

# CHAPTER FOUR

## 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.

There are no national laws, regulations, or requirements governing the design or installation of fluoridation equipment. The U.S. Environmental Protection Agency (USEPA) does set standards for the maximum amount of natural fluoride that can be in drinking water-maximum Containment Levels (MCL)-but these standards do not apply directly to adjusted fluoridation. The laws, regulations, and requirements for water fluoridation come from the individual state drinking water programs. CDC has been the national focus for water fluoridation and has developed many recommendations concerning the engineering aspects of fluoridation.

In general, the following practices for the engineering aspects of fluoridation are followed by the state drinking water programs:

1. A permit from the state is almost always required before the community (or school) can fluoridate.
2. Plans and specifications must be prepared (in many states by a licensed professional engineer) and submitted to the state for approval prior to construction.
3. Safety devices are required. These vary greatly from state to state, but they generally include vacuum breakers, anti-siphon devices, and bypass lines.
4. In many states, a fluoridation system can't be started up until it has been inspected and approved by the state engineers. In some states, the operators are also required to have some formal training prior to startup.
5. Most states require safety equipment for the water plant operator, such as long gauntlet gloves, chemical aprons, respirators, goggles, showers, eye wash facilities etc.
6. Adherence to and better enforcement of these requirements are needed.
7. Almost all states now require some level of operator certification prior to their operating the fluoridation system.
8. Almost all states require daily sampling for fluorides. Many states require

daily sampling from each individual source (well).

8. Generally all states require certain records to be kept, such as daily sample results, daily water treated amounts, daily weights of chemicals, calculation of fluoride levels, etc., generally at each fluoridated source (well). Copies of these records are submitted to the appropriate state agency.

Most states do not strongly enforce their rules and regulations concerning fluoridation. Water fluoridation is not covered under the Safe Drinking Act of 1974 (or the amended Act of 1986), and thus is given a lower priority than items covered in the Act. While some of those involved in fluoridation tend to disagree with that position, it is a fact of life and probably will remain so.

#### 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 surface 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 solid contact treatment plant is a form of the water softening treatment plant. (It combines the rapid mix, formulation, and setting basins into one unit.) The iron and manganese removal treatment plant is an aeration treatment plant and a form of a single well system. (See Figures 4-1, 4-2, 4-3 below)

Sometimes the water system is a combination of the three major types. For example, a large water system may include a well held and a city reservoir, thus combining surface treatment and water softening. Sometimes it is hard to type cast a particular water plant because it will contain several types within its system. A water system can be as simple as a one distribution water line to as complex as a multiple type treatment system. Fortunately, most of the approximately 60 000 water systems in this country will clearly be one type of water system.

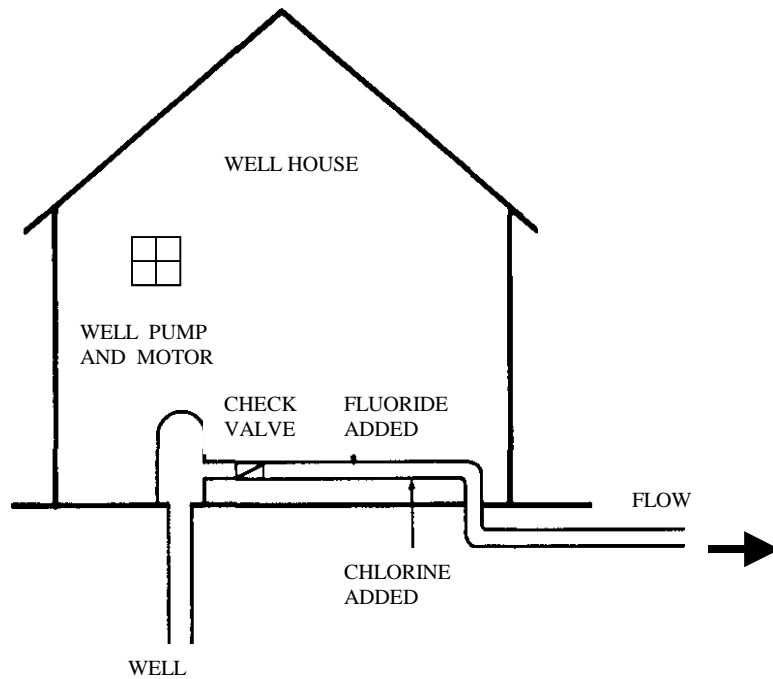
**FIGURE 4-1  
SINGLE WELL WATER SYSTEM**

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

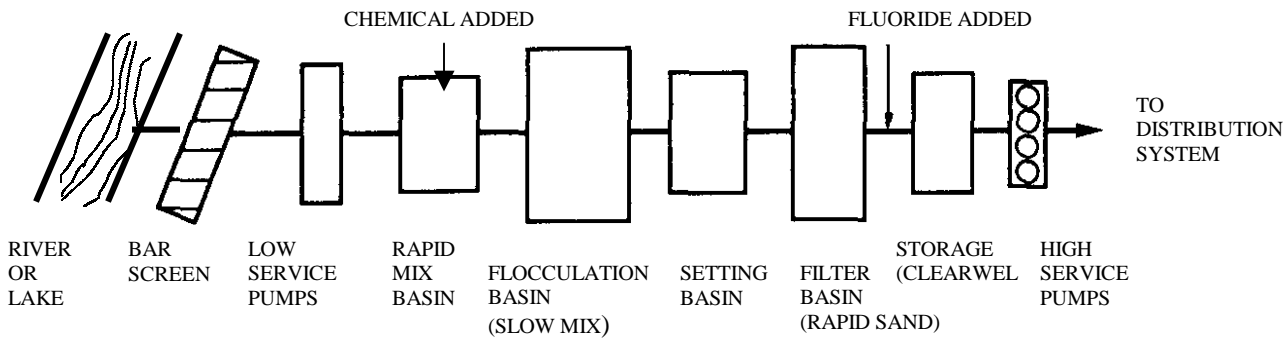
Type of System	Source of Water	Chemicals Commonly Used*
Multiple Wells	Ground	Polyphosphate, Carbon Dioxide
Distribution	Other Systems	Chlorine, Fluoride, Polyphosphate, Chlorine/Fluoride
Solid Contact (Water Softening) Plant	Ground	Chlorine, Fluoride, Lime, Alum, Polyphosphate, Carbon Dioxide
Iron/Manganese Removal Plant	Ground	Chlorine, Fluoride, Potassium permanganate, Manganese Greensand
Ion Exchange	Ground/Surface	Chlorine, Fluoride, Zeolite, Polystyrene Rensins

\*Many other chemicals can be used, depending on the characteristics of the water-see Table4-2.

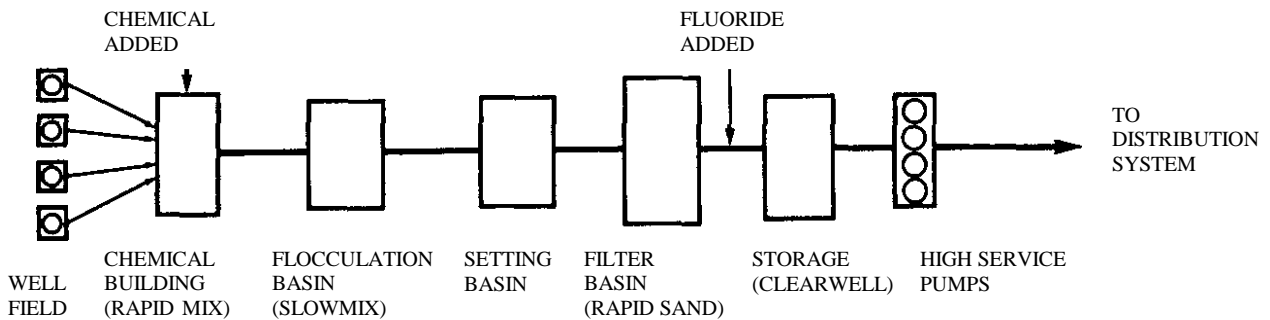
**FIGURE 4-1  
SINGLE WELL WATER SYSTEM**



**FIGURE 4-2  
WATER SURFACE TREATMENT PLANT DIAGRAM**



**FIGURE 4-3  
WATER SOFTENING PLANT DIAGRAM**



### 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 fluoride in a single well system or gas chlorination in a surface 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 performing maintenance. The color scheme is recommended in the " 1992 Recommended Standards for Water Works-A Report of the Committee of the Great Lakes-Upper Mississippi Board of State Engineers." For all fluoride lines the pipes

should be light blue with red bands. Also, 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 100ppm 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 joint, 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 filter 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, dechlorinated
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, Glaucinite (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 (NaHCO <sub>3</sub> ) (baking soda)	pH control

Name	Use
*40. Sulfuric acid	pH control
*41. Potassium hydroxide	pH control
42. Potassium permanganate	Disinfection, remove color, oxident
43. Polyelectrolytes	Coagulant aid
44. Polyphosphates	
-Calcium pyrophosphate	Corrosion control, Iron control
-Zinc pyrophosphate	Corrosion control, Iron control
-sodium tri-polyphosphate	Corrosion control,
-sodium hexa-metaphosphate	Corrosion control
45. Sodium fluoride	Fluoridation
46. Sodium fluorosilicate	Fluoridation
*47. Fluorosilicic acid	Fluoridation
48. Copper sulfate	Algae control

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\* Very hazardous material for plant operator

At the fluoride injection point, the location of the chemical line should be 45 degrees from 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.)