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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with fluoridation and fluoride feeding equipment. Enclosed are objectives, an instructor guide, student handouts and transparency masters. The module considers the principles and purposes of fluoridation, methods of feeding fluoride, operation and maintenance of feeding equipment, feed rates and defluoridation in general. (Author/RH)

FLUORIDATION AND DEFLUORIDATION

Training Module 2.230.2.77

Prepared for the

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by

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September, 1977

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INSTRUCTOR GUIDE

for

Training Module for II2WWS

Module No: II2WWS	Module Title: Fluoridation and Defluoridation
	Submodule Title:
Approx. Time: 16 hours	Topic: Summary

Objectives: Upon completion of this module, the participant will be able to:

1. Evaluate the fluoridation needs for a water supply.
2. Design the optimal fluoridation system for a water supply.
3. Evaluate the analytical requirement for a water supply.
4. Determine if a defluoridation system is required for a water supply.

Instructional Aids:

1. Handout
2. Transparancies #1-#23

Instructional Approach:

Discussion and class problems

References:

1. Water Fluoridation Principles and Practices, Manual No. M4, AWWA
2. Manual of Instruction for Water Treatment Plant Operators, HES
3. Standard Methods for Examination of Water and Wastewater, 14th Ed.
4. Methods for Chemical Analysis of Water and Waste, EPA

Class Assignments:

Read Handout & Work Problems #1-#2

Module No: II2WWS	Topic: Summary
Instructor Notes:	**Instructor Outline:**
1. Distribute Handout	1. Discuss the need, design, laboratory control and safety requirements for a fluoridation system.
2. Present Transparencies	2. Give evaluation of 30 questions.

Module No: II2WWS	Module Title: Fluoridation and Defluoridation
	Submodule Title:
Approx. Time: 1 hour	Topic: Introduction

Objectives: Upon completion of this topic, the participants will be able to:

1. Describe what fluoridation is.
2. Describe the need for fluoride in drinking water
3. Analyze a given water supply and determine the optimal fluoride concentration.
4. Analyze a given water supply and determine the concentration of fluoride above which defluoridation would be required.

Instructional Aids:

1. Handout - Introduction
2. Transparency #1 - History of fluoridation
3. Transparency #2 - Fluoride concentration vs dental caries
4. Transparency #3 - EPA Drinking Water Fluoride Standard

Instructional Approach:

Discussion and problem solving

References:

1. Water Fluoridation Principles and Practices, Manual No. M4, American Water Works Association
2. Manual of Instruction for Water Treatment Plant Operators, Health Education Service

Class Assignments:

1. The participant will read Handout-Introduction
2. The participant will work a class problem #1 to determine maximum allowable and optimal fluoride concentration for a given water supply.

Module No:	Topic:
II2WWS	Introduction

Instructor Notes:	Instructor Outline:
1. Present Transparency #1	1. Discuss the history of fluoridation and the total population affected.
2. Present Transparency #2	2. Discuss the benefits of fluoridation and the age groups mostly affected.
3. Present Transparency #3	3. Discuss the limits for fluoride in the EPA Drinking Water Standards. Discuss why air temperature is used. Discuss the optimum concentration.
4. Present Class Problem #1. Work problem with class participation.	4. a) Defluoridation b) .9 mg/l c) 1.4 mg/l d) .7 mg/l

Module No: II2WWS	Module Title: Fluoridation and Defluoridation
	Submodule Title:
Approx. Time: 1½ hours	Topic: Principles of Fluoridation

Objectives: Upon completion of this topic, the participant will be able to:

1. Describe the role of fluoride in prevention of dental caries.
2. List compounds commonly used in controlled fluoridation.
3. List one advantage and one disadvantage for each compound used in controlled fluoridation.

Instructional Aids:

1. Handout-Principles of Fluoridation
2. Transparency #4-Sodium Fluoride
3. Transparency #5-Fluosilicic Acid
4. Transparency #6-Sodium Silicofluoride
5. Transparency #7-Summary of Fluoride Compounds
6. Transparency #8-Summary of Chemical Use

Instructional Approach:

Discussion

References:

1. Water Fluoridation Principles and Practices, Manual No. M4, American Water Works Association.
2. Manual of Instruction for Water Treatment Plant Operators, Health Education Service

Class Assignments:

1. The participant will read Handout - Principles of Fluoridation

Module No: II2WWS	Topic: Principles of Fluoridation

Instructor Notes:	Instructor Outline:
1. Present Transparency #4	1. Discuss advantages and disadvantages of using sodium fluoride for controlled fluoridation. a. Chemical Costs b. Capital Costs c. Safety d. Operation
2. Present Transparency #5	2. Discuss advantages and disadvantages of using fluosilicic acid for controlled fluoridation. a. Chemical Costs b. Capital Costs c. Safety d. Operation
3. Present Transparency #6	3. Discuss advantages and disadvantages of using sodium silicofluoride for controlled fluoridation. a. Chemical Costs b. Capital Costs c. Safety d. Operation
4. Present Transparency #7	4. Compare the various compounds and their uses for different applications. a. Review material from previous transparencies 1) Chemical Costs 2) Capital Costs 3) Safety 4) Operation
5. Present Transparency #8	5. Compare the various compounds and general types of installation. a. Types of installations for different sizes of communities

Module No: II2WWS	Module Title: Fluoridation and Defluoridation
	Submodule Title:
Approx. Time: 3 hours	Topic: Solution Feeders Used for Adding Fluorides

Objectives: Upon completion of this topic, the participant will be able to:
1. List chemicals that are commonly fed by solution feeders.
2. List types, advantages and disadvantages of solution feeders.
3. Describe required maintanance for solution feeders.
4. Describe safety and hazards in handling chemicals.
5. Compute desired solution feed rate for a given water supply.
6. Select a solution feeder system for a given application.

Instructional Aids:
1. Handout - Solution Feeders
2. Transparency #9 - Typical Solution Feeder
3. Transparency #10 - Typical Dilute Acid Feeder
4. Transparency #11 - Positive Displacement Solution Feeders
5. Transparency #12 - Example problem on feeder selection

Instructional Approach:
Discussion and problem solving

References:
1. Water Fluoridation Principles and Practices, Manual No. M4, American Water Works Association
2. Manual of Instruction for Water Treatment Plant Operators, Health Education Service

Class Assignments:
1. The participant will read Handout - Solution Feeders

Module No: II2WWS	Topic: Solution Feeders Used for Adding Fluorides

Instructor Notes:	Instructor Outline:
1. Present Transparency #9	1. Discuss the typical solution feeder installation. Discuss which chemicals are commonly used with system. Discuss operational problems, necessary safety practices, and maintenance for systems. a. Softener & meter b. Float valve c. Distributor tubes d. Pumps
2. Present Transparency #10	2. Discuss the typical dilute acid feeder installation. Discuss which chemicals are commonly used with system. Discuss operational problems, necessary safety practices and maintenance for systems. a. Transfer pump b. Mixer c. Air Gap d. Pumps
3. Present Transparency #11	3. Discuss the positive displacement solution feeds available. Discuss advantages and disadvantages of each. a. Resistance to corrosion b. Resistance to abrasive materials (scale) c. Type of flow produced d. Repair record
4. Present Transparency #12	4. Work solution feeder selection problem using and discuss the reasons for the various equations. Work problem with student guidance.

Module No: II2WWS	Module Title: Fluoridation and Defluoridation
	Submodule Title:
Approx. Time: 3 hours	Topic: Dry Feeders used for Adding Fluoride.

Objectives: Upon completion of this topic, the participant will be able to:
1. List chemicals that are commonly fed by dry feeders.
2. List types, advantages and disadvantages of dry feeders.
3. Describe required maintanance for dry feeders.
4. Describe safety and hazards in handling chemicals.
5. Compute desired chemical feed rate for a given water supply.
6. Select a chemical feeder system for a given application.

Instructional Aids:
1. Handout - Dry Feeders
2. Transparency #13-#16 - Dry Feeders
3. Transparency #17 - Example of proper safety labeling

Instructional Approach:

Discussion and problem solving

References:
1. Water Fluoridation Principles and Practices, Manual No. M4; American Water Works Association
2. Manual of Instruction for Water Treatment Plant Operators, Health Education Service

Class Assignments:
1. The participant will read Handout - Dry feeders.

Module No: II2WWS	Topic: Dry Feeders Used for Adding Fluoride

Instructor Notes:	Instructor Outline:
1. Present Transparencies #13-#16	1. Discuss each type of dry feeder. Include operation, maintenance, advantages and disadvantages compared to other dry feeders. Also include accuracy and safety with each feeder. a. Screw-type Feeder 1) Varying characteristics of chemical 2) Scaling in solution tank 3) Control 4) Capital costs b. Roll-type Feeder 1) Varying characteristics of chemical 2) Scaling in solution tank 3) Control 4) Capital costs c. Belt-type Feeder 1) Varying characteristics of chemical 2) Scaling in solution tank 3) Control 4) Maintenance of belt & yoke 5) Capital costs d. "LOSS-IN-WEIGHT" Feeder 1) Varying characteristics of chemical 2) Scaling in solution tank 3) Control 4) Maintenance of screw drive & scale beam 5) Capital costs
2. Present Transparency #17	2. Work a typical dry feeder problem. Work problem explaining in detail why each step is being taken. Complete problem with student guidance.

Module No: II2WWS	Module Title: Fluoridation and Defluoridation
	Submodule Title:
Approx. Time: 3 hours	Topic: Selection of Optimal Fluoridation System

Objectives: Upon completion of this topic, the participant will be able to:

1. Select the necessary auxiliary equipment for a fluoridation system.
2. Design the optimal fluoridation system for a given water system.

Instructional Aids:

1. Handout - Optimal Fluoridation System
2. Transparency #18 - Auxiliary Equipment
3. Transparency #19 - Design of Fluoridation System
4. Transparency #20 - Fluoridation Check List

Instructional Approach:

Discussion and problem solving

References:

1. Water Fluoridation Principles and Practices, Manual No. M4, American Water Works Association
2. Manual of Instruction for Water Treatment Plant Operators, Health Education Service

Class Assignments:

1. The participant will read Handout - Optimal Fluoridation System
2. The participant will work problem #2 on design of a fluoridation system for a given water supply.

Module No: II2WWS	Topic: Selection of Optimal Fluoridation System

Instructor Notes:	Instructor Outline:
1. Present Transparency #18	1. Discuss the necessary auxiliary equipment needed for a fluoridation system. Discuss in detail the reason and points of application for each item.
2. Present Transparency #19	2. Discuss the Ten States Standards for fluoridation systems.
3. Present Transparency #20	3. Discuss the fluoridation check-list and how it can be used to evaluate a system design.
4. Present Class Problem #2. Work problem with class participation.	4. a) .8 mg/l b) Fluosolicic Acid Diluted $250 and up c) (.3)(.15)(8.34) = .38 lbs/day use 50¢/lb (.38)(.5) = $.19/day

Module No: II2WWS	Module Title: Fluoridation and Defluoridation
	Submodule Title:
Approx. Time: 3 hours	Topic: Analytical Control

Objectives: Upon completion of this topic, the participant will be able to:
1. Define the monitoring requirements for a given water supply set forth by the USEPA.
2. Define the monitoring requirements for a given water supply set forth by the Iowa D.E.Q.
3. List the approved methods of analysis.
4. Interpret laboratory data for plant control.

Instructional Aids:
1. Handout - Laboratory Control
2. Transparency #21 - Monitoring requirements
3. Transparency #22 - Laboratory Control

Instructional Approach:

Discussion

References:
1. Standard Methods for Examination of Water and Wastewater, 14th Ed.
2. Methods for Chemical Analysis of Water and Waste EPA

Class Assignments:
1. The participant will read Handout - Analytical Control

Module No: II2WWS	Topic: Analytical Control
Instructor Notes:	**Instructor Outline:**
1. Present Transparency #21	1. Discuss the necessary monitoring requirements for fluoridation systems.
2. Present Transparency #22	2. Discuss in detail the various methods for fluoridation testing. Include type of equipment needed and relative cost.

Module No: II2WWS	Module Title: Fluoridation and Defluoridation
	Submodule Title:
Approx. Time: 1 hour	Topic: Defluoridation

Objectives: Upon completion of this topic, the participant will be able to:

1. Describe a basic defluoridation system

Instructional Aids:
1. Handout - Defluoridation
2. Transparency #23 - Basic Defluoridation System

Instructional Approach:

Discussion

References:
1. <u>Water Fluoridation Principles and Practices</u>, Manual No. M4, American Water Works Association
2. <u>Manual of Instruction for Water Treatment Plant Operators</u>, Health Education Service

Class Assignments:

1. The participant will read Handout - Defluoridation

Module No:	Topic:
I2WWS	Defluoridation

Instructor Notes:	Instructor Outline:
1. Present Transparency #23	1. Discuss the various defluoridation systems. Include costs and how they operate. State the chemistry involved for removal.

Module No: II2WWS	Module Title: Fluoridation and Defluoridation
	Submodule Title:
Approx. Time: 1 hour	Topic: Evaluation

Objectives:

The participant should be able to answer correctly 25 of the 30 questions asked.

Instructional Aids:

None

Instructional Approach:

Examination

References:

None

Class Assignments:

None

Module No:	Topic:
II2WWS	Evaluation

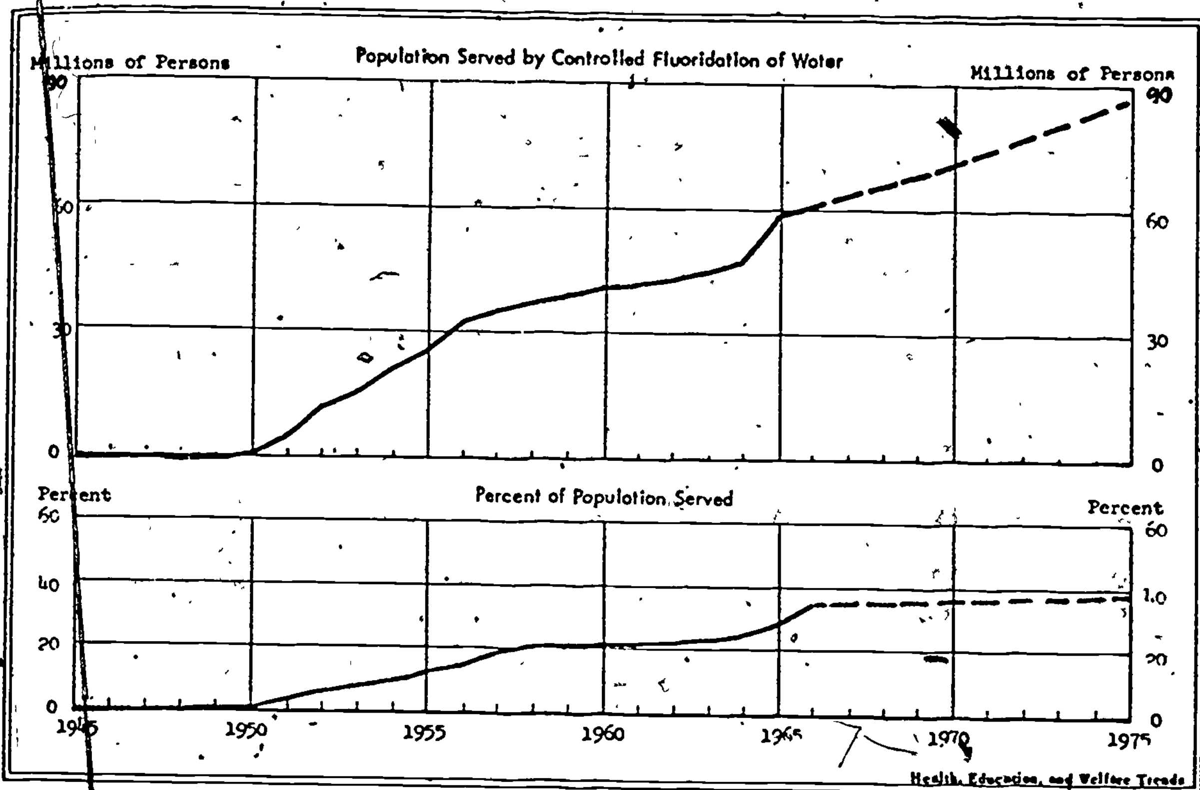
Instructor Notes:	Instructor Outline:
1. Distribute exam. Each participant is to complete the exam independently and with no books or notes. Collect after 1 hour.	

TRANSPARENCIES

for

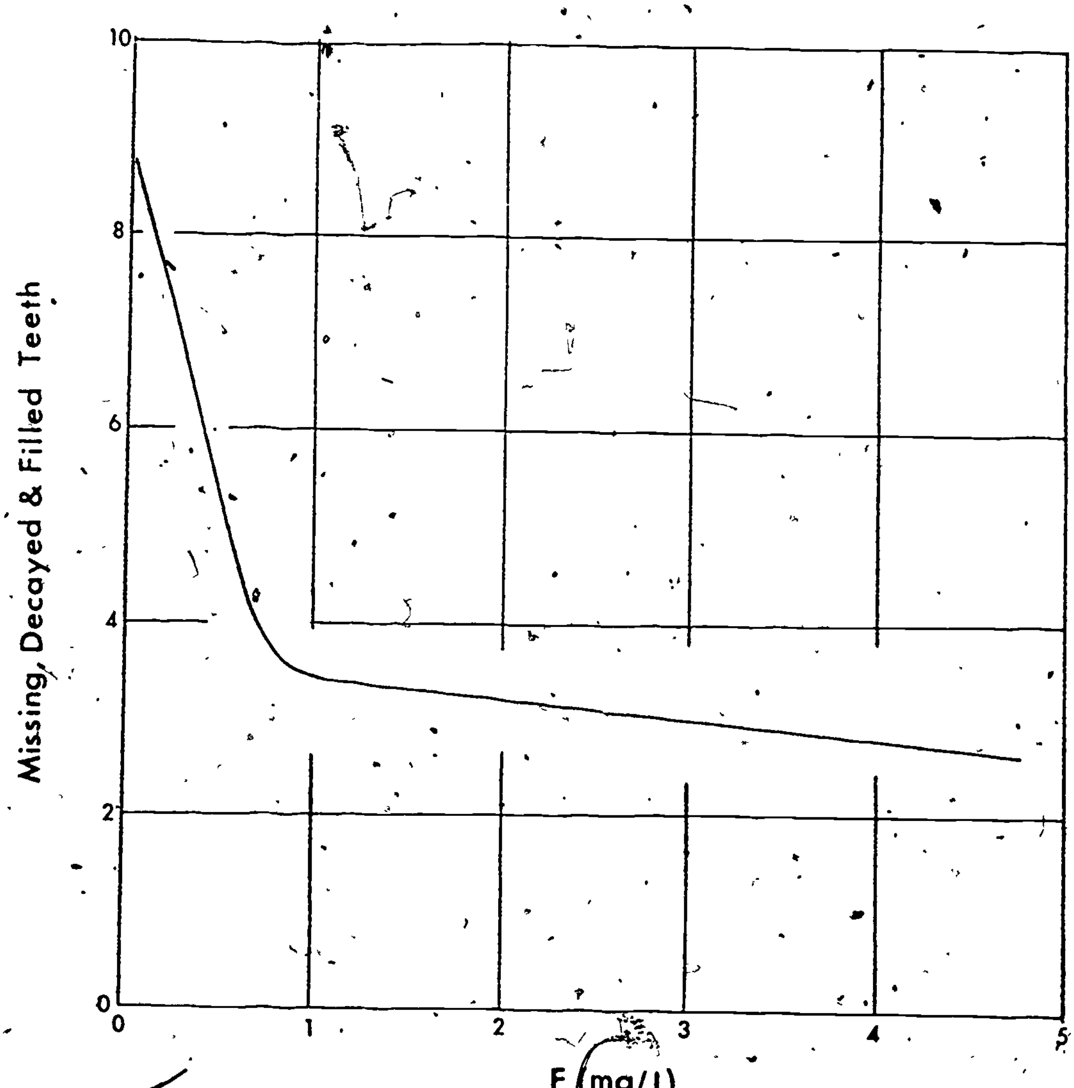
Training Module II2WWS

HISTORY OF FLUORIDATION



TRANSPARENCY I12WMS - #1

FLUORIDATIONS EFFECT OF DENTAL CARIES



TRANSPARENCY I.12!!S - #2

RECOMMENDED FLUORIDE CONCENTRATIONS

Annual Average of Maximum Daily Air Temperatures Based on Temperature Data Obtained for a Minimum of 5 Years (°F)	Fluoride-Ion Concentrations (mg/l) Recommended Limits Lower	Optimum	Upper	Approval Limit
50.0–53.7	0.9	1.2	1.7	1.8
53.8–58.3	0.8	1.1	1.5	1.7
58.4–63.8	0.8	1.0	1.3	1.5
63.9–70.6	0.7	0.9	1.2	1.4
70.7–79.2	0.7	0.8	1.0	1.2
79.3–90.5	0.6	0.7	0.8	1.1

Source: *1974 Drinking Water Standards and Guidelines, Water Supply Division, Environmental Protection Agency.*

SODIUM FLUORIDE

Item	Sodium Fluoride NaF
Form	Powder or crystal
Molecular weight	42.00
Commercial purity—*per cent*	90 - 98
Fluoride ion—*per cent* (100 per cent pure material)	42.25
Pounds required per mg for 1.0 ppm F at indicated purity	18.8 (98 per cent)
pH of saturated solution	7.6
Sodium ion contributed at 1.0 ppm F—*ppm*	1.17
F ion storage space—*cu ft/100 lb*	22 - 34
Solubility—at 25C *g/100 g water*	4.05
Weight—*lb/cu ft*	65 - 90
Cost:	
Cents/lb	18 - 25
Cents/lb available F	41 - 57
Shipping containers	100-lb bags 125—400-lb fiber drums, bulk

TRANSPARENCY II2WS - #4

FLUOSILICIC ACID

Item	Fluosilicic Acid H_2SiF_6
Form	Liquid
Molecular weight	144.08
Commercial purity—*per cent*	22 - 30
Fluoride ion—*per cent* (100 per cent pure material)	79.2
Pounds required per mg for 1.0 ppm F at indicated purity	35.2 (30 per cent)
pH of saturated solution	1.2 (1 per cent solution)
Sodium ion contributed at 1.0 ppm F—*ppm*	0.00
F ion storage space—*cu ft/100 lb*	54 - 73
Solubility—at 25C *g/100 g water*	Infinite
Weight—*lb/cu ft*	10.5 lb/gal (30 per cent)
Cost: *Cents/lb* *Cents/lb available F*	2½ - 15 14 - 63
Shipping containers	13-gal carboys 55-gal drums, bulk

SODIUM SILICOFLUORIDE

Item	Sodium Silicofluoride Na_2SiF_6
Form	Powder or very fine crystal
Molecular weight	188.05
Commercial purity—*per cent*	98 - 99
Fluoride ion—*per cent* (100 per cent pure material)	60.7
Pounds required per mg for 1.0 ppm F at indicated purity	14.0 (98.5 per cent)
pH of saturated solution	3.5
Sodium ion contributed at 1.0 ppm F—*ppm*	0.40
F ion storage space—*cu ft/100 lb*	23 - 30
Solubility—at 25C *g/100 g water*	0.762
Weight—*lb/cu ft*	55 - 72
Cost: *Cents/lb*	8 - 10
Cents/lb available F	13 - 17
Shipping containers	100-lb bags 125—400-lb fiber drums, bulk

SUMMARY OF FLUORIDE COMPOUNDS

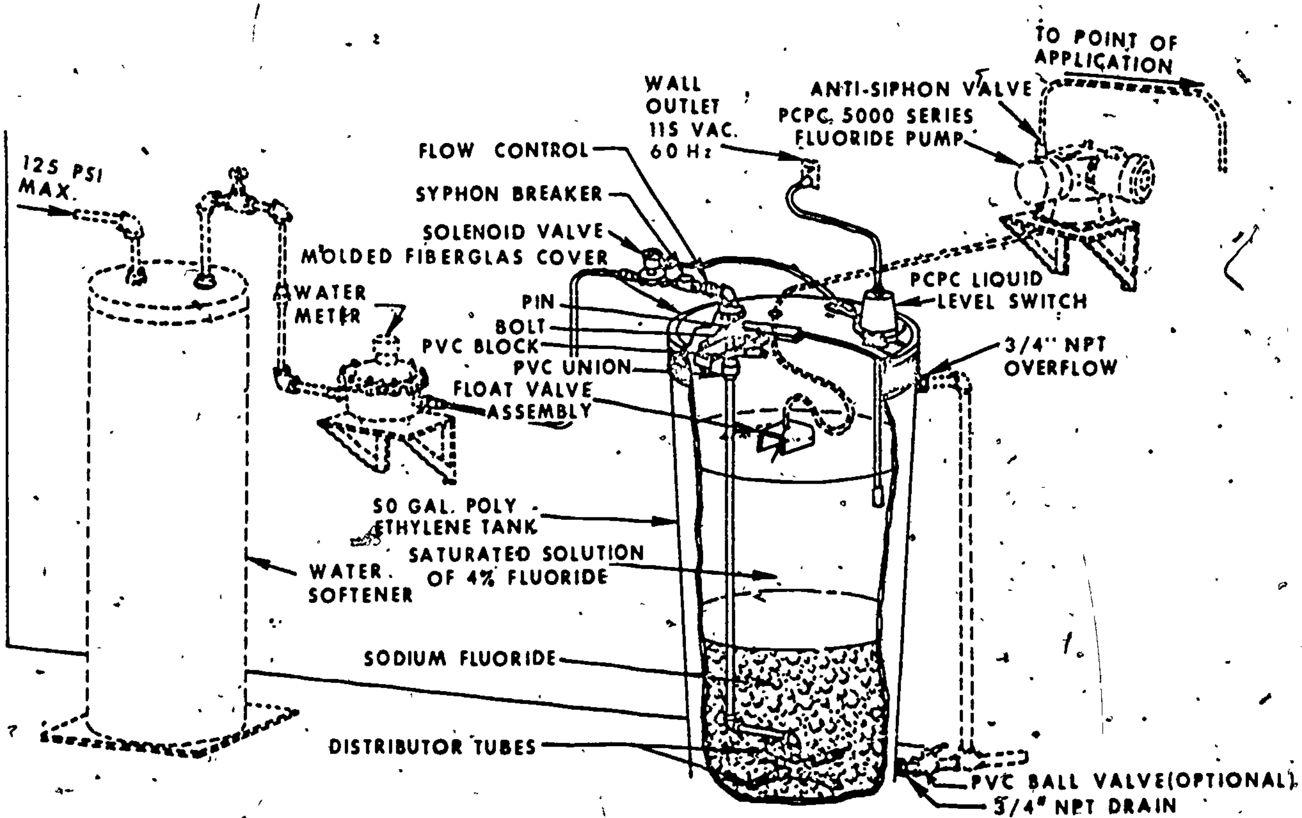
Item	Sodium Fluoride NaF	Sodium Silicofluoride Na_2SiF_6	Fluosilicic Acid H_2SiF_6
Form	Powder or crystal	Powder or very fine crystal	Liquid
Molecular weight	42.00	188.05	144.08
Commercial purity—*per cent*	90-98	98-99	22-30
Fluoride ion—*per cent* (100 per cent pure material)	42.25	60.7	79.2
Pounds required per mg for 1.0 ppm F at indicated purity	18.8 (98 per cent)	14.0 (98.5 per cent)	35.2 (30 per cent)
pH of saturated solution	7.6	3.5	1.2 (1 per cent solution)
Remarks	*a–h*	*c, d, h*	*d–f, h, i, j*
F ion storage space—*cu ft/100 lb*	22-34	23-30	54-73
Solubility—at 25C *g/100 g water*	4.05	0.762	Infinite
Weight—*lb/cu ft*	65-90	55-72	10.5 lb/gal (30 per cent)
Cost:			
Cents/lb	18-25	8-10	2½-15
Cents/lb available F	41-57	13-17	14-63
Shipping containers	100-lb bags 125—400-lb fiber drums, bulk	100-lb bags 125—400-lb fiber drums, bulk	13-gal carboys 55-gal drums, bulk

[a] Ceramic crocks or other corrosion-resistant containers.
[b] Conditioning make-up water to minimize clogging by sludge.
[c] Respirator (dust mask).
[d] Rubber gloves.
[e] Residual.
[f] Weighing scales.
[g] Polyphosphate feed to stabilize solution and minimize incrustation.
[h] Automatic stop-start controls.
[i] Acidproof aprons.
[j] Industrial goggles for protection against acid.

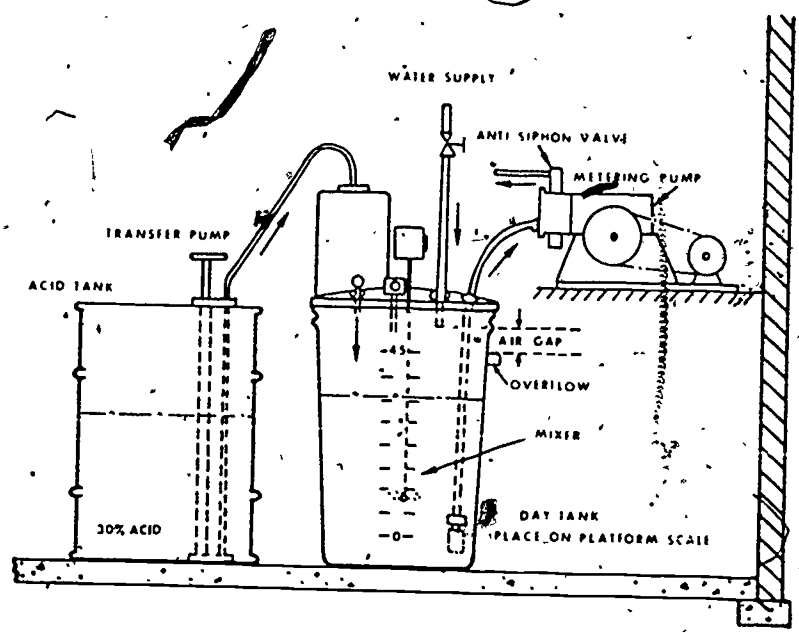
SUMMARY OF CHEMICAL USE

Population Size of Water Supply Systems	Number of Systems Fluoridating	Sodium Fluoride Dry	Sodium Fluoride Solution	Sodium Silicofluoride Dry	Sodium Silicofluoride Solution	Fluosilicic Acid Solution	Ammonium Fluosilicate Dry	Ammonium Fluosilicate Solution	Calcium Fluoride Solution	Other, Adjusted Natural Fluoride, And Not Specified
Totals	1,785	147	412	710	67	383	1	6	1	58
1,000,000 and OVER	5			1		4				
500,000 thru 999,999	13			11		2				
250,000 thru 499,999	16	4		9	1	1		1		
100,000 thru 249,999	47	6	1	26	2	12				
50,000 thru 99,999	60	2	1	47	2	8				
24,000 thru 49,999	140	19	8	80	10	19	1	1		2
10,000 thru 24,999	335	37	33	192	8	56				9
5,000 thru 9,999	344	41	57	167	12	61		1		4
2,500 thru 4,999	303	21	86	115	10	66		2		3
1,000 thru 2,499	342	17	137	58	17	105		1		7
UNDER 1,000	144		89	2	5	48				
NOT SPECIFIED	36			2		1				33

TYPICAL SOLUTION FEEDER

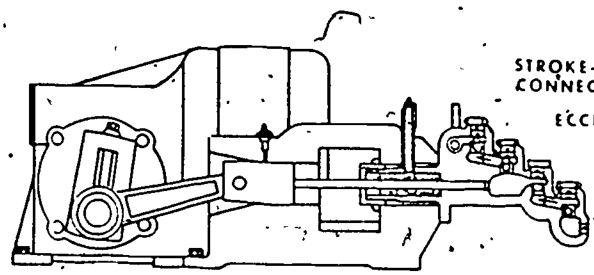


TYPICAL DILUTE ACID FEEDER

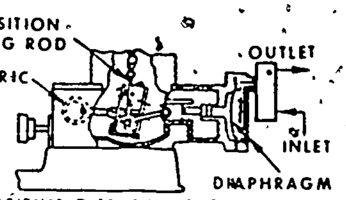


TRANSPARENCY II2MS - #10

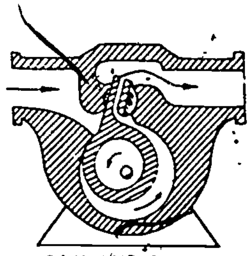
POSITIVE DISPLACEMENT SOLUTION FEEDERS



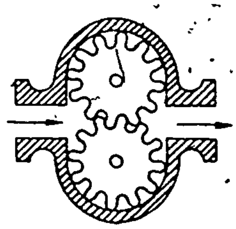
POSITIVE-DISPLACEMENT-PLUNGER PUMP



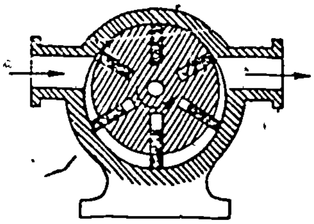
POSITIVE-DISPLACEMENT DIAPHRAGM PUMP



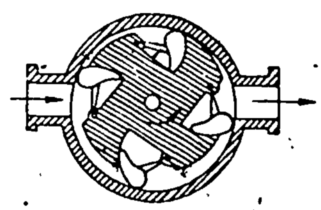
CAM AND PISTON



GEAR



VANE SLIDING



VANE SWINGING

SOLUTION FEEDER SELECTION PROBLEM

Problem: Select a solution feeder for the following application:

Water flow—200 gpm at 75 psi

Fluoride source — saturator (produces a 4 per cent sodium fluoride solution, 18 000 ppm as F)

Desired fluoride level — 1.0 ppm

Calculated solution feed rate: $R_1 \times C_1 = R_2 \times C_2$

where

R_1 = water rate, in gallons per minute

C_1 = fluoride level, in parts per million

R_2 = solution feed rate, in gallons per minute (the unknown quantity, in this case)

C_2 = solution strength in parts per million

then

$$200 \text{ gal/min} \times 1.0 \text{ ppm} = x \times 18\,000 \text{ ppm}$$

$$x = \frac{200 \text{ gal/min} \times 1.0 \text{ ppm}}{18\,000 \text{ ppm}} = 0.011 \text{ gal/min}$$

$$\frac{0.011 \text{ gal}}{\text{min}} \times \frac{60 \text{ min}}{\text{hr}} = \frac{0.67 \text{ gal}}{\text{hr}}$$

Feeders available:

Manufacturer A, Model 1203, three-step pulley drive.

Delivery rate:

at 13 spm, 0.02 - 0.3 gpm at 100 psi

at 26 spm, 0.04 - 0.6 gph

at 46 spm, 0.06 - 1.06 gph

Manufacturer B, Model 5701-111, single speed (37.5 spm)

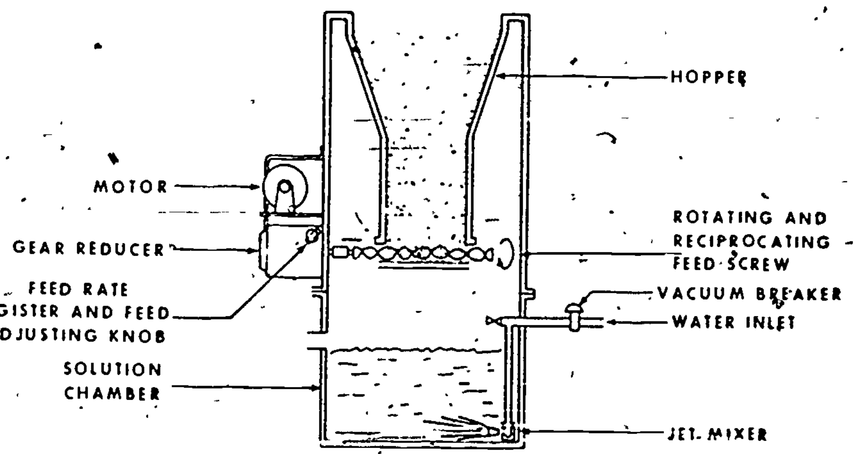
Delivery rate: 0.05 - 5 gph maximum

Manufacturer C, Model 12000, electronic stroking control (3 - 72 spm)

Delivery rate: 0.01 - 1.6 gph

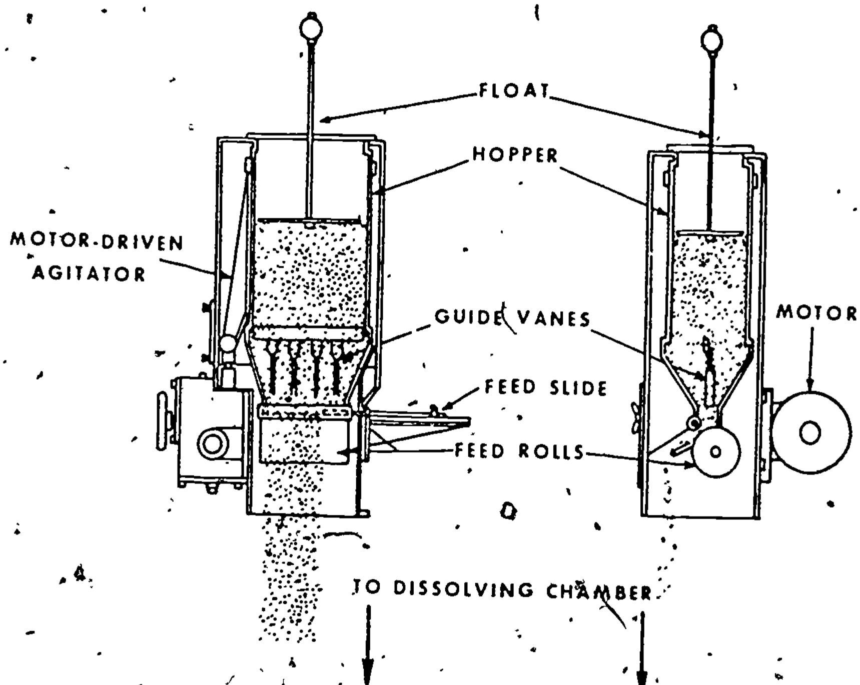
Selection: The required delivery rate falls within the range of all three feeders, so all are possibly acceptable. However, the delivery rate would require the highest stroke frequency of the feeder from Manufacturer A, a situation which, while not unacceptable, is not preferred. Similarly, the delivery rate is too close to the minimum of the feeder from Manufacturer B to be completely satisfactory. The feeder from Manufacturer C appears to be the best choice, since the delivery rate is approximately in the middle of its range. A further investigation into the feeder characteristics should be made in order to ascertain the combination of output per stroke and stroke frequency that would be required, and to verify that neither is near the extremes of the feeder capability.

SCREW-TYPE DRY FEEDER



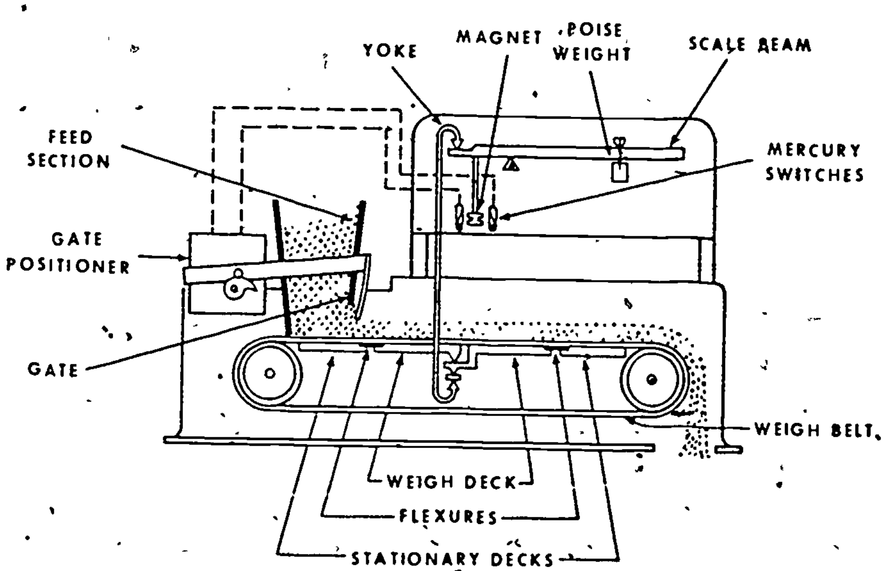
TRANSPARENCY H2-HS - #13

ROLL-TYPE DRY FEEDER



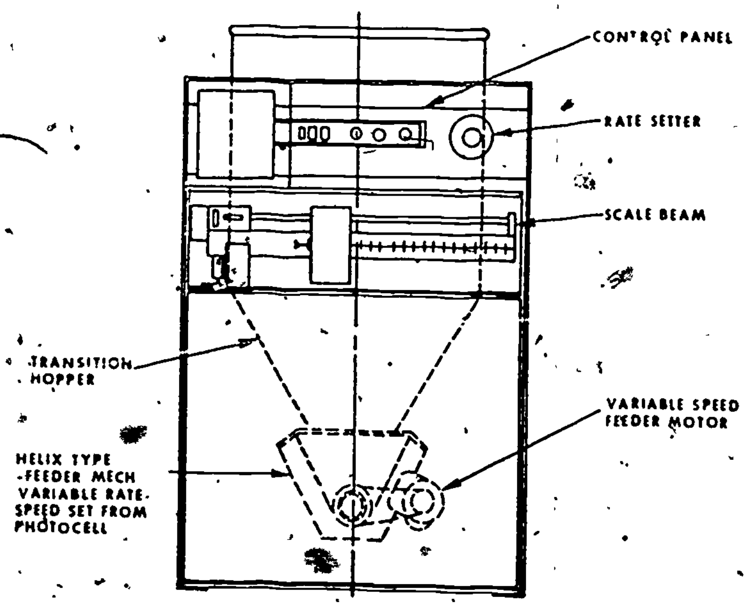
TRANSPARENCY II2WS - #14

BELT-TYPE DRY FEEDER



TRANSPARENCY II2WS - #15

"LOSS-IN-WEIGHT" TYPE DRY FEEDER



TRANSPARENCY II2MS - #16

DRY FEEDER OPERATIONS PROBLEM

To determine the accuracy and reliability of a dry feeder, a small balance or scales and a stopwatch, or a watch with a sweep second hand, are required. Insert a shallow pan or sheet of cardboard between the measuring mechanism and dissolving chamber of the feeder while the feeder is operating, making sure that all the chemical that feeds through will be collected. Collect the chemical that is fed in several short periods; for example, 5 periods of 5 min each. Weigh each of the amounts collected and the total. Provided the weighings and timings are accurate, the individual samples will indicate the uniformity of feed, and the total will indicate the accuracy of feed rate.

Example: Weights of sodium silicofluoride in grams collected in 5-min periods

	35	
	35	
	34	
	36	
	35	
Total:	175	Average: 35 g/min

Uniformity: 35g $\pm$ 1 g in 5 min (about 3 per cent variation)

Feed rate: $\dfrac{35\,g}{5\,min} \times \dfrac{60\,min}{hr} = 420$ g/hr or 0.925 lb/hr

The uniformity of feed in this case would be acceptable. If fluoride levels are to be maintained within 10 per cent, the feeder delivery rate should be maintained at the highest accuracy possible. Repeating a test with longer sampling periods would tend to show a smaller percentage of variations if the feeder is in proper working condition.

FLUORIDATION AUXILIARY EQUIPMENT

1. METERS
2. SCALES
3. SOFTENERS
4. MIXERS
5. DISSOLVING TANKS
6. FLOW METERS
7. DAY TANKS
8. BAG LOADERS
9. DUST COLLECTORS AND WET SCRUBBERS
10. ALARMS
11. VACUUM BREAKERS
12. HOPPERS
13. WEIGHT RECORDERS
14. CONTROLLERS
15. EDUCTORS
16. PUMPS
17. TIMERS
18. HOPPER AGITATORS
19. FLOW-SPLUTTERS

4.7.1 Fluoride compound storage

Compounds shall be stored in covered or unopened shipping containers and should be stored inside a building. Unsealed storage units for hydrofluosilicic acid should be vented to the atmosphere at a point outside any building.

4.7.2 Chemical feed equipment and methods

In addition to the requirements in Part 5, fluoride feed equipment shall meet the following requirements:

a. scales or loss-of-weight recorders shall be provided for dry chemical feeds,

b. feeders shall be accurate to within five percent of any desired feed rate,

c. to avoid precipitation of fluoride, the fluoride compound should not be added before lime-soda softening and shall not be added before ion exchange softening,

d. the point of application of hydrofluosilicic acid, if into a horizontal pipe, shall be in the lower half of the pipe,

e. a fluoride solution shall be applied by a positive displacement pump having a stroke rate not less than 20 strokes per minute,

f. adequate anti-siphon devices shall be provided for all fluoride feed lines.

4.7.3 Protective equipment

At least one pair of rubber gloves, a respirator of a type certified by the National Institute for Occupational Safety and Health for toxic dusts or acid gas (as necessary), an apron, or other protective clothing, and goggles or face masks shall be provided for each operator. Other protective equipment must be provided as necessary.

4.7.4 Dust control

a. Provision must be made for the transfer of dry fluoride compounds from shipping containers to storage bins or hoppers in such a way as to minimize the quantity of fluoride dust which may enter the room in which the equipment is installed. The enclosure shall be provided with an exhaust fan and dust filter which place the hopper under a negative pressure. Air exhausted from fluoride handling equipment shall discharge through a dust filter to the outside atmosphere of the building.

b. Provision shall be made for disposing of empty bags, drums or barrels in a manner which will minimize exposure to fluoride dusts. A floor drain should be provided to facilitate the hosing of floors.

FLUORIDATION CHECK LIST

Chemical And System	Sodium Fluoride Manual Solution Preparation	Sodium Fluoride Automatic Solution Preparation	Fluosilicic Acid Diluted	Fluosilicic Acid 23 - 30%	Sodium Silicofluoride Or Sodium Fluoride Dry Feed			
Water Flow Rate	Less Than 500 gpm	Less Than 2000 gpm	Less Than 500 gpm	More Than 500 gpm	More Than 100 gpm		More Than 2 MGD	
Population Served By System Or Each Well Of Multiple-Well System	Less Than 5000	Less Than 10,000	Less Than 10,000	More Than 10,000	More Than 10,000		More Than 50,000	
					Sodium Silicofl.	Sodium Fluoride	Sodium Silicofl.	Sodium Fluoride
Chemical Cost, FOB Manufacturer	22 - 25¢/lb	20 - 22¢/lb	8 - 15¢/lb (30% Basis)	$51 - $58/ton (23% Basis)	9 - 10¢/ lb	18 - 20¢/lb	8 - 9¢/lb	18 - 20¢/lb
Chemical Cost/lb Fluoride Ion	50 - 57¢	46 - 50¢	33 - 63¢	14 - 16¢	15 - 17¢	41 - 46¢	13 - 15¢	41 - 46¢
Equipment Cost/Unit	$100 - $500	$500 - $1000	$250 And Up	$500 And Up	$1,000 And Up		$3000 And Up	
Equipment Required	Solution Feeder, Mixing Tank, Scales, Mixer	Solution Feeder, Saturator, Water Meter	Solution Feeder, Scales, Measuring Container, Mixing Tank, Mixer	Solution Feeder, Day Tank, Scales, Transfer Pump	Volumetric Dry Feeder, Scales, Hopper, Dissolving Chamber		Gravimetric Dry Feeder, Hopper, Dissolving Chamber	
Feed Accuracy	Depends On Solution Preparation And Feeder	Depends On Feeder	Depends On Solution Preparation And Feeder	Depends On Feeder	Usually Within 3%		Usually Within 1%	
Chemical Specifications And Availability	Crystalline NaF, Dust-Free, In Bags Or Drums. Generally Available.	Downflow - Coarse Crystalline NaF In Bags Or Drums. May Be Scarce. Upflow - Fine Crystalline NaF	Low-Silica Or Fortified Acid In Drums Or Carboys. Generally Available.	Bulk Acid In Tank Cars Or Trucks. Available On Contract	Powder In Bags, Drums Or Bulk. Generally Available.			
Handling Requirements	Weighing, Mixing, Measuring	Dumping Whole Bags Only	Pouring Or Siphoning, Measuring, Mixing, Weighing	All Handling By Pump	Bag Loaders Or Bulk Handling Equipment Required			
Feeding Point	Injection Into Filter Effluent Line Or Main	Injection Into Filter Effluent Line Or Main	Injection Into Filter Effluent Line Or Main	Injection Into Filter Effluent Line Or Main	Gravity Feed From Dissolving Chamber Into Open Flume Or Clear-Well, Pressure Feed Into Filter Effluent Line Or Main			
Other Requirements	Solution Water May Require Softening	Solution Water May Require Softening	Dilution Water May Require Softening	Acid-Proof Storage Tank, Piping, Etc.	Dry Storage Area, Dust Collectors, Dissolving-Chamber Mixers, Hopper Agitators, Eductors, Etc.			
Hazards	Dust, Spillage, Solution Preparation Error	Dust, Spillage	Corrosion, Fumes, Spillage, Solution Preparation Error	Corrosion, Fumes, Leakage	Dust, Spillage, Arching And Flooding In Feeder And Hopper			

MONITORING REQUIREMENTS

A. ENVIRONMENTAL PROTECTION AGENCY
   1. DRINKING WATER STANDARDS
      A) SURFACE WATER SUPPLIES
         ONE SAMPLE PER YEAR
      B) GROUND WATER SUPPLIES
         ONE SAMPLE PER TWO YEARS
   2. FLUORIDATION PROGRAM
      A) ONE SAMPLE PER DAY AT PLANT AND AT SOME POINT IN THE DISTRIBUTION SYSTEM.

B. IOWA DEPARTMENT OF ENVIRONMENTAL QUALITY
   1. DAILY SAMPLING AT THE PLANT
   2. MONTHLY REFEREE SAMPLES FROM THE STATE HYGENICS LABORATORY

LABORATORY CONTROL

A. ALIZARIN METHOD

B. SPADNS METHOD

C. ELECTRODE METHOD

DEFLUORIDATION

A. ACTIVATED ALUMINA
   REGENERATED WITH 1% SOLUTION OF CAUSTIC SODA

B. BONE CHAR
   REGENERATED WITH 1% SOLUTION OF CAUSTIC SODA

C. ION EXCHANGE

CLASS PROBLEMS

for

Training Module II2WWS

CLASS PROBLEM #1

1. If a water supply serves an area with an annual maximum daily air temperature of 70°F and has a natural fluoride concentration of 7.0 mg/l:

   a) What fluoridation system should be used?

   b) What will be the optimal concentration?

   c) What will be the maximum allowable concentration?

   d) What will be the recommended minimum concentration?

CLASS PROBLEM #2

1. A community of 2,000 people is considering a new fluoridation system. The current water supply is a well water having a natural background fluoride concentration of .5 mg/l.

   a. If the average maximum air temperature is 75°F, what should the fluoride concentration be adjusted to?

   b. What fluoridation feeding system would be the most economical? Approximately what would the cost be?

   c. If the community uses 150,000 gallons per day, what will be the chemical cost?

CLASS HANDOUT

for

Training Module II2WWS.

Handout for II2WWS - Fluoridation and Defluoridation

I. Introduction
   A. History of fluoridation
   B. Benefits of fluoridation
   C. Drinking water standards

Annual Average of Maximum Daily Air Temperatures Based on Temperature Data Obtained for a Minimum of 5 Years (°F)	Fluoride-Ion Concentrations (mg/l)			
	Recommended Limits			Approval Limit
	Lower	Optimum	Upper	
50.0–53.7	0.9	1.2	1.7	1.8
53.8–58.3	0.8	1.1	1.5	1.7
58.4–63.8	0.8	1.0	1.3	1.5
63.9–70.6	0.7	0.9	1.2	1.4
70.7–79.2	0.7	0.8	1.0	1.2
79.3–90.5	0.6	0.7	0.8	1.1

Source: *1974 Drinking Water Standards and Guidelines, Water Supply Division, Environmental Protection Agency.*

II. Principles of Fluoridation
   A. Sodium fluoride
   B. Fluosilicic Acid
   C. Sodium Silicofluoride
   D. Summary of fluoride compounds

Item	Sodium Fluoride NaF	Sodium Silicofluoride Na_2SiF_6	Fluosilicic Acid H_2SiF_6
Form	Powder or crystal	Powder or very fine crystal	Liquid
Molecular weight	42.00	188.05	144.08
Commercial purity—*per cent*	90-98	98-99	22-30
Fluoride ion—*per cent* (100 per cent pure material)	42.25	60.7	79.2
Pounds required per mg for 1.0 ppm F at indicated purity	18.8 (98 per cent)	14.0 (98.5 per cent)	35.2 (30 per cent)
pH of saturated solution	7.6	3.5	1.2 (1 per cent solution)
Remarks	*a–h*	*c, d, h*	*d–f, h, i, j*
F ion storage space—*cu ft/100 lb*	22-34	23-30	54-73
Solubility—at 25C *g/100 g water*	4.05	0.762	Infinite
Weight—*lb/cu ft*	65-90	55-72	10.5 lb/gal (30 per cent)
Cost:			
Cents/lb	18-25	8-10	2½-15
Cents/lb available F	41-57	13-17	14-63
Shipping containers	100-lb bags 125—400-lb fiber drums, bulk	100-lb bags 125—400-lb fiber drums, bulk	13-gal carboys 55-gal drums, bulk

[a] Ceramic crocks or other corrosion-resistant containers.
[b] Conditioning make-up water to minimize clogging by sludge.
[c] Respirator (dust mask).
[d] Rubber gloves.
[e] Residual.
[f] Weighing scales.
[g] Polyphosphate feed to stabilize solution and minimize incrustation.
[h] Automatic stop-start controls.
[i] Acidproof aprons.
[j] Industrial goggles for protection against acid.

III. Solution Feeders Used for Adding Fluoride
    A. Typical solution feeders
    B. Typical dilute acid feeder
    C. Positive displacement solution feeders
IV. Dry Feeders Used for Adding Fluoride
    A. Screw-Type
    B. Roll-Type
    C. Belt-Type
    D. "Loss-In-Weight" Type
V. Selection of Optimal Fluoridation System
    A. Auxiliary Equipment
    B. Ten States Standards

4.7 FLUORIDATION

Commercial sodium fluoride, sodium silicofluoride and hydrofluosilicic acid shall conform to the applicable AWWA standards. Other fluoride compounds which may be available must be approved by the reviewing authority. The proposed method of fluoride feed must be approved by the reviewing authority prior to preparation of final plans and specifications.

4.7.1 Fluoride compound storage

Compounds shall be stored in covered or unopened shipping containers and should be stored inside a building. Unsealed storage units for hydrofluosilicic acid should be vented to the atmosphere at a point outside any building.

4.7.2 Chemical feed equipment and methods

In addition to the requirements in Part 5, fluoride feed equipment shall meet the following requirements:

a. scales or loss-of-weight recorders shall be provided for dry chemical feeds,

b. feeders shall be accurate to within five percent of any desired feed rate,

c. to avoid precipitation of fluoride, the fluoride compound should not be added before lime-soda softening and shall not be added before ion exchange softening,

d. the point of application of hydrofluosilicic acid, if into a horizontal pipe, shall be in the lower half of the pipe,

e. a fluoride solution shall be applied by a positive displacement pump having a stroke rate not less than 20 strokes per minute,

f. adequate anti-siphon devices shall be provided for all fluoride feed lines.

4.7.3 Protective equipment

At least one pair of rubber gloves, a respirator of a type certified by the National Institute for Occupational Safety and Health for toxic dusts or acid gas (as necessary), an apron, or other protective clothing, and goggles or face masks shall be provided for each operator. Other protective equipment must be provided as necessary.

4.7.4 Dust control

a. Provision must be made for the transfer of dry fluoride compounds from shipping containers to storage bins or hoppers in such a way as to minimize the quantity of fluoride dust which may enter the room in which the equipment is installed. The enclosure shall be provided with an exhaust fan and dust filter which place the hopper under a negative pressure. Air exhausted from fluoride handling equipment shall discharge through a dust filter to the outside atmosphere of the building.

b. Provision shall be made for disposing of empty bags, drums or barrels in a manner which will minimize exposure to fluoride dusts. A floor drain should be provided to facilitate the hosing of floors.

4.7.5 Testing equipment

Equipment shall be provided for measuring the quantity of fluoride in the water. Such equipment shall be subject to the approval of the reviewing authority.

C. Fluoridation Check List
   (See Figure #1)

VI. Analytical Control
- A. Monitoring requirements
  - 1. Environmental Protection Agency
    - a. Drinking Water Standards
      - 1) Surface water supplies
        one sample per year
      - 2) Ground water supplies
        one sample per two years
    - b. Fluoridation Program
      - 1) One sample per day at plant and at some point in the distribution system.
  - 2. Iowa Department of Environmental Quality
    - a. Daily sampling at the plant
    - b. Monthly referee samples from the State Hygienics Laboratory.
- B. Laboratory Control
  - 1. Alizarin Method
  - 2. SPADNS Method
  - 3. Electrode Method

VII. Defluoridation

A. Activated Alumina

B. Bone Char

C. Ion Exchange

Chemical And System	Sodium Fluoride Manual Solution Preparation	Sodium Fluoride Automatic Solution Preparation	Fluosilicic Acid Diluted	Fluosilicic Acid 23 - 30%	Sodium Silicofluoride Or Sodium Fluoride Dry Feed			
Water Flow Rate	Less Than 500 gpm	Less Than 2000 gpm	Less Than 500 gpm	More Than 500 gpm	More Than 100 gpm		More Than 2 MGD	
Population Served By System Or Each Well Of Multiple-Well System	Less Than 5000	Less Than 10,000	Less Than 10,000	More Than 10,000	More Than 10,000		More Than 50,000	
					Sodium Silicofl.	Sodium Fluoride	Sodium Silicofl.	Sodium Fluoride
Chemical Cost, FOB Manufacturer	22 - 25¢/lb	20 - 22¢/lb	8 - 15¢/lb (30% Basis)	$51 - $58/ton (23% Basis)	9 - 10¢/ lb	18 - 20¢/lb	8 - 9¢/lb	18 - 20¢/lb
Chemical Cost/lb Fluoride Ion	50 - 57¢	46 - 50¢	33 - 63¢	14 - 16¢	15 - 17¢	41 - 46¢	13 - 15¢	41 - 46¢
Equipment Cost/Unit	$100 - $500	$500 - $1000	$250 And Up	$500 And Up	$1,000 And Up		$3000 And Up	
Equipment Required	Solution Feeder, Mixing Tank, Scales, Mixer	Solution Feeder, Saturator, Water Meter	Solution Feeder, Scales, Measuring Container, Mixing Tank, Mixer	Solution Feeder, Day Tank, Scales, Transfer Pump	Volumetric Dry Feeder, Scales, Hopper, Dissolving Chamber		Gravimetric Dry Feeder, Hopper, Dissolving Chamber	
Feed Accuracy	Depends On Solution Preparation And Feeder	Depends On Feeder	Depends On Solution Preparation And Feeder	Depends On Feeder	Usually Within 3%		Usually Within 1%	
Chemical Specifications And Availability	Crystalline NaF, Dust-Free, In Bags Or Drums. Generally Available.	Downflow - Coarse Crystalline NaF In Bags Or Drums. May Be Scarce. Upflow - Fine Crystalline NaF	Low-Silica Or Fortified Acid In Drums Or Carboys. Generally Available.	Bulk Acid In Tank Cars Or Trucks. Available On Contract	Powder In Bags, Drums Or Bulk. Generally Available.			
Handling Requirements	Weighing, Mixing, Measuring	Dumping Whole Bags Only	Pouring Or Siphoning, Measuring, Mixing, Weighing	All Handling By Pump	Bag Loaders Or Bulk Handling Equipment Required			
Feeding Point	Injection Into Filter Effluent Line Or Main	Injection Into Filter Effluent Line Or Main	Injection Into Filter Effluent Line Or Main	Injection Into Filter Effluent Line Or Main	Gravity Feed From Dissolving Chamber Into Open Flume Or Clear-Well; Pressure Feed Into Filter Effluent Line Or Main			
Other Requirements	Solution Water May Require Softening	Solution Water May Require Softening	Dilution Water May Require Softening	Acid-Proof Storage, Tank, Piping, Etc.	Dry Storage Area, Dust Collectors, Dissolving-Chamber Mixers, Hopper Agitators, Eductors, Etc.			
Hazards	Dust, Spillage, Solution Preparation Error	Dust, Spillage	Corrosion, Fumes, Spillage, Solution Preparation Error	Corrosion, Fumes, Leakage	Dust, Spillage, Arching And Flooding In Feeder And Hopper			

FIGURE II2-WS - 1

EXAMINATION

for

Training Module II2WWS

Examination for II2WWS - Fluoridation and Defluoridation

1. Fluoridation is a common water treatment process for the prevention of ________________.

2. Maximum fluoride levels in drinking water have been set by ________________ ________________.

3. The maximum fluoride level in drinking water depends on ________________ ________________.

4. List three common chemicals used in fluoridation.

   a.
   b.
   c.

5. List four dry fluoride feeds.

   a.
   b.
   c.
   d.

6. List three laboratory tests used to control fluoridation.

   a.
   b.
   c.

7. Defluoridation is generally accomplished using ________________, ________________ or ________________.

8. Monitoring requirements state that samples are to be collected daily at ________________ and ________________.

9. If a water plant adds .6 mg/l of fluoride to 1 mgd, how many pounds of fluoride will be needed per day?________________ If the fluoride is added by use of a 20% solution, how many gallons of fluoride solution will be pumped per day?________________

TRUE OR FALSE. CIRCLE THE CORRECT ANSWER.

T or F 10. Fluoride solutions are very soluble in high calcium waters.

T or F 11. Fluoride benefits increase with increased concentration.

T or F 12. Fluosilicic Acid is usually shipped as a powder.

T or F 13. Solution feeders are normally less expensive and easier to operate than dry feeders.

T or F 14. Dry feeders are normally more economical for large water supplies.

T or F 15. A respirator and eye protection should always be used when handling dry fluoride chemicals. ______

T or F 16. Softeners or polyphosphates are normally required for solution feeders. ______

T or F 17. DEQ requires referee samples be tested by plant operators and the State Hygienic Laboratory.

T or F 18. The electrode method for fluoride determination is the only one method approved by EPA.

T or F 19. Defluoridation systems are normally regenerated with caustic soda.