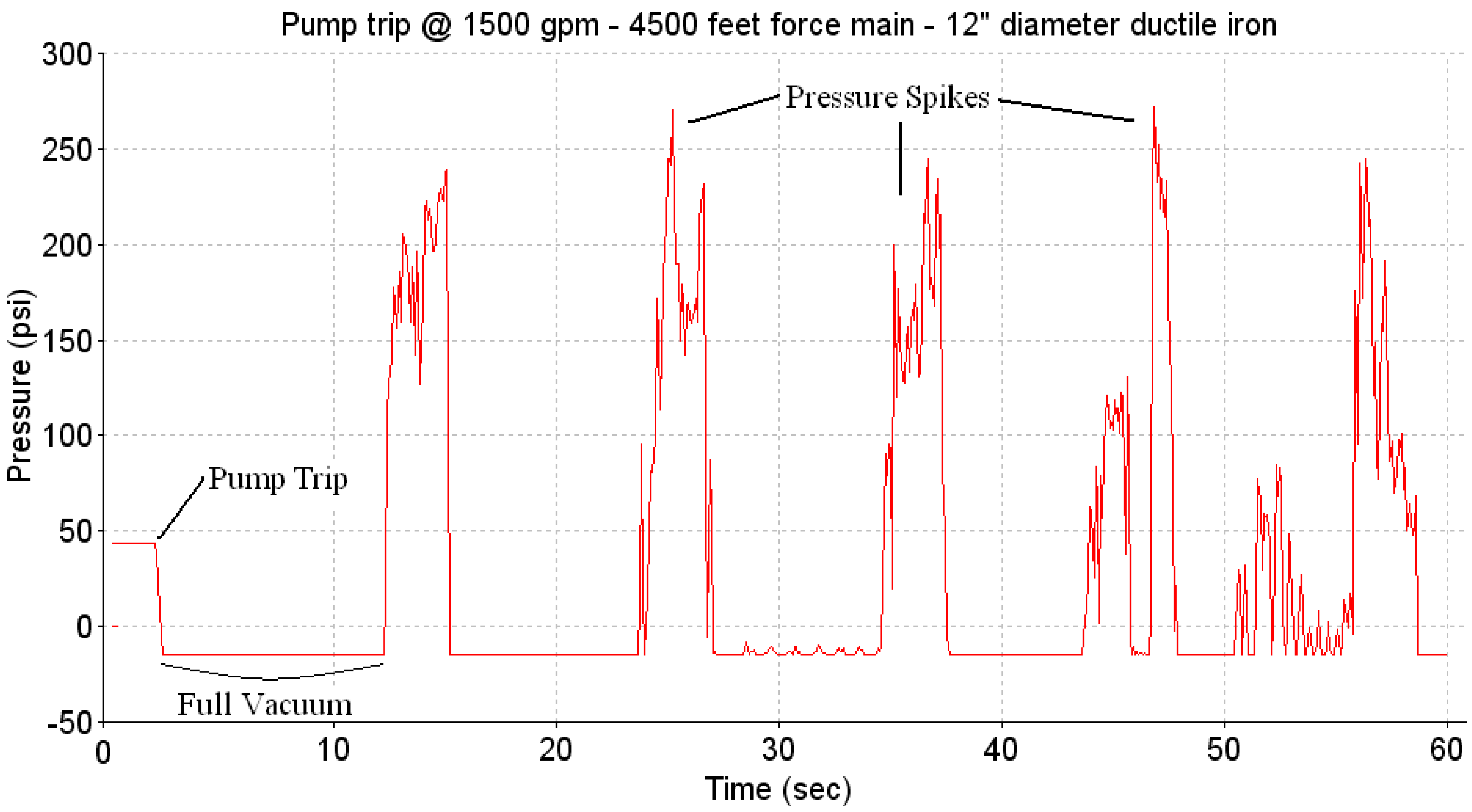
Pressure Spike



Pump trip - check valve



Surge pressures caused by a pump trip



Damaged valve at pump station

Two Types of Cavitation…

- *1 - Dynamic Cavitation*: On pump impeller
- *2 – Transient Cavitation*: Inside pipes

Dynamic Cavitation – Negative pressure on pump impeller

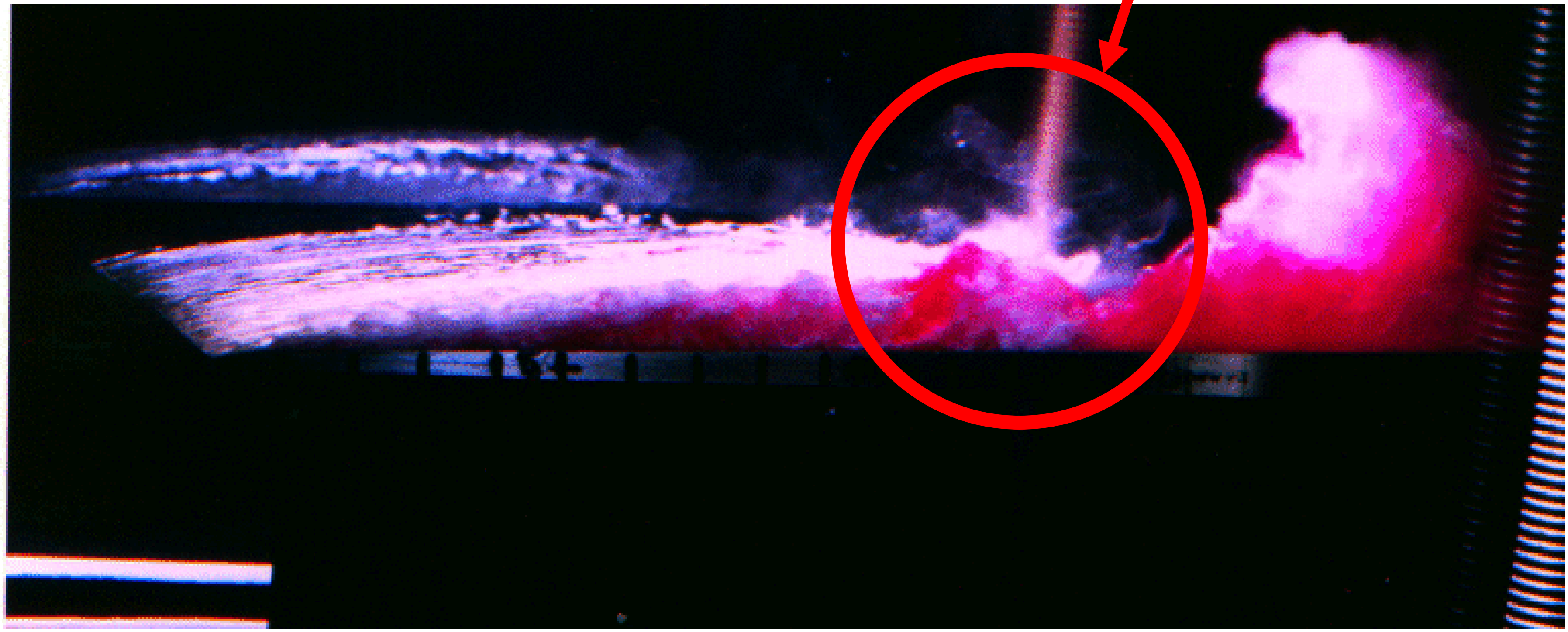
Vapor pocket collapse effects on pump impellers

If cavitation destroys pump impellers…

- What does cavitation do to pipes?

Cavitation inside pipes

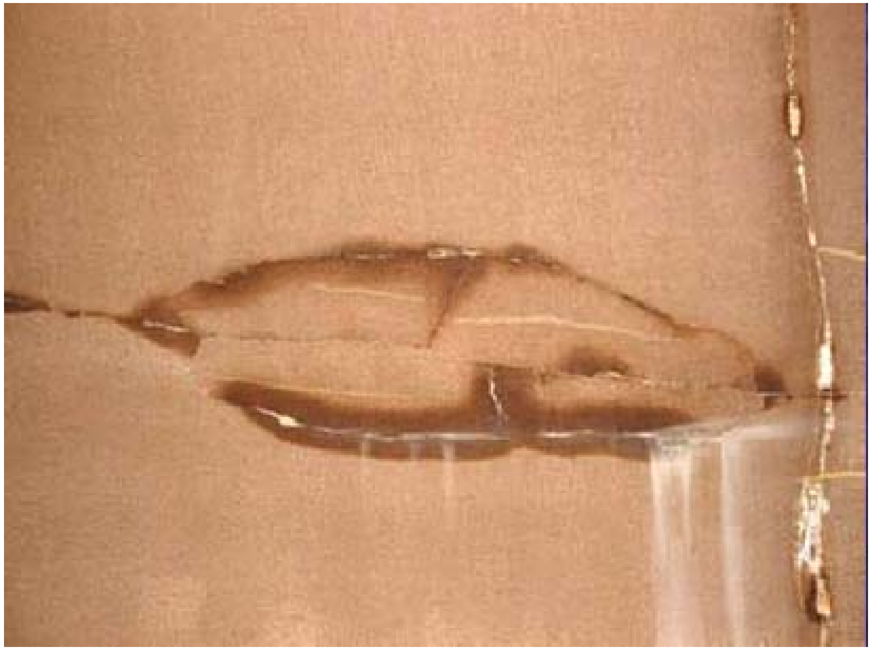
Vapor pocket collapses – HIGH PRESSURE

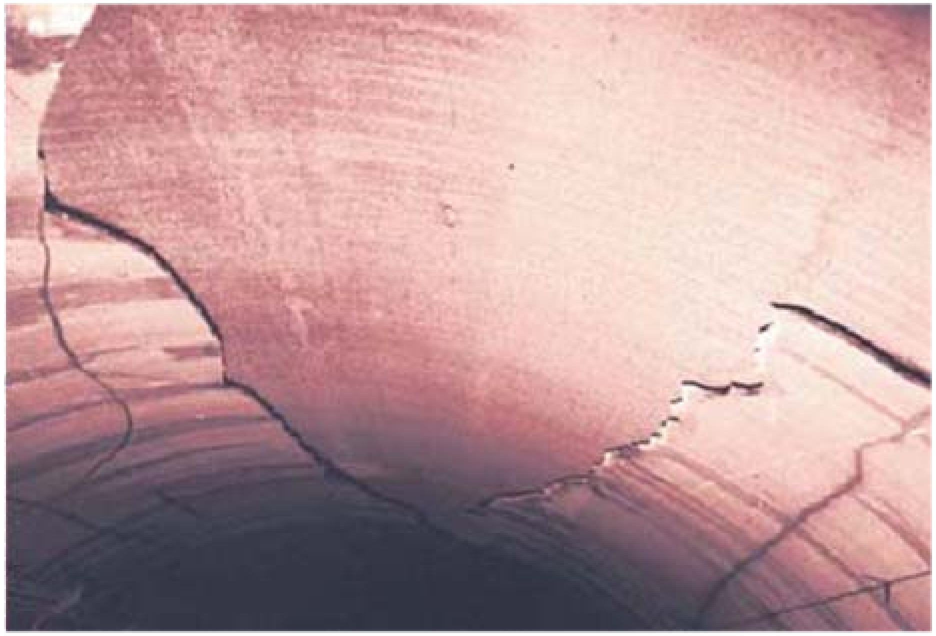


Cavitation inside pipes

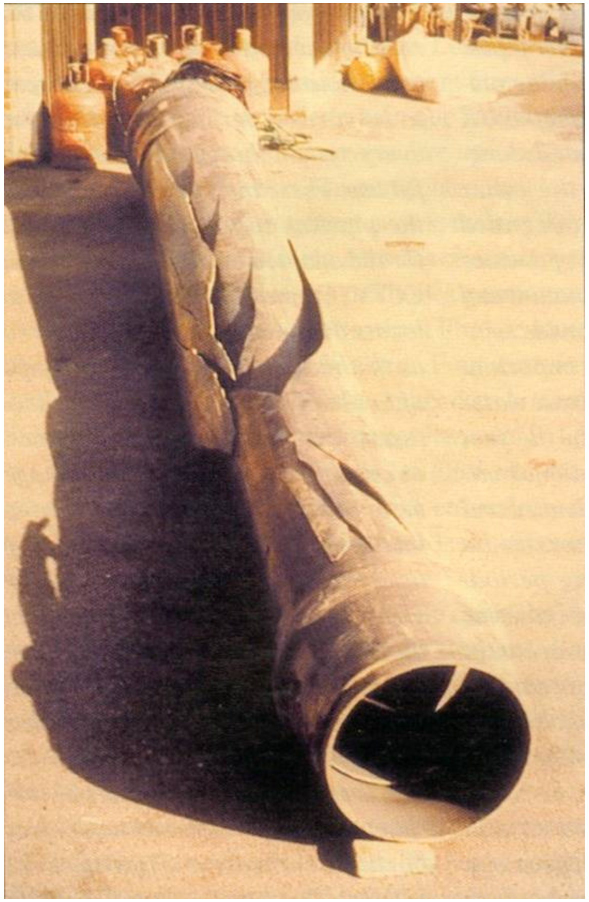
- Vapor Pocket Collapse
  - Erosion
  - Fatigue
  - Pipe Wall Becomes thinner
  - Pipe break

Pipe lining damaged by negative pressures





Pipe collapse



Costly repairs…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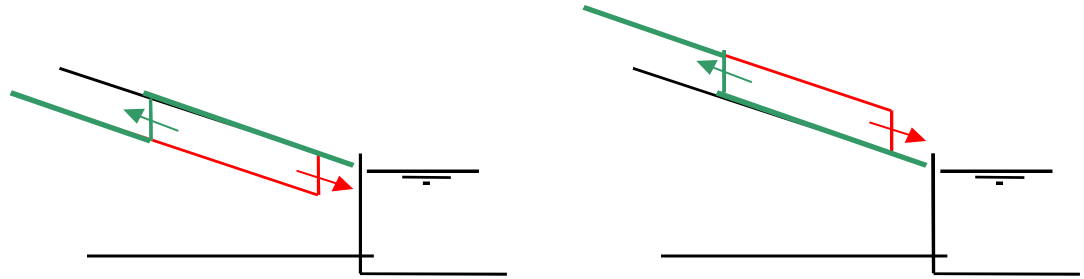
In summary, Pressure Waves…

- Origin: Rapid variation of flow velocity
- Pressure waves propagate in the system
  - Velocities up to 4500 fps
    - Velocity depends on pipe material/diameter/thickness
- High points in the system are more at risk
  - Most likely to reach cavitation at high point
  - Water column separation
- Pressure waves are reflected at the ends of the system

WAVE REFLECTION

Storage tank

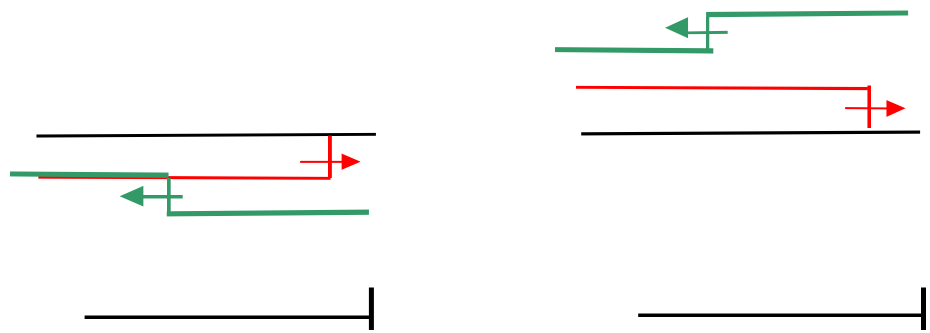
Same magnitude – opposite sign



Dead End

Same magnitude – same sign

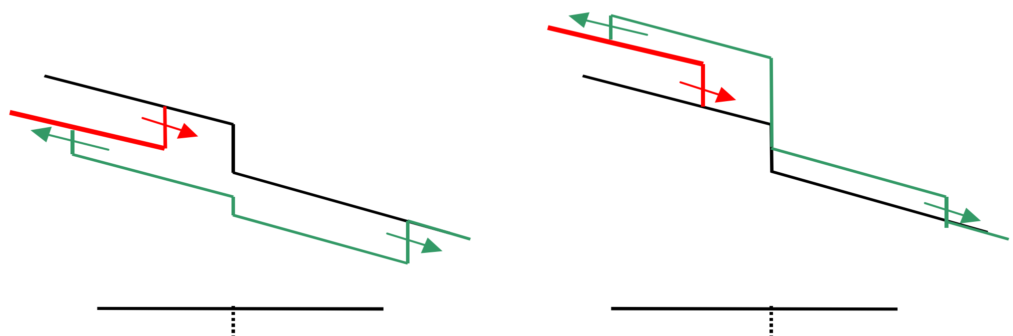
PRESSURE DOUBLES!!



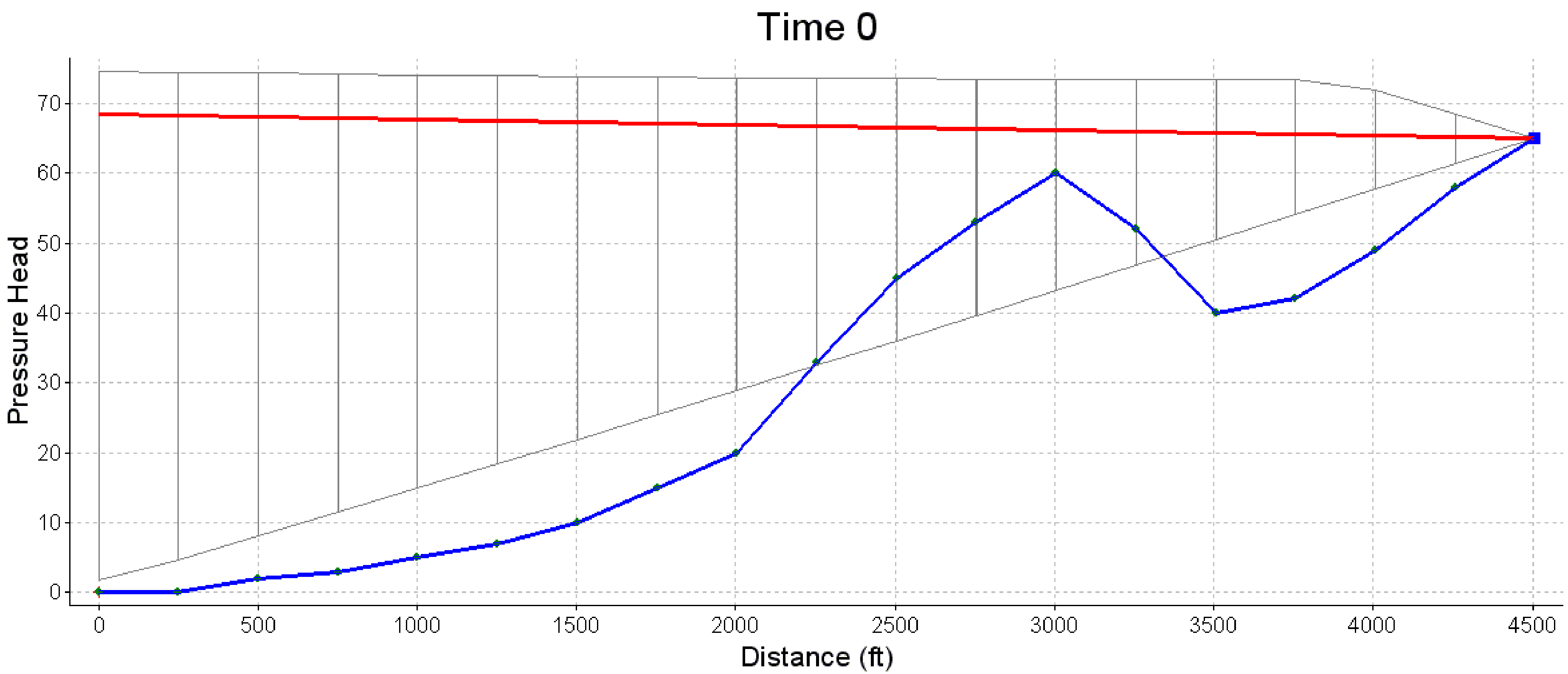
Local head loss

Part reflected back – same sign

Part keeps going – same sign



Software animation of pressure waves



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How to reduce water hammer?

- Flywheel
- Vacuum/air release valve combinations
- Surge anticipation valve
- Variable Frequency Drive (VFD)
- Stand pipe
- Bypass check valve
- Surge vessel

Flywheel

- Increase rotating inertia of the pump with a flywheel
  - Increases energy requirements
- Can’t be used on submersible pumps
- Accurate balance of the wheel

Vacuum Breaker

- May be required as little as every 500ft
- Require high maintenance
- Reaction time (delay to fully open)
- Large volume of air admitted in the pipe

Surge anticipation valve

- Surge anticipation valve
  - Good to relieve high pressure
  - Ineffective against low pressure

Variable Frequency Drive (VFD)

- Great for normal operation
  - Controlled pump startup
  - Controlled pump shutdown

- Ineffective during power failure

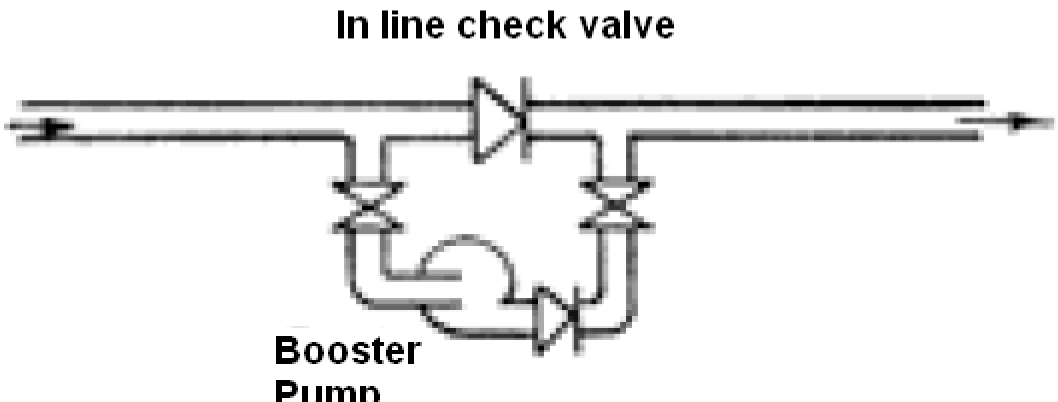
Stand Pipe

- Large structure
  - Needs to be taller than the maximum head
  - Expensive solution

Stand Pipe

Bypass check valve

- Needs positive pressure upstream to provide energy
- Simple for overcoming negative pressures
- Does not provide protection for positive pressures



Surge vessel

•<u>Advantages:</u>

Energy Free
Give and receive energy
Low maintenance

NEEDS TO BE SIZED PROPERLY with computer software

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CHARLATTE AMERICA FAYAT GROUP HYDRAULIC VESSEL DIVISION

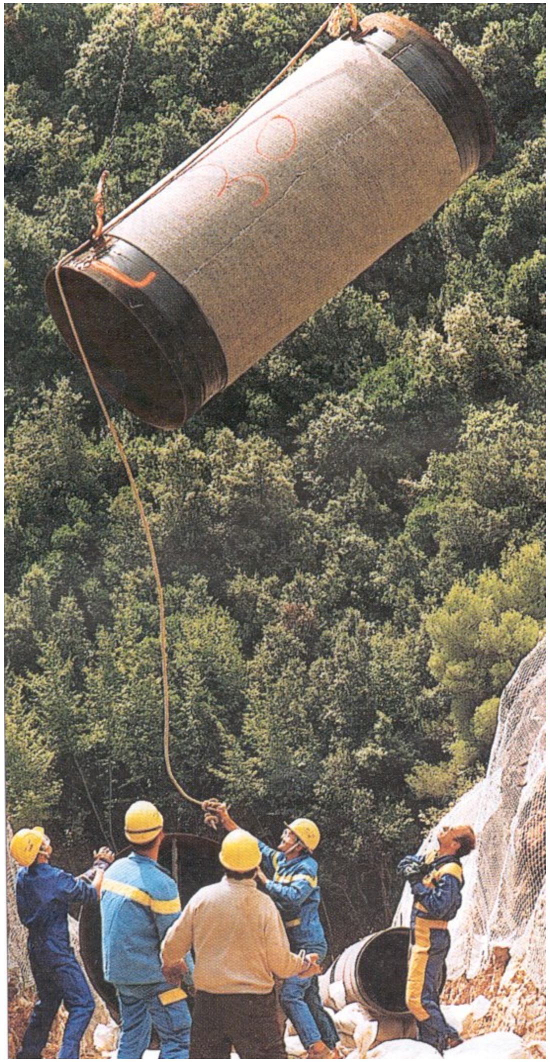
Information required to do a surge analysis

- Existing Hydraulic Model
  - EPAnet file export => KYpipe

- Hydraulic Information About the System
  - Detailed profile of the pipe
  - Maximum and Minimum allowed pressures
  - Maximum Flow Rate
  - Pipe characteristics (diameter/material)

Welded Steel Pipe

- Allowed negative pressure
  - -10.0 psig
- Speed of pressure waves
  - 1600 fps



Concrete

- Allowed negative pressure
  - 0 to -10.0 psig (depending on seals technology)
- Speed of pressure waves
  - 1800 fps

Pre-Stressed Concrete

- Allowed Negative Pressure: 0 psig
- Speed of pressure wave: 1800 fps

HDPE – Thermo-Welded

- Allowed negative pressure
  - -10.0 psig
- Speed of pressure waves
  - 800 fps

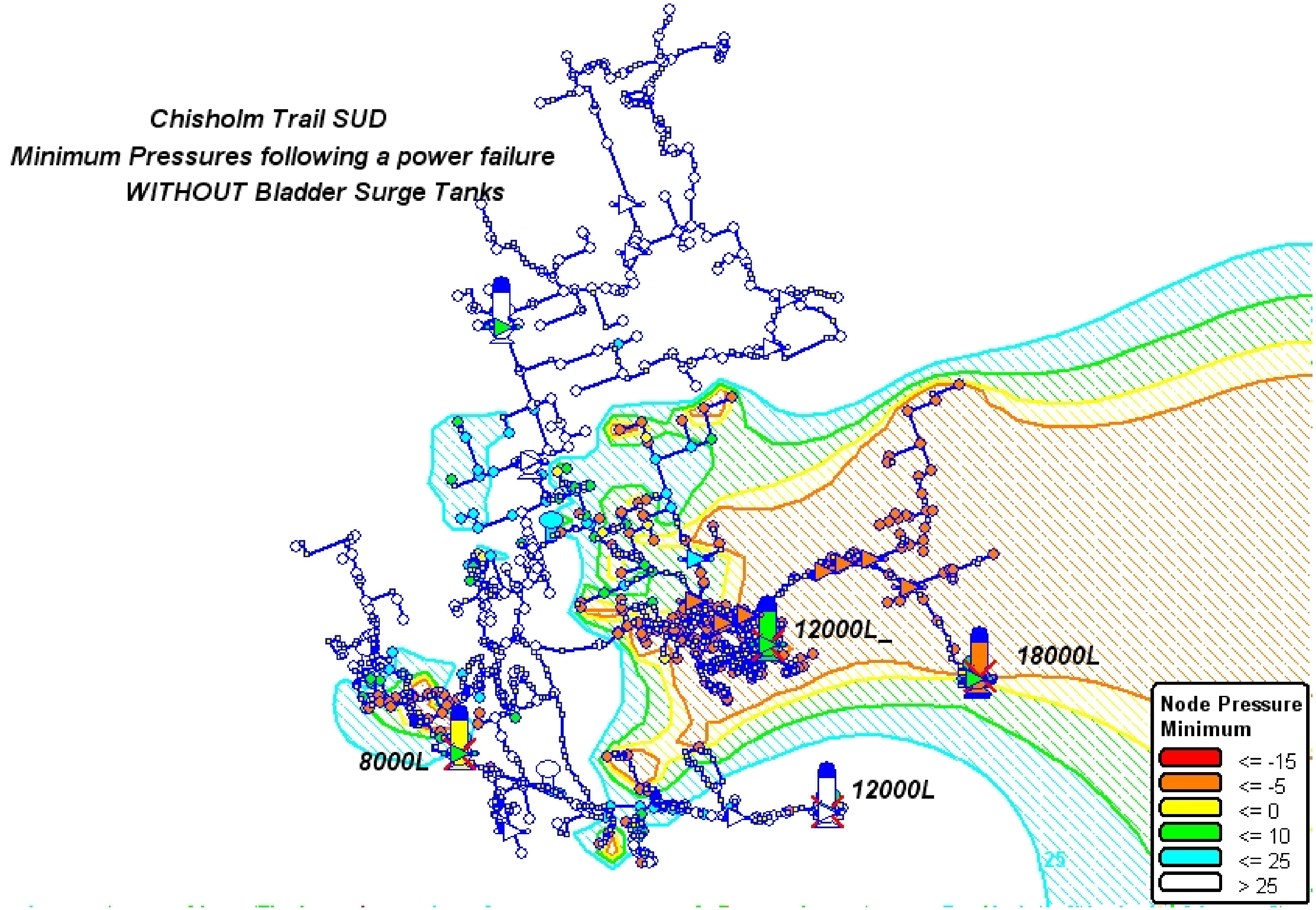
PVC Pipe

- Allowed negative pressure
  - 0 to -3.0 psig
- Speed of pressure waves
  - 700 fps

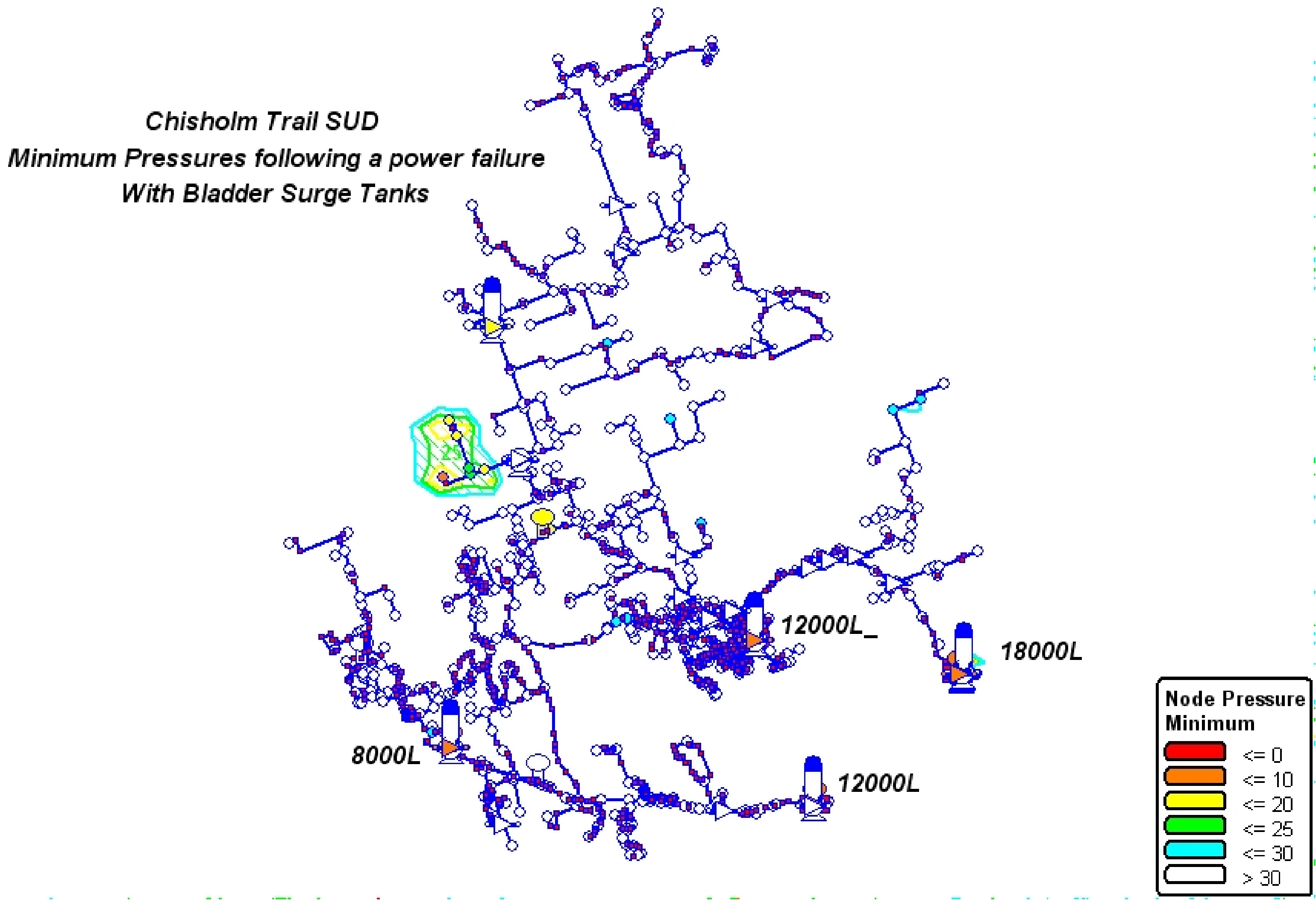
Ductile Iron Pipe

- Allowed negative pressure
  - -6.0 psig
- Speed of pressure waves
  - 4500 fps

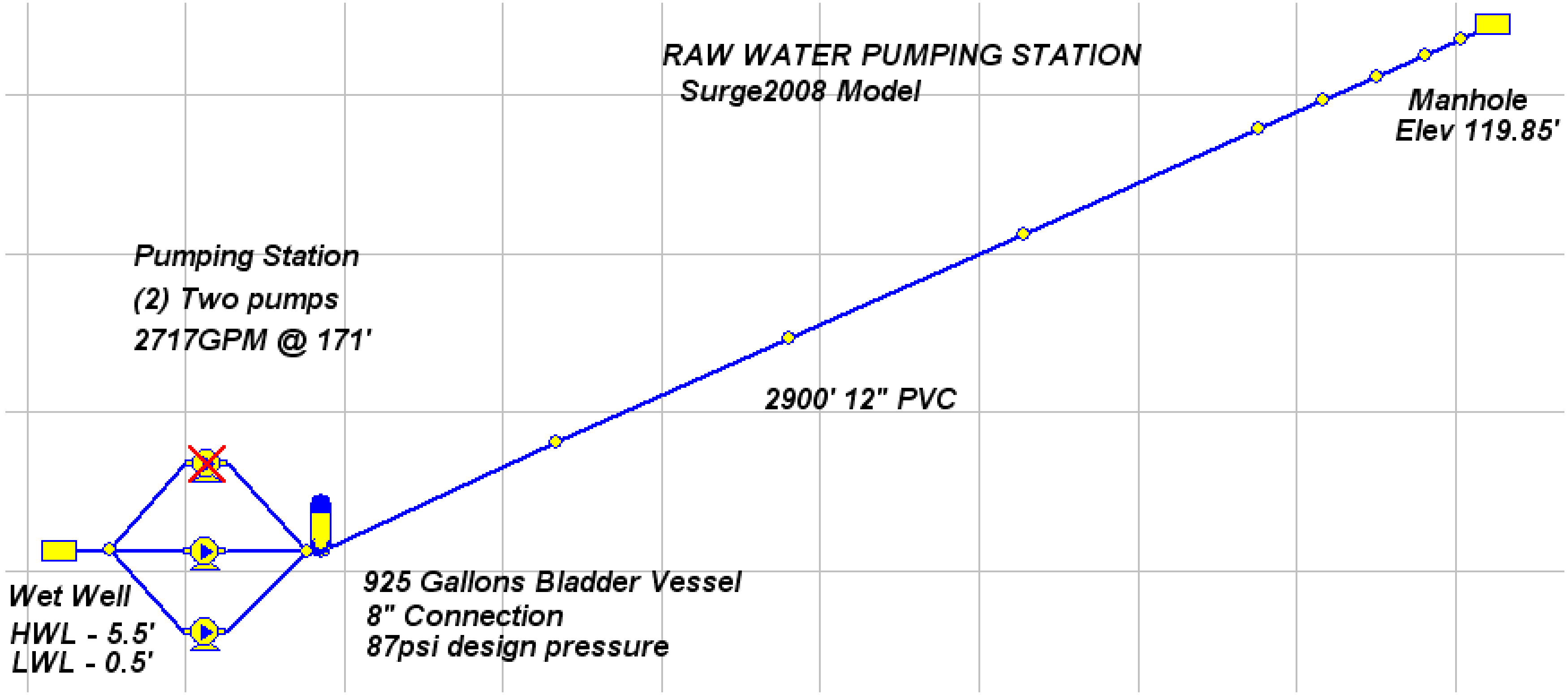
KYpipe model of potable water distribution system



KYpipe model of potable water distribution system



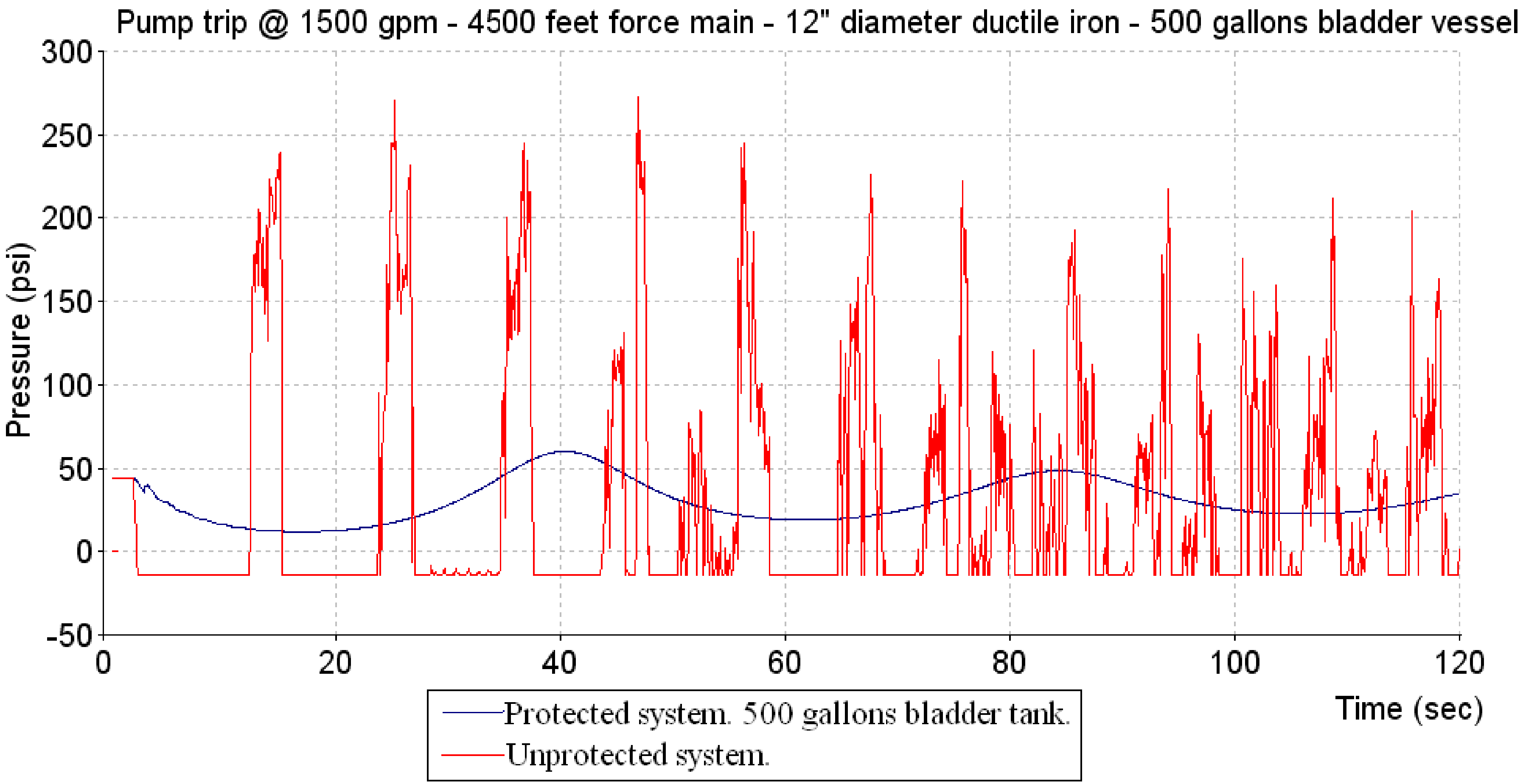
KYpipe model of Waste Water system



Sizing a surge tank with KYPIPE

- Model will help determine the required surge tank's…
  - Volume
  - Design pressure
  - Outlet diameter
  - Precharge pressure

Surge pressures resulting from a pump trip – with and without surge tank



HYDROPNEUMATIC VESSELS

SURGE PROTECTION
PRESSURE REGULATION
PUMP CYCLE CONTROL

COMPRESSOR TYPE

OR

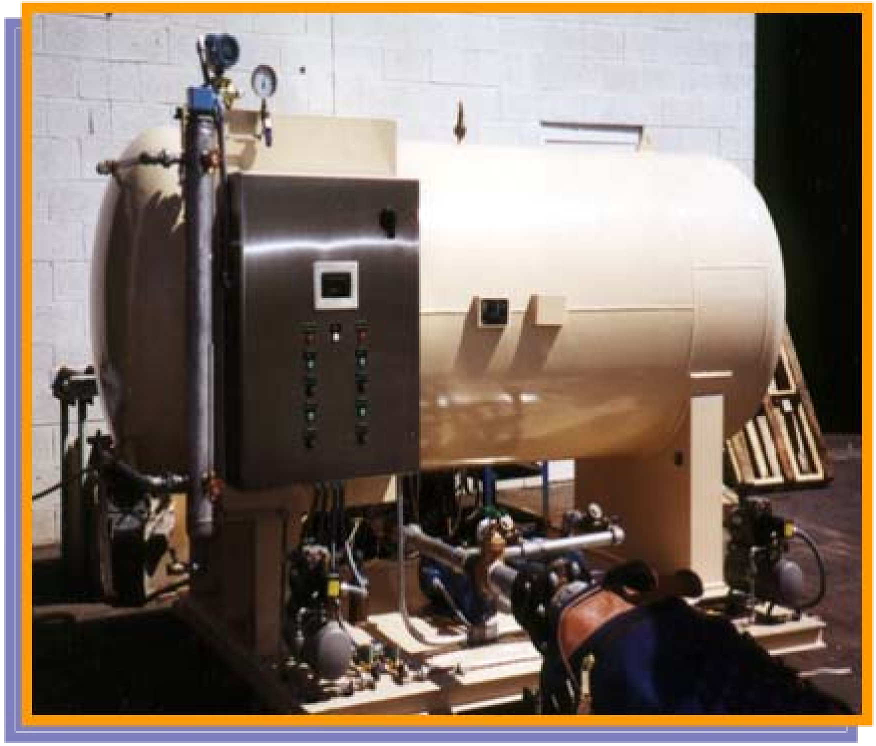
BLADDER TYPE

COMPRESSOR VESSELS

Achieve their balance through a complicated system of controls.

- **Air Receivers**
- **Solenoid valves**
- **Measuring Probes**
- **Compressor**
- **Control Panel**

All these require constant maintenance, otherwise the system is not protected against water hammer.



The permanent dissolution of air into the water will eventually reappear elsewhere in the system.

$$$$$$$$$$$$$$$$$$

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BLADDER VESSELS

Hydraulically work the same as compressor tanks.

The major differences are…

- Precharge air is permanently contained within the vessel.

- Air doesn't dissolve in the liquid

NO NEED FOR COMPRESSOR

STAND ALONE SYSTEM

LOW MAINTENANCE

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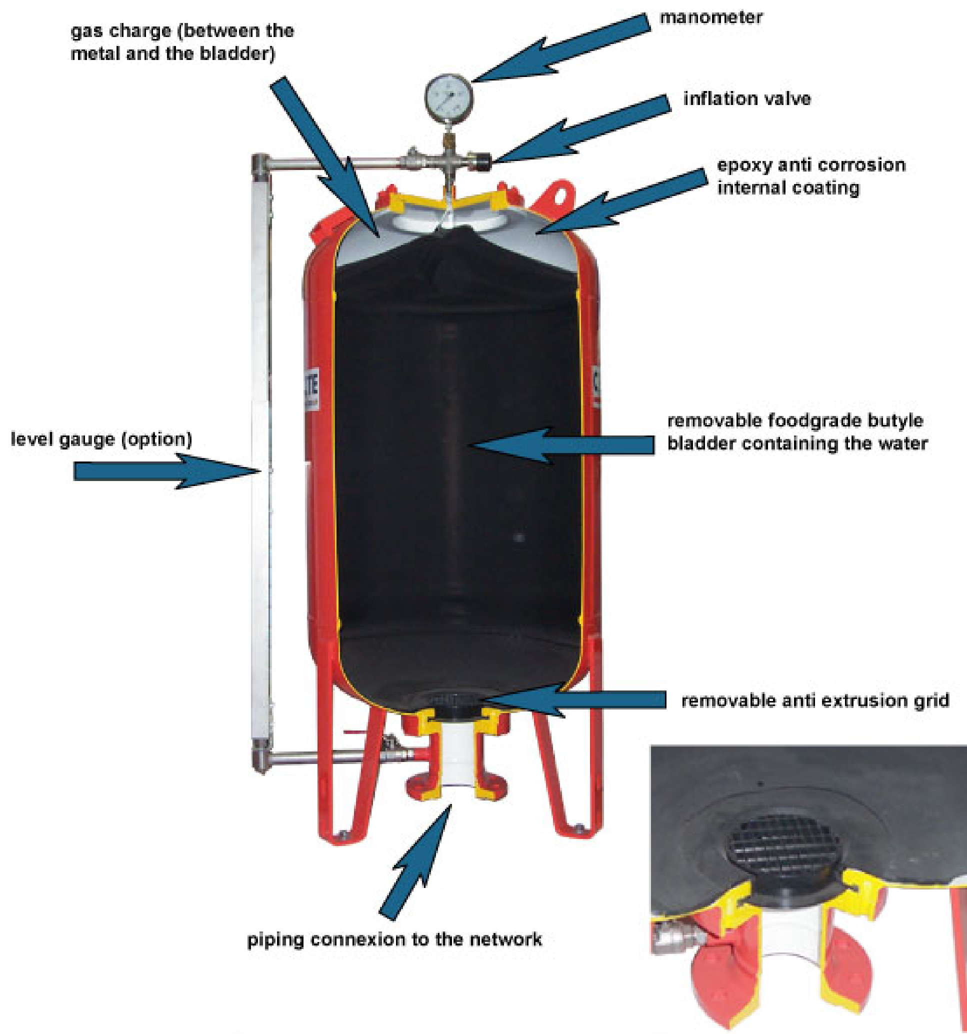
- Liquid contained within a rubber bladder.

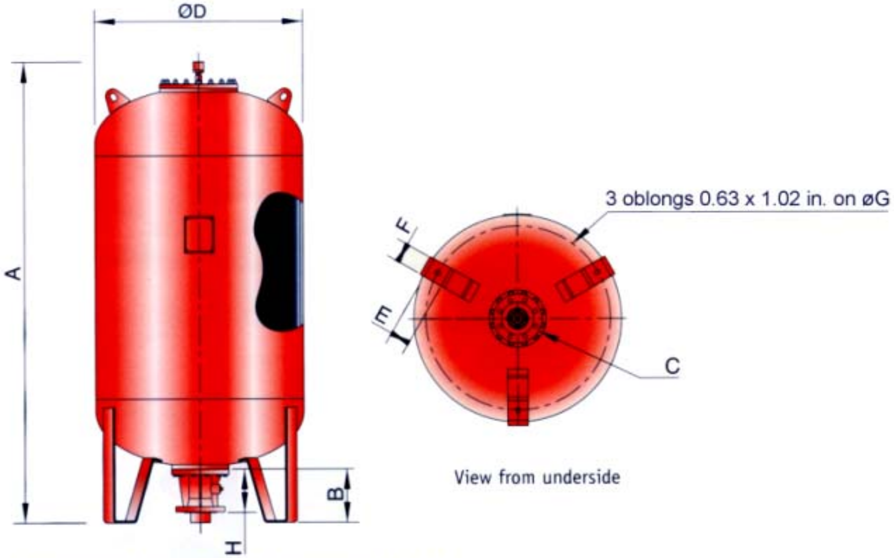
- Bladder acts as a barrier between the gas and the liquid

- Predetermined precharge (air or nitrogen) is trapped between the shell and the bladder.

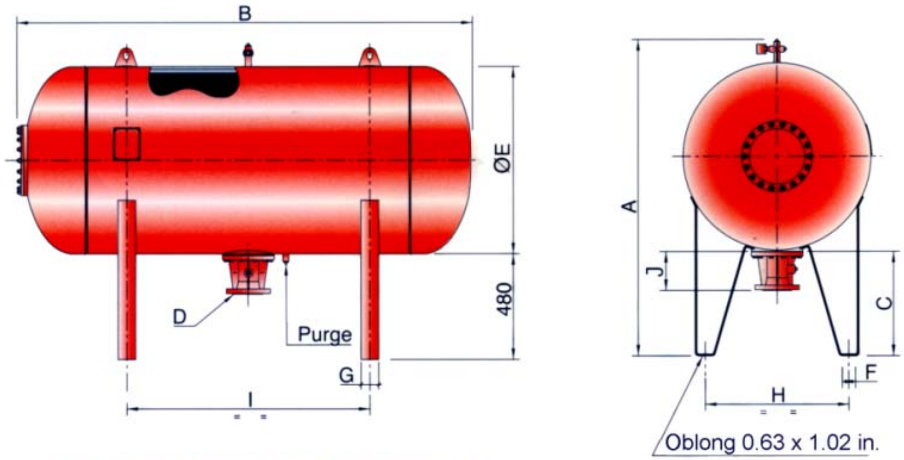
- Anti-extrusion grid



Foodgrade butyle bladder surge vessel

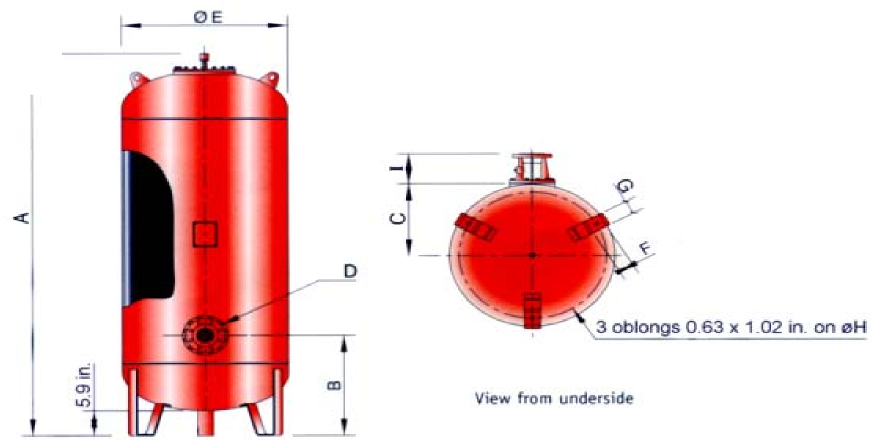


The height of the outlet from the ground = B - H



The height of the outlet from the ground = C - J

Left side view



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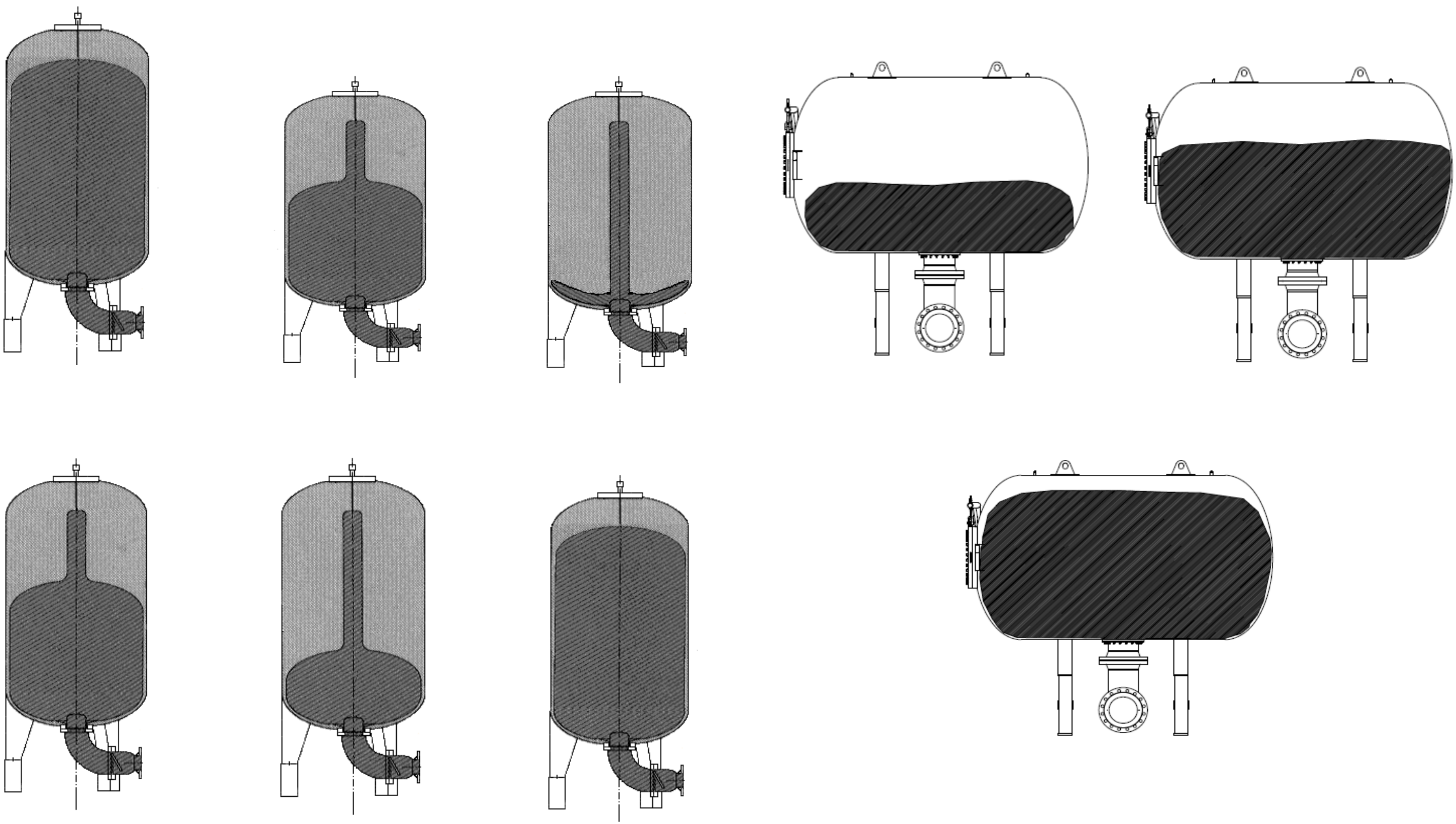

In waste water the bladder is inverted and connected to the top of the vessel.

The precharge is contained inside the bladder. By allowing the sewage to be contained inside the vessel and only using vertical configurations one can control the problems of sedimentation.

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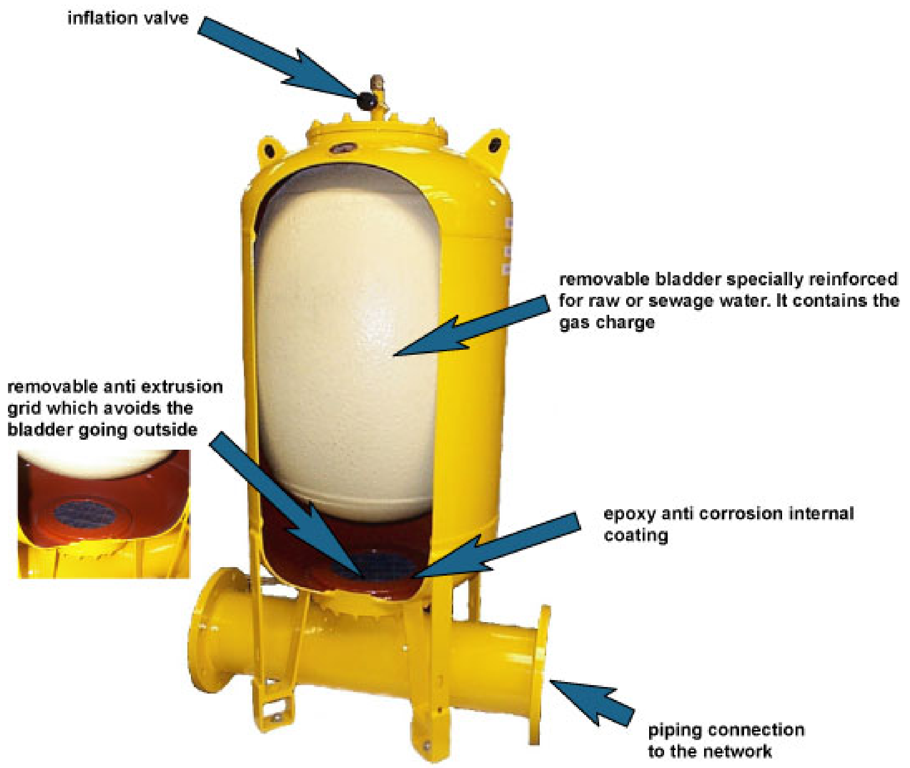

Reinforced bladder waste water surge vessel

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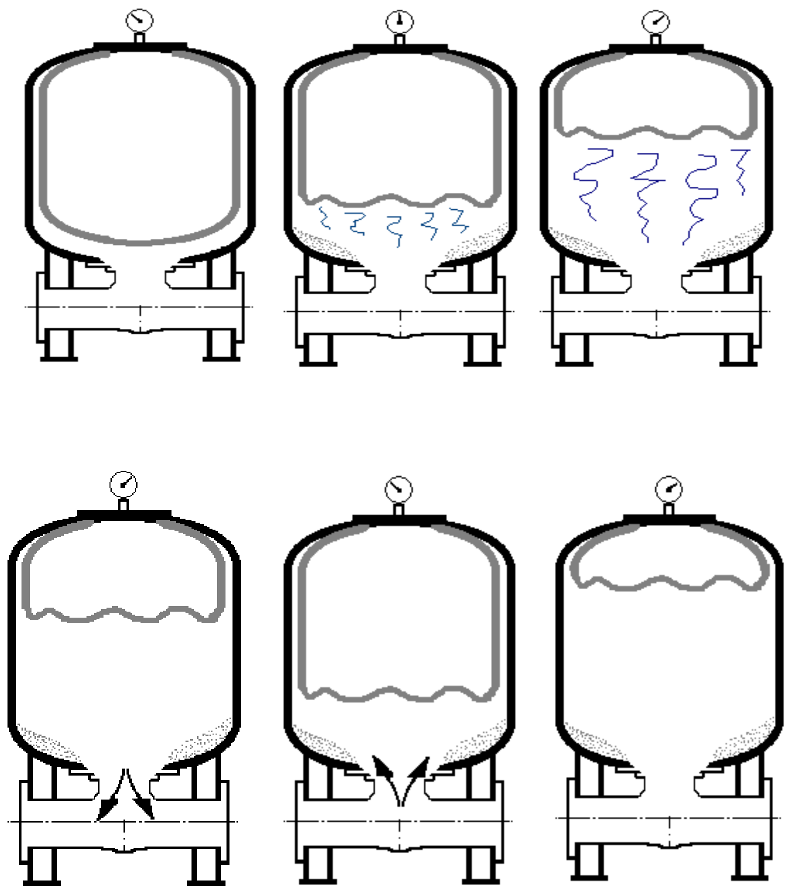
E.U.V.
Waste Water

- Vertical only due to sedimentation
- Head Losses and sedimentation build up are calculated in outlet design
- Tee, 90 degree and bottom outlets
- Range: 50 to 15,000 gallons.
- 10 to 15 year life expectancy for bladders.
- Warranty directly related to Charlatte’s involvement in sizing vessel.
- Load Cell monitoring



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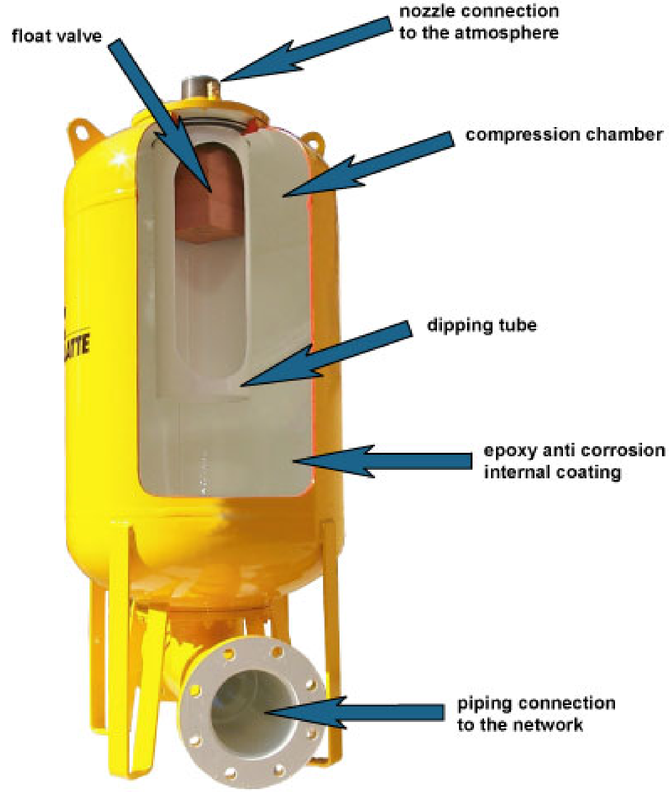

Automatic air regulation surge vessel (ARAA)
Waste water

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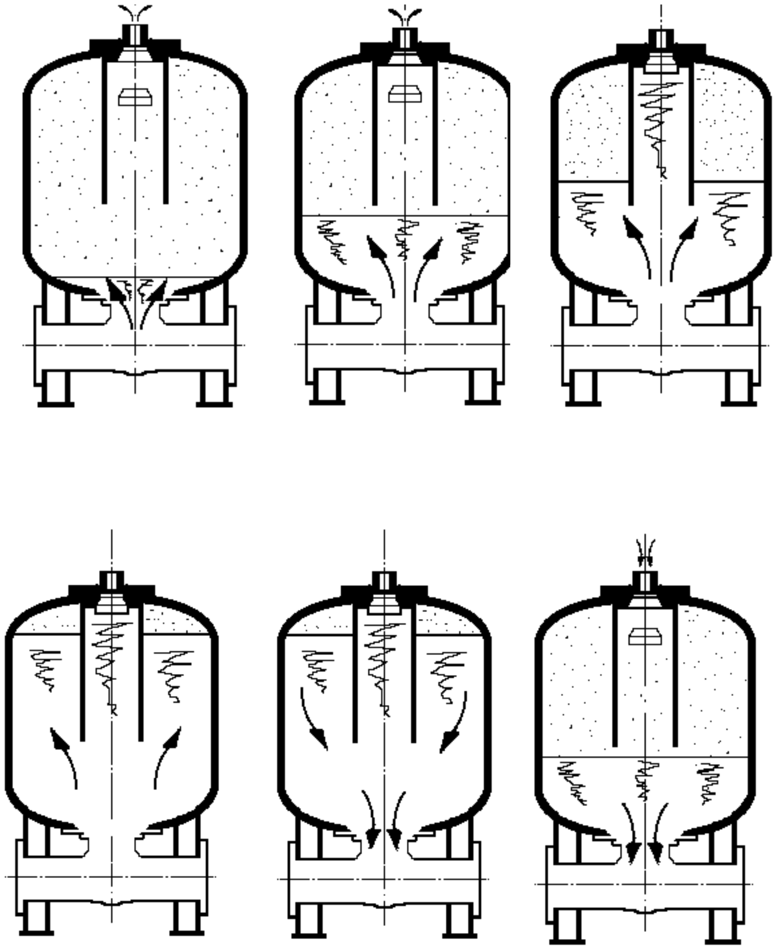
ARAA
Waste Water



- When it is possible a good solution is to use external atmospheric energy and feed the system with atmospheric air, using limitless amounts of free energy. This job is perfectly achieved by the A.R.A.A. vessel, without any air bubbles being introduced into the pipe work.
- As these flat profiles are frequent in sewage systems, the design of the device is adapted to raw water and effluents. They have been successfully used for over ten years from 50 gallons up to 25,000 gallons.

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MANUFACTURING

NSF

NB

ASME International

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Surge tank not properly welded

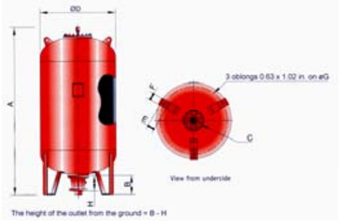
Tank Leg Design

CHARLATTE - Not Charlatte

COATING AND TESTING BLADDERS

EUV WASTE WATER BLADDER

POTABLE WATER BLADDER



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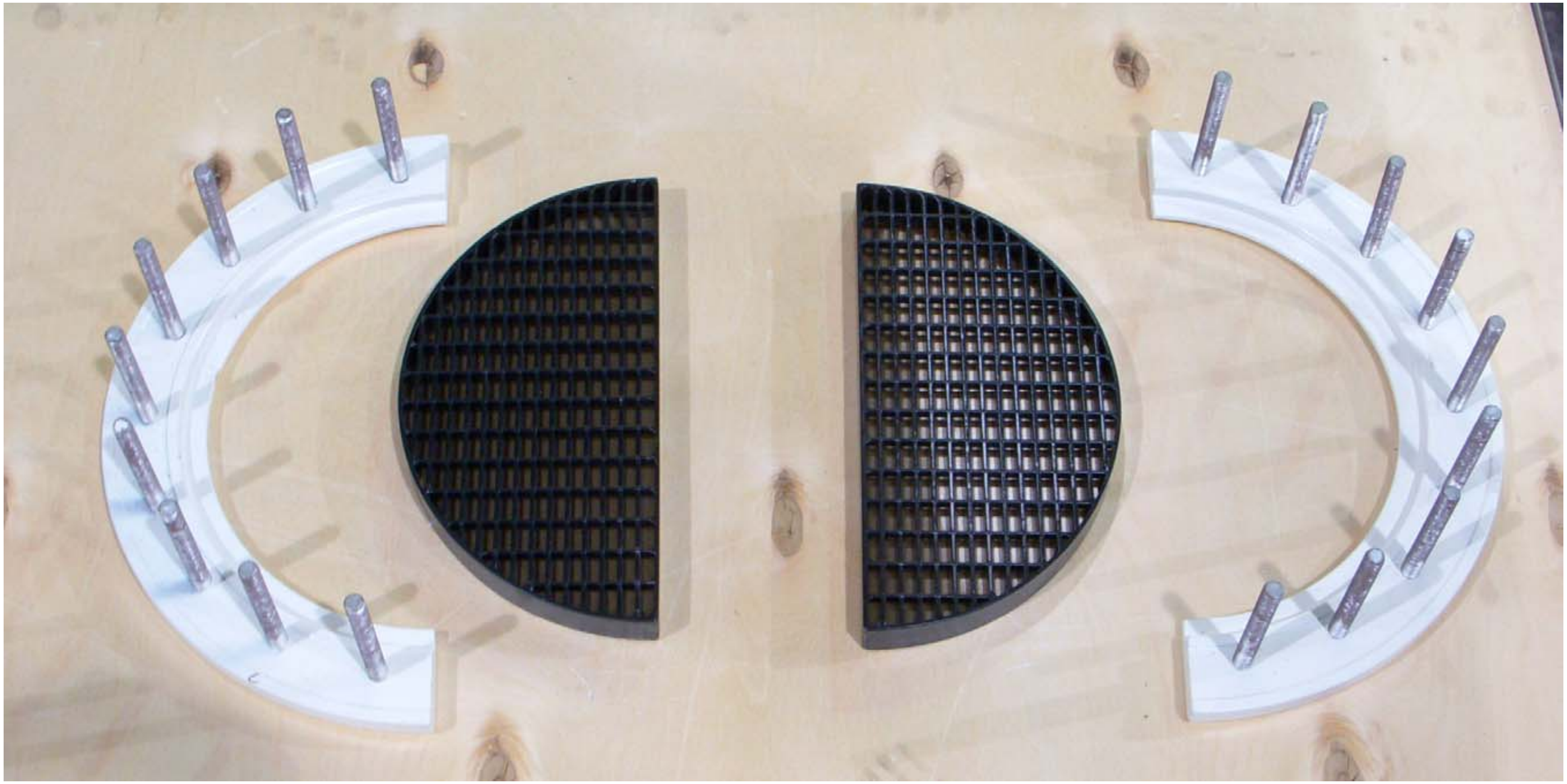
Hydrochoc 30,000 gallon potable bladder surge vessel Chicago

Anti-extrusion grid and bladder clamping system



Outlets 8” dia. and above

BLADDER TYPE VESSELS

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4 x 25,000 gallons

Clear Water
Bladder Tanks

150 psi design pressure

10’ dia. X 55’ Length

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SURGE VESSELS IN SERVICE

TAZEWELL COUNTY PSA
TAZEWELL COUNTY, VIRGINIA.
2x400 GALLON
POTABLE WATER BLADDER VESSELS.

CITY OF FAIRVIEW OREGON.

2x528 GALLON WASTE WATER BLADDER SURGE VESSELS.

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2x20,000 GALLON BLADDER SURGE VESSELS.

VERTICAL 3x18,000 GAL

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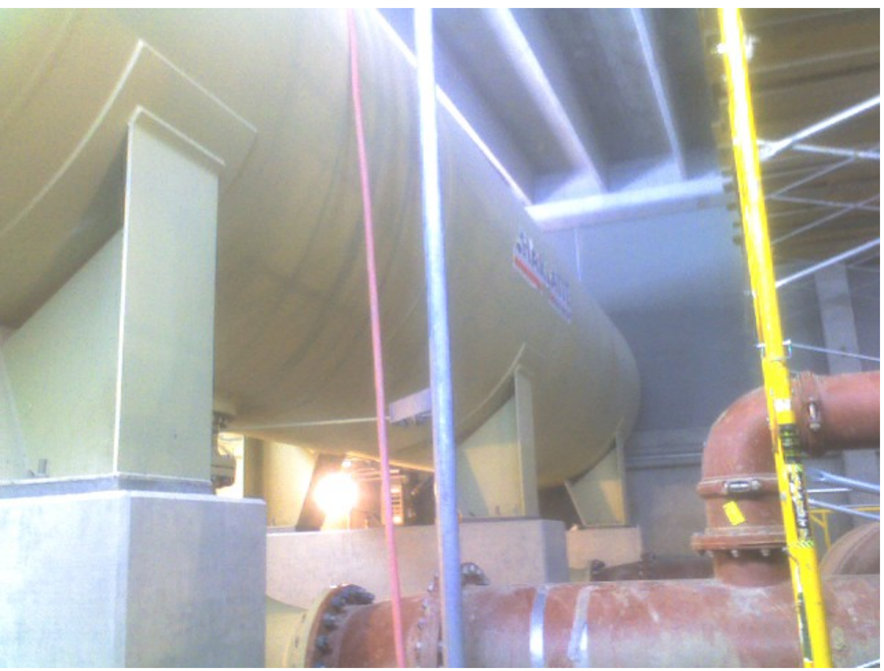
Hydrochoc 22,500 gallon 150 psi bladder type surge vessels Omaha Nebraska.

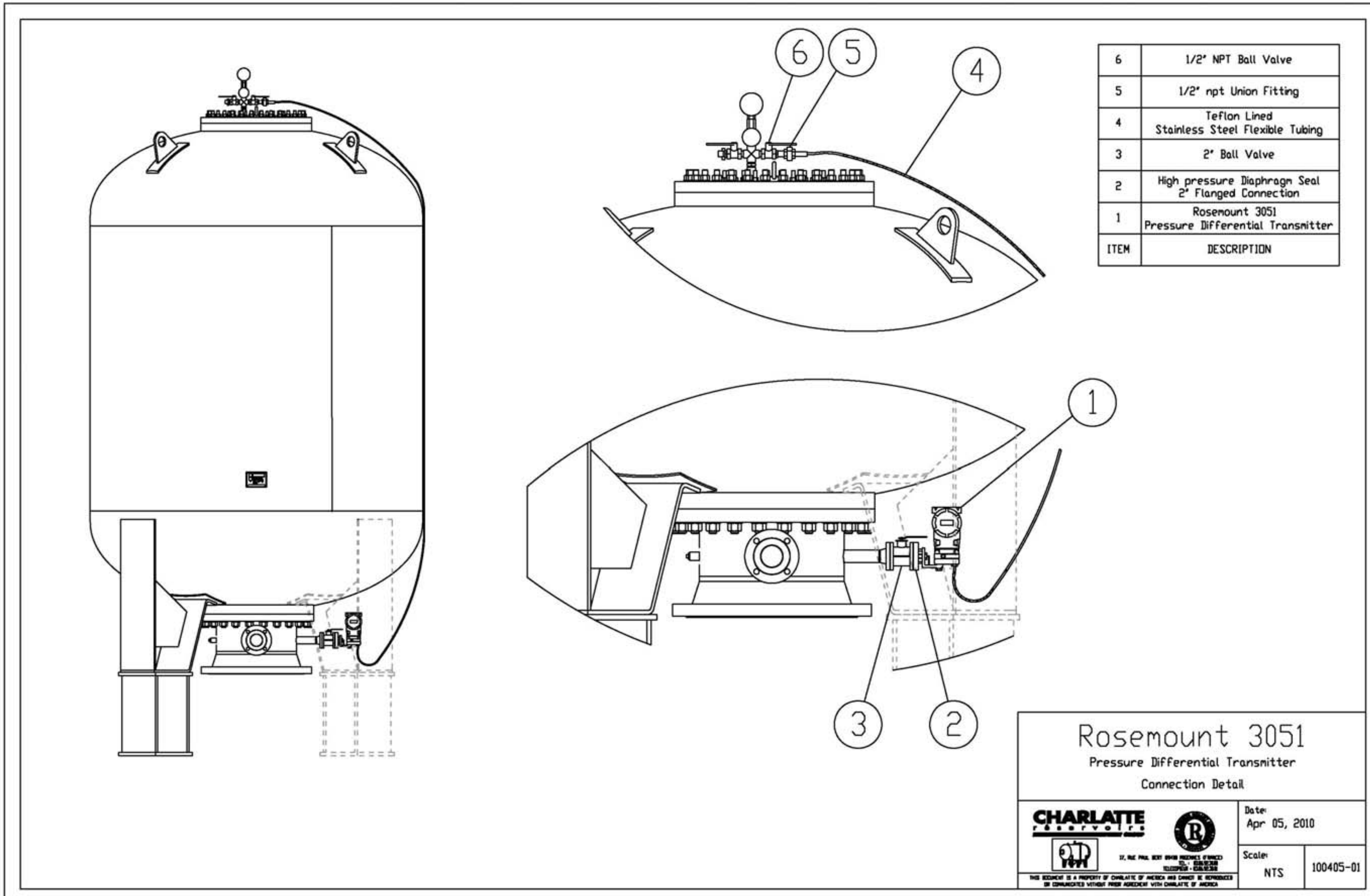


2 Hydrochoc 10,000 gallon 250 psi bladder type surge vessels Ontario Canada.

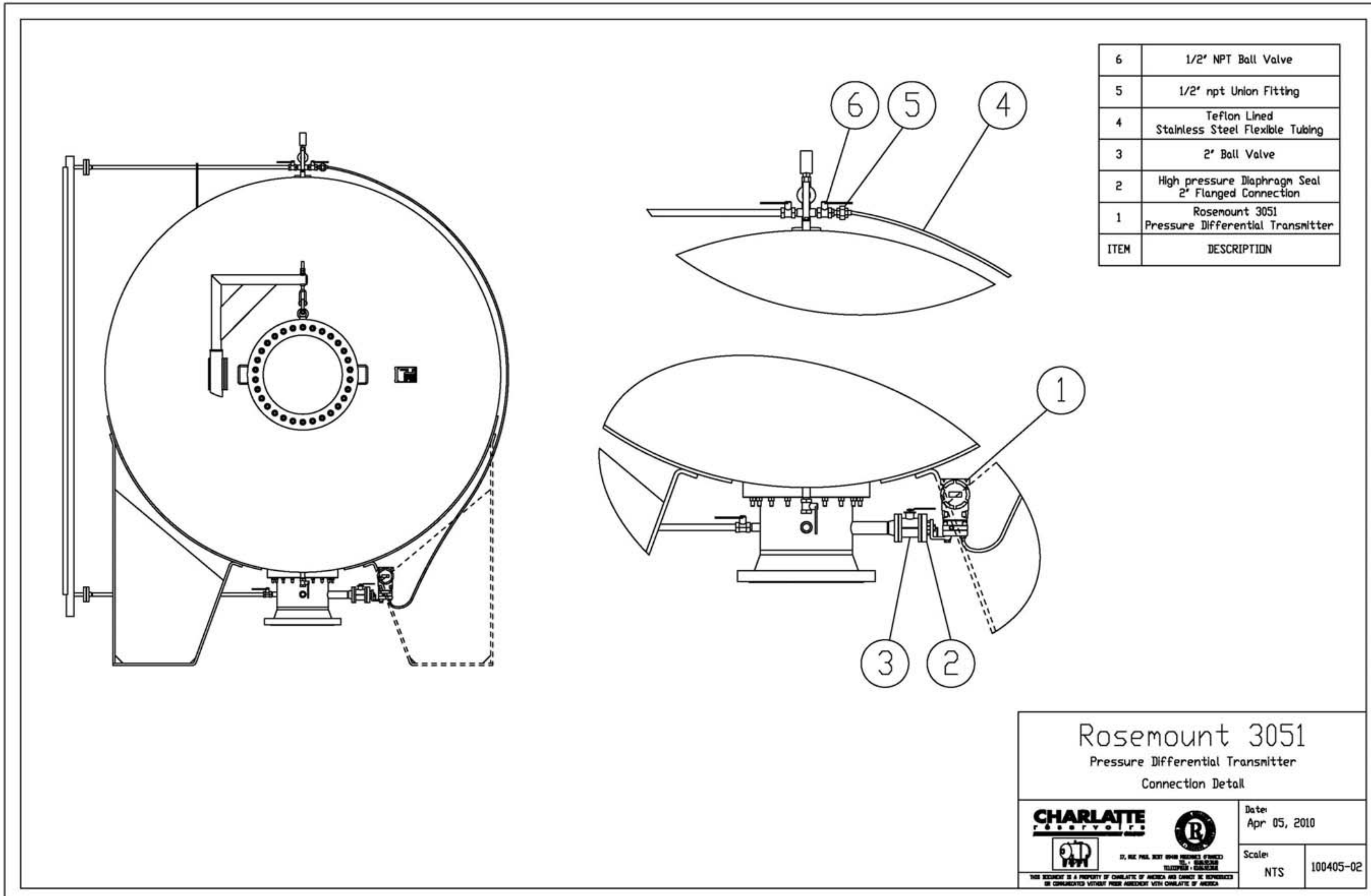
1,050 gallons Hydrofort Vessel in Kuai, Hawaii

-Pump Cycle control tank.
-Magnetic Level Gauge controls the pumps.

LEVEL MONITORING SYSTEM



LEVEL MONITORING SYSTEM



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EUV 3x10,000 gallon 450psi Raw water inverted bladder surge vessels

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Hydrofort 7925 gallon bladder type hydro vessel Florida

EUV 2641 gallon inverted bladder for wastewater Georgia.

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8 x 26,500 gallons compressor tanks – Abu Dhabi

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