

Stainless steel feed rollers, which are driven in opposite directions form the material into a smooth ribbon of uniform thickness. The feed rate is adjusted externally on a graduated feed slide by varying the width of this ribbon.

If the feeder is equipped with a variable speed drive, it has no feed slide. The feed rate is then adjusted by changing input rpm to the three-speed gearbox. Material leaves the rolls at a uniform rate, falls into a solution tank, and is discharged to the main water system.

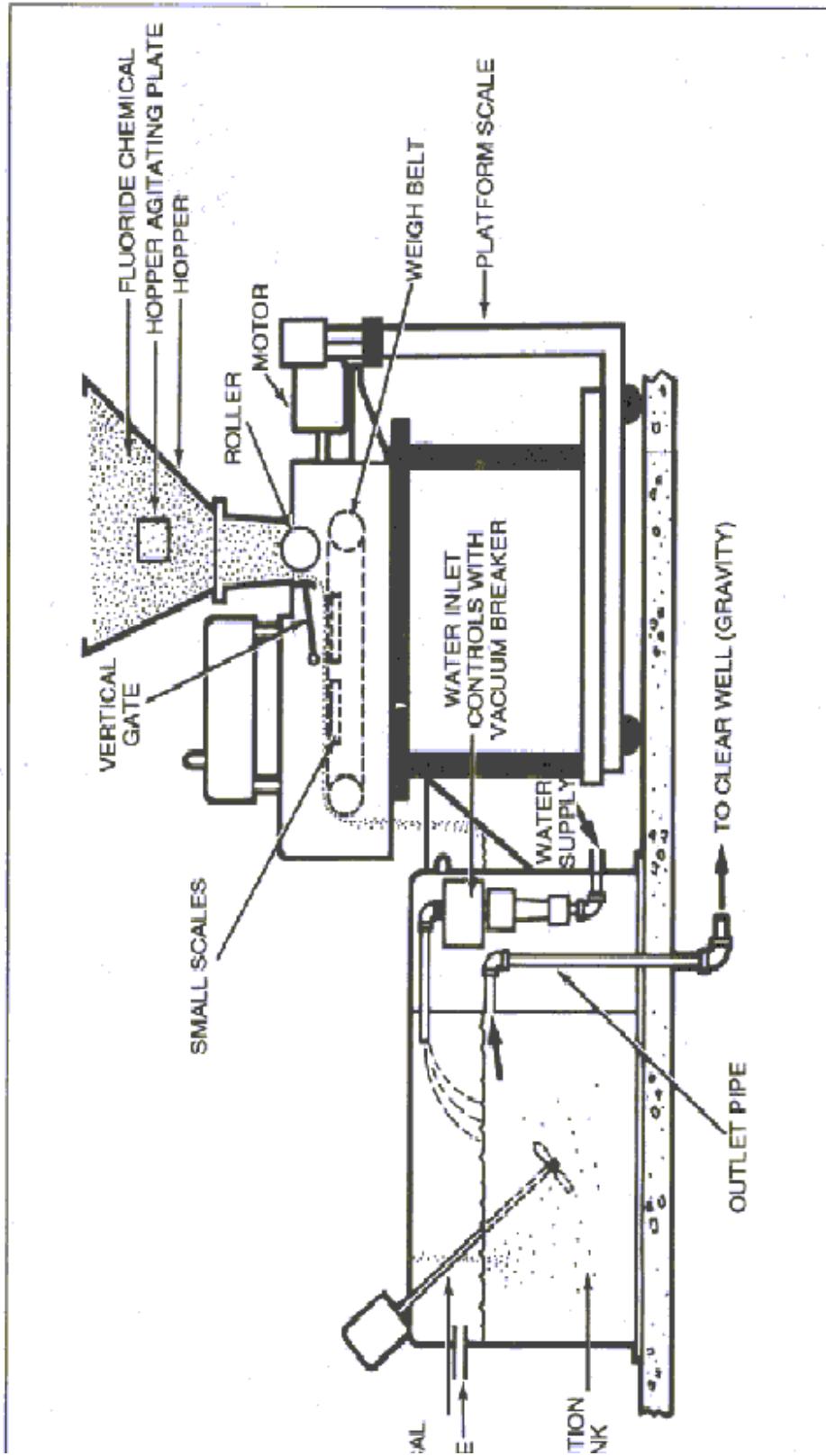
The roll-type volumetric feeder feeds powdery or granular dry, free-flowing materials at rates from 6 lbs/hr to 2,100 lbs/hr, although the very fine powder will tend to run freely through the rollers.

The oscillating-pan type of feeder consists essentially of a flat, narrow pan or trough into which the fluoride compound falls from a hopper above. Either the pan or the lower pall of the hopper slowly oscillates along the axis of the pan, forcing the removal along the two open edges of the pan of a portion of the chemical in the pan. Delivery rates are controlled by both the speed of oscillation and the length of the stroke or the thickness of the chemical on the pan.

The vibratory-pan dry feeder is a device for discharging a volume of chemical from a pan, chute, or trough made to vibrate electrically. A magnet is energized by means of a pulsating current (either ordinary alternating current or rectified, pulsating direct current). The trough is mounted on springs and connected directly to the magnet. The action of the tray is downward and backward on the power stroke, and upward and forward on the next stroke through the action of the springs. The material on the tray moves forward slightly on each stroke and appears to flow like water because of the high stroking frequency (3,600 strokes per minute on (60-cycle current). The rate of delivery is controlled by a rheostat, which determines the voltage and consequently, the degree of movement of the trough.

The most popular type of volumetric feeder is the rotating screw feeder. (**See Figure 3-7 page 45**) The fluoride chemical is placed in the hopper through the top. It settles to the bottom by gravity. An arrangement with vibrating plates in the hopper walls provides constant agitation. The agitation extends to the feed screw (hopper bottom) and is designed to prevent arching and packing. It also helps maintain uniform delivery to the feed screw. An eccentric on the feed screw shaft drives a rocker arm connected to vibrating plates in the hopper walls. The feed screw gives single-ended delivery of fluoride to the solution tank at a uniform rate via the discharge line. There is a range of feed rates between 0.02 and 5,000 lbs. per hour.

FIGURE 3-8
GRAVIMETRIC FEEDER, BELT-TYPE



3.4.3 Gravimetric Feeders

Gravimetric feeders discharge chemicals at a constant weight rather than at a constant volume during a given period of time. There are two general types of gravimetric dry feeders—those based on loss-in-weight of the feeder and those which are based on the weight of material on a section of a moving belt. Many gravimetric dry feeders also incorporate some of the features of volumetric feeders, in that they have rotary feed mechanism between the hopper and the weighing section, or use a mechanical vibrator to move chemicals out of the hopper. Since, ultimately, it is the weight of material per unit of time that is measured and regulated, such variables as material density or consistency have no effect on feed rate. This accounts for the extreme accuracy of which these feeders are capable.

The first type (loss in weight) consists of a hopper suspended from a scale system, an electrical-mechanical system for moving the poise on the scale beam, a mechanical means for moving the compound from the hopper in an amount depending on the position of the scale beam, and a solution tank. The lead screw drive (a synchronous motor) moves the poise along the beam at a pre-set rate of speed. If more material is fed momentarily than indicated by the position of the poise, then the beam will lower. This action moves the control wedge (near the oscillator) downward, permitting a decrease in the amplitude of the stroke driving the star wheel or vibrating feeder mechanism. Less material will then be delivered until the weight of the compound remaining in the hopper is again balanced by the weight of the scale beam. The margin of error in feeding for this type of feeder is generally less than 1 percent. The minimum delivery is 1.6 pounds per hour with range of feed in the order of 100 to 1, while some models can deliver more than 2 tons per hour.

The other type of gravimetric feeder is one in which a section of a loaded, moving belt is continuously weighed. (See **Figure 3-8 page 42**) The weight of the belt is balanced by a scale beam. The position of the beam controls delivery of the compound onto the belt. Any deviation from this weight on the belt causes the vertical gate to go up or down, thus causing more or less material to fall onto the belt. Vibrations imparted to a diaphragm on the hopper are generated by an eccentric and transmitted through a wedge that varies the amplitude of the vibrations, depending on the position of the scale beam. Accuracy in these feeders is in the order of 99 percent or more. Range of feed is as much as 100 to 1, and adjustments are readily made merely by moving the poise on the scale beam.

3.4.4 Solution Tanks

The materials discharged from a dry feeder are continuously dissolved in a chamber beneath the feeder. From this chamber the clear solution falls or is pumped into the water to be treated. This chamber has been referred to as the solution tank, dissolver tank, solution pot or dissolving chamber. While some chemicals can be fed directly into flumes or basins without using a solution tank, fluorides are not among them. The necessity for accurate feed rates will not permit the possibility of slurry feed, which may form build-ups of undissolved dry material.

Solution tanks come in sizes from 5 gallons on up, with the size often being determined by the size of the feeder under which they are mounted. If there is a choice, the largest size available should be used for fluoride compounds. Mixing of the chemical with water may be accomplished by a system of baffles, and agitation can be provided by a paddle driven by jets of water, but it is strongly recommended by CDC that a mechanical mixer be used. (Please refer to Section 3.5.7.) Experience has shown that the jet mixer is not nearly as dependable as a good mechanical mixer, even under ideal conditions. Solution tanks should be covered, if possible, and the lid should be lined with fiberglass. The solution tank should be made of stainless steel or fiberglass. Because of the corrosive nature of sodium fluorosilicate, painted metal solution tanks are not recommended.

FIGURE 3-7
VOLUMETRIC FEEDER, SCREW-TYPE

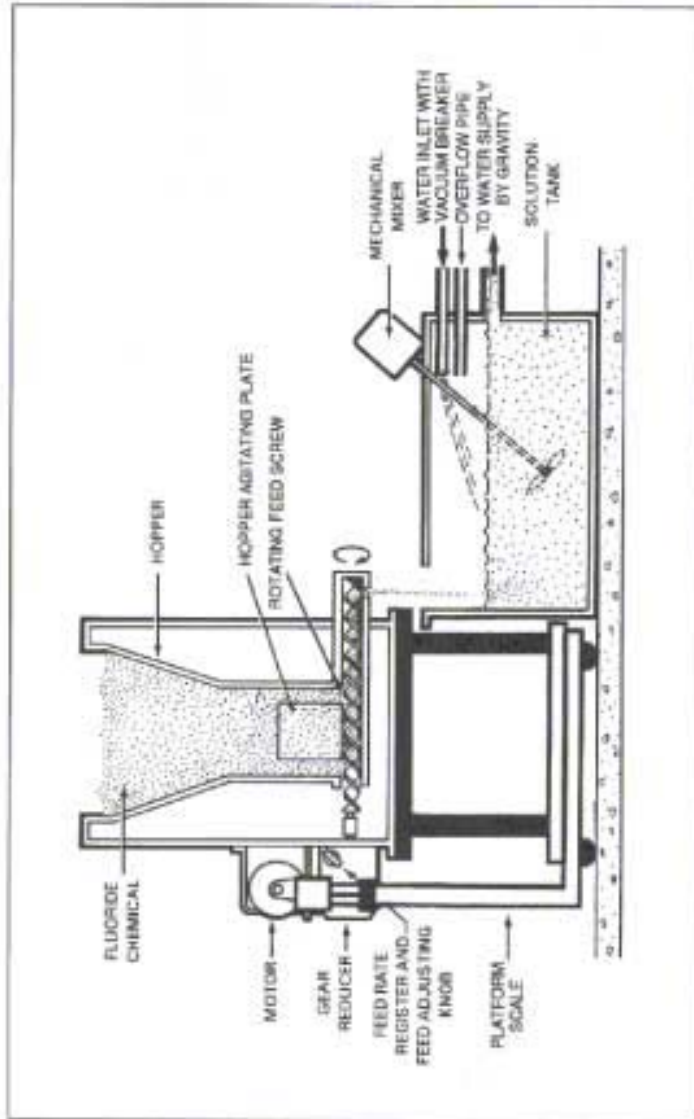
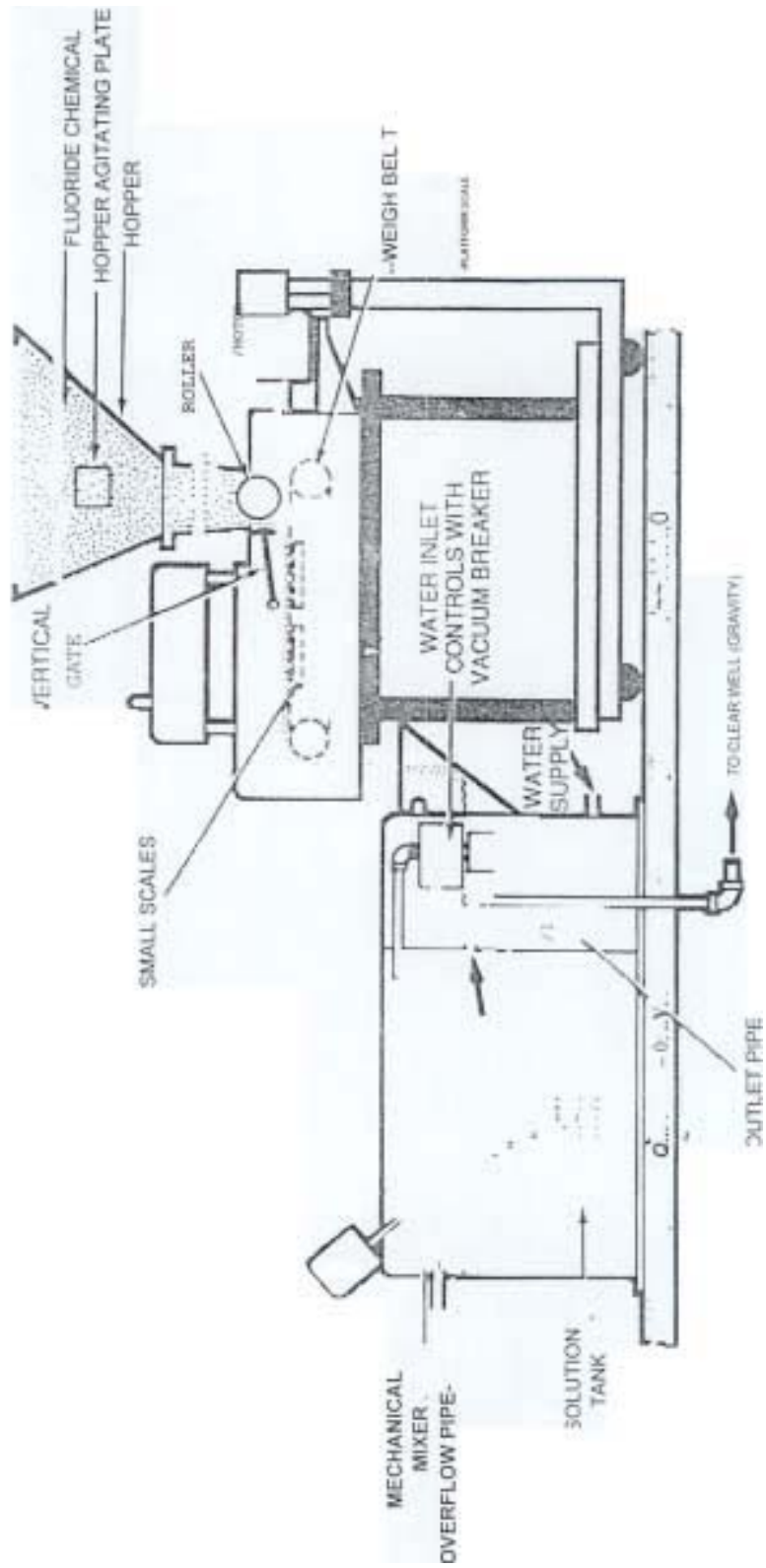


FIGURE 3-8
GRAVIMETRIC FEEDER, BELT-TYPE



The failure to produce a clear, homogeneous solution discharge from the solution tank of a dry feeder indicates that: (1) The solution tank is too small; (2) the detention time is too short; (3) too little solution water is being provided; (4) agitation is insufficient, and/or (5) dry chemical is short-circuiting and is not being adequately mixed with the water.

It has been determined experimentally that detention time (the length of time the fluoride compound remains in the solution tank) needs to be a minimum of 5 minutes to provide a concentration which is one-fourth the maximum solubility, provided the water temperature is above 60degrees F and the chemical is in the form of a fine powder. If the chemical is in the form of crystals or the water temperature is below 60 degrees F, the dissolving time should be doubled; if both, the time should be tripled (i.e., 15 minutes).

Short-circuiting (which is the flow of water directly from the inlet to the outlet without any mixing) is essentially a problem in the solution tank design, and is more likely to occur in the smaller tanks, If short-circuiting does occur, the remedy is to add baffles to the tank so that the path of the chemical to the outlet of the chamber is sufficiently deflected to provide the necessary mixing for solution.

Since the usual arrangement for a solution tank is to have the water inlet below the outlet, there is a cross-connection that requires adequate safety measures. If a break occurs in the water line, fluoride solution from the solution tank could be drawn back into the water line. If the solution tank is not already equipped with a correctly placed vacuum-breaker, one should be installed on the water inlet as near as possible to the entry and be elevated above the lip of the tank. If there is a solenoid or manually operated valve on the water inlet lines **the vacuum breaker must be installed between the valve and the tank** for adequate cross-connection protection. (See Section 3.5.4)

3.4.5 Dry Feeder Accessories

For holding the fluoride chemical, many dry feeders will be purchased with a small hopper. In large installations, an additional extension is provided above the main hopper for additional chemical storage. Access to the extension hopper is usually located one floor above the dry feeder. The sodium fluorosilicate, if stored on the second floor, can then be conveniently loaded into the hopper.

In small plants, the chemical hopper should be large enough to hold slightly more than the entire bag or drum of chemical. The hopper does not have to be completely emptied before a new bag or drum can be added. By loading an entire container this way, handling of chemicals, dust, and spillage is minimized.

When the hopper is installed directly above the feeder, the operator must lift the bag of chemical a considerable height to fill the hopper. A bag loader is essential in this situation. A bag loader is a hopper extension large enough to hold a single 100 lb. bag of chemical. The front of the loader is hinged so that it will swing down to a more accessible height. The bag is fastened by running an attached rod through the bottom of the bag.

The bag is then opened and the loader is swung back into position. This device makes emptying the bag easier and minimizes dust.

Handling powdered dry chemicals always generates dust. For this reason, an operator should wear a respirator. When small quantities of fluoride are being handled, ordinary care will minimize dust, and good housekeeping plus an exhaust fan, will keep the storage and loading area relatively dust-free. However, when larger quantities (more than one bag at a time) are handled, dust prevention and collection facilities should be provided.

A dust canopy that completely encloses the hopper-filling area and is equipped with an exhaust fans prevents dust from spreading throughout the loading area. To prevent dust from escaping into the atmosphere and into the area surrounding the water plant, dust filters should be incorporated into the exhaust system. Dust collectors and exhaust fans are sometimes incorporated into the hoppers of larger dry feeders.

A float in the hopper lid indicates the level of material in the hopper. The sides of the hopper and the built-in guide vanes flex with an oscillating motion to provide constant agitation. This prevents arching, caking, or packing and assures uniform feeding to the feed rollers.

It is strongly recommended that a beam scale be used to weigh the dry chemicals or solutions that are added. A recorder can be attached to keep a record of the weight of the chemical fed. Many volumetric dry feeders have recorders available as an accessory.

3.4.6 Calibration of Dry Feeders

The rate of feed of a dry chemical feeder can be varied by adjusting the controls according to a scale. The numbers on this scale have no particular units and cannot be converted to ppm or mg/L until a calibration chart or curve has been prepared. A separate calibration chart is required for each machine and for each chemical fed by the machine. If it is possible to operate your water plant at more than one rate, then you must also have different calibration charts for each plant rate.

To calibrate a dry feeder, fill the hopper to the normal depth with the chemical to be fed. Be sure the chemical is dry, free-flowing, and contains no lumps.

Set the machine adjustment on a low number-certainly lower than the normal operation. Allow the machine to run for few minutes so that it is feeding uniformly. Use a pan or cardboard box (which has been weighed empty), to catch the total discharge of chemical from the feeder for several minutes (say 5 minutes). Weigh the chemical on the laboratory balance (in grams) and record on a chart.

Repeat the same operation for other scale settings on the machine usually four or five different settings. Be sure to cover the full range at which the feeder will be operated.

Post the calibration curves near the machine (be sure to label each curve for the right machine) so that they can be used without mistakes or loss of time.

The feed rate of a given machine, when operating at a given setting, will vary, depending on machine wear, humidity, variation in texture of the chemical being fed etc.; therefore, **a calibration curve should not be used over an extended period without verifying the accuracy of the curve.**

3.5 Auxiliary Equipment

3.5.1 Introduction

Most water systems that add fluoride do need additional equipment beyond the bare minimum equipment required. The following sections will explain each type of auxiliary equipment commonly used and where each item belongs in a fluoridation system. As the size and complexity of the fluoridation system grows, the amount and complexity of auxiliary equipment required also increases.

3.5.2 Water Meters

Meters are used for two primary purposes in water plants in connection with fluoridation. One use is to register total flow (water flow) to determine the amount of fluoride chemicals based on water usage. The other important use is as a pacing meter for variable flow conditions. The pacing meter will vary the frequency of a metering pump to maintain a desired fluoridation dosage at any flow rate.

The water meter, often absent in the smallest water plants, is one of the primary requisites for accurate fluoride feedings. A water meter measures the flow of water in a water line (volume). Usually, the unit of measurement is gallons or cubic feet. This type of meter in the water line at home is read once a month and the difference between two months' figures is the amount of water used that month. But note, that with a water meter there is no way to know the **rate of flow** or when the water was used.

One other use of small totalizing water meters is to record the make-up water for a sodium fluoride saturator. The amount of make-up water is directly related to the amount of sodium fluoride injectors since a saturator provides a constant 4 percent solution. By relating make-up water to total water being treated over an equal time span, fluoride dosage can be monitored and adjusted. This requires the smallest type of positive displacement totalizing water meter available (usually 5/8") that will record low flows since saturator make-up flows are very low. Many times the term "water meter" is used to describe water meters, flow meters, pacing meters, compound meters, etc. While this is incorrect, it is a common practice in the waterworks field.

3.5.3 Pacing Meters

A flow meter, in contrast to an ordinary water meter, measures **rate of flow** rather than **volume of flow**. It registers units of gallons per minute, gallons per hour, cubic feet per minute etc. and is installed in-line where the flow is to be measured. Some types of flow meters, in addition to measuring the rate of flow can also produce signals relative to the rate of flow. These flow meters are called pacing meters.

Many water systems, because of their design, will have varying flows. Varying flows can be the result of: (1) gravity flow; (2) systems that have two or more water pumps that feed into a common line and are not always all operating simultaneously, and (3) a variable output from pumps because of a changing head. It can be more economical to use one fluoridation system paced by a meter on a common main than to have a system for each pump. The paced systems is generally more accurate than a chemical metering pump timed to turn on with a water pump.

Pacing meters provide a signal that is proportional to rate of flow. Some meters also provide totalizing as a secondary function, which is useful but not necessary. This signal that is proportional to rate of flow controls the fluoride injection pump output, which is also directly proportional to the water flow in the line being treated, so as to maintain the desired dosage ratio at all flow rates possible.

Two types of signals are generally used for pacing chemical metering pumps. They are the standard analog 4 to 20 mA DC instrument signal and a digital signal whose frequency is proportional to flow rate and digitally proportional to volume.

A pacing meter is a complicated piece of equipment and should only be used in fluoridation systems when it is necessary. In a typical water plant, when there is only one well pump operating at a fixed rate, the fluoride feeder can be tied electrically to the pump operation and a pacing system is not required. When the well is in operation, the water flow is constant, and the fluoride-metering pump can feed at a constant rate. Generally, a meter paced system is necessary when the rate of flow past the point of injection varies by more than +15-20 percent of the average flow.

3.5.4 Vacuum Breakers

The simplest method for preventing a potential back-siphonage situation is to provide an air-gap in the line. Since an air-gap is sometimes impossible or impractical, a device known as a vacuum breaker is installed.

Many states require a vacuum breaker (non-pressure type) on the potable make-up water lines to upflow type saturators, dry feeder solution tanks, and hose bibs located in the fluoride area. The most common use in fluoridation is on the make-up water lines to the saturators. (See **Figure 3-9 below.**) The vacuum breaker is different from a metering pump anti-siphon (backpressure) valve, and the two must not be confused.