Water Treatment
Operation & Maintenance

Exam Review

Terminology
- 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
- Feet of Head

Pathogenic
- Disease causing organisms
- Includes Viruses, Protozoa, or Bacteria
- Causes diseases such as typhoid, cholera and dysentery
- Organisms that don’t cause disease are non-pathogenic

Purpose of Treatment Process
- Screens
  - Remove debris
- Pre-chlorination
  - Kills pathogens, controls taste and odors. Possible problems with DBP’s
  - Use UV or Ozone instead
- Chemicals
  - Assist with the process
- Flash mixer
  - Mixes chemicals with water
- Coagulation/flocculation
  - Slowly mixes the chemical and particles together.

Intakes & Screens
- Multiple inlet intake structures allows operators to pull from depth of better quality
- Should prevent large debris & fish from entering treatment plant
- Should be designed to handle flows
- Manually cleaning screens for small amounts of debris
- Turnover cause mainly by change in water temperature & density

Thermocline
- Epilimnion - upper layer that circulates warm water where dissolved oxygen concentrations are moderate to high
- Thermocline - separates upper and lower layers
- Hypolimnion, a cold, deep-water, non-circulating layer in which oxygen is low or absent

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Pre-sedimentation
- Removal of debris
- Helps control impact of changing raw water
- Impoundments are types of pre-sedimentation systems

Aeration
- Removes dissolved gases
- Removes dissolved metals such as iron
- Releases volatile chemicals

Coagulation/Flocculation
- Zeta Potential
  - The repelling force that keeps particles separated
- Coagulation
  - Is the adding & rapid mixing of chemical coagulants in water to reduce turbidity prior to filtration
  - Is a chemical reaction between coagulant, turbidity, & alkalinity.
  - Neutralizes negative (-) charges
- Flocculation is a process that form floc to settle out impurities in the water & reduce turbidity prior to filtration
- Floc grows with the collision of the particles
- Troubleshooting
  - Paddle speed- slow speed floc will settle prematurely
  - Velocity through basin
  - Short circuiting

Primary Coagulants
- Aluminum sulfate
- Ferrous sulfate
- Ferric sulfate
- Cationic polymer
- Calcium hydroxide
- Calcium oxide
- Sodium aluminates

Coagulant Aids
- Calcium hydroxide
- Calcium oxide
- Sodium aluminates
- Bentonite
- Calcium carbonate
- Sodium silicate
- Anionic polymer
- Nonionic polymer

Sedimentation
- Allows solids to settle out before filtration
- Sedimentation - With Settling Tubes
  - As required by drinking water rules
- Sedimentation - Without Settling Tubes
  - 2 hours detention time
  - WLR (weir loading rate) <20,000 g/d/ft weir length
  - Head on rectangular weir is measured from crest to top of water on weir plate
  - 0.5 fpm velocity
  - 8 to 12 ft depth
**Sedimentation**
- Sedimentation Troubleshooting
  - Short circuiting
  - Temperature
  - Working properly determined by the measurement of turbidity in compared to turbidity out.
  - Wind currents
  - Velocity
    - Increase in flow
  - Floating materials
  - Sludge removal
  - Sludge accumulation
  - Noisy drive chain

**Sedimentation Troubleshooting**

**Tube Settler**

**Filtration Systems**

**Conventional – Pressure Filters**
- Screens
- Pre-chlorination
- Chemicals
- Flash mixer
- Coagulation/ flocculation
- Sedimentation
- Filtration
- Post chlorination
- Chemicals
- Clear well

**Conventional Treatment**
- Screens
- Pre-chlorination
- Chemicals
- Flash mixer
*Coagulation, Flocculation, Sedimentation, & Filtration
- Post chlorination
- Chemicals
- Clear well

**Non-conventional**
- Direct filtration
*No sedimentation
- Slow sand filter
*No: Chemicals
- Flash mixing
- Coagulation
- Flocculation
- Sedimentation

**Filtration**
- Removes small contaminants
  - Bacteria: Salmorella, E. Coli
  - Protozoan: Giardia, Cryptosporidium
  - Virus: Hepatitis A, Rotavirus
- Types
  - Mechanical filter
  - Absorption filter
  - Slow sand
  - Rapid sand
  - Mixed media
- Highest rate of flow
  - Water flows through the filter by percolation
  - Head loss gauge measures pressure drop as water passes thru the filter

**Filtration Rates**
- Terminal Head Loss water can no longer be filtered
- Recommended flow rates are 15 to 20 GPM per square foot
- Closing inlet valve & measure drop in the water level over time you can determine flow thru filter
- Too large of floc can cause the filter to clog at a rapid rate
- Filter Loading rates are defined as gallons of water applied to each square foot of filter surface area
Filter Media Types
- Sand
- Anthracite
- Garnet
- Granular Activated Carbon
- Green Sand
- Measured by sieve analysis to determine size

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FILTRATION
- Trouble shooting
  - Method of determining flow through a filter without a meter.
  - Measure the rise or fall of the water in the filter over time
  - Used for removal of Giardia & Cryptosporidium
  - Aeration
    - Dissolves gases
    - Dissolves metals
    - Removes volatile chemicals

Disinfection
- Process to kill or inactivate most pathogens in water.
- There are several ways to disinfect
- Chlorine is most popular method because of cost and it leaves a residual throughout the system
- UV
- Ozone - doesn’t leave a measurable residual in the system
Breakpoint Chlorination Graph

- Chlorine smell would indicate you need to add more to reach breakpoint

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Disinfection By-products

- TTHM - Total Trihalomethanes
- Adsorption where molecules collect & adhere to a surface of an adsorbent solid (GAC) would help reduce TTHM's
- Combination of chlorine and organics
- Warmer temperatures and pH form THM's faster
- THM precursors would indicate THM forming throughout the system
- Aeration & Clarification can remove THM precursors

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Organic Matter

- TTHM
  - Total trihalomethanes
  - MCL = 80 ppb (0.080 mg/l)
- HAA5
  - Haloacetic acids
  - MCL = 60 ppb (0.060 mg/l)
- Reduction and removal through:
  - Absorption
  - Aeration
  - Oxidation
  - Clarification

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Under Drains

- Used for backwashing
- Collects the filtered water
- Keeps the media bed in the filter

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Backwash

- Open backwash valve slowly
- Backwash is based on:
  - Increase in Effluent Turbidity
  - Head Loss
  - Filter Run Times determined by plant (many use 36 hrs)
- Backwash duration depends on amounts of sludge & debris in filter
- Typical Backwash Rate: 15 to 20 gpm/sq.ft.

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Filter Head Loss Gauge

- Used to measure drop in pressure thru filter
- Terminal head loss = No water flowing
Surface Washer
- Mudballs and surface mats are reduced

Sludge Collectors
- Fix noisy drive chains by tightening and aligning the chain & casing

3 Most Important Monitoring Parameters For Safe Drinking Water
- Bacteria
- Turbidity - operator has most control over
- Chlorine residual

Jar Testing
- Duplicates the treatment plant processes such as detention time, mixing conditions & settling conditions
- Helps provide optimal dosages
- Helps optimize coagulation process
- Floc remaining longer than 15 to 20 minutes probably won’t settle out

Water Hardness
- Caused by salts of calcium & magnesium (bicarbonate, carbonate, sulfate, chloride & nitrate)
- Causes formation of soap curds
- Increased use of soap
- Deposits in boilers & fixtures
- DAMAGES industrial processes

Water Hardness & Corrosion
- Objectionable tastes
- Magnesium leaves black stains
- Galvanic Corrosion cause by dissimilar metals in a drinking water system
- Hardness test uses EDTA titrant
- Expressed as mg/L CaCO3
- Soft water considered as 0 to 50 mg/L of CaCO3
- High dissolved CO2 would increase corrosion
Corrosion
- Electrochemical phenomenon observed as red water
- Calcium carbonate saturation used for corrosion control
- 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

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.
- Tuberculation reduces C value

PVC has higher C-factor than concrete

Head Loss
- Friction head loss: caused by valves, bends, pipe roughness, etc.
- Water hardness caused by calcium & magnesium
- Coefficient tests can indicate whether or not friction losses are increasing
- Galvanic corrosion can happen when connecting brass to steel

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

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
- Removed thru aeration and filtration
- Iron & manganese react with dissolved oxygen forming insoluble compounds
- Polyphosphates & flushing reduce iron deposits

Turbidity- NTU’s
- The following is the most frequent method used to water quality & the cloudiness of the water
- Uses light to measure
- The higher the NTU, the dirtier the water, the more possibility of microbiological contamination
- NTU= Nephelometric Turbidity Unit
Turbidity
- Physical characteristic of water making it appear cloudy.
- Caused by suspended matter.
- The most monitored treatment of water for quality.
- The greatest control factor in treatment of water.
- Increased influent turbidity means an increase in chemicals.
- Masks pathogens from disinfections.

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.

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
- The higher the alkalinity, the better the floc formation

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.
- PVC pipe is least affected by acidic water
- Reinforced concrete pipe would most likely corrode in acidic water
- Corrosiveness on pipes can be detected by plotting Bayliss Curve or Langlier Index
- Weight of metal coupons used to determine corrosiveness
- A negative number on Langlier Index would be corrosive

pH
- Any substance that releases HYDROGEN IONS (H+) when mixed with water is acidic (0-6)
- Any substance that releases HYDROXYL IONS (OH-) is a base (8-14)
- Alkalinity changes will affect the coagulation process
- pH is measured by use of a PROBE OR A COLORIMETRIC METHOD.
- SIGNIFICANCE:
  - Affects chlorination, coagulation, softening, and corrosion
  - CO₂ – Carbon dioxide reduces the pH

Temperature
- Characteristics of Temperature
  - The colder the water, the more dense.
  - The colder the water, the less activity.
  - Higher disinfection concentration is required in cold water.
  - Low temps decrease the rate of floc settling
  - F (Fahrenheit)  C (Celsius)
- Main impacts
  - Affect to speed of biological and chemical reactions
  - Affect to rate of biological decomposition
  - Changes to chlorine demand
Temperature
- Low temperatures the bacteria kill rate is lower
- Chlorine residual will remain longer in cold water
- Warm water will cause bacteria to bloom
- Calcium Carbonate will form more rapidly in hot water
- Temperature drops would cause carryover in sed. basins

Chemicals
- **Chemical Storage**
  - Cool, dry place
  - Away from general traffic
  - Non-treatment chemicals
  - Spillage control – clean plan
  - Empty drum disposal
  - According to manufacturer’s recommendation

Chemical Compounds
- Aluminum sulfate
- Ferrous sulfate
- Ferric sulfate
- Cationic polymer
- Calcium hydroxide
- Calcium oxide
- Sodium aluminates
- Calcium Carbonate

Aluminum Sulfate (Alum)
- Part of coagulation/flocculation process & creates the floc
  - An anhydrous acid
  - Affects skin and mucous tissues
  - Need goggles, face shields, dust mask, gloves, boots, rubber apron, clothing to protect skin & proper ventilation
  - MCL for atmosphere
  - 15 mg/cm for 8 hours
  - When added to water:
    - Dissolved Sulfate increases
    - Alkalinity decreases
    - pH decreases
  - MCL in finished water is 450 mg/l

Alum
- Alum is a mild corrosive
- Never use the same conveyor system for alum and quicklime
- Potential for explosion
- pH below 5 floc won’t form properly

Ferric Chloride
- Is a very corrosive material
- Should prevent splashing
- Use eye protection, rubber gloves, and protective clothing
- When spilled on skin, flush with large amounts of water
**Chemicals**
- Corrosion Control
  - Calcium hydroxide
    - Hydrated lime
      - Increases pH
  - Sodium hydroxide
    - Caustic soda
- Softening
  - Calcium oxide
  - Quicklime
  - Sodium carbonate
  - Soda ash
- Fluoridation
  - Sodium fluorosilicate
  - Sodium fluoride
  - Fluorosilicic acid
  - Hydrofluoric acid
  - SPADNS test for fluoride

**Chlorine**
- Gas is heavier than air
- Have eyewash/shower available
- Most leaks occur around control valve
- Cylinder liquid form expands 460 times
- When changing cylinders, shut gas off at cylinder first, evacuate lines
- Produces hydrochloric acid mixed with moisture
- Use rubber gloves & ventilate
- Should practice response once per year
- Inspect daily for leaks in system
- Higher alkaline = more chlorine

**Chlorine Leaks**
- Put on SCBA
- Turn on ventilation fan
- Have help standing by

**Three Forms of Chlorine**
- **POWDER** 65% HTH (High Test Hypochlorite)
  - Calcium Hypochlorite
- **LIQUID**-Sodium Hypochlorite
  - *Bleach 5%*
  - *T-Chlor 15%*
  - *GAS 99.9%*
  - *Extremely corrosive with water/humidity*
  - *Compressible*
  - *Changes to liquid at 82 psi*
  - *68 deg. F*
  - *2.5 times heavier than air*
  - *Greenish-yellow color*
  - *Must meet NSF approval*

**Calcium Hypochlorite & Quicklime**
- Calcium Hypochlorite
  - Can create heat & oxygen to start a fire
  - HTH- High Test Hypochlorite
- Quicklime
  - Extremely caustic material
  - Reacts violently with water
  - Reaction can cause fire or explosion
  - Store totally dry area
  - Do not allow to mix with alum

**Chloramines**
- Formation of chloramines is a chemical reaction
- The reaction is between hypochlorous acid (or aqueous chlorine) with ammonia.
- Formation of chloramines weakens the disinfecting strength of chlorine
**Chloramination**
- Chloramines are a reaction between applied chlorine and ammonia.
- When done intentionally it can reduce tastes and odors.
- Chloramines are a weaker disinfection than chlorine.

**DPD**
- Method of measuring chlorine residual in the water.
- Testing agent turns chlorinated water a pink color. More intense color, higher residual.
- DPD= N,N-diethyl-p-phenylene-diamine.

**Fluoride**
- Victims exposed to large amounts should be removed from area.
- Operators should know the hazards contained in MSDS.
- Can cause dental stains & mottling of teeth.
- SPADNS test to analyze fluoride levels.

**Over Feeding Fluoride**
- Can Mottle Teeth.

**Caustic Soda Safety**
- Strong caustic alkali and very hazardous.
- Very reactive.
- Dissolves human skin.
- Generates heat when mixed with water.
- Reacts with amphoteric metals generating hydrogen gas which is flammable or explosive.
- Use special precautions when handling.

**Chemical Safety for Acids**
- Chemicals cause visible destruction or irreversible damage to skin tissue at the point of contact.
- Swallowing can damage esophagus & stomach.
- Wear personal protective equipment.
- Flush affected area with clean water.
- Use sodium bicarbonate to neutralize acids.
- Add acid to the water.
Polymers
- Used as coagulant and filter aids
- Keep polymer dust off floors
- Will create very slippery surfaces when on floors
- Use inert, absorbent material such as sand to clean up spills

Potassium Permanganate
- Strong oxidizing agent, use caution
- Turns water pink
- Will react easily with organic materials
- Will ignite when in contact with antifreeze, sawdust compounds and many other materials
- All lubricants & fuels are potential fire hazards
- Store separately from other chemicals in a cool dry location
- Used for taste & odor, TTHM control, reduces Iron, Hydrogen Sulfide (rotten egg smell) & Manganese

Explosions
- Don’t use sawdust to absorb liquids
- Powder activated carbon is the most volatile powder
- Methane is the most common combustible gas

Activated Carbon
- Used for taste & odor problems
- Is considered the most volatile powder
- Keep away from Cl2 compounds and KMnO4, possible spontaneous combustions
- The main problems are dust and fire control
- Will burn with intense heat, and without smoke or visible flame
- Keep electrical equipment clean
- Carbon dust can cause short-circuit fires
- Use explosion-proof electrical equipment
- Used prior to chlorination because they react with each other

Taste & Odor
- Activated Carbon & KMNO4 are chemicals used
- Threshold Odor Number (TON) is a unit of measure for odors in water & should be conducted at 60 deg. Celsius
- Water devoid of oxygen produces odor and anaerobic bacteria growth
- Sludge accumulations could cause problems
Algae Control Chemical

- Copper Sulfate
  - Indicators that affect copper sulfate:
    - Alkalinity
    - Type of algae
    - Temperature

Nitrite – Cause & Effect

- Cause
  - Large concentration of fertilizers.
- Effect
  - Blue-baby syndrome
  - High Nitrate Levels
    - MCL 10 mg/l
    - 5 mg/l – quarterly monitoring
    - Nitrate turns in nitrite and replaces oxygen in blood. Thus babies and immuno-deficient individuals are affected.

Fusible Plug

- Safety Device
- Made out of lead
- Melts between 160 to 165 degrees

Sampling

- Grab samples taken in instantaneous conditions at certain times & locations

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
- Sample should be transported as soon as possible in a cool container with ice pack
- Routine bact’l’s should be taken at the customers tap at various points that represent the entire system

Bacteriological Sampling Procedures

- Should allow sample tap water to run several minutes or as long as necessary to clear service line
- Sampling bottle/bag should be filled to just above fill line or 1 inch from top
- Results are meaningless if sample is contaminated
- Sample identification cards need to filled out completely
- Should be sterilized by lab
- Sodium Thiosulfate
  - Dechlorination agent in bacteriological sample container
Coliform

- Coliform - a group of bacteria found in the intestines of warm blooded animals & also plants, soil, air and water
- **Total Coliform** - a measurement that shows if coliform bacteria is present in a water system & are an indicator organism
- **Fecal Coliform** - a specific class of bacteria coming from animal intestines. If sample is coliform positive, a fecal coliform test is performed.

GWR

- December 1, 2009
- **TC+ bacterial Samples**
  - Requires Triggered Source Water sample (TSW)
  - Of all sources that were in operation at time of +TC sample
  - Email on sources not sampled – not running
  - Test for fecal coliform

GWR continued

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

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

Electrical Motor

- Clean dust from a motor with compressed air.
- Measure speed with tachometer
- Auxiliary motors can be used in emergencies
- Brake HP is amount of HP supplied by the motor to the pump
Circuit Breaker
- Opens or closes the electrical circuit to motors
- Function as overload device
- Opens automatically when an overload occurs to protect circuit

Electric Motors
- Upon start up an electric motor will develop a load to turn the pump shaft and impeller
- Torque causes motor to draw a high amperage
- To change rotation on 3 phase, switch any 2 leads
- Voltage imbalances cause 3 phase motors to overheat & burn out the insulation
- Tachometer used to determine speed of motor/pump

Volt – Ohm Meter
- **Volts**
  - Measure of the force of electrons
  - Set the volt meter at a higher setting than the voltage being measured.
- **Ohms**
  - Measurement of resistance
- **Amps**
  - Measurement of the flow of electrons

Transformer
- The purpose of the transformer is to increase (step up) or decrease (step down) voltage.

Confined Spaces
- Carbon dioxide will settle near floor
- Blowers are the most effective means to reduce atmospheric hazards
- Ventilate until proper oxygen levels are reached (minimum 19.5%)

Security
- Deter
- Detect
- Delay
- Respond
Safety Security
- Reservoir sites
- Sources
- Main Offices
- Vehicles
- Vaults

Distribution Systems
- Looped systems have continuous flow & less water quality problems
- Water quality problems could indicate a closed valve or partially open
- Leak surveys done at night
- 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
  - Leaks will get worse not better

Ground Water - Wells
- Water bearing formation called an aquifer

Maintenance Records
- Why keep maintenance records?
  - Develop preventative maintenance program
  - Prolong life of equipment
  - Maps
  - Maintain backup equipment
  - Reduce liabilities
  - Improve customer service

New & Repaired Water Mains
- Pressure test
- Disinfected in accordance with AWWA standard C651
- Must be disinfected with some type of chlorine
- Tablet or a solution are typically used
- Chlorine must be flushed with potable water
- Take chlorine residuals
- Must take bacteria samples

Water Distribution Systems
- Operation and Maintenance
  - Water main design
  - Distribution system pressures
    - 20 psi at all times
    - 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
New Minimum PSI Standards

- Maintain minimum of 20 psi at all times
- For Construction after 3/1/06
  * 20 psi during fire flow
  * 30 psi during peak instantaneous demand
  * 40 psi during peak day demand

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.
- Needs to be centered on the thrust force

Water Storage Reservoir

- Provides a volume of water to the water system during average and peak demands
- Provides adequate pressures throughout the water systems
- Covered to prevent bacterial & algae growth
- Reserve storage
- Fire protection

Storage Reservoirs

- 2 categories of paint - long life and short life
- Frequent pumping & changing depth can reduce freezing
- Sandblasting is recommended to prepare inside for painting, inspect every 3 to 5 years
- Stagnant water causes quality problems
- They’re most susceptible to water quality degradation from external sources

Parts of a Well

- Pumps from a geologic formation called an aquifer
- When water passes through porous layers of soil it’s called percolation
- Sanitary seal – prevents contamination from entering
- Well casing – pipe placed inside well to keep it open
- Grout – mixture of cement, water and sand pumped between the casing & the drilling hole (annulus)

Parts of a Well

- Well Screen – unrestricted water flow and small enough to stop sand from entering
- Gravel pack – aids screen in filtering sand.
Wire to Water Efficiency
- Energy required to overcome pump inefficiencies
- The combined efficiency of the pump and the motor together. Also called the overall efficiency.
- \[ \text{Water HP} \times \frac{HP}{100} = \% \text{ Wire to Water Efficiency} \]
  \[ \text{Motor HP} \]
  \( (\text{Flow, gpm}) (\text{Total Dynamic Head, ft}) (0.746 \text{ kw/hp}) (100) = \% \text{ WWE} \)
  \( (3,960) \text{ (Electrical Demand, kilowatts)} \)

Cavitation
- Main cause of losing pump suction
- Sounds like pumping rocks or pinging
- Vibration & popping noises caused by low pressure in volute
- Generally caused by vapor bubbles
- Vapor bubbles implode causing damage to pump
- Volute case needs to be full of water
- Prevented by having adequate suction pressure and proper bowl depths

Cross Connections
- Cross connection: a connection between a potable & an unapproved source.
- Caused most disease outbreaks
- Two Types of Backflow
  - Backsiphonage: backflow caused by a negative or below atmospheric pressure in a water system where a vacuum exists such as draining as system (fire fighting can cause)
  - Backpressure: when users pressure is higher than the system pressure
- Approved assemblies are used to keep contaminants out the drinking water system
- Protection established by degree of hazard

Air Gap- Safest Method
- A physical break between the end of a pipe and an open vessel flood rim
  - Minimum of 1” or two times the diameter of the pipe.
- Backflow protection
  - Backsiphonage
  - Hazard
  - High degree or health risk
- Required on all sewer, wastewater or sludge connections

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.
- In absence of a flow meter on a filter you can close the inlet valve and measure the drop over time.

AWWA C651 – Water Mains
- Methods
  - Tablet or granular – 25 mg/l – 24 hours
  - Continuous Feed – 10 mg/l after 24 hours
    - Fill main with water
    - Flush out debris
    - Fill with chlorinated water
Final flushing
- Clearing main of heavily chlorinated water
- Disposing chlorinated water
  - Discharge can cause damage to the environment
- Neutralizing agents
  - Sulfur dioxide, sodium bisulfates, sodium sulfide, sodium thiosulfates, ascorbic acid
- Flushing at 2.5 fps
  - Scour the insides of the pipe.

Neutralizing agents
- Sulfur dioxide, sodium bisulfates, sodium sulfide, sodium thiosulfates, ascorbic acid

Flushing at 2.5 fps
- Scour the insides of the pipe.

Procedure existing water mains
- Positive pressure during repairs
- Swabbing
- Flushing
- Slug chlorination
  - 300 mg/l – 15 minutes
- Sampling – to prove procedure effectiveness

Bacteriological Testing
- Standard Conditions
  - AWWA C651-05
    - 2 samples - 24 hours apart
    - One set collected every 1200 feet
    - Plus one set from ends of main
    - At least one on each branch

Special Conditions
- Trench water entered
- Excessive quantities of dirt
- Water stand for 16 hours before 1st test
- Sampling procedures
  - No hose
  - No fire hydrant
  - What does your ordinance say about testing
  - Orem’s Ordinance

Bacteriological Testing
- Trench water entered
- Excessive quantities of dirt
- Water stand for 16 hours before 1st test
- Sampling procedures
  - No hose
  - No fire hydrant
  - What does your ordinance say about testing
  - Orem’s Ordinance

Pressure Testing New Water Main
- Pipe should sit idle for at least 24 hours
- Should be done at 150 psi
- Or 1.5 times the normal pressures
- Duration 4 Hours
Valves
- Gate Valve: Isolation, should be either all the way open or all the way closed (least amount of head loss)
- Air and vacuum relief: allows air in and air to escape.
- Altitude valve: opens when system psi drops below a certain pressure and closes when the reservoir reaches a predetermined level.
- Glove valves used for flow & pressure regulating

Gate Valves - Isolation

Altitude Valve – good for regulating tanks

Pump Control Valves
- Minimizes water hammer
- Starts & stops on a closed valve

Butterfly Valves -
- Higher resistance to flow
- Operates easily & quickly
- They cost less than gate valves
- Used for flow control
Ball & Plug Valves

Sluice Gate & Sleeve Valves

Check Valves

- Permit flow in one direction
- Swing Checks
- Spring loaded silent checks

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.

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.
- Meters should not have more than 20 psi of head loss.
- Meters one inch and smaller shouldn't have more than 15 psi of head loss
- Venturi meter is not a prime mover

Meter Accuracy

- Worn meters under register & give the customer free water
- Over time a worn meter will cost the water system revenue.
- Formula: \[ \text{Meter Accuracy} = \frac{\text{Meter, GPM}}{\text{Volume, GPM}} \times 100\% \]
- Compound meters are used for low to intermediate flows & occasionally for high flows
Positive Displacement Meter
- Nutating disk: nutating means nodding. When the water flows the disk rotates.

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
- Propeller, Venturi, insertion type, and most electronic types
- Rotors or propellers are turned by velocity of meter

Air Release Valves (Air Vac) – air in & out
- Should be placed at high points in the water system.
- Outlet should be screened about 12” min. above ground

Line Collapse
- Caused by not opening a downstream valve before they began sucking water from the other end
- A vacuum developed before they realized what happened and the pipe pancaked
- The pipe is the main transmission line to supply water for the City of Folsom

HYDROPNEUMATIC TANKS
- Frequent on/off cycling indicates water logged tank
- Operate by applying air pressure to tank
- Tank levels controlled by pressure switches to pumps
- Air leaks can cause pumps to run continuously
- 1/3 to 2/3 air to water ratio limiting storage capacity
**Acronyms**

Forms of expressing a flow of water over a period of time:

- **GPM**
  - Gallons per minute
- **MGD**
  - Million gallons per day
- **CFS**
  - Cubic feet per second

**PSI** = pounds per square inch
- The pounds of force on a given area. The area is expressed in a square inch.

60 pounds per square inch, or 60 PSI

Methods for measuring chemicals or other constituents in drinking water

- **ppm**
  - Parts per million
  - Refers to 1 gallon or lb. of a chemical in 1 million gallons or lbs. of water
- **mg/l**
  - Milligrams per liter
  - The same measurement as ppm expressed in metric measurements

- **ppb**
  - Parts per billion
  - The measure of 1 gallon or lb. of a chemical in 1 billion gallons or lbs. of water
- **ug/l**
  - Microgram per liter
  - The same measurement as ppb expressed in metric measurements

1000 ppb or ug/l = 1 ppm or mg/l
- Example: 80 ppb is the same as 0.080 mg/l

**Definitions**

- **Toxic**
  - A substance that is poisonous to a living organism.
- **Potable**
  - Water that does not contain objectionable pollution, contamination, minerals, or infective agents and is satisfactory to drink.
- **Culinary**
  - Fit for human consumption.
- **Action Level**
  - Required actions if lead and copper standards are exceeded:
    - **MCL**
      - Lead – 15 ppb, or 0.015 ppm
      - Copper – 1300 ppb, or 1.3 ppm

**Fire Hydrants**

- Dry barrel hydrant used in areas susceptible to freezing.
- Drain hole allows water to drain from barrel so water won’t freeze and crack the hydrant.
- **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.
If the cut stake for a fire hydrant is marked AC-4.25@ and the hydrant is 7 ft. 6 in. tall, how high will the top be above the finished grade?

- 7' 6" convert to decimal
- 7.5 – 4.25 = 3.25
- 3.25 is the answer

Thrust Blocking
- Thrust Block - a concrete mass between elbows, crosses & tees in undisturbed soil at the side or bottom of the pipe trench.
- Keeps 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
- Should be calculated & designed properly

Thrust Blocks

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%

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.

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
Electrolysis

- Decomposition of material by an outside electric current
- Electric current caused by movement of water in the line
- Cathodic protection installed to prevent

Tanks – Cathodic Protection