5 Common-Sense Practices of Well-Run Water & Wastewater Facilities

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7 Contact Hours
9 CC10 Hours

Facility operators must look both operational and measurement practices needed to achieve a well run operation. Participants will explore the two most important measurement parameters an operator can make, but which typically take a back-seat in importance. In addition, three key operational practices most often ignored in the chemical feed process will be discussed, such as the advantages of always using the weakest possible strength of a chemical that is practical. Just because one can buy 12% Hypochlorite, or 50% caustic, doesn't necessarily it should be dosed at full strength.

1. Discuss important measurement parameters;
2. Describe practices needed to achieve a well-run operation and
3. Examine the advantages of using the weakest possible strength of a chemical.

I. Temperature - Most measured parameter is also the least regarded (30 Minutes)
   A) Routine measurements
   B) Most reported
   C) Temperature’s importance sometimes isn’t clearly understood

II. **<u>ALL</u>** Water/wastewater tasks relate direct to temperature measurement (60 Minutes)
   A) Chlorination (chemicals, applications, residual measurements)
   B) Fluoridation (chemicals, & applications)
   C) Corrosion Management (Lead/Copper Rule)
   D) Chemical Feed, coagulants, defoamers, polymers, etc.
   E) Activated Sludge
   F) BNR
   G) Settle-ability
   H) Anaerobic processes (sludge digestion)
   I) Laboratory/field sampling and testing
   J) Pumps, motors, controls centers
   K) Others

III. Alkalinity Monitoring (60 Minutes)
   A) Definition
   B) Measurement demonstrations
   C) Reference
   D) Applications in water/wastewater process
   E) Verification
   F) Case Histories of users

III. Always verify every chemical delivery too the facility (90 Minutes)
   A) Confirming against purchase specs.

B) Verifying what comes into the plant
C) Tool to use to aid this process
    1. pH
    2. Specific Gravity, product density
    3. Direct chemical measurements
    4. weight
    5. viscosity
D) Preventing catastrophic events

IV. Always use the weakest possible chemical strength in your facility (90 Minutes)
A) Safety & handling issues
B) Limiting chemical deterioration
C) Maximizing pump selection
D) Getting the most out of the operation and maintenance budget

V. Always remember, every chemical dose potentially leave behind two things…….some may not be self-evident (60 Minutes)
A) Minimizing byproducts
B) Minimizing & maximizing residuals
C) Identifying little-recognized residual
D) Maximizing the measurement of these two components
    1) colorimetric- most common
    2) Titrametric methods
    3) Amperometric – most accurate
    4) Probe based

VI. Review, question and answers (30 Minutes)

5 Common-Sense Practices of Well-Run Water & Wastewater Facilities

Test Questions

- Our chemical supplier always delivers our chemicals as specified?   T or F
- We always <u>VERIFY</u> every chemical delivered on site?   T or F
- <u>VERIFY</u> means what to us?_____________
- Chemical dosing changes are only needed when flow or demand changes?   T or F

Test Questions

- What's the most common means used by operators to establish & set chem. feed?_______________
- We always use either chem. strength & math calculation or Jar Test to set our chem. feed dose

  True False
- We always use the weakest practical chemical strength when dosing? True or False
- All Chemicals have the potential to leave at least two things behind. A_____ & B______

Test Questions

- The best way to minimize chemical deterioration is what__________________?
- We always routinely calibrate our chemical pumps True or False
- What's the most important test parameter in running a water or wastewater system?
- What's the second most important?

Summary of Practices

1. The most important measurement taken at your facility by an operator is TEMPERATURE
2. The second most important measurement taken by an operator is ALKALINITY
3. When chemical dosing, always use the WEAKEST possible strength of that chemical that is practical
4. VERIFY DELIVERY & STRENGTH of all chemicals used in your facility
5. Operators must always remember that all chemicals dosed leave behind potentially two things: RESIDUALS AND BY-PRODUCTS………..sometimes those residuals are not always self-evident.

This Temperature Segment is Here To

- Remind operators that perhaps the most measured parameter is also the least regarded
- ALL Water/wastewater work tasks relate directly to temperature measurements

Common Water/Wastewater Tasks Versus Temperature

Chlorination Disinfection

- As water **temperatures** increase Chlorine effectiveness increases
- However, higher water **temperatures**, faster the rate of Chlorine dissipation
- Hypochlorite's freeze **temperatures**
- Solid Chlorine dissolves easily in warm **temperature** waters
- Tablet dispensers rate of dissolutions vary With **temperature**

Hypochlorite Freeze Chart

Sol. Strength, %	Freezing Temp
6	20
8	15
10	10
12	3
14	-3
15	-8

Hypochlorite Disinfection

- Higher the hypochlorite strength, faster rate of deterioration
- Deterioration rates of hypochlorites are function of **temperatures** exposure.

Fluoride Chemical Compounds

- Sodium Fluoride
  - First to be used in Fluoridation
  - White, odorless crystals
  - Free-flowing
  - Solubility is almost constant at 4% within typical water **temperatures**
  - 100 lb bags and drum to 400lb
  - AWWA standard B701

Fluoride Chemical Compounds

- Sodium Fluorosilicate
  - Least expensive
  - White, yellow-white crystalline powder
  - Limited solubility in water, decreases as water **temperature** decreases
  - Odorless, hydroscopic,
  - Saturated solution has pH of 3.0 to 4.0
  - Similar packaging to NaF

Temperature/Fluoride issues?

- Residuals sampling & analysis
- NaF dissolving water temperature
- Sodium Fluorosilicate solubility
- Corrosion issues related to Fluorosilic Acid
- Motors and electrical
- ....More?

Lead/Copper Rule Water Quality Parameters

- pH
- Alkalinity
- Calcium Hardness
- Total Dissolved Solids (TDS)
- **Temperature**

Corrosion Management- Indexes

- Langelier corrosion index
- Helps determine whether water supply is:
  - Aggressive, leaches metal pipes
  - Depositing, lays a protective film of Calcium Carbonate, (CaCo3)
- Reduces the 5 parameter data to one simple number. **Temperature** is one of the 5

Langelier Index Water Quality Parameter - Temperature

- Measured as degrees Celsius or Fahrenheit
- Significant effect on overall corrosion
- Important in Langelier Index calculations

5 Water Quality Parameters - Langelier Index

- Mathematically combined
- Effect of pH on the solubility of Calcium Carbonate
- Water at some pH is saturated w/ Calcium Carbonate
  - Called pHs

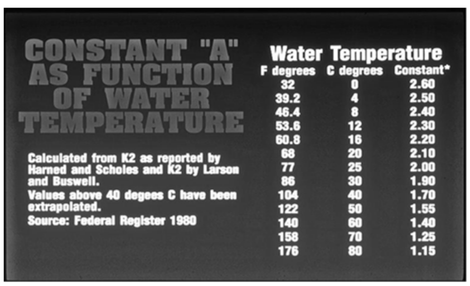
Langelier Index - Meaning

- If Positive (+)
  - a depositing or scale forming water
- If Negative (-)
  - a corrosive/leaching water
- If Zero
  - Balanced

Langelier Calculations

- Temperature (Log) + TDS (Log) minus
  - Alkalinity (Log)
  - Hardness (Log)
- Equals = Saturation pH or pHs
- measured potable water pH minus (-) pHs =
  - Langelier Saturation Index

Langelier Index Temperature Log Conversions



CONSTANT "A" AS FUNCTION OF WATER TEMPERATURE

Calculated from K2 as reported by Harned and Scholes and K2 by Larson and Buswell.
Values above 40 degees C have been extrapolated.
Source: Federal Register 1980

Water Temperature		
F degrees	C degrees	Constant*
32	0	2.60
39.2	4	2.50
46.4	8	2.40
53.6	12	2.30
60.8	16	2.20
68	20	2.10
77	25	2.00
86	30	1.90
104	40	1.70
122	50	1.55
140	60	1.40
158	70	1.25
176	80	1.15

Langelier Index - Example

Water supply with the following characteristics

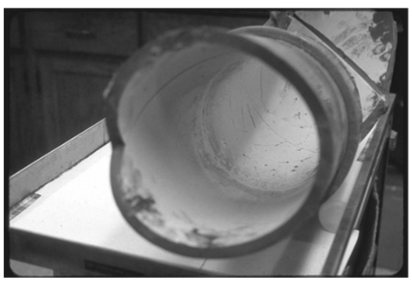
- Measured Values:
  - pH, 8.5
  - Ca Hardness, 75 PPM
  - Alkalinity, 100 PPM
  - Temperature, 50° F
  - TDS, 300 PPM
- Logs or Constants -charts:
  - pH, 8.5 (as measured)
  - Ca Hardness Log, 1.87
  - Alkalinity Log, 2.00
  - Temperature log, 2.35
  - TDS Log, 9.85

Langelier Example Calculations

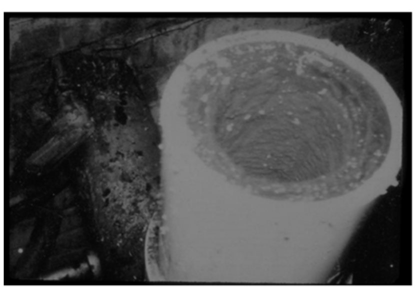
- Temp (Log), 2.35 + TDS (Log) 9.85 = 12.20
- Minus (-) Alkalinity (log) -1.87
- Minus (-) Ca Hardness (Log) -2.00
- Equals(=) Saturation pH (pHs) 8.33
- Measured potable water pH 8.50
- Minus (-) pHs -8.33
- Langelier Saturation Index = +.17

(A slightly depositing water supply with this temperature!!)

Langelier Results



Temperature Effects?



Extreme-Temperature Effects?

Temperature in the Lab & Field

- Water/Wastewater sampling require specific preservation **temperature** measurements
- Sample preservation requires specific **temperature** control
- Most bacteriological tests are **temperature** dependent (35ºC, 37ºC) Coliform, E-Coli, etc.
- Most probe based measurements (DO, pH, Cond.,) are **temperature** compensated

Temperature in the Lab & Field

- Most Colorimetric tests use reagent systems that develop color in proportion to concentration…..Color development time is **temperature** dependent. (ie: DPD Chlorine residual)
- Sample pretreatment may require high **temperatures** & (specific reagents) to remove interferences. (Fluoride)

Temperature in the Lab & Field

- COD, Total Phosphorus require high **temperature** (150ºC) sample heating to digest
- BOD test, require specific sample incubation **temperatures** (20ºC)
- Bringing water to boiling **temperatures** to created distilled water & calibration procedure for thermometer calibrations

Temperature in the Lab & Field

- Jar testing sample **temperatures** must match plant conditions to give accurate results

Wastewater Biology-Temperature

- BNR- nitrifying bacteria very **temperature** dependent
- Denitrification organisms **temperature** dependent
- Activated Sludge processes are **temperature** dependent
- Anaerobic digester bacteria- three different types of **temperature** depend organisms.

Nitrification Control, Temperature

- Nitrifers lose about ½ their activity for ea 10ºC temperature drop
- In winter, put an additional aeration tank on line, or increase MLSS
- Either action will increase MCRT

Effect of Temperature on Nitrification

- As temperature increases, nitrifier growth rate increases (4°C to 35° C range)
- As nitrifier growth rate increases, required MCRT decreases
- “Ball Park” – For every 10°C increase in temperature nitrifier growth rate doubles, required MCRT is cut in half & required MLSS concentration is also reduces

Anaerobic Digestion Temperatures

- May operate in three distinct bacterial **temperature** ranges promoting three distinct types of bacterial population:
  - Psychrophilic – near room **temperature**
  - Mesophilic – near 70º to 113ºF
  - Thermophilic – near 113ºF to 135ºF
- All of these organisms require a uniform **temperature** mix

Wastewater Biology-Temperature

- Lagoon system pond “turn-over” occurs due to **temperature** stratification (differences)
- Primary clarifier solids settling rates are **temperature** dependent
- Positive displacement blowers use to supply low pressure, high volume, air **temperatures** can approach 200ºF

Clarifier Settling Characteristics

- Water expands as **temperature** increases (density)
- Contracts as **temperatures** decrease (density)
- As clarifier water **temperatures** increase, the settling rate of particles increases
- As **temperatures** decrease, so does the settling rate
- Changes in water density effect overall settling characteristics

Grennell Glacier, Water Temp 28º F

Trickling Filters-Temperature

- General decrease in biological activity due to lower wastewater **temperatures**
- Freezing **Temperatures** can clog distribution nozzles
- Adjust or remove splash plates to reduce spray effect during freezing **temperatures**

Chemical Feed - Temperature

- Chemical solution **temperatures**
- Some chemical products density/Specific Gravity change with **temperature** changes
- Chemical feed pumps have a specific operating **temperature** range
- Coagulations chemical doses will vary with the water **temperature**, colder **temperatures**, higher collision rates/dose needed.

Reverse Osmosis Flow Rates

- Temperature and Pressure effect flow rates
- As water temperature increases, typical flows thru membrane increase
- As water temperature decreases, typical flows thru membranes decrease
- Some membrane designs are base-lined at 77°F
- Correction factors for other temperatures

Reverse Osmosis Flow Correction

Temperature °F	Temperature °C	Flow Correction
90	32.2	1.25
85	29.4	1.16
80	26.7	1.09
77	25.0	1.00
70	21.1	0.86
65	18.3	0.79
60	15.6	0.71
55	12.8	0.61
50	10.0	0.53

Other Plant Issues - Temperature

- UV Lamp **temperatures** – constant water flow past lamps to cool.
- Electric panels **temperatures**
- Pump **temperatures**, motor bearing temperatures
- Plant heating and cooling **temperatures**

AC Motor **Temperature** Limit Charts

TABLE 15.4 A.C. MOTOR TEMPERATURE LIMITS[a]

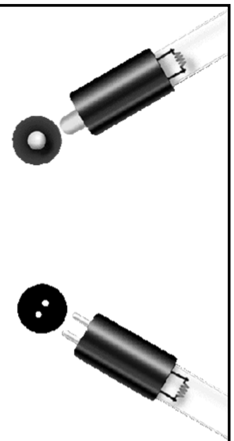
	Temperature (Deg. C)				
	Class A		Class B	Class F	Class H
1.0 Service Factor					
Drip-proof					
Ambient Temperature	40	40	40	40	40
Rise by Thermometer	40	..	..	..	..
Rise by Resistance	..	50	80	105	125
Service-Factor Margin	10	10	..	..	..
Hot-Spot Allowance	15	5	10	10	15
Total Temperature	105	105	130	155	180
TEFC					
Ambient Temperature	40	40	40	40	40
Rise by Thermometer	55	..	..	..	..
Rise by Resistance	..	60	80	105	125
Hot-Spot Allowance	10	5	10	10	15
Total Temperature	105	105	130	155	180
TENV[b]					
Ambient Temperature	40	40	40	40	40
Rise by Thermometer	55	..	85	..	..
Rise by Resistance	..	65	..	110	135
Hot-Spot Allowance	10	0	5	5	5
Total Temperature	105	105	130	155	180
Encapsulated[c]					
Ambient Temperature				40	40
Rise by Thermometer				85	110
Hot-Spot Allowance				5	5
Total Temperature				130	155
1.15 or Higher Service Factor					
All Motors					
Ambient Temperature				40	40
Rise by Thermometer[d]				90	115
Hot-Spot Allowance				10	10
Total Temperature				140	165

[a] Adapted from National Electrical Manufacturers Association (NEMA) publication MG 1-12.39 and 12.40.
[b] Including all fractional-horsepower totally enclosed motors and fractional-horsepower motors smaller than frame 42.
[c] Enclosed.
[d] At service-factor load.

UV Light Sources

Types of UV Lamps

- Low Pressure
- Low Pressure / High Output
- Medium Pressure



UV Light Sources

General Lamp Comparison

C	Low Pressure	Low Pressure High Output	Medium Pressure
Temp. C	35-45	50-85	400-800
Power (W)	40-65	200-400	1000-30,000
Experience	Extensive	Limited	Moderate
# of Lamps Req'd	High (X)	Moderate (~X/3)	Low (~X/10)
UVC	35%	32%	20%

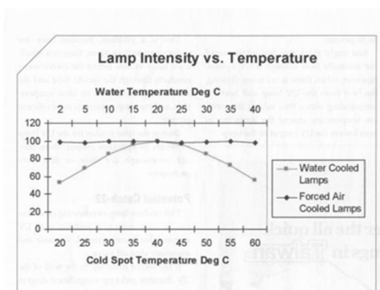
UV Lamp Efficiency

- Low-Pressure, LPHO lamps vaporize Mercury to produce 254nM germicidal light beam
- Amount of light produced is proportional to temp of the “Cold Spot” (coolest section of lamp)
- Should be around 42° C

UV Lamp Efficiency

- Depends upon temperature of air surrounding the lamp
- Lamps within quartz sleeve, immersed in water have different efficiency
- Water temperature effects surrounding air temperature.

UV Lamps Efficiency



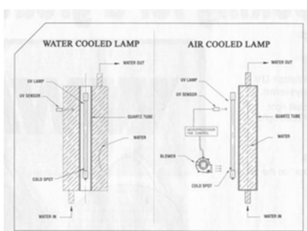
UV Lamp Efficiencies

- UV lamps enclosed in quartz tube
- Air-space inside & quartz thickness dictate lamp temp.
- Water is used to cool lamp to around 42° C
- Lamps are most efficient around this temp.

UV Cooling System Design

- Deviation from operating temp can result in 50% reduction in lamp output.
- Lamp Temp control can be either water or air cooled.
- Air cooled may maintain temp for efficiently.
- Microprocessor /sensor controlled

Water/Air cooling Systems



Temperature Effects Every Task We Perform in Our Water & Wastewater Facilities!!

ALKALINITY

Alkalinity - Definition

- Ability of water to resist change in pH
- Buffering capacity
- Results as CaCo3

Benefits?

- Immediate results
- Better process control
- Potential to save on electrical costs
- Predictability

Types of Alkalinity

- Total Alkalinity
  - Carbonate
  - Bicarbonate
  - Hydroxide
  - Other minor forms,(Borate, Phosphates)

Why Monitor Alkalinity?

- Direct/Immediate Indicator
- Predictable
- Real time, right now results

Monitoring Methods

- Onsite
- Portable/insitu
- On-line process
  - Monitor
  - Control

Alkalinity

- Key parameter in both:
  - Water
  - Wastewater
  - Simple monitoring test

Water

- Treatment processes need Alk
  - Lime-Softening
- Certain treatment chemicals use up Alk
  - Alum
  - Ferric Chloride

Lead/Copper Rules

- Alkalinity
  - Key water quality parameter
  - Required measurement
  - Minimize leeching

Corrosion Control

- Major element of corrosion Indexes
  - Langelier
  - Aggressive
  - Driving Force, etc
- Depositing waters

Potable Waters (well, Surface)

- Low raw Alkalinity
- Low pH's common

Water Treatment

- Raise pH & Alkalinity
  - Caustic
  - Soda Ash
  - Lime
  - Calcite

Alkalinity Chemicals

pH adjustment chemical	Typical feed rate	1 mg/L adds ___mg/L alkalinity[a]	Equipment required
Lime, as $Ca(OH)_2$	1–20 mg/L (8–170 lb/MG)	1.35	Quicklime-slaker, hydrated lime-solution tank, and feed pump with erosion-resistant lining as eductor
Caustic soda, NaOH (50% solution)	1–29 mg/L (8–170 lb/MG)	1.25	Proportioning pump or rotameter
Soda ash, Na_2CO_3	1–40 mg/L (8–350 lb/MG)	0.94	Solution tank, proportioning pump, or rotameter
Sodium bicarbonate, $NaHCO_3$	5–30 mg/L (40–250 lb/MG)	0.59	Solution tank, proportioning pump, or rotameter

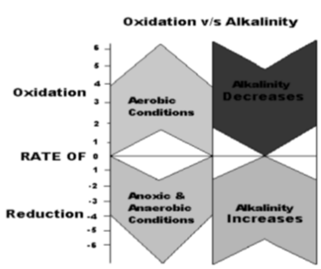
[a]Caustic soda and lime add only hydroxide alkalinity. Soda ash and sodium bicarbonate add carbonate or bicarbonate alkalinity, depending on pH.

Wastewater

Rate of change in Alkalinity corresponds to the biological reaction

- Aerobic reactions
  - Alkalinity decrease
- Anoxic & Anaerobic reactions
  - Alkalinity Increase

Oxidation v/s Alkalinity



Wastewater

- Measuring Alk changes
  - Indicates rate of biological reactions
- Biological reactions change Alkalinity
  - @ a predictable rate

DO v/s Alkalinity

- DO measure of residual
- Oxygen demand met
- Excess DO provides no additonal Info

Alkalinity v/s DO

- Indicates rate of oxidation
- Independent of other factors
- Direct relationship(Nitrification)

Ball Park Parameters

- Calculate Ammonia v/s Alkalinity Demand
- Effluent - > 50 -70 ppm
- Raw infu - 200 ppm

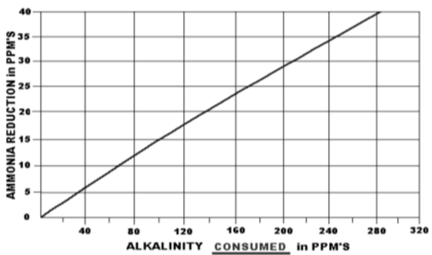
Alkalinity measurements

- Essentially Bicarbonate
- Real time
- Predictable

Bio. Nutr. Remov.(BNR)

- Nitrification(Aerobic)
  - For every ppm of Ammonia
  - Uses 2 Bicarb for every Ammonia converted
  - Uses 7.1 ppm Alk.

Nitrifications v/s Alkalinity



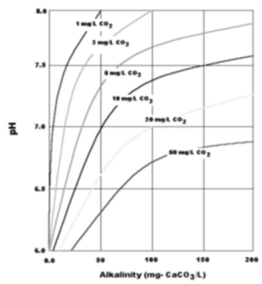
Bio. Nutr. Remov.(BNR)

- Denitrification(Anoxic)
  - 1 bicarb produced for every Nitrate converted
  - For every PPM of Nitrates
  - Adds 3.6ppm Alk.

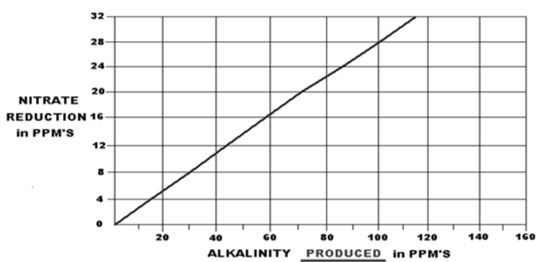
ALK V/S CO2

- Buildup thru bacterial actions
- Change pH
- O2 drives off CO2
- Raises pH

CO2 Concent. @ pH/ALK



Denitrification v/s Alkalinity



Predictability

- Rate of Alkalinity loss predicts Nitrification rate
- Rate of Alkalinity gain predicts Anoxic/Anaerobic rate
- Alkalinity rate gain difference
  - Distinquish between anaerobic/septic conditions

Always Use the Weakest Practical Strength a Chemical Solution

Advantage to Lower Strengths

- Safety and handling issues decrease with strength
- Deterioration of chemical tend to decrease with strength
- Operational problems tend to mitigate, (off-gas, corrosive atmosphere, loss-of-pump prime)
- Greater selection of chemical pumps with lower concentration of chemical

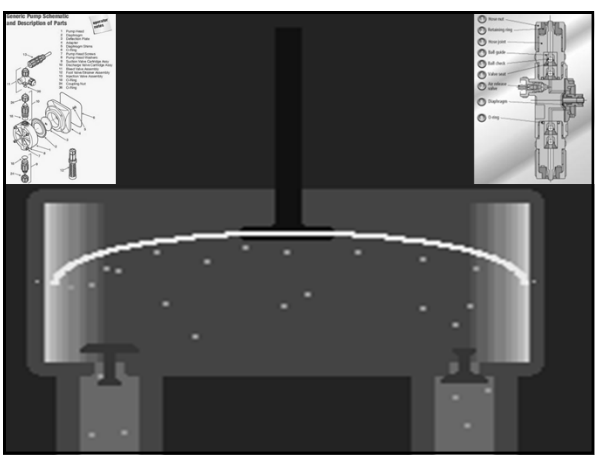
Chemical Deterioration

- Time
- Environmental issues
- Moisture
- Agitation
- Off-gas hazards

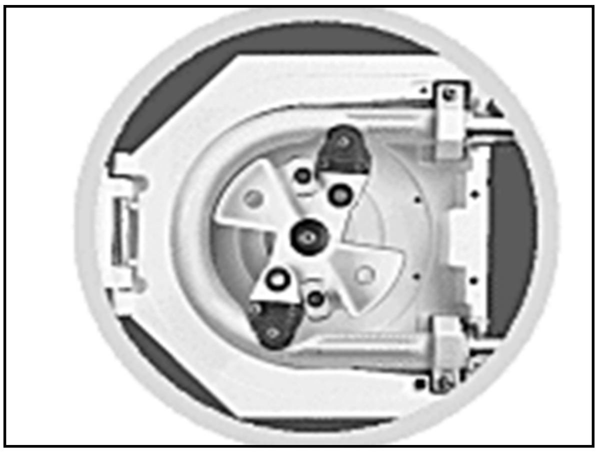
Chemical Dispensing Issues

- Product deterioration
- Manufacturing/delivery consistency
- Limiting chemical residuals
- Maintaining proper doses, (manual or automated control systems)
- Dispenser selection, maintenance
- Regulatory mandates,(minimizing byproducts)

Diaphragm Chemical Pumps

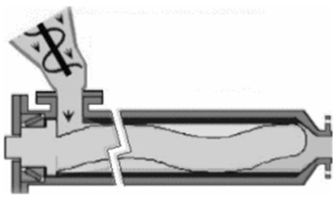


Peristaltic (Tubing) Pumps



Progressive Cavity pumps

Progressive Cavity Pumps, Animated

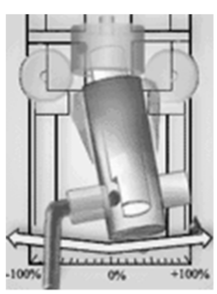


Valve-less Ceramic Disk Pump

Patented "No Valve" Design eliminates problems caused by valves which clog, leak, and require service.

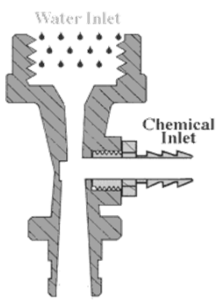
- One Moving Part CeramPump® design utilizes a single dimensionally stable, chemically inert CERAMIC piston ensuring long term, drift free fluid control.
- Accuracy, Precision, & Reliability measured in millions of "trouble free"cycles.
- Aspirate, Dispense, & Meter fluids from microliters to liters at **an accuracy of 1% and a precision of 0.5%** for millions of cycle

Valve-less Ceramic Head Pumps



Venturi Driven Chem. Pumps

Venturi Driven Pumps



How to select? (Cont'd)

Advantages

- **Diaphragm**
  - Long history
  - Ability to fine tune
  - Work against high discharge pressures
- **Peristaltic**
  - Few replacement parts
  - Liquid never touches motor or electronics
  - Little or no off-gassing

The Choice is Yours!

Tips for Best Operation

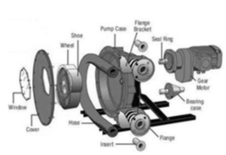
- Proper sizing
  - Growth
  - Pump range

Maintenance and Troubleshooting

- Generic
  - Follow manufacturers specifications
  - Keep workspace clean
  - Lockout/Tagout
  - Consistency
    - Develop Standard Operating Procedure
    - Scheduling

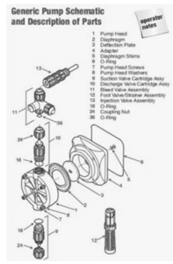
Maintenance and Troubleshooting (Cont'd)

- Peristaltic (Items to check)
  - Tubing and Screen
  - Wheel, Shoe, and Case
  - Fittings
  - Electrical Connections
  - Excessive vibration and/or noise



Maintenance and Troubleshooting

- Diaphragm (Items to check)
  - Tubing and Screen
  - Valve Assemblies
  - Diaphragm
  - Fittings
  - Electrical Connections
  - Excessive vibration and/or noise



Centrifugal Pump Efficiencies

- Type of Pump
- Largest Solids Size
- Fluid Viscosity
- Impeller Trim
- High Suction – N_s
- Mechanical Friction (Packing, Bearings)
- Internal Clearances (Wear Rings)
- Internal Surface Friction

Hazardous Issues to Avoid

- Contact with organic compounds like oils, greases, fuels
- Contact with ammonia compounds – potential fumes & gas production
- Contact with strong acids – elemental chlorine produced
- Never, ever tolerate “drip-leaks” from pipe joints, seals, etc

“Drip-Leak” Potential Hazards

- “Drip-leaks/seal leaks may solidify & dry out completely
- Powder may contain Sodium Chlorate
- If impacted with hammer during maintenance, could ignite or explode
- Any clothing with Chlorate dust runs a risk of ignition
- Special care by washing/diluting all powder formations to minimize

Common Chemical Problems

- Deterioration
- Concentration
- Temperature of the solution
- Contact w/ metal impurities
- pH of chemical solution
- Exposure to light
- Overall ionic strength of the solution

Chemical Handling Precautions

- Containers closed & covered when not in use
- Adequate ventilation, respiratory protection
- Avoid a fumes
- Avoid contact with skin or eyes
- Wash your any contacted area
- Avoid contact of oxidizers w/ wood paper fibers, spontaneous combustion may occur

Chemical Piping, Tanks Precautions

- Tanks: watch solids build-up, strainer & foot-valve fouling
- Piping: Plastic pipe joinery may be problematic. (12% bleach will "blow" right thru household CPVC cement)
- Use high-strength glues, perhaps with screw-threads.

Chemical Spill Management

- Leak mitigation
- Containment
- Recovery
- Absorption – Do not use sawdust!!! with oxidizers, (bleach)
- Dilution
- Neutralization

Hypochlorite Spill Reporting

In the United States under the Comprehensive Environmental Resource and Conservation Liability Act (CERCLA), any release of 100 lbs. (45.4 kilograms) or more of sodium hypochlorite to the environment within a 24-hour period, not specifically allowed by an operating permit, must be reported immediately (within 15 minutes) to the National Response Center (NRC) at 1-800-424-8802 or 202-426-2675.

Chemical Feed Problems

- Chemical feed system leaks
  - Pump selection, piping system joints
- Chemical off-gassing- loss of prime
  - Simple solution............DILUTION!!!!
  - Degassing valves
- Residuals measurement repeatability
  - Proper mixing
  - Mechanical
  - Static mixing

Problem..Problems..Problems

Minimizing Deterioration

- Dilution
  - Watch dilution water quality
  - Verify dilution strength
- Climate control
- Product life cycle
- Maintain routine delivery cycles

Always Verify Every Chemical Delivery to the Facility

Advantages of Verification

- Confirm product received is product ordered
- Confirm product conformity to purchase specification
- Detect underlying issues with product, (sedimentation, color, odor prior to introduction into the process
- Ultimately save your facility from a potential catastrophic event

Product Strength measurements

- Initial strength measurements
- Confirm delivered strength
- Determine rate of deterioration over time
  - calculate initial dose
  - Calculate dose over variable flow conditions versus strength

Measuring Chem. Characteristics

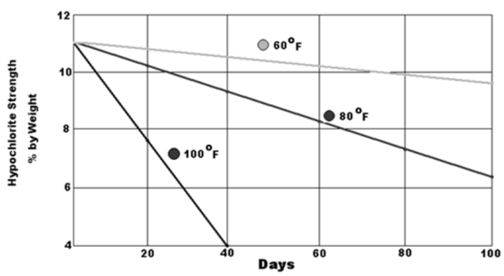
Strength .

Specific Gravity

pH

Color/viscosity

Hypochlorite Decay Rate Chart



Chemical Strength - How?

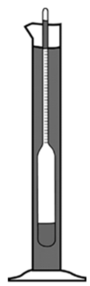
Refractometer

Hydrometer

Chemical

SG Chemical Strength

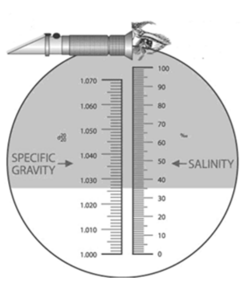
Hydrometers



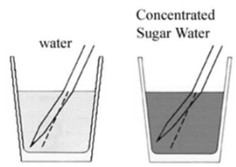
Specific Gravity Measurements

Refractometers

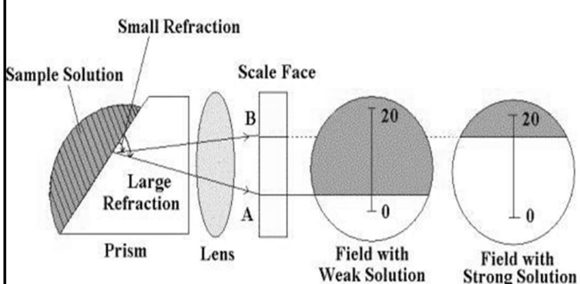
Reading A Refractometer



Principles of Refractometer



Principles of Refractometry



Specific Gravity by Weight

- 10 mL sample in a weighing bottle
- Analytical weight measurement to 4 decimals places
- Divide the measured weight by 10
- Result represents Specific Gravity
- Convert to % available Chlorine
- ***Note: This method can used to measure SG of any liquid chemical***

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Balances

SG Conversion Tables

TABLE II

SODIUM HYPOCHLORITE CONCENTRATIONS vs. SPECIFIC GRAVITY*

Trade %	gpl	wt. % NaOCl	SP.GR @ 20° C
1.0	10.0	1.03	1.020
1.5	15.0	1.53	1.027
2.0	20.0	2.03	1.034
2.5	25.0	2.52	1.041
3.0	30.0	3.01	1.048
3.5	35.0	3.48	1.055
4.0	40.0	3.95	1.062
4.5	45.0	4.42	1.069
5.0	50.0	4.88	1.076
5.5	55.0	5.33	1.083
6.0	60.0	5.78	1.089

Specific Gravity Limitations

- Other components of hypochlorite "add" to SG
  - Sodium chloride concentration
  - Caustic concentration- excess present
  - Amount of Sodium Chlorate present
  - Amount of available chlorine
  - Older deteriorating chemicals – SG's tend to be higher rather than lower, (evaporation, chem reactions)
  - Temperature compensation of the measuring apparatus.
    - Most measurement taken at 20°C

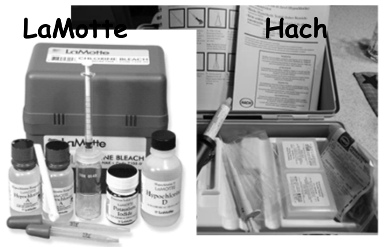
Minimizing Deterioration

- Dilution – a 2-1 dilution will lead to 5-fold reduction in decay rate
- Climate control
- Product life cycle
- Maintain routine delivery cycles
- Always uses the weakest strength solutions possible, based upon needs

Minimizing Deterioration

- Contaminating metal introduction from: piping, storage, transportation, diluting solutions
- UV light decay – transmitting tanks, storage, FRP tanks
- Nuisance metals like calcium & magnesium: precipitation
- Solution pH: between 11.9 to 13 offer the greatest stability of product
- Temperature exposure: higher temperature solution……faster the rate of decay

Direct Chemical Tests

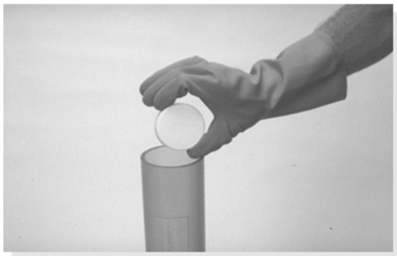


Even Most Dry Chemical Needs to be Dissolved in Water to Accurately Feed

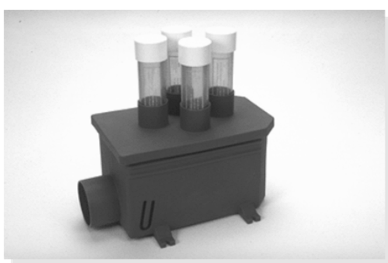
Solid Dry Chlorine

- **Granular, Powder, Tablet**
- **65 to 70% Free Chlorine**
- **Dissolved in Water, then Fed via Chemical Feed Pump**
- **Labor Intensive to Prepare and Handle**
- **Sodium Fluoride - Solids**

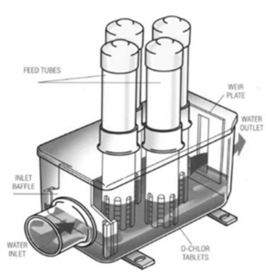
Dry Tablet Chemical



Tablet Dispensers

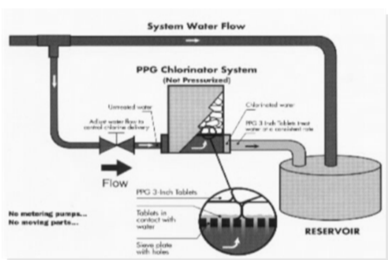


Tablet Dispensers



Tablet Dispensers

Tablet Dispenser Diagram



Fluoride Chemical Equipment

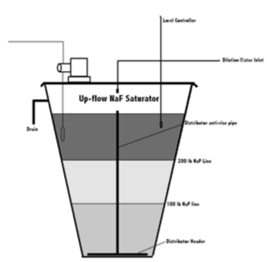
- Solution Feeders
  - Positive displacement pumps
  - From solution tanks
  - From saturators
  - Manual and proportional controlled
  - Similar to Hypochlorite pumps

Fluoride Saturators

- Simple means to maintain 4% solution of NaF at normal water temps.
- Ideal for small systems
- Two Types:
  - Upflow – water flow up through the NaF crystals
  - Downflow – water flows down through NaF and associated sand/gravel bed to collection manifold

Fluoride (NaF) Saturator

Cross-Section NaF Saturator

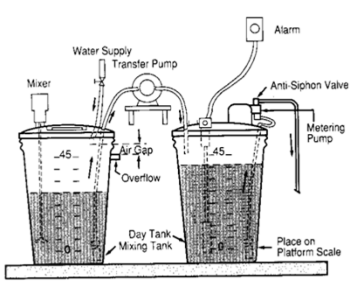


Saturator Maintenance

- Ca scale buildup
- Cleaning at least every 12 month or sooner depending on water issues
- Routine pump maintenance
- Accessory equipment function tests:
  - Solenoid valve(s)
  - Float Switch
  - Level light

Fluoride Solution Feeders

Manual Fluoride Solution Feeder

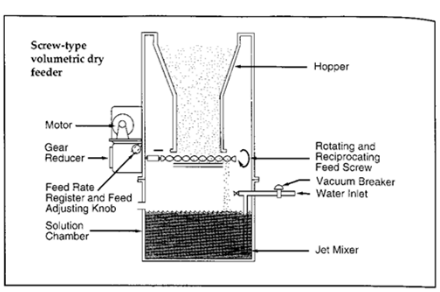


Chemical Solution Dispensers

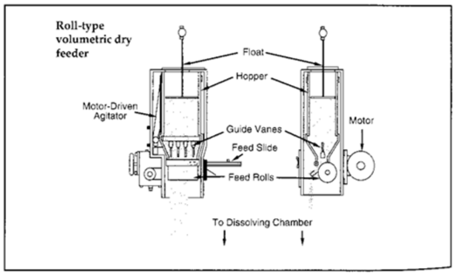
Fluoride Chemical Equipment

- Gravimetric
  - Delivers large quantity
  - Accurate
  - Easy to flow proportion
- Discharged dry chemical falls into solution chamber, dissolved
- Gravity flow or pumped
- Sodium Fluoride or Fluorosilicate application

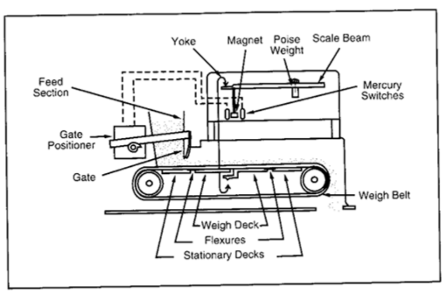
Volumetric Dry Fluoride Feeder



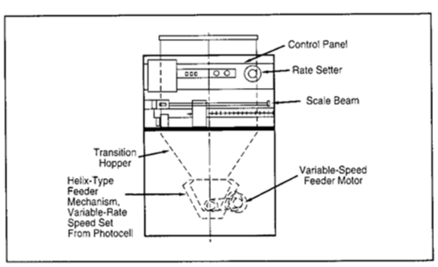
Volumetric Roll Dry-Feeder



Gravimetric Belt Feeder



Weight-loss Gravimetric Feeder



Every Chemical Added to Your Process May Potentially Leave Things behind:

Residual & Byproducts, Which May Not Always Be Self-evident

Limiting Chemical Residuals

- Chlorine, (free & total residual)
- Chloramines, (ammonia)
- Calcite, (hardness)
- Ferric Chloride, (iron)
- Alum (aluminum)
- Potassium Permanganate, (manganese)
- Fluoride (excess fluoride)
- Hydrogen Peroxide (oxygen)
- Solid Dry Chlorine, HTH, (hardness)

Maximize your Chemical Dose by

- Accurate chemical dosing
- Frequent pump, dry feeder volume output calibrations
- Verify all pump settings
- Many things will change chemical dose settings:
  - Temperature
  - Density
  - Specific gravity
  - Accurate residuals testing

Verifying Chemical Feed Results

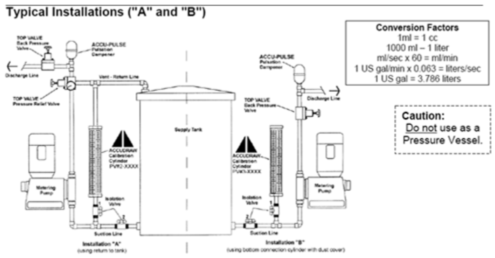
- Residuals Testing
- Coupon studies (corrosion control)
- Bacteriological studies
- Analytical studies
  - pH
  - Turbidity
  - Temperature
  - Conductivity

Pump Accessories

- Calibration cylinders
- Inlet strainers/foot valves
- Injection nozzles
- Multi-function valves
- De-gassing valves
- Flow indicators
- Auto-head flush systems
- Mounting brackets

Calibration Chambers

Typical Calibration Cylinder



Injection Nozzles

Flow Sensors, Bypass Valves

Degassing Valves

Accurate Residuals Testing

- Choose the Best Method
- Calibrate frequently
- Verify reagent systems life-cycle
- Maintain test protocol to manufacturer's specification.
- Replace expendables frequently

Colorimeters

Seven Deadly Sins of Colorimetric Testing

- Glassware errors
- Battery replacement
- Reagent systems shelf-life
- Colorimeter chamber issues
- Standards (primary versus secondary)
- Chlorine Demand Free Dilution Waters
- Blanking (sample versus reagent)

Glassware Issues

- Reagent System Staining
- Cleanliness
- Scratches
- Variability between different pieces of glassware
- Glassware variability in a single cuvette

Amperometric Titrator

PWD Probe Ammonia Testing

Seven Deadly Sins of Probe and Meter Measurements

- Probe /meter selection
- Proper filling solutions
- Probe storage errors
- Limiting ions and demand in dilution waters
- Infrequent calibrations
- Forgetting temperature compensation
- Reused standards/buffers

Conclusions

- While mandated measurements of pH, DO, & Residuals will never lose importance, TEMP. & ALKALINITY may be most valuable for process management
- Always VERIFY every chemical received at your facility
- Watch those BY-PRODUCTS and RESIDUALS
- Use the most PRACTICAL strength of your chemicals the works for your particular operations