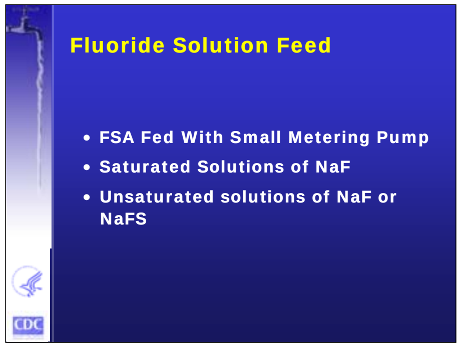
Now that we covered the fluoride additives, we can discuss the equipment and facilities needed for water fluoridation.

Adding fluoride to water involves precise delivery of small quantities of additives. It is always important in water treatment to have reliable facilities and equipment to ensure that the process is maintained with low operator supervision. Because the fluoride additives are corrosive in the concentrated state, we need to use materials with suitable corrosion resistance. And operators are important people, so we need to ensure their safety in handling the concentrated fluoride additives, which are hazardous products.

Fluoride additives, whether purchased in a liquid or dry form, are almost always fed, or added, into the drinking water supply in a liquid form.

The equipment used for fluoridation is the same as for other water supply additives used in a treatment plant.

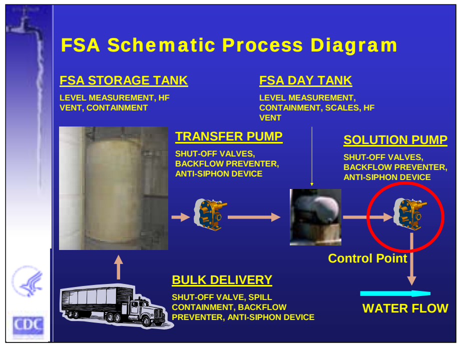


First, let’s look at how the different additives we discussed are fed into the water. Depending on which product is used, there are different methods for feeding the additives.

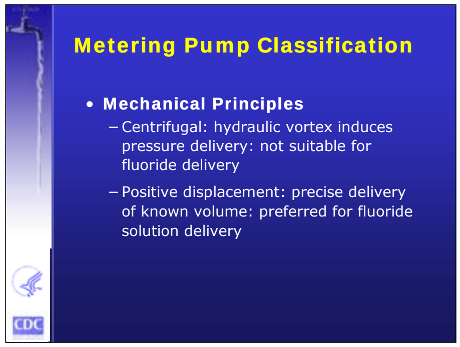
FSA can be fed into the water supply with a metering pump.

Saturated solutions of sodium fluoride (NaF) can be produced in a saturator and then fed into the water system with a metering pump.

Unsaturated solutions of either sodium fluoride or sodium fluorosilicate (NaFS) measured using dry feeders, on either a volumetric or a weight basis, are then added to water in a mixing tank, and then added to the water stream.



When FSA is the additive of choice, the process can be quite simple. If the facility is sufficiently large, then delivery can be by tanker truck and the FSA storage tank, with a 3-month supply, is filled by the tanker truck. A transfer pump would refill a day tank with a maximum 3-day storage volume. The final step is a solution metering pump to deliver a precise quantity to the water flow. Each step along the way would have a backflow preventer and anti-siphon device to minimize accidents. Unless a leak occurs, there is very little operator exposure. The solution pump is the control point for a FSA system.

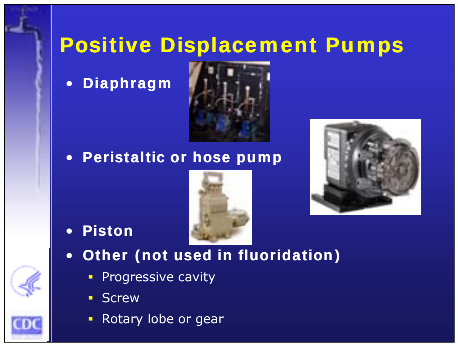


Pumps used to deliver fluoride products to drinking water must be accurate and consistent in their delivery rate. We want to maximize benefits and minimize the risk of fluorosis.

Metering feed pumps used in water plants vary in their actions and design but often are of two mechanical categories.

The centrifugal action pumps are widely used in water treatment plants and are sometimes used for other compounds but are not used for feeding fluoride into the water system, because their delivery can be variable and not very precise. You may recognize these as the small utility pumps you buy at the store or the sump pump in your basement. A centrifugal pump may be used as a transfer pump to move FSA from a bulk tank to a day tank but, as a rule, should not be used to feed into the system.

The other category of pump is the positive displacement pump, and the one we will discuss next.



As the name implies, positive displacement pumps are designed to deliver a constant amount of solution over a wide range of system pressures. There are three main categories of positive displacement pumps that traditionally have been used for water fluoridation.

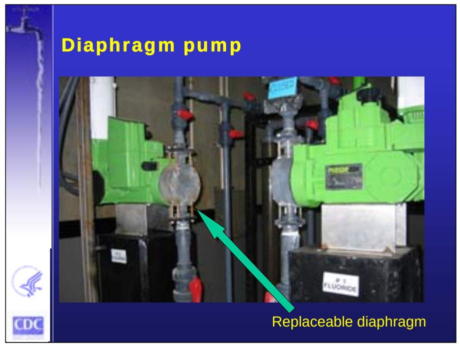
The most common fluoride feed pump is the diaphragm pump.

The peristaltic metering pump is gaining somewhat in popularity. A peristaltic pump is also called a hose or tube pump, because a hose is squeezed by a rotating element, resulting in delivery of a precise quantity of solution.

The piston pump has a piston that moves back and forth to pump the fluoride solution into the water main, much like the operation of an internal combustion engine. Its main advantage is for high-pressure applications. Its main disadvantages are a high purchase cost and high operating and maintenance costs. Some are still in use, but for the most part they are used less frequently for water fluoridation.

There are other positive displacement pumps, including the progressive cavity pump, the screw pump, and the rotary lobe or gear pump. These generally are not used for fluoride solutions, mainly because of the limitations of incompatible corrosion of the materials used to fabricate those pumps.

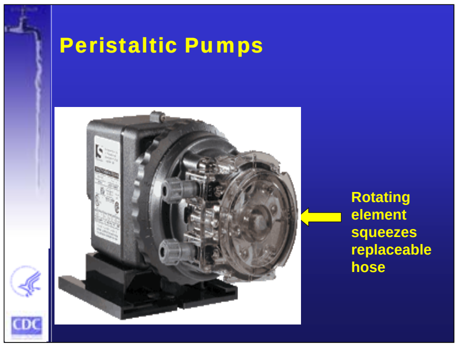
Best practice is to have the pump fed by a day tank and not from the bulk storage tank. The pump should not have a flooded suction as these can tolerate a suction lift, and that minimizes the potential for an overfeed event.



Diaphragm pumps have an oscillating membrane head, which alternately sucks the solution into the pump and then discharges the solution. Inlet and discharge check valves ensure that the fluid moves in one direction. The diaphragm pumps have a replaceable head, which should be replaced annually as a preventive maintenance measure. Also, the check valves need to be inspected and replaced if necessary.

Diaphragm pumps are currently the most common pump in fluoride feeding applications. They do offer good suction lift and the diaphragm protects that pump mechanism from the corrosive solution. They have a very wide feed range, up to 1:500, by varying the strokes per minute and length of stroke.

Diaphragm pumps can experience pulsating flow, although some of the newer ones have built-in flow modulators to minimize flow variability.



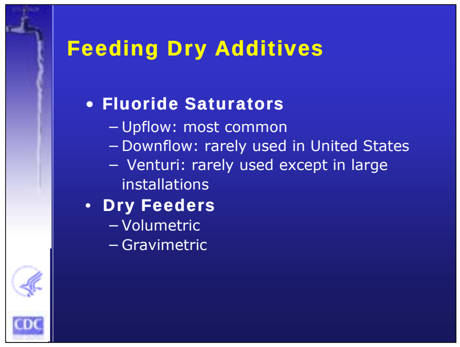
Peristaltic pumps were invented in 1971 as a concrete pump. But as soon as they were available, their value for chemical pumps was recognized.

Peristaltic pumps are also known as hose or tube pumps. They have a rotating element that squeezes the hose, delivering a precise quantity of solution. They have few moving parts and are easy to prime. The hose is replaceable and is the only wearing part. These pumps can provide a variable delivery by changing the speed of the rotating element—the faster it rotates, the more solution can be delivered, and by changing the diameter of the hose element. Some models can operate with large suction lifts. Typically, the hose is replaced annually. Although these have not been used as often in the past, they are gaining in popularity because of their ease of use and maintenance.

Peristaltic pumps have two main groups. The Tube Pumps have a relatively low discharge pressure of less than 40 psi limiting their usage to low-head applications. The reinforced hose pumps are able to achieve discharge pressures of up to 200 to 300 psi, but are more expensive and has a smaller range of capacities. Peristaltic pumps typically operate over a range of 1:200 or 1:300.

Peristaltic pumps are least likely to experience pulsating flow, so they have the best potential for reliable metering flow.

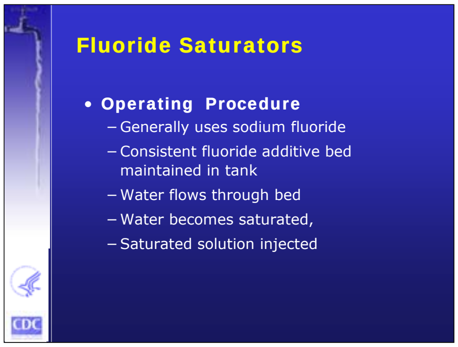
It is recommended that the storage tanks be enclosed in a designated room. This installation has a view window so that key controls and operations can be monitored without entering the room. This room also includes a depressed floor to provide firm spill containment in the event of a leak or spill. Not all treatment facilities have such a containment, but if your facility is considering an expansion or redesign, this is something to consider.



Dry additives typically are fed into the water system as a saturated or unsaturated solution. Either a saturator or a feeder can be used.

A fluoride saturator is a device to dissolve the dry additive, much like salt or sugar dissolving in water, forming a saturated solution. The most common type of saturator is the upflow saturator, which is typically used in the United States. The downflow saturator is rarely used and is not available in the United States. The venturi saturator has not been sold for many years, but occasionally you may encounter one. Saturators normally are used only with sodium fluoride, because it provides a saturated solution of known concentration, whereas sodium fluorosilicate has a variable solubility based on temperature, so the concentration of the saturated solution is difficult to predict.

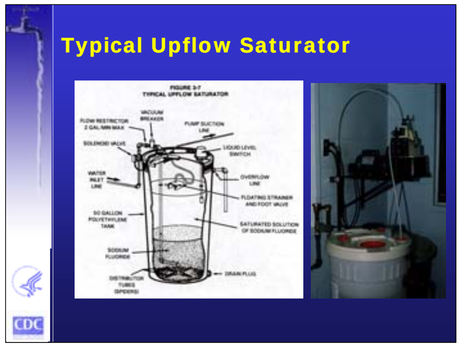
Dry feeders are more expensive than saturators, but they offer greater flexibility and can be used for either sodium fluoride or sodium fluorosilicate. Dry feeders are commonly used at water treatment facilities for dry additive feeds other than fluoride additives. They are commonly used to feed dry additive to a solution tank for mixing before addition to the flow. You need to discuss dry feeders with the manufacturers, either volumetric or gravimetric.



A fluoride saturator, either the downflow or the upflow type, maintains a bed, or layer, of sodium fluoride in a tank. Water flows through the bed and dissolves the sodium fluoride.

The minimum depth of the sodium fluoride in the saturator should be 12 inches, although a deeper bed of 16 to 18 inches is better, and this can be marked on the outside of the tank so that the operator can determine the depth of the additive at a glance. The saturator should never be filled high enough to allow some undissolved additive to reach the pump suction line. Only granular sodium fluoride should be used in a saturator, because the powdered additive tends to plug or allow short-circuiting of the water without becoming fully dissolved.

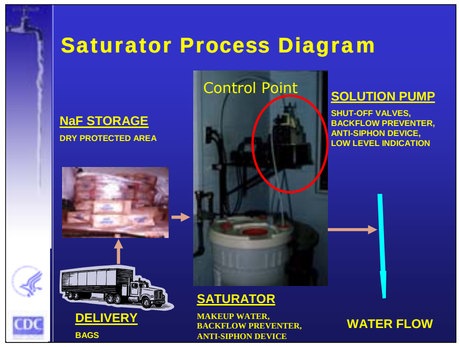
A chemical feed pump is then used to add a precise quantity of saturated solution to the drinking water supply.



By the 1980s, the downflow saturator had been replaced by the upflow saturator mainly because of operation and maintenance problems with the downflow saturator. One big advantage is that the sand and gravel were eliminated. But the inlet waterline is plumbed directly to the distribution piping at the bottom of the tank and, with no air gap possible, a vacuum breaker and backflow preventer are needed. This is one type of upflow saturator, but there are different varieties on the market.

One of the things you should notice in the photo is the small footprint or area required for the feed equipment. It can literally be put in the corner or along the wall—anywhere you have some open space.

The manufacturer of this saturator has a molded spot on the lid for the pump to sit on, but here it is mounted on a shelf. This makes it easier to reach the saturator for inspection and maintenance. An electrical outlet should be in series with the high-service or well pump motor starter. Having a flow switch is a good idea.



When a saturator is used, the process can be quite simple. The storage area should be convenient to the saturator for ease in filling, and the sodium fluoride is added to the saturator to maintain a uniform bed depth. Makeup water refills the saturator to create a saturated solution. The control point for a saturator is the feed pump which controls the addition of fluoride to the water flow.

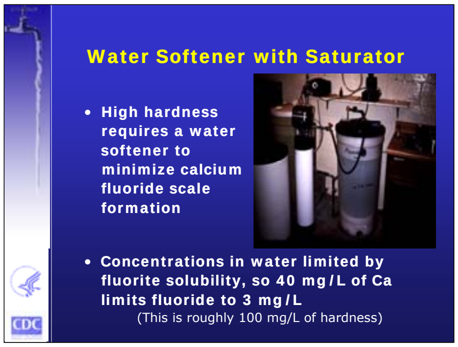
If operated properly, the solution is completely saturated by the time it passes all the way through the bed. For very small communities, the upper portion of the tank can serve as a day tank and the lower portion of the tank as the saturator. Every day, the operator verifies that there is sufficient additive in the bed and then turns on the water to fill the upper portion to the fill line. This displaces the saturated solution in the bed into the day-tank upper portion of the tank.

For larger flows, the saturator is inadequate for use as a day tank, and, in those cases, the saturator should be coupled with a day tank that is filled from the saturator. Although a standard saturator is roughly the size of a 55-gallon drum, very large saturators can be custom fabricated for use on larger facilities. However, a more typical application would be to use a dry chemical feeder for larger facilities.

This saturator is fabricated integrally with a solution containment in case of spill or overflowing.

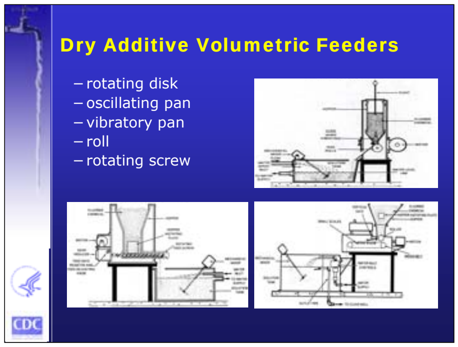
Saturators typically are used for sodium fluoride, because that additive forms a uniform solution of approximately 40,000 mg/L, or 4 g per 100 mL. With a typical available fluoride content of 45% (55% of the weight is sodium and 45% is fluoride), the saturated solution is a constant 18,000 mg of fluoride ion per L. Saturators can also be used with sodium fluorosilicate, but the solubility of sodium fluorosilicate varies according to water temperature, so the actual solution concentration is inconsistent. This would require constant testing of the concentration of the solution strength. Therefore, it is advisable to avoid using saturators for sodium fluorosilicate as the operational problems can be significant.

The inflow rate on the water makeup line needs to be regulated so the water does not travel through the sodium fluoride bed in less than about 10 minutes. For automated systems, it is normal to set the controls to refill the tank when the solution level drops one-quarter inch. For manual controlled systems that have a single refilling each day, try to avoid refilling solution greater than the bed depth. If the bed depth is 18-inches, do not refill more than 18-inches of solution.



In areas with high hardness, a water softener is often needed on the make-up water feed to minimize the potential for calcium fluoride scale formation. To avoid scale formation in hard water, either a water softener is needed, or FSA would be the system to minimize scale formation. 10-State standards specifies water softening if hardness exceeds 75 mg/L as calcium carbonate.

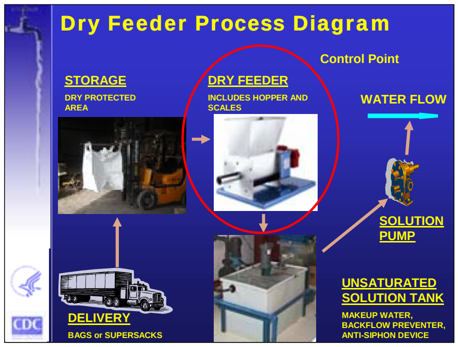
Dry feeders deliver a constant volume of fluoride additive and generally are used with sodium fluorosilicate; they can also be used with sodium fluoride.



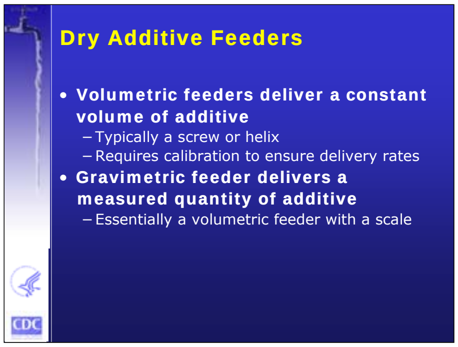
There are several varieties of dry feeders. These are useful if you are handling large quantities of dry additive and are also available for very small dry additive feed rates. They are more mechanically complex and are more expensive than a saturator. Although a saturator is a simpler operation, it is suitable for use only with sodium fluoride because sodium fluorosilicate does not have a constant solubility. The saturated solution of sodium fluorosilicate is temperature dependent.

A typical installation has the dry feeder deliver the additive to a solution tank. Dry feeders are fundamentally different than a saturator. A saturator prepares a saturated solution, whereas a feeder will add additive to excess dilution water in the dissolving tank. Consequently, a dry feeder does not require softened water, whereas a saturator often requires softened water.

A feeder is a better application for larger facilities and can provide more flexibility, with a choice of either sodium fluoride or sodium fluorosilicate feeds. If you think you want to use a dry additive and this is the type of feeder you want to use, then discuss the options with the various manufacturers.

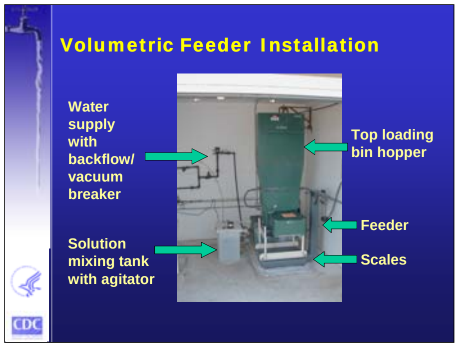


When sodium fluorosilicate is the additive of choice, the process can be quite simple. The additive, in bags or supersacks, is delivered to the facility. The material is dispensed by the dry feeder at a regulated rate, and is mixed with water in a solution tank to an unsaturated solution. Then it is fed to the plant flow. The control point is the dry feeder.



Volumetric feeders deliver a constant volume, but they require periodic recalibration to ensure a consistent delivery. Historically, volumetric feeders are the most common device for chemical metering in water plants due to their lower cost.

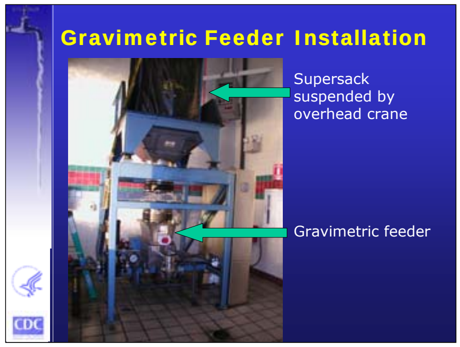
A gravimetric feeder is a volumetric feeder with a scale integrated with the feeder so that the feed rate can be maintained to a pre-set delivery level. The cost for this device is generally higher than a volumetric feeder, but they are more reliable.



A volumetric feeder can be a simple installation with a standard chemical feeder and a top loading bin hopper. The feeder will dispense a precise quantity of additive to the solution tank. The feeder and bin in this installation are mounted on a scale so that the amount of additive used can be precisely measured each day. If you have a high erroneous fluoride measurement, the scale allows the operator to verify the actual amount of additive that was used and compare the calculated and measured rates. The water supply has a backflow preventer and vacuum breaker to prevent backflow or siphoning of the solution into the water system.

This type of installation is typical of a sodium fluorosilicate feed. Because the solubility of the fluorosilicate varies with temperature, the solution pump is sized to deliver a constant feed rate based on the maximum quantity of solution at the lowest operating temperature for the largest facility flow rate, and the quantity of fluoride feed is precisely controlled by the speed of the feeder. The top loading bin hopper is sized for a 1- to 3-day supply of sodium fluorosilicate. The minimum time for mixing sodium fluorosilicate is 5 minutes, but sizing the solution mixing tank for a 10- to 30-minute detention will ensure good dissolution.

Here is another feeder installation. It has a slightly larger bin hopper, and there is a loading platform so the operator can have easy access to the bid feed location. For even larger facilities, the bin loading location might be on the floor above the one with the hopper, or you can get bin loaders with elevator lifts as part of the bid loading so the bags can be added at ground level of the building.



For high-capacity feed systems using a dry feeder, the feeder can be combined with a supersack. In this application, the supersack is suspended by an overhead crane eliminating the need for a feed bin. If the feeder is a gravimetric feeder instead of a volumetric feeder, then the feed rate can be documented. This installation uses a venturi for solution, but that is not recommended for fluoride unless it is directed to a tank for further mixing as sodium fluorosilicate takes approximately 10 to 20 minutes to fully dissolve.


Handling Supersacks
Lifted by overhead crane or forklift
CDC

Unlike sodium fluoride, which has a constant solubility, sodium fluorosilicate has a solubility that varies with temperature, from 0.44 g per 100 mL (which is 1/10th that of sodium fluoride) at 32°F to 2.45 g per 100 mL at 212°F. When the water temperature is 77°F, the solubility is approximately 0.762 g per 100 mL, or 1/5th the saturated solution strength of sodium fluoride at the same temperature. Consequently, it requires a lot more water to form a solution.

Experience has shown that sodium fluorosilicate requires a minimum of 5 minutes to fully dissolve into solution. However, hard water, water temperatures colder than 60°F, and a crystalline form of the additive instead of a powdered form can increase the time necessary to fully dissolve sodium fluorosilicate into solution. If any of these conditions exists, double the time for solution to 10 minutes, and if two or all three exist, then triple it to 15 minutes.

If a dry feeder is used for sodium fluoride, a 5-minute solution tank detention is normally satisfactory. However, it would be prudent to design the dry feeder to be suitable for either sodium fluoride or sodium fluorosilicate feed to give an operator the advantage of being able to use either additive. If the feeder is suitable for sodium fluorosilicate, it will be satisfactory for sodium fluoride. However, a system designed for sodium fluoride might not work properly for sodium fluorosilicate.

Verify with manufacturers on the compatibility of the materials, but there are some general considerations on acceptable materials of construction. For tanks, cross-linked polyethylene tanks are the best choice for FSA, but polypropylene, rubber-lined steel, or Kynar-lined steel tanks are acceptable. Rubber-lined tanks require inspection and repair of the rubber lining periodically.

Stainless or carbon steel tanks should be avoided. The nickel in austenitic stainless, such as grade 316, will form a partial protective nickel-fluoride surface, but the resistant film will not be continuous, and welded surfaces will be attacked. Fiberglas tanks can be used, but should only be used at larger facilities that have the resources and knowledge for inspection and repair of damage to the lining as the hydrogen fluoride can attack the embedded glass fibers. If concrete is used as a base for the tank or as a chemical containment barrier, then it should be coated to resist minor exposure using an epoxy undercoat with a urethane topcoat. Alternately, a manhole rehabilitation spray-on polyurethane coating could be satisfactory.

Rubber-lined tanks were the original material of choice. Although the rubber-lining of trucks or railcars is typically neoprene today, Gutta percha was the original. Gutta percha, made from latex-bearing sap of *Palaquium Gutta* or *Isonandra Gutta* trees native to the Malayan archipelago, was one of the first natural plastics to be exploited by man. Chemically, it is the same as that other rubber tree extracts. Brown in color, it softens in warm water and can be molded into any shape, resulting in a hard but not brittle character when cooled. "Gutta percha" is based on the Malay words "*getah*" (sap) and "*perca*" (strip of cloth). Gutta percha was used for electrical wire insulation until polyethylene replaced gutta percha as the insulator of choice.

Historically, paraffin bottles were occasionally used in laboratories for small quantities, since it's molecular structure of carbon chains with 20 atoms is similar to the long-chained carbon-based PE.

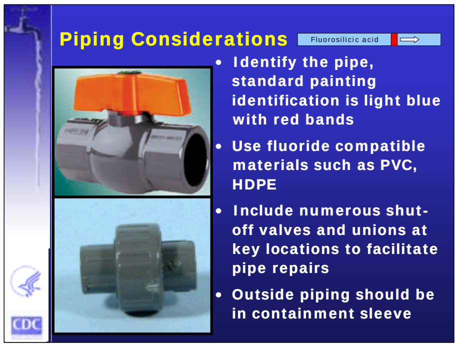
PVC, CPVC or Polyethylene piping is commonly used for FSA solutions, but polypropylene can also be used. PVC has been more commonly used, but its disadvantages are that it is a rigid connection with many joints for potential leaking where polyethylene is a flexible piping. Tygon tubing and neoprene rubber hoses can also be used, but typically used for hose or peristaltic pumps. Monel, a nickel-rich steel alloy, is FSA resistant and is suitable as an injector.

Stainless or carbon steel piping should be avoided, as well as copper tubing or brass fittings. Although neoprene rubber has good chemical compatibility to FSA, butyl rubber does not and should be avoided.

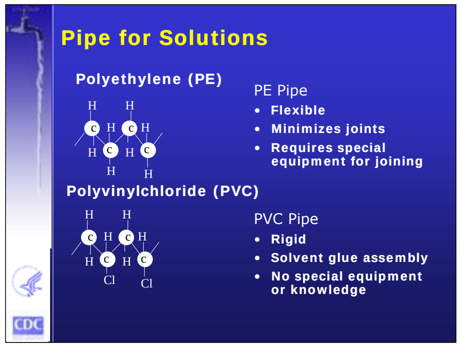
Pump materials can include many materials, considerably beyond what is shown here. In general, Teflon and Viton are both good materials, and other surface treatment may also be suitable. Check with your pump supplier and ensure that the materials are fluoride resistant. Teflon is a polyethylene with fluorine just like PVC is polyethylene with chlorine.

As with tanks and piping, avoid stainless and carbon steel surfaces.

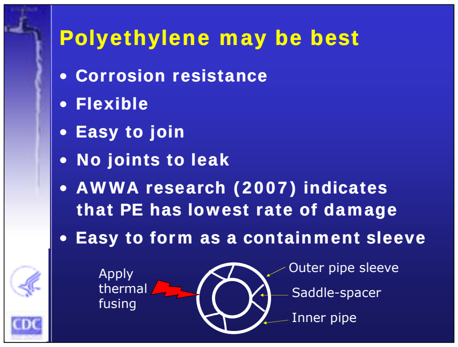
Sodium fluoride and sodium fluorosilicate solutions are more forgiving than FSA, due to their moderate pH and the absence of hydrogen fluoride, but the best practice is to stick with the same materials as would be suitable for FSA. By doing this, if there is ever the need to change additives, the system will already be compatible.



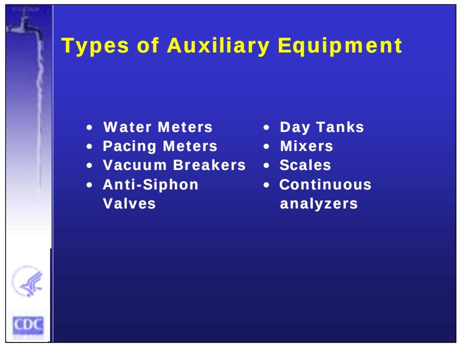
Use fluoride-compatible materials such as polyvinyl chloride (PVC), chlorinated PVC (CPVC), and HDPE in pipe manifolds. Be sure to include numerous shut-off valves and unions at key locations to facilitate pipe repairs. Use a color-coding system to clearly mark that the supply is a fluoride solution. A recommended painting scheme is light blue with red bands, with an arrow indicating the direction of flow and the word “Fluoride” on the pipe.



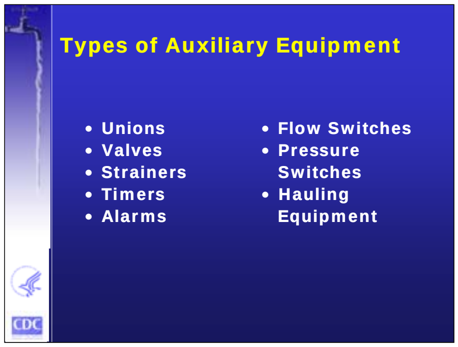
Polyethylene and Polyvinylchloride are the two pipe materials best suited for fluoride solution piping. They are both formed from ethylene gas, which as 2 carbon atoms, but are polymerized into long-strand carbon chains. PVC has one alternate hydrogen replaced by a chlorine atom. Their chemical resistance is approximately the equivalent, but their physical properties are quite different. PVC is historically the pipe material used for most facilities, and it is a rigid thermoset which needs to be “glued” using a chemical solvent. It will have many joints which are prone to leaking and as a rigid pipe, is subject to fracture. PE is a flexible pipe and as thermoplastic, can be joined by melting the edges to a continuous run without any leaks or potential leaking. However, this requires specialized equipment and experience by the fabricator.



I personally believe polyethylene pipe is the best for fluoridation. It has excellent corrosion resistance, it is flexible, easy to join with a small heating element, no joints to leak which is common with PVC, and AWWA research suggests it has the lowest rate of damage for pipe materials. Also, it is easy to form with a containment sleeve.

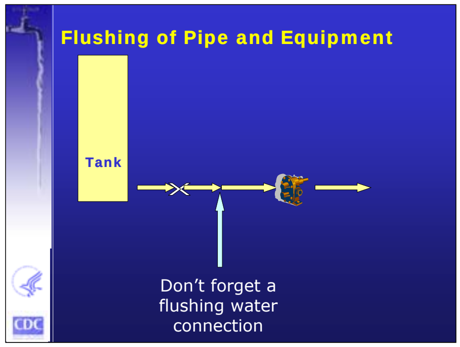


A complete system needs vacuum breakers, anti-siphon valves, and day tanks; it may also include water meters, pacing meters, mixers, scales, and continuous analyzers. As with any process, the more ability the operator has to operate and manage the system, the better will be the results.

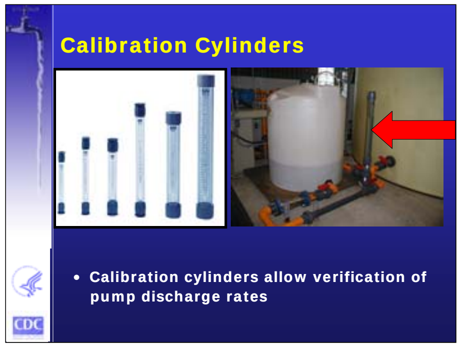


Whether you are installing a new system or rebuilding an older system, be sure to include the piping fittings and other auxiliary items to make your job easier.

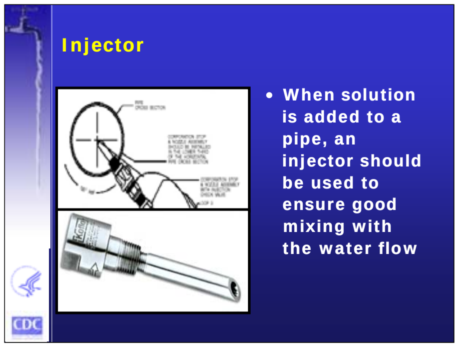
Backflow prevention and air-relief valves in key locations can preclude draining or siphoning tanks, which could result in overfeeds or solution spills.



When installing the equipment and piping, remember that it will be necessary to maintain or repair the equipment, and the solutions are potentially hazardous to personnel. Remember to install a flushing water connection so that pipes and equipment can be cleaned before being disassembled.

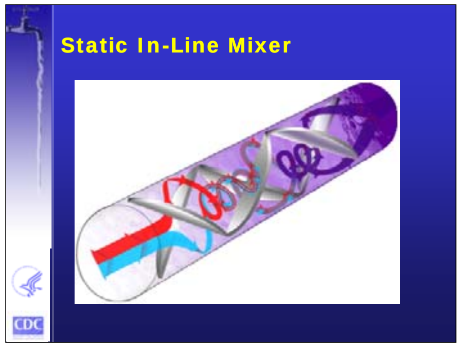


Calibration cylinders installed in the piping manifold allow pump discharges to be checked so that flows are accurate. This is particularly important with fluoride, as the flow rates tend to be very small.

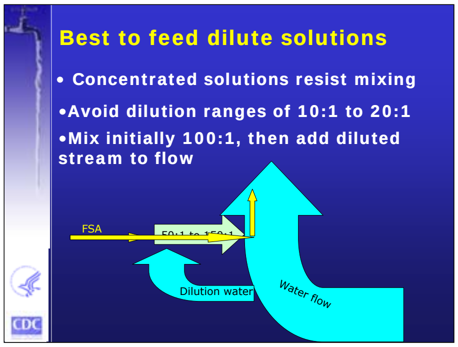


When adding solution to a pipe, an injector can enhance the mixing of the solution with the water flow. The injector should be placed in the lower third of the pipe and extend into the pipe approximately one-third of the pipe's diameter.

Some contractors will install the injector into the crown (top) of the pipe due to easy access, but this will result in poor mixing. The fluorosilicic acid solution is denser (heavier) than water, so if the injector is pointed down towards the pipe invert (bottom), then the solution will sink to the bottom of the pipe and the solution plume will be poorly mixed.

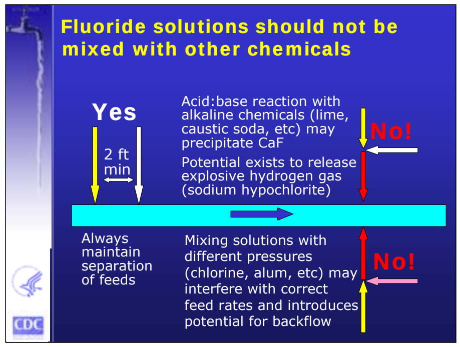


A static mixer is a screw-like vane pipe insert to promote mixing of the solution with the water flow. This is particularly important if the first customer is only a short distance downstream from the facility.

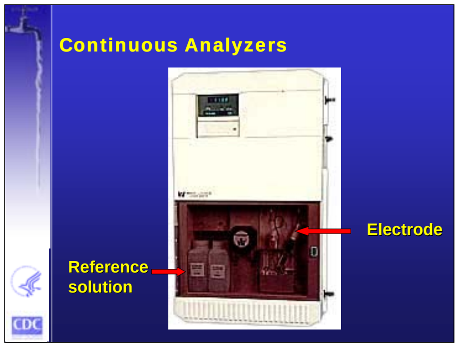


Concentrated solutions do resist mixing. If you have long pipe runs with several twists and turns, the solution will eventually mix, but if you want to ensure a rapid and consistent mixing, then use a dilution flow to dilute the concentrated FSA before adding to the main flow stream. Mix in the range of 100 to 1, avoiding the danger zone of 10:1 to 20:1 when scaling can occur.

Here are examples of silica deposits within pipes if the wrong dilution occurs. In one case, the strainer is clogged. In the other, the pipe scales. Remember, most waters have from 5 to 30 mg/L of silica, so there is a another source of silica that just from the FSA.



Fluoride solutions should not be mixed with other chemicals. And consider what potential reactions can occur when concentrated chemicals could potential react with each other.



Instrumental analysis has shown significant improvements in quality and reliability. This is also true for continuous online fluoride analysis. These units are available from $5,000 on the low end to $10,000 on the high end. The difference can be summed up by the adage “you get what you pay for.” However, these devices are becoming more common, and operators find that they are important operational tools to manage the fluoride level. They can also initiate actions at preset alarm points, which can be valuable at water facilities that are not manned 24 hours per day. In many facilities, the use of these devices ultimately saves operator time and improves the results. There will be increasing reliance on the use of these as well as other devices in the future.

Scales for drums and tanks are an excellent means of accurately documenting the use of fluoride solution. An advantage of using scales is that there is nothing extending into the atmosphere of the tank so hydrogen fluoride corrosion is avoided. If your installation does not have a scale, consider adding one for improved management and verification of precise fluoride feed. Scales can be obtained for any size, including for an entire tank. Normally, only a day tank needs to be weighed.

Electronic scales use an electronic load cell to measure weight. A load cell is based on a Wheatstone Bridge to provide precise measurement. One load cell provides accuracy to within 1 % and for typical solution day tanks would be a satisfactory measurement. For a typical small to medium sized plant with a day tank of 50 gallons or less, an electronic scale would cost approximately $3,000. For a dry chemical feeder with the feed bin mounted on top, a scale with three load cells would be accurate to within 0.1 % and could cost $3,500 to $5,000.

All tanks should have containment in the event of a spill. Commercially available containment pallets can provide secure protection for various sizes of tanks and totes. Be sure to have a containment pallet sufficient to hold the entire contents of the drum or container in the event of a spill.

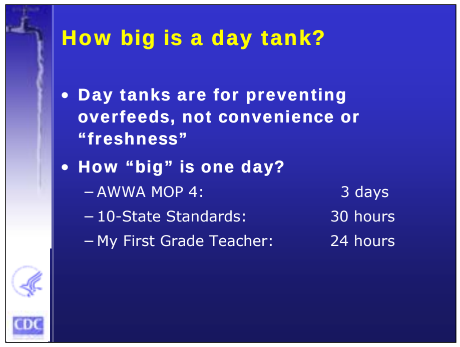
For handling bags of dry additive with hopper bins, a bag loader can minimize dusting, reducing operator exposure. The bags should not be torn open, but slit the top with a knife after it is secured in the loading swing-door to minimize loose dust.

It is always recommended that chemical additions be fed from a day tank, not the larger storage tank. The reason is that, in the event of an accident or error, a very large amount of additive could be accidentally added from the larger storage tank. However, use of a day tank avoids accidentally adding excessive fluoride. You will need to check your state regulations on the size of day tanks, for the recommendations can vary. 10-State Standards specifies a maximum of 30-hours, with AWWA suggesting that a day tank can be sized for up to a 3-day supply. Some state programs may have a smaller maximum permissible capacity. The CDC recommends that a day tank be sized for a 1- to 2-day capacity.

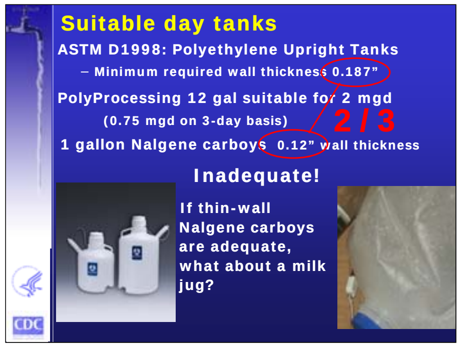
The saturator can also be sized to double as a day tank. The upper portion of the tank above the additive bed can serve as the day tank if it is sized appropriately. A volumetric feeder can also be sized with a feed hopper that can hold a designated amount of additive that is less than a 3-day supply.

The solution pumps should also be appropriately sized. If you are using a metering pump to deliver a precise quantity of saturated solution, then you want a high-quality pump with reliable delivery. The pump should not have excess delivery capacity. By matching the maximum delivery to only that needed for maximum delivery of the required fluoride solution at a peak design event, excessive feed of fluoride is avoided.

If you are using a volumetric feeder with unsaturated solutions, then the pump might be sized to deliver the peak flow needed to convey the fluoride additive at the peak flow event with the lowest operating temperature at the treatment facility.



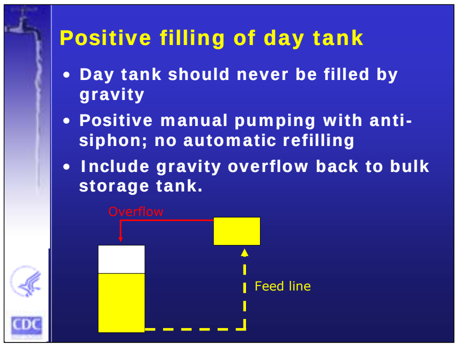
Day tanks are for preventing overfeeds. There are different criteria for a day tank, and the AWWA MOP No. 4 allows a 3 day tank, while the 10-State Standards only permits a 30 hour basis. A 30 hour capacity would avoid excessive feed rates if a pump and control system was improperly calibrated or incorrectly set by the operator. A 3 day limitation at 1 mg/L could still allow a 3 mg/L feed that would not exceed the MCL of 4 mg/L, but might result in a 12 mg/L level if the tank was fully discharged over a 6 hour period.



ASTM D1988 specifies that polyethylene upright tanks should have a minimum wall thickness of 0.187". PolyProcessing, a large supplier of polyethylene tanks, lists the smallest tank meeting this criteria as a 12 gallon capacity. This would suitable for a 2 mgd treatment facility at 30 hours, or a 0.75 mgd facility if you are willing to use the 3-day basis.

What about adapting a Nalgene laboratory carboy which can be in the range of 1 to 10 gallons? They only have a 0.12" wall thickness which is only two-thirds of the ASTM criteria, and would therefore be inadequate. Are you willing to sacrifice the criteria? What about a gallon milk jug that also has a thin wall? Would that be adequate? It gets back to the joke about the man asking a woman if she would go to bed with him for a million dollars and she agrees. Then he asks if she will do it for 50 dollars. She questions "Just what do you think I am?", and the man replies " We have already established what you are, now we are negotiating the price."

Can you use an electronic day tank to avoid the cost of a separate tank and the associated equipment. Electronic devices are subject to failure, so you would need a redundant measurement to verify that an excessive feed is not occurring. This could be a load cell set for pre-determined maximum weight loss in a certain time interval plus a continuous analyzer, or two redundant continuous analyzers.



Day tanks should never be filled by gravity feed. They need a positive pumping which is manually initiated. Never have an automatic refilling of a day tank. And a day tank should have an overflow return to the bulk tank.