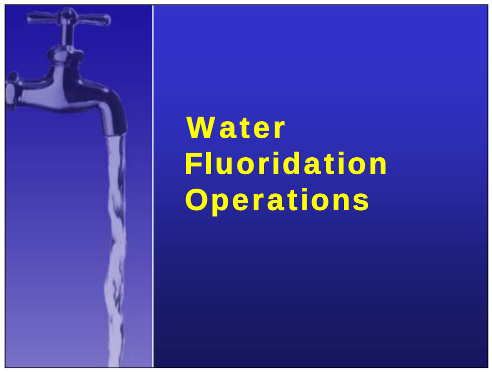
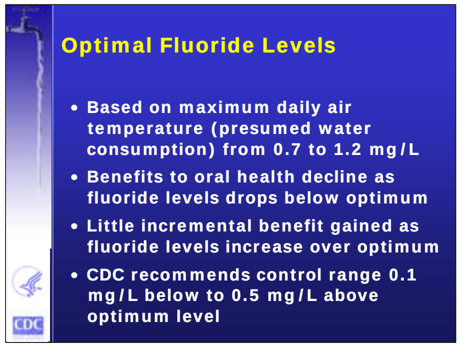


Operations is where the operator is successful or not.



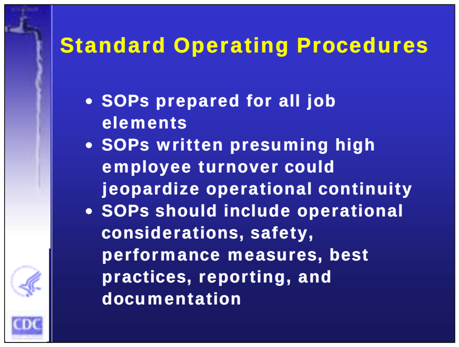
We are adding these compounds to the water so that we can adjust the fluoride concentration to the optimal level for preventing tooth decay. The optimal fluoride level for a location is based on the average maximum daily air temperature, and we use data from a 5-year period. This average is for the entire year; we do not recommend changing the optimal level to account for seasonal temperature variations.

It is important to remember that benefits to oral health decline as fluoride levels drop below optimum, and only a small incremental benefit is gained as fluoride levels rise above optimum. The CDC recommends a control range of 0.1 mg/L below the optimal level to 0.5 mg/L above the optimal level, but some states have different control ranges.

For the full benefits of fluoridation to be realized, fluoride must be maintained at or near the optimal level. For [Georgia], the optimal level is [0.80] mg/L. The principal reason for low or erratic fluoride levels is poor operation and maintenance.

Everything to do with water fluoridation is something a water plant operator already does for another process, so there are no new skills to master. But, it is important to understand what types of things an operator should be doing to resolve problems when they occur.

For operators to successfully do their job, they must understand the job and what is required to achieve success. This includes providing good operator training on the job objectives and requirements, guidance on best practices to conduct the work, SOPs specific to the facility, and demands of the job.

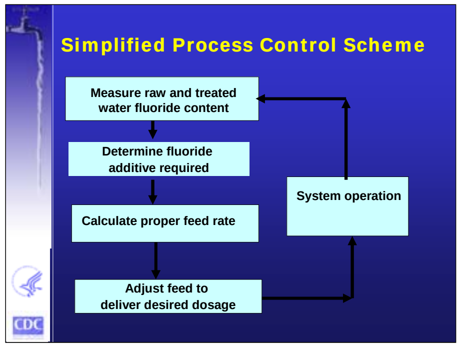


To the operators, guidance means they have all the information needed to do the job correctly.

SOPs should always be prepared for all job elements so operators have the information for the job at hand.

SOPs should be written presuming that high employee turnover could jeopardize operational continuity when new people show up.

SOPs should include operational considerations, safety, performance measures, best practices, reporting, and documentation on all aspects of a job. Check with other facilities to see if they have SOPs for process management, which you might be able to use for a head start in preparing your own SOPs. If you can't find another facility, then either contract with a firm to assist you, or begin writing down everything that is relevant to a process, and, over time, you will have prepared your SOP.

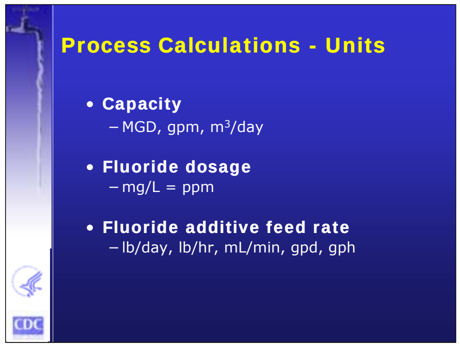


Here is the simplified process control scheme. To control the fluoridation process, the steps include

- Raw water sampling;
- Fluoride analysis to know how much additive is in the solution, such as FSA or dissolved dry additive;
- Determination of the fluoride dosage;
- Calculation of the proper feed rate;
- Calibration of the feeder; and
- Sampling of the treated water to verify operation.

Many operators may ask if it is necessary to calculate the feed-rate if they can control it by adjusting the feed-rate and observing the result without doing the confirming math. That approach is a reactive approach, and typically leads to unanticipated swings in operation that can result in a water quality violation. It is only by having the calculated feed rate as a comparison that the operator can anticipate changes in operation that need to be addressed before they result in uncontrolled swings in operation. The reactive form of plant operations will lead to bigger problems as the operator struggles to recover from an event that they are unclear as to the cause.

Best Practices in operation are to document all Standard Operating Procedures (SOPs). This would include the calculations necessary for monitoring the plant operation. The first time the calculations are prepared will take some time, but once prepared, the daily review should only take a minute, which is time well-spent.

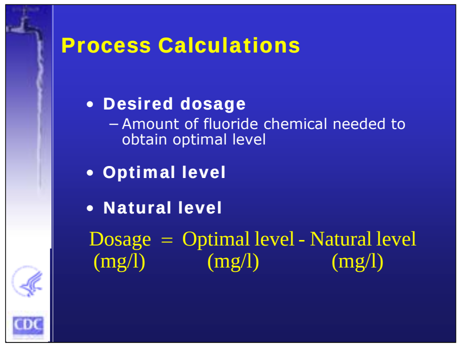


To get the right dosage of fluoride additive, it is necessary to know how much to add. This requires some math, but the calculations are the same type as those required for other chemical additives at a treatment facility. So let's review the simple math calculations that are needed for any process control in a water facility. As is the case with other calculations, it is normally necessary to express the calculations in units of measurement.

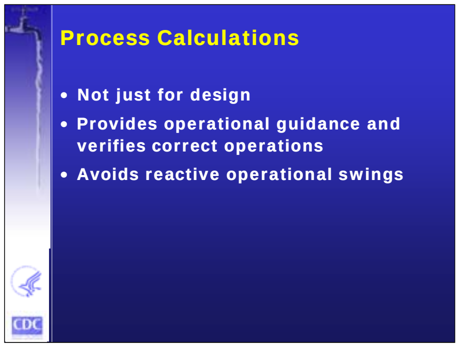
For the plant flow, million gallons per day (MGD), or gallons per day (gpd) for smaller facilities, and cubic meters per day (m^3/day) in the metric system.

For the dosage, either milligrams per liter (mg/L) or parts per million (ppm), which is approximately the same thing.

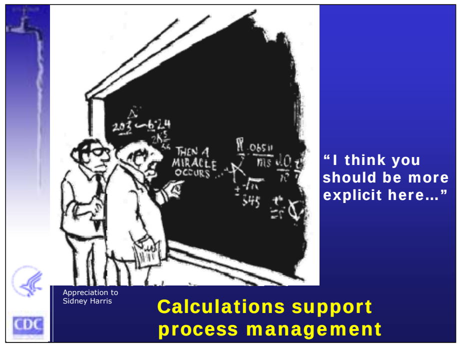
The additive feed rate is normally expressed as pounds per day (lb/day) or pounds per hour (lb/h) for dry additives, or as milliliters per minute (mL/min), gallons per day (gpd), or gallons per hour (gph) for FSA feed.

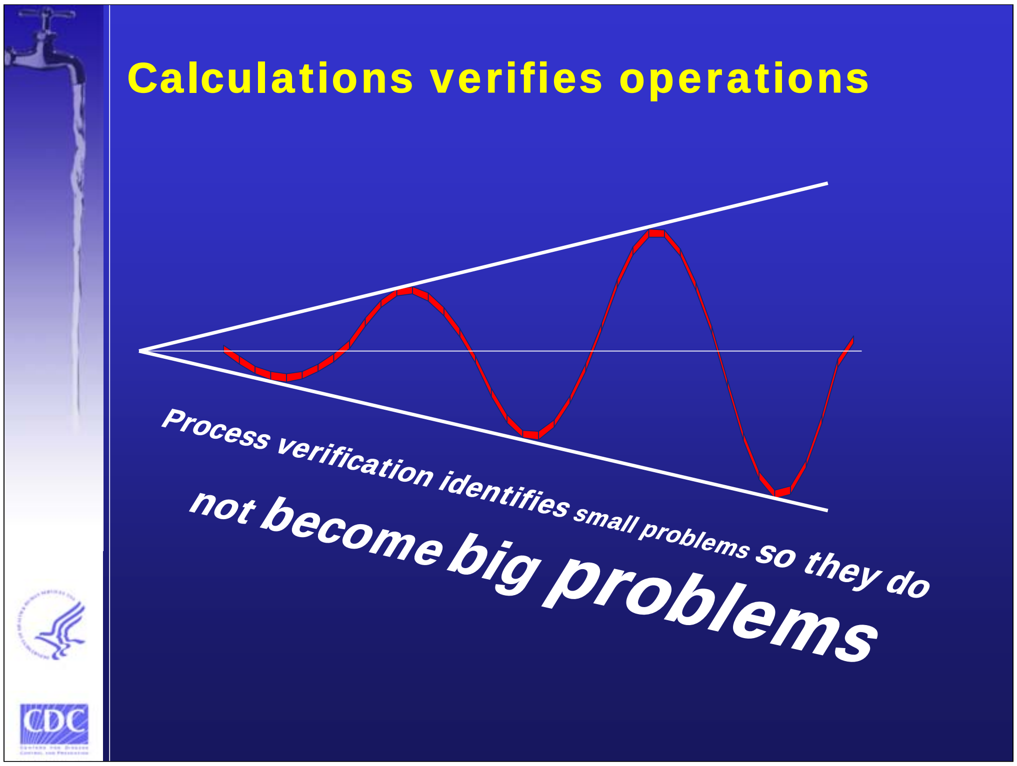


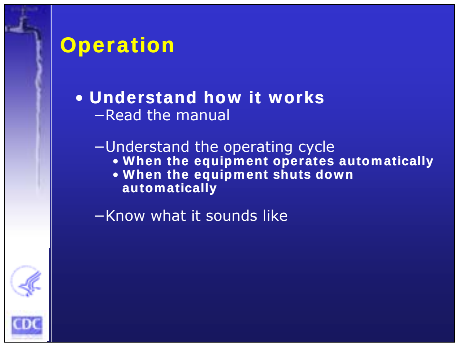
To determine the amount of fluoride additive, you need to know the optimal level for your location and what the natural fluoride level is for your source water. The optimal level can be determined by consulting with your state water fluoridation program, and the natural level must be measured. Some locations will find the natural level to be stable, but other locations will find it changes based on seasonal influences. Once you know the target optimal level and the natural level, you can determine the necessary dosage by simple subtraction. For example, if the optimal level is 0.8 mg/L, and the natural level is 0.2 mg/L, then the dosage is 0.6 mg/L.



Calculations are a necessary part of good operations. It is not acceptable to “tweak” plant operations by adjusting feed rates based on if yesterday was too high or low. Each day, an operator should calculate what is the proper feed rate and confirm that the equipment settings are appropriate. Once the calculations are done the first time, a daily adjustment is quite simple and easy. This avoids the potential of reactive operational swings which can result in distorted or exaggerated changes.


THEN A
MIRACLE
OCCURS...
“I think you should be more explicit here…”
Appreciation to Sidney Harris
Calculations support process management


Calculations verifies operations
Process verification identifies small problems so they do
not become big problems



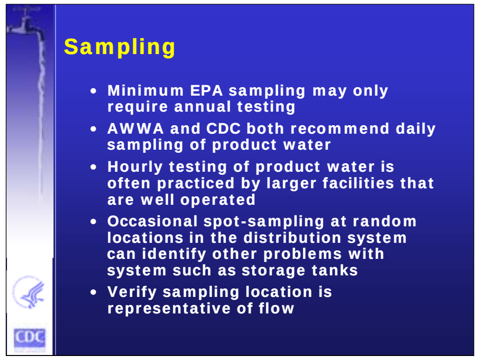
There are some simple actions an operator can follow for process control.

First, understand the process and how it works.

Second, read the manual.

Understand the operating cycle, when the equipment operates, and when the equipment shuts down,

Know what things sound like when it is working well, and when it is not working well.



Sampling is an essential activity. The minimum EPA sampling for fluoride presumes that a facility does not adjust fluoride and has only the natural level. Consequently, EPA may require only annual testing. But when you are adding fluoride, you need additional information to verify operation. Both the AWWA and CDC recommend daily sampling of product water, and some of the better operated larger facilities may also practice hourly testing of product water to optimize chemical usage.

Make sure you use good locations for collecting samples. Verify that your sampling provides a representative concentration of the added fluoride. Occasional spot-sampling at random locations in the distribution system can identify other problems with the system such as storage tanks.

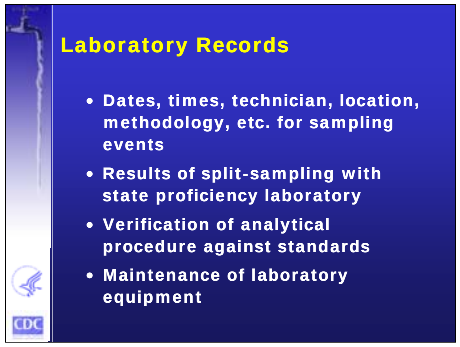
Accurate and consistent records are essential to good facility operations. Always check on what requirements your state may have on records and reporting requirements for water treatment facilities. For your facility, you need to maintain complete operational records, laboratory records, maintenance records, and customer comments.

Operational records for fluoridation include both the source and the product water fluoride level. The product water should be measured daily, but the source water may need to be sampled only quarterly if the fluoride concentration is reasonably consistent. Be sure to record where each sample is taken, who collected the sample, and the date and time of each sampling event. Also record the amount of fluoride additive used daily, for it is important to document how much was actually added, particularly if you have a sample that is excessively high as a false reading, along with a record of how much water is used if you are using a dry additive. Some states may have a requirement to record fluoride pounds or solution used for the measured water produced.

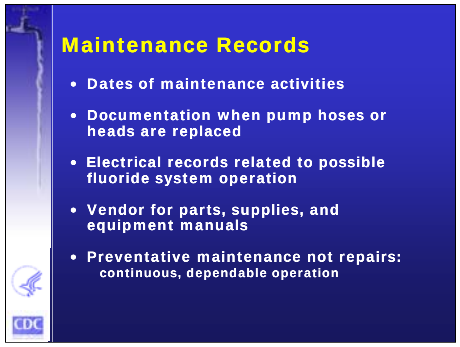
There are also records important for the operator adjustments. These can include calibration curves for pump or feeder settings. The calibration curves should be verified quarterly to account for changes in product quality and wear of equipment. As has been pointed out previously, the characteristics of the additive can change from batch to batch, so verify the chemical purity with each new delivery.

Ask your state program if they have any special records that are requested by the state.

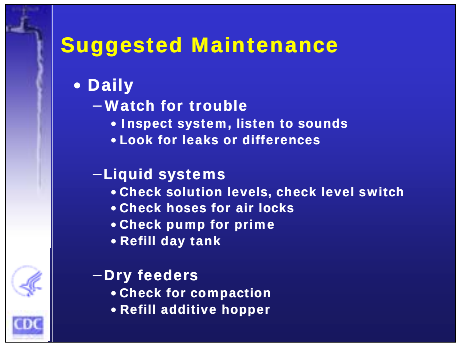
To correctly operate the fluoridation system, certain tests must be prepared on the finished water to verify correct operation. Every water plant operator should then submit those results to the state water fluoridation program. The reason is that the results can then be compiled in a national database that is available to public health officials, medical doctors, dentists, and other health care providers to make good decisions for communities and patients on oral health based on actual fluoride levels. These results should be submitted at least monthly. Some states require weekly submissions.



Be sure to record where each sample is taken, who collected the sample, and the date and time of each sampling event. Split sampling and testing with another reference laboratory are important to verify that your laboratory technicians are conducting the tests correctly and to reveal if there are interfering ions. Include tests on known reference standards to verify your analytical procedure. Also, maintain records on the laboratory equipment.



As part of a complete records program, certain maintenance records should be kept. It is good to know when parts such as hoses and pump diaphragms were last replaced, when changes to the electrical system that might affect the fluoride system were made, where parts can be procured for maintenance, and other relevant documentation. Remember that preventive maintenance is the best policy, and that does not mean what repairs were made. The objective of a good maintenance program is to provide continuous, dependable operation.



On a daily basis

Watch for trouble

Inspect system, listen to sounds

Look for leaks or differences

Liquid systems

Check solution levels, check level switch

Check hoses for air locks

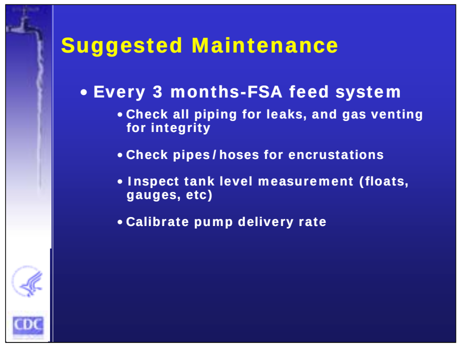
Check pump for prime

Refill day tank

Dry feeders

Check for compaction

Refill additive hopper



For FSA systems, every 3 months

- Check all piping for leaks, and gas venting for integrity
- Check pipes/hoses for encrustations
- Inspect tank level measurement (floats, gauges, etc.)
- Calibrate pump delivery rate

For dry feeders, every 3 months

•Thoroughly clean, remove cinders/encrustations

•Check belts; adjust if necessary

•Lubricate bearings

•Calibrate feeder dispensing rate

•Rotate your inventory; check to ensure no bags in storage are older than 3 months, and use the oldest bags first to avoid product deterioration.

For a saturator, every 3 months

•Thoroughly clean, remove cinders/encrustations

•Verify uniform flow through additive bed: no short circuiting or piping (piping is when a flow channel like a "pipe" allows water to travel through bed without contact with additive)

•Verify water softener in working order

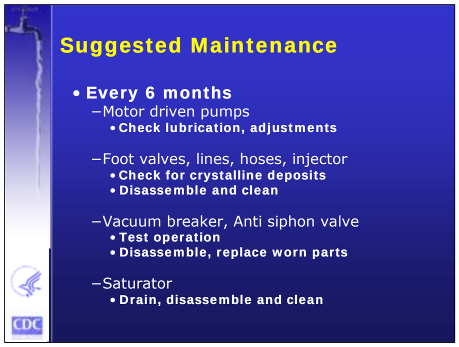
•Clean water strainer

•Check all piping for leaks

•Inspect tank level measurement (floats, gauges, etc.)

•Calibrate pump delivery rate

•Rotate your inventory; check to ensure no bags in storage are older than 3 months, and use the oldest bags first to avoid product deterioration.



Every 6 months

Motor driven pumps

•Check lubrication, adjustments

Foot valves, lines, hoses, injector

•Check for crystalline deposits

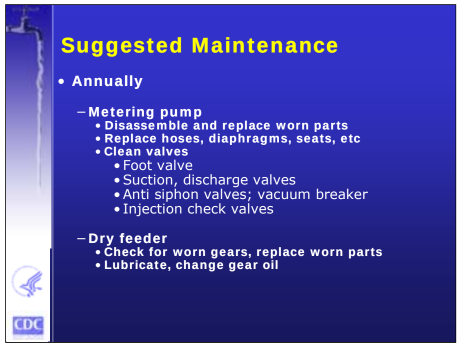
•Disassemble and clean

Vacuum breaker, anti-siphon valve

•The International Plumbing Code stipulates that all backflow prevention valves, anti-siphon valves, and vacuum breakers must be tested at the time of installation; after they are moved, relocated, or reinstalled; and a minimum of once every year. Replace any worn parts.

Saturator

•Drain, disassemble, and clean



Annually

Metering pump

•Disassemble and replace worn parts

•Replace hoses, diaphragms, seats, etc.

•Clean valves

Foot valve

Suction, discharge valves

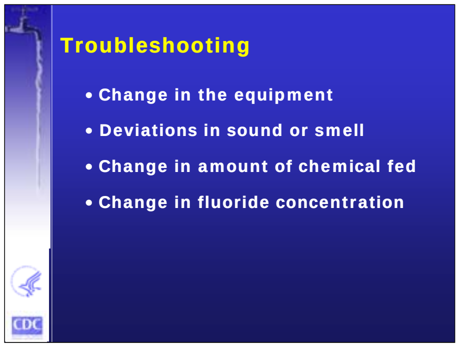
Anti-siphon valves; vacuum breaker. The International Plumbing Code stipulates that all backflow prevention valves, anti-siphon valves, and vacuum breakers must be tested at the time of installation; after they are moved, relocated, or reinstalled; and a minimum of once every year; replace any worn parts.

Injection check valves

Dry feeder

•Check for worn gears, replace worn parts

•Lubricate, change gear oil



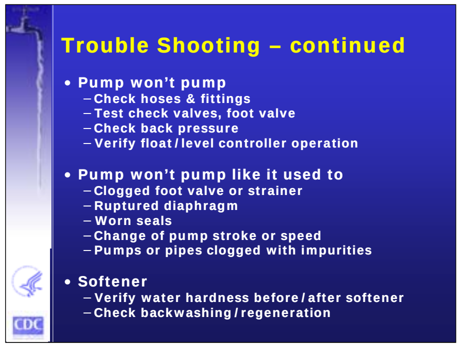
Troubleshooting is when you need to identify why there is problem and solving it. Things to begin with in troubleshooting include

Changes in the equipment,

Deviations in sound or smell,

Change in the amount of chemical fed, or

Change in the fluoride concentration.



Some things you might have to do in troubleshooting include these common problems:

Pump won't pump

Check hoses and fittings

Test check valves

Check foot valve—must be in vertical position

Check back pressure

Verify that pump is primed

Verify float/level controller operation

Pump won't pump like it used to

Clogged foot valve or strainer

Ruptured diaphragm

Worn seals

Change of pump stroke or speed

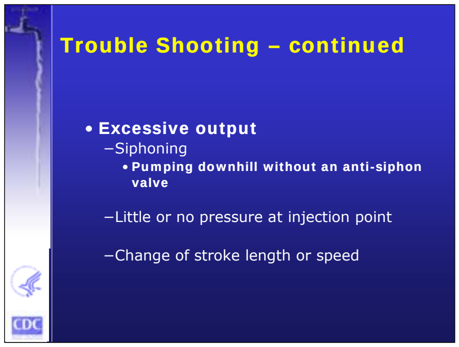
Pumps or pipes clogged with impurities

Check pump adjustment knobs—they tend to loosen on their shaft

Softener

Verify water hardness before/after softener

Check backwashing/regeneration



If you experience excessive output

Siphoning

Pumping downhill without an anti-siphon valve

Little or no pressure at injection point

Change of stroke length or speed

Dry feeders may have these problems:

Feed helix not turning but power ON

Check for obstructions

Chemical will not feed

Increase frequency of hopper agitator

Check moisture content (fish eyes)

Is material bridging or packing in bin?

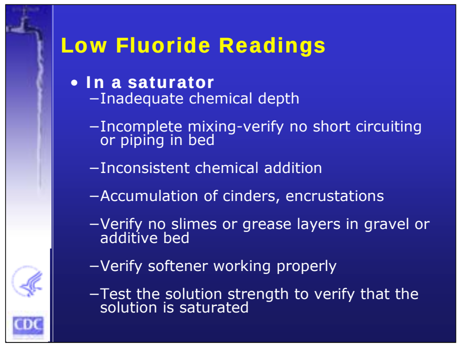
Erratic feed

Binding of drive shaft or helix

Low speeds

It is important that the dry additive be fully dissolved and not fed to the water flow as a partially dissolved slurry. If the solution is not a clear, homogeneous solution, then one of several things likely needs to be changed.

First, check the size of the dissolving chamber. Is it adequately sized? It is necessary to have at least 5 minutes, but as discussed on the previous slide, it might be necessary to have 10 minutes or even 15 minutes. Next, check on the required amount of dilution water and verify that there is excess dilution water delivered. Because the dilution water must mix with the additive, verify that the mixer has suitable power and is in working order. A last thing to verify is that the flow is not short-circuiting the tank, resulting in insufficient detention time.



If you have low fluoride readings in a saturator

Inadequate chemical depth

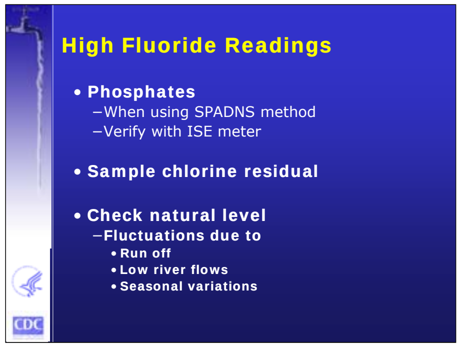
Incomplete mixing, verify no short circuiting or piping in bed

Inconsistent chemical addition

Accumulation of cinders, encrustations

Verify no slimes or grease layers in gravel or additive bed

Verify softener working properly; test solution strength to verify that the solution is saturated



If you have high fluoride readings, check the following:

Phosphates

When using sodium 2-(parasulfophenylazo)-1,8-dihydroxy-3,6-naphlene disulfonate (SPADNS) method

Verify with ISE meter

Sample chlorine residual

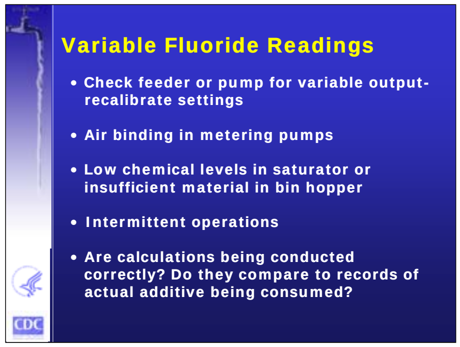
Check natural level

Fluctuations due to

Runoff

Low river flows

Seasonal variations



With variable fluoride readings,

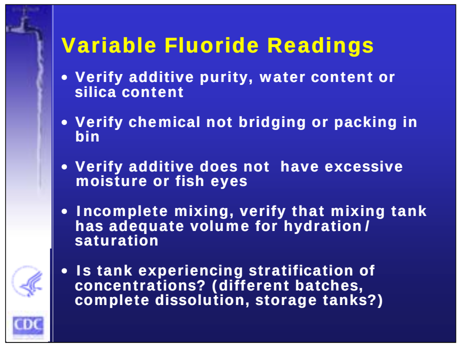
Check feeder or pump for variable output, and recalibrate the settings.

Check for air binding in the metering pumps.

Has the saturator chemical bed been partially depleted, or is there insufficient material in the bin hopper?

Does your plant operate with intermittent operations; if so, are the electrical interconnections wired properly?

You may want to check your calculations and compare the calculated amount of chemical additive fed with the measured amount. Are the calculated levels comparable to the actual additive being consumed?



Some other considerations with variable fluoride readings include these items:

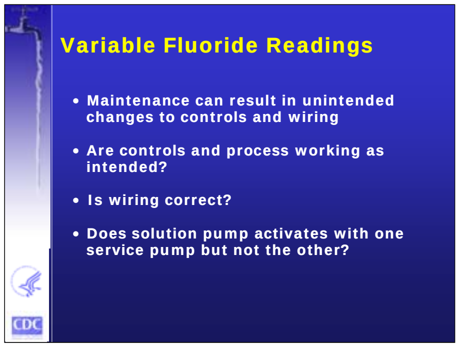
Verify additive purity, water content, or silica content

Verify chemical not bridging or packing in bin

Verify additive does not have excessive moisture or fish eyes

Incomplete mixing, verify that mixing tank has adequate volume for hydration/saturation

Is tank experiencing stratification of concentrations? (Different batches, complete dissolution, storage tanks?)



Additional considerations with variable fluoride readings.

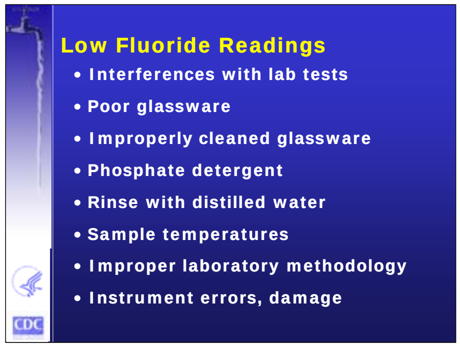
Maintenance can result in unintended changes to controls and wiring.

Are controls and process working as intended?

Is wiring correct?

Does solution pump activate with one service pump but not the other?

Is there a changing flow rate that might result in variable fluoride readings?



There can also be laboratory influence results for low fluoride readings.

Interference with lab tests

Poor glassware

Improperly cleaned glassware

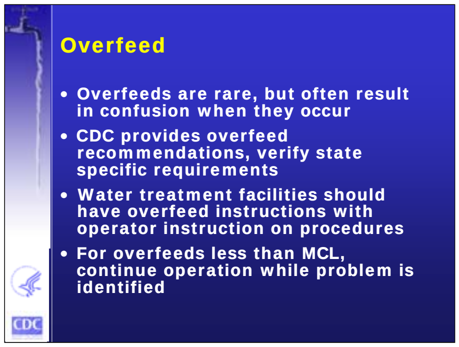
Phosphate detergent

Rinse with distilled water

Sample temperatures

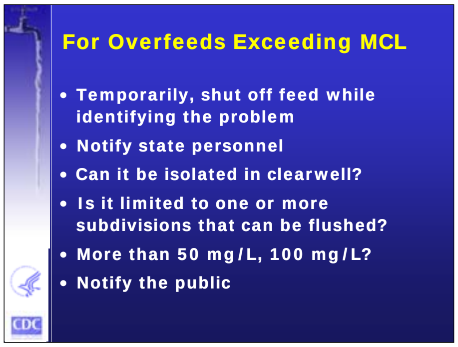
Improper laboratory methodology

Instrument errors, damage



In actual experience, overfeeds are rare; many facilities will never have an overfeed incident in the life of the facility, but they do occasionally happen. CDC provides overfeed recommendations; verify what are the specific requirements in your state.

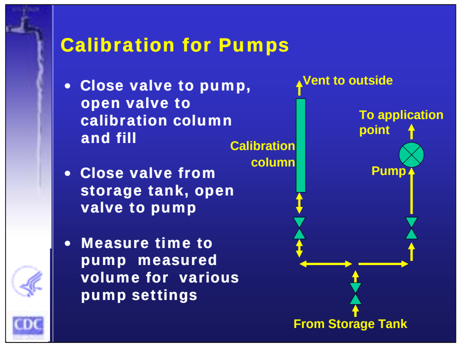
Each water treatment facility should prepare overfeed instructions with specific operator instructions on procedures for the plant. This might include flushing lines or some other appropriate activity. Each community should identify in advance what needs to be done. Consult with your state program to learn their policies on overfeed events.



CDC recommendations in EARWF advise to keep feeding up to the MCL and working to identy the problem, but if the overfeed exceeds the MCL, terminate the feed. Be sure that all appropriate state personnel are notified of the event including drinking water administrator for the state and the state dental director.

Try to understand the area extent of the overfeed. Is it limited to one clearwell that can be isolated and then bled back into the distribution system over several days? It normally takes one or several days for water to move throughout the distribution system, so ascertain if the excessive fluoride water is limited to one or more subdivisions near the water plant, or if it is more extensively distributed around the community. If it is limited in extend, immediately implement a hydrant flushing program to purge the system of the excessive fluoride water.

Quantify the excessive levels. If it is is more than 100 mg/L, then you have a serious problem with dangerous fluoride levels. If it is more than 50 but less than 100 mg/L, then you might have some people who could get sick. If it is less than 50 mg/L, remember that many people around the world regularly consume water with 20 to 40 mg/L fluoride content, and after many years, they will develop skeletal fluorosis. But skeletal and enamel fluorosis is a long-term condition, and excessive levels for one or two days is not a great health risk. The kidneys are efficient in removing fluoride from your body, and the excessive levels will elevate the fluoride in your blood for a long-term effect, but not a short-term concern.

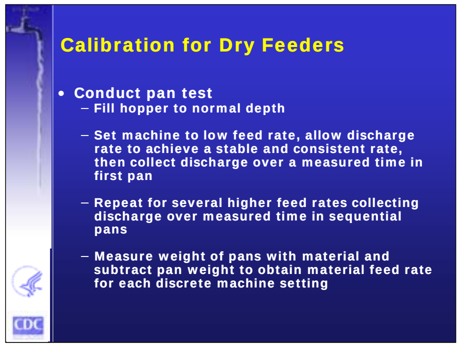


Calibration of equipment to verify rate of feed has been mentioned as an essential part of accurately controlling the system. You probably already do this, but let's review the steps involved.

First, you close the valve to the pump, and open the valve to the calibration column and fill it. Don't open the valve all the way at once or you might overfill the calibration column—allow it to fill slowly.

Then close the valve from the storage tank, and open the valve to the calibration column and pump to full-open position.

Then measure the time to pump a measured flow for several pump settings, including a rate below your normal feed rate and above your normal feed rate in addition to flow rates around the expected feed rate. If you don't have a calibration column, consider adding one to the piping. The columns are relatively inexpensive, and the piping modifications can probably be accomplished in a couple of hours.



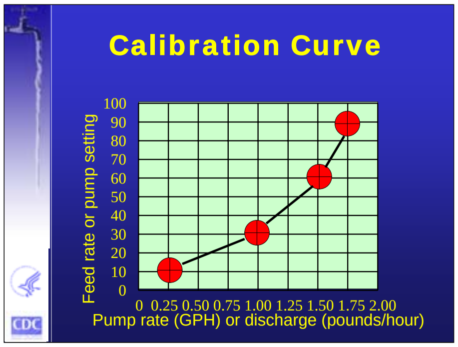
Calibration of dry feeders involves use of a pan test. Here is how a pan test is conducted.

Fill the hopper to a normal depth

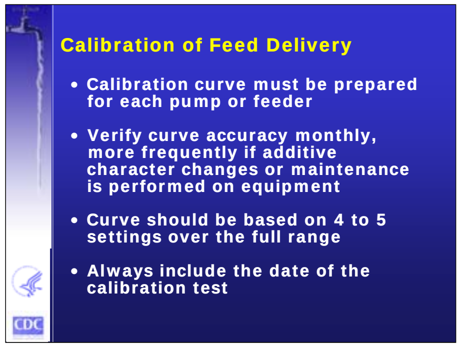
Set the machine to low feed rate, collect discharge over a measured time

Repeat for several higher feed rates, including rates above and below your expected feed rate

Measure weight of pan with material and subtract pan weight to obtain material feed rate for each equipment setting



Once you have collected the discharge rate from the pump or the feeder, you can plot the results on a chart. Draw a line between the dots, and you have the result. This chart is prepared plotting the feed rate settings, normally 0%–100%, against either the pumping rate in gallons per minute or the discharge rate in pounds per hour.



Some considerations on calibrating a feed rate:

Calibration curve must be prepared for each pump or feeder.

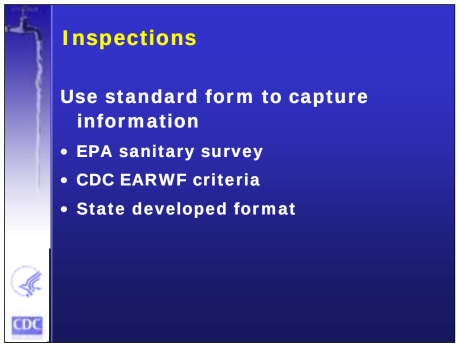
Verify curve accuracy quarterly, more frequently if additive character change or maintenance is performed on equipment. The equipment will have wear and tear that will influence the operating characteristics over time. Also, the additive can change in character such as having a moisture content or higher silica content, so verify the nature of the additive during the calibration test.

Curve should be based on four or five settings over the full range.

Always include the date of the calibration test and compare the results with previous calibration tests.

Inspections are an important part of the fluoridation program. They can

- Confirm that a new installation was constructed correctly
- Observe that a facility is operating correctly
- Identify deficiencies
- Project replacements to equipment and facility to maintain future operations

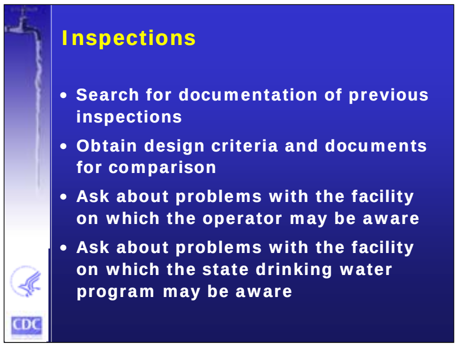


The EPA sanitary survey may have information on inspections of the facility that could be use, including facility design criteria and contact information, so be sure to obtain a copy of the most recent sanitary survey. Many sanitary survey inspectors are not trained for inspecting fluoridation facilities. It would useful to see if you can include specific fluoridation training for those inspectors so that they can conduct better inspections.

The CDC EARWF criteria provides forms for inspections that may be useful for a state program.

Many state programs have developed their own inspection forms.

The inspections are important to document what equipment is installed, its condition, capacities, and design criteria. Inspections should also be able to identify deficiencies requiring repair or action, and they should verify that the facility is operating the fluoridation system correctly. Many deficiencies may be a result of improper installation or inadequate maintenance. Deficiencies should include piping and electrical wiring which may result in problems.



When preparing for an inspection, search for documentation of previous inspections, obtain the design criteria and documents as a comparison, and ask the operator if they are aware of any problems that should be investigated.

Some of the tools that will help with conducting the inspection include

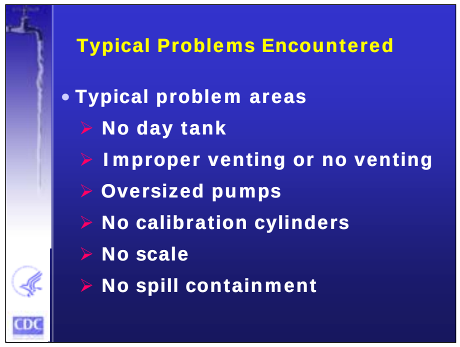
•Past reports

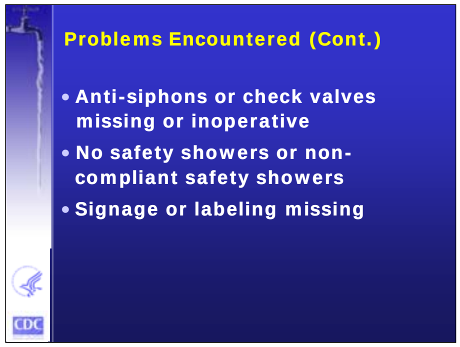
•Forms

•Camera

• Personnel safety gear

•Flashlight and measuring tape


Typical Problems Encountered
• Typical problem areas
No day tank
Improper venting or no venting
Oversized pumps
No calibration cylinders
No scale
No spill containment


Problems Encountered (Cont.)
• Anti-siphons or check valves missing or inoperative
• No safety showers or non-compliant safety showers
• Signage or labeling missing
CDC