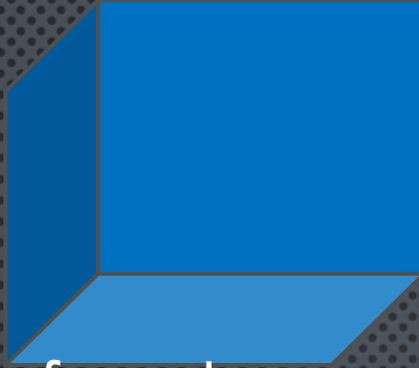


PRESSURE

A QUICK REVIEW



One Cubic foot of water contains _____ gallons of water at a weight of _____ lbs/gallon or _____ lbs/ft³

If you divide 62.4 by 1 square foot of surface area in inches (144) you arrive at .433psi per foot of water

$$1 \text{ psi} = 2.31 \text{ ft} \quad (1 \div .433)$$

A tank with 120 feet of water has a pressure of 52psi

$$120 \div 2.31 = 52 \text{ psi}$$

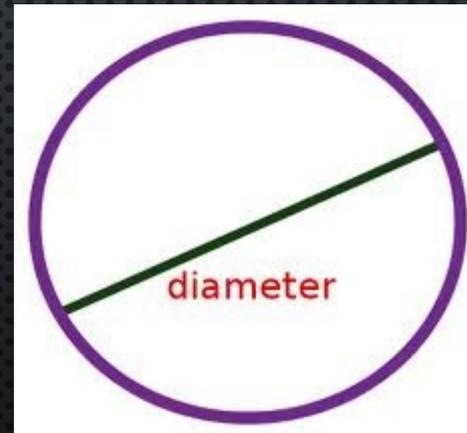
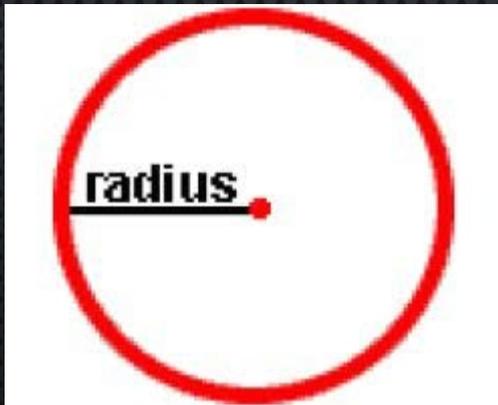
EVERYONE LOVES π



Refresher: Area of a circle

$$A = \pi \cdot r^2$$

Or $.785 \cdot d^2$



An 18 inch water main

$$9 \times 9 \times 3.14 = 254.34 \text{ in}^2$$

$$18 \times 18 \times .785 = 254.34 \text{ in}^2$$

How to get a quick ballpark estimate

$$9 \times 9 = 81 \quad 81 \times 3 = 243 \text{ in}^2$$

POTENTIAL ENERGY

100 PSI X 250 SQUARE INCHES = 25,000 LBS OF FORCE



LINCOLN HEIGHTS



THE PLAN

Following a repair to the suction header for pump #1 at Lincoln Heights Booster Station it was put back in service. The Valve Crew found another leak, this time on the discharge of pump #4

After evaluating the pipe, it was decided to replace all steel from the discharge pipe inside the basement to the new valve installed outside.

Asbuilts were reviewed of the pipe installation completed in May of 2000

It was discussed that they would leave Annex pumps 5,6,7 and 8 in service and only take pumps 1,2,3 and 4 in the main building offline.



CONSTRUCTION OF THE DISCHARGE HEADER



ASBUILT FILES PHOTOS

A FALSE SENSE OF SECURITY

INCIDENT: On Friday, October 19, 2007 at approximately 9:10am while replacing 18" discharge line at Lincoln Heights Booster Station, on Pump #4, the 18" discharge valve and spigot pipe blew out of the 36"x18" TR Flex Tee

Two workers were able to get clear of the excavation with minor bumps and bruises. Two workers were instantly trapped in the basement.

FAILED RESTRAINT



FORCES AT WORK

140 PSI AGAINST AN 18" CLOSED VALVE

- $254.34 \times 140 = \mathbf{35,607.6 \text{ POUNDS OF PRESSURE}}$ AGAINST THE VALVE.
- Water hammer occurred with the starting and stopping of the annex pumps, check valves slammed shut. The approximate force of 100,00+ psi
- Over 27,000 gallons per minute flooding the basement, the workers were instantly trapped.

FRUSTRATION



TRANSFORMERS NEXT TO LINCOLN HEIGHTS



WATER LEVEL



RESPONSE TO THE SITUATION

POSITIVE FACTORS:

All workers responded appropriately to the emergency. They notified the operators at Upriver, Station A and 911.

After notifications, the priorities were:

- Control the Water
- Get the doors open to release water and get to the trapped employees
- Get the two trapped employees out of the basement, administer First aid
- Secure the area

BACK DOOR TORN DOWN



AREA SECURED





AFTERMATH



CONTRIBUTING FACTORS

- **Policy**: Although it is not that common, it is not unusual to leave the discharge header in service while being worked on. There has been no policy or procedure to limit or turn off a header before it is worked on.
- **Water Hammer**: Water Hammer occurred when pumps were turned on and off in the annex.
- **Limited egress from basement**: All doors in the basement opened inward. Due to the large amount of water entering the basement, the doors could not be opened.
- **False sense of security**: The discharge valve on pump #4 was installed in May of 2000 with a TR Flex gripper ring. At the crew meeting to discuss the project, employees had 8x10 color pictures of the 2000 installation. Although a couple of the workers remember talking about taking the header offline, it was never specifically addressed

RECOMMENDATIONS MADE

- Suction and discharge headers will be taken out of service or controlled to ensure the safety of employees, when piping is being worked on.
- Precautions will be taken for limited egress. All confined space procedures will be followed. The doors broken down during the incident will be replaced with a roll-up door and with a man-sized walk-through door beside it that will open out.
- Formal training, specific to each crew, will be afforded employees.
- Lock out –Tag out procedures will be implemented on suction and discharge headers.
- Gripper ring restraint will no longer be accepted.
- To help control water hammers, an engineered surge tank will be installed on pumps 1, 2, 3, and 4 and controlled valves will be installed on pumps 5, 6, 7, and 8.

GRIPPER RING SCARS











