

# Operation and Maintenance

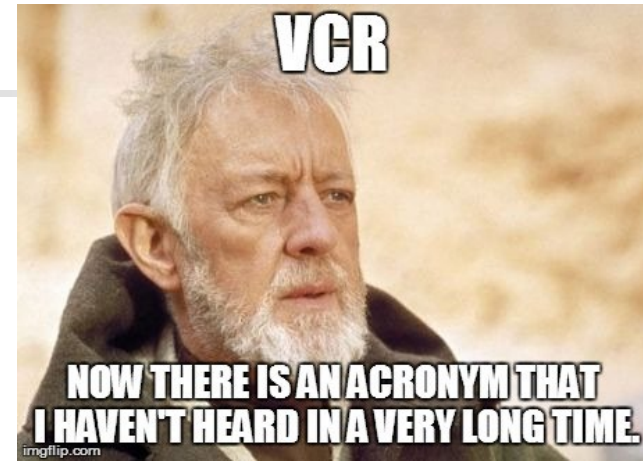


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Exam Review

# Acronyms

- GPM= gallons per minute
- MGD= million gallons per day
- TTHM= total trihalomethane
- PSI= pounds per square inch
- NTU= Nephelometric Turbidity Unit
- mg/L= milligrams per litre or ppm= parts per million are the same
- TON= Threshold Odor Number for odor in the water. Should be conducted at 60 degrees C



# System Monitoring

To Ensure  
Drinking Water is  
safe monitor for:

- Bacteria
- Turbidity
- Chlorine residual



# Sample Bottles

- Sampling bottle/bag should be filled just above the fill line or about one inch from top.
- Bottles need to be sterilized by the lab & ready for use
- Bottles have Sodium Thiosulfate in them to neutralize the chlorine



# Bacteriological Sampling Procedures

- Should allow sample tap water to run several minutes or as long as necessary to clear service line
- Results are meaningless if sample is contaminated
- Sample identification cards need to be filled out completely
- Red water could indicate bacteria or an electro-chemical phenomenon



# Bacteriological Sampling Procedures

- If sample is OK, this only indicates that water was safe at point of sample.
- Coliform is an indicator of bacteria presence absence of coliform indicates water is safe
- Sample should be transported as soon as possible in a cool container with ice pack.
- Routine bactis should be taken at the customer's tap at various points that represent the entire system
- Chain of custody forms need to be filled out completely

Not smooth nosed



# Composite Sample

- A series of grab samples taken from the same sampling point at different times and mixed together
- Grab samples represent instantaneous conditions at the time and location the sample was taken



# Nitrates

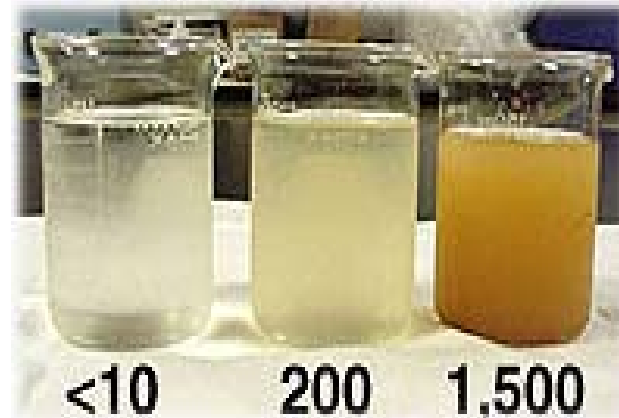
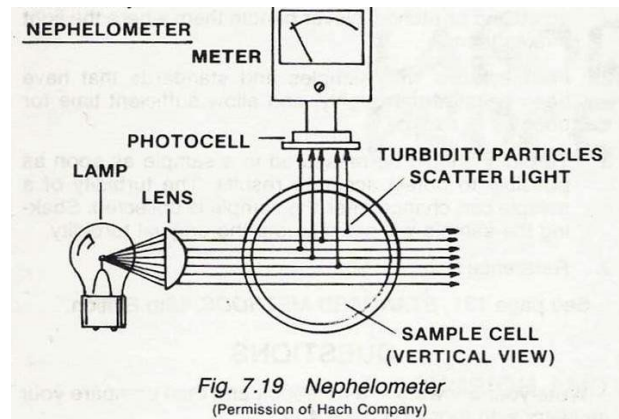
- Fertilizing lawns and farms can cause elevated levels of nitrates
- Nitrates cause Methemoglobinemia known as “blue baby” syndrome





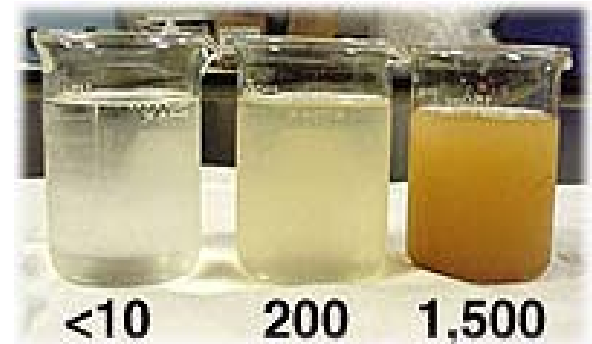
# Nephelometric Turbidity Unit (NTU)

- The method used to measure the cloudiness of the water.
- The higher the NTU, the dirtier the water, the greater the possibility of microbiological contamination.
- Turbidity can mask bacteria
- The use of light through water to measure



# Particle Counter

- The method used to measure the cloudiness of the water – the amount of particles and the size of particles.
- The dirtier the water, the greater the possibility of microbiological contamination.



# Weirs

- Measured from the crest of the weir to the horizontal water surface in the weir stilling basin

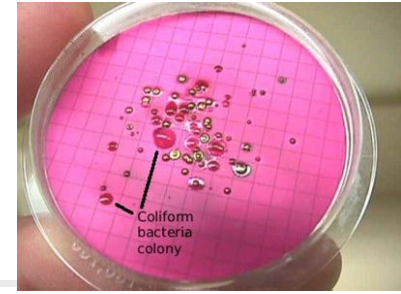


# Membrane Filter Test

- Analyzes coliform bacteria colonies
- Any positive sample requires repeats
- More than one positive is a quality violation



# GWR



## TC+ bacterial Samples

- Requires Triggered Source Water sample (TSW)
- All sources that were in operation at time of +TC sample
- You can email DDW on sources not sampled – not running
- Test for fecal coliform



# GWR continued

- 5 additional samples if first Triggered Source Water sample is Fecal+
- 2 or more sources requires you to submit new sample site plan
- Correct significant deficiencies within 120 days



# New Minimum PSI Standards

- Water pressure is measured in psi
- Maintain minimum of 20 psi at all times
- 20 psi during fire flow
- 30 psi during peak instantaneous demand
- 40 psi during peak day demand



# Sanitary Surveys Performed By

- Executive Secretary shall ensure a sanitary survey is conducted at least every 3 years
- Division of Drinking Water
- DEQ District Engineers
- Local Health Departments
- Forest Service Engineers
- Utah Rural Water Association staff
- Consulting Engineers
- Others authorized by Executive Secretary





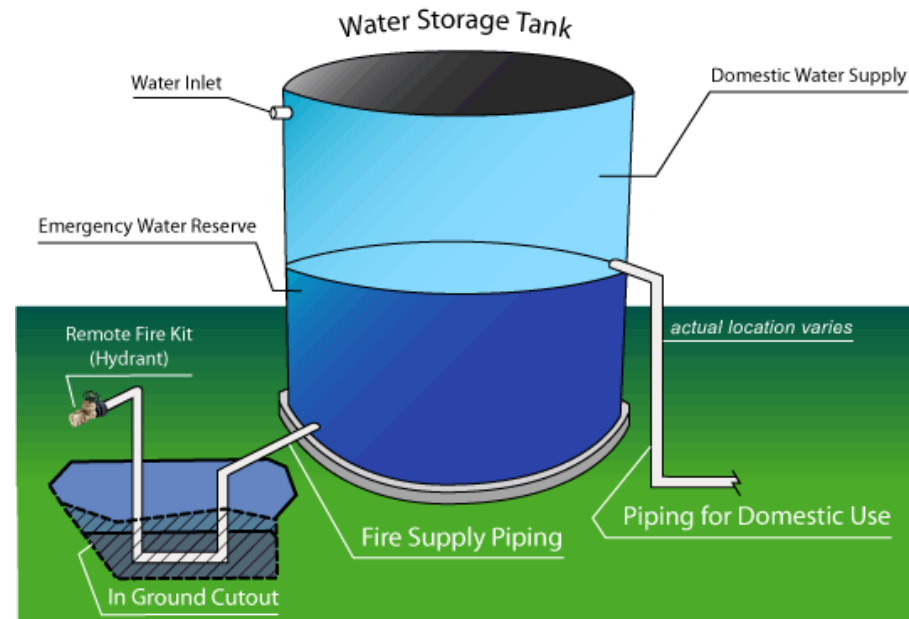
# Aesthetics

- Means attractive or appealing.
- With respect to water it means taste, odor, or coloration of the water.
- Things that affect this are extreme hardness or high total dissolved solids
- Effects range from bad smell and poor taste to causing stains on laundry and/or fixtures
- Hydrogen sulfide causes rotten egg odors



# Water Storage Reservoirs

- Provides adequate water to the water system during average and peak demands
- Provides adequate pressures throughout the water systems
- Must be covered to prevent algae and bacterial growth
- Reserve storage
- Fire protection
- Most susceptible to degradation from external sources



Measured as volume

# Screen Sizes

- #14 mesh for air vents and air vacuum release valve
- Air vac vent pipe above the flood line
- #4 mesh for overflow and drain lines
- #14 mesh = 14 squares per inch
- #4 mesh = 4 squares per inch

#14



#4



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# Pressure Tanks

- Blow off valves should be able to discharge at pumping rate
- Frequent on & off cycling of the booster pump shows lack of air in tank & is water logged



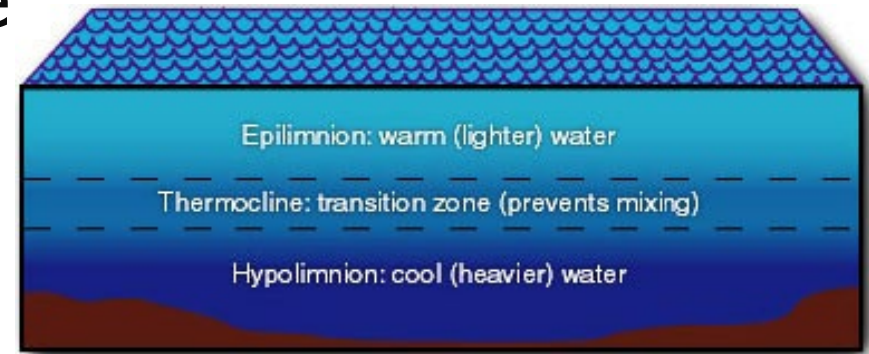
# Reservoir Maintenance

- Comprehensive inspections and cleaning inside of tank should be done every 3 to 5 years or more frequently
- Repair
- Disinfect
- Take bacti's
- Inspect Vents- for ice, screen holes, etc.
- Long & short life coatings for tank interiors



# Surface Reservoirs

- Most significant reason for turn over is a change in surface water temperature and density
- Act as pre-sedimentation basins
- Water is most dense at 39.2 deg F, 4 deg C.
- Colder water has more oxygen



# SCBA

- Self Contained Breathing Apparatus
- Always use when around gas leaks & oxygen deficient areas



# Confined Spaces

- Reservoir site entry
- Sources- where chemicals are stored
- Vehicles- Keep away from manhole
- Vaults- Carbon Monoxide (CO) will settle to the floor.
- Minimum oxygen level of 19.5%





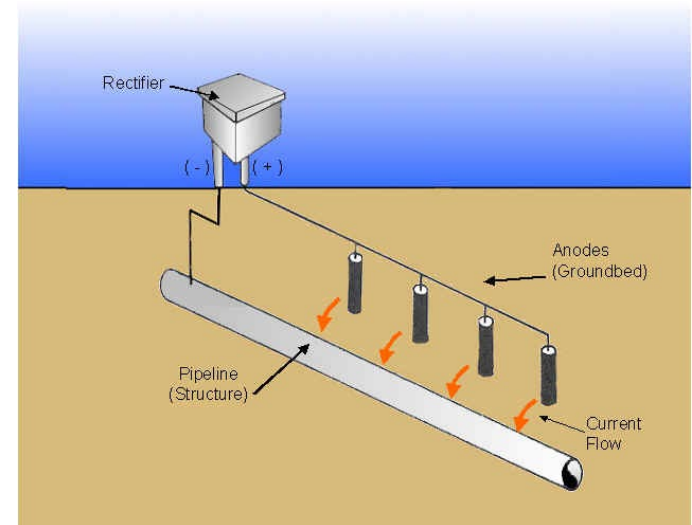
# Chemical Handling

- All chemicals should be stored according to the manufacturer's specs
- Chemical compound has multiple chemicals such as calcium carbonate



# Tank Maintenance

- Cycling of water (movement) to prevent freezing
- Cathodic protection to protect from corrosion
- Age of the water in the tank attributed to quality problems cause by low demand or short circuiting
- Sandblasting is recommended for preparing interior of tank
- Should be sampled for possible water quality changes



# Disinfection of Reservoirs

- Facility disinfected before it is put on line
- Disinfected after cleaning, repair, painting
- AWWA C652
  - Full reservoir – 10 mg/l/ 24 hours
    - 6 hour/24 hour
  - Spraying interior – 200 mg/l – 30 minute detention time
  - Fill 5 %/ 50 ppm – 6 hours, then fill rest of tank <2 ppm – 24 hours
- At least one bacteriological sample (TC-)



# Water Distribution Systems

- Leaks get worse
- Do a water audit to identify water & revenue losses
- Leak surveys should be done during low flows
- Cracked mains should be replaced
- Pressures can be measured at a fire hydrant or pressure regulating station
- Distribution system pressures
  - 20 psi at all times for peak instantaneous flows
  - Minimum Water main size
    - 8 inch with fire hydrants
      - Unless you have an engineer signature to buy off on it
    - 4 inch without fire hydrants



# Distribution Systems



- Water mains
  - 10 Feet horizontal distance from sewer main
  - Water main and sewer mains must cross at least 18" of separation
  - Water line is on top
  - Water & sewer not installed in the same trench.
  - Anaerobic growth develops in water devoid of oxygen causing odor problems
  - Hydraulic adequacy determined by pressure measurements throughout system at various times
  - Looped to prevent dead ends, quality problems, and better flow

# Customer Service Connection

- Corporation valve (corp stop) for customer service line shut off
- 3/4" most common customer service connection
- Thaw service line with hot water or warm air
- Consider flow rate & pressure for sizing



# New Main Installation

- Jacking and Boring is the most common technique for the construction of a pipeline under a heavily traveled highway or railway without disrupting the traffic



# New Water Mains

- Steps taken to put into service
  - Pressure and leak test
  - Flush out debris
  - Keep pipe clean
  - Disinfect the pipe – AWWA C651
  - Take a chlorine residual
  - Flush highly chlorinated water
  - Bacteriological Samples –
    - 2 samples taken 24 hours apart. Why?
    - Special conditions
  - Keep ends of pipe plugged when unmanned





# Pressure Testing New Water Main

- Should be done at 50% higher than normal operating pressure or 150 psi whichever is larger
- Duration 4 Hours
- New connections installed under pressure are called hot taps





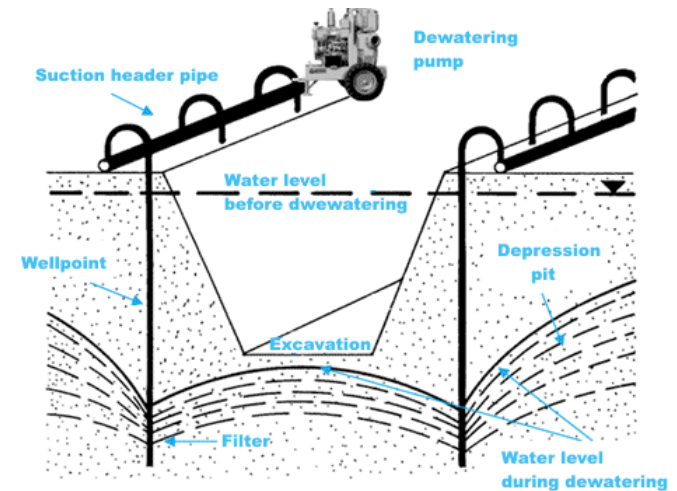
# Water Mains

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- Never shut main valve completely (may cause a back siphon)
- Disinfect with tablets or granular @ 25 mg/L for 24 hours
- Continuous Feed – 10 mg/L after 24 hours
  - Fill main with water
  - Flush out debris
  - Fill with chlorinated water

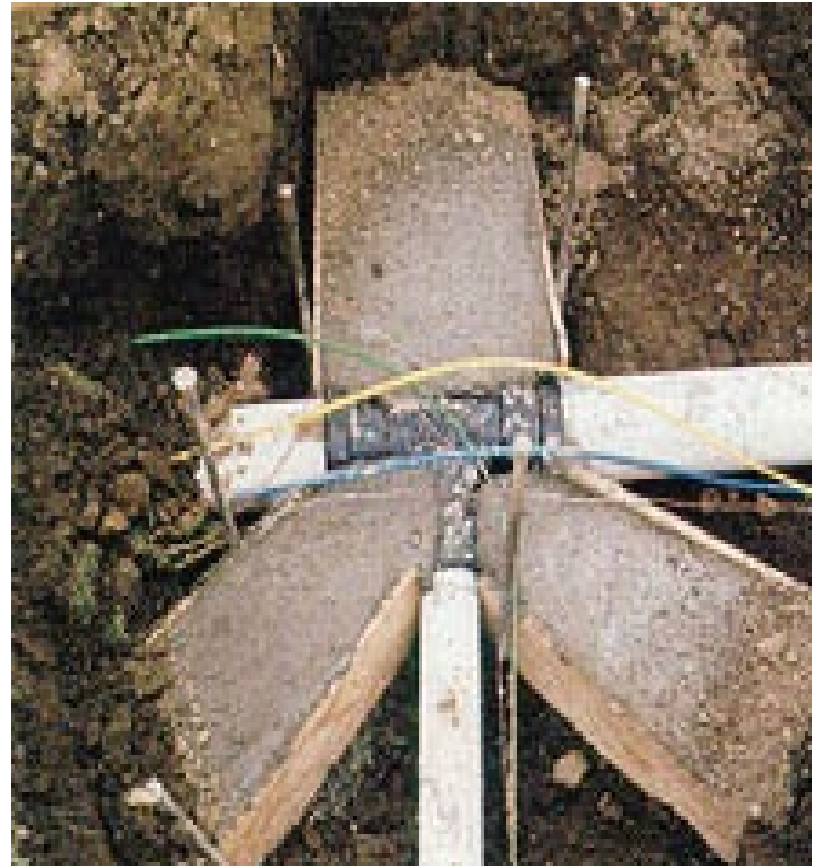
# Backfilling Mains

- Notify other utilities or blue stakes before digging
- Soil placed equally on both sides half way up of the pipe in layers hand tamped
- Pipe should be covered by about 12" of soil
- "Well Point" used to dewater trenches
- Shallow mains more susceptible to freezing



# Thrust Blocking

- Thrust Block - a concrete mass cast in place between a fitting and the undisturbed soil at the side or bottom of the pipe trench.
- Purpose is to keep fittings from moving & either coming loose or apart from the force of the water pressure in the pipe.
- Thrust anchors – used when thrust blocks cannot be used
- Restrained fitting – use of clamps or anchor screws on fittings
- Tie rods – used on mechanical joint fittings that are located close together
- Block should be centered on thrust force



# Thrust Blocks

- Should be place behind the foot of the hydrant at the flow line



# Fire Hydrants

- Hydrant bury is the distance below the ground to the main connection.
- Because of increased population growth and scaling of pipes, hydrant flow tests should be performed periodically & after major changes to distribution system
- Dropping a weighted string down the barrel of hydrant to check for water is called "Stringing"
- Nozzles are usually 2.5 and 4.5 inches
- Painted different colors to show flow





# Hydrant Cap Color Codes

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<b>Class</b>	<b>Color</b>	<b>Water Flow (GPM)</b>
■ AA	Light blue	1500 or more
■ A	Green	1000–1499
■ B	Orange	500–999
■ C	Red	Less than 500

# Fire Hydrants

- Flushing hydrants can stir up silt creating water quality problems
- Should be tested for flow with a pitot gauge
- Flow tests show quantity of available water
- Should be metered by contractors to account for water use

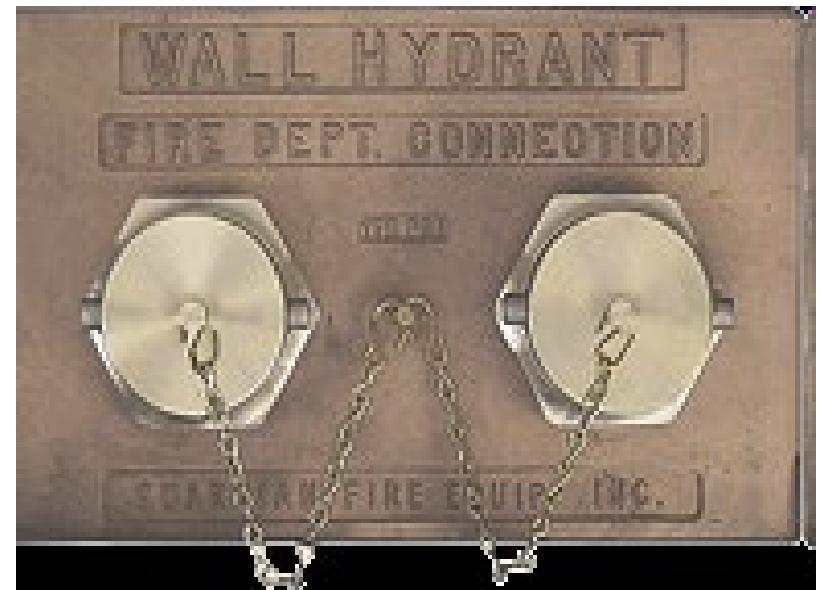






# Flush Hydrants

- Means hydrant is flush with a wall or ground
- For areas where post hydrants are not suitable



# Flushing the System

- Dead End Systems
- Water Quality Issues
- Customer Complaints
- Be mindful of environmental concerns
- During periods of low demand



# Flushing Procedure

- Notify customers thru billing, newspaper, or electronic media of times and places affected or anything affecting the condition of their water
- Explain Intent Of Flushing
- Notify Hospitals, Dialysis Patients, Restaurants, Laundromats, & Others That May Be Affected



# Flushing The System

- When The System Has Become Contaminated
- Newly Installed Or Repaired Mainlines



# Flushing Hydrants

- Helps remove taste & odor causing deposits
- Helps remove encrustations that may restrict flow
- Helps remove sand, rust, & biological materials that cause water quality problems



# FLUSHING PROCEDURE

- Try To Avoid Flooding Traffic Areas
- Open Hydrant Fully For 5 To 10 Minutes To Stir Up Deposits
- Don't let nearby areas drop below 20 psi to avoid negative pressures
- Record Pertinent Data: Odor, Water Appearance, Times, & Places, Etc.



# Fire Fighters

- Fire fighters can create negative pressures
- Dead end systems would likely have inadequate flows for firemen





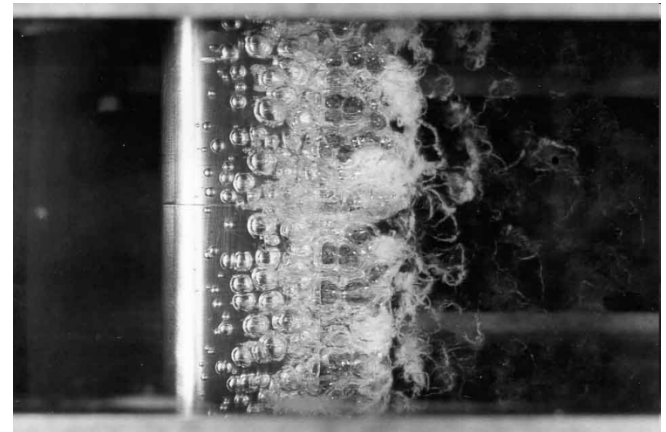
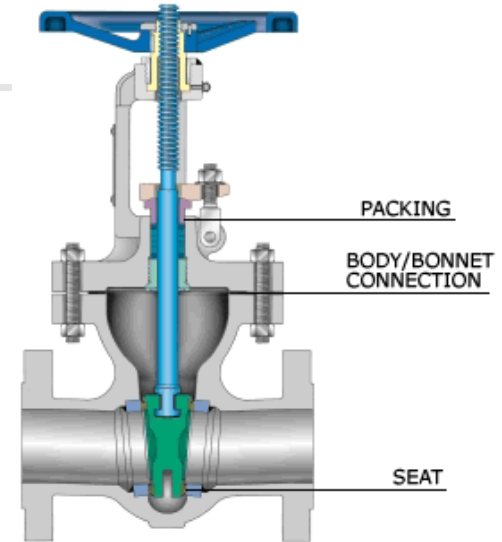
# Valves

- All system valves should be exercised annually
- Purpose is to isolate sections of the system



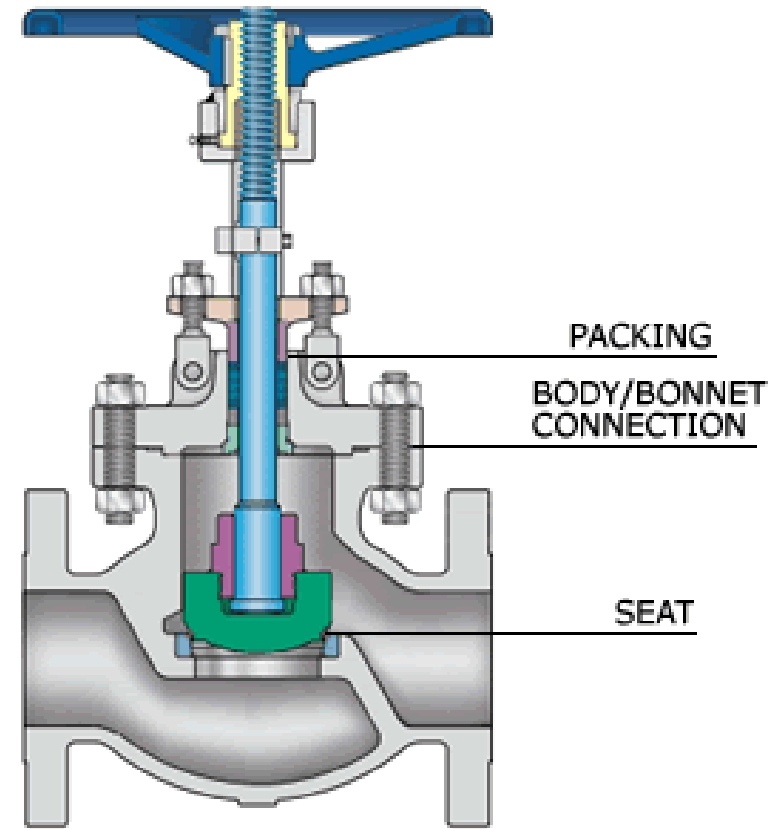
# Gate Valves

- Most commonly used valve in distribution system
- Gate Valve: Isolation only, should be either all the way open or all the way closed
- Cavitation (formation & collapse of bubbles) can occur
- Fully open has least amount of head loss from other valves
- Can be repacked without taking out of service



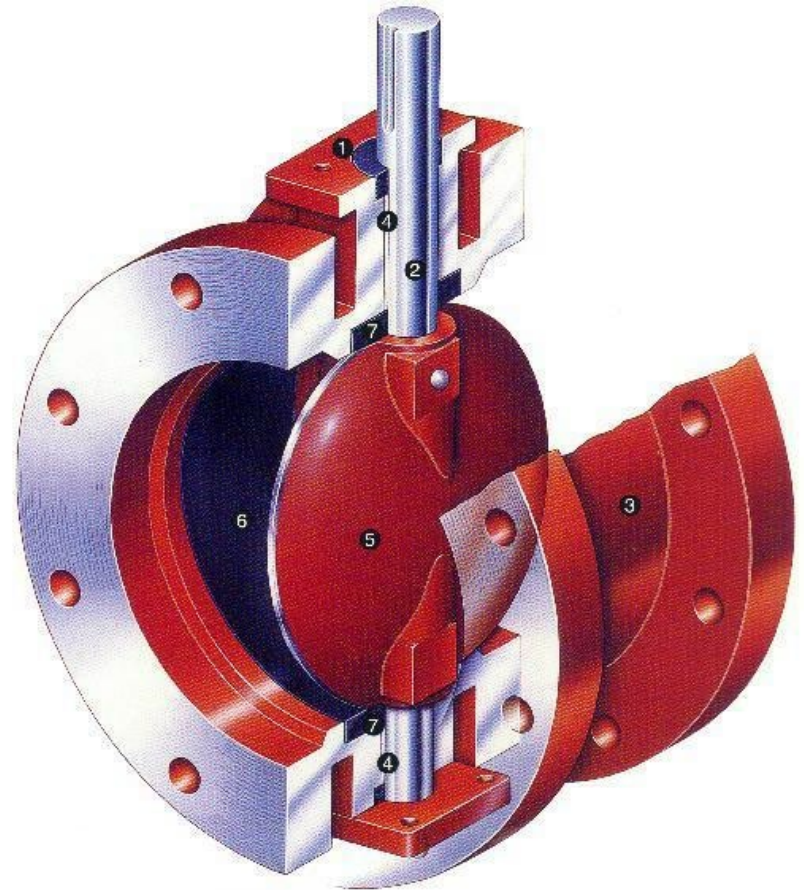
# Globe Valves

- Best for flow control throttling, & pressure regulating



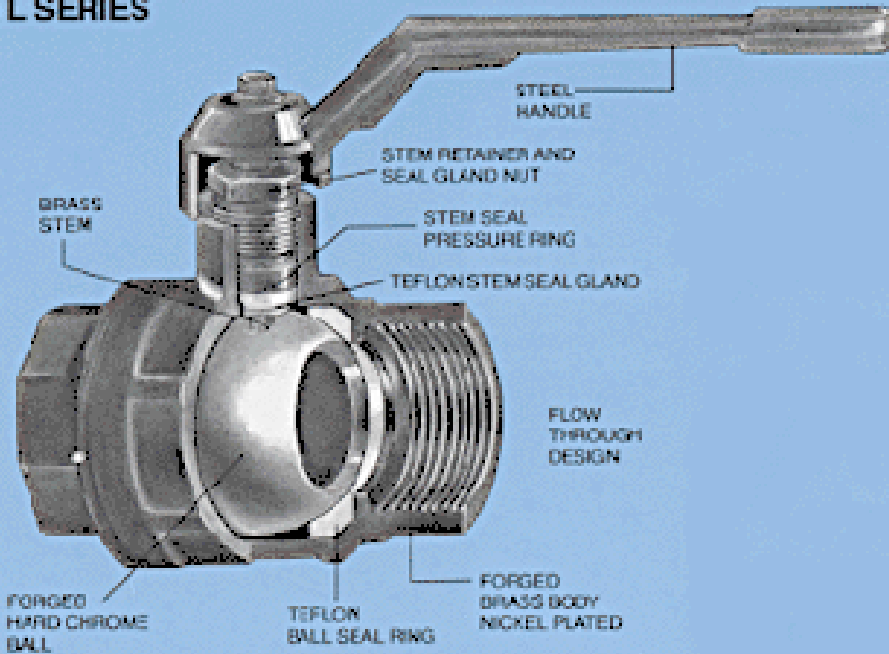
# Butterfly Valves -

- Higher resistance to flow
- Operates easily & quickly
- They cost less than gate valves
- Used for flow control & isolation



# Ball & Plug Valves

## FF & L SERIES



# Sluice Gate & Sleeve Valves



# PRV Valves

- Pressure Sustaining/Reducing: maintain either upstream or downstream pressures depending on the position of the pilot screw.
- Need to be maintained periodically
- Help reduce water hammer



# Pressure Reducing Valves

- Installed in parallel to handle high & low flows





# Altitude Valve

- A good valve to regulate tank levels
- Altitude valve:  
opens when system psi drops below a certain pressure and closes when the reservoir reaches a predetermined level.



# Pump Control Valves

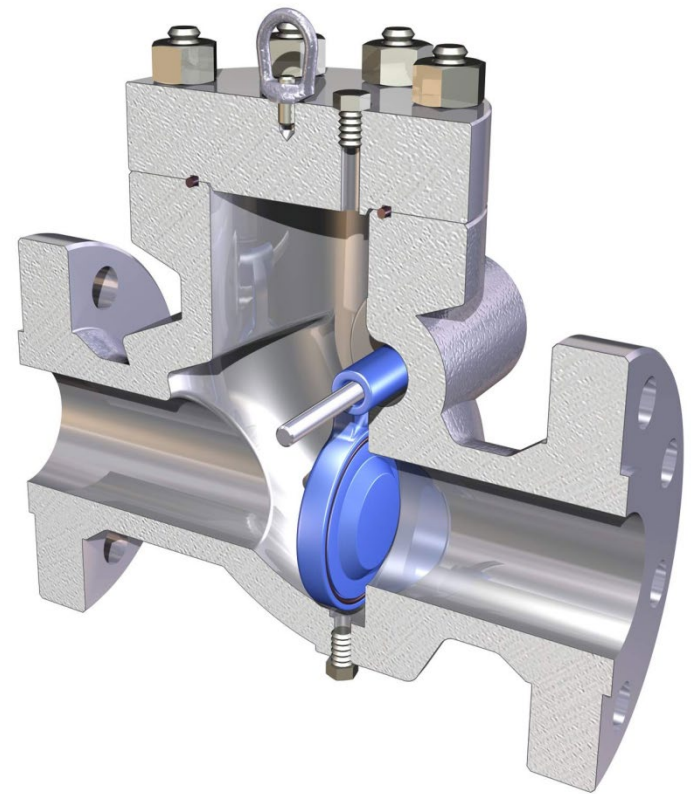
- Allow pumps to be started & stopped against a closed valve
- Best method to control water hammer



▲ 125-27 shown

# Check Valves

- Keep flows going one direction
- Flow must be directional with pump discharge lines, customer service lines, and water treatment plants



# Air Release Valves (air-vacs)

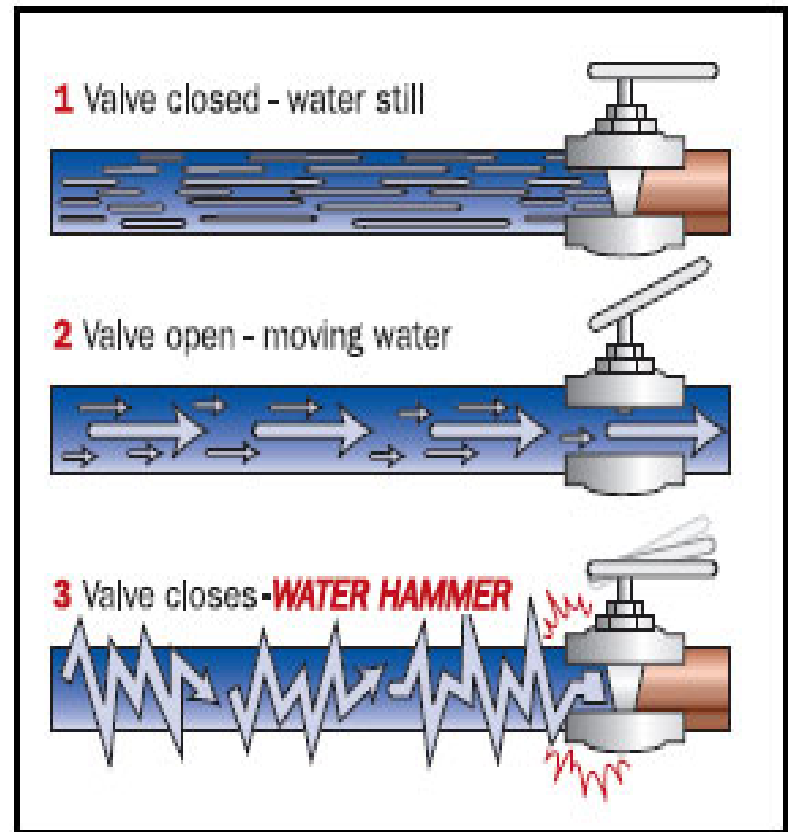
- Allow air in & out
- Should be placed at high points in the system
- Need to be screened & protected from flooding
- Relief valve outlet 12" above ground





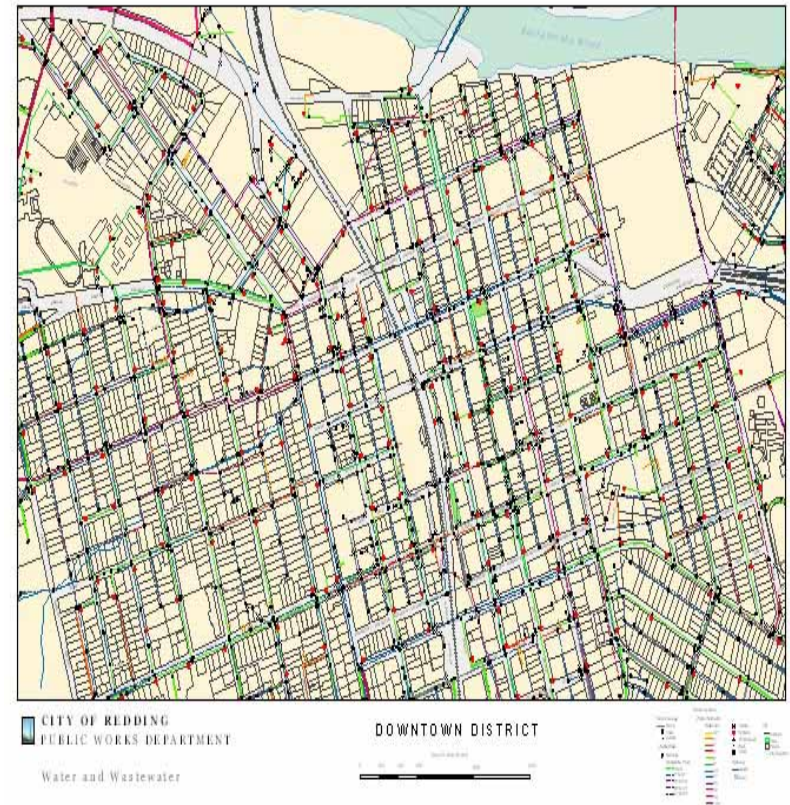
# Water Hammer

- Occurs when a valve is closed quickly or pump shuts down and causes the water pressures to rise and fall rapidly.
- Sounds like some hammering on pipe.
- Can damage pipes, causing them burst.



# System Mapping

- Accurate mapping ensures the operators can locate the valves and main lines in case of a main break or leak



# pH

- pH: expression that refers to the basic or acidic conditions of the water
- pH is measured on a scale from 0 to 14.
- Less than 7 is more acidic, greater than 7 is more basic or higher alkalinity 7 is neutral.





# pH

- pH and alkalinity tests can be performed to assess the corrosiveness of the water
- Alkalinity expressed as Calcium Carbonate
- Chlorine lowers the pH & chlorine rate may need to be increased



# Water Hardness

- Caused mainly by salts of calcium and magnesium, such as bicarbonate, carbonate, sulfate, chloride and nitrate.
- Causes formation of soap curds
- Deposits show chemical instability
- Deposits of scale in boilers & fixtures
- Damages in some industrial processes
- Objectionable tastes in water





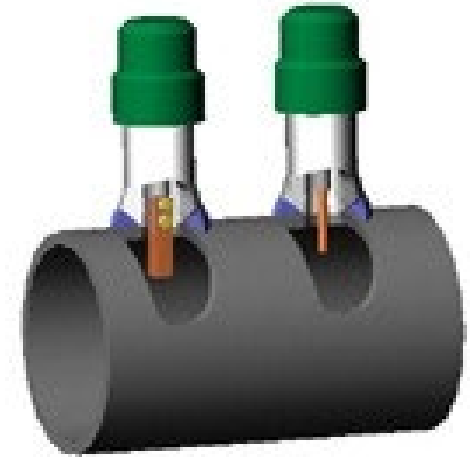
# Langlier Saturation Index (LSI)

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- Measures corrosiveness of water
- LSI (Carrier) Indication
- -2.0 to less than -0.5: Serious corrosion or aggressive
- -0.5 to less than 0: Slightly corrosion but non-scale forming
- LSI = 0.0 Balanced but pitting corrosion possible
- 0.0 to less than 0.5: Slightly scale forming and corrosive
- 0.5 to less than 2: Scale forming but non corrosive

# Corrosive

- Electrochemical phenomenon
- Measurements:
  - Langelier index
  - Positive number: Deposit
  - Negative number: Corrosive
  - Metal coupons used to measure corrosiveness of water – determined by weight loss of coupon
- Adjustments can be accomplished by:
  - Chemicals which increase or decrease the depositing, or
  - Sequester the problem with the use of polyphosphates
  - pH/Alkalinity adjustment w/Lime, Sequestering & Chelation



# Alkalinity

- A measurement of the water's capacity to neutralize an acid
- Alkalinity is determined by titrating to an end point with a pH meter or the use of the methyl orange test
- Use sulfuric acid to perform test
- Affects the coagulation process
- Insoluble calcium carbonate compounds cause build up of scale
- Hardness expressed as mg/L in  $\text{CaCO}_3$ , to be considered soft should be 0 to 50 mg/L



# Head Loss

- Valves, elbows, pipe characteristics, etc. contribute to loss of flows
- Pipe roughness coefficient tests to see if friction losses are increasing
- Bursting strength of pipe refers to pipe's ability to withstand internal forces



# Head Loss

- Friction head loss: caused by valves, bends, pipe roughness, etc.
- Friction headloss is in direct proportion to the increase in the velocity of the water flow
- Various factors can slow down the velocity of water.
- Alkalinity expressed as Calcium Carbonate



# FRICTIONAL HEADLOSS

- Energy used up by water movement
- Two Conditions that affect head loss:
  1. Roughness of the pipe
  2. Velocity of the water
- Two Conditions that affect Roughness:
  1. Age – Condition
  2. Type of pipe Materials





# C-Factor

- Indicates the smoothness pipe material
- The higher the C value, the smoother the pipe.
- To calculate measure flow, pipe diameter, distance between two pressure gauges, and the friction losses between the gauges.
- 3 most common types of plastic pipe are PVC, PE, & ABS
- PVC least susceptible to corrosion
- C value reduced by tuberculation



PVC has higher C- factor than concrete

# Water Loss

- Affected by: leaks, pressures, efficiency of the meter maintenance, attention given to leak reduction & unauthorized use of water
- Some systems 10% of the water produced
- Other systems not until 20%



# Consumer Calls

- Persons name, address, & phone
- What's the problem: taste, odor, discolor, etc.
- When was problem first noticed?
- Duration of problem?
- Are neighbors having same problems?
- Has it resulted in any illness?
- Has Local Health Dept. or DDW been notified?
- Can they get a sample in a clean glass?





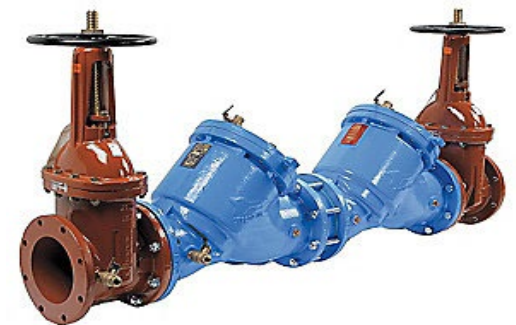
# Cross Connections

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- Determined by the degree of hazard
- Cross connection: a connection between a potable and an unapproved source.
- Two Types of Backflow:
  - Backsiphonage: backflow caused by a negative or below atmospheric pressure in a water system.
  - Backpressure: when users pressure is higher than the system pressure
- Water user is responsible to keep contaminants out of the water system
- Flush out debris and trapped air in newly installed assemblies
- An effective program helps minimize degradation of the water system
- Responsible for most waterborne disease outbreaks

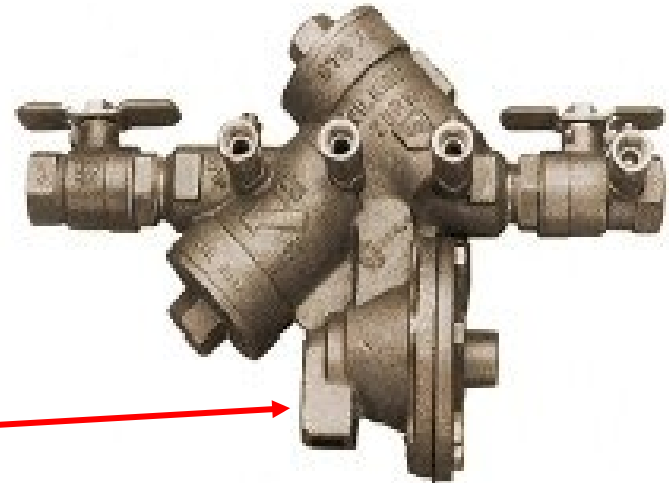
# Devices and Assemblies

- Keep contaminants out
- Air Gap: a physical break between to connections. Minimum of 1" or two times the diameter of the pipe & safest method of backflow prevention
- Double Check Assembly: Has two independent internally loaded check valves, 2 shut off valves, & 4 test cocks.



# Cross Connections

- Reduced Pressure Principle Assembly: For High Hazards, has 2 spring loaded check valves, a relief valve, 4 test cocks, and 2 shut off valves. Relief port can't be submerged & installed 12" above floor
- Pressure Vacuum Breaker: internal check valve, an internal loaded air poppet, 2 shut off valves and 2 test cocks. Not designed for back pressure



# Cross Connection

- Atmospheric Vacuum Breakers not designed to protect against back pressure
- Prior to the installation of any backflow prevention assembly or device owner should be advised thermal expansion hazards



# Wire to Water Efficiency

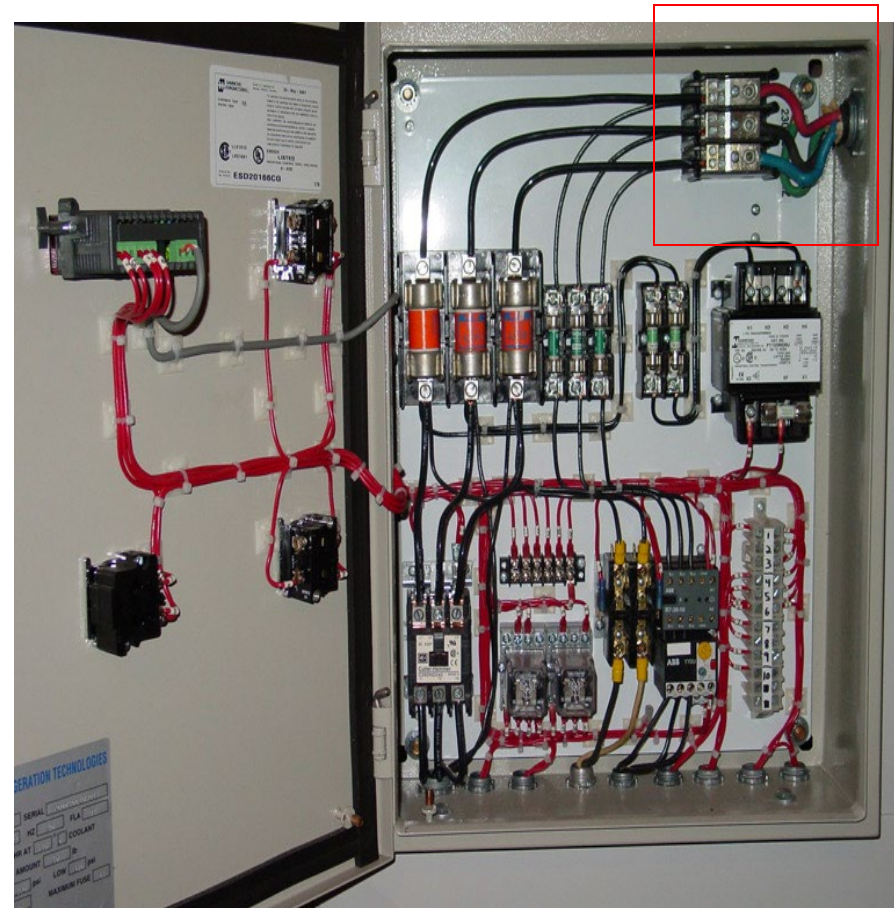
- The combined efficiency of the pump and the motor together. Also called the over all efficiency.
- $\text{Water HP} / \text{Electrical HP} \times 100\% = \text{over all efficiency}$
- The amount of energy required to overcome the inefficiencies of the pump and motor





# Electric Motors

- Upon start up an electric motor will develop a torque to turn the pump shaft and impeller
- Torque causes motor to draw a high amperage
- Amperage drops once the pump is up to speed.
- To change rotation on 3 phase, switch any 2 leads
- Transformers step down voltage
- Circuit breakers protect from circuit overloads



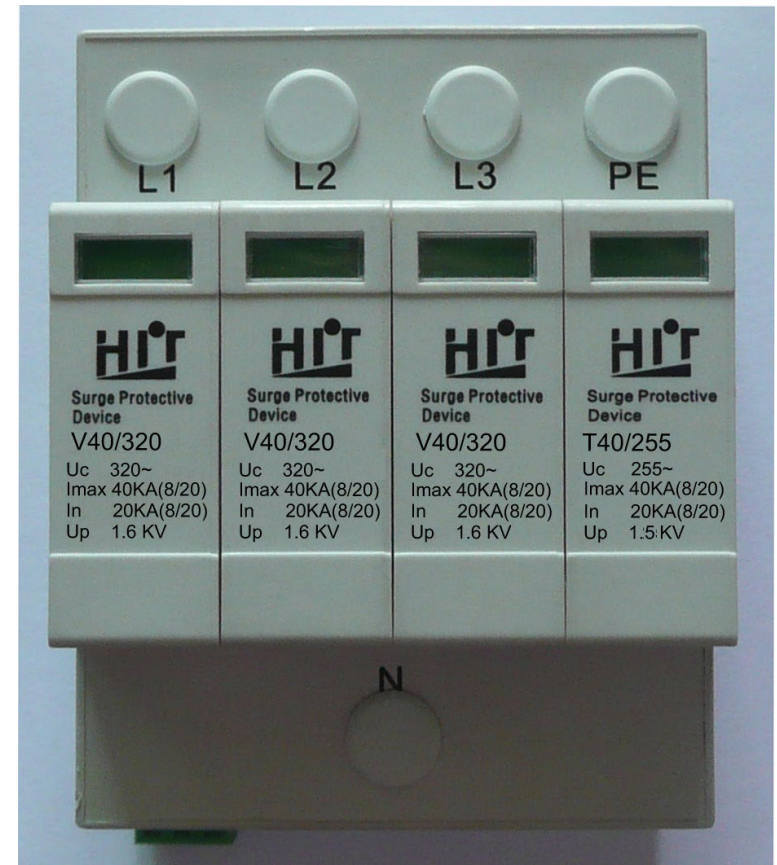
# Digital Multimeters

- Ohm meters measure resistance
- Volt meters measure voltage
- Amp meters measure current
- Tachometer would show pump speed
- Setting should be set to next highest level of what you measuring



# Lightning Arrestor

- Becomes a low resistance conductor to ground when the line voltage exceeds a predetermined amount
- Used to protect equipment from lightning strikes.
- No device made to protect against a direct hit.



# Power Sources

- Primary Sources- Power Company
- Auxiliary Sources- Diesel, Natural Gas, & Gasoline Powered Generators may be necessary in an emergency



# Meter Sizing Considerations

- Pressure at the service connection
- Highest fixture in the building being served
- Any back flow prevention device
- A 5/8 inch meter should be tested every 5 to 10 years.
- Meter should not have more than 20 psi of head loss.
- One inch and smaller meters shouldn't exceed 15 psi of head loss



# Small Meter Installation

- Meter pit located on public property
- Meter pit relatively safe from vehicle & snow removal equipment
- Riser pipes should be 1 to 2 inches away from meter box walls
- Use of meter yoke
- Use jumper cable to protect from electrical shock from piping in the home



# Meter Accuracy

- Measure water flow
- Worn meters will cause the meter to under register, allowing the customer to receive more water than they pay for.
- Unaccountable water loss is the term used in determining meter accuracy & leakage
- Over time a worn meter will cost the water system revenue.
- Formula: **Meter Accuracy = (Meter, GPM)(100%) / Volume, GPM**



# Magnetic Meters

- Maintenance calibration should include flow at zero flow rate





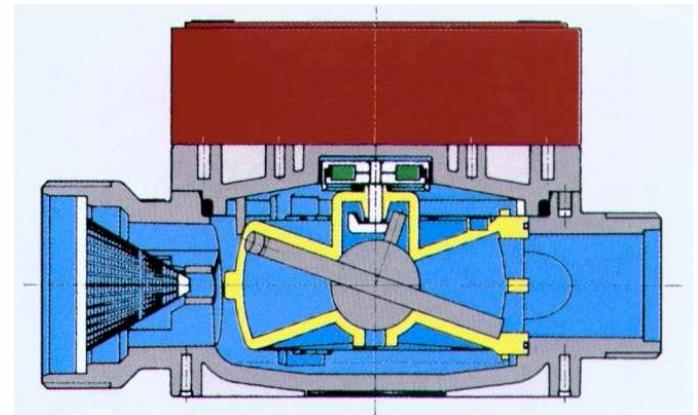
# Compound Meters

- For low to intermediate flows
- Occasionally high flows



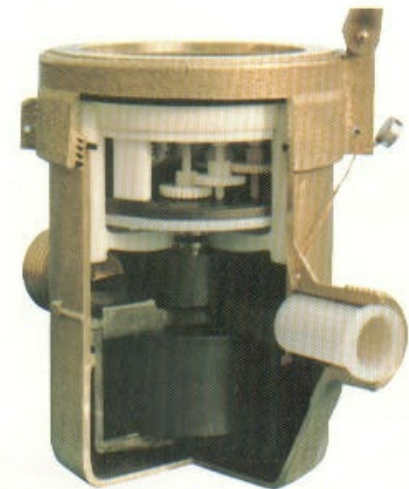
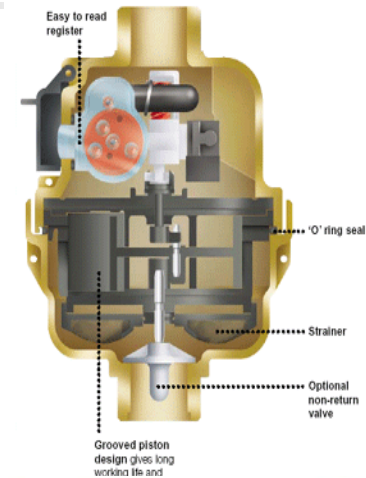
# Positive Displacement Meter

- Nutating disk:  
nutating means  
nodding. When the  
water flows the disk  
rotates.



# Oscillating Piston Meter

- Displacement type
- Water flows into a chamber and displaces piston
- Oscillating circular motion moves meter
- Higher head loss than nutating disk



# Velocity Meter & Venturi

- Mechanical rotors or propellers are turned by velocity of water to measure flow
- Venturi meters measure differential pressure & have no moving parts.
- Venturi meters are best for providing uninterrupted flow

Velocity Meter



# Iron

- Consumer complaints
- Can cause stains on laundry & fixtures
- Formation of iron bacteria that form slick slimes on pipe walls
- Taste and odor problems
- Reacts with chlorine increasing use
- Can be removed thru aeration, flushing & polyphosphates
- Mixed with manganese react with dissolved oxygen forming insoluble compounds



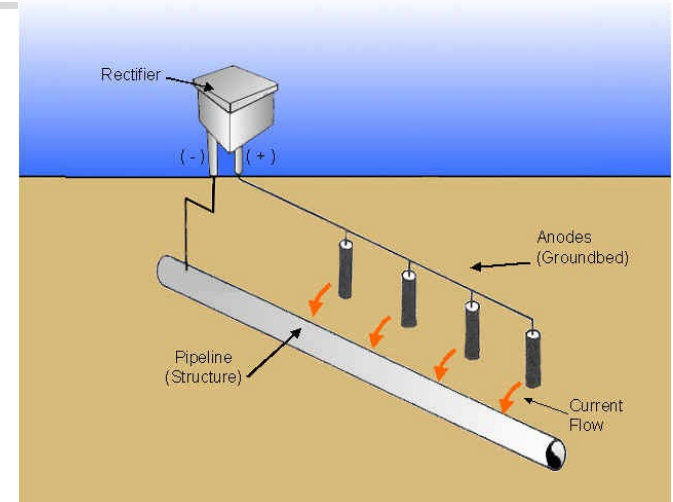
# Manganese

- Iron mixed with manganese reacts with dissolved oxygen forming insoluble compounds
- Causes black stains

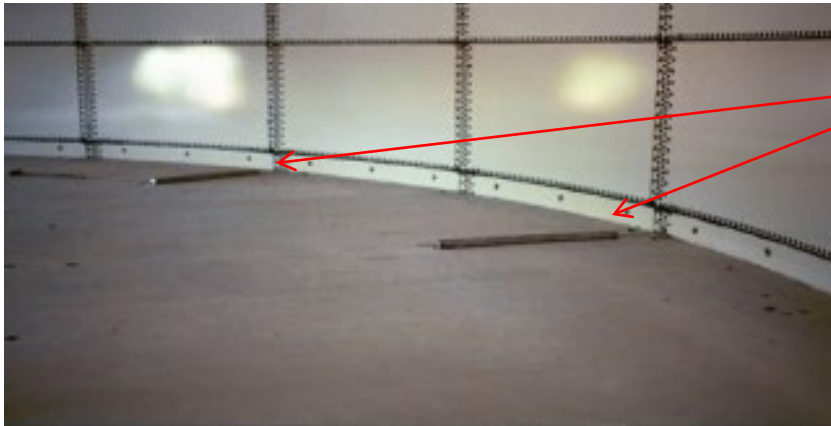


# Electrolysis

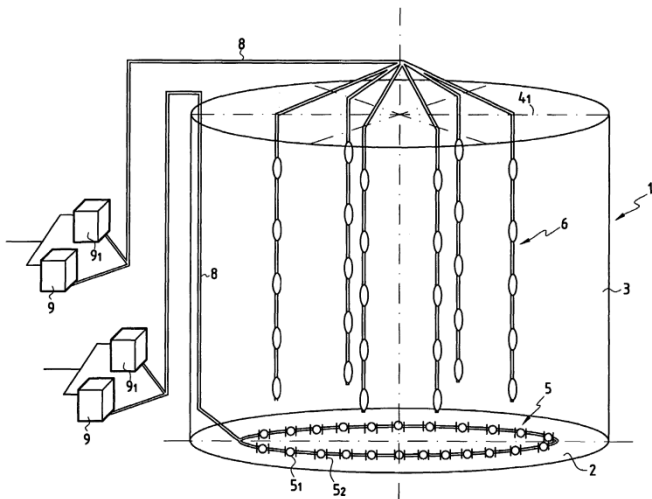
- Decomposition of material by an outside electric current
- Electric current caused by movement of water in the line
- Cathodic protection installed to prevent corrosion
- Magnesium anodes help prevent galvanic corrosion
- Galvanic corrosion caused by connecting dissimilar metals
- Metal coupons evaluated for weigh loss



# Tanks – Cathodic Protection



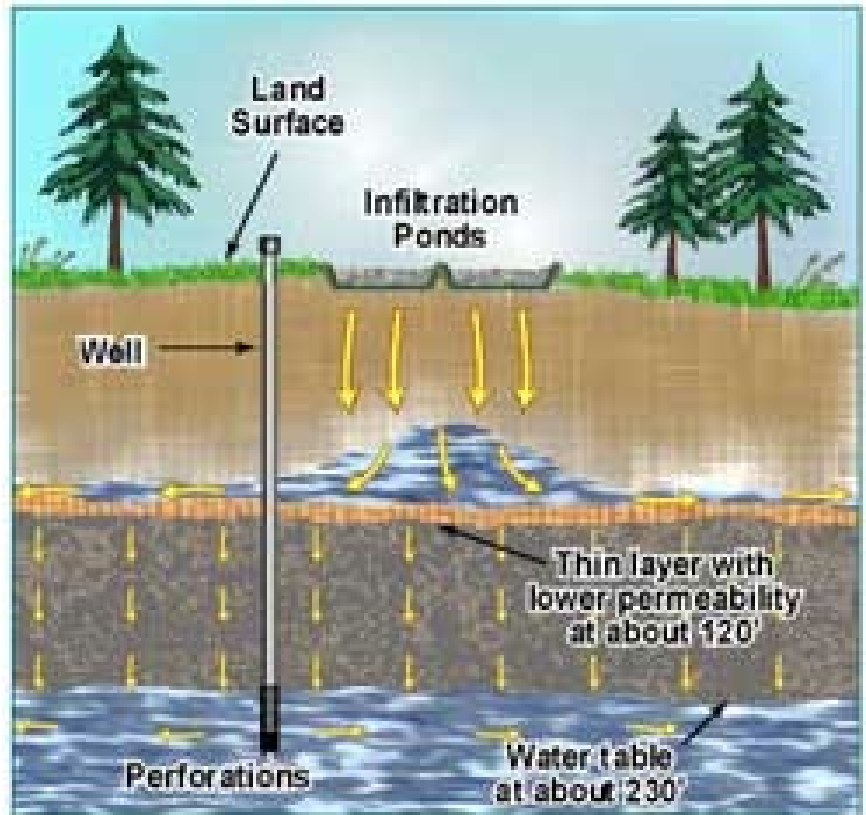
Anodes





# Ground Water

- Water passing thru porous soil is called percolation
- Water bearing geological formation is called an aquifer





# Well Maintenance

- Water needs to be pumped to waste until it clears up



# ACCURATE RECORD KEEPING

- Shows decreases in flow and pressures
- Insures each piece of equipment receives proper attention to prolong its life
- Shows when preventive maintenance or repairs were last performed
- Reduces liability to operator & improves customer service
- Work orders best way to track system maintenance

This schedule is intended as a guide only. Each system/application is different and should be evaluated/serviced according to its own custom maintenance schedule.

Check	Daily	Weekly	50 Hrs.	500 Hrs.*	1500 Hrs.*	3000 Hrs.*
Clean Filters	•					
Oil Level/Quality	•					
Oil Leaks	•					
Water Leaks	•					
Belts, Pulley		•				
Plumbing		•				
Initial Oil Change			•			
Oil Change				•		
Seal Change					•	
Accessories					•	
Valve Change						•

- \* If alternate to Cat Pumps® custom-blend, premium grade, petroleum-base hydraulic oil is used, change cycle should be every 300 hours.
- \* Each system's maintenance cycle will differ. If system performance decreases, check immediately. If no wear at 1500 hours, check again at 2000 hours and each 500 hours until wear is observed. Valves typically require changing every other seal change.  
Duty cycle, temperature, quality of pumped liquid and inlet feed conditions all effect the life of pump wear parts and service cycle.  
Remember to service the regulator/unloader/relief valve at each seal servicing and check all system accessories and connections before resuming operation.  
Refer to Service Manual or service DVD for additional assistance.