Water and Wastewater Chemical Feed Applications and Process Control

SDS

AWT

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Specific Gravity

FeCl3

Mg/L

VICl

Certificate of Analysis

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Part 1 Chemical Feed Applications

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Class Format and Participation

Course was designed to challenge operators of all levels of skill and years of experience.

An understanding of Chemical Feed Applications does not require a vast amount of memorization of facts and figures.

Rather it requires maintaining a library of information and the skills associated with using that information.

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Class Format and Participation

Class Handouts should serve as your starting library for that purpose.

The class will cover some moderately difficult subjects.

Don’t feel like you have to memorize a lot of facts and figures to pass the Post Test and receive full credit for the class.

Post Test is *(timed)* open book and notes the Math Workshop will prepare you for the math portion of the Post Test.

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Class Format and Participation

We will take 2 short 5 min breaks in the AM and 2 in the PM Session. Lunch will be an hour.

Attendance will be taken following breaks and throughout the class. Keep your Chat Active.

You must take the Post Test and Evaluation or be counted absent from the class.

Post Test is 20 question with 70% (14) correct to pass and receive 1.5 x TRE credits. You will automatically receive your score by email.

There are 9 math problems in the Post Test.

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Required Class Handouts

Class Handouts (*revised 12/2021*)

- HO1 Periodic Table.pdf — **1 page**
- HO2 Part 1.pdf — **21 pages**
- HO3 Part 2 Math Review.pdf — **9 pages**
- HO4 FeCl3 SDS.pdf — **8 pages**
- HO5 Math Levels 1 thru 4 w answers.pdf — **18 pages**

57 pages total

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Outline

- Introductions
- Units, Constants, and using the Periodic Table
- Some Common Conversion Factors
- A little metric
- Less commonly used flow rates

Outline Part 1

- Common Chemical Products
  - Oxidizers
  - Sulfur Compounds
  - Alkalinity/pH addition
  - Metal Salts (Al and Fe)
  - Polymers
  - Phosphates
  - Fluoride compounds

Outline Part 1

- Common Treatment Goals
  - Wastewater Treatment Goals
  - Water Treatment Goals
  - Hardness and Softening
  - Corrosion Control

Outline Part 1

- "Need to Know" for Chemical Feed Applications
  - What are you trying to remove, add, or treat?
  - Mistakes are easy to make and often dangerous.
  - -- Safety Data Sheets
    - Specific Gravity
    - Safety, Fire, and Regulations

Outline Part 1

- "Need to Know" for Chemical Feed Applications **(continued)**
  - Pounds available for Dry Products
  - Pounds per Gallon for Liquid Products
  - Chemical Solutions
    - VIC1 = V2C2 formula

Not on Post test

Outline Part 2

- Math Review
  - Tank Capacity
  - Flow conversion
  - Pounds Formula
  - Chlorine Dosage, Demand and Residual

Outline Part 2

- Calculate Chemical Dosages
  - Products that are 100% by Weight
  - Products that are less than 100% by Weight
    - Dry
    - Liquid

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Outline Part 2

- Math Workshop
  - Levels 1 to 4
  - If easy for you skip lower levels
- Evaluations
- Final Assessment
  - 20 question Posttest
    - 9 math problems

**Have Part 2 handy when taking the Post Test.
For Formulas used.**

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Introductions

**Helpful Hint:
Many key points will be stressed throughout the class lecture.
Follow along slide by slide and mark the slides containing key points.
Remember the Post Test
is Open Book but is also <u>Timed</u>.**

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Units, Constants, and using Periodic Table

Units Commonly Used

- gpd gallons/day
- MGD million gallons/day
- gpm gallons/minute
- gph gallons/hour
- mg/L milligrams / Liter
- ppm parts per million
- ppd pounds per day
- ppg pounds per gallon

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Units, Constants, and using Periodic Table

Constants Commonly Used

- 8.34 lbs per gallon (weight of water)
- 7.48 gallons in a cubic foot
- 1440 minutes in a day
- 694 gallons per minute = 1 MGD
- 3.14 π (pie) (use w/ radius)
- 0.785 ¼ π (pie) (use w/ diameter)

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Units, Constants, and using Periodic Table

Metric weights and volumes

- 1 liter of water weighs 1,000 grams
- 1 milliliter of water weighs 1 gram
- 3.785 liters of water = 1 US Gallon
- 0.946 liters of water = 1 Quart
- 1 cubic meter = 35.315 cubic feet
- 1 cubic meter = 264.172 US gallons

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Units, Constants, and using Periodic Table

Less commonly used flow rates

- 1.55 ft^3/sec = 1 MGD
- 1 cubic meter/sec = 264 gals/sec
- 1 cubic meter/sec = 15,850 gals/min
- 1 MGD (us gallons) = 3,785.4 cubic meter/day
- 1 gph = 63.09 ml/min
- 1 gph = 3.7854 L/hr

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Units, Constants, and using Periodic Table

Element Block

Refer to: HO1 Periodic Table

26
Fe
Iron
55.845

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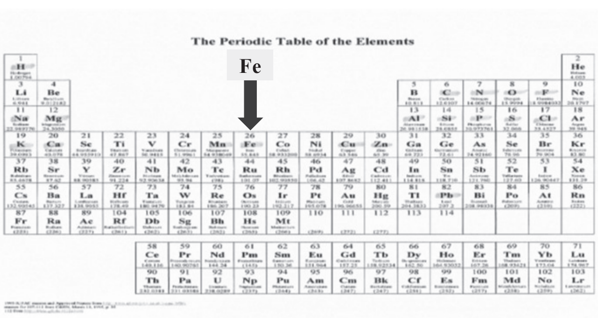
Periodic Table



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Units, Constants, and using Periodic Table

Element Block

Atomic Number →

26
Fe
Iron
55.845

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Units, Constants, and using Periodic Table

Element Block

Chemical Symbol →

26
Fe
Iron
55.845

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Units, Constants, and using Periodic Table

Element Block

Common Name →

26
Fe
Iron
55.845

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Units, Constants, and using Periodic Table

Element Block

26
Fe
Iron

Atomic Weight → 55.845

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Units, Constants, and using Periodic Table

- Using the periodic table find the Atomic Weight of the following:
  - Aluminum (Al) **27**
  - Iron (Fe) **56**
  - Chlorine (Cl)
  - Sulfur (S)
  - Oxygen (O)
  - Hydrogen (H)

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Units, Constants, and using Periodic Table

What is the total <u>Atomic Weight</u> of the following:

$FeSO_4$

Fe		S		O_4		
56	+	**32**	+	**(16 x 4)**	=	

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Units, Constants, and using Periodic Table

What is the **percentage** of Iron (Fe) in the following:

$FeSO_4$

<u>56 (atomic weight of Fe)</u>
152 (total atomic weight)

= % Fe)

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COMMON CHEMICAL PRODUCTS

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COMMON CHEMICAL PRODUCTS

- <u>Oxidizers **(OX)**</u>
  - Potassium Permanganate
  - Hydrogen Peroxide
  - Chlorine **(Cl2)**

    Chlorine Gas **Liquid Chlorine or Chlorine Gas**

    Calcium <u>Hypo</u>chlorite **HTH**

    Sodium <u>Hypo</u>chlorite **Bleach**

Hypochlorite – $(ClO)^2$

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COMMON CHEMICAL PRODUCTS

- Sulfur Compounds **(S)**
  - Reducing agents
    - Sulfur Dioxide (gas)
    - Sodium Bisulfite
    - Sodium Metabisulfite

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Common Metals

Approximately ¾ of all know elements are metals.

Most common metals:

Aluminum (Al)	Iron (Fe)
Calcium (Ca)	Sodium (Na)
Potassium (K)	Magnesium (Mg)

Most metals will react and combine with other elements to form compounds. Most metals are found in Ore form because of this.

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Metal Salts

- A Metal Salt is a compound containing metal and non-metal components.
- Keep in mind the following are considered metals:
  - Calcium (Ca)
  - Sodium (Na)
  - Magnesium (Mg)
  - Manganese (Mn)

Did you know that most of the elements on the periodic table are Metals?
Linked Files\Periodic-Table-Metals.png

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Non-Metals

Common Non-Metals we see in water and wastewater chemistry are:

Hydrogen (H)	Carbon (C)
Oxygen (O)	Fluorine (F)
Phosphorus (P)	Nitrogen (N)
Chlorine (Cl)	Bromine (Br)
Iodine (I)	

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COMMON CHEMICAL PRODUCTS

- Alkalinity/pH addition **(ALK)**
  - Lime (Calcium Carbonate or Calcium Hydroxide)
  - Caustic Soda (Sodium Hydroxide)
  - Soda Ash (Sodium Carbonate)
  - Baking Soda (Sodium Bicarbonate)
  - Magnesium Hydroxide (milk of magnesia)

These are all Metal Salts

Let's find The metals

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COMMON CHEMICAL PRODUCTS

- Alkalinity/pH addition **(ALK)**
  - Lime (Calcium Carbonate or Calcium Hydroxide)
  - Caustic Soda (Sodium Hydroxide)
  - Soda Ash (Sodium Carbonate)
  - Baking Soda (Sodium Bicarbonate)
  - Magnesium Hydroxide (milk of magnesia)

OK now let's Find the Non-Metals In these Metal Salts

Hydroxide -- O and H

Carbonate -- O and C

Bicarbonate – H, O, + C

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COMMON CHEMICAL PRODUCTS

- Aluminum (Al) Iron (Fe) Salts
  - Aluminum compounds
    - Poly-Aluminum Chlorides **(PAC)**
    - Alum (Aluminum Sulfate) $Al_2(SO_4)_3$
    - Sodium Aluminate ($NaAlO_2$)
  - Iron compounds
    - Ferrous Sulfate ($FeSO_4$)
    - Ferric Chloride ($FeCl_3$)
    - Others?

Name some uses for these Metal Salts

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COMMON CHEMICAL PRODUCTS

- Polymers **(Poly)**
  - **Positive charge (cationic)**
    - **Removes negatively charged particles**
    - **Primary flocculent or coagulant**
  - Negative charge (anionic)
    - Used as a flocculent or coagulant aid
  - Neutral charge (nonionic)
    - Used as a flocculent or coagulant aid

Polymers are Mainly made up of C H O N Non-Metals

Most of the particles and contaminants that we remove In water and wastewater treatment are negatively charged.

Also rated by molecular weight (density)

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COMMON CHEMICAL PRODUCTS

Phosphates **(Phos)**

- **Ortho**phosphates
  - With or without Zinc
    - **Zinc Orthophosphates are normally used in low hardness waters**
    - Zinc can be used as a "tracer"
    - Excessive amount of zinc in the Water System may affect the WWTP

Ortho Means Straight or Correct

Remember

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COMMON CHEMICAL PRODUCTS

Phosphates **(Phos)**

- Orthophosphates
  - **Used to form insoluble metal compounds to coat pipe walls blocking corrosive activity**
  - Commonly referred to as a Corrosion Inhibitor

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COMMON CHEMICAL PRODUCTS

Phosphates **(Phos)**

- Polyphosphates
  - Are polymers containing linked orthophosphate ions in various structures and are used mainly for sequestering Fe and Mn
  - Which also helps with corrosion control. While addressing dirty water complaints

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COMMON CHEMICAL PRODUCTS

Phosphates **(Phos)**

- **Polyphosphates**
  - **Sequestrating Fe and Mn**
    - **Does not remove Fe and Mn**
    - **Instead binds them in soluble form**
    - **To prevent oxidation with air or chlorine. The cause of dirty water complaints.**

Fe = Iron
Mn = Manganese

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COMMON CHEMICAL PRODUCTS

Phosphates **(Phos)**

- Polyphosphates
  - Prevent and reduce crystalized Ca and Mg
  - Which improves Orthophosphates' ability to form an inhibiting coating

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COMMON CHEMICAL PRODUCTS

Phosphates **(Phos)**

- Blended Phosphates
  - **Typically a proprietary blend of Orthophosphates and Polyphosphates**
  - Used to address more than one treatment goal

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COMMON CHEMICAL PRODUCTS

- Fluoride compounds **(F)**
  - Hydrofluosilicic Acid (liquid)
  - Sodium Fluoride (dry)
  - Sodium Silicofluoride (dry)

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COMMON TREATMENT GOALS

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Common Treatment Goals

- Wastewater Treatment
  - Odor and Corrosion Control
    - **OX and Cl2**
      - **Oxidizers will increase ORP**
    - **Fe**
    - **Nitrates (NO3-N)**

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Common Treatment Goals

- Wastewater Treatment
  - Phosphorous Removal
    - **Al**
    - **Fe**
    - **Poly**

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Let's Talk a Little Process Control

Phosphorus Removal Using Al and Fe compounds (in WWTPs)

- TP in domestic WW influent
  - 6 to 10 mg/L
- Startup Dosages **(no Bio-P removal)**
  - 0.87 #Al to #P to remove
  - 1.8 #Fe to #P to remove

EPA manuals late 1970's

Today most domestic WWTPs have some Bio-P removal and achieve additional P removal by adding product at aeration or just ahead of final clarifiers. Today expect Al and Fe starting dosages to be 2 to 4 times the ones above.

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Let's Talk a Little Process Control

Phosphorus Removal Using Al and Fe compounds (in WWTPs)

- Plants without **Bio-P removal**
  - May utilize Two Point Chemical Addition
  - Head of Primary Clarifiers
  - Head of Final Clarifiers

Older WWTPs Used 2 feed locations

Many of the WWTPs today have some Bio-P removal and achieve additional P removal by adding product at aeration or just ahead of final clarifiers.
Most WWTPs are now optimized for BNR over Bio-P Removal.

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Let's Talk a Little Process Control

Iron (Fe) compounds fed in the collection system or Headworks of WWTPs for Odor Control.

May also remove some Phosphorous.
Use caution with higher dosages of Iron products at these locations to avoid Phosphorous deficiency.

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Let's Talk a Little Process Control

- Conventional Biological Uptake of P
  - 1 part of P for every 100 parts of CBOD
  - Any more than this is consider Bio-P removal (Biological Nutrient Removal)

Conventional Nutrient Uptake Ratio
100 CBOD: 5 N: 1 P
Any removal greater than this is BNR
Biological Nutrient Removal

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Let's Talk a Little Process Control

- Most operators will favor setting up operations to maximize Nitrification/Denitrification over Bio-P Removal

BNR WWTPs

Why?

Nitrification / Denitrification favors
- Higher MLSS Solids and longer DT
- Chemical addition is available for P removal (chemical trimming)

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Let's Talk a Little Process Control

- Chemical Trimming following Bio-P removal
  - TP typically < 2 mg/L
  - Head of final clarifiers (common)
  - Ferrous compounds at aeration (best)
  - Ferric compounds ahead of clarifiers (best)

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Common Treatment Goals

- Wastewater Treatment
  - pH and Alkalinity Control (Alk)
    - Lime (Calcium Carbonate or Calcium Hydroxide)
    - Caustic Soda (Sodium Hydroxide)
    - Soda Ash (Sodium Carbonate)
    - Baking Soda (Sodium Bicarbonate)
    - Magnesium Hydroxide (milk of magnesia)

Remember these are ? **Metals Salts**

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Common Treatment Goals

- Wastewater Treatment
  - Disinfection
    - **Cl2**
    - **ALK** products can be used for Sterilization

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Common Treatment Goals

- Wastewater Treatment
  - De-chlorination
    - **S**
    - **Reducing Agents**
      - **Lowers ORP to negative mV values**
      - **Industrial WW Applications**

S stands for sulfur products

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Common Treatment Goals

- Water Treatment
  - Coagulation
    - **Al (PAC)**
    - **Fe**
    - **Poly**

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Common Treatment Goals

- Water Treatment
  - Taste and Odors
    - **Ox**
    - **Cl2**
      - **Chlorine Gas**
      - **Sodium Hypochlorite**
      - **Calcium Hypochlorite**

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Common Treatment Goals

- Water Treatment
  - pH and Alkalinity **(Alk)**
  - Lime (Calcium Carbonate or Calcium Hydroxide)
  - Caustic Soda (Sodium Hydroxide)
  - Soda Ash (Sodium Carbonate)

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Common Treatment Goals

- Water Treatment
  - –Disinfection
    - **Cl2**
    - **Iodine**
    - **Bromine (pools/industrial)**
    - **Chloramines**

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Common Treatment Goals

- Water Treatment
  - –Fluoridation
    - **F**
    - **Determine % F Ion (by weight)**

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Common Treatment Goals

- Water Treatment
  - –Corrosion Control
    - **Alk**
    - **Phos**

<u>Remember</u>
Orthophosphates and Polyphosphates

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Common Treatment Goals

- Water Treatment
  - –**<u>Iron and Manganese Control</u>**
    - **Ox (with filtration)**
    - **Cl2 (with filtration)**
    - **Potassium Permanganate (with filtration)**
    - **Polyphosphates by sequestering Fe and Mn**

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Let's Talk a Little Process Control

<u>Corrosion Control (water distribution)</u>

- Extremely Complex Issue
- Multiple Factors Involved
- Treatment and operational practices that work in one system may increase corrosion in another system

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Let's Talk a Little Process Control

<u>A few of the factors that affect corrosion - Good or Bad</u>

- Temperature
- pH and stability or buffering
- Type of disinfectant
- Dissolved Oxygen
- Amount, type, and dosage of Orthophosphates and Polyphosphates

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Let's Talk a Little Process Control

A few more factors

- Chloride and Sulfate
- Calcium
- Iron and Manganese
- Ammonia
- Hydrogen Sulfide
- Silica
- Microbial activity
- Natural Organic Matter (NOM)

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Let's Talk a Little Process Control

A few lessons from Flint MI

- Think of the Distribution System as a huge reactor with chemical, physical, and biological reactions going on.
- An engineering "Corrosion Control and Treatment Feasibility Study" should be completed whenever treatment or source waters change. Best to assume nothing.

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Let's Talk a Little Process Control

- Suggested 3 tier approach to corrosion control
  - Continue Lead pipe/connect replacements (decades to replace)
  - High Velocity Flushing
  - **Blended Phosphates (Aqua Mag)**
    - **Orthophosphates to form insoluble metal compounds to thinly coat pipe walls**
    - **Polyphosphates to sequester Fe & Mn**
      - **Keeping particles soluble**

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Question

- What 2 metal salts are the main source of hardness in water sources and supplies?

Calcium (Ca) and Magnesium (Mg)

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Hardness and Softening

- **Hardness is mainly caused by Calcium (Ca) and Magnesium (Mg) - metal salts**
- Iron (Fe), Manganese (Mn), Zinc (Zn) and a few other metals also contribute to hardness but usually not in significant quantities

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Hardness and Softening

- In public water systems Chemical Precipitation and Ion Exchange are the most common treatments used to remove hardness.
- Lime and Soda Ash are commonly used for Chemical Precipitation to remove or reduce hardness

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Lime and Soda Ash Softening

- Lime is used to remove Carbonate Hardness
- Soda Ash is used to remove hardness caused by Non-Carbonate compounds.
- Hardness causing minerals are precipitated out.

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Hardness and Softening

- Soft: 0 to 75 mg/L as $CaCO_3$
- Moderate: 75 to 150 mg/L as $CaCO_3$
- Hard: 150 to 300 mg/L as $CaCO_3$
- Very Hard: above 300 mg/L as $CaCO_3$

Hardness in the upper Moderate, Hard, and Very Hard ranges can reduce pipe capacity and result in consumer complaints.

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Hardness and Softening

- Total Hardness, mg/L =
- 2.50 x Calcium conc. (mg/L) +
- 4.12 x Magnesium conc. (mg/L)

- The above factors 2.50 and 4.12 are used to convert Calcium and Magnesium concentrations to Calcium Carbonate $CaCO_3$ Equivalent (*Total Hardness value*)

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"Need To Know" for Chemical Feed Applications

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"Need to Know"

- Understand there are always compatibility and safety concerns
- Calculating storage and treatment tank capacities
- Converting flow
- Pounds formula
  - Calculate Loadings
  - Calculate Dosages
- Chlorine Dosage, Demand, and Residual

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"Need to Know"

- What are you trying to remove, add, or treat?
  - Turbidity, Color, TSS
  - Phosphorous
  - Odors
  - pH/ Alkalinity adjustment
  - Fluoride
  - Corrosive Water

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"Need to Know"

- Mistakes are easy to make
  - A chemical feed application mistake can be costly and someone may get MAIMED or KILLED.
  - Assume nothing with regards to compatibility and safety
  - Get proper advice
    - Chemical Suppliers
    - Engineers
    - Experienced Operators
  - Over-sizing/Under-sizing equipment

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"Need to Know"

Mistakes are easy to make

What might happen if you use an aluminum fitting on the truck unloading hose while off-loading (aluminum sulfate) alum?

Most likely nothing unusual

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"Need to Know"

Mistakes are easy to make

OK, what might happen if you use the same aluminum fitting on the truck unloading hose while off-loading Ferric Chloride?

Someone might be blinded for life or worse

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"Need to Know"

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"Need to Know"

- Safety Data Sheets (SDS)
  - Within the last 12 or so years (SDS) have replaced the older Material Safety Data Sheets (MSDS)
  - The new SDS format is compliance with international standards and has a few more sections than the older MSDS format.

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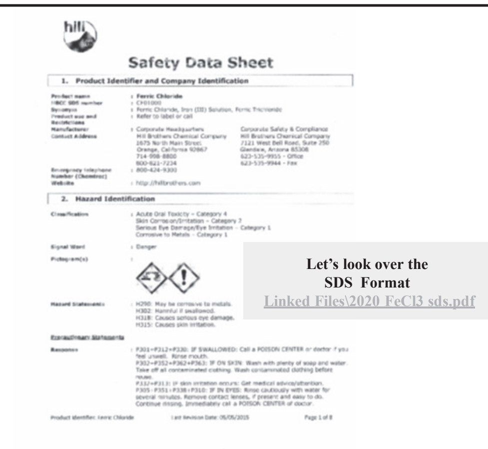

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"Need to Know"

- Let's walk through the Safety Data Sheet for Ferric Chloride (see handout)
  - Section 1 Product Identifier and Contact Information
  - Section 2 Hazard Identification
    - Hazard Statement / Response
  - Section 3 Composition/ Information on Ingredients
    - 39 – 44% Ferric Chloride
    - < 5% Hydrochloric Acid

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"Need to Know"

- Let's walk through the Safety Data Sheet for Ferric Chloride (see handout)
  - Section 4 First Aid Measures
  - Section 5 Fire Fighting Measures
    - During fire toxic gases are generated
  - Section 6 Accident Release Measures
    - Containment / neutralization / prevent runoffs
    - NPDES permits requirements

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"Need to Know"

- Let's walk through the Safety Data Sheet for Ferric Chloride (see handout)
  - Section 7 Handling and Storage
    - Vapors
    - Store away from heat and alkaline products
    - Pump and hoses material compatibility
    - Proper ventilation
  - Section 8 Exposure Controls/ Personal Protection

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"Need to Know"

- Let's walk through the Safety Data Sheet for Ferric Chloride (see handout)
  - Section 9 Physical and Chemical Properties
    - Specific Gravity (SG) 1.26 to 1.48 (39-44%)
    - pH < 2 **39% 1.26 SG 44% 1.48 SG**
    - Melting point / Freezing point 30.2° F
      - A little miss leading - crystalizing of acid
      - Not freezing to the point of being solid
      - -58° F Freezing point for 40% ferric chloride

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"Need to Know"

- Let's walk through the Safety Data Sheet for Ferric Chloride (see handout)
  - Section 10 Stability and Reactivity
    - Incompatible Materials / Decomposition when heated
  - Section 11 Toxicological Information
  - Section 12 Ecological Information
  - Section 13 Disposal Consideration
  - Section 14 Transportation

Additional Safety Data Sheet (SDS) Sections

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"Need to Know"

- Let's walk through the Safety Data Sheet for Ferric Chloride (see handout)
  - Section 15 Regulatory Information
    - Not an Extremely Hazardous Substance (EHS) under SARA 302
      - Example EHS are Chlorine Gas and Ammonia Gas
    - Hazard Label Warning
      - Corrosive, Class 8
  - Section 16 Other Information

Last 2 Safety Data Sheet (SDS) Sections

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Now let's take a closer look at Specific Gravity

Specific Gravity

- Specific Gravity (sg) is the measurement or comparison of the density of a liquid or a gas
  - Water has a sg of 1.0
  - More dense liquids will have a sg > 1.0
  - Less dense liquids will have a sg < 1.0
  - Air has a sg of 1.0
  - Gases denser than air will have a sg > 1.0
  - Gases less dense than air will have a sg < 1.0

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Specific Gravity

- **Specific Gravity (sg) of liquids:**
  - **Sodium Hypochlorite 12.5% has a sg of 1.2**

Common Name - Bleach

8.34 ppg (water) x 1.2 sg = ppg

So Sodium Hypochlorite 12.5% weighs 10.008 ppg

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Specific Gravity

- Specific Gravity (sg) of Gases:
  - Chlorine Gas has sg of 2.5

If there is a Chlorine gas leak Where will it Accumulate?

Air has a sg of 1.0
Chlorine Gas has a sg of 2.5

So, Chlorine Gas is
2.5 time heavier than Air.

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"Need to Know"

- You must understand what part of the chemical or product you are using?
  - Liquid – Sodium Hypochlorite ← 12.5% available Cl2 by weight
  - Dry – Calcium Hypochlorite ← 65% available Cl2 by weight
  - Iron Salts — Fe
  - Alum or Aluminum Salts? — Alum WTPs, Al WWTPs
  - Fluoride Compounds — F
  - Alkalinity Products — # of available alkalinity

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"Need to Know"

- Sodium Hypochlorite
  - Most Common Concentrations
    - 15% Trade or 12 to 13% by weight
    - Trade is % by volume
- Specific Gravity
  - 6% by weight 1.09 (say 1.1)
  - 12.5% by weight 1.196 (say 1.2)

% of Available Chlorine

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"Need to Know"

- Sodium Hypochlorite
  - How many pounds of available Cl2 in 12.5% conc.?

8.34 weight of water
x 1.2 Specific Gravity
x (12.5% by weight)
Let's do the math pounds of available Cl2/gallon

This applies to fresh 12.5% Sodium Hypochlorite

  - Set up dosage as if each gallon = 1.25 # of Cl2

Remember this stuff

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"Need to Know"

- Calcium Hypochlorite
  - Sometimes referred to as HTH
  - 60 to 70% available Cl2 (generally)

1 # of 65% HTH = **0.65** # of available Cl2

So if you need 1# of Cl2
1# / 0.65 (% by weight) = **Let's do the math**

Remember this stuff

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"Need to Know"

- Iron Salts
  - Ferrous Sulfate (FeSO4)
  - Ferric Chloride (FeCl3)
- 39% Ferric Chloride
  - Specific Gravity 1.26
    - **Meaning 1.26 times more dense than water**
    - **8.34 x 1.26 = 10.5 ppg**

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"Need to Know"

- 39% Ferric Chloride (slide 1)
  - How many pounds of Ferric Chloride per gallon?

8.34	weight of water
x1.26	Specific Gravity
x 0.39	(39% by weight)
	pounds of Ferric Chloride / Gallon

Let's do the math

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"Need to Know"

- 39% Ferric Chloride (slide 2)
  - How many pounds of Iron per gallon? Find % of Fe in FeCl3

Fe		Cl3		
56	+	**(35 x 3)**	=	**161** **Total Atomic Weight**

56 Fe / 161 Total = 0.3478
or 34.8 % Fe

The Compound FeCl3 Contains 34.8% Fe

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"Need to Know"

- 39% Ferric Chloride (slide 3)
  - How many pounds of Iron per gallon?

4.10	pounds of Ferric Chloride / Gallon
x 0.348	(34.8% Fe in FeCl3)
Let's do the math	**pounds of Fe / Gallon**

pounds of Fe/Gallon of 39% FeCl3

117

"Need to Know"

- 39% Ferric Chloride (slide 4)
- Typical Dosage Data
  - **Phosphorous Removal**
    - 1.8:1 Fe:P (EPA starting dosage)
    - Start with higher dose if TP < 2 mg/L at treatment location
  - **Hydrogen Sulfides (H2S) Removal**
    - ½ gallon of FeCl3 (36 to 40%)
      - removes 1.0 # H2S
      - Typical manufacturer's recommendation

118

"Need to Know"

- Alum or Aluminum Sulfate
  - Alum is a little more difficult
  - 48.5% Alum
    - Refers to Filter or Hydrated Alum
  - $Al_2(SO_4)_3.14H_2O$ (crystallized water)
  - "Al" means Aluminum
  - "Alum" short for Aluminum Sulfate

119

"Need to Know"

- One Gallon of 48.5% Alum
  - Weighs approximately 11.10 pounds
  - Contains approximately 5.38 pounds of Filter Alum

Water Treatment Operators for Coagulation

  - Contains approximately 0.49 pounds of Al per gallon

WWTP Operators for P removal

120

"Need to Know"

- Fluoride Compounds
  - Hydrofluosilicic Acid (liquid)
    - 17 to 24% as F
  - Sodium Fluoride (dry)
    - 43 to 44% as F
  - Sodium Silicofluoride (dry)
    - 59% as F
  - Dose in mg/L of Fluoride Ion

121

"Need to Know"

- Alkalinity Products
  - Sodium Bicarbonate (Baking Soda) **#1**
    - 1 # equals about 0.65 pound of alkalinity
  - **Sodium Hydroxide (Caustic Soda)** **#2**
    - **1 # equals about 1.2 pounds of alkalinity**
  - Sodium Carbonate (Soda Ash) **#3**
    - 1 # equals about 0.9 pound of alkalinity

#1 and #3 provides safer forms of Alkalinity
#2 Transfers Alkalinity faster

Post Test

122

"Need to Know"

- Dosing to Increase Alkalinity

Example:

Due to biological activity your WWTP's effluent alkalinity drops to 60 mg/L or lower based on some grab samples.

Flow is 1 MGD and you want to increase Alkalinity by 90 mg/L (targeting 150 mg/L).

123

"Need to Know"

- Dosing to Increase Alkalinity

90 mg/L * 8.34 * 1 MGD = **751 ppd** of Alkalinity to be added:

Sodium Bicarbonate (Baking Soda)
Dry product:
1 # equals about 0.65 pound of alkalinity

751 ppd of Alk required / 0.65 =
of product required

124

"Need to Know"

- Dosing to Increase Alkalinity

751 ppd of Alkalinity to be added:

Sodium Hydroxide (Caustic Soda)
50% caustic soda weighs 12.7 ppg
6.35 ppg of caustic soda

1 # **Caustic Soda** equals about **1.2 # of alkalinity**
751 ppd / (**6.35 ppg x 1.2)** =
751 ppd / (**7.62 ppg as Alk)** = Now Calculate

125

"Need to Know"

- Find safe starting dosages
  - Chemical Suppliers
  - Engineer
  - Piloting or Jar Testing
  - EPA Manuals, WEF MOPs, AWWA Manuals

126

"Need to Know"

- A selected chemical treatment may interfere with other treatment goals
  - Over-charging water/wastewater
    Too much cationic polymer or metal salts.
    These are Positively (+) charged to remove (-) particles.
  - Drop in pH below acceptable range
    Not enough buffering capability in the water.
    Biological Activity. Use of an incompatible product.
  - Nutrient deficiency (wastewater)
    Using too much Fe or Al salts to remove Phosphorus
    on front end of plant (before biological process).
  - Other problems?

127

"Need to Know"

- What and how to monitor
  - pH/Alkalinity (W and WW)
    - Chemical and Biological Processes
    - Maintaining adequate buffering capacity
  - TSS/Turbidity
    - Jar Testing, Settleability Test (W + WW)
    - Changes in water sources (W)

128

"Need to Know"

- What and how to monitor
  - Chemical P Removal (WW)
    - Dosage, Alk., pH
    - Potential affects on biological processes
  - Corrosion Control (W)
    - Dosage, Alk., pH
    - Complaints, Lead and Copper, Zinc
    - Chlorine Residuals, water age
    - Changes in water sources or quality

2.0 mg/L Free Cl2 Residual can Increase copper levels

129

"Need to Know"

- What and how to monitor
  - Odor Control (WW)
    - Dosages, pH, Alk.
    - Hydrogen Sulfides
    - Nitrates (when adding them)
  - Fluoride addition (W)
    - Dosage, background F

Anoxic Bacteria Will break Down NO3 For O To keep from Going septic

130

Information on the following slides will not be on Post Test

- We will review as time permits.

131

Chemical Solutions

V1 x C1 = V2 x C2

Volume 1 x Concentration 1 =
Volume 2 x Concentration 2

132

Chemical Solutions

If you are currently using **<u>1.5 gallons</u>** of **<u>5%</u>** sodium hypochlorite solution, how many **<u>gallons</u>** of **<u>2%</u>** sodium hypochlorite will be necessary?

V1C1 = V2C2

V1 = 1.5 gals C1 = 5%

V2 = ?? gals C2 = 2%

Not on Post Test

133

Chemical Solutions

V1C1 = V2C2

Vol. 1 x Conc. 1 = Vol. 2 x Conc. 2

1.5 gals x 5 % = V2 x 2%

7.5 gals/%	=	**V2 x 2%**
7.5 gals/% / **2%**	=	**V2 x 2%** / **2%**
	=	**V2**

Let's finish the Math together

134

Chemical Solutions

Your 30-gallon day tank contains 12 gallons of 10% Sodium Hypochlorite Solution. You filled the tank up with water. What is the new concentration?

V1C1 = V2C2

V1 = 12 gals C1 = 10%

V2 = 30 gals C2 = ??%

Not on Post Test

136

Chemical Solutions

V1C1 = V2C2

Vol. 1 x Conc. 1 = Vol. 2 x Conc. 2

12-gals x 10 % = 30-gals x C2

120 gals/%	=	**30-gals x C2**
120 gals/% / **30-gals**	=	**30-gals x C2** / **30-gals**
	=	**C2**

Let's finish the Math together

137

Understanding Filter Alum Chemistry

- The chemistry of Filter Alum is a little complex
- The following slides show how to calculate the pounds per gallon of Aluminum (Al) in Aluminum Sulfate (Filter Alum).

138

$Al_2(SO_4)_3.14H_2O$

- Al_2 + $(SO_4)_3$
- 27 x 2 + (32 + (16 x4)) x 3
- 54 + (32 + 64) x 3
- 54 + (96 x 3)
- 54 + 288 = **342 the AWT of $Al_2(SO_4)_3$**

For information only and will NOT be on Post Test

139

$Al_2(SO_4)_3.14H_2O$

- $14H_20$
- 14 x (H_2O)
- 14 x (2 + 16)
- 14 x 18 = **252 the AWT of $14H_2O$**

For information only and will NOT be on Post Test

140

$Al_2(SO_4)_3.14H_2O$

- 342 the AWT of $Al_2(SO_4)_3$
- \+ <u>252</u> the AWT of $14H_2O$
- **594 total AWT**

- 54 Al AWT / 594 tot. AWT = 0.091 **or 9.1%**

For information only and will NOT be on Post Test

141

Al in Filter Alum

• Filter Alum weighs	11.10 ppg
• 48.5% Alum	x 0.485
• 9.1% Al	<u>x 0.091</u>
•	0.4898 ppg
• **0.49 ppg of Al**	

For information only and will NOT be on Post Test

142

- Typical Dosage Data for **<u>Alum</u>**
  - –Phosphorous Removal
    - When following Bio-P removal
    - **Al:P = <u>2# to 5# Al : 1 # P</u>** **Lower if no Bio-P**
  - –Coagulation Drinking Water
    - 1 to 30 mg/L **<u>as Alum</u>**
  - –Enhanced Settling Wastewater
    - 10 to 80 mg/L **<u>as Alum</u>**
      - –**Nutrient deficiency is a potential problem with the higher dosages?**

Not on Post Test

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