Indiana Drinking Water Operator Training WT3 Study Guide

Overview of State and Federal Regulatory Authorities

U.S. Environmental Protection Agency (U.S. EPA or USEPA)

The Federal agency that determines and enforces, among other things, drinking water standards for the United States and its territories. The U.S. EPA has different regions throughout the country. Indiana is part of U.S. EPA Region 5, along with Illinois, Michigan, Minnesota, Ohio, and Wisconsin. EPA may allow any state to administer and enforce drinking water regulations if the state regulations are at least as stringent as the federal regulations (this process is called “primacy”). Each state must apply for and receive primacy from EPA for each regulation adopted by the state. Indiana has been granted **primacy** by EPA to administer and enforce most of its drinking water regulations.

Indiana Department of Environmental Management

The Indiana Department of Environmental Management (IDEM) is an agency within the State of Indiana with a mission is to implement federal and state regulations to protect human health and the environment while allowing the environmentally sound operations of industrial, agricultural, commercial, and governmental activities vital to a prosperous economy.

The IDEM is broken into four Offices: Office of Air, Office of Land, Office of Water, Office of Program Support, and Office of Legal Counsel.

Office of Water Quality

The Office of Water Quality (OWQ) is an Office within the IDEM with a mission to monitor, protect, and improve Indiana’s water quality to ensure its continued use as a drinking water source, habitat for wildlife, recreational resource, and economic asset.

The office achieves this by developing rules, guidance, policies and procedures; assessing surface and ground water quality; regulating and monitoring drinking water supplies and wastewater facilities; protecting watersheds and wetlands; and providing outreach and assistance to the regulated community and the public while supporting environmentally responsible economic development. Indiana's Water Quality Standards as mandated by the Clean Water Act are the measure used for these activities.

Drinking Water Branch

The Drinking Water Branch (DWB) is a branch of IDEMs Office of Water Quality that carries out the requirements of the federal Safe Drinking Water Act (SDWA) which is designed to ensure that Public Water Systems (PWS) deliver water to Hoosier homes and businesses that is adequate in quantity and is safe to drink.

The Drinking Water Branch consists of five sections: Total Coliform & Compliance Support, Chemical & Surface Water Compliance, Field Inspections, Groundwater, Operator Certification and Capacity Development, and Permits.

Overview of State and Federal Regulations

Indiana Administrative Code (IAC)

Indiana regulations that govern how the federal regulations are enforced in the state of Indiana. The DWB primarily utilizes IAC 327 Article 8. The IAC also establishes maximum contaminant levels (MCLs) for turbidity, microbiological contaminants, and radioactive contaminants.

NIOSH – National Institute of Occupational Safety and Health

Among other things, this institute regulates and approves Personal Protective Equipment (PPE) such as masks.

Safe Drinking Water Act

This law established national drinking water standards that were to be administered and enforced by State agencies. The SDWA was originally passed, or adopted, by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources. The 1996 amendments greatly enhanced the existing law by recognizing source water protection, operator training, funding for water system improvements, and public right-to-know as important components of safe drinking water. The SDWA applies to every public water system in the United States.

SDWA requires the EPA to review its regulations every six years and strengthen them as science advances.

Administration

Monthly Report of Operations (MRO)

All community public water supplies that add chemicals to their water are required to make daily entries onto a monthly report of operations (MRO). The certified operator-in-charge must sign the report and submit the MRO to IDEM within 10 days following the end of each month.

Recordkeeping - Records need to be kept for as long as legally required:

Chemical analyses – 10 years

Bacteriological – 5 years

Sanitary Survey – 10 years

Uniform Rate: A type of rate structure for charging customers to access the water.

Operator Responsibility

The primary responsibility of a water treatment operator is to produce safe and pleasant drinking water.

A WT3 Operator must be a high school graduate and have two years' experience at a WT3 facility. Four semesters, or 6 quarters of applicable education may be considered as a substitution for one year of experience. A WT3 facility requires a minimum of five visits per week by a licensed operator.

WT3 operators can only operate WT3, WT2, and WT1 systems. **WT3 operators are the only ones who can operate a WT3 system.**

WT3 Systems:

Acquire Water from ground water or purchase.

Use a chemical feed.

Have filtration, ion exchange, or lime soda softening.

Safety

Confined Space

A confined space is a space that is large enough for a person to enter and conduct work, however, has limited means for entry or exit. This is unfavorable for natural ventilation and can reduce the amount of breathable air in the environment, especially when working with hazardous or toxic substances.

Confined spaces are not designed for continuous occupancy. They contain hazards that can cause injury or death. Because of this, a confined space should **never** be entered unless you have the **appropriate training and permitting. The safe range for oxygen levels in a confined space is between 19.5% and 23.5%.** The lower explosive limit (LEL) and lower flammability limit (LFL) are below 10%.

Confined space permits require the entry supervisor to know the conditions of the confined space. The entry supervisor is also responsible for terminating entries.

A Self-contained Breathing Apparatus (SCBA) can be used in confined spaces. These units are fitted with a low-air pressure alarm to alert the wearer when they need to leave the area.

System Classification

A water treatment three (WT3) system:

(A) Acquires water from one (1) of the following:
  (i) Ground water
  (ii) Purchase

(B) Utilizes chemical feed.

(C) Has one (1) of the following:
  (i) Pressure or gravity filtration
  (ii) Ion exchange processes if the population served is five hundred one (501) or greater.
  (iii) Lime soda
  (iv) Reverse osmosis

Public Water Supply – has at least fifteen (15) service connections or regularly serves twenty-five (25) individuals daily, at least sixty (60) days per year.

Types of Public Water Systems:

Community – provides water to the same population year-round.

Non-transient/non-community - provides water to the same population at least 6 months out of the year (i.e. schools or factories).

Transient non-community – provides water to a changing population of twenty-five (25) people at least sixty (60) days out of the year, but not the same group of people (i.e. rest areas or campgrounds).

Source Water

Conservation - Water conservation allows for a reduced demand on water supply source.

Conserving measures may be necessary during drought conditions or population expansions.

Hydrological Cycle: The hydrological cycle covers the “continuous exchange” of water between the earth and the atmosphere.

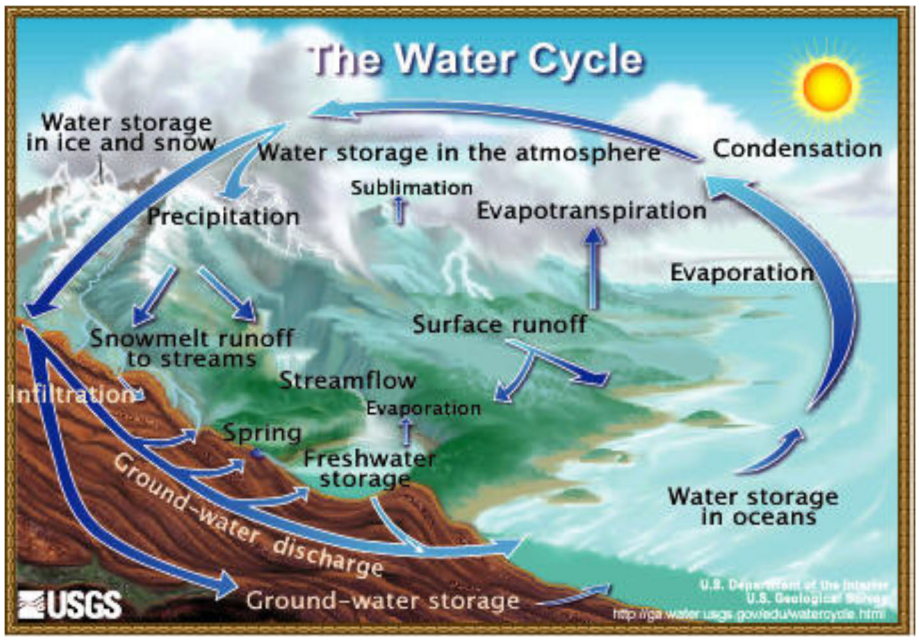

Figure 1: The Water Cycle (U.S. Geological Survey 2019)

Condensation: The process of water vapor in the air turning into liquid water.

Evaporation: The conversion of water from a liquid into a gas.

Evapotranspiration: Evapotranspiration only covers water entering the atmosphere but does not include water moving from the atmosphere back to the earth.

Precipitation: Water that falls to the earth. Most precipitation falls as rain, but includes snow, sleet, drizzle, and hail.

Percolation: The slow seepage of water into and through the ground. The slow passage of water through a filter medium.

Sublimation: The process where ice and snow (solid) change into water vapor (gas) skipping the liquid phase.

Transpiration: The process of liquid water evaporating from plants and trees into the environment.

Water expands roughly 9% between its liquid and solid forms (ice).

Groundwater Storage and Discharge

Aquifers:

The saturated underground formation that will yield usable amounts of water to a well or spring. The formation could be sand, gravel, limestone or sandstone. The water in an aquifer is called groundwater.

Confined aquifer is the saturated formation between low permeability layers that restrict movement of water vertically into or out of the saturated formation. Water is confined under pressure similar to water in a pipeline. In some areas confined aquifers produce water without pumps (flowing artesian well).

Unconfined aquifer (water table aquifer) is the saturated formation in which the upper surface fluctuates with addition or subtraction of water. The upper surface of an unconfined aquifer is called the water table. Water, contained in an unconfined aquifer, is free to move laterally in response to differences in the water table elevations.

Anaerobic and Aerobic zones: Microbial growth occurs where these zones meet.

Wells:

A well is used to extract groundwater from an aquifer that can then be utilized for drinking water purposes.

Components

Well screens- Filters out large media in the aquifer from entering the well.

Sanitary Seal - A seal around the wellhead that prevents contamination of the well. A sanitary seal is created by grouting a wellhead.

Clearwells - Water storage structures usually located at the end of a treatment train or well system. Typically used for contact time when chemical treatment additives are used.

Well-site surveys

A survey conducted when a well is proposed. This is done to ensure the well can meet the demand, has the appropriate sanitary setback to avoid contamination, and can be dug and implemented safely.

Well source protection – includes the depth of the well, type of soil, and integrity of the well casing.

Specific Capacity - A formula for determining if a well can adequately meet the demand of a proposed population or use.

$$\frac{\text{Pump rate (Yield)}}{\text{Drawdown}}$$

Sanitary setback/ Isolation area - An area of at least 200 feet from a wellhead that does not contain any potential contamination sources. If the groundwater will be treated, the sanitary setback can be reduced from 200 feet down to 100 feet.

Groundwater can contain high amounts of iron – this can be removed through oxidation and filtration.

When determining the presence of iron, sample as close to the groundwater source as possible – this will give an accurate representation of any iron levels.

Drawdown – The lowering of the groundwater surface caused by withdrawal or pumping of water from a well. It is the difference between the static water level and the pumping water level in a well pumped at a constant flow rate.

GWUDI – Groundwater Under the Direct Influence of Surface Water

groundwater that has surface water characteristics. GWUDI is pumped from wells and then treated. GWUDI shows signs of a surface water system if the temperature of the water changes with the seasons. A true groundwater system will not change more than a degree or two year-round – also referred to as an unconfined aquifer.

If groundwater has significant shifts in water quality indicators such as turbidity, temperature, pH, or conductivity that correlates to nearby surface water conditions, that source may be classified as GWUDI.

Public water systems classified as GWUDI are subject to turbidity monitoring. Turbidity is a measure of water clarity – how much material suspended in water decreases the passage of light through water. Turbidity measures the amount of light scattered by the suspended particles. Turbidity measurements for GWUDI

Pumps

Cavitation - caused by unusually low pressure within the pump. This can be avoided by monitoring the speed of the variable-speed pump.

Centrifugal - Used to pump water from shallow wells (less than roughly 25 feet of head). and can operate against a closed valve.

Components: Suction pipe
Impeller (Ensure impeller is free from debris and primed)
Discharge pipe
Motor
Shaft

Deep Well Turbines - Made to operate both in the well (bowl and turbine) and above ground (motor) with a drive shaft connecting the two.
The largest of pump types, this pump operates at high pressure and has high efficiency, but also high maintenance costs.

Jet - A centrifugal pump that uses a venturi, or a restriction at the nozzle of the suction pipe, to increase effectiveness of the pump.

Submersible - Made to operate within the well casing. This pump is small and sealed, making it difficult or impossible to do maintenance or repairs, but reduces the likelihood of losing its prime.

Components:
Motor
turbine pump
water screen

Two pumps of the same flow and pressure rating that are piped in series would result in double the head.

$$\text{Water Horsepower} = \frac{(\text{Flow rate in GPM})\,(\text{Total Head Feet})}{3960}$$

Water Sampling

Waterborne Diseases:

E. Coli (Escherichia Coli) microorganisms come from human and animal fecal waste. Can cause gastrointestinal illness (e.g., diarrhea, vomiting, cramps).

Fecal Coliform - Fecal coliform microorganisms come from human and animal fecal waste. Can cause gastrointestinal illness (e.g. diarrhea, vomiting, cramps).

Giardia lamblia - A microorganism found in human and animal fecal waste. Can cause gastrointestinal illness (e.g., diarrhea, vomiting, cramps).

Methemoglobinemia “blue baby syndrome” - Caused by nitrite (when nitrate reacts with chlorine it creates nitrite).

Typhoid - A bacterium that is transmitted through contaminated water.

Wilson’s Disease - Caused by the body’s inability to metabolize Copper.

Total Coliform Sampling

Total Coliform are used as in indicator that other potential harmful bacteria may be present. If a sample has the presence of total coliform bacteria, then a test needs to be done to determine the presence of Escherichia coli (E. coli).

Presence-Absence test – tests for presence of coliform, sometimes abbreviated P/A test.

Grab Sample requiring a volume of 100 mL

Coliform bacteria are the easiest to control at a water treatment plant.

Sample Procedure - When sampling, it is best to use a clean faucet that has a dedicated hot and cold tap. Flush the system thoroughly, disinfect the faucet, flush again, then take the sample. Ensure the lid of the container is facing down, is not placed on a counter, and is not touched. Fill the container without splashing or rinsing.

Following the sample, a system has thirty (30) hours to get the sample to a lab. The sample should be kept between 4° and 10° Celsius.

The population served determines the number of coliform analysis samples required. If a routine sample tests positive for total coliforms, additional samples must be taken from the original tap, along with samples pulled from upstream and downstream.

If a sample tests positive for Coliform, IDEM must be notified within 24 hours!

Lead and Copper Monitoring

The lead and copper rule (LCR) dictate the monitoring requirements for lead and copper in systems. Lead and copper are based on “Action Levels” rather than “Maximum Contaminant Levels”. The action level for lead (Pb) is 0.015 mg/L. The action level for copper (Cu) is 1.3 mg/L. If the lead or copper concentrations reach the action level, the water system must take steps to reduce the amount of lead or copper.

A system must first take one sample per six-month monitoring period for two consecutive monitoring periods (one calendar year). Then the system may reduce to once per calendar year for three years, then reduce to once every three years.

Should a system’s lead and copper sample exceed action levels, the sample reduction is reset, and the system starts back at sampling once per six-month monitoring period.

Lead and copper samples are collected at kitchen or bath cold water taps and collected at drinking water taps in businesses. The sample containers are 1000 mL rather than 100mL like Coliform samples.

When monitoring for lead and copper, the system must use the first-draw or first-flush of the system after it has been unused for six hours.

The Lead and Copper Rule does not include cast iron pipes with lead joints.

Chemical Contaminant Monitoring

Asbestos - Inorganic contaminant from old insulation, the decay of asbestos cement in water mains, and the erosion of natural deposits. Potential health effects include increased risk of lung tumors and intestinal polyps.

Arsenic - sampling/monitoring verifies proper operation of any arsenic treatment.

When analyzing for manganese, samples are preserved with nitric acid.

When analyzing for inorganic heavy metals, the sample needs to be acidified to a pH at or below 2.

Organic compounds are acids, bases, or salts that contain carbon.

Inorganic compounds are acids, bases, or salts that do not contain carbon.

Inorganic Chemicals (IOCs)

Arsenic, iron, chromium, manganese, sodium, nitrates, sulfate, zinc, (i.e., heavy metals)

Secondary Standard/MCL for Mn - .05 mg/L, Fe - .3 mg/L

Nitrates and Nitrites

Inorganic contaminant from runoff from fertilizer use, leaching from septic tanks and sewage systems, and erosion of natural deposits.

Nitrate MCL: 10 mg/L

Nitrite MCL: 1 mg/L

Anion exchange is the most effective way to remove nitrite and nitrate.

Proper holding time of a non-acidified chlorinated nitrate sample is fourteen (14) days.

Synthetic Organic Compounds (SOCs)

Herbicides and pesticides

Volatile Organic Compounds (VOCs)

Industrial solvents

Waivers - A system can use waivers to reducing monitoring frequency for total coliform, VOCs, SOCs, and asbestos.

Public Notification

If a system violates IDEM rules, they must notify their consumers with a public notice within a certain amount of time.

Tier I Violation – 24 hours (immediate notification)

Tier II Violation – 30 days

Tier III Violation – 12 months

Tier I violations pose an immediate, or acute, health risk, while Tiers II and III do not.

When a system has complied with a public notification requirement, the system has ten (10) days to submit it to IDEM.

Disinfection

Process that inactivates pathogenic organisms by chemical oxidants. Reduces or eliminates pathogens. A system that disinfects their water can reduce a sanitary setback on a groundwater source from 200 feet to 100 feet.

Chlorine - Most common disinfectant; can come in the form of gas, bleach(liquid), powder, or tablets.

Chlorine gas - Toxic, yellow-green gas that is 2.49x the density of air meaning it will sink.

Highly reactive and ignites hot iron.

When pressurized, becomes a liquid.

Chlorine demand

In water, chlorine is measured as free or total.

Breakpoint chlorination is achieved when chlorine dosage is increased and a corresponding increase in residual chlorine is detected.

Free: the concentration of residual chlorine in water present as dissolved gas (Cl_2). Residual chlorine should not drop below .2 mg/L for more than 4 hours.

Total: the amount of free chlorine plus combined chlorine (chloramines)

(DPD) color comparator - Quickest and simplest way to measure free chlorine residuals.

Measures as the difference between the amount of chlorine added and the amount of residual chlorine remaining after a given contact time (usually ten minutes).

CT – calculation abbreviation – (Free Cl)(contact time) = mg-min/L

The lower the pH, the more effective chlorination is. Water with a pH of 5 would have the highest concentration of hypochlorous acid.

Safety Regulations for Cl

EPA: A system with 2,500 pounds of chlorine for a single process must complete a risk management plan (RMP).

OSHA: A system with 1500 pounds of chlorine for a single process must complete a site assessment under the process safety management (PSM) regulations.

Fluoride

Inorganic contaminant which comes from a water additive that is used to promote strong teeth, erosion of natural deposits, and discharge from fertilizer and aluminum factories. Can cause dental fluorosis (staining) and skeletal fluorosis (bone damage).

According to the Indiana State Department of Health, people who drink optimally fluoridated water from birth will experience approximately 20-40 percent less tooth decay in their lifetime. A desirable concentration of fluoride is .8 to 1 mg/L, though the CDC recommends 0.7 mg/L. Some water sources already contain fluoride, therefore a system using fluoride must test daily for fluoride both in the raw water (naturally occurring) as well as finish water (adjusted). IAC MCL is 4.0mg/L.

A system that adds fluoride must monitor the fluoride levels for naturally occurring fluoride to determine the appropriate amount to add to the water.

When sampling for fluoride, a system should **not** use a glass or metal container.

Disinfection byproducts – DBP - (MCL/Monitoring)

Disinfection byproduct – harmful chemical byproducts that are carcinogenic (trihalomethanes and haloacetic acids)

Nitrite - Occurs when nitrate reacts with chlorine.

Disinfectant By-product Rule

The purpose of this rule is to reduce public exposure to three chemical disinfectants (chlorine, chloramines, and chlorine dioxide) and many disinfection by-products (total trihalomethanes (TTHM), haloacetic acids (HAA5), chlorite, and bromate). MCL for TTHM is .08 mg/L or 80 ppb MCL. The MCL for HAA5 is .06 mg/L or 60 ppb, sometimes referred to as the 80/60 rule.

If total trihalomethane (TTHM) and haloacetic acids (HAA5) are less than or equal to .040 mg/L and less than or equal to .030 mg/L respectively, then a water system with reduced monitoring **does not** need to use enhanced coagulation to achieve the total organic carbon (TOC) percent removal.

Sample bottles contain a small amount of chemicals (sodium thiosulfate or sodium sulfite) which stops the chemical reaction that occurs between chlorine and THM precursors.

Dissolved organic matter will account for the least amount of total dissolved solids (TDS)

Chlorine is effective at killing bacteria but has limited effectiveness against protozoa that form cysts in water, such as Giardia and Cryptosporidium. UV treatment is more effective in inactivating cysts in low turbidity water.

Hydrogen Sulfide in water may be effectively controlled by aeration.

Important Terms:

Aeration - Oxidizes water to remove gases and other elements in treatment.

Ammonia - Chemical compound is written as NH_3.

Autoclave - A piece of laboratory equipment that sterilizes glassware and other items by using pressurized steam.

Beaker - A piece of laboratory glassware that is primarily used to measure approximate volumes and mix chemicals.

Cations - an ion that has a positive electric charge and is attracted toward the cathode in electrolysis.

Colorimeter - Chlorine testing; can use for other types of samples (hardness depending on how the colors change).

The volume of reagent solution used is important because it can dilute the concentration of the colored end product in the reacted sample.

Turbidity can cause a false reading in this tool.

Ions - an atom or group of atoms or molecules that has acquired an electric charge by losing or gaining one or more electrons.

Jar Test - A laboratory procedure that simulates a water treatment plant's coagulation/flocculation unit with differing chemical doses and energy of rapid mix, energy of slow mix, and settling time.

Pathogen - An agent that causes disease, especially a living microorganism such as a bacterium. Examples include e. coli, fecal coliform, and giardia lamblia.

Heterotrophic Plate Count (HPC) – Measures a population of bacteria that are naturally present in the environment.
HPC has no health effects but can indicate how effective treatment is at controlling microorganisms.

pH - Potential of Hydrogen - A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. The pH scale ranges from 0 to 14. Alkalinity is the capacity of water to neutralize acids; that is, the measure of how much acid can be added to a liquid without causing a significant change in pH. A system can use lime or caustic soda to raise the pH of their water.

Standardized solution - used to determine the concentration of another solution.

Solute - a substance that is dissolved in another and will not settle out.

Solvent – a substance that dissolves another substance.

Specific gravity - The weight of any liquid in comparison to an equal volume of water.
Based on water at 4° Celsius or 39.2° Fahrenheit.

Titration - The process of adding the chemical reagent in increments until the completion of the reaction, as signaled by the end point.

Volumetric flask - will most accurately measure a solution.

Filtration

Step to remove impurities from source water.

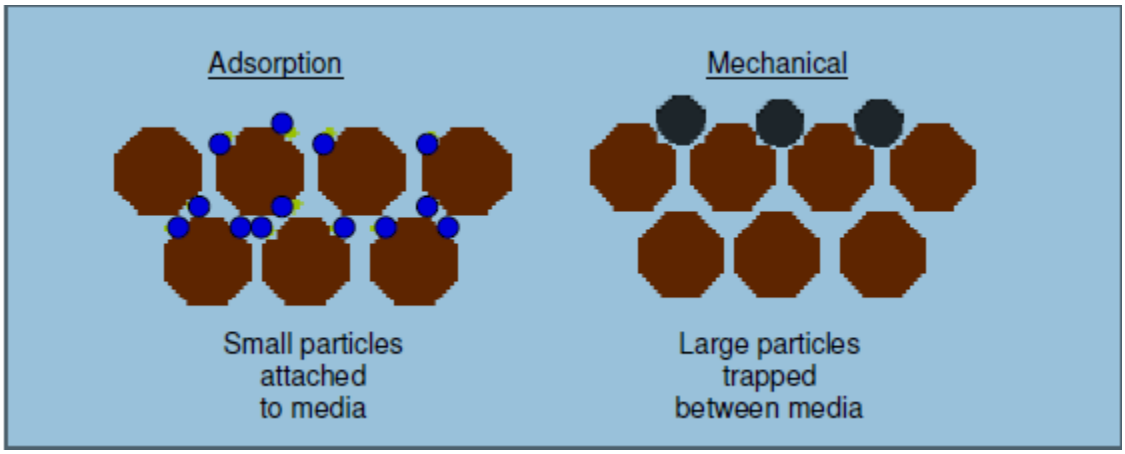

Figure 2: Adsorption v. Mechanical Filtration (IDEM 2014)

Adsorption occurs when the particles suspended in the liquid **attach** to the filter media (greensand filters), whereas mechanical filtration occurs when the particles physically get trapped in the filter media (conventional or gravity filters). Backwash cycles clean mechanical filters to extend their lifespan.

Backwashing – reversing the flow through the filter to remove the entrapped material deposited into the filter. Backwash rate should be ramped up slowly to avoid causing damage to the filter bed. Improper backwash rates can lead to filter media loss.

Filter backwash rule requires recycled filtration backwash water be returned upstream of the filtration process.

Filter Pore Size – Micro > Ultra > Nano > Reverse Osmosis (RO)

Microorganism size – Virus < Bacterium < Protozoa

Pressure filter capacity is 6-12 gpm/ft^2, gravity filter is 1-2 gpm/ft^2.

Air binding - Caused by the release of dissolved gases in saturated cold water when pressure decreases in filter beds.

Head loss - As the filter accumulates contaminants, the water level will rise due to the build-up of particles from adsorption and mechanical filtration. This is called “head loss.” Operating experience will determine the head loss point at which the filter should be backwashed (cleaned).

Iron (MCL) – iron levels above 0.3 mg/L can cause red water. May be filtered out in the oxidized ferric form.

- High iron levels can also cause coffee to get very dark due to the reaction between iron and the tannic acid in coffee or tea.
- Potassium Permanganate can be used to remove iron from water.
- High iron can cause issues with ion-exchange water softening.
- High iron can stain plumbing fixtures and clothes red.
- Filtration when combined with oxidation is the most effective option for removing iron from groundwater.

Common Filtration Issues

Gravel on the surface of a sand filter can indicate a “blown” or upset filter.

Mudballs - Clumps of filter media and other material caused by an insufficient frequency of backwashing.

Schmutzdecke - A mixture of fine sand and a sticky mat of suspended matter that forms on the surface of a sand filter. German translation is filth ceiling/floor.

Manganese greensand - Optimum operating quality can be achieved by maintaining the greensand to ensure effluent stays at or below 0.05 mg/L.

After backwashing and stratifying, ensure 8-9% of the greensand is skimmed off.

To increase the length of a filter run, add a layer of anthracite.

Reverse Osmosis - Reverse osmosis is the smallest of membrane technologies with microfiltration being the largest.

Utilizes a permeable membrane for filtration, which, while fragile, it is the most effective for removal of arsenic.

Turbidity - A measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness.

Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites, and some bacteria. These microorganisms can come from soil runoff. They can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.

Customers will notice 5 NTU or more turbidity. Turbidity of 1-2 NTU is the optimum level.

Softening

Sawyer, Briggs, or Ficke classification considered water with a calcium carbonate ($CaCO_3$) measure at or above 300mg/L very hard.

Softening water is most effective for the removal of nitrite, iron, and arsenic.

Too soft of water will cause soap scum.

Hardness is usually measured in milligrams per liter (mg/l) as calcium carbonate ($CaCO_3$) or grains per gallon (GPG).

(1 GPG = 17.1 mg/l)

hardness in water (types)

Langeliers Index is used to calculate the calcium carbonate stability of water.

LSI pH = pHA (actual) –pHS (saturation) A negative sum indicates the likelihood the water is corrosive, and a positive number indicates the water has the propensity to be scale forming. When the LSI/ LI is 0, water is said to be in equilibrium.

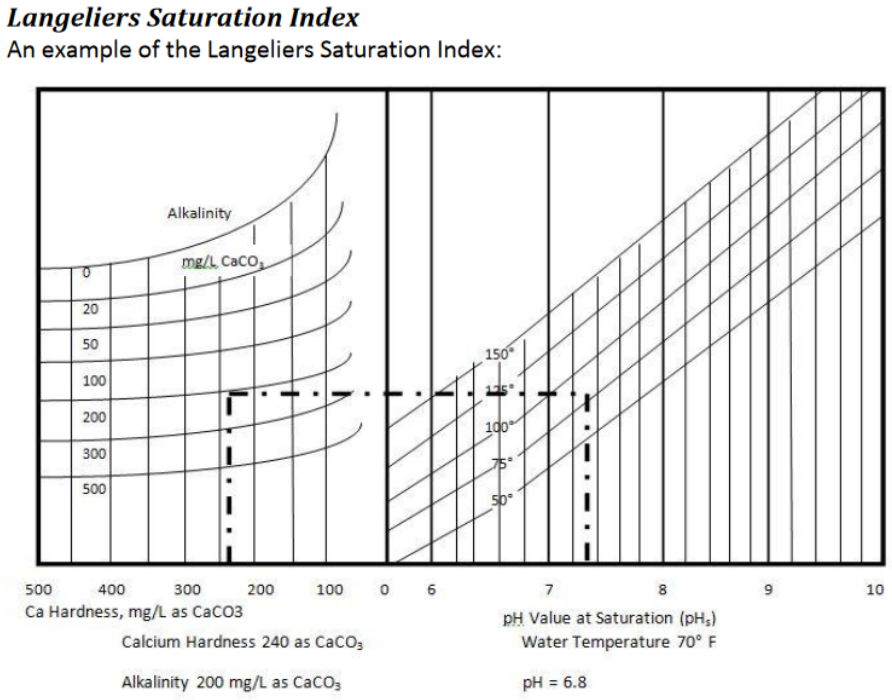

Figure 3 – Determination of pHs for the Langelier saturation index, given hardness, alkalinity, and temperature (assuming average total dissolved solids of about 500 mg/L (Basic Science Concepts and Applications, Fourth Edition, American Water Works Association, 2010, courtesy of Ondeo Nalco, Ondeo Nalco Center, Naperville, IL)

Carbonate hardness or temporary hardness is from heating water causing precipitation (dropping out of solution) of carbonate hardness.

Can be reduced with lime soda softening by adding slake lime ($Ca(OH)_2$) to precipitate the hardness which is then filtered out.

Non-carbonate hardness is permanent and comes from sulfates and chlorides of calcium and magnesium in water.

Can be reduced by adding soda ash (Na_2CO_3) after lime soda softening.

A water treatment plant softening their water should analyze hardness daily.

Ion exchange units (purpose):

Ion exchange softening works by exchanging the ions of sodium salts (NaCl) for calcium carbonate (CaCO3) removing the hardness from the water and replacing it with salt. This process utilizes a resin bed. Once the resin in the bed is spent it is “exhausted”. To recharge the resin bed and extend its life, pass brine through the bed.

For individuals/areas on salt- or sodium-restricted diets, potassium chloride (KCl) can be used instead of sodium chloride.

Ion exchange should not be used when the concentration of iron (Fe), manganese (Mn) or the combination of the two exceeds 0.3 mg/l. Ion exchange should not be used on raw or wash waters containing (high) dissolved oxygen (DO). Though water softeners will remove some soluble iron and manganese.

Meters

A mechanism by which to measure the input or output of chemicals or water.

Positive Displacement - Primarily used for lower flows (around .25 to 150 GPM); range from .5 inches to 2 inches. An example would be a rotameter. Used with chlorine/chemical feed.

Turbine - Primarily used for flows at or above 150 GPM; range from three inches to 20 inches.

Cross Connection Control/Backflow Prevention

Cross connection/backflow prevention - Cross Connection Control or Backflow Prevention is a mechanism that prevents contaminated water from flowing backwards in a water system.

Backflow prevention devices:

Air gap – the most common and most reliable CCC; requires gap to be twice the diameter of the pipe or a minimum of one inch.

Reduced pressure principle (RP)

Vacuum Breaker

- Pressure (PVB) vs. Atmospheric (AVB)
- Usually for irrigation

Double Check Valve (DC)

Reduced Pressure Zone (RPZ) – Used in critical hazardous environments.

Useful Information for Distribution Systems – Not Specific to WT3 Exam

Storage Tanks

A container that can hold large amounts of water that allow a system to meet demands more than their pumping capacity. Like a pressure tank but uses gravity or additional pumps provide pressure rather than compressed air.

Booster Stations and pumps - Implements for a distribution system to ensure proper pressure and distribution are met.

Cathodic Protection/ corrosion control - Corrosion is caused by hydrogen and sulfide gas. The process to protect the integrity of the storage tank involves a sacrificial piece of metal (an anode) and a reverse electrical current to allow metal from the anode (instead of the metal from the storage tank) to flow into the water.

Cathode - Cathodic metals are the least reactive.

Galvanic corrosion - involves the direct current (DC) electricity that is electrochemically generated between dissimilar metals.

Elevated - A storage tank that is usually taller than it is wide with at least one pipe running from the ground to the center of the tank that contains the tank's riser.

Legged: tank supported by several legs with a single pipe/leg supporting the center of tank containing the riser.

Pedestal: tank that has a single support running up from the ground that both supports the tank and contains its riser.

Foot valve - A type of check valve located at the bottom end of the suction pipe on a pump.

Ground level - A Storage tank that is usually wider than it is high; located on the surface or just below ground level. Will either use a pump to distribute water (if at the same level as the wellhead(s)) or use gravity (if at a higher elevation than the wellhead(s)).

A cylindrical prism-shaped storage tank is called a standpipe.

In a rural water system, half of the water stored in a tank is reserved for fire protection.

Overflow Pipes

Overflow pipes allow water to flow out of a tank when the level reaches too high. Like vents, these pipes must be screened with at least a #24 screen and free of debris.

Overflow pipes must include some type of cross connection control to prevent backflow into the tank. They also need to empty far enough away from the base that any effluent does not affect the foundation.

Snubbers

Small fittings that restrict flow, preventing rapid pressure changes that cause water hammer.

Valves

Opening and closing valves slowly prevents rapid shifts in water pressure which cause water hammer.

Larger valves use a by-pass valve to reduce water hammer in large mains.

Vents

Present on non-pressurized storage tanks, vents allow air to move in and out of the tank. Because of this all vents need to be screened with at least a #24 screen and clear of debris.

Distribution System

Dead ends - A portion of the distribution system that does not continue past the point.

Dead ends must be flushed more frequently to reduce the risk of stagnant water.

Galvanized pipes are coated in zinc on the inside and outside.

Stained plumbing fixtures - Fixtures or clothes stained red can indicate high iron in the water.

Fixtures or clothes stained black can indicate manganese presence above 0.2 mg/L in water.