

Distribution System Maintenance



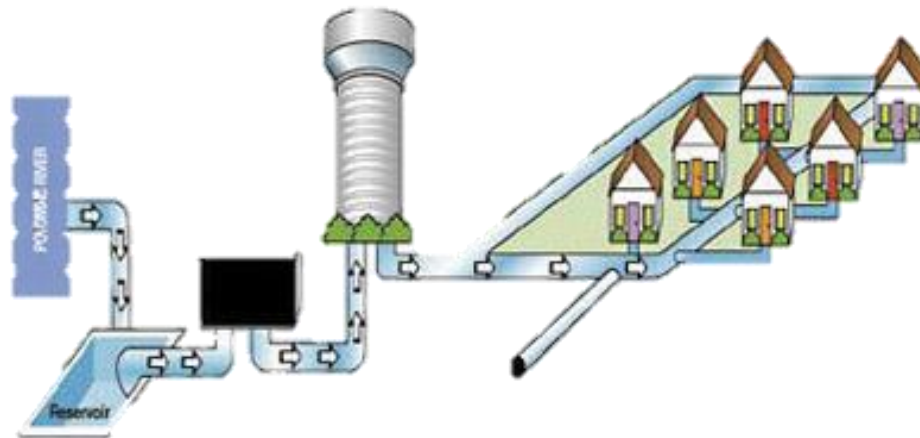
Outline

- Distribution system components
- Line repairs
- Valves, hydrants, service lines, water meters
- Corrosion
- Maintenance
- Asset management
- Water loss and leak detection
- Cross-connections



Distribution System

The link between the water source and the customer/consumer



Distribution system components



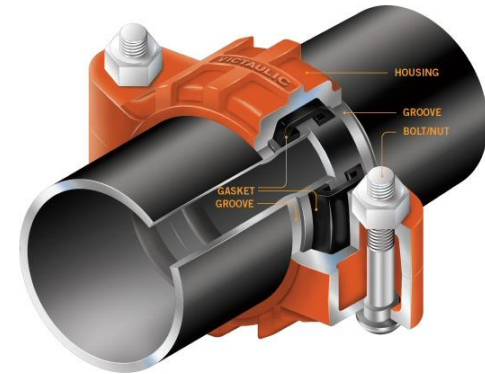
Types of Pipes

- Cast iron (CIP) and ductile iron pipe (DIP)
- Strength, load bearing capacity
- DIP stronger, less rigid than gray CIP
- Both brittle, inflexible
- Heavy, subject to corrosion
- CIP less resistant to corrosion than DIP
- 3- to 54-inch-diameter, 18- to 20-foot lengths
- Flanged joints above ground, bell/spigot and mechanical joints below ground
- Service taps either directly tapping (difficult!) or saddles



Types of Pipes (continued)

- Steel
- NSF or AWWA C-200 standard
- Schedule 40 and Schedule 80
- Lighter, easier to handle, more flexible than IP
- Very susceptible to corrosion
- Lower bearing strength, collapse under vacuum
- Joining: threaded coupling, welded coupling, Dresser or Victaulic coupling, flanges, rubber ring push-on



Types of Pipes (continued)

- Asbestos-Cement Pipe (ACP)
 - Less expensive, lighter, easier to install and tap than IP
 - Resists corrosion and tuberculation
 - Joined using sleeved couplings and O-rings
 - Health hazard (carcinogenic)
 - Brittle, cracks under trench loads, difficult to repair
 - Repairs with C-900 PVC
- Plastic (PVC, HDPE)
 - Light, easy to install and repair
 - Unaffected by corrosion
 - Susceptible to thermal expansion (lengthwise)
 - Fragile – select backfill material



Corrosion

- Attacks metal components of distribution system
 - Causes rust; increases friction loss
 - Can cause Pb, Cu problems (brass 7-11% Pb)
 - Dissolved Cl, CO₂ or DO; low pH, alkalinity can cause corrosion
- Determining corrosion potential
 - Langelier Index based on lab data
 - temp, TDS, Ca and alkalinity
 - [online calculator](https://www.cleanwaterstore.com/technical/water-treatment-calculations/share-calculator/langlier.php)



<https://www.cleanwaterstore.com/technical/water-treatment-calculations/share-calculator/langlier.php>



Other Types of Corrosion

- Galvanic
 - 2 dissimilar metals in contact with each other
 - Submerged in water
 - Generates electric current between metals
 - Plating leads to metal failure
 - Meter installations, service connections



Other Types of Corrosion (cont.)

- Electrolysis
 - DC current through metal pipes
 - Discharges to ground
 - Metal plates from pipe to ground – failure point
- Corrosive (acidic) soil
 - External corrosion potential
 - Need to coat CIP and DIP



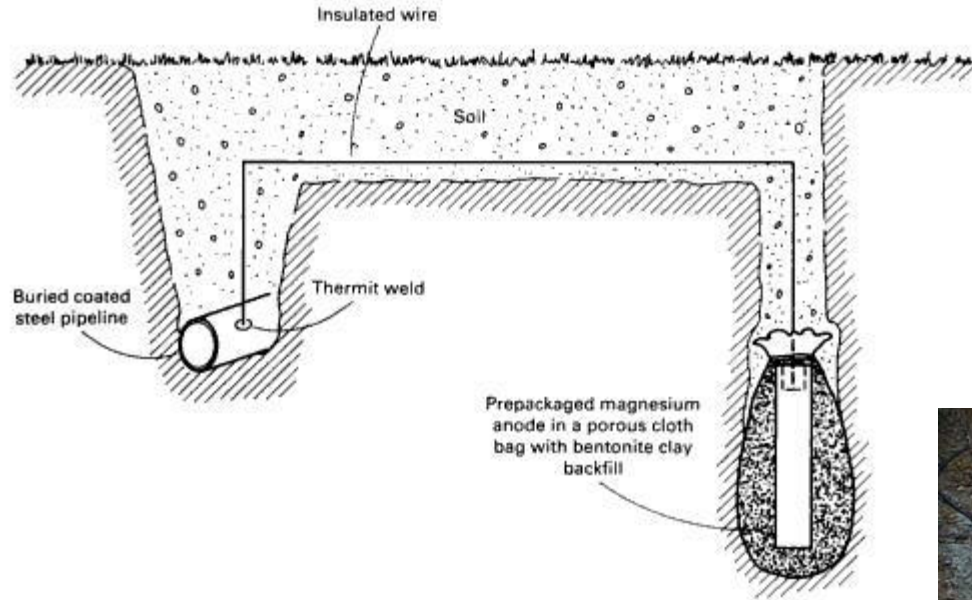
Cathodic Protection

cathodic protection - the prevention of electrolytic corrosion in something metallic such as an underground pipe or a ship by making it the cathode in an electrolytic cell

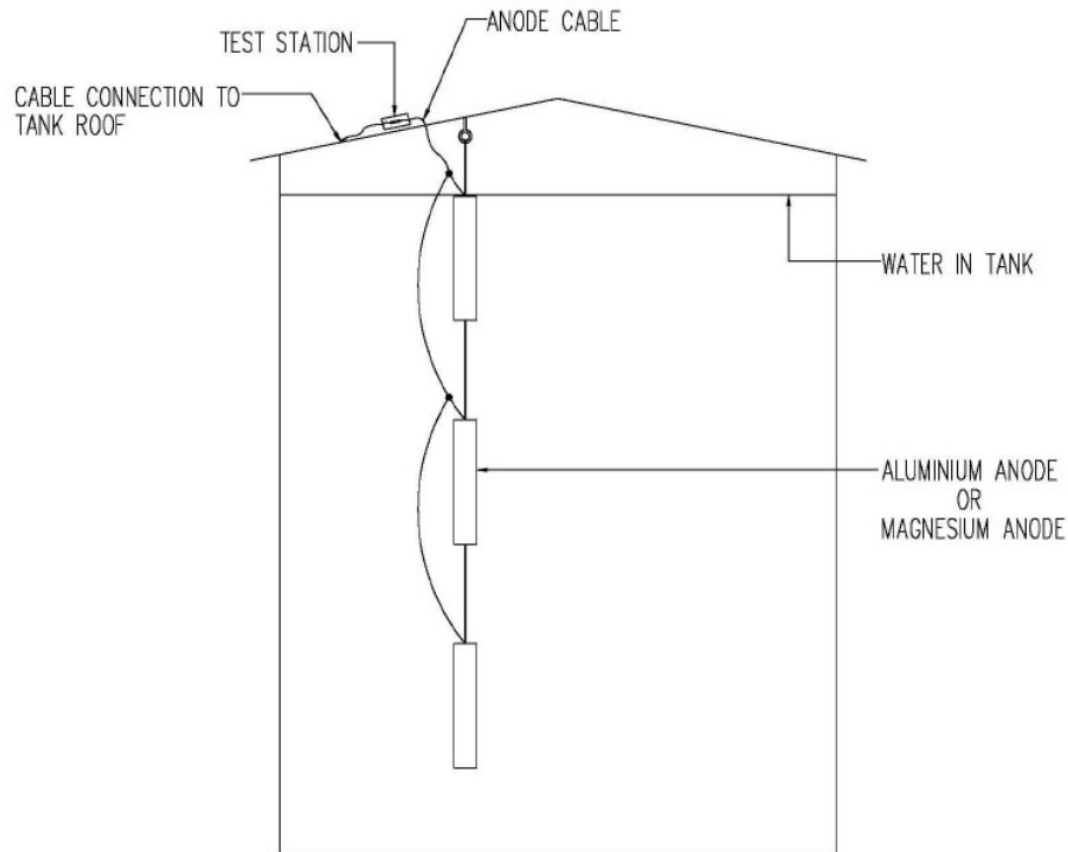
Which components do you think might need cathodic protection?



Sacrificial Anode



Tank Corrosion Protection



TANK INTERNAL
SACRIFICIAL STRING ANODE CATHODIC PROTECTION SYSTEM

Microsoft Outlook 2010

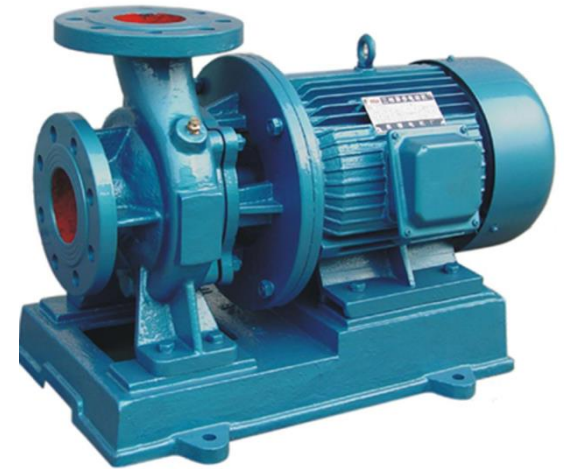


System Hydraulics

- Friction loss
 - Loss of energy – Bernoulli equation
 - Factors
 - Pipe length, diameter
 - Flow rate
 - “C” factor – coefficient of friction
- Water hammer or pressure surge
 - Due to quickly stopping pipe flow
 - The faster the stop, the bigger the surge
 - Rupture lines, lift hydrants
 - Open & close valves slowly (pump control valves)
 - Use thrust blocks

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + h_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + h_2$$

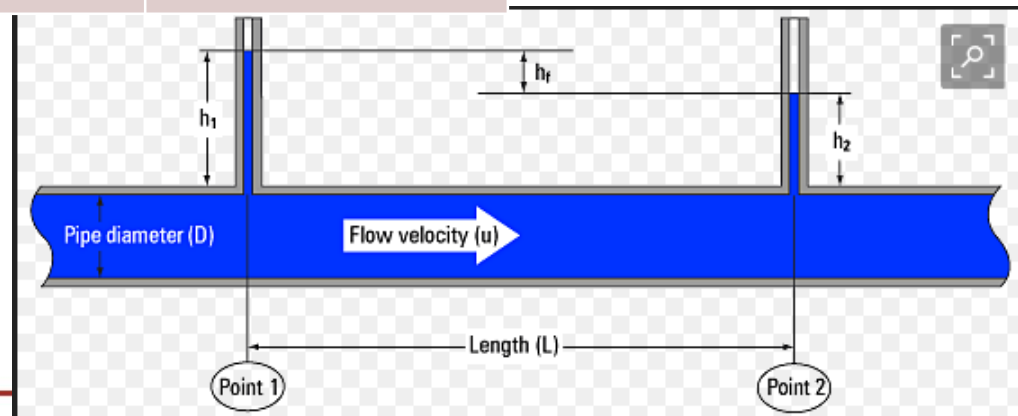
Head Pressure Head Velocity Head Potential



Friction Loss in Pipe

- Proportional to Flow and Inside Diameter

Dia (in)	Flow (gpm)	HL (ft/100 ft)
3	500	73.6
4	500	16.4
6	500	5.67



System Hydraulics (continued)

- Thrust blocks
 - Prevent joint leakage
 - Bends, elbows, tees, dead-ends
 - Thrust factors
 - Bend angle
 - Pipe diameter
 - Internal pressure
 - Use 1.5:2 safety factor multiplier to account for surges
 - Size of block depends on surrounding soil type
 - Hard clay can support up to 9000 #/ft²
 - Soft clay can support up to ~ 1000 #/ft²

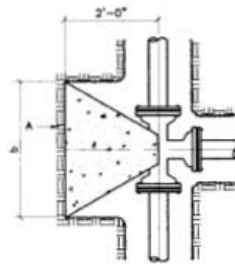


Thrust in Piping Systems

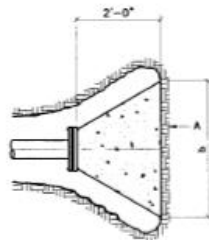
Force of water where changes in fluid velocity, pipe size, or pipe direction occur (such as at fittings, caps, valves, tees, bends, or reducers).



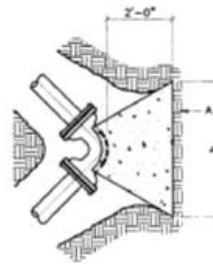
Thrust Blocks



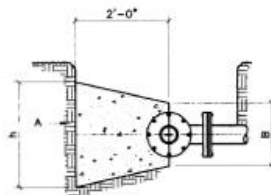
PLAN



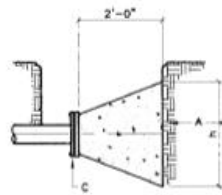
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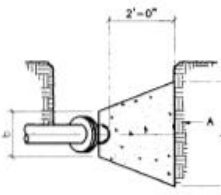
PLAN



ELEVATION
CONCRETE BLOCKING
FOR TEE



ELEVATION
CONCRETE BLOCKING
FOR PLUG OR CAP



ELEVATION
CONCRETE BLOCKING
FOR ELBOW

GENERAL NOTES:

- 1 ALL THRUST CONTROL BY RESTRAINED JOINTS ONLY UNLESS DIRECTED BY ENGINEER.
- 2 PIPE SIZE GREATER THAN 14" REQUIRES DESIGN BY ENGINEER TO BE SUBMITTED TO THE ENGINEER FOR APPROVAL.
- 3 CONCRETE BLOCKING PER SEC. 101 EXTERIOR CONCRETE, $f'_c=3500$ psi @ 28 DAYS.

PIPE SIZE	ELBOW ANGLE	ELBOW (b) DIM.	ELBOW (h) DIM.	TEE OR PLUG (b) DIM.	TEE OR PLUG (h) DIM.
4"				2'	1'
4"	90° 45°	2'	2'		
4"	22 1/2° 11 1/4°	2'	2'		
6"				2'	2'
6"	90° 45°	2'	2'		
6"	22 1/2° 11 1/4°	2'	2'		
8"				3'	3'
8"	90°	3'	3'		
8"	45°	2'	2'		
8"	22 1/2° 11 1/4°	2'	2'		
10"				3'	3'
10"	90°	3'-6"	3'-6"		
10"	45°	3'	3'		
10"	22 1/2° 11 1/4°	2'	2'		
12"				3'-6"	3'-6"
12"	90°	4'	4'		
12"	45°	3'-6"	3'-6"		
12"	22 1/2° 11 1/4°	2'	2'		
14"				4'	4'
14"	90°	5'	5'		
14"	45°	3'-6"	3'-6"		
14"	22 1/2° 11 1/4°	3'	3'		

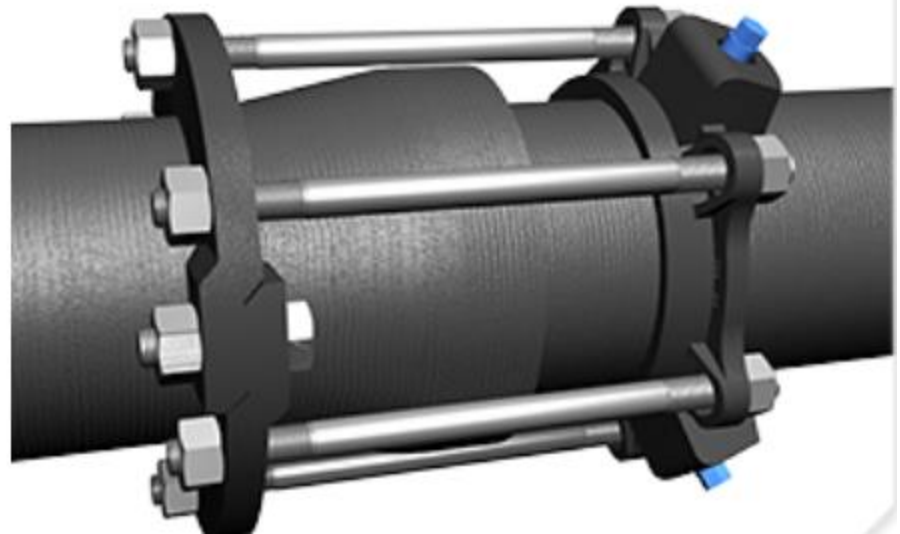
CONSTRUCTION NOTES:

- A UNDISTURBED EARTH.
- B O.D. OF PIPE + 8".
- C O.D. OF CAP OR PLUG, MIN. 12"x12".

REVISIONS	NM APWA WATER CONCRETE BLOCKING DESIGN
	DWG. 2320 FEB. 2006



Mechanical Joint Restraints



Calculating Restrained Lengths

Restraint Length Calculator

Project Name [Notes](#)

Site Name [Notes](#)



Item 1 of 1

[Pipe Material](#) ?

[Soil Type](#) ?

[Safety Factor](#) ?

[Trench Type](#) ?

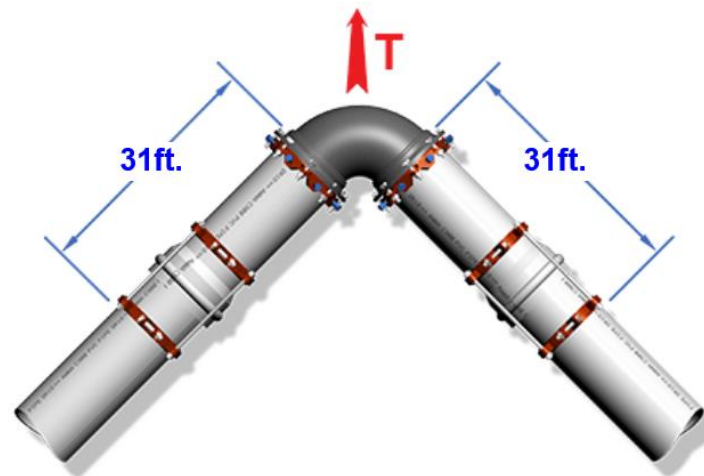
[Depth of Bury \(ft.\)](#) ?

[Test Pressure](#) ?

[Fitting Type](#) ?

[Nominal Size](#) ?

[Bend Angle](#) ? x



31 ft. = Length to be restrained on each side of the bend

13,647 lbs. = Thrust

CALCULATED RESTRAINT LENGTH

*ALL JOINTS WITHIN THE CALCULATED LENGTH MUST BE RESTRAINED

*IF YOUR DISTANCE BETWEEN FITTINGS IS LESS THAN OR EQUAL TO THE CALCULATED



Separation Distances

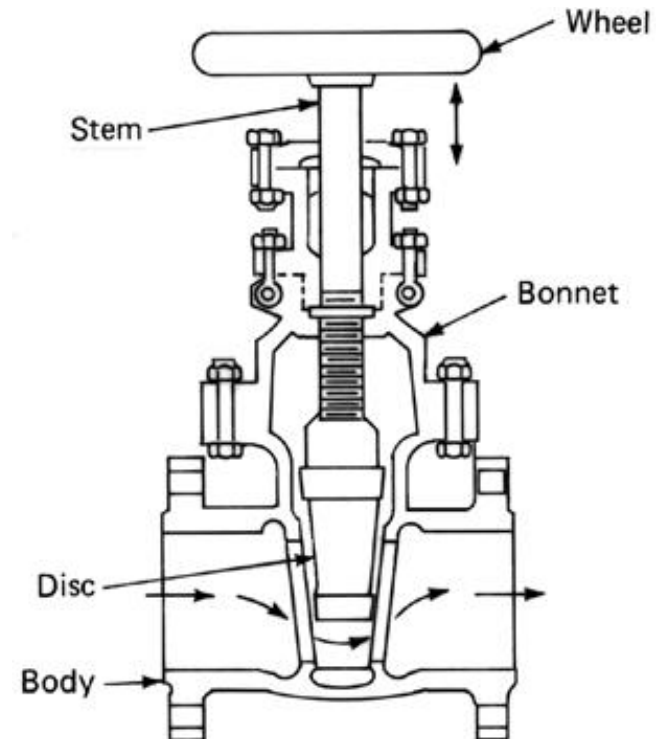
- Horizontal
 - 10 feet minimum
- Vertical – water over wastewater
 - 18 inches minimum
- Vertical – wastewater over water
 - Water-tight 20 ft casing around wastewater pipe
 - Water line required to be at least 10 feet from either end of casing

**NEED TO REFER TO NMED REGULATIONS AND
LOCAL ORDINANCES FOR SPECIFIC SEPARATION
DISTANCES**



Valves

- Uses
 - Control flow (rate, direction) and pressure
 - Maintenance (isolation)
 - Vent
- General maintenance
 - Exercise at least once annually
 - Check for leaks – stem, stuffing box



Types of Valves

- Gate – CTC, CTO
 - Isolation
 - NOT for flow control
 - Least friction loss when open
- Butterfly
 - Isolation
 - Easier to open than gates (1/4 turn)
 - Can be used to control flow
- Ball or plug
 - Similar to butterfly
 - 2nd most common valve: corp and curb stops
 - Usually not used in sizes $>2\frac{1}{2}$ -inches



Types of Valves (continued)

- Check
 - Swing in horizontal; lift in vertical
 - Discharge side of pumps; foot valves
- Air release
 - Vent
- Globe
 - Flow control (2-way)
 - Mixing (3-way)
 - Hydraulically operated, diaphragm-actuated



Control Valves

- Altitude
 - <https://www.cla-val.com/documents/pdf/E-210-03.pdf>
 - <https://www.youtube.com/watch?v=vWyApKcGqVw>
 - Closes when storage tank full
 - Required for systems that contain several tanks at different elevations
- Pressure reducing
 - <https://www.youtube.com/watch?v=oFXW-rJQJrA>
 - <https://www.youtube.com/watch?v=NQqZYWDS6aw> (start-up)
 - Reduces/maintains steady downstream pressure
 - Min/max ranges
 - Improper sizing can cause water hammer



Control Valves

- Pressure relief
 - <https://www.youtube.com/watch?v=bvp7Zqls7Fw>
 - Provide protection against high pressures that may develop
 - Used in conjunction with pressure reducer
 - Acts as by-pass (cross-connection potential)
- Pressure sustaining
 - <https://www.youtube.com/watch?v=rOKJokoWttM>
 - Throttles (restricts) flow to maintain user-defined upstream pressure
 - Upstream pressure increases
 - Downstream pressure decreases
 - Example; maintaining pressure in upstream multistory building



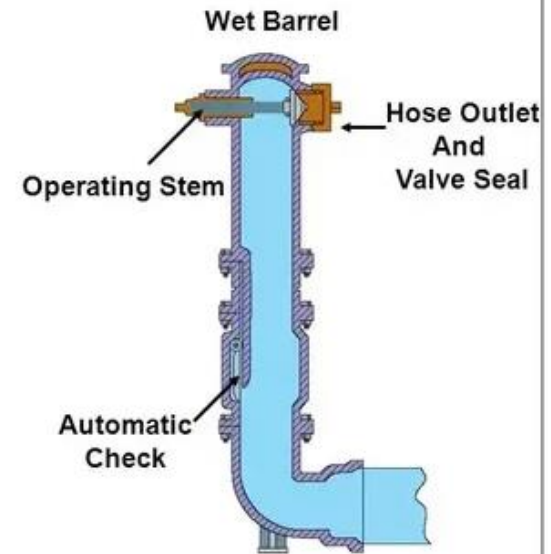
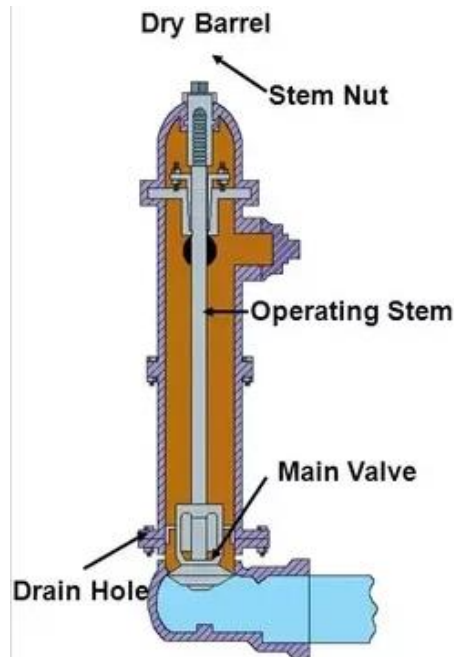
Hydrants

- Fire insurance rates
 - Maximum 500 to 600 feet residential spacing
 - Minimum 6-inch lines
 - Dead ends
 - Operated every 6 months, flow tested annually
- Other uses
 - Flush, vent lines
 - Pressure and flow testing



Hydrants (continued)

- Wet barrel
 - Always pressurized; main valve at top
- Dry barrel – used in freezing conditions
 - Bottom main valve
 - Drain hole – potential cross-connection



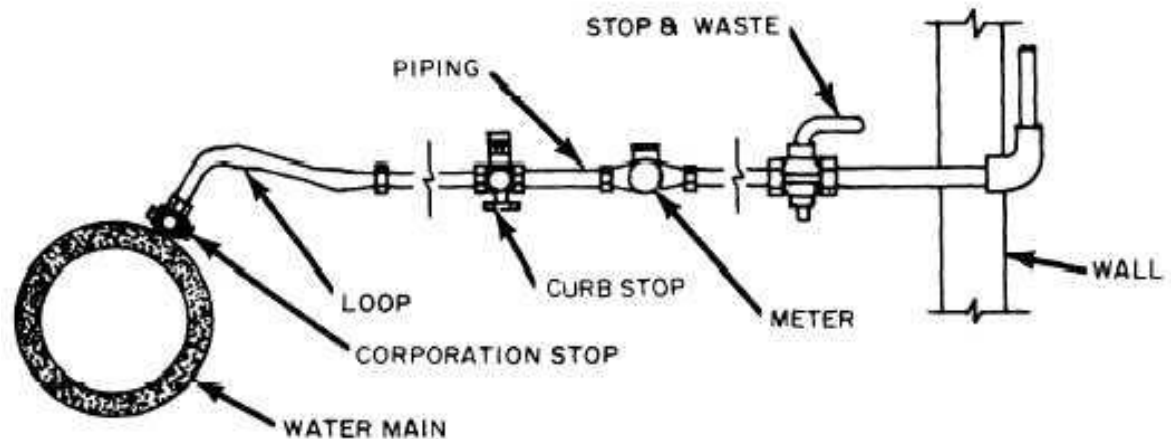
AWWA Fire Flow Standards

- Distribution
 - 6-inch minimum diameter lines
- Storage
 - 1,250 gallons per minute for 120 minutes
(2 hours) = 150,000 gallons



Services

- Corporation stop
 - “Hot” or “wet” tap into pressurized water line
 - Direct tap or saddle strapped to line
 - 45-degree angle from horizontal - protect from backhoe



Services (continued)

- Service line
 - Copper, PVC, PE
 - Galvanized and lead service lines should be replaced
 - Bend to allow flex if pipe settles or shifts
- Curb stop (copper shut-off valve)
 - Located in easement for service isolation
 - Meter stop can be used instead of curb stop
- Meters and service lines must be installed below frost line



Service Meters

- “Cash Registers”
- Worn or broken meters under-register flow
- Test a selection of customer meters annually:
 - Recalibrate
 - Repair
 - Replace
- Accuracy for most meters should be +/- 1.5 percent



Types of Service Meters

- Positive displacement
 - Most common; applications up to 2 inches
 - Fill/empty cycle of calibrated chamber
 - Displaces disc (nutating) or oscillating piston
 - Disc or piston action transferred to head by gears or magnetic drives



Types of Service Meters (cont.)

- Turbine or rotor
 - 5/8" and larger, low pressure applications
 - Dependable with relatively low head loss
 - Water velocity proportional to turbine rotation
 - Turbine shaft connected to meter register
 - Multi-jet meters for low flow applications



Types of Service Meters (cont.)

- Venturi
 - High flow applications
 - Measures difference in pressure head at throat (conservation of energy, Bernoulli equation)
 - Low head loss; very dependable (no moving parts)



Types of Service Meters (cont.)

- Compound meter
 - Two-in-one meters
 - Displacement meter for low flows
 - Turbine meter for higher flows
- Magnetic Meters
 - No moving parts
 - Applies a magnetic field – measures potential difference



Meter Installations & Accuracy

- Generic recommendation:
- 10 pipe diameters straight pipe upstream and 5 downstream
- Meter accuracy varies by type (magnetic most accurate)
- Size must be appropriate for actual flow experienced
- Age matters (more with mechanical meters)



Line Repairs



Line Repairs

- Line breaks
 - Disruption of service - PR
 - Water loss = revenue loss
 - Cross-contamination
- Leak Detection
 - Observation (greener grass/weeds)
 - Report (by customers)
 - Line isolation (in rural areas, at night)
 - Comparison between production and billing
 - Rapid drop in storage



Line Repairs (continued)

- 3 Steps
 - Leak location (often occurs at the joints)
 - Repair
 - Disinfection (repair or new construction)
- SOPs
 - Customer notification
 - Health & safety
 - Maintenance activities
 - Emergency repair call-outs
 - Recordkeeping

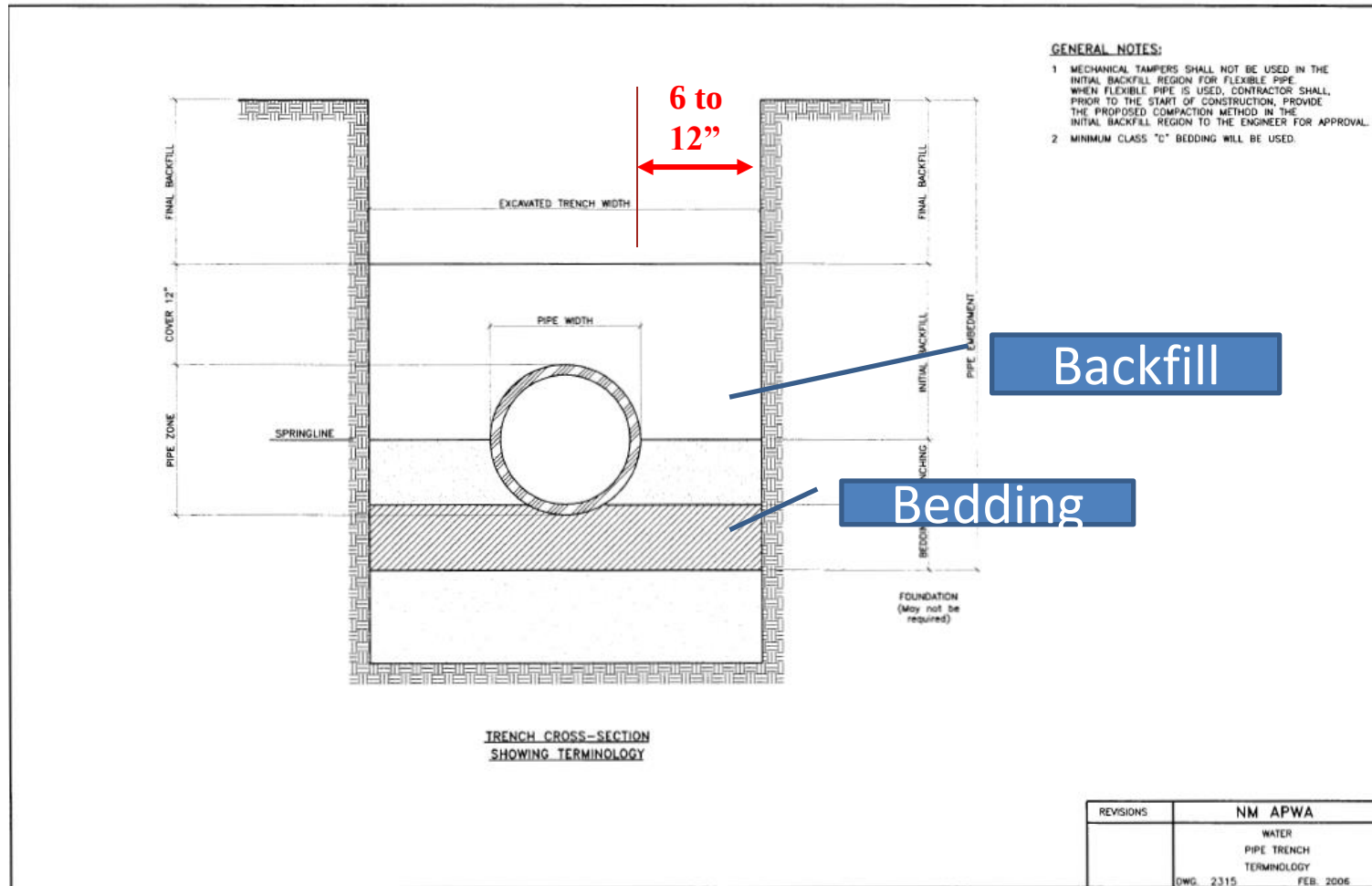


Backfill

- Type of material important
 - Abrasive, sharp edges
 - Sand
 - First lift - tamp when pipe half exposed
 - Second lift - again when pipe covered by ~ 6"
- Steel conduit
 - Protects pipe (especially plastic) from vibration and stress loadings (under railroads, highways)
 - Easier to repair, replace
- Metal tape, 12-gauge Cu wire
 - Mark plastic line for metal detection
 - Install after tamping second lift, before refilling trench



Trench Detail



Disinfection of New and Repaired Lines

- AWWA Standard C-651 or 10 state standards
- Flushing
 - Minimum velocity – 2.5 feet per second
 - 2 times pipe volume minimum
- Disinfect with chlorine
 - Usually start with 50 mg/L dosage
 - Target 5 mg/L residual 24 hours after dosage added
 - Can increase dose to achieve residual with shorter contact time (critical line)
- Flush to remove chlorinated water
- Collect Bac-T sample(s)



Taking care of your system



Operational Objectives

- Determine potential for degradation of water quality in distribution system
 - Reliability
 - Quality
 - Quantity
 - Vulnerability of distribution system
- Ensure sampling/monitoring plans conform with requirements and adequately assess water quality in distribution system



Valve Maintenance Data

- Map of system showing valve locations
 - Make, type, and size
 - Number of turns to open/shut
 - Exercise date(s)
 - Maintenance date(s)
 - Condition of the valve



Line Cleaning

- Flushing

- **Spot Flushing** - Reactive. Most common type of flushing. Responding to customer complaints
- **Stagnant Area Flushing** - Short term preventative. Used in areas with longer detention times (dead ends, low demands
- **System-wide Flushing** - Long term preventative. Most comprehensive form of flushing. Maintains water quality and useful life of mains.



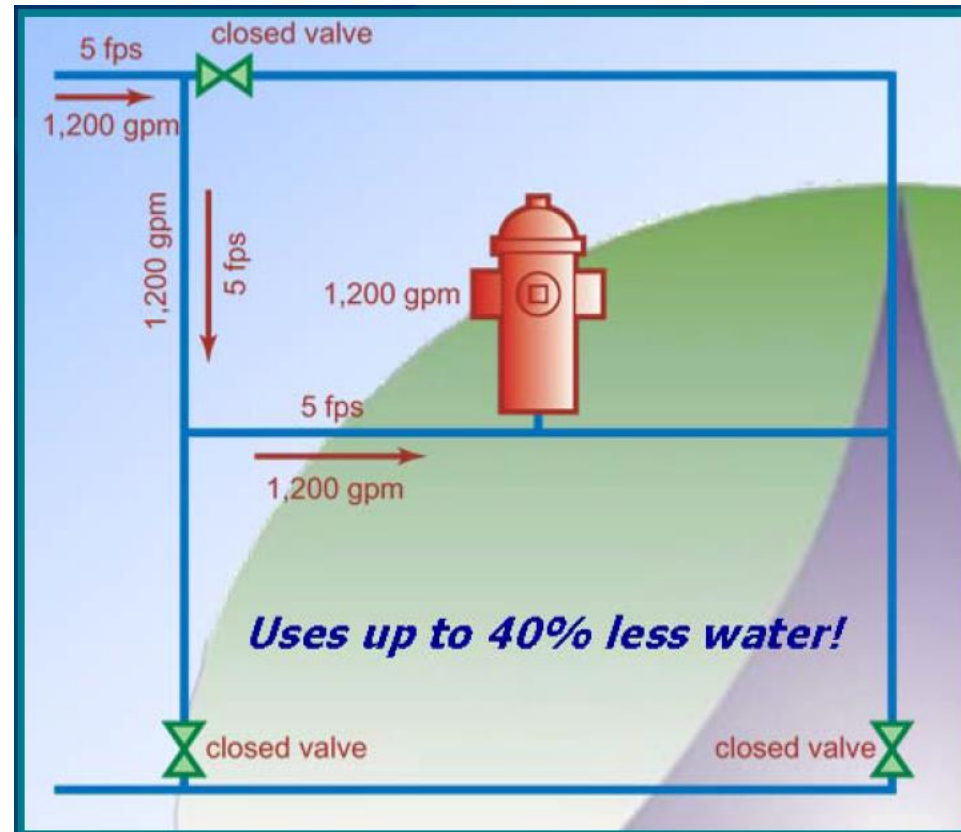
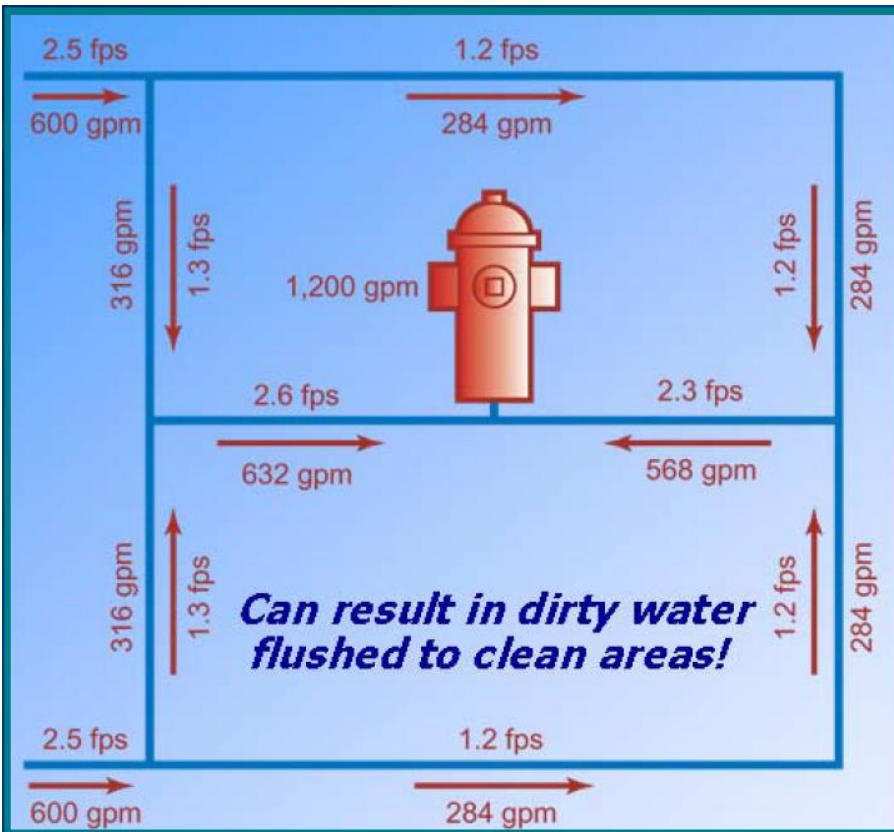
Line Cleaning

- Routine flushing
 - When to flush?
 - monthly, quarterly, annually?
 - before and after main disinfection
 - in response to complaints
 - in response to reg violations (bac.t, low TCR)
 - Valve inspection and exercising
 - Hydrant inspection and operation
 - Where to flush?



Line Cleaning

- Unidirectional Flushing



Line Cleaning

- Unidirectional Flushing - What data will you need?

complaint records
flushing data
fire hydrant testing
water quality data
maintenance records
records of high flows
condition of mains



Line Cleaning

- Unidirectional Flushing - How it works?
 - Develop a flushing plan for each area (system maps!!!!)
 - Inform sensitive customers
 - Confirm storm drains or natural water courses can handle the flow
 - Close valves to isolate section from the rest of the system
 - Flush one small section at a time
 - Open hydrant slowly until the desired flow is obtained
 - Keep flushing velocities 2.5 - 12 fps, maintain min 20 psi



Line Cleaning

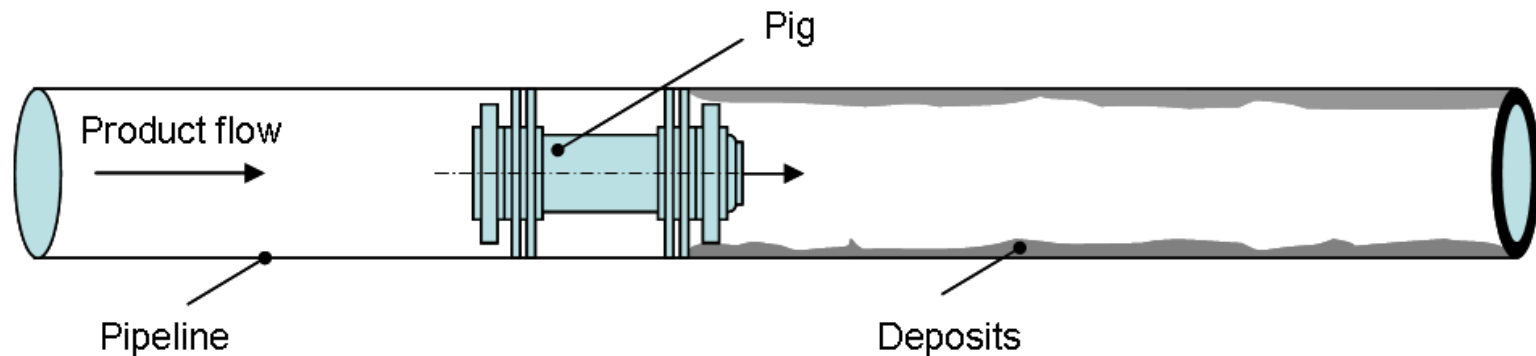
- Unidirectional Flushing - How it works?
 - Flush from the source towards periphery
 - Flush at night when possible
 - Record data
 - When water clears, close hydrant slowly
 - Reopen valves
 - Proceed to the next section

Video in [YouTube](#)



Line Cleaning

- Pipe pig
 - Bullet-shaped foam swab
 - Pushed through pipe using water pressure
 - Special launch sites
 - Extraction points



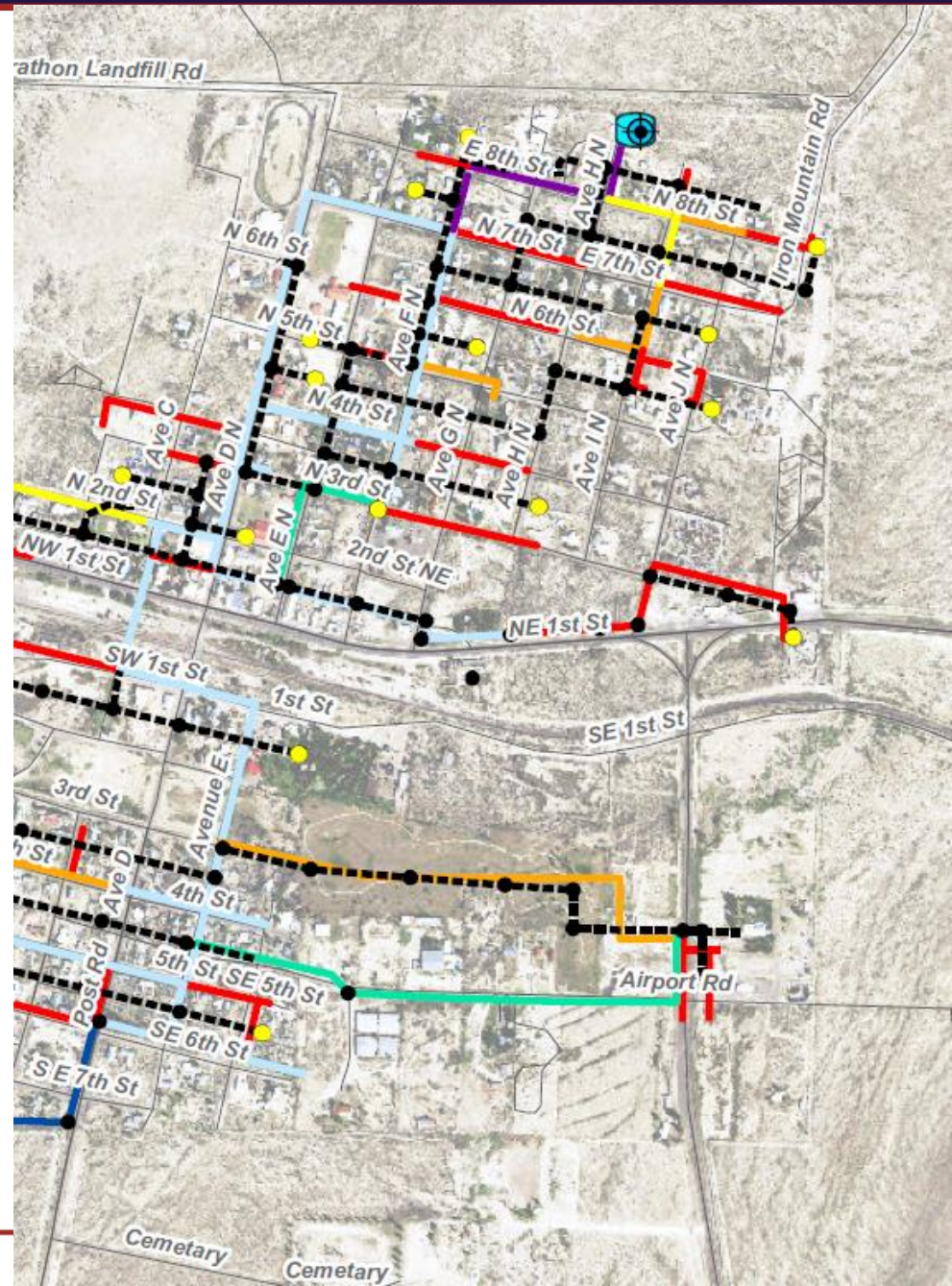
Mapping

- Understanding your system
- Preserving the knowledge
- DSSP, Emergency Response Plan, O&M Plan, Flushing Program, Asset Management, etc.
- Maps should include:
 - locations of all the water system facilities
 - pipes (size, material, age, condition)
 - valves
 - service connections, water meters



Mapping

- Mapping tools:
 - Google Maps
 - Scribble Maps
 - ESRI Free Trial
 - ESRI ArcGIS



Asset Management



Asset Management: A Process

"Asset management is managing infrastructure assets to minimize the total cost of owning and operating them while continuously delivering the service levels customers desire."

—from the publication *Managing Public Infrastructure Assets*

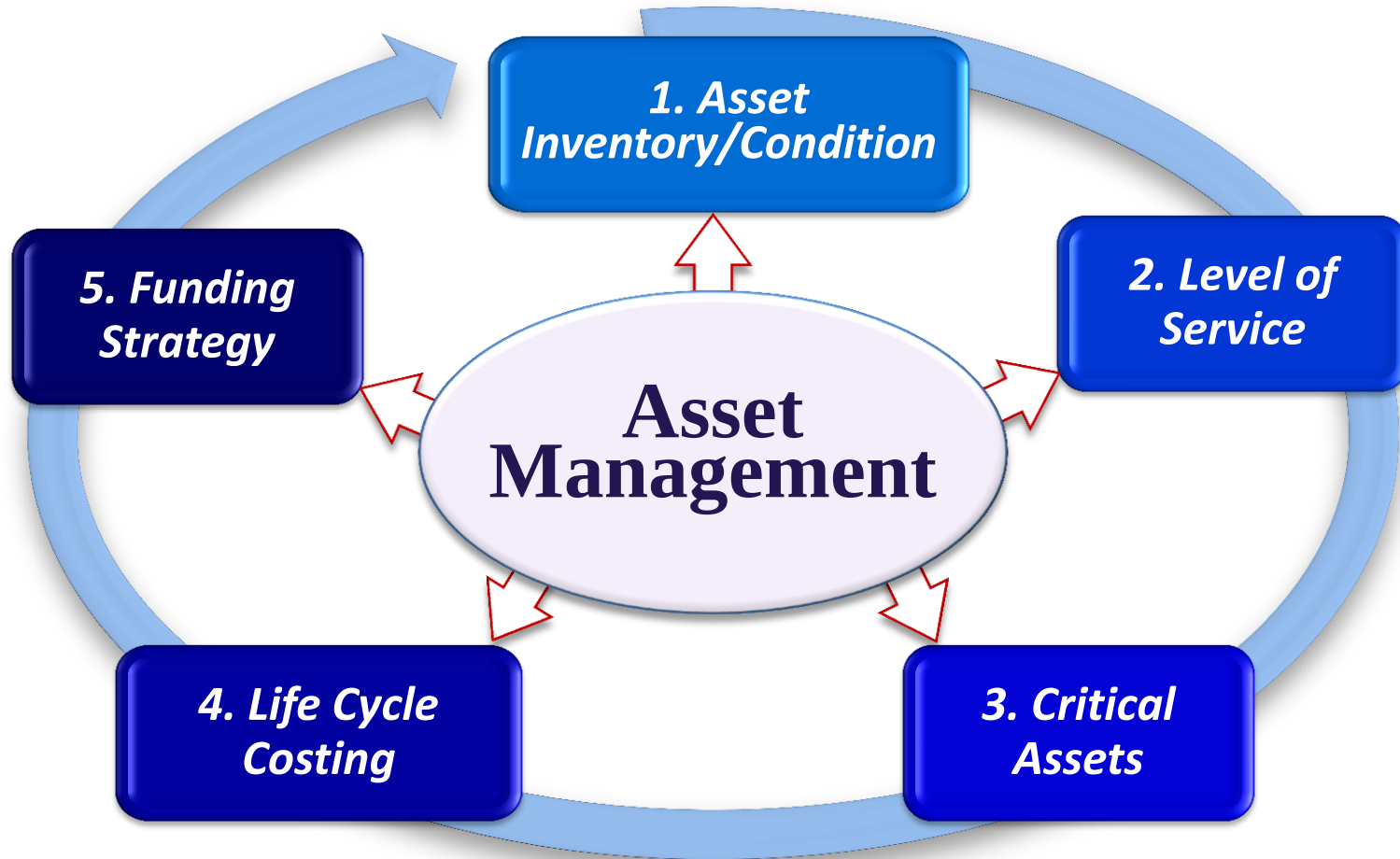


Why do you need Asset Management?

- Regulatory requirements
 - CMOM (Capacity, Management, Operation and Maintenance Programs for Sanitary Sewer Collection Systems)
 - GASB 34 (Governmental Accounting Standards Board Station No. 34)
 - NMFA (New Mexico Finance Authority)
- Save cost on replacement by extending the life of assets
- Some funding sources require an AM Plan



AM Core Components



Asset Management Questions

- What assets do we have and where are they?
- What are they worth?
- What is their condition?
- What do we need to do with them?
- When do we need to do it?
- How much will it cost?
- How will we finance it?



Asset Management Benefits

- Increased knowledge of assets, including which ones are the most critical
- Data-driven decision-making
- Understanding of the relationship between preventive maintenance and replacement
- Consideration of the capacity of the asset when deciding to repair or replace



Water audit and leak detection

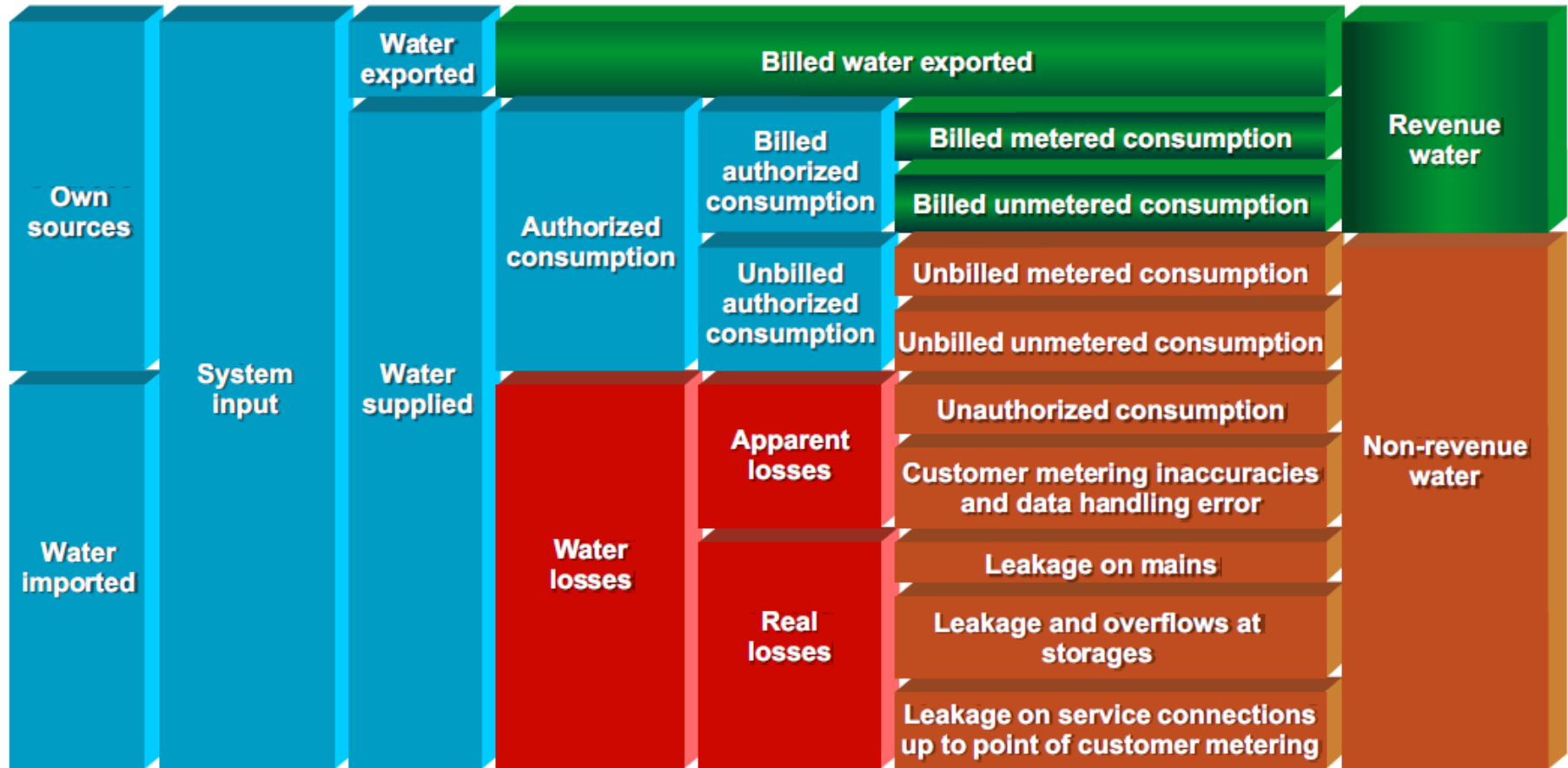


AWWA Water Audits

- M36 Method for conducting water audits:
- Audit looks at:
 - Production
 - Billing
 - Budget
 - Data collection
- Based on an audit - where is water lost? (real vs apparent)



AWWA Water Audits (continued)



Elimination of Water Loss

- Water loss limits – no longer useful thresholds
 - $\leq 10\%$ acceptable
 - 10-15% - some improvement needed
 - $> 15\%$ unacceptable, serious problem
- Reasons for water loss
 - Inaccurate or non-working meters
 - Leaks
 - Illegal taps
 - Overflowing tank(s)
- Leak detection program



Leak Prevention and Detection

- Components
 - Selection of appropriate types of equipment – pipes, valves, hydrants, meters
 - Proper installation
 - Calibration (accuracy)
 - Maintenance and replacement
 - Data collection and calculation practices



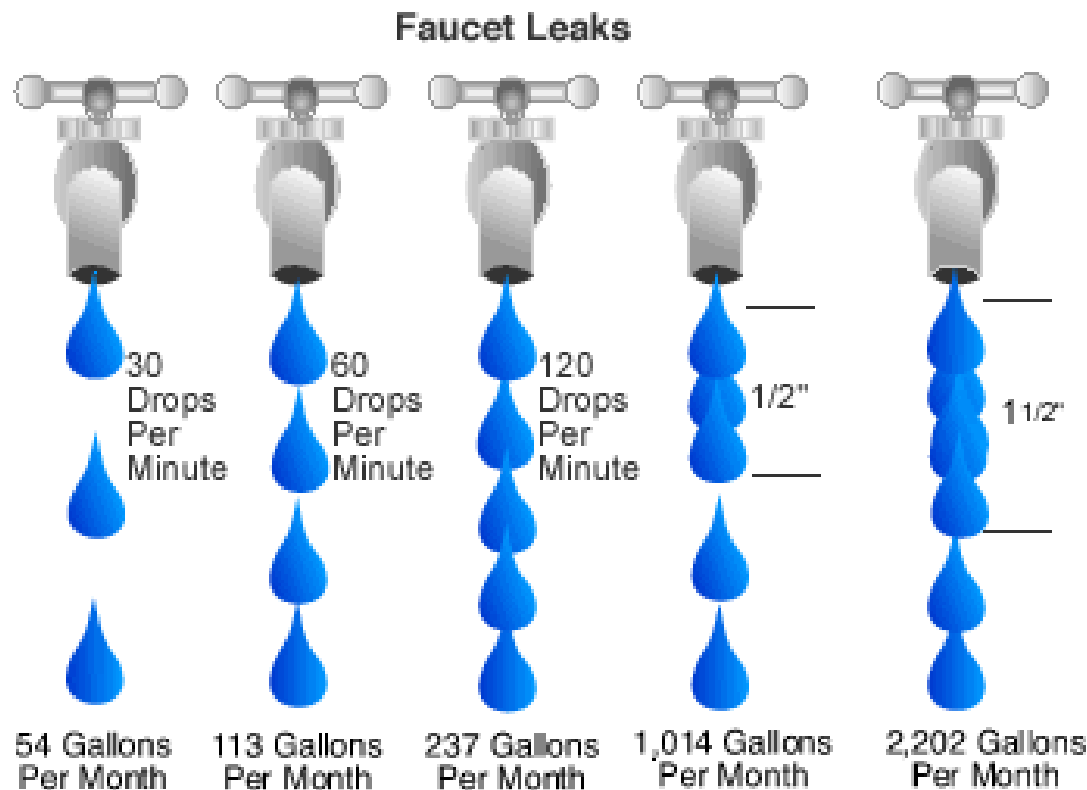
How Much Water is Leaking?

Size of Hole	Gallons Water Per Month*
1/32"	6,300
1/16"	25,000
1/8"	100,000
3/16"	225,000
1/4:	400,000
*at 60 psi	



How Much Water is Leaking?

Faucet Leaks



Cross-Connections



Cross Connections

- Any link between potable and non-potable water systems that allow contamination to enter the potable system
- Contaminants can enter the potable supply when the pressure in the non-potable system is greater than the pressure in the potable system



Cross Connections (continued)

- Pressure differential causes 2 types of backflow – back pressure backflow or back siphonage backflow
 - Back pressure occurs when the non-potable system has a greater pressure than the potable system
 - Back siphonage occurs when there is a vacuum in the potable system causing non-potable water to be siphoned into the potable system



Examples

- Backwash drains – filters, softeners
- Ice, soft drink machines, HVAC, washing machines
- Chemical feed make-up and carrier water
- Split-feed (pre- and post-chlorination) system
- Water flush for pump bearings
- Fire hydrant drain lines

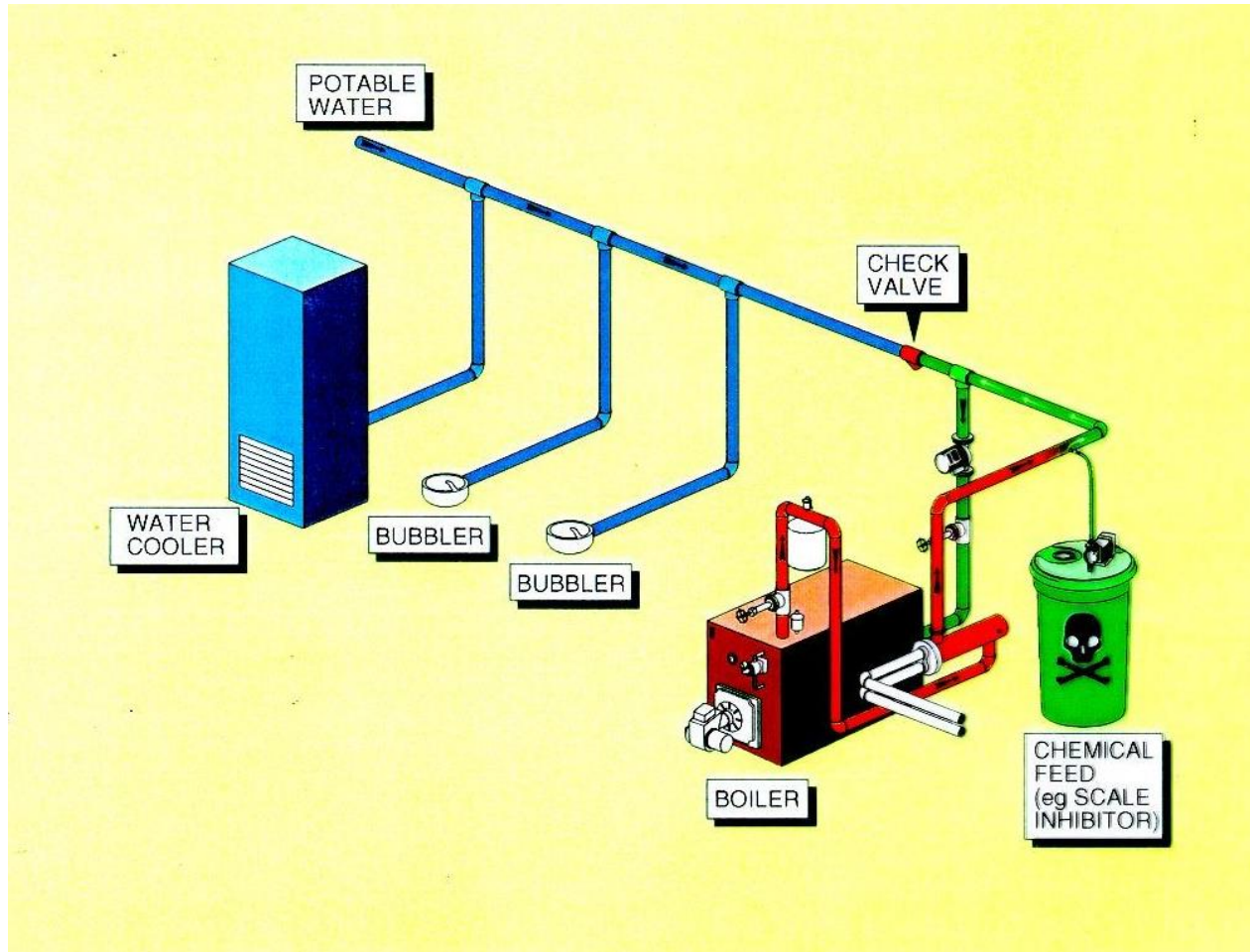


Additional Examples

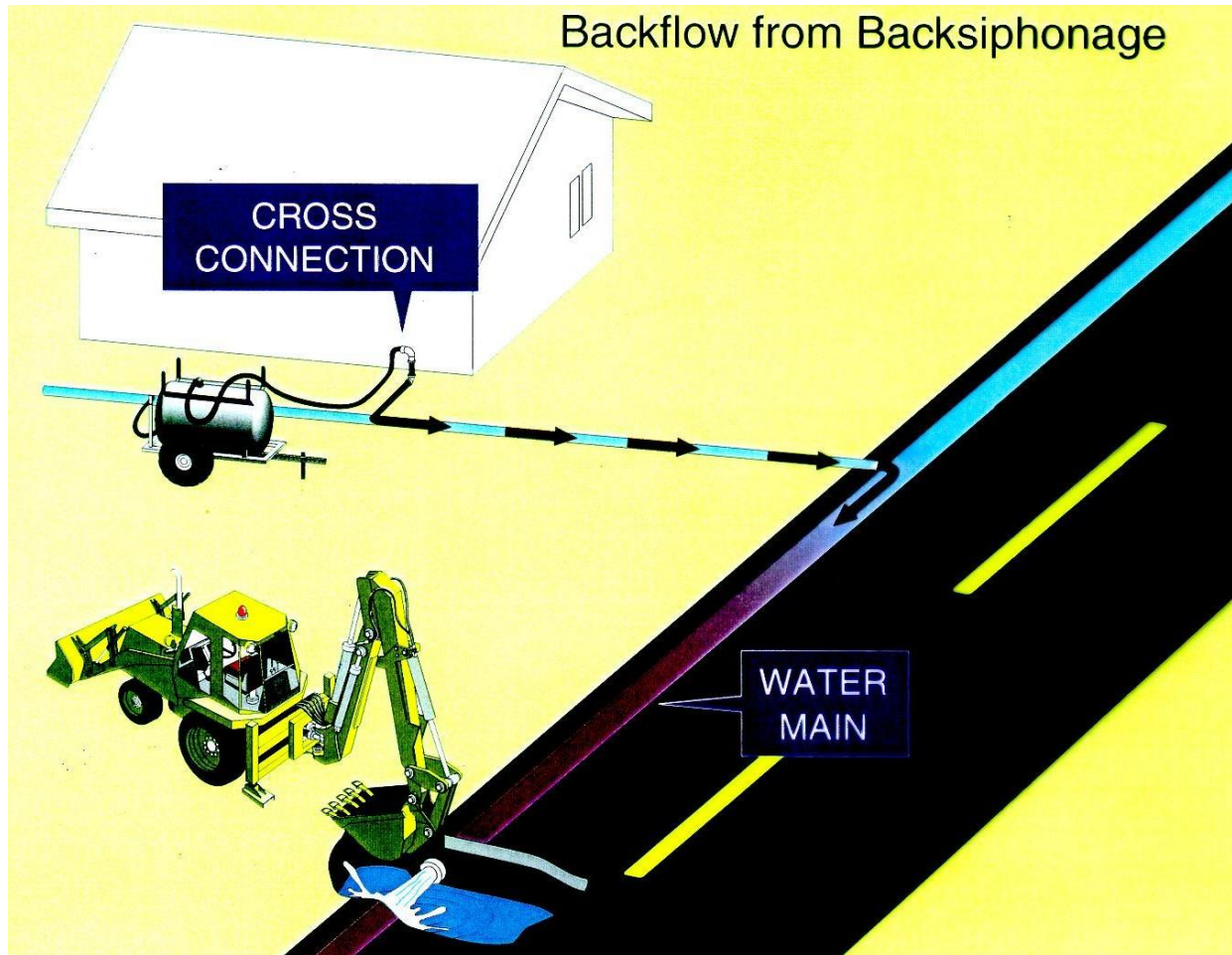
- Old wells
- Heating systems – make-up water, glycol
- Hose bibs, sinks
- Distribution system entry points
- Household residential boilers – huge danger
 - Rarely serviced, poorly controlled

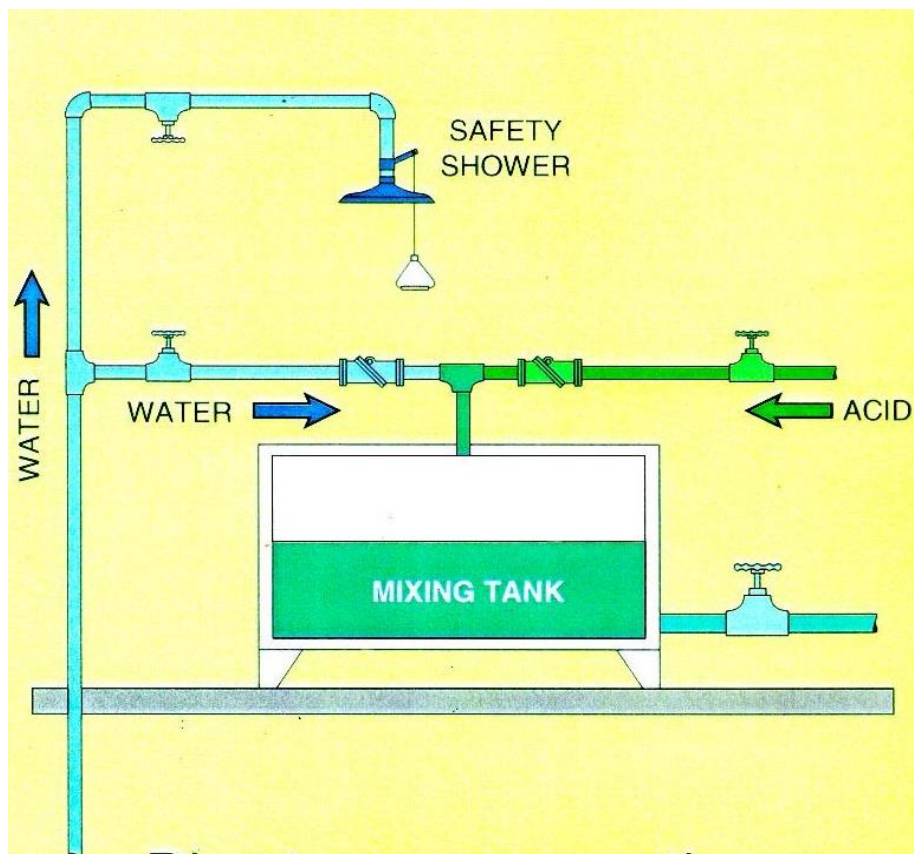


Backflow from Backpressure

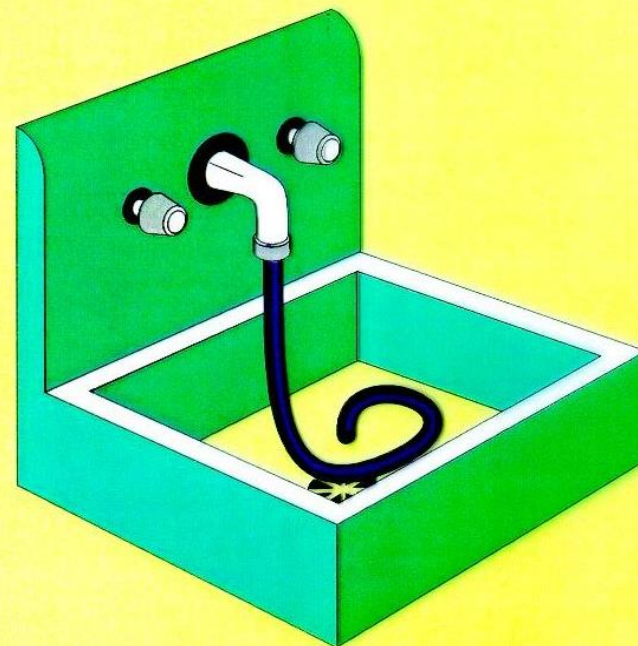


Backflow from Backsiphonage





Direct cross connection



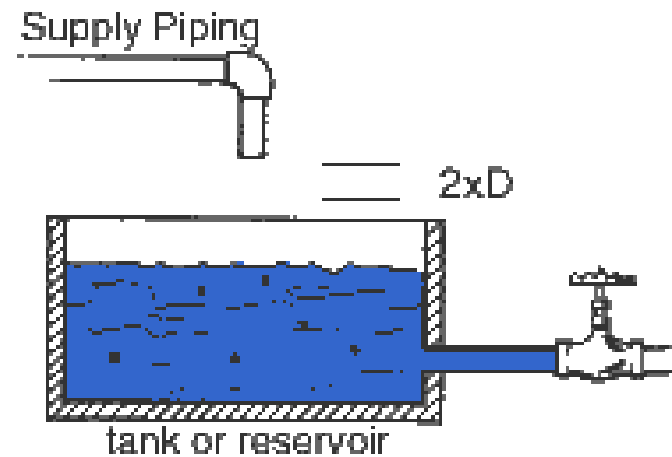
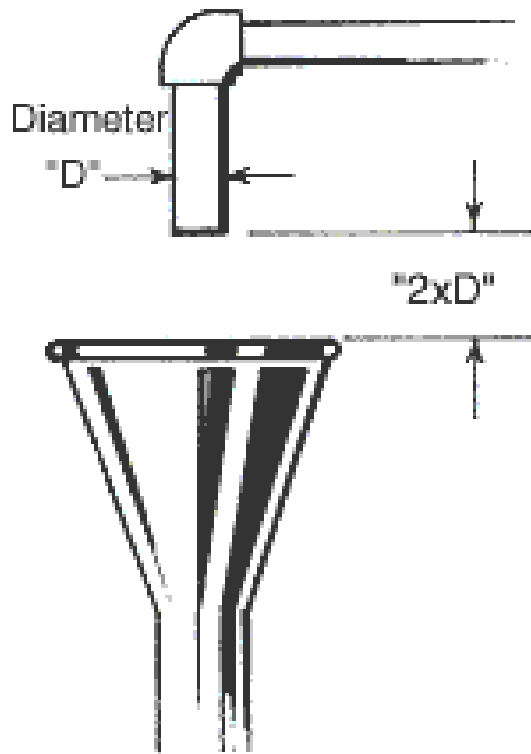
Indirect cross connection

Protection Against Cross Connections

- Adequate distribution system pressures
- Air gap
- Atmospheric vacuum breakers (AVB)
 - Includes hose bib vacuum breakers
- Pressure vacuum breakers (PVB)
 - Includes backflow preventer w/ intermediate atmospheric vent for ½" and ¾" lines
- Double check valve (DCV) assembly
- Reduced pressure zone (RPZ) backflow preventer
- Institutionalized X-conn control program



Air Gap



<https://www.youtube.com/watch?v=FpZd0ZmBI4A> (0:00 – 1:23)





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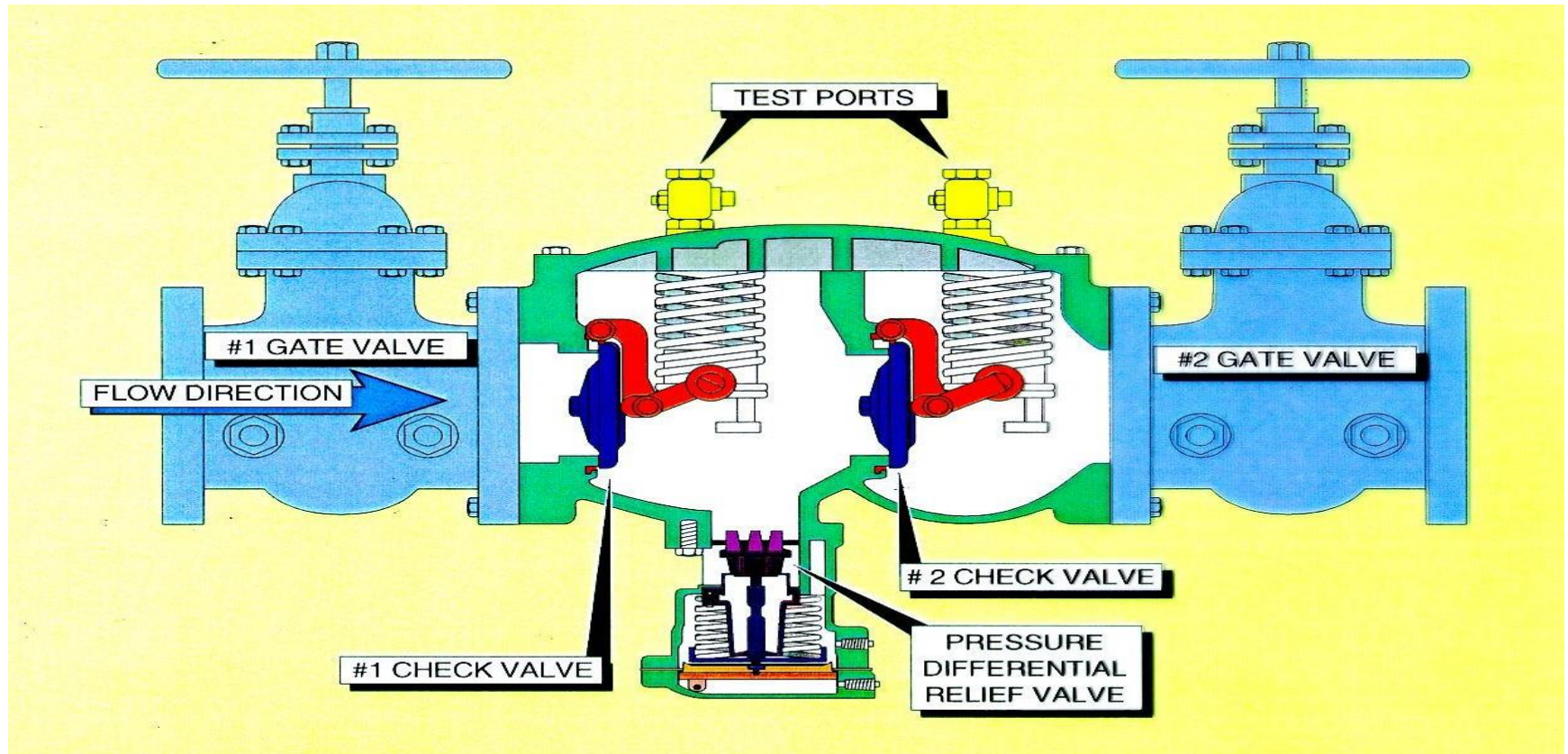


Reduced Pressure Zone Backflow Preventer

- Most reliable mechanical device
 - Creates an air gap
- High hazard protection
- Used on all direct connections for back pressure and back siphonage
- Must be inspected and tested annually by certified personnel



Reduced Pressure Zone Backflow Prevention Assembly (RPZ)



<https://www.youtube.com/watch?v=FpZd0ZmBI4A> (1:24 – 5:51)

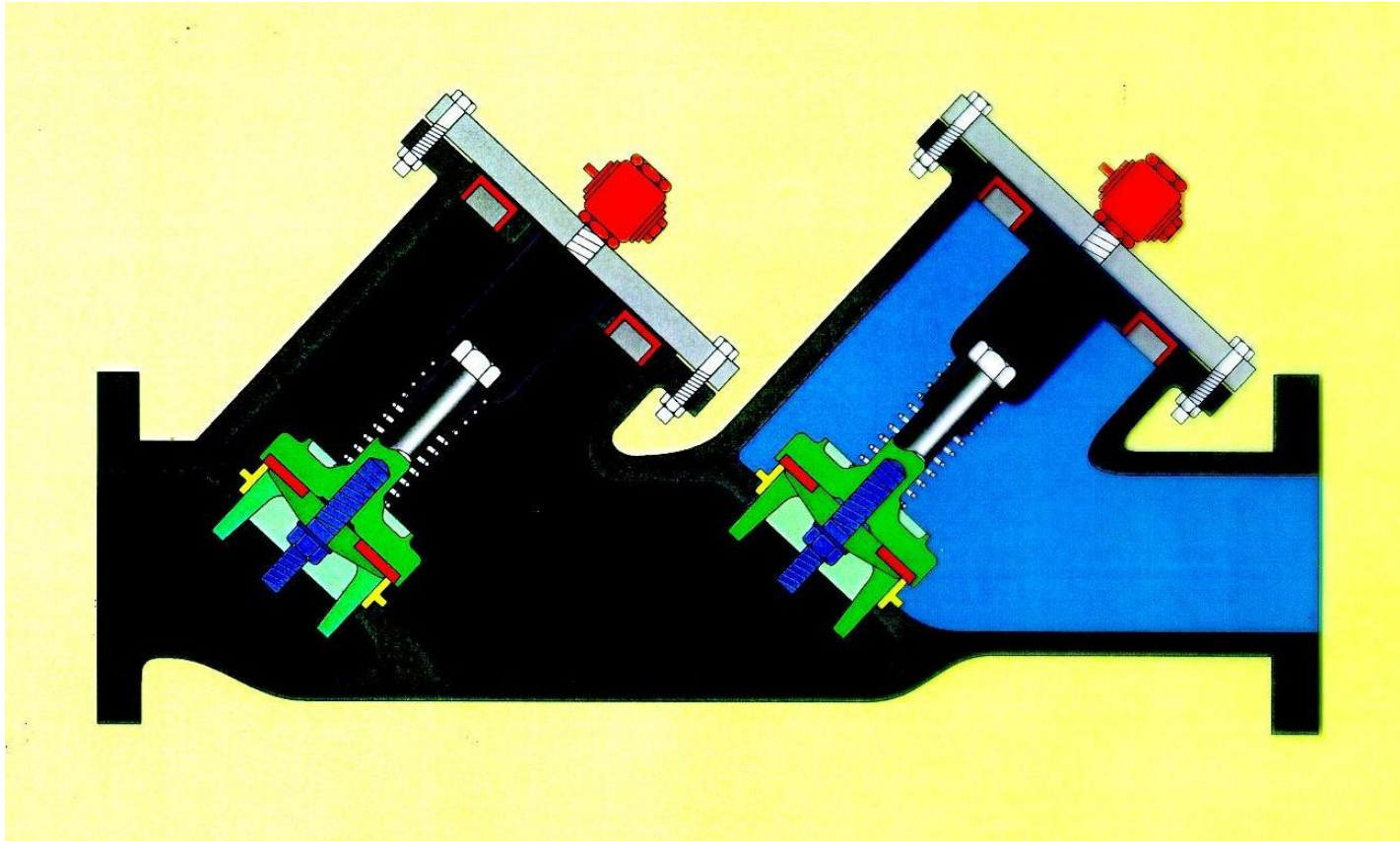


Double Check Valve Assembly

- 2 independently operating, internally loaded check valves
- 2 tightly closing shut-off valves
- 4 appropriately located test cocks
- Back siphonage and back pressure protection
 - Protection for low levels of hazard
 - Non-potable source is polluted, not contaminated
- Operates with low head loss
- Must be inspected and tested annually



Double Check Valve



<https://www.youtube.com/watch?v=FpZd0ZmBI4A> (5:52 – 6:59)

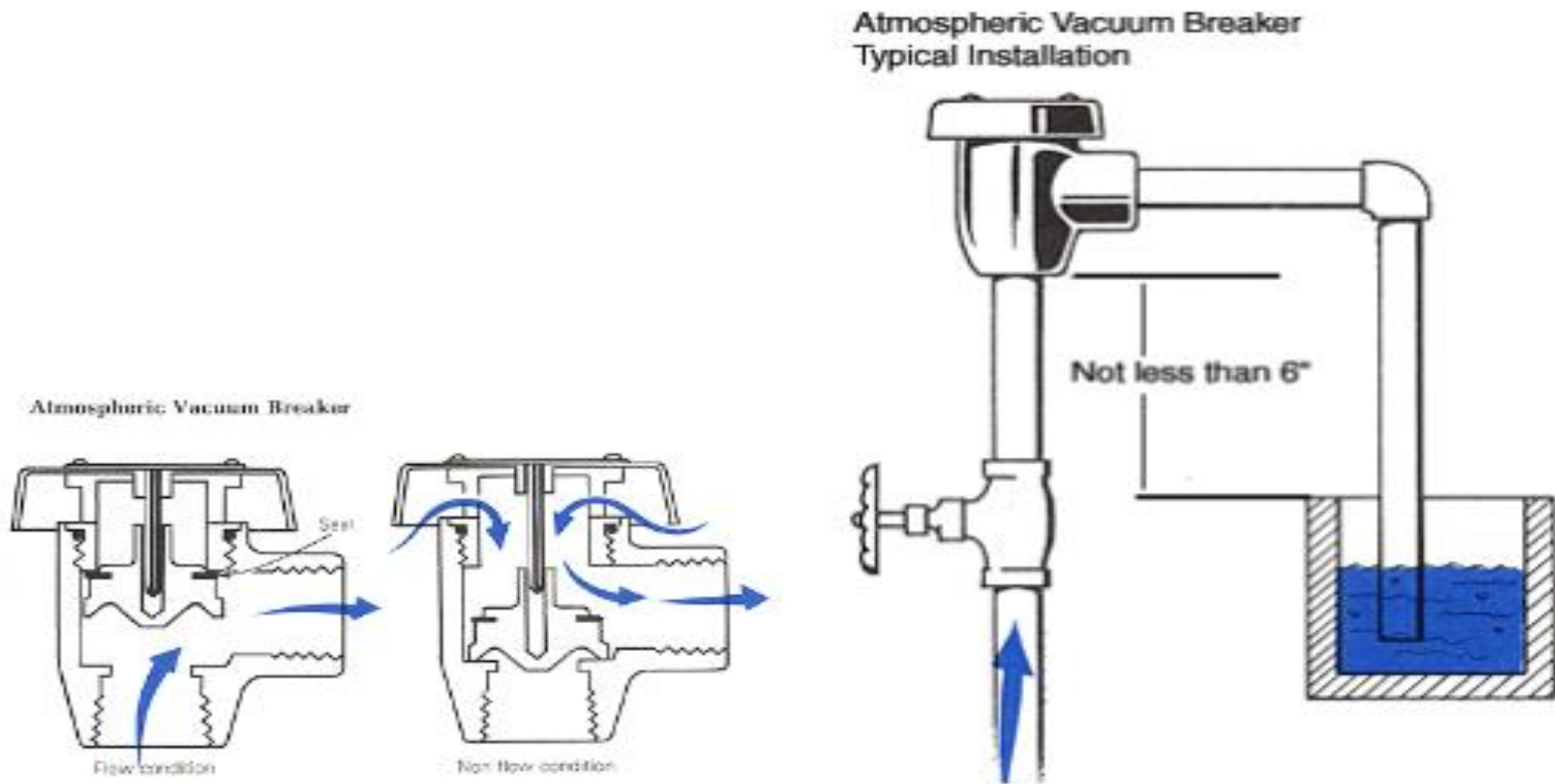


Atmospheric Vacuum Breaker

- Incorporates atmospheric vent in conjunction with a check valve
- Supply of potable water seals off vent
- Negative pressure in supply line permits check valve to seal the orifice
- At the same time the vent opens allowing air to enter the system to break the vacuum
- Can be used where the vacuum breaker is never subjected to back pressure and is installed on discharge side of the last control valve above the usage point
- Cannot be used under continuous pressure – check valve tends to ‘modulate’ permitting backflow
- Low hazardous application only



Atmospheric Vacuum Breaker



<https://www.youtube.com/watch?v=FpZd0ZmBI4A> (7:00 – 8:16)

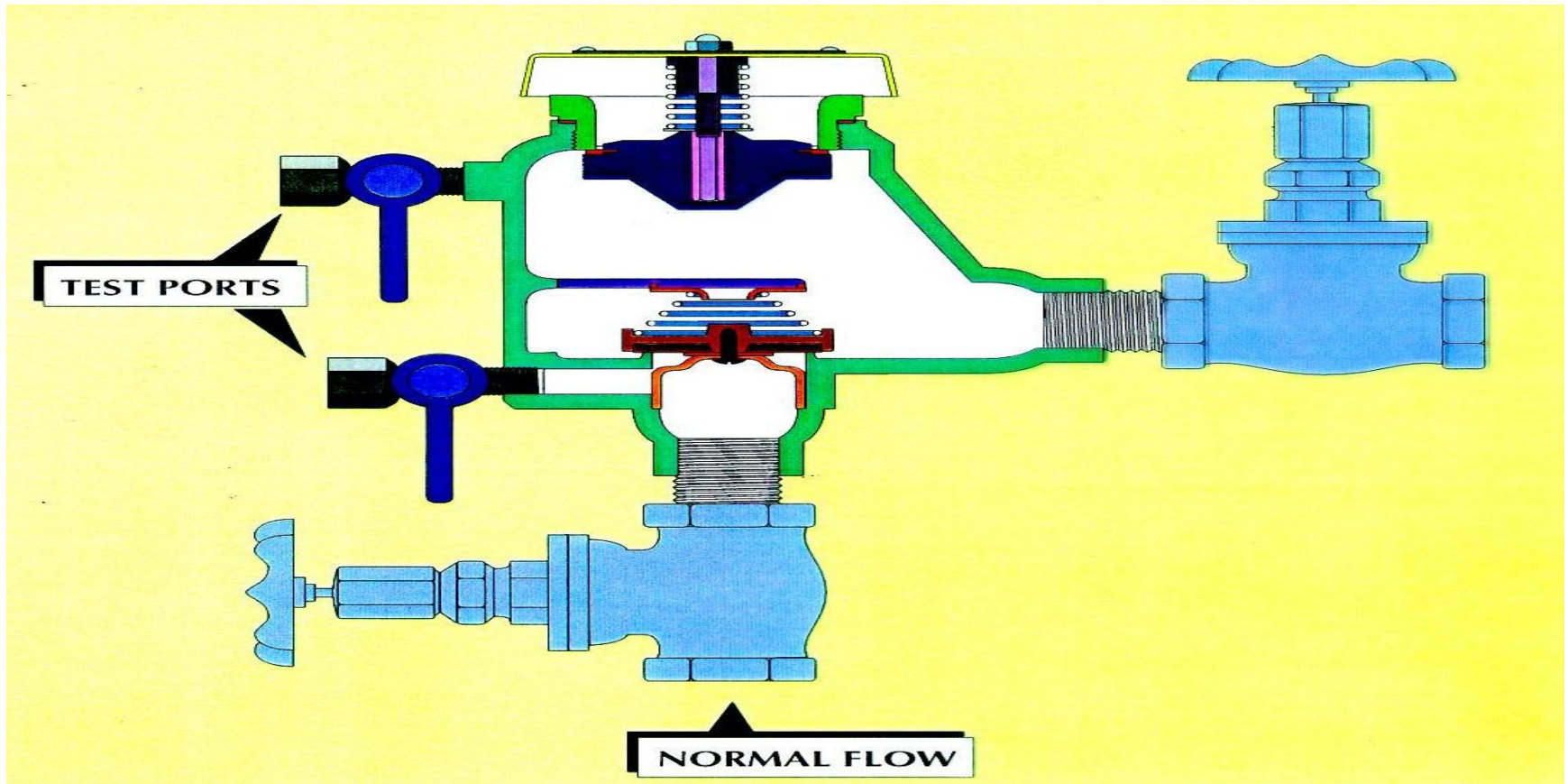


Pressure Vacuum Breaker

- Assembly consisting of an inlet valve with a spring loaded poppet, a spring loaded check valve, 2 test cocks, and 2 shut-off valves
- For use in pressurized systems
- Operates only when vacuum occurs
- Designed to operate for extended periods under continuous pressure
- Should not be subjected to back pressure
- Must be installed a minimum of 12 inches above highest outlet
- Must be tested annually
- Can be used for intermediate/high hazard applications where air gap not possible



Pressure Vacuum Breaker



<https://www.youtube.com/watch?v=FpZd0ZmBI4A> (8:17 – 9:01)



Cross-Connection Examples



Air Gap

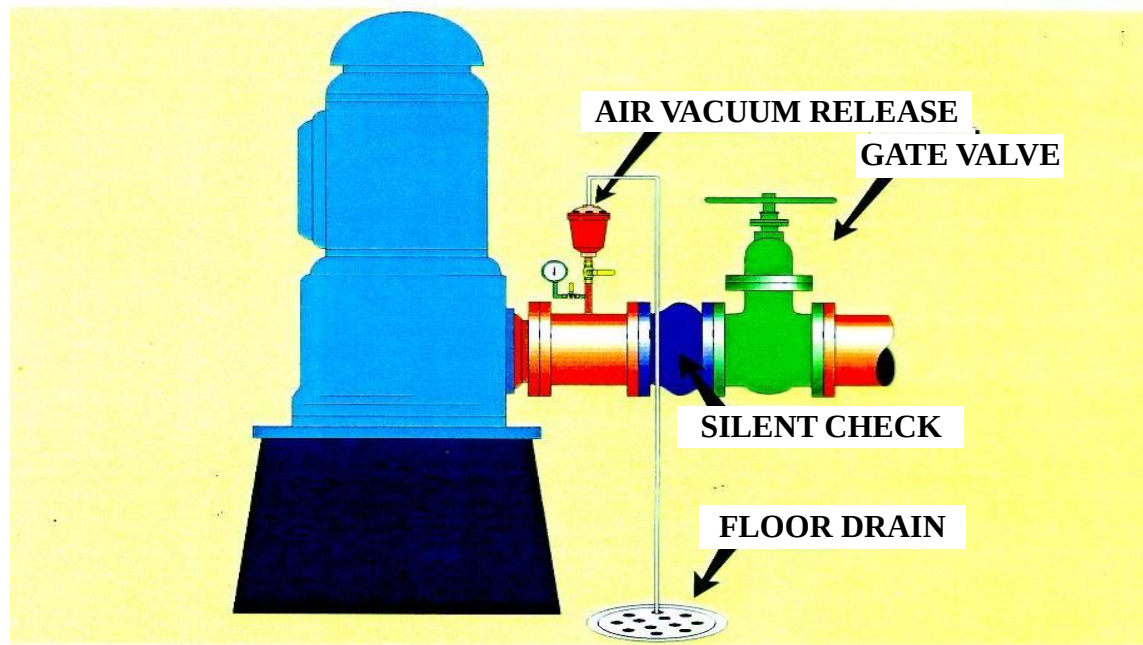






Pumping Station Cross-connections

- Priming of raw water pumps with finished water
- Air relief valves piped directly to a drain
- Cooling water for an emergency generator submerged in a drain or returned to the potable supply



Air Release Valve Plumbed Directly to Drain





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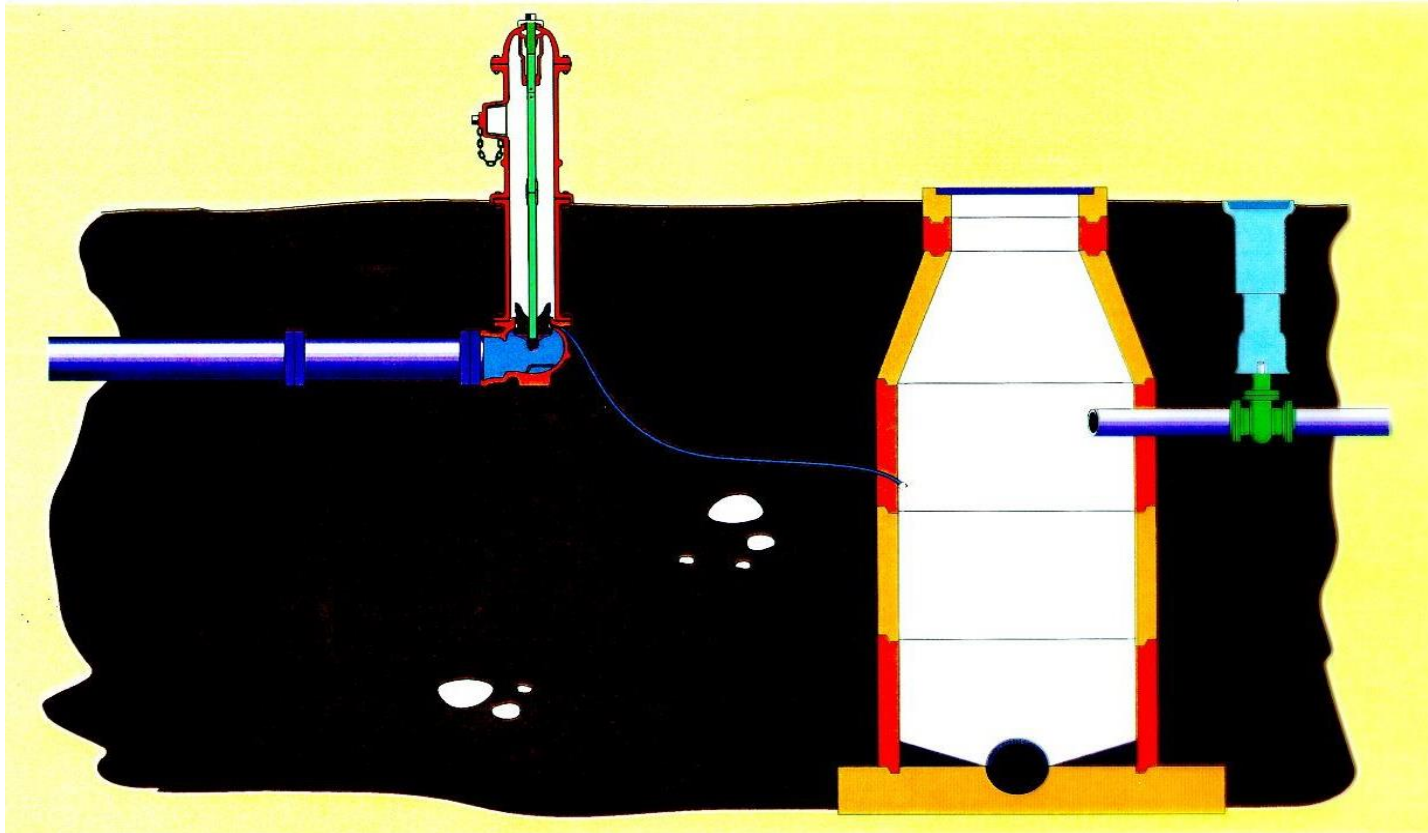




Clear Well or Storage Tank Overflow



Distribution System



Fire hydrant drain to sewer

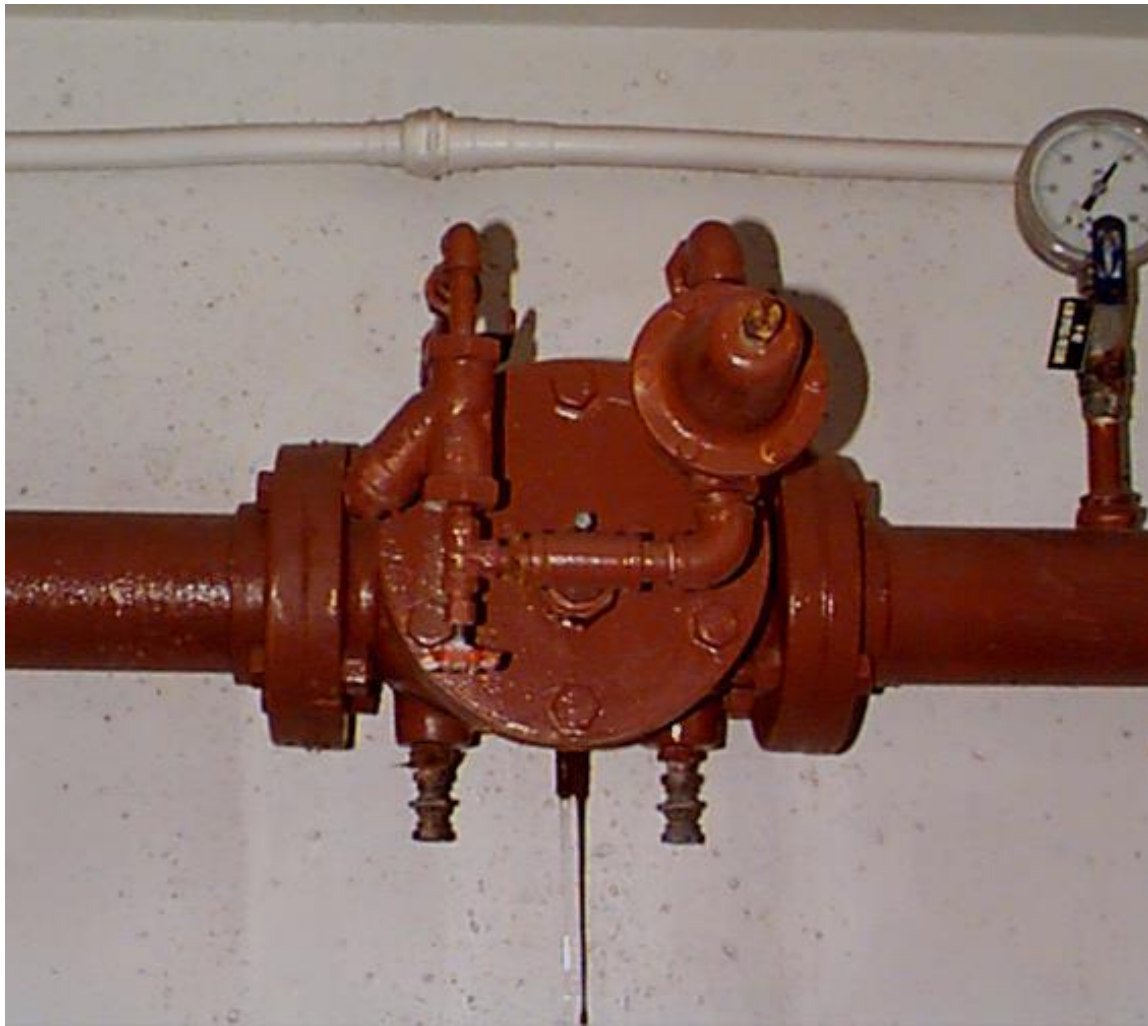






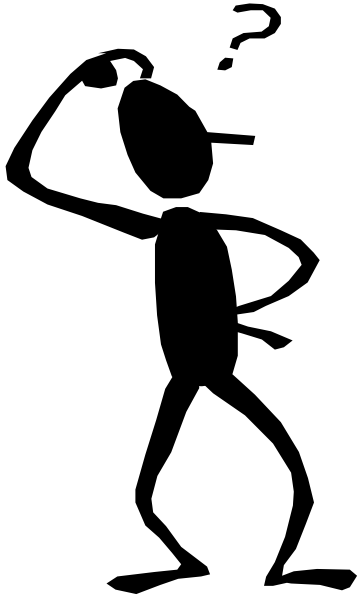






Air gaps – good & not so good





- **Any Questions?**

