



WELCOME!

Water Treatment Math



Your Moderator Today...



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WELCOME!

This training is presented by RCAC with funding provided by the California State Water Resources Control Board Division of Drinking Water (DDW)



The Rural Community Assistance Partnership



RCAC Programs

- ◆ Affordable housing
- ◆ Community facilities
- ◆ Water and wastewater infrastructure financing (Loan Fund)
- ◆ Classroom and online training
- ◆ On-site technical assistance
- ◆ Median Household Income (MHI) surveys



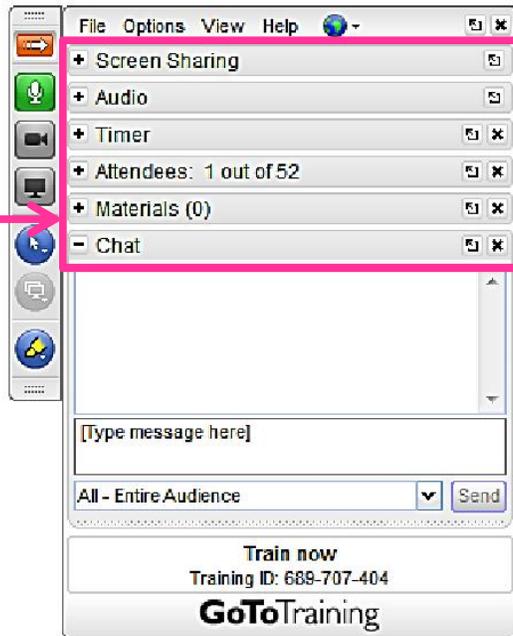
Performance Assessment Rating Tool (PART)



- ◆ 4 to 6 weeks from today
- ◆ Email w/ today's workshop in subject line
- ◆ 2 questions – 3 minutes maximum
- ◆ How did you use the information that was presented today?
- ◆ Funders are looking for positive changes
- ◆ Help us continue these free workshops!



Control Tabs



Audio Controls



Attendee List

Today's Materials

The screenshot shows the GoToTraining interface with a sidebar on the left containing icons for Screen Sharing, Audio, Timer, Attendees, Materials, and Chat. The main window has a menu bar (File, Options, View, Help) and a list of sections: Screen Sharing, Audio, Timer, Attendees (1 out of 52), Materials (0), and Chat. The Attendees section is expanded to show a list of names, with 'Neil Worthen (Organizer, P...)' visible. Below the list are buttons for Mute All, Unmute All, and Invite Others. The Materials section is also expanded, showing a list of materials. At the bottom, there is a 'Train now' button with the Training ID: 688-707-404 and the GoToTraining logo.

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Chat here

The screenshot shows the GoToTraining interface with the sidebar on the left. The main window shows the same list of sections as the previous screenshot, but the Chat section is expanded. The Chat section is highlighted with a pink box and contains a text input field with the placeholder text "[Type message here]". Below the input field are buttons for "All - Entire Audience" and "Send". At the bottom, there is a 'Train now' button with the Training ID: 688-707-404 and the GoToTraining logo.

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Questions?



**Text your questions and comments
anytime during the session**



Your Trainer Today

- ◆ John Hamner - Rural Development Specialist
jhamner@rcac.org



Your Trainer Today

Turn on the recorder!



WELCOME!

Water Treatment Math



Water Math Topics Today

- ◆ Expected Range of Knowledge
 - ▶ Basic conversions
 - ▶ Volumes
 - ▶ Chlorination & chemical feed
 - ▶ Detention time
 - ▶ Filtration
 - ▶ Velocity

State Water Resources Control Board

Drinking Water Treatment Exams Expected Range of Knowledge

Exam Content	Number of questions				
	Grade	T1	T2	T3	T4
Source Water		25	25	20	15
Water Treatment Processes		25	25	35	20
Operation/Maintenance		20	20	15	15
Laboratory Procedures		15	15	15	15
Regulations/Administrative Duties		15	15	15	35

Source Water

Watershed Protection, Wells / Groundwater, Surface Water / Reservoirs, Raw Water Storage, Clear Well Storage

Water Treatment Processes

Coagulation/Flocculation/ Sedimentation, Filtration, Disinfection, Demineralization, Corrosion Control, Iron and Manganese removal, Fluoridation, Water Softening, BAT, (Best Available Technology)

Operation / Maintenance

Chemical feeders, Pumps and Motors, Blowers and Compressors, Water meters, Pressure gauges, Electrical generators, Safety, SCADA systems

Laboratory Procedures

Sampling, General Lab Practices, Disinfectant analysis, Alkalinity analysis, pH analysis, Turbidity analysis, Specific conductance, Hardness, Fluoride analysis, Color analysis, Taste and Odor analysis, Dissolved Oxygen analysis, Algae Count, Bacteriological analysis

Regulations/Administrative Duties

Planning, Organizing, Directing, Controlling, Staffing, Implementing Regulations, Record keeping, Safe Drinking Water Act and amendments, Surface Water Treatment Rule and amendments, Primary Contaminants, Secondary Contaminants, Lead and Copper Rule, Fluoride Regulations, Operator Certification Regulations

EXPECTED RANGE OF KNOWLEDGE WATER TREATMENT EXAMS

(Items marked "T1-T4" may be on the T1 – T4 exams)

(Items marked "T2-T4" may be on the T2 – T4 exams but not on the T1 exam)

Source Water

Wells/Groundwater

T1-T4	Knowledge of the characteristics of aquifers
T1-T4	Knowledge of the chemical components of groundwater
T1-T4	Knowledge of potential contamination in groundwater
T1-T4	Knowledge of well sampling techniques
T1-T4	Knowledge of groundwater characteristics
T1-T4	Ability to analyze water quality characteristics
T1-T4	Ability to calculate well drawdown
T2-T4	Ability to recognize hydrological changes
T2-T4	Ability to calculate a disinfectant dosage in a well
T2-T4	Ability to recognize the influence of surface water on a groundwater source
T2-T4	Ability to calculate well specific capacity
T3-T4	Knowledge of the source water assessment process
T3-T4	Ability to recognize abnormal chemical characteristics of water
T3-T4	Ability to calculate well head pressure

Water Treatment Exam Math

T1-T4	Ability to calculate well drawdown
T1-T4	Ability to calculate flow rates, water velocity
T1-T4	Ability to calculate the volume of water contained in a storage facility
T1-T4	Ability to calculate a chemical, disinfectant dosage
T1-T4	Ability to determine water level
T1-T4	Ability to calculate volumes, dilution factors, feed rates, and chemical concentrations
T1-T4	Ability to calculate a de-chlorination dosage
T1-T4	Ability to calculate chlorine residual
T1-T4	Ability to convert a head pressure to water elevation
T2-T4	Ability to calculate well specific capacity
T2-T4	Ability to calculate detention time
T2-T4	Ability to calculate chemical solution concentration
T2-T4	Ability to calculate filter-aid dosage
T2-T4	Ability to calculate filter backwash rate
T2-T4	Ability to calculate an ammonia/chlorine ratio
T2-T4	Ability to calculate a chemical feed rate (dose) for corrosion control
T2-T4	Ability to calculate a chemical dosage for Fe/Mn removal, fluoridation
T2-T4	Ability to calculate a dosage on a chemical feeder



What are we actually doing?

We are CONVERTING!

- ◆ Pay attention to the units of measure...



Units of Measure Examples...

$24 \text{ hr/day} \times 60 \text{ min/hr} \times 60 \text{ sec/min} = \text{sec/day}$

$\text{MGD} \times 8.34 \text{ lbs/gal} \times \text{ppm} = \text{lbs/day}$

$50 \text{ ft} \times .433 \text{ psi/ft} = \text{psi}$



Water Math – Terms, Definitions and Water Measurements

- ◆ Gallons per cubic ft = gal/cu ft
- ◆ Pounds per gallon = lbs/gal
- ◆ Pounds per square inch = psi
- ◆ Gallons per day = gpd
- ◆ Gallons per minute = gpm
- ◆ What about percentages?

What would 75% be in the form of a decimal?

75

.75

7.5

75.0

.075

75.0

What would 5% be in the form of a decimal?

5

.05

5.0

5.00

.005

005.0

NO UNIT OF MEASURE!

- ◆ Percentages as a decimal
- ◆ Ratios
- ◆ Pi (3.14)
- ◆ .785 = 78.5% (diameter)

STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH DRINKING WATER OPERATOR CERTIFICATION PROGRAM		
<p>Units and Conversion Factors</p> <p>1 cubic foot of water weighs 62.3832 lb 1 gallon of water weighs 8.34 lb 1 liter of water weighs 1,000 gm 1 mg/L = 1 part per million (ppm) 1% = 10,000 ppm ft² = square feet and ft³ = cubic feet 1 mile = 5,280 feet (ft) 1 yd² = 27ft² and 1 yard = 3 feet 1 acre (a) = 43,560 square feet (ft²) 1 acre foot = 325,829 gallons 1 cubic foot (ft³) = 7.48 gallons (gal) 1 gal = 3.785 liters (L) 1 L = 1,000 milliliters (ml) 1 pound (lb) = 454 grams (gm) 1 lb = 7,000 grains (gr) 1 grain per gallon (gpg) = 17.1 mg/L 1 gm = 1,000 milligrams (mg) 1 day = 24 hr = 1,440 min = 86,400 sec 1,000,000 gal/day = 86,400 sec/day = 7.48 gal/cu ft = 1.55 cu ft/sec/MGD</p> <p>CHLORINATION</p> <p>Dosage, mg/l = (Demand, mg/l) + (Residual, mg/l)</p> <p>(See lbs = Vol. MG x ppm or mg/L x 8.34 lbs/gal)</p> <p>HTH sold (lbs) = $\frac{(Vol. MG) \times (ppm \text{ or } mg/L) \times 8.34 \text{ lbs/gal}}{(\% \text{ Strength} / 100)}$</p> <p>Liquid (gpl) = $\frac{(Vol. MG) \times (ppm \text{ or } mg/L) \times 8.34 \text{ lbs/gal}}{(\% \text{ Strength} / 100) \times \text{Chemical Vol. (lbs/gal)}}$</p> <p>PRESSURE</p> <p>PSI = $\frac{(Head \text{ ft})}{2.31 \text{ ft/gal}}$ PSI = Head ft x 0.433 PSF</p> <p>Head, Feet = (0.785) (D, ft)² x 144 in²/ft² x PSI</p>	<p>VOLUME</p> <p>Rectangular Basin = $\text{Volume, gal} = (\text{Length, ft}) \times (\text{Width, ft}) \times (\text{Height, ft}) \times 7.48 \text{ gal/cu ft.}$</p> <p>Cylinder Volume, gal = $(0.785) \times (\text{Dia, ft})^2 \times (\text{Height, Depth, or Length, in ft}) \times 7.48 \text{ gal/ft}^3$</p> <p>Time, hrs = $\frac{\text{Volume, gal}}{(\text{Pumping Rate, GPM} \times 60 \text{ Min/hr.})}$</p> <p>Supply Time = $\frac{\text{Storage Volume, Gal}}{((\text{Flow In, GPM} - \text{Flow Out, GPM}) \times 60 \text{ min/hr.})}$</p> <p>SOLUTIONS</p> <p>Lbs/Gal = $\frac{(\text{Solution } \%) \times 8.34 \text{ lbs/gal} \times \text{Specific Gravity}}{100}$</p> <p>Lbs Chemical = $\text{Specific Gravity} \times 8.34 \text{ lbs/gal} \times (\text{Solution})$</p> <p>Specific Gravity = $\frac{\text{Chemical Vol. (lbs/gal)}}{8.34 \text{ (lbs/gal)}}$</p> <p>% of Chemical in Solution = $\frac{(\text{Dry Chemical, Lbs}) \times 100}{(\text{Dry WA Chemical, Lbs}) + (\text{Water, Lbs})}$</p> <p>GPD = $\frac{(\text{MGD}) \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\% \text{ purity}) \times \text{Chemical Vol. (lbs/gal)}}$</p> <p>GPD = $\frac{(\text{Feed, ml/hr} \times 144 \text{ min/hr.})}{(1,000 \text{ mL} \times 3785 \text{ L/Gal})}$</p> <p>Two - Normal Equations $\frac{Q_1}{C_1} = \frac{Q_2}{C_2}$ C) $C_1 V_1 + C_2 V_2 = C_3 V_3$ C = Concentration, V = Volume, Q = Flow</p>	<p>PUMPING</p> <p>1 horsepower (hp) = 746 watts = 0.746 kW = 3300 gal/min-ft</p> <p>Water Hp = $\frac{(\text{GPM}) \times (\text{Total Head, ft})}{(8.33 \text{ gal/min-ft})}$</p> <p>Brake Hp = $\frac{(\text{GPM}) \times (\text{Total Head, ft})}{(3960) \times (\text{Pump } \% \text{ Efficiency})}$</p> <p>Motor Hp = $\frac{(\text{GPM}) \times (\text{Total Head, ft})}{(3960) \times \text{Pump } \% \text{ Eff.} \times \text{Motor } \% \text{ Eff.}}$</p> <p>*Watt to Water Efficiency = $(\text{Motor } \% \text{ Efficiency} \times \text{Pump } \% \text{ Efficiency})$</p> <p>Cost, \$ = $(\text{hp}) \times (0.746 \text{ kW/hp}) \times (\text{Operating Hrs.}) \times \text{cost/kWh}$</p> <p>Flow, velocity, area</p> <p>Q = A x V Quantity = Area x Velocity</p> <p>Flow (ft³/sec) = $\frac{\text{Area (ft}^2\text{)} \times \text{Velocity (ft/sec)}}{7.48 \text{ gal/cu ft}}$</p> <p>$\frac{\text{MGD} \times 1.55 \text{ cu ft/sec/MGD}}{36 \text{ in pipe diameter} \times \text{pipe diameter} \text{ ft} = \text{sq ft}}$</p> <p>General</p> <p>(\$ Cost / day) = $\text{Usage} \times (\\$ \text{ Cost})$</p> <p>Removal, Percent = $\frac{(\text{Inlet Q}) \times 100}{\text{In}}$</p> <p>Specific Capacity, GPM/ft = $\frac{\text{Well Yield, GPM}}{\text{Diameter, ft}}$</p> <p>Gals/Day = $(\text{Population}) \times (\text{Gals/Capita/Day})$</p> <p>GPD = $\frac{(\text{Water Res. 2} - \text{Water Res. 1})}{(\text{Number of Days})}$</p> <p>Volume, Gal = GPM x Time, minutes</p> <p>SCADA 4 mA to 20 mA analog signal</p> <p>(See signal mA - 4 mA off set.) x process unit and range (15 mA span)</p> <p>4 mA = 0 20 mA = range</p>

<p>FILTRATION</p> <p>Filtration Rate (GPM/sq ft) = $\frac{\text{Filter Production (millions gal/day)}}{(\text{Filter area sq ft}) \times (1,440 \text{ min/day})}$ sq ft = square feet</p> <p>Loading Rate (GPM/sq ft) = $\frac{(\text{Flow Rate GPM})}{(\text{Filter Area sq ft})}$</p> <p>Daily Filter Production (GPD) = $(\text{Filter Area sq ft}) \times (\text{GPM/sq ft}) \times (1,440 \text{ min/day})$</p> <p>Backwash Pumping Rate (GPM) = $(\text{Filter Area sq ft}) \times (\text{Backwash Rate GPM/sq ft})$</p> <p>Backwash Volume (Gallons) = $(\text{Filter Area sq ft}) \times (\text{Backwash Rate gpm/sq ft}) \times (\text{Time min})$</p> <p>Backwash Rate (GPM/sq ft) = $\frac{(\text{Backwash Volume gallons})}{(\text{Filter Area sq ft}) \times (\text{Time min})}$</p> <p>Rate of Rise (inches per min) = $\frac{(\text{Backwash rate gpm/sq ft}) \times 12 \text{ inches ft}}{3.78 \text{ gal/cu ft}}$</p> <p>Unit Filter Run Volume (UFRV) = $\frac{(\text{millions produced in a filter run})}{(\text{Filter area sq ft})}$</p>	<p>C • T CALCULATIONS</p> <p>$C \cdot t = (\text{Chlorine Residual, mg/L}) \times (\text{Time, minutes})$</p> <p>Time, minutes = $\frac{C \cdot t}{(\text{Chlorine Residual, mg/L})}$</p> <p>Chlorine Residual (mg/L) = $\frac{C \cdot t}{(\text{Time, minutes})}$</p> <p>Inactivation Ratio = $\frac{(\text{Actual System } C \cdot t)}{(\text{Table "B" } C \cdot t)}$</p> <p>$C \cdot t_{\text{Calculated}} = T_{10} \text{ Value, minutes} \times \text{Chlorine Residual, mg/L}$</p> <p>Log Removal = $10.0 - \frac{\% \text{ Removal}}{100} \times \text{Logkey} \times (-1)$</p>
<p>SEDIMENTATION</p> <p>Surface Loading Rate (GPD/sq ft) = $\frac{(\text{Total Flow, GPD})}{(\text{Surface Area, sq ft})}$</p> <p>Detention Time, hr = $\frac{\text{Volume}}{\text{Flow}}$</p> <p>Detention Time hours = $\frac{\text{volume (cu ft)} \times 7.48 \text{ gal/cu ft} \times 24 \text{ hr/day}}{\text{Gal/day}}$</p> <p>Flow Rate = $\frac{\text{Volume}}{\text{Time}}$</p> <p>Weir Overflow Rate, GPD/L.F. = $\frac{(\text{Flow, GPD})}{(\text{Weir length, ft.})}$</p>	<p>Chemical Dosage Calculations Note (% purity) and (% commercial purity) used in decimal form</p> <p>Lbs/day gas feed dry = $\frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{\% \text{ purity}}$</p> <p>Lbs/day = $\frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{\% \text{ purity}}$</p> <p>GPD = $\frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\% \text{ purity}) \times \text{lbs/gal}}$</p> <p>GPD = $\frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\text{commercial purity } \%) \times (\text{ion purity } \%) \times (\text{lbs/gal})}$</p> <p>ppm or mg/L = $\frac{\text{lbs/day}}{\text{MGD} \times 8.34 \text{ lbs/gal}}$ or $\frac{\text{millions} \times \% \text{ purity} \times \text{lbs/gal}}{\text{MGD} \times 8.34 \text{ lbs/gal}}$</p>

<p>Units and Conversion Factors</p> <p>1 cubic foot of water weighs 62.3832 lb</p> <p>1 gallon of water weighs 8.34 lb</p> <p>1 liter of water weighs 1,000 gm</p> <p>1 mg/L = 1 part per million (ppm)</p> <p>1% = 10,000 ppm</p> <p>ft² = square feet and ft³ = cubic feet</p> <p>1 mile = 5,280 feet (ft)</p> <p>1 yd³ = 27ft³ and 1 yard = 3 feet</p> <p>1 acre (a) = 43,560 square feet (ft²)</p> <p>1 acre foot = 325,829 gallons</p> <p>1 cubic foot (ft³) = 7.48 gallons (gal)</p> <p>1 gal = 3.785 liters (L)</p> <p>1 L = 1,000 milliliters (ml)</p> <p>1 pound (lb) = 454 grams (gm)</p> <p>1 lb = 7,000 grains (gr)</p> <p>1 grain per gallon (gpg) = 17.1 mg/L</p> <p>1 gm = 1,000 milligrams (mg)</p> <p>1 day = 24 hr = 1,440 min = 86,400 sec</p> <p>1,000,000 gal/day ÷ 86,400 sec/day ÷ 7.48 gal/cu ft = 1.55 cu ft/sec/MGD</p>	<p style="text-align: center;">State of California Math Conversion Sheet Provided At Exam</p>
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CHLORINATION

$$\text{Dosage, mg/l} = (\text{Demand, mg/l}) + (\text{Residual, mg/l})$$

$$\text{(Gas) lbs} = (\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})$$

$$\text{HTH Solid (lbs)} = \frac{(\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})}{(\% \text{ Strength} / 100)}$$

$$\text{Liquid (gal)} = \frac{(\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})}{(\% \text{ Strength} / 100) \times \text{Chemical Wt. (lbs/gal)}}$$

PRESSURE

$$\text{PSI} = \frac{(\text{Head, ft.})}{2.31 \text{ ft./psi}} \quad \text{PSI} = \text{Head, ft.} \times 0.433 \text{ PSI/ft.}$$

$$\text{lbs Force} = (0.785) (D, \text{ ft.})^2 \times 144 \text{ in}^2/\text{ft}^2 \text{ PSI.}$$

VOLUME

Rectangular Basin =

Volume, gal

(Length, ft) x (Width, ft) x (Height, ft) x 7.48 gal/cu.ft.

Cylinder , Volume, gal =

(0.785) x (Dia, ft)² x (Height, Length, Depth, in ft.) x 7.48 gal/ft³

Time, Hrs. = $\frac{\text{Volume, gallons}}{\text{(Pumping Rate, GPM, x 60 Min/Hr)}}$

Supply, Hrs.= $\frac{\text{Storage Volume, Gals}}{\text{(Flow In, GPM – Flow Out, GPM) x 60 min/hr.}}$

SOLUTIONS

Lbs/Gal = $\frac{(\text{Solution \%})}{100} \times 8.34 \text{ lbs/gal} \times \text{Specific Gravity}$

Lbs Chemical =
 $\text{Specific Gravity} \times 8.34 \text{ lbs/gallons} \times \text{Solution (gal)}$

Specific Gravity = $\frac{\text{Chemical Wt. (lbs/gal)}}{8.34 \text{ (lbs/gal)}}$

% of Chemical in Solution = $\frac{(\text{Dry Chemical, Lbs})}{(\text{Dry Wt. Chemical, Lbs}) + (\text{Water, Lbs})} \times 100$

GPD = $\frac{(\text{MGD}) \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\% \text{ purity}) \times \text{Chemical Wt. (lbs/gal)}}$

GPD = $\frac{(\text{Feed, ml/min.} \times 1,440 \text{ min/day})}{(1,000 \text{ mL} \times 3.785 \text{ L/Gal})}$

Two – Normal Equations:

a) $C_1V_1 = C_2V_2$ $\frac{Q_1}{V_1} = \frac{Q_2}{V_2}$

b) $C_1V_1 + C_2V_2 = C_3V_3$

C = Concentration, V = Volume, Q = Flow

Flow, velocity, area

$$Q = A \times V \quad \text{Quantity} = \text{Area} \times \text{Velocity}$$

$$\text{Flow (ft}^3/\text{sec)} = \text{Area(ft}^2) \times \text{Velocity (ft/sec)}$$

$$\frac{\text{MGD} \times 1.55 \text{ cu ft/sec/MGD}}{.785 \times \text{pipe diameter ft} \times \text{pipe diameter ft}} = \frac{\text{cu ft/sec}}{\text{sq ft}} = \text{ft/sec}$$



General

$$(\$) \text{ Cost / day} = \text{Lbs/day} \times (\$) \text{ Cost/lb}$$

$$\text{Removal, Percent} = \frac{(\text{In} - \text{Out})}{\text{In}} \times 100$$

$$\text{Specific Capacity, GPM/ft.} = \frac{\text{Well Yield, GPM}}{\text{Drawdown, ft.}}$$

$$\text{Gals/Day} = (\text{Population}) \times (\text{Gals/Capita/Day})$$

$$\text{GPD} = \frac{(\text{Meter Read 2} - \text{Meter Read 1})}{(\text{Number of Days})}$$

$$\text{Volume, Gals} = \text{GPM} \times \text{Time, minutes}$$

FILTRATION

$$\text{Filtration Rate (GPM/sq.ft)} = \frac{\text{Filter Production (gallons per day)}}{(\text{Filter area sq. ft.}) \times (1,440 \text{ min/day})} \quad \text{sq. ft. = square feet}$$

$$\text{Loading Rate (GPM/sq. ft.)} = \frac{(\text{Flow Rate, GPM})}{(\text{Filter Area, sq. ft.})}$$

$$\text{Daily Filter Production (GPD)} = (\text{Filter Area, sq. ft.}) \times (\text{GPM/sq. ft.} \times 1,440 \text{ min/day})$$

$$\text{Backwash Pumping Rate (GPM)} = (\text{Filter Area, sq. ft.}) \times (\text{Backwash Rate, GPM/sq. ft.})$$

$$\text{Backwash Volume (Gallons)} = (\text{Filter Area, sq. ft.}) \times (\text{Backwash Rate, gpm/sq. ft.}) \times (\text{Time, min.})$$

$$\text{Backwash Rate, GPM/sq. ft.} = \frac{(\text{Backwash Volume, gallons})}{(\text{Filter Area, sq. ft.}) \times (\text{Time, min})}$$

$$\text{Rate of Rise (inches per min.)} = \frac{(\text{backwash rate gpm/sq.ft.}) \times 12 \text{ inches/ft}}{7.48 \text{ gal/cu.ft.}}$$

$$\text{Unit Filter Run Volume, (UFRV)} = \frac{(\text{gallons produced in a filter run})}{(\text{filter area sq. ft.})}$$

SEDIMENTATION

$$\text{Surface Loading Rate, (GPD/sq. ft.)} = \frac{(\text{Total Flow, GPD})}{(\text{Surface Area, sq. ft.})}$$

$$\text{Detention Time} = \frac{\text{Volume}}{\text{flow}}$$

$$\text{Detention Time hours} = \frac{\text{volume (cu ft)} \times 7.48 \text{ gal/cu ft} \times 24 \text{ hr/day}}{\text{Gal/day}}$$

$$\text{Flow Rate} = \frac{\text{Volume}}{\text{Time}}$$

$$\text{Weir Overflow Rate, GPD/L.F.} = \frac{(\text{Flow, GPD})}{(\text{Weir length, ft.})}$$

Chemical Dosage Calculations

Note (% purity) and (% commercial purity) used in decimal form

$$\text{Lbs/day gas feed dry} = \text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}$$

$$\text{Lbs/day} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{\% \text{ purity}}$$

$$\text{GPD} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\% \text{ purity}) \times \text{lbs/gal}}$$

$$\text{GPD} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\text{commercial purity \%}) \times (\text{ion purity \%}) \times (\text{lbs/gal})}$$

$$\text{ppm or mg/l} = \frac{\text{lbs/day}}{\text{MGD} \times 8.34 \text{ lbs/gal}} \quad \text{or} \quad \frac{\text{gallons} \times \% \text{ purity} \times \text{lbs/gal}}{\text{MG} \times 8.34 \text{ lbs/gal}}$$

Questions?



**Text your questions and comments
anytime during the session**

My biggest tip for newbies!

Cancelation of units!



Simple conversions – box 1

1. Convert 10 cubic feet of water into pounds of weight



Simple conversions – box 1

1. Convert 10 cubic feet of water into pounds of weight

$$10 \text{ cu ft} \times 62.38 \text{ lbs/cu ft} =$$



Simple conversions – box 1

2. How many pounds does 15 gallons of water weigh?



Simple conversions – box 1

2. How many pounds does 15 gallons of water weigh?

$$15 \text{ gal} \times 8.34 \text{ lb/gal} =$$



Simple conversions – box 1

8. How many gallons of water are in 3 acre feet of water?



Simple conversions – box 1

8. How many gallons of water are in 3 acre feet of water?

$$3 \text{ ac ft} \times 325,829 \text{ gal/cu ft} =$$



Simple conversions – box 1

10. How many gallons are pumped each day if a pump is capable of pumping 50 gallons per minute and the pump runs for 9 hours a day?



Simple conversions – box 1

10. How many gallons are pumped each day if a pump is capable of pumping 50 gallons per minute and the pump runs for 9 hours a day?

$$50 \text{ gal/min} \times 60 \text{ min/hr} \times 9 \text{ hr/day} =$$



Questions?



**Text your questions and comments
anytime during the session**



CHLORINATION

$$\text{Dosage, mg/l} = (\text{Demand, mg/l}) + (\text{Residual, mg/l})$$

$$\text{(Gas) lbs} = (\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})$$

$$\text{HTH Solid (lbs)} = \frac{(\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})}{(\% \text{ Strength} / 100)}$$

$$\text{Liquid (gal)} = \frac{(\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})}{(\% \text{ Strength} / 100) \times \text{Chemical Wt. (lbs/gal)}}$$

Chemical Dosage Calculations

Note (% purity) and (% commercial purity) used in decimal form

$$\text{Lbs/day gas feed dry} = \text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}$$

$$\text{Lbs/day} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{\% \text{ purity}}$$

$$\text{GPD} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\% \text{ purity}) \times \text{lbs/gal}}$$

$$\text{GPD} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\text{commercial purity \%}) \times (\text{ion purity \%}) \times (\text{lbs/gal})}$$

$$\text{ppm or mg/l} = \frac{\text{lbs/day}}{\text{MGD} \times 8.34 \text{ lbs/gal}} \quad \text{or} \quad \frac{\text{gallons} \times \% \text{ purity} \times \text{lbs/gal}}{\text{MG} \times 8.34 \text{ lbs/gal}}$$

What am I adding to the water to treat it?

- ◆ Chemicals
- ◆ Chlorine
 - ▶ Gas
 - ▶ Calcium hypochlorite
 - ▶ Sodium hypochlorite



Water Math Conversions – Chemical/Chlorine Dosage

In dosage problems, quantities of chemical are *given* in the following increments:

- ◆ Lbs or lbs/day
- ◆ Gallons (chemical solution quantity) or Gal/day
- ◆ mg/L or ppm
- ◆ MG or MGD

What does Miller Genuine Draft have to do with water treatment?

When working dosage, convert Q to MG or MGD!

How many MGD is 2,000,000 gal/day?

- A. 2 MGD
- B. .2 MGD
- C. .02 MGD

What is not given in the question?

- ◆ THE CONVERSION NUMBER!
 - ▶ 8.34 lbs/gal
 - ▶ Chemical weight
 - ▶ 8.34 lbs/gal X specific gravity

Dosage

- ◆ Example: If a given water source had a chlorine demand of 3 mg/L and you wanted a chlorine residual of .5 mg/L leaving the plant, what would your dose be?

$$\text{Dosage, mg/l} = (\text{Demand, mg/l}) + (\text{Residual, mg/l})$$



Chlorination – box 2

1. If the chlorine dose added to drinking water equaled 10 mg/L and the chlorine demand was 9 mg/L, what is the chlorine residual in ppm?



Chlorination – box 2

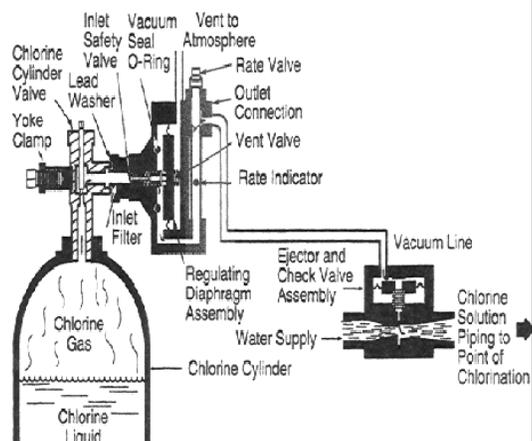
1. If the chlorine dose added to drinking water equaled 10 mg/L and the chlorine demand was 9 mg/L, what is the chlorine residual in ppm?

$$10 \text{ mg/L} - 9 \text{ mg/L} = 1 \text{ mg/L}$$



Chlorine Gas

- ◆ Chlorine gas is fed in lbs or lbs/day



Chlorination – box 2

- ◆ Example: If a chlorine gas concentration of 15 ppm were added to a storage tank holding 2.5 MG, how many lbs of chlorine would be needed?

$$\text{(Gas) lbs} = (\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})$$



Chlorination – box 2

2. If a storage tank had 1 MG of water and it needed to be dosed with 11 mg/L of gas chlorine, how many pounds of chlorine would this take?



Chlorination – box 2

2. If a storage tank had 1 MG of water and it needed to be dosed with 11 mg/L of gas chlorine, how many pounds of chlorine would this take?

$$1 \text{ MG} \times 8.34 \text{ lb/gal} \times 11 \text{ mg/L} = 91.74 \text{ lb}$$



Chlorination – box 2

- ◆ Example: If a new storage tank measured 40 ft in diameter and were 30 ft tall, how many pounds of chlorine gas would be needed to dose this tank at 9 mg/L?

$$\text{(Gas) lbs} = (\text{Vol, MG}) \times (\text{Dosage, mgl}) \times (8.34 \text{ lbs/gal})$$

Chlorination – box 2

- ◆ Example: If a new storage tank measured 40 ft in diameter and were 30 ft tall, how many pounds of chlorine gas would be needed to dose this tank at 9 mg/L?

$$.785 \times 40 \text{ ft} \times 40 \text{ ft} \times 30 \text{ ft} \times 7.48 \text{ gal/ft}^3 = 281,846$$

$$\text{(Gas) lbs} = (\text{Vol, MG}) \times (\text{Dosage, mgl}) \times (8.34 \text{ lbs/gal})$$

Chemical Dosage Calculations

Note (% purity) and (% commercial purity) used in decimal form

$$\text{Lbs/day gas feed dry} = \text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}$$

$$\text{Lbs/day} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{\% \text{ purity}}$$

$$\text{GPD} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\% \text{ purity}) \times \text{lbs/gal}}$$

$$\text{GPD} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\text{commercial purity } \%) \times (\text{ion purity } \%) \times (\text{lbs/gal})}$$

$$\text{ppm or mg/l} = \frac{\text{lbs/day}}{\text{MGD} \times 8.34 \text{ lbs/gal}} \quad \text{or} \quad \frac{\text{gallons} \times \% \text{ purity} \times \text{lbs/gal}}{\text{MG} \times 8.34 \text{ lbs/gal}}$$

Chlorination – box 13

2. If a treatment plant had a daily flow of 900,000 gallons per day and it needed to be dosed with 8 mg/L of gas chlorine, how many pounds of chlorine would this take?



Chlorination – box 13

2. If a treatment plant had a daily flow of 900,000 gallons per day and it needed to be dosed with 8 mg/L of gas chlorine, how many pounds of chlorine would this take?

$$.9 \text{ MGD} \times 8.34 \text{ lb/gal} \times 8 \text{ mg/L} = 60 \text{ lb/day}$$



Questions?



**Text your questions and comments
anytime during the session**



5 minute break



Dosage, Calcium Hypochlorite

- ◆ An operator may be given dry chemicals (usually chlorine) that is not 100% strength
- ◆ Consider this in the dosage problem
- ◆ Remember to convert the % to a decimal (divide by 100)



Percentages

- ◆ How would an operator enter the percentage 70% into the calculator?
 - A. 70
 - B. 7.0
 - C. .70



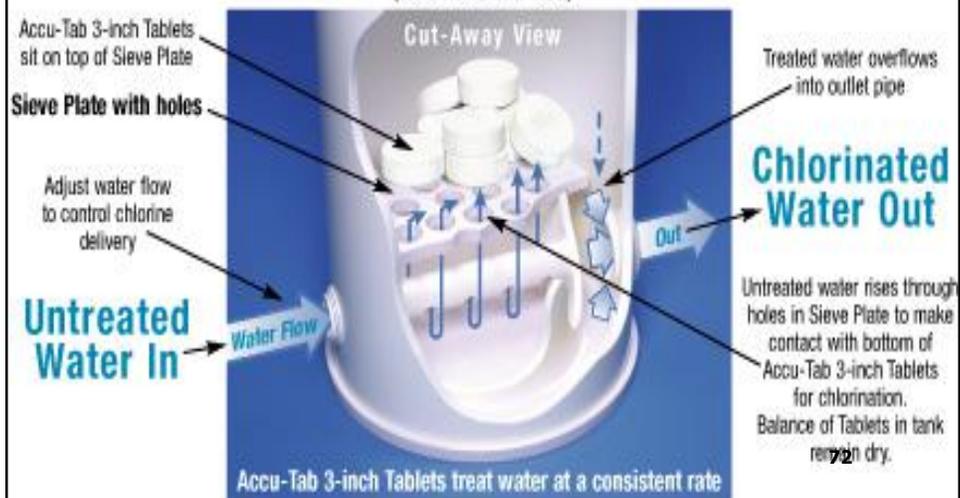
Calcium Hypochlorite



Calcium Hypochlorite

Accu-Tab® System

(Not Pressurized)



Chlorination – box 2

- ◆ Example: If a storage tank with 0.5 MG was treated with 65% calcium hypochlorite and the dose was 10 ppm, how many pounds of chemical would be needed?

HTH Solid (lbs) =

(Vol MG) x Dosage, mg/L) x (8.34lbs/gal)



RCAC.org

(% Strength/100)

Chlorination – box 2

3. If a 500,000 gallon storage tank was going to be dosed with 8 ppm of 65% HTH, how many pounds of HTH would this take?



RCAC.org

Chlorination – box 2

3. If a 500,000 gallon storage tank was going to be dosed with 8 ppm of 65% HTH, how many pounds of HTH would this take?

$$\frac{.5 \text{ MG} \times 8 \text{ ppm} \times 8.34 \text{ lb/gal}}{.65} = 51.31 \text{ lb}$$



Chlorination – box 2

- ◆ Example: If a storage tank 50 feet in diameter & 40 feet tall was treated with 70% calcium hypochlorite at a dose of 10 ppm, how many pounds of chemical would be needed?

$$\text{HTH Solid (lbs)} = \frac{(\text{Vol MG}) \times \text{Dosage, mg/L} \times (8.34 \text{ lbs/gal})}{(\% \text{ Strength}/100)}$$



Chlorination – box 2

- ◆ Example: If a storage tank 50 feet in diameter & 40 feet tall was treated with 70% calcium hypochlorite at a dose of 10 ppm, how many pounds of chemical would be needed?

$$.785 \times 50 \text{ ft} \times 50 \text{ ft} \times 40 \text{ ft} \times 7.48 \text{ gal/ft}^3 =$$

$$\frac{.587 \text{ MG} \times 8.34 \text{ lbs/gal} \times 10 \text{ ppm}}{.70} = 69.9 \text{ lbs}$$



.70

Chemical Dosage Calculations

Note (% purity) and (% commercial purity) used in decimal form

$$\text{Lbs/day gas feed dry} = \text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}$$

$$\text{Lbs/day} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{\% \text{ purity}}$$

$$\text{GPD} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\% \text{ purity}) \times \text{lbs/gal}}$$

$$\text{GPD} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\text{commercial purity } \%) \times (\text{ion purity } \%) \times (\text{lbs/gal})}$$

$$\text{ppm or mg/l} = \frac{\text{lbs/day}}{\text{MGD} \times 8.34 \text{ lbs/gal}} \quad \text{or} \quad \frac{\text{gallons} \times \% \text{ purity} \times \text{lbs/gal}}{\text{MG} \times 8.34 \text{ lbs/gal}}$$



Dosage –box 13

- ◆ Example: If 70% available HTH chlorine were added to water at a concentration of 15 ppm in a daily flow of 2.5 MGD, how many lbs would be used daily?

$$\text{Lbs/day} = \frac{\text{MGD} \times 8.34 \text{ lbs/gal} \times (\text{ppm or mg/l})}{\% \text{ purity}}$$



Questions?



**Text your questions and comments
anytime during the session**



Disinfection with bleach

- ◆ Liquid comes in;
 - ▶ Gallon containers
 - ▶ 55 gallon drums
 - ▶ Large totes, bulk
- ◆ Does not weigh the same as a gallon of water, but...
- ◆ Assume it does if they do not mention it!



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Percentages

- ◆ How would an operator enter the percentage 5.25% into the calculator?

5.25
.525
.0525
.00525
.05

Chlorination – box 2

- ◆ Example: If .75 MG was treated with a 15% chlorine solution and a dose of 10 ppm was desired, how many gallons of solution would be required?

$$\text{Liquid (gal)} = \frac{(\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})}{(\% \text{ Strength} / 100) \times \text{Chemical Wt. (lbs/gal)}}$$

Chlorination – box 2

4. A water storage tank with 1.2 MG is going to be chlorinated using 15% liquid chlorine at a dose of 4 ppm. How many gallons of chlorine will this take?

Chlorination – box 2

4. A water storage tank with 1.2 MG is going to be chlorinated using 15% liquid chlorine at a dose of 4 ppm. How many gallons of chlorine will this take?

$$\frac{1.2 \text{ MG} \times 4 \text{ ppm} \times 8.34 \text{ lb/gal}}{.15 \times 8.34 \text{ lb/gal}} = 32 \text{ gal}$$

Chlorination – box 2

- ◆ Example: If 500,000 gallons was treated with a 5.25% chlorine solution weighing 9 lbs/gal and a dose of 10 ppm was desired, how many gallons of solution would be required?

$$\text{Liquid (gal)} = \frac{(\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})}{(\% \text{ Strength} / 100) \times \text{Chemical Wt. (lbs/gal)}}$$

Chlorination – box 2

- ◆ Example: If 500,000 gallons was treated with a 5.25% chlorine solution weighing 9 lbs/gal and a dose of 10 ppm was desired, how many gallons of solution would be required?

$$\frac{.5 \text{ MG} \times 8.34 \text{ lbs/gal} \times 10 \text{ ppm} = 88 \text{ gal}}{.0525 \times 9 \text{ lbs/gal}}$$

Chemical Dosage Calculations

Note (% purity) and (% commercial purity) used in decimal form

$$\text{Lbs/day gas feed dry} = \text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}$$

$$\text{Lbs/day} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{\% \text{ purity}}$$

$$\text{GPD} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\% \text{ purity}) \times \text{lbs/gal}}$$

$$\text{GPD} = \frac{\text{MGD} \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\text{commercial purity } \%) \times (\text{ion purity } \%) \times (\text{lbs/gal})}$$

$$\text{ppm or mg/l} = \frac{\text{lbs/day}}{\text{MGD} \times 8.34 \text{ lbs/gal}} \quad \text{or} \quad \frac{\text{gallons} \times \% \text{ purity} \times \text{lbs/gal}}{\text{MG} \times 8.34 \text{ lbs/gal}}$$



Dosage – box 13

- ◆ Example: If 15% chlorine bleach were added to your water at a concentration of 15 ppm, and your daily flow was 2.5 MGD, how many gallons would be needed daily?

$$\text{GPD} = \frac{(\text{MGD}) \times (8.34 \text{ lbs/gal}) \times (\text{ppm or mg/l})}{(\% \text{ purity}) \times \text{lbs/gal}}$$



Dosage – box 13

- ◆ Example: If 12.5% chlorine bleach were added to a flow of 850,000 gal/day at a concentration of 6 ppm, and the product weight 10 lbs/gal, how many gallons would be needed daily?

$$\text{GPD} = \frac{(\text{MGD}) \times (8.34 \text{ lbs/gal}) \times (\text{ppm or mg/l})}{(\% \text{ purity}) \times \text{lbs/gal}}$$



Dosage – box 13

- ◆ Example: If 12.5% chlorine bleach were added to a flow of 3 MGD at a concentration of 6 ppm, and the bleach had a specific gravity of 1.2, how many gallons of bleach would be needed daily?

$$\text{GPD} = \frac{3 \text{ MGD} \times 8.34 \text{ lbs/gal} \times 6 \text{ ppm}}{.125 \times (8.34 \text{ lbs/gal} \times 1.2)}$$



Dosage – box 13

- ◆ Example: If 75 gal/day of 15% chlorine bleach were added to a flow of 950,000 gal/day, and the product weight 10 lbs/gal, what is the dosage rate in mg/L?

$$\text{Ppm} = \frac{\text{gallons} \times \% \text{ purity} \times \text{lbs/gal}}{\text{MGD} \times 8.34 \text{ lbs/gal}}$$



Questions?



**Text your questions and comments
anytime during the session**



Detention Time – box 11

- ◆ Detention time refers to the time that it takes a volume of water to move through a process or vessel
- ◆ This time can be determined by dividing the vessel volume (in gallons) and time per day by the flow

Rectangular Sed Basin Example

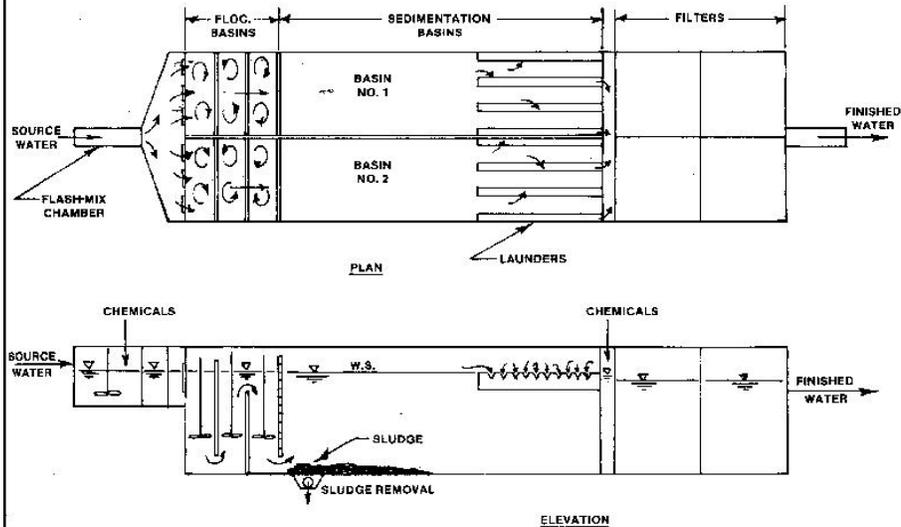


Fig. 5.21 Rectangular sedimentation basin

Factors Affecting Sedimentation

- ◆ Dissolved substances
- ◆ Flocculation characteristics
- ◆ Environmental (wind etc)
- ◆ Basin hydraulics



SEDIMENTATION

$$\text{Surface Loading Rate, (GPD/ sq. ft.)} = \frac{(\text{Total Flow, GPD})}{(\text{Surface Area, sq.ft.})}$$

$$\text{Detention Time} = \frac{\text{Volume}}{\text{flow}}$$

$$\text{Detention Time hours} = \frac{\text{volume (cu ft)} \times 7.48 \text{ gal/cu ft} \times 24 \text{ hr/day}}{\text{Gal/day}}$$

$$\text{Flow Rate} = \frac{\text{Volume}}{\text{Time}}$$

$$\text{Weir Overflow Rate, GPD/L.F.} = \frac{(\text{Flow, GPD})}{(\text{Weir length, ft.})}$$

Detention Time – box 11

- ◆ Example: What is the detention time in **hours** for a flow of 2,200,000 gal/day through a tank that measures 50 ft long, 40 ft wide and 30 ft tall?

$$\text{DT hours} = \frac{\text{volume (cu ft)} \times 7.48 \text{ gal/cu ft} \times 24 \text{ hr/day}}{\text{Gal/day}}$$



Detention Time – box 11

- ◆ Example: What is the detention time in **hours** for a flow of 2,900,000 gal/day through a tank that measures 50 ft in diameter by 60 feet tall?

$$\text{DT hours} = \frac{\text{volume (cu ft)} \times 7.48 \text{ gal/cu ft} \times 24 \text{ hr/day}}{\text{Gal/day}}$$



Detention Time – box 11

- ◆ Example: If 300,000 gal/day flows through a sedimentation basin that measures 60 ft in diameter and 20 ft tall, what is the detention time in days?

$$\frac{\text{ft} \times \text{ft} \times \text{ft} \times 20 \times 7.48 \text{ gal/ft}^3 \times 1 \text{ day}}{\text{gal/day}}$$



Detention Time – box 11

- ◆ Example: How many **minutes** would it take a drop of water to pass through a contact basin 20 ft in diameter, 10 ft tall if the flow were 800,000 gal/day?

$$\frac{\text{ft} \times \text{ft} \times \text{ft} \times 7.48 \text{ gal/ft}^3 \times 1440 \text{ min/day}}{800,000 \text{ gal/day}}$$



Questions?



**Text your questions and comments
anytime during the session**



Velocity

Water traveling through a pipe will need to be converted into cu ft/sec *and* divided by the square footage (area) of the pipe

$$Q \div A = V$$

OR



Flow, velocity, area

$$Q = A \times V \quad \text{Quantity} = \text{Area} \times \text{Velocity}$$

$$\text{Flow (ft}^3\text{/sec)} = \text{Area(ft}^2\text{)} \times \text{Velocity (ft/sec)}$$

$$\frac{\text{MGD} \times 1.55 \text{ cu ft/sec/MGD}}{.785 \times \text{pipe diameter ft} \times \text{pipe diameter ft}} = \frac{\text{cu ft/sec}}{\text{sq ft}} = \text{ft/sec}$$

Velocity – box 7

- ◆ Example: If a flow of 1,200,000 gpd were flowing through a 18 inch pipe, what is the velocity in ft/sec?

$$\frac{\text{MGD} \times 1.55 \text{ cu ft/sec/MGD}}{.785 \times \text{pipe diam ft} \times \text{pipe diam ft}} = \frac{\text{cu ft/sec}}{\text{sq ft}} = \text{ft/sec}$$

Velocity – box 7

- ◆ Example: If a flow of 1,200,000 gpd were flowing through a 18 inch pipe, what is the velocity in ft/sec?

$$\frac{1.2 \times 1.55 \text{ cu ft/sec/MGD}}{.785 \times 1.5 \text{ ft} \times 1.5 \text{ ft}} = \frac{\text{cu ft/sec}}{\text{sq ft}} = \text{ft/sec}$$

Velocity – box 7

- Example: If 240,000 gpd were flowing through an 8 inch pipe, what is the velocity through the pipe in ft/sec?

$$8 \text{ inches} \div 12 \text{ in/ft} = .666 \text{ ft}$$

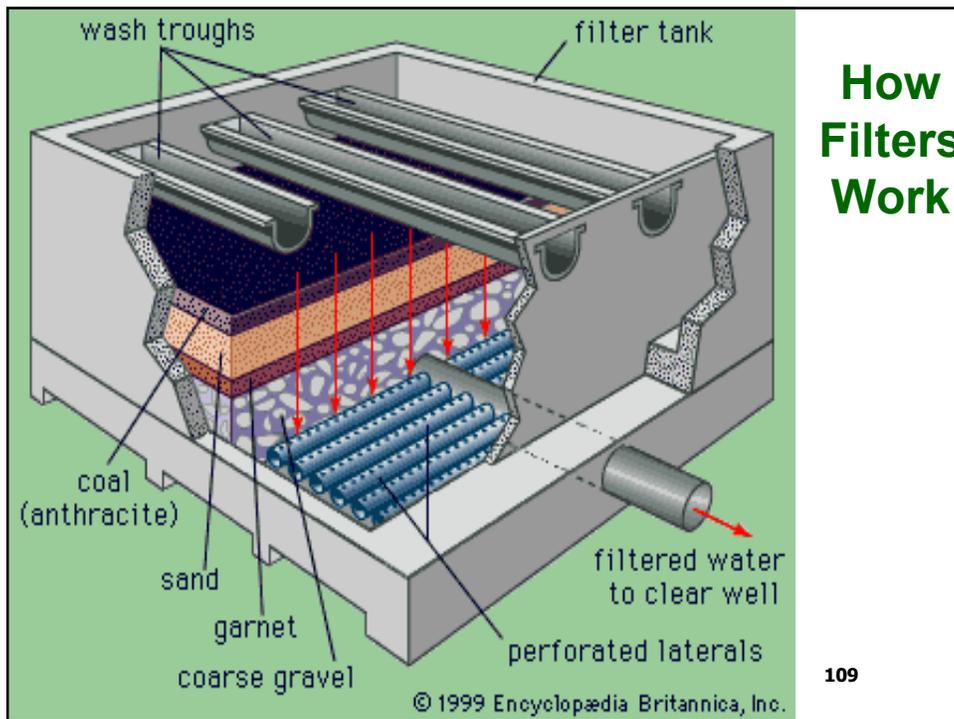
$$\frac{.24 \text{ MGD} \times 1.55 \text{ cu ft/sec/MGD}}{.785 \times .666 \text{ ft} \times .666 \text{ ft}} = \frac{\text{cu ft/sec}}{\text{sq ft}} = \text{ft/sec}$$



Filtration Rates

- ◆ The surface area of filtration media is where most material is removed





How Filters Work

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Filtration Rates

- ◆ Filtration rates are determined by dividing the flow (usually in gpm) by the square footage of the filter media material
- ◆ Gpm/sq ft



FILTRATION (number 1)

$$\text{Filtration Rate (GPM/sq.ft)} = \frac{\text{Filter Production (gallons per day)}}{(\text{Filter area sq. ft.}) \times (1,440 \text{ min/day})}$$

$$\text{Loading Rate (GPM/ sq. ft.)} = \frac{(\text{Flow Rate, GPM})}{(\text{Filter Area, sq. ft.})}$$

$$\text{Daily Filter Production (GPD)} = (\text{Filter Area, sq. ft.}) \times (\text{GPM/ sq. ft.} \times 1,440 \text{ min/day})$$

$$\text{Backwash Pumping Rate (GPM)} = (\text{Filter Area, sq. ft.}) \times (\text{Backwash Rate, GPM/ sq. ft.})$$

FILTRATION (number two)

$$\text{Backwash Volume (Gallons)} = (\text{Filter Area, sq. ft.}) \times (\text{Backwash Rate, gpm/ sq. ft.}) \times (\text{Time, min}).$$

$$\text{Backwash Rate, GPM/ sq. ft.} = \frac{(\text{Backwash Volume, gallons})}{(\text{Filter Area, sq. ft.}) \times (\text{Time, min})}$$

$$\text{Rate of Rise (inches per min.)} = \frac{(\text{backwash rate gpm/sq.ft.}) \times 12 \text{ inches/ft}}{7.48 \text{ gal/cu.ft.}}$$

$$\text{Unit Filter Run Volume, (UFRV)} = \frac{(\text{gallons produced in a filter run})}{(\text{filter area sq. ft.})}$$

Area in Filtration Units – Problem and Set Up

- ◆ Example: How many square feet of surface area are there in two filter units that measure 20 feet wide and 40 feet long ?

- ◆ Set up:

$$\underline{\quad} \text{ ft x } \underline{\quad} \text{ ft x } \underline{\quad} = \quad \text{ sq ft}$$

Filtration Rates

- ◆ Example: What is the filtration rate in gpm/sq ft if a flow of 1,000,000 gal/day flows through a filter measuring 20 ft by 25 ft?

- ◆ Set up:

$$\frac{\underline{\hspace{2cm}} \text{ gal/day} \div 1440 \text{ min/day}}{\underline{\quad} \text{ ft x } \underline{\quad} \text{ ft}} = \frac{\text{gpm}}{\text{sq ft}}$$

$$\text{Gpm} \div \text{sq ft} = \text{gpm/sq ft}$$

Filtration Rate Flow

- ◆ Example: When the flow to a filter is shut off and the water drops 20 inches in 9 minutes, how fast is the water dropping in feet per minute?

- ◆ Set up:

$$\underline{\quad} \text{ in} \div 12 \text{ in/ft} = \quad \text{ ft}$$

$$\underline{\quad} \text{ ft} \div 9 \text{ min} = \quad \text{ ft/min}$$

Filtration Rate Flow

- ◆ Example: What is the flow through a filter in cu ft/min if the water drops .18 ft per minute and the filter is 25 ft wide and 30 ft long?

- ◆ Set up:

$$\underline{\quad} \text{ ft} \times \underline{\quad} \text{ ft} \times \underline{\quad} \text{ ft/min} = \quad \text{ cu ft/min}$$

Filtration Rate Flow

◆ Example: What is the flow through a rapid sand filter in gpm if flow = 135 cu ft/min?

◆ Set up:

$$\underline{\quad} \text{ cu ft/min} \times 7.48 \text{ gal/cu ft} = \quad \text{ gpm}$$

Backwash rates

◆ Example: What is the backwash flow required in gpm to backwash a 25 ft wide by 30 ft long filter if a backwash flow of 20 gpm/sq ft is required?

◆ Set up:

$$\underline{\quad} \text{ ft} \times \underline{\quad} \text{ ft} = \quad \text{ sq ft}$$

$$\underline{\quad} \text{ sq ft} \times \underline{\quad} \text{ gpm/sq ft} = \quad \text{ gpm}$$

Questions?



**Text your questions and comments
anytime during the session**



Thank You For Attending!

We look forward to seeing you
in future online classes!

ahengel@rcac.org

jhamner@rcac.org



Thank You For Attending!

J

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(575) 527-5372