Operation and Maintenance

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 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 bacteria 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
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

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 caused 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.
- ¾” 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
- **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 halfway 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
- **Restrainted fittings** – 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 placed 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 and 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**

<table>
<thead>
<tr>
<th>Class</th>
<th>Color</th>
<th>Water Flow (GPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>Light blue</td>
<td>1500 or more</td>
</tr>
<tr>
<td>A</td>
<td>Green</td>
<td>1000–1499</td>
</tr>
<tr>
<td>B</td>
<td>Orange</td>
<td>500–999</td>
</tr>
<tr>
<td>C</td>
<td>Red</td>
<td>Less than 500</td>
</tr>
</tbody>
</table>

**Dry Barrel Hydrants**

- Drain hole drains barrel to protect from freezing.
- Partially open drain valve would cause excessive leakage from drain hole.
- Must be tested for leakage with main valve open and caps on.
- Use a listening device to check for leaking valve seat.
- Operating valve located in the base of the hydrant.

**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

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

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

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 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)**
- 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 CaCO₃, 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

**FRICIONAL 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

- 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 values, & 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 overall efficiency.
- Water HP/Electrical HP x 100% = overall 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 are 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: \( \text{Meter Accuracy} = \frac{\text{Volume, GPM}}{\text{Meter, GPM}(100\%) - \text{Volume, GPM}} \)

**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

### 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 weight loss

### Tanks – Cathodic Protection
- Anodes
Ground Water

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

Wells

- **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)
- **Specific capacity** is the well yield in GPM per foot of drawdown

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

The end

- Contact Information
- Kim Dyches
  - 801-536-4202
  - kdyches@utah.gov