CHAPTER 4

INSTALLATION OF FLUORIDATION SYSTEMS

4.1 GENERAL

It is impossible to discuss installation of fluoridation equipment without some basic knowledge of water treatment systems. While detailed descriptions are beyond the scope of this manual, some basic facts can be presented. Some simplification is necessary in the interest of clarity. This chapter includes some terms, such as rapid sand filters, clearwells, flocculation basins, solid contact basins, etc. without providing detailed explanations. We suggest that the reader refer to a good textbook on water treatment plant design for additional information.

The legal requirements pertaining to the implementation of water fluoridation in South Africa are contained in the regulations on the fluoridation of public water supplies, but there are no national laws, regulations, or requirements governing the design or installation of fluoridation equipment.

4.2 TYPES OF WATER PLANTS

The installation of the fluoridation equipment, especially the point of injection, depends greatly on the type of water system or water treatment plant. While the classification of water plants can be confusing even to engineers, broad general types of systems can be identified. (See Table 4-1 below.)

The three major types of water systems are the single well, conventional surface water treatment plant, and the water softening treatment plant. Many times the water system is one of these major types but much more complex. For example, the multiple well water system is a complex single well system. The solids contact treatment plant is a form of water treatment plant which combines the rapid mix, flocculation, and setting basins into one unit. An iron and manganese removal treatment plant may require aeration and other additional treatment steps. (See Figures 4-1, 4-2 and 4-3)

Sometimes the water system is a combination of the three major types. For example, a large water system may include a well field, conventional treatment and softening. Sometimes it is hard to type cast a particular water plant because it will contain several types within its system.

TABLE 4-1
TYPES OF WATER SYSTEMS

Type of System	Source of Water	Chemicals Commonly Used*
Single Well	Ground	Chlorine, Fluoride, Polyphosphate
Surface Water Treatment Plant	Surface (Lake, River)	Chlorine, Fluoride, Lime, Alum, Potassium, Activated Carbon, Polyelectrolyte, Permanganate
Water Softening Plant	Ground/Surface	Chlorine, Fluoride, Alum, Lime, Carbon Dioxide,

		Polyphosphate,
Multiple Wells	Ground	Chlorine, Fluoride, Polyphosphate
Distribution	Other Systems	Chlorine, Fluoride
Solid Contact (Water Softening) Plant	Ground/Surface	Chlorine, Fluoride, Alum, Lime, Polyphosphate, Carbon Dioxide
Iron/Manganese Removal Plant	Ground/Surface	Chlorine, Fluoride, Potassium Permanganate, Manganese, Greensand
Ion Exchange	Ground/Surface	Chlorine, Polystyrene, Resins

FIGURE 4-1
SINGLE WELL WATER SYSTEM

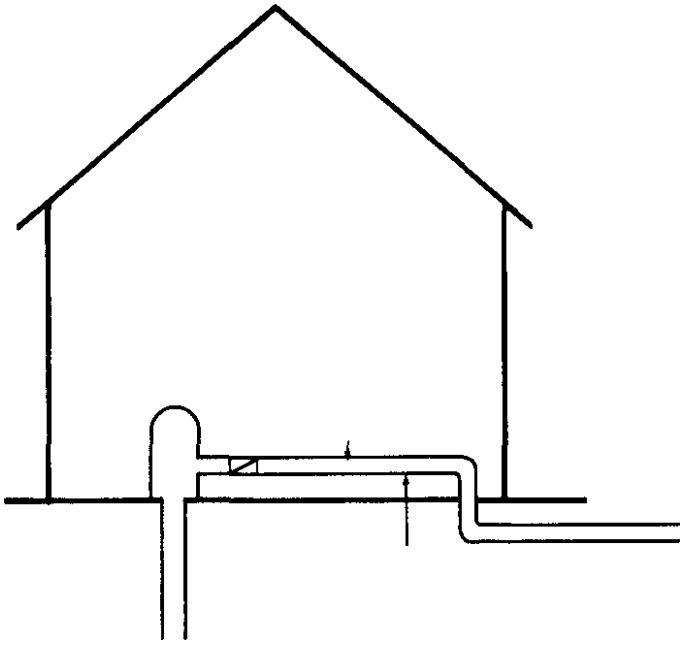
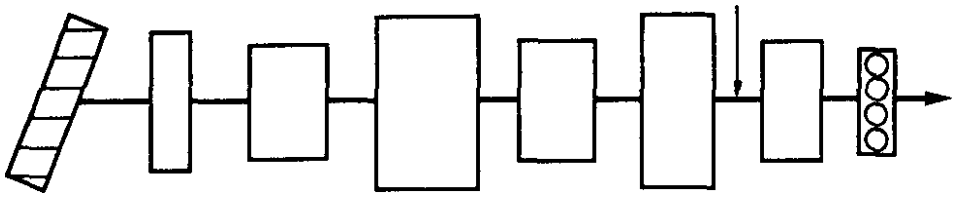


FIGURE 4-2
DIAGRAM OF A CONVENTIONAL TREATMENT PLANT FOR TREATING SURFACE WATER



4.3 CHEMICALS USED IN WATER TREATMENT PLANTS

The number and kind of chemicals used in a water treatment plant vary widely. (See Table 4-2) In general, the chemicals used depend on the characteristics of the water to be changed rather than the type of water plant. For example, chlorine is used for disinfection, fluorides for fluoridation, activated carbon for taste and odor control, etc. The specific type of chlorine or fluoride chemical used may depend upon the type of water plant for example, sodium hypochloride and sodium fluoride in a single well system and gas chlorination and sodium fluosilicate in a large conventional treatment plant.

In order to make the pipes easier to identify, painting the pipes in the pipe galleries of water treatment plants is a good practice. Color coding helps to prevent possible errors when taking samples or per- forming maintenance. The name "fluoride" and the direction of flow should be printed on the pipe.

4.4 FLUORIDE INJECTION POINT

The first consideration in selecting the fluoride injection point is that it must be a point through which all the water to be treated passes. In a water plant, this can be in a channel where the other water treatment chemicals are added, in a main coming from the filters, or in the clear well. If there is a combination of facilities, such as a treatment plant for surface water plus supplemental wells, it must be at a point where all water from all sources passes. If there

is no such common point, it means that separate fluoride feeding installations will have to be made for each water facility.

Another consideration in selecting a fluoride injection point is the question of fluoride losses in filters. Whenever possible, fluoride should be added after filtration to avoid the substantial losses that can occur, particularly with heavy alum doses or when magnesium is present and the lime-soda ash softening process is being used. There can be up to a 30 percent loss if the alum dosage rate is 100 ppm of alum. On rare occasions, it may be necessary to add fluoride before filtration, such as in the case where the clearwell is inaccessible or so far away from the plant that moving chemicals would not be economical, or to avoid a second separate injection point.

When other chemicals are being fed, the question of chemical compatibility must be considered. If any of these other chemicals contain calcium, the fluoride injection point should be as far away as possible in order to minimize loss of fluoride by precipitation. For example, if lime (for pH control) is being added to the main leading from the filters, fluoride can be added to the same main but at another point, or it can be added to the clearwell. If the lime is being added to the clearwell, the fluoride should be added to the opposite side. If it is not possible to separate injection points, an in-line mixer must be used. If post-lime is added in treatment, it is preferable to use a sodium fluoride make-up water line before the lime is added.

In a single well system, the fluoride injection point will be in the discharge line of a pump. If there is more than one pump, it can be in the line leading to the elevated tank or other storage facility. In the surface water treatment plant and the water softening plant, the ideal location of the fluoride injection point is in the line from the rapid sand filters to the clearwell. This will provide maximum mixing. Sometimes the clearwell is located directly below the rapid sand filter, and discharging any chemicals directly to the clearwell is difficult.

TABLE 4-2
CHEMICALS USED IN A WATER TREATMENT PLANT

	NAME	USE
*	1. Ammonia (anhydrous)	Disinfection
*	2. Hydroxide ammonium	Disinfection
	3. Ammonium sulfate	Disinfection
	4. Bromine	Disinfection
	5. Chlorine (gas)	Disinfection, oxidation agent
	6. Chlorine dioxide	Disinfection
	7. Hydrochlorites	
	Calcium hypochlorite (HTH)	Disinfection
	Sodium hypochlorite (household bleach)	Disinfection
*	8. Ozone	Disinfection
	9. Silver nitrate	Disinfection - home units
	10. Ultraviolet light	Disinfection
	11. Activated carbon	Adsorption material
	12. Charcoal (carbon)	Adsorption material
	13. Aluminum ammonium sulfate	A metal coagulant, dechlorinator
	14. Sulfur dioxide	Dechlorination agent
	15. Sodium sulfite	Dechlorination agent

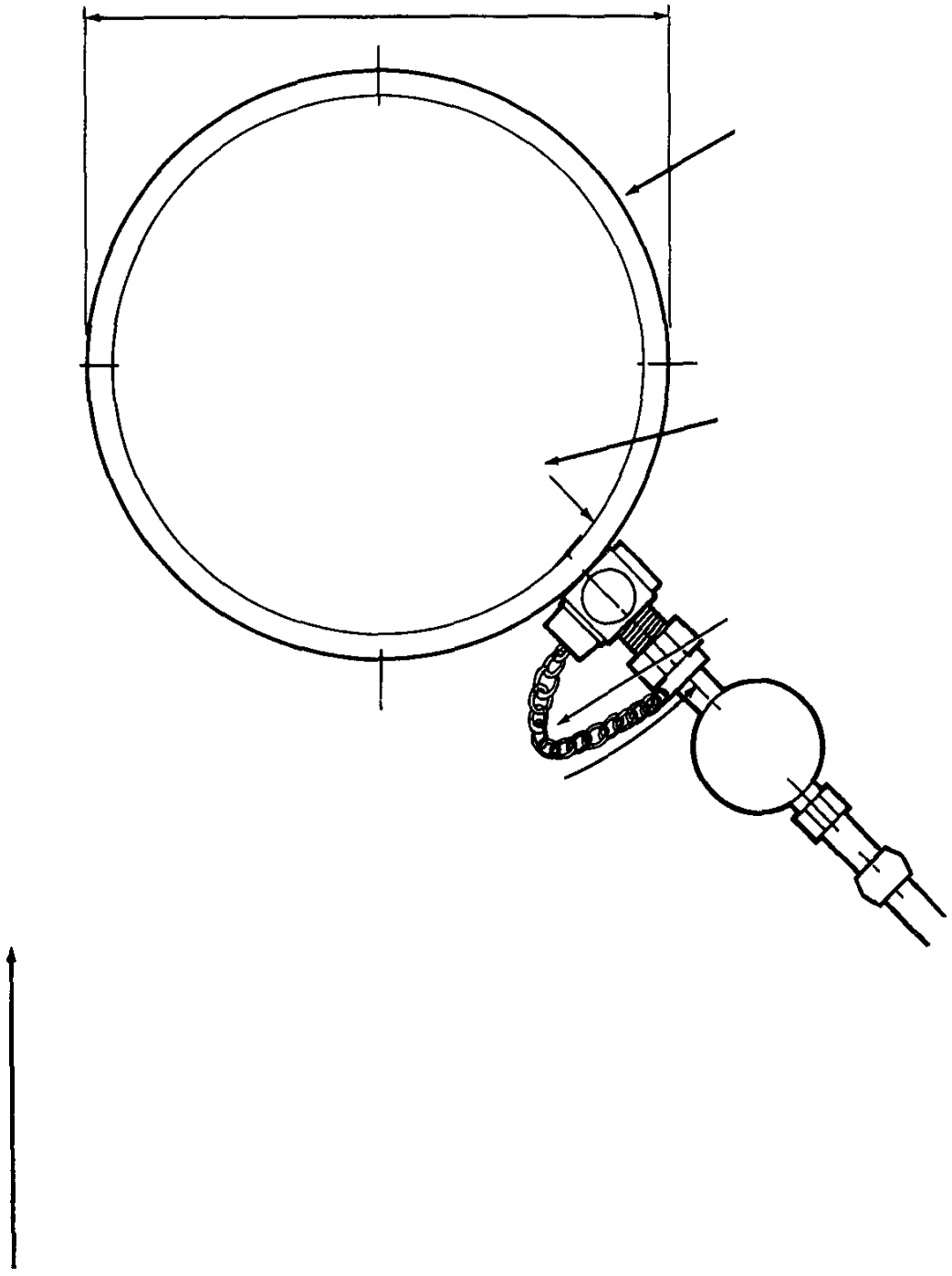
	16. Sodium bisulfite	Dechlorination agent
	17. Sodium thiosulfate	Dechlorination agent
	18. Ion - exchange resins	Water softener media
	19. Sodium chloride (salt)	Water softener media
	20. Glauconite (greensand)	Water softener media
	21. Silica sand	Filter media
	22. Anthracite coal	Filter media
	23. Aluminum sulfate (alum)	A metal coagulant
	24. Ferric sulfate	A metal coagulant
	25. Ferrous sulfate	A metal coagulant
*	26. Ferric chloride	Coagulant
	27. Sodium aluminate	Coagulant pH control
	28. Aluminum potassium sulfate	Coagulant
*	29. Calcium oxide (quick lime)	pH control, coagulant
	30. Calcium hydroxide (hydrated lime)	pH control, coagulant
	31. Clay (Bentonite)	Coagulant aid
	32. Calcium carbonate	Coagulant aid, pH control
	33. Activated silica	Coagulant aid
	34. Sodium silicate	Coagulant aid
	35. Sodium carbonate (soda ash)	pH control, coagulant
	36. Carbon dioxide (gas)	pH control
*	37. Hydrochloric acid	pH control
*	38. Sodium hydroxide	pH control, corrosion control

	39. Sodium bicarbonate (NaHCO3) (baking soda)	pH control
*	40. Sulfuric acid	pH control
*	41. Potassium hydroxide	pH control
	42. Potassium permanganate	Disinfection, remove color, oxident
	43. Polyelectrolytes	Coagulant aid
	44. Polyphospates	
	Calcium polyphosphate	Corrosion control, Iron control
	Zinc polyphosphate	Corrosion control, Iron control
	Sodium tri-polyphosphate	Corrosion control
	Sodium hexa-metaphosphate	Corrosion control
	45. Sodiumfluoride	Fluoridation
	46. Sodium fluorosilicate	Fluoridation
*	47. Fluorosilicic acid	Fluoridation
	48. Coppersulfate	Algae control

*** Very hazardous material for plant operator**

At the fluoride injection point, the location of the chemical line should be 45 degreesfrom the bottom of the pipe and protrude 1/3 of the pipe diameter into the pipe. This will allow better mixing without sediments collecting around the injection point. The fluoride injection point should never be located at the top of the line because of the air binding problems. A valve, injection nozzle, or corporation stop should be part of the installation. It is strongly recommended that an anti-siphon device always be included. (See Figure 4-4 below.)

FIGURE 4-4



4.5 EQUIPMENT INSTALLATION

4.5.1 General

Fluoridation installation should be considered during the design stage. The decisions made during the design phase will greatly affect the installation. The best installation is one that incorporates as many of these factors as possible:

1. Simple, accurate feeding equipment
2. Minimum chemical handling
3. Consistent with the above two factors, the lowest overall cost based on

amortization of equipment and cost of chemical
4. Ease in collecting reliable records
5. Minimum maintenance of feeder, piping, and injector equipment

A thorough knowledge of the types of equipment available is a must in order to determine the best installation.

Before a type of feeder can be selected, sufficient and appropriate space for its installation must be provided. If there is an existing water plant where other water treatment chemicals are being fed, usually space for an additional feeder is no problem. If there is no treatment plant, as is often the case with well systems, then there may be a well house, or perhaps even some type of shelter, near an elevated storage tank. The feeder must be placed in a dry, sheltered area, near the point of fluoride injection, and preferably in a place that has storage space for chemicals. Electrical power (in most cases) and a water line for solution preparation must be available. The location must be accessible for chemical replenishment and maintenance. Other than these basic requirements, consideration should be given to the desirability of isolation of chemical storage from other materials, for adequate ventilation, and for general convenience.

When the fluoridation system is tied electrically to the well pump, it should be physically impossible to plug the fluoride metering pump into any "hot" electrical outlet. The pump should be plugged only into the circuit containing the overfeed protection. One method of ensuring this is to provide a special plug on the metering pump which is compatible only with a special outlet on the appropriate electrical outlet. This special plug should be clearly labeled. This recommendation is true for both acid feed and saturator systems.

The fluoride feed system must be installed so that it cannot operate unless water is being produced (interlocked). For example, the metering pump must be wired electrically in series with a main well pump or a service pump. If a gravity flow situation exists, a flow switch or pressure device should be installed. The interlock might not be required for water systems that are manned 24 hours per day. The fluoride feed line(s) should be either coloured-coded, when practical, or clearly identified by some other means. Colour coding helps prevent possible errors when taking samples or performing maintenance. The word “fluoride” and direction of flow should be indicated on the pipe. The priming switch on the metering pump must be spring-loaded to prevent the pump from being started erroneously with the switch in the priming position.

4.5.2 Fluorosilicic Acid Installation

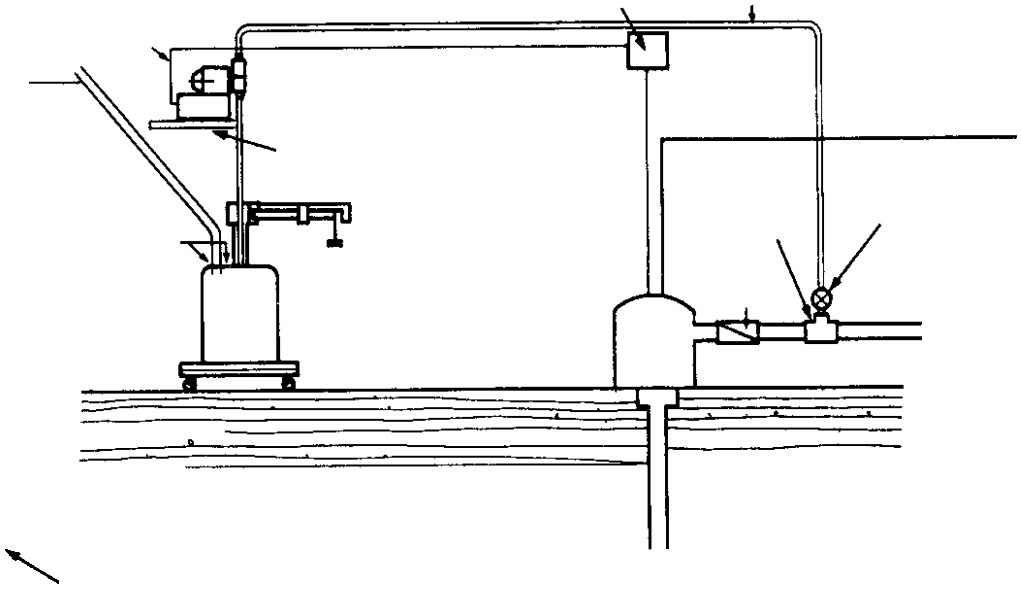
The simplest and easiest fluoridation installation is an acid feed system with a single well. The typical installation would include a carboy of acid (or drum), small metering pump, and scales. The carboy (or drum) should be vented to the outside and sealed around the pump intake line and vent line. If the room where the fluoride equipment is located is exposed to strong direct sunlight, the tubing pigment should be black. The black color screens out the
ultraviolet rays, which can cause cracking of the translucent tubing.

The metering pump should be located on a shelf not more than 1,22 meter above the carboy or solution container, if possible. Note: Many manufacturers recommend that the pump be located so that it has a flooded suction line (low). This is not

recommended in fluoridation. The suction line should be as short and straight as possible, there should be a foot-valve and strainer at the bottom and, if necessary, a weight to hold it down.

The discharge line from the metering pump should be as short and straight as possible. Avoid sharp curves or loops in the line. Injecting solution into the top of a pipe should be avoided, since air collects there and can work its way into the metering pump check valve or the discharge line and cause air-binding. It is recommended that an anti-siphon valve be installed at the injection point.

FIGURE 4-5



Many metering pumps come equipped with, or have available as an accessory, an anti-siphon discharge valve. This may be mounted directly on the pump head. If solution is to be fed into an open channel or a low-pressure pipeline, a "loaded" discharge valve should be used. This is a spring-loaded check or diaphragm valve, which will not open until the pump discharge pressure exceeds a certain fixed value. A common setting is about 103,4 kPa.

As mentioned above, the carboy of acid should be completely sealed. This is a major problem at many fluoridation sites. Several kinds of carboys are used as containers for acid. The most common (and the latest style) is a flat top. An example of how the carboy or drum container can be sealed is shown in Figure 4-6.

Many states are concerned about the possibility of a fluoride overfeed not only because of

the risk to health involved but also because of the adverse publicity. If this becomes a major consideration, a physical break box can be used. The break box reduces the chance for an overfeed from siphoning, with only a marginal increase in cost. Only the amount of acid in
the break box can be siphoned into the main water line. Even in very small installations, this amount would be relatively insignificant. This rather ingenious installation was developed by the state of Minnesota. The major difference in cost is the dual head metering pump instead of a single head metering pump.

The installation of an acid feed system in a larger water plant that uses bulk storage is similar to the simple well installation with some exceptions. A day tank is necessary instead of a carboy. Under normal operating conditions, the day tank should not contain over a 2 days' supply of acid. The day tank must also be sealed around the outer lip of the container, the vent hole, the pump suction line opening, and the fill pipe entrance.

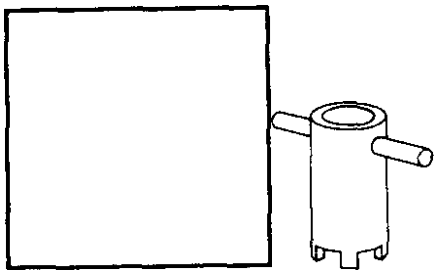
There should be flexible connections in the bulk storage line and in the pump suction line (if it is not flexible tubing). This is to prevent inaccurate reading on the scales. The vent line should go from the day tank to the bulk storage tank (near the top), instead of just to an outside wall. The metering pump should discharge the acid into the line going into a clearwell. If the discharge is directly into the clearwell, the anti-siphon device is still needed at this discharge point.

The bulk storage tank must be vented on top and should be surrounded by a berm to contain any spills.

4.5.3 Sodium Fluoride Installation (Saturators)

The sodium fluoride saturator is a very simple fluoridation system. It requires only a little more space and piping than the straight acid feed. Many of the same comments made on the acid feed installations apply to the saturator installations. The metering pump should be located not more than 1,22 meter over the low saturated water line in the saturator. The suction line should be as short as possible. The metering pump should be equipped with an anti-siphon valve. There also should be an anti-siphon valve at the fluoride injection point if the fluoride solution is injected into a water main.

FIGURE 4-6



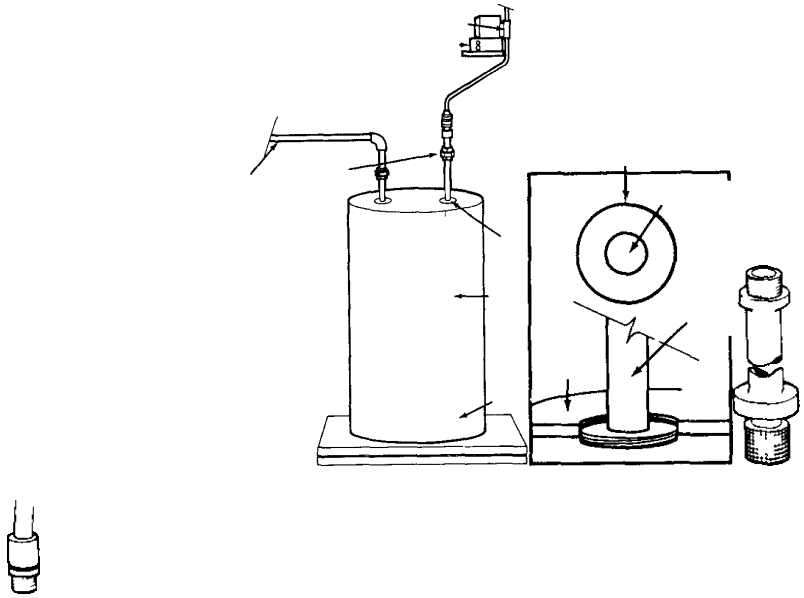
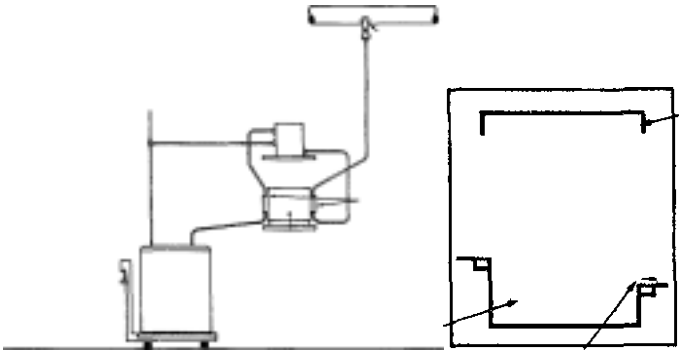


FIGURE 4-7



The fluoride saturator does not need to be sealed as tightly as the acid carboy. Saturator systems should have a water meter and, **if necessary**, a water softener. The feed water line should contain a Y-strainer and sufficient unions to allow easy removal of piping. Softeners are required when the total hardness (as $CaCO_3$) exceeds 75 mg/l, since hardness greater than this will result in an excessive amount of work in clearing stoppages or removing scale. The entire water supply does not need to be softened, only the water used for solution preparation.

Only granular sodium fluoride should be used in saturators, because powdered or very fine sodium fluoride tends to cause clogging in the saturator. A sediment filter (20 mesh) should be installed in the water make-up line going to the sodium fluoride saturator. The filter should be installed between the softener and the water meter. When mounting a metering pump on a shelf or platform above the saturator, it is advisable to offset it sufficiently to permit access to the container for filling and cleaning. Mounting the metering pump on the lid of the saturator is not recommended.

A saturator should never be pushed to its design capacity limit for any length of time. When a saturator's capacity is approached, then another method of fluoridation should be considered, such as the use of fluorosilicic acid.

The upflow saturator installation is very similar to the downflow saturator installation, with some exceptions. If a liquid level switch is used, CDC recommends that there be a solenoid valve and a vacuum breaker be installed. The vacuum breaker must be between the solenoid valve and the water inlet. Also, CDC recommends that a flow restrictor with a maximum flow of 2 liters per minute be installed to allow adequate contact time. (Note: Many states allow flow restrictors of up to 8 liters.) There must be a minimum water pressure in the inlet line of 130 kPa.

The recommendation for a different kind of metering pump plug, with sign, to prevent connecting the metering pump into a "hot" electrical outlet is especially important with an upflow saturator installation.

This is because a solenoid valve requires the "hot" electrical connection, and, itthus becomes easy to make a mistake.

4.5.4 Sodium fluorosilicate installation (Dry Feeders)

Only the installation on the volumetric dry feeder will be discussed because it is the most typical one used. (See the Figure 4-10 below.) The gravimetric feeder installation would be, in essence, the same. When installing a dry feeder, placement should be so that the solution

FIGURE 4-8

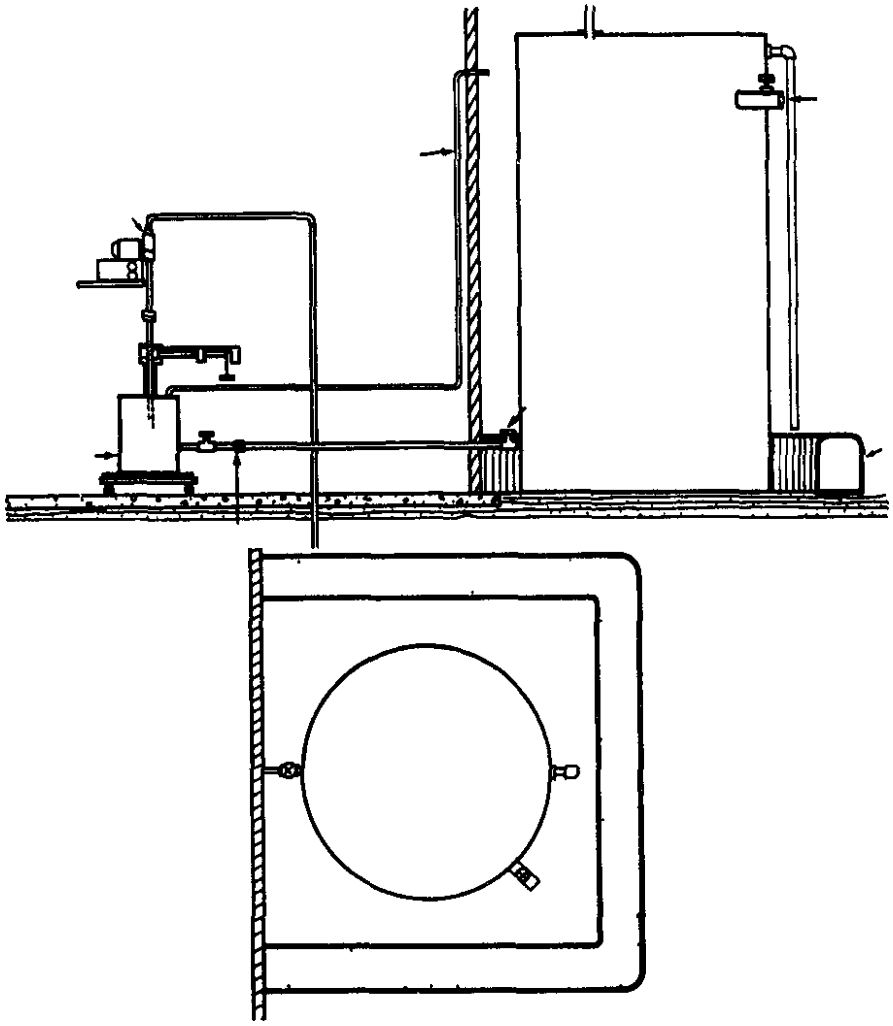
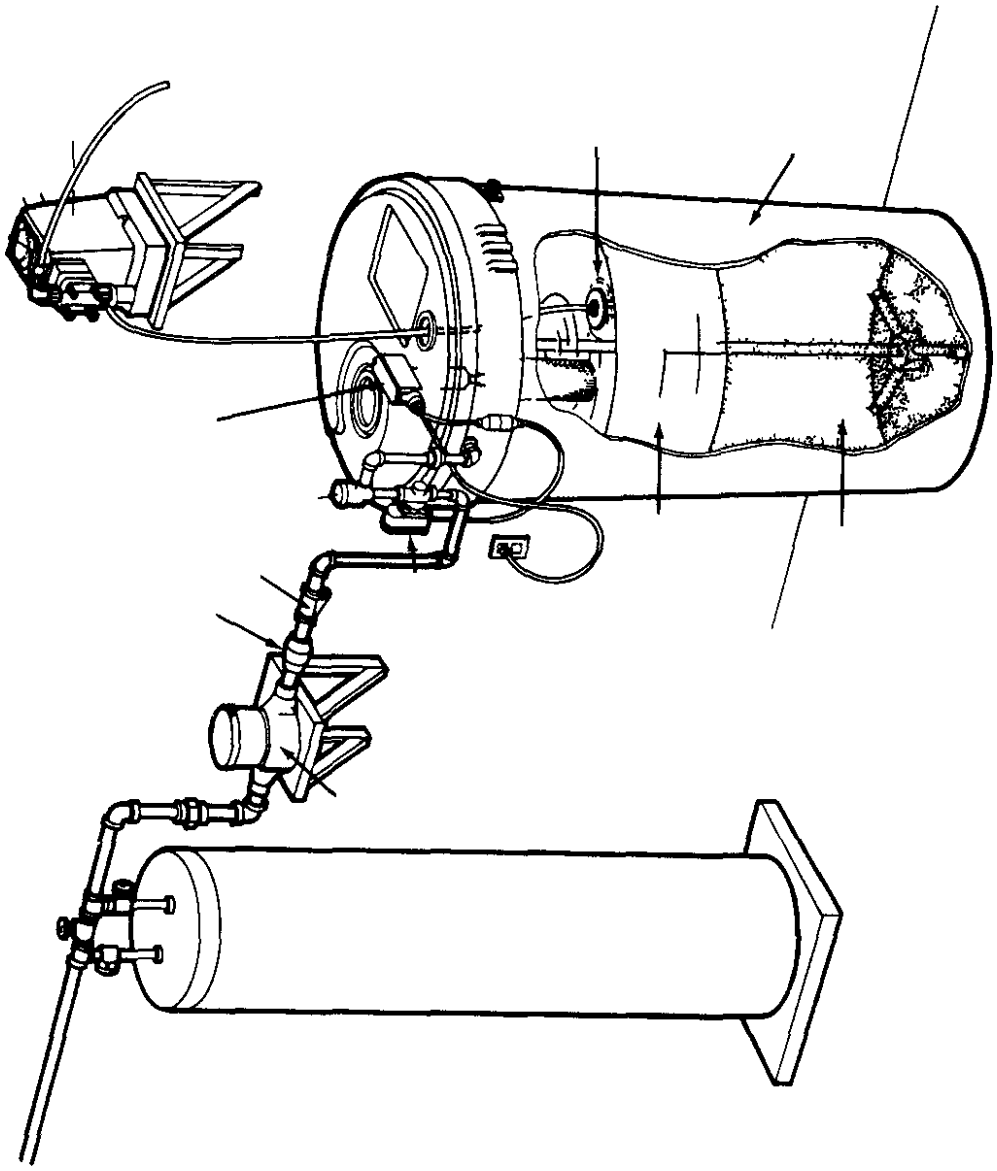


FIGURE 4-9



from the solution tank can fall directly into the chemical feed channel, if possible. If other considerations dictate that the feeder be placed some distance from the point of application, the drain line should be as direct as possible, with adequate slope and sufficient size to preclude precipitation build-ups and subsequent stoppages. Scales must be provided for weighing the amunt of chemical used in a dry feeder. Obviously, the dry feeder installation must be on a firm, level foundation if the scales are expected to perform satisfactorily. If there is a small hopper on the feeder, it must be readily accessible for filling, and if an extension hopper is used, it should extend vertically upward to the filling area, without angles that could trap material. For the water supply line to a volumetric feeder, there must be a section of flexible hose between the solution tank and the water pipe to permit free movement of the feeder and scale platform. A mechanical mixer should be used in every solution tank of a dry feeder when sodium fluosilicate is used.

The water supply line to a dry feeder must be equipped with an air-gap or mechanical vacuumbreaker, or some other type of anti-siphon device. The air gap is the most positive protection against the dangers of a cross connection. If water pressure is too

high to permit the use of an air gap, one of the other devices may be used, but in any case, the vacuumbreaker must be placed between the point of entry to the solution tank and any restrictive device in the pipeline, and must be installed in an elevated location.

FIGURE 4-10