DOCUMENT RESUME

ED 151 227 SE 024 038

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TITLE Basic Ion Exchange Softening. Training Module 2.210.2.77.
SPONS AGENCY Department of Labor, Washington, D.C.; Iowa State Dept. of Environmental Quality, Des Moines.
PUB DATE Sep 77
NOTE 64p.; For related documents, see SE 024 025-047; Contains occasional light and broken type; Transparency 16 removed due to copyright restrictions

EDRS PRICE MF-$0.83 HC-$3.50 Plus Postage.
DESCRIPTORS *Instructional Materials; *Post Secondary Education; Secondary Education; *Teaching Guides; *Units of Study
IDENTIFIERS Ion Exchange; *Operations (Water); *Water Treatment

ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with ion exchange softening. It includes objectives, an instructor guide, student handouts, and transparency masters. This is the first level of a three module series. The module considers the principles, components, operation, maintenance, laboratory control and safety for ion exchange softening units. It is designed for individuals with little or no operating experiences. (Author/RH)

BASIC ION EXCHANGE SOFTENING

Training Module 2.210.2.77

Prepared for the

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by

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The publication of these training materials was financially aided through a contract between the Iowa Department of Environmental Quality and the Office of Planning and Programming, using funds available under the Comprehensive Employment and Training Act of 1973. However, the opinions expressed herein do not necessarily reflect the position or policy of the U. S. Department of Labor, and no official endorsement by the U. S. Department of Labor should be inferred.

September, 1977

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INSTRUCTOR GUIDE

for

Training Module II2SWS

Module No:	Module Title:
II2SWS	Basic Ion Exchange Softening
	Submodule Title:
Approx. Time: 10 hours	Topic: Summary

Objectives: Upon completion of this module, the participant will be able to:
1. Describe the operation of a basic ion exchange softener.
2. Describe the maintenance of a basic ion exchange softener.
3. Describe the laboratory control necessary for ion exchange.
4. Describe the safety requirements for ion exchange softening.

Instructional Aids:
1. Handout
2. Transparencies #1-#20

Instructional Approach:

Discussion and Class Problems

References:
1. Manual of Instruction for Water Treatment Plant Operators, Health Education Service
2. Manual of Water Utility Operations, Texas Water Utility Assoc.
3. Elements of Ion Exchange, Kunin
4. Standard Methods for the Examination of Water and Wastewater, 14th Ed.
5. Methods for Chemical Analysis of Water and Waste, EPA

Class Assignments:

The participant will
1. Read Handout
2. Complete Problems-#1-#4

Module No:	Topic:
II2SWS	Summary

Instructor Notes:	Instructor Outline:
1. Distribute Handout 2. Present Transparencies	1. Discuss and identify the purpose, operation, maintenance, laboratory control and safety requirements for ion exchange softening. 2. Give evaluation of 30 questions.

Module No:	Module Title:
II2SWS	Basic Ion Exchange Softening Submodule Title:
Approx. Time: 1/2 hour	Topic: Introduction

Objectives: Upon completion of this topic, the participant will be able to:
1. Describe what hardness is.
2. Describe what ion exchange softening is.
3. State advantages of ion exchange softening.
4. State disadvantages of ion exchange softening.

Instructional Aids:

1. Handout - Introduction
2. Transparency #1-What is Hardness.
3. Transparency #2-What is Softening.
4. Transparency #3-Advantages of ion exchange.
5. Transparency #4-Disadvantages of ion exchange.
6. Transparency #5-Review of Terminology.

Instructional Approach:

Discussion

References:

1. Manual of Instruction for Water Treatment Plant Operators, Health Education Service
2. Manual of Water Utility Operations, Texas Water Utilities Assoc.
3. Elements of Ion Exchange, Kunin

Class Assignments:

The participant will

1. Read Handout - Introduction

Module No:	Topic:
II2SWS	Introduction

Instructor Notes:	Instructor Outline:
1. Present Transparency #1	1. Discuss What Hardness Is. a. Chemical Components of Hardness b. Types of Hardness 1) Carbonate 2) Non carbonate c. Typical Hardnesses in the U.S. d. Typical Hardnesses in Iowa.
2. Present Transparency #2	2. Discuss What Softening Is. a. Removal of Hardness b. Types of Softening 1) Chemical 2) Ion exchange
3. Present Transparency #3 and #4	3. Why Soften a. Advantages 1. Consume less soap and detergent. 2. Increase the life of clothing and other articles being cleaned. 3. Increase the life of pipes and fixtures, heating systems, and boiler shells and tubes for depositing water. 4. Certain industrial processes require it. 5. Some indications that hard water may be the cause of certain cardiovascular diseases. 6. Remove radioactive nuclides. b. Disadvantages 1. With improper control, softened water may be more corrosive or scaling than the raw water. 2. If ion exchange softening is used, the sodium content of the water is greatly increased with a potential cardiovascular health hazard to certain people.

Module No:	Topic:
II2SWS	Introduction

Instructor Notes:	Instructor Outline:
	b. Disadvantages (continued) 3. If ion exchange softening is used, the total dissolved solids of the product water is increased. 4. With both processes, a waste sludge or waste brine has to be disposed of.
4. Present Transparency #5 Ask the class to provide the instructor with the correct definition for each term and write it on the transparency.	4. 1. Hardness-The concentration of Calcium, Magnesium and other divalent cations found in water. 2. Carbonate Hardness-That portion of hardness that is in combination with biocarbonate. 3. Non Carbonate Hardness-That portion of hardness that is in combination with sulfates, chlorides, nitrates and other anions. 4. Softening - The removal of hardness ions from the water. 5. Chemical Softening - The removal of hardness ions by precipitation with lime and soda ash. 6. Ion Exchange Softening - The removal of hardness ions by exchanging them with sodium ions.

Module No:	Module Title:
II2SWS	Basic Ion Exchange Softening
	Submodule Title:
Approx. Time:	Topic:
1 hour	Principles of Ion Exchange Softening

Objectives: Upon completion of this topic, the participant will be able to:
1. Write the chemical reactions for ion exchange softening
2. Write the regeneration reactions for ion exchange softening

Instructional Aids:
Handout - Principles of Ion Exchange Softening
Transparency #6-Softening reactions
Transparency #7 - Softening reactions in the resin
Transparency #8 - Regeneration reactions

Instructional Approach:

Discussion and Class problem

References:

1. Manual of Instruction for Water Treatment Plant Operators, Health Education Service
2. Manual of Water Utility Operations, Texas Water Utilities Assoc.
3. Elements of Ion Exchange, Kunin

Class Assignments:

The participant will
1. Read Handout - Principles of Ion Exchange Softening
2. The participant will complete Problem #1 on chemical reactions.

Module No:	Topic:
II2SWS	Principles of Ion Exchange Softening

Instructor Notes:	Instructor Outline:
1. Present Transparency #6	1. Discuss the softening reactions. $\begin{Bmatrix} Ca \\ Mg \end{Bmatrix} \begin{Bmatrix} (HCO_3)_2 \\ SO_4 \\ Cl_2 \end{Bmatrix} + Na_2 R \longrightarrow$ $Na_2 \begin{Bmatrix} (HCO_3)_2 \\ SO_4 \\ Cl_2 \end{Bmatrix} + \begin{Bmatrix} Ca \\ Mg \end{Bmatrix} R$
2. Present Transparency #7	2. Discuss the reactions taking place inside the resin.
3. Present Transparency #8	3. Discuss the regeneration reactions. $\begin{Bmatrix} Ca \\ Mg \end{Bmatrix} R + 2\ Na\ Cl \longrightarrow$ $Na_2 R + \begin{Bmatrix} Ca \\ Mg \end{Bmatrix} Cl_2$
4. Repeat Trarsparency #7	4. Discuss the reaction taking place inside the resin.
5. Present class Problem #1 Work part A. with class participation. Have class work part B. on their own and help those with problems.	5. Part A 1. 2 moles 2. (250 mg/l)/(162 mg/m mole) (2 moles) (23 mg/m mole) = 71 mg/l Na increase 3. (250 mg/l)/(162 mg/m mole) (40 mg/m mole) = 62 mg/l Ca originally ∴ solids increase = 71-62 = 9 mg/l

Module No:	Topic:
II2SWS	Principles of Ion Exchange Softening

Instructor Notes:	Instructor Outline;
	5. Part B 1. 2 2. (250 mg/l)/(120 mg/m mole)(2 moles)(23 mg/m mole) = 95 mg/l Na increase for Mg ∴ total increase = 71 + 95 = 106 mg/l Na increase 3. (250 mg/l)/(120 mg/m mole)(25 mg/m mole) = 50 mg/l Mg originally ∴ solids increase for Mg would be: 95-50 = 45 mg/l and total increase would be: 9 + 45 = 54 mg/l

Module No:	Module Title: Basic Ion Exchange Softening
II2SWS	Submodule Title:
Approx. Time: 1 hour	Topic: Components of Ion Exchange Softener

Objectives: Upon completion of this topic, the participant will be able to:
1. Identify the basic components of an Ion Exchange Softener.

Instructional Aids:
1. Handout - Components of Ion Exchange Softener
2. Transparency #9 - Basic Components of an Ion Exchange Softener
3. Transparency #10 - Basic Components of a brine tank

Instructional Approach:
Discussion

References:
1. Manual of Instruction for Water Treatment Plant Operators, Health Education Service
2. Manual of Water Utility Operations, Texas Water Utilities Assoc.
3. Elements of Ion Exchange, Kunin

Class Assignments:
The participant will

1. Read Handout - Components of Ion Exchange Softener
2. Complete Problem #2 identifying components of a softener.

Module No:	Topic:
II2SWS	Components of Ion Exchange Softener

Instructor Notes:	Instructor Outline:
1. Present Transparency #9	1. Discuss the Components of the Softener. a. Identify each b. Purpose of each
2. Present Transparency #10	2. Discuss the components of the Brine Tank a. Identify each b. Purpose of each
3. Present Class Problem #2 Have class match name of component with number on their own. Then work the problem with class participation.	3. Review the components and purpose in working the problem.

Module No:	Module Title:
II2SWS	Basic Ion Exchange Softening Submodule Title:
Approx. Time: 2 hour	Topic: Basic Operation of Ion Exchange Softener

Objectives: Upon completion of this topic, the participant will be able to:
1. State the steps necessary to regenerate a softener.
2. State the reason for each step of regeneration.
3. Compute when a softener should be regenerated.

Instructional Aids:
1. Handout - Basic Operation of Ion Exchange Softening
2. Transparency #11- Softener regeneration
3. Transparency #12- Calculations for regeneration
4. Transparency #13-Typical data sheet

Instructional Approach:
Discussion and class problem

References:
1. Manual of Instruction for Water Treatment Plant Operators, Health Education Service
2. Manual of Water Utility Operations, Texas Water Utilities Assoc.
3. Elements of Ion Exchange, Kunin

Class Assignments:
1. The participant will read Handout - Basic Operation of Ion Exchange Softening
2. The participant will complete Problem #3 calculating when a softener should be regenerated and how much salt should be added to the softener.

Module No:	Topic:
II2SWS	Basic Operation of Ion Exchange Softeners

Instructor Notes:	Instructor Outline:
1. Present Transparency #11	1. Discuss the Regeneration of a softener. a. Identify which valves are to be opened and closed. b. Discuss the reason for each step.
2. Present Transparency #12	2. Discuss the pounds of salt required to regenerate a softener.
3. Present Transparency #13	3. Discuss the items on the data sheet and their importance.
4. Present Class Problem #3 Have class work problem on their own. Then work the problem with class participation.	4. Review the salt dosage for regeneration in working the problem. a. (174) (11,500) = 1,000,000 grains capacity water contains $170/17$ = 10 grains hardness ∴ for full exhaustion capacity is $1,000,000/10$ = 100,000 gallons of water b. (100,000) (2/3) = 66,667 gallons of water c. (.5) (1000) = 500 lbs of salt d. (.3) (667) = 200 lbs of salt

Module No:	Module Title:
	Basic Ion Exchange Softening
II2SWS	Submodule Title:
Approx. Time:	Topic:
2 hours	Water Stabilization

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

1. Determine the proper water composition for the water distribution system.
2. Determine the proper chemical feeds to obtain the necessary water stabilization.

Instructional Aids:

1. Handout - Water Stabilization
2. Transparency #14 - Factors affecting water stabilization.
3. Transparency #15 - Ryznar Index
4. Transparency #16 - Saturation pH

Instructional Approach:

Discussion and class problem

References:

1. Manual of Instruction for Water Treatment Plant Operators, Health Education Service
2. Manual of Water Utility Operations, Texas Water Utilities Assoc.
3. Elements of Ion Exchange, Kunin

Class Assignments:

1. The participant will read Handout-Water Stabilization
2. The participant will complete Problem #4-Water Stabilization

Module No:	Topic:
II2SWS	Water Stabilization

Instructor Notes:	Instructor Outline:
1. Present Transparency #14	1. Discuss the factors and their importance in water stabilization. Discuss by passing water to achieve a 80 mg/l finished water.
2. Present Transparency #15	2. Discuss the Reizener curve and equation. Point out the index is only a guide and not absolute. For cold water a S.I. of 6.0 is a good starting point.
3. Present Transparency #16	3. Discuss the use of the diagram for use in calculating pHs. Work problem at bottom of diagram.
4. Present Class Problem #4 Have class work problem on their own. Then work the problem with class participation.	4. Review the idea of bypassing to obtain the desired water. Then calculate the proper finished water pH. a) $\frac{80}{360} \times 100 = 27\%$ b) Hardness = 360 X 27% = 80 mg/l as $CaCO_3$ Calcium = 180 X 27% = 49 mg/l as $CaCO_3$ Alkalinity = 300 mg/l as $CaCO_3$ Temperature = 60°F pH = 7.3 Total Dissolved Solids = 1000 mg/l Note: TDS has little effect on pHs, therefore, assume a value slightly higher than natural water. c) pHs = 9.30 + .2 + 2.07 - 1.31 - 2.49 = 7.77 pH = 2(7.77) - 6.0 = 9.5

Module No:	Module Title:
	Basic Ion Exchange Softening
II2SWS	Submodule Title:
Approx. Time:	Topic:
1/2 hour	Preventative Maintenance

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

1. State those items necessary for a basic preventive maintenance program.

Instructional Aids:

1. Handout - Preventative Maintenance
2. Transparency 17-Preventative Maintenance

Instructional Approach:

Discussion

References:

1. Manual of Instruction for Water Treatment Plant Operators, Health Education Service
2. Manual of Water Utility Operations, Texas Water Utilities Assoc.
3. Elements of Ion Exchange, Kunin

Class Assignments:

1. The participant will read Handout - Preventative Maintenance

Module No:	Topic:
II2SWS	Preventative Maintenance

Instructor Notes:	Instructor Outline:
1. Present Transparency #17	1. Discuss Preventative Maintenance for a zeolite softener.

Module No:	Module Title:
II2SWS	Basic Ion Exchange Softening
Approx. Time:	Submodule Title:
1/2-hour	Topic: Safety

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

1. State the potential hazards in operating a ion exchange softener.
2. State the proper corrective measures to minimize safety hazards.
3. State the proper actions required after an accident.

Instructional Aids:

1. Handout - Safety
2. Transparency #18 - Safety

Instructional Approach:

Discussion

References:

1. Manual of Instruction for Water Treatment Plant Operators, Health Education Service
2. Manual of Water Utility Operations, Texas Water Utilities Assoc.
3. Elements of Ion Exchange, Kunin

Class Assignments:

1. The participant will read Handout - Safety

Module No: II2SWS	Topic: Safety

Instructor Notes:	Instructor Outline:
1. Present Transparency #18	1. Discuss safety in operating a zeolite softener.

Module No:	Module Title:
II2SWS	Basic Ion Exchange Softening Submodule Title:
Approx. Time: 1½ hour	Topic: Laboratory Control

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

1. Select the proper analytical tests for operational control.
2. Explain the necessary analytical tests for operational control.
3. Interpret the results of analytical tests use in operational control.

Instructional Aids:

1. Handout-Laboratory Control
2. Transparency #19 - Laboratory Control
3. Transparency #20 - Soup Test

Instructional Approach:

Discussion and class problem

References:

1. Standard Methods for the 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 - Laboratory Control

Module No:	Topic:
II2SWS	Laboratory Control

Instructor Notes:	Instructor Outline:
1. Present Transparency #19	1. Discuss the various laboratory analysis and the need for each.
2. Present Transparency #20	2. Discuss the soap test.

Module No:	Module Title:
II2SWS	Basic Ion Exchange Softening
	Submodule Title:
Approx. Time:	
1 hour	Topic:
	Evaluation

Objectives:

The participant should be able to answer correctly 30 of the 36 questions asked.

Instructional Aids:

None

Instructional Approach:

Examination

References:

None

Class Assignments:

None

Module No:	Topic:
II2SWS	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 #1 - #20

for

Training Module II2SWS

WHAT IS HARDNESS?

1. CHEMICAL COMPONENTS
   A) Ca^{++}
   B) Mg^{++}
   C) OTHER

2. TYPES OF HARDNESS
   A) CARBONATE

      $Ca(HCO_3)_2$ OR $Mg(HCO_3)_2$

   B) NON CARBONATE

      $CaSO_4$ OR $Mg(Cl)_2$

WHAT IS SOFTENING?

1. REMOVAL OF HARDNESS

2. TYPES
   A) CHEMICAL PRECIPITATION
   B) ION EXCHANGE

WHY SOFTEN?

1. ADVANTAGES
   - A) CONSUME LESS SOAP AND DETERGENT
   - B) INCREASE THE LIFE OF CLOTHING AND OTHER ARTICLES BEING CLEANED.
   - C) INCREASE THE LIFE OF PIPES AND FIXTURES, HEATING SYSTEMS, AND BOILER SHELLS AND TUBES IN DEPOSITING WATER.
   - D) CERTAIN INDUSTRIAL PROCESSES REQUIRE IT.
   - E) SOME INDICATIONS THAT HARD WATER MAY BE THE CAUSE OF CERTAIN CARDIOVASCULAR DISEASES.
   - F) REMOVE RADIOACTIVE NUCLIDES.

WHY SOFTEN?

2. DISADVANTAGES

A) WITH IMPROPER CONTROL, SOFTENED WATER MAY BE MORE CORROSIVE OR SCALING THAN THE RAW WATER.

B) IF ION EXCHANGE SOFTENING IS USED, THE SODIUM CONTENT OF THE WATER IS GREATLY INCREASED WITH A POTENTIAL CARDIOVASCULAR HEALTH HAZARD TO CERTAIN PEOPLE.

C) IF ION EXCHANGE SOFTENING IS USED, THE TOTAL DISSOLVED SOLIDS OF THE PRODUCT WATER IS INCREASED.

D) WITH BOTH PROCESSES, A WASTE-SLUDGE OR WASTE BRINE HAS TO BE DISPOSED OF.

REVIEW OF TERMINOLOGY

1. HARDNESS -

2. CARBONATE HARDNESS -

3. NONCARBONATE HARDNESS -

4. SOFTENING -

5. CHEMICAL SOFTENING -

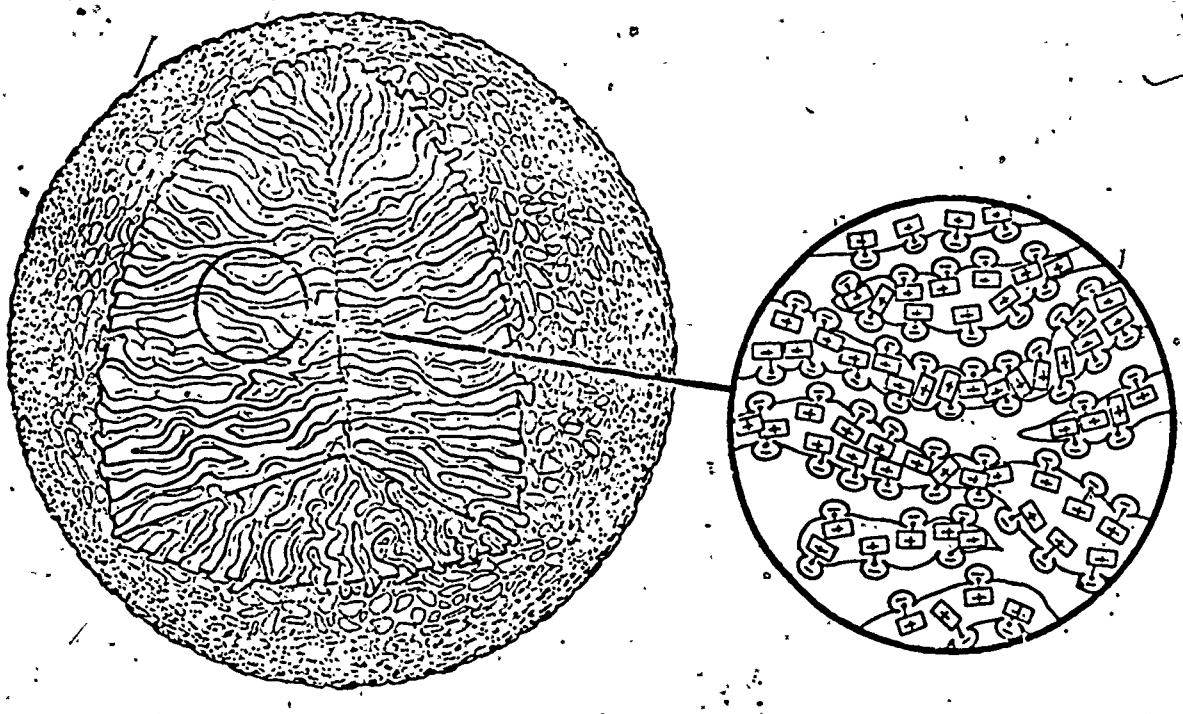
6. ION-EXCHANGE SOFTENING -

SOFTENING REACTIONS

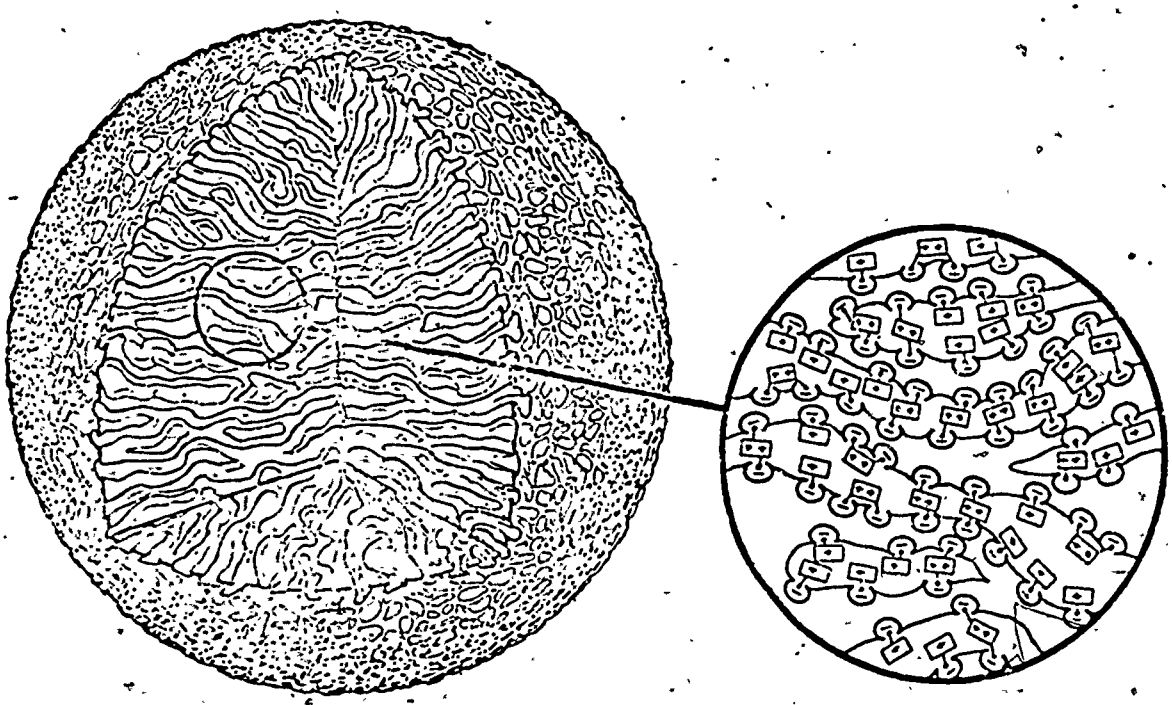
HARD WATER + SODIUM EXCHANGE RESIN → SOFT WATER + EXHAUSTED EXCHANGE BED

$$\left\{\begin{matrix}CA\\MG\end{matrix}\right\}\left\{\begin{matrix}(HCO_3)_2\\SO_4\\CL_2\end{matrix}\right\} + Na_2R \longrightarrow Na_2\left\{\begin{matrix}(HCO_3)_2\\SO_4\\CL_2\end{matrix}\right\} + \left\{\begin{matrix}CA\\MG\end{matrix}\right\}R$$

SOFTENING REACTIONS IN THE RESIN



REGENERATED RESIN



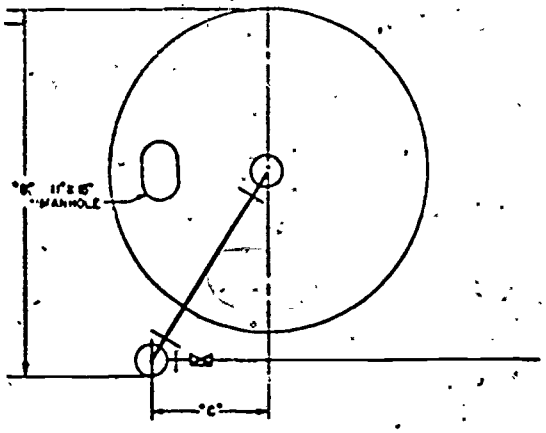
PARTIALLY EXHAUSTED RESIN

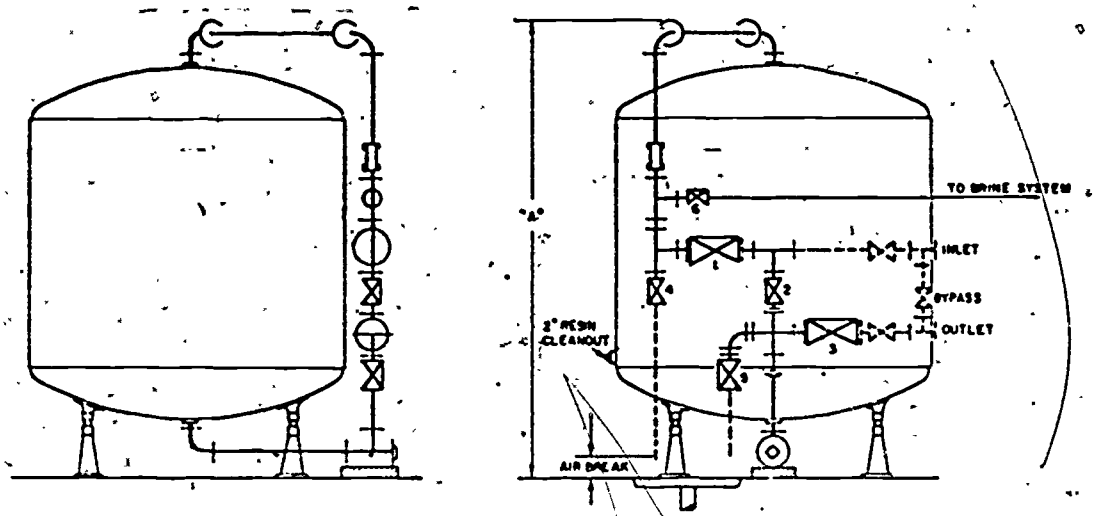
REGENERATION REACTIONS

Exhausted Exchange Bed		Sodium Chloride (Salt) Solution		Sodium Exchange Bed	Waste Brine
$\begin{Bmatrix} Ca \\ Mg \end{Bmatrix} R$	+	$2\,NaCl$	$\longrightarrow$	Na_2R	+ $\begin{Bmatrix} Ca \\ Mg \end{Bmatrix} Cl_2$

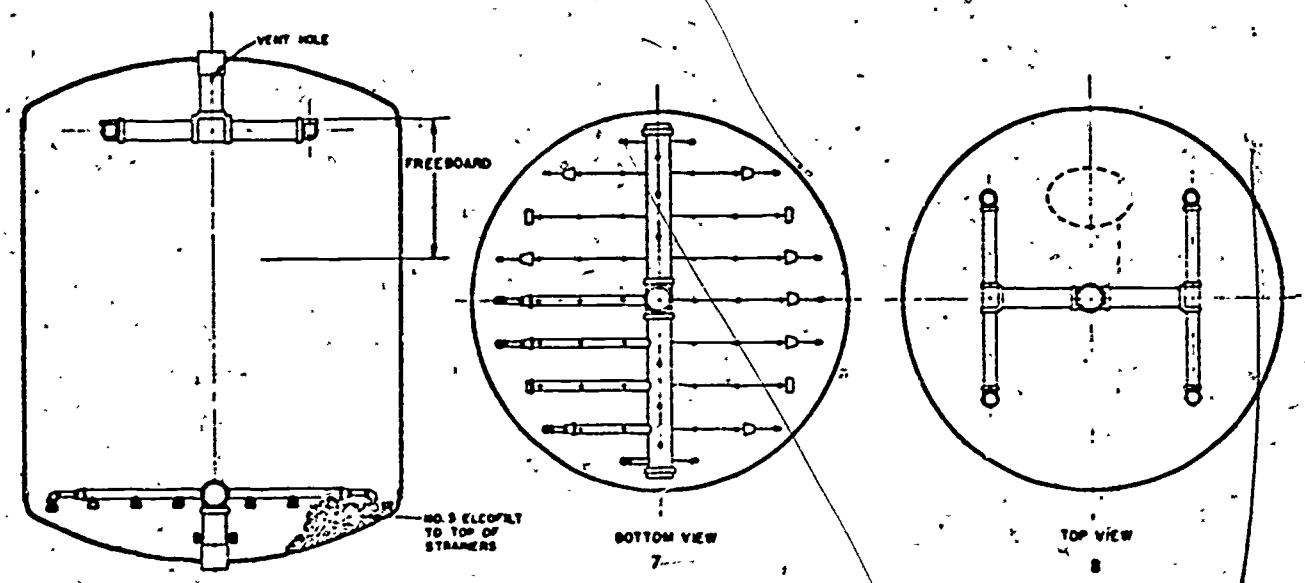
BASIC COMPONENTS OF A SOFTENER

1. Inlet valve
2. Backwash control valve
3. Outlet valve
4. Backwash outlet valve
5. Brine to waste valve
6. Brine control valve
7. Bottom manifold
8. Top manifold



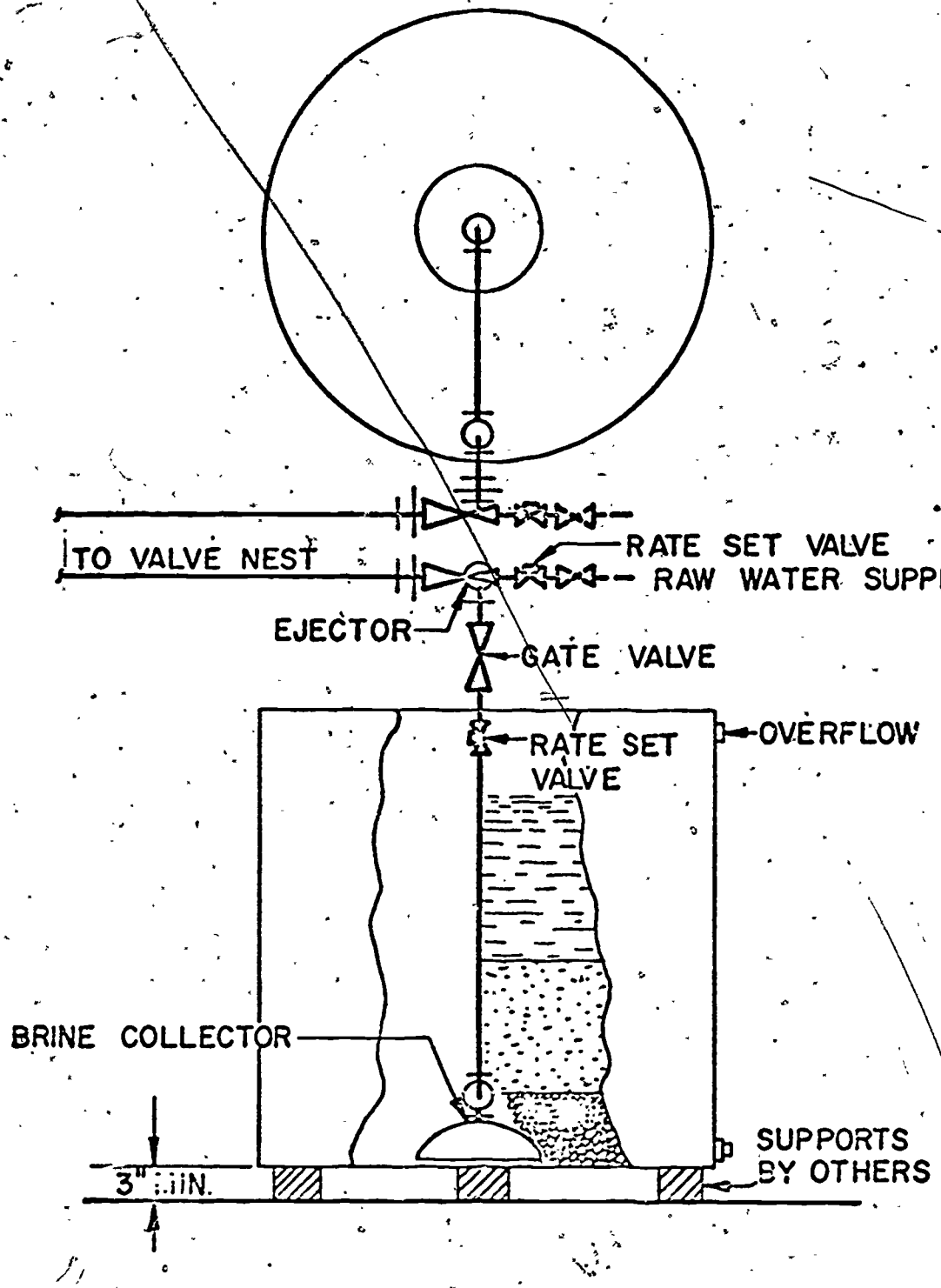


SOFTENER EXTERNAL VIEW



SOFTENER INTERNAL VIEW

BASIC COMPONENTS OF A BRINE TANK



SALT DOSAGE FOR REGENERATION

1. FULL EXHAUSTION - .5 LBS/1000 GRAINS REMOVED
2. 2/3 EXHAUSTION - .3 LBS/1000 GRAINS REMOVED

EXAMPLE:

SOFTENER CONTAINS RESIN HAVING A TOTAL CAPACITY OF 200,000 GRAINS. FOR FULL EXHAUSTION, THE SALT DOSAGE WOULD BE:

$$(.5 \text{ LBS}/1000 \text{ GRAINS})\ (200{,}000 \text{ GRAINS})\ (1 \text{ GRAIN}/1000 \text{ GRAINS}) =$$

100 LBS OF SALT

FOR 2/3 EXHAUSTION, THE SALT DOSAGE WOULD BE:

$$(.3 \text{ LBS}/1000 \text{ GRAINS})\ (200{,}000 \text{ GRAINS})\ (1 \text{ GRAIN}/1000 \text{ GRAINS})\ (2/3) =$$

40 LBS OF SALT

REGENERATION OF A SOFTENER

IV. BASIC OPERATION OF ION EXCHANGE SOFTENER

A. REGENERATION

1. BACKWASH SOFTENER FOR FIVE MINUTES OR UNTIL WASHWATER IS CLEAR, WHICH EVER ONE IS LONGER.
2. ADD THE REQUIRED AMOUNT OF BRINE TO THE SOFTENER FROM THE BRINE SATURATOR.
3. CONTINUE ADDING WATER AT A SLOW RATE UNTIL A SALT TASTE IS NOTICED AT THE WASTE.
4. DISCONTINUE WATER ADDITION AND ALLOW BRINE TO REMAIN IN SOFTENER FOR 15-30 MINUTES.
5. START SLOW RINSE UNTIL ALL SALT TASTE IS GONE.
6. START FAST RINSE FOR 10-15 MINUTES.
7. PLACE UNIT INTO SERVICE.

TYPICAL DATA SHEET

Location _____ Week of _____ to _____ 19_____

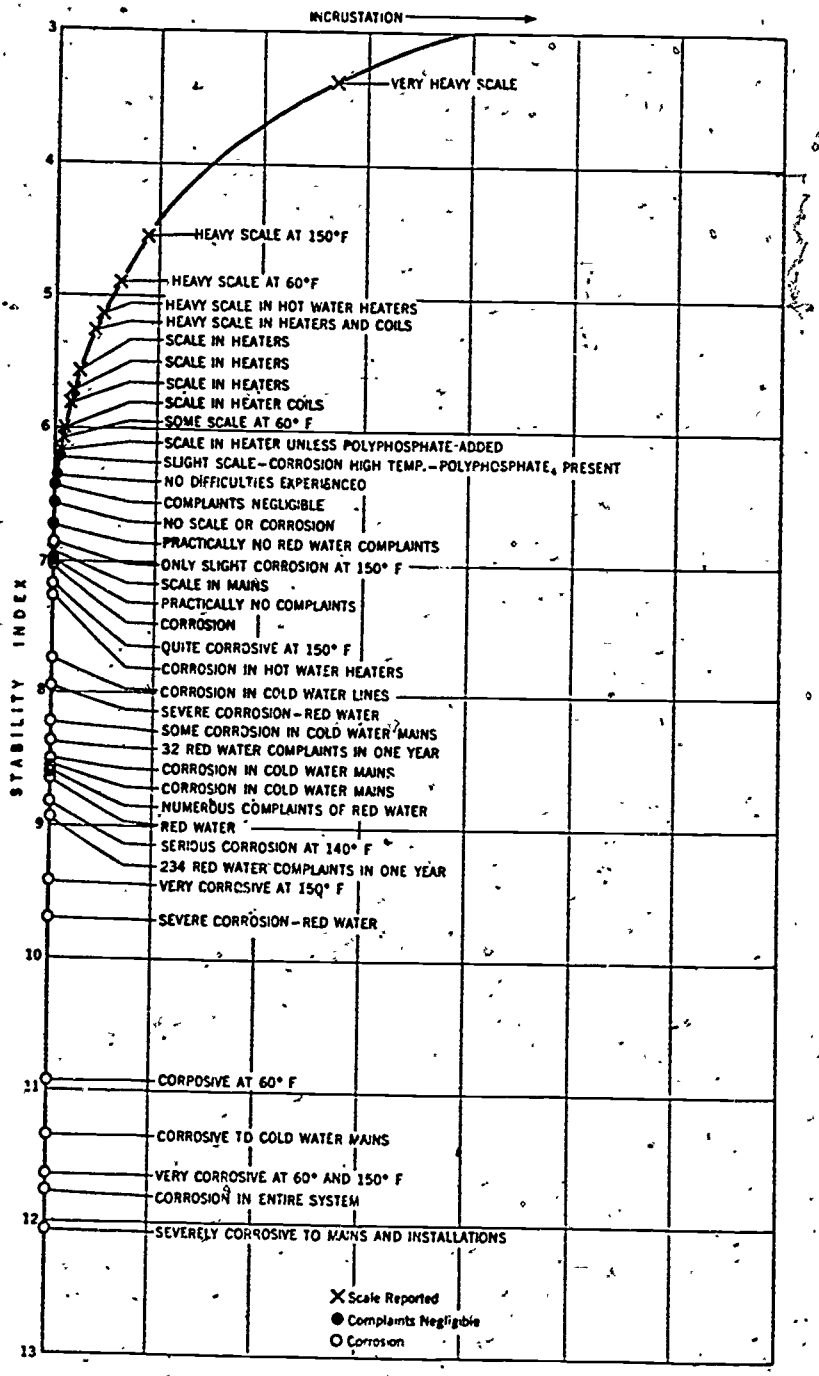
Day		Meter Readings E = End S = Start T = Total gallons						Raw Hardness gr. /gal.	lbs. salt added to tank	Oper-ator	Remarks
		Unit # 1		Unit # 2		Unit # 3					
		Softened	Backwash	Softened	Backwash	Softened	Backwash				
Sun.	E										
	S										
	T										
Mon.	E										
	S										
	T										
Tues.	E										
	S										
	T										

ETC.

FACTORS AFFECTING WATER STABILIZATION

1. TEMPERATURE
2. CALCIUM
3. TOTAL DISSOLVED SOLIDS
4. ALKALINITY
5. pH

RYZNAR INDEX



$$S.I. = 2\,pHs - pH$$

TRANSPARENCY 112SWS - #15

TRANSPARENCY 16 "SATURATION PH" REMOVED PRIOR TO BEING SHIPPED TO EDRS FOR FILMING DUE TO COPYRIGHT RESTRICTIONS.

PREVENTATIVE MAINTENANCE

A. ACCURATE RECORD OF PERFORMANCE
   1. PERIODIC CAPACITY CHECKS
   2. PERIODIC BRINE FLOW CHECKS

B. KEEP ALL PARTS WELL PAINTED TO PREVENT CORROSION

C. PROPERLY TREAT UNITS WHEN THEY ARE LAID UP
   1. FOR ABOVE FREEZING TEMPERATURES
      A) BACKWASH AND REGENERATE
      B) LEAVE A VALVE OPEN TO RELEASE ANY PRESSURE BUILDUP
   2. FOR BELOW FREEZING TEMPERATURES
      A) BACKWASH
      B) FILL TANK WITH STRONG BRINE
      C) LEAVE A VALVE OPEN TO RELEASE ANY PRESSURE BUILDUP

SAFETY

A. ELECTRICAL SAFETY
   1. ALWAYS USE GROUNDED OR DOUBLE INSULATED ELECTRICAL TOOLS WHEN WORKING ON SOFTENERS.
   2. IF SOFTENER HAS AUTOMATIC CONTROLS ALWAYS CONNECT TO AN APPROPRIATELY GROUNDED OUTLET. REPLACE ANY WORN OR FRAYED POWER CORDS.

B. LIFTING HEAVY SALT BAGS
   1. ALWAYS LIFT FROM THE KNEES TO PREVENT PERSONAL INJURY.

C. EYE PROTECTION
   1. ALWAYS WEAR EYE PROTECTION WHEN HANDLING SALT OR WORKING AROUND THE BRINE TANK.
   2. IF SALT GETS INTO YOUR EYE, FLUSH WITH A LARGE QUANTITY OF FRESH WATER.

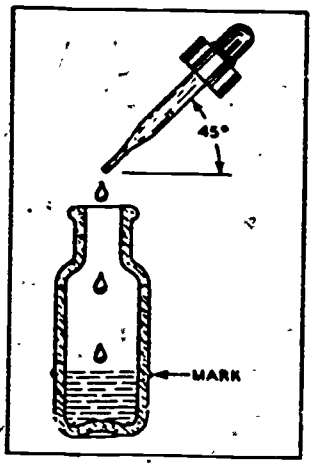
LABORATORY CONTROL

A. PHYSICAL
   1. TEMPERATURE - FINAL
   2. PRESSURE LOSS THROUGH SOFTENER

B. CHEMICAL
   1. ALKALINITY - FINAL
   2. TOTAL AND CALCIUM HARDNESS - RAW AND FINAL
   3. TOTAL DISSOLVED SOLIDS - FINAL
   4. pH - FINAL
   5. SOAP TEST - FINAL

SOAP TEST

1. RINSE THE TESTING BOTTLE THOROUGHLY. THEN FILL IT TO THE MARK WITH FINISHED WATER WHEN SOFTENER IS IN SERVICE.



2. HOLD THE DROPPER AT A 45-DEGREE ANGLE AND ADD THREE (3) FULL DROPS OF STANDARD SOAP SOLUTION. HOLD THE TESTING BOTTLE IN ONE HAND WITH THUMB CLOSING THE END OF THE BOTTLE AND SHAKE IT VIGOROUSLY. WITH SOFT WATER ("ZERO-SOFT") A SUDS WILL BE FORMED THAT WILL STAND FOR SEVERAL MINUTES.

3. WHEN A SUDS FORMS THAT WILL STAND FOR SEVERAL MINUTES THE SAMPLE "TESTS SOFT".

4. IF, ON THE OTHER HAND, A SUDS IS NOT OBTAINED OR IT WILL NOT STAND FOR SEVERAL MINUTES, THE SAMPLE "TESTS HARD".

CLASS PROBLEMS

for

Training Module II2SWS

CLASS PROBLEM #1

PART A.

1. For a water containing calcium bicarbonate ($Ca(HCO_3)_2$), how many moles of sodium will be released for each mole of calcium?

2. If a water contained 250 mg/l of calcium bicarbonate, how much will the sodium concentration increase?

3. How much will the total dissolved solids increase?

CLASS PROBLEM #1

PART B.

1. For a water containing magnesium sulfate ($MgSO_4$), how many moles of sodium will be released for each mole of magnesium?

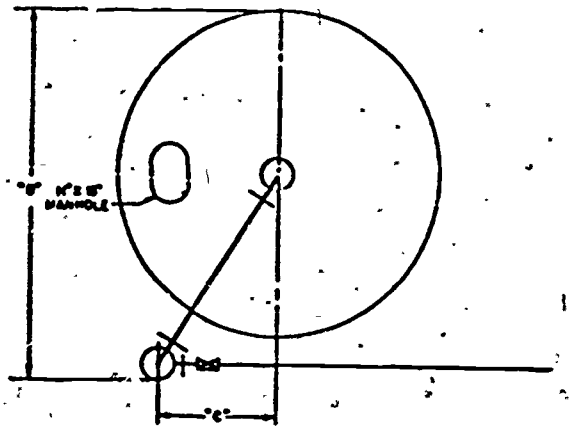
2. If a water contained 250 mg/l of calcium bicarbonate and 250 mg/l of Magnesium Sulfate, how much will the sodium concentration increase?

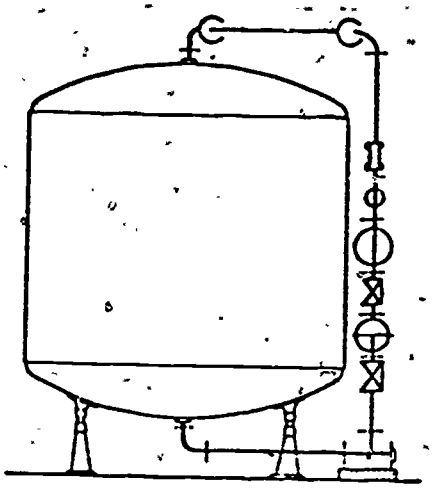
3. How much will the total dissolved solids increase?

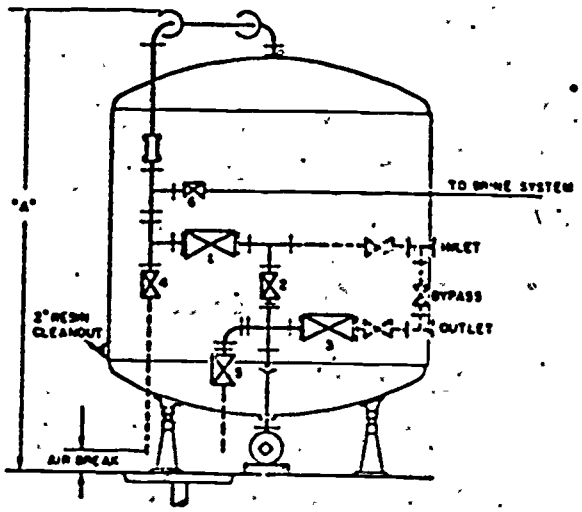
CLASS PROBLEM #2

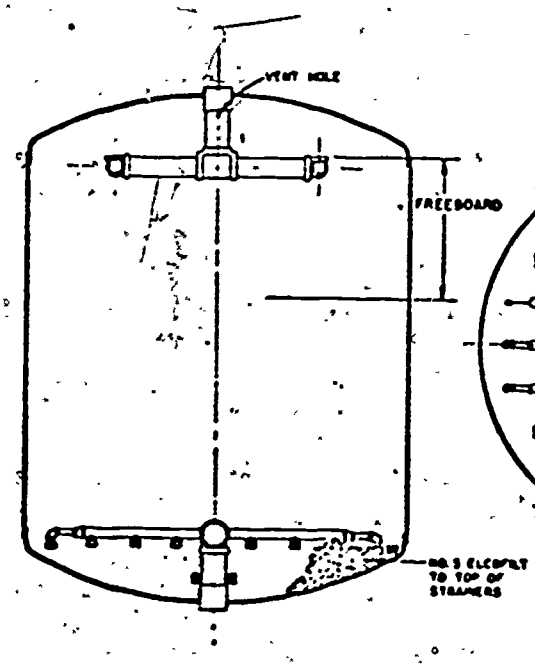
1. Match each number with the correct component

Top Manifold _____
Outlet Valve _____
Backwash outlet valve _____
Brine to waste valve _____
Bottom manifold _____
Backwash control valve _____
Inlet valve _____
Brine control valve _____









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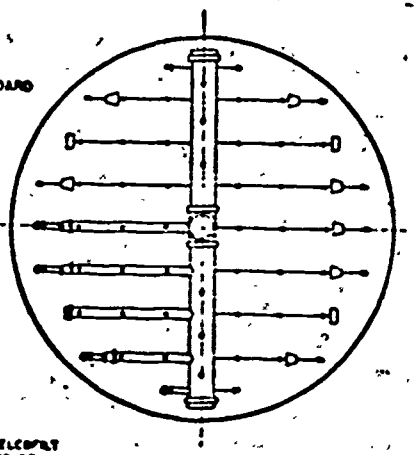
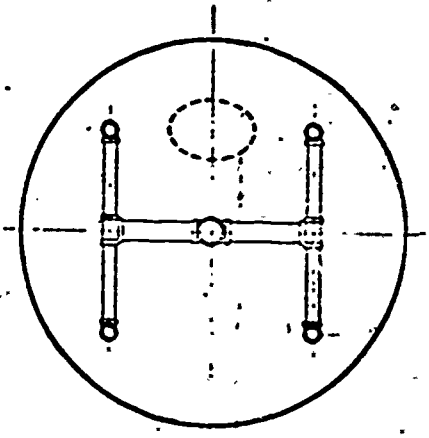


BOTTOM VIEW



TOP VIEW

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CLASS PROBLEM #3

1. A softener contains 174 cu. ft. of synthetic zeolite resin having a capacity of 11,500 grains per cu. ft.

   a. If raw water contains 170 mg/l as $CaCO_3$ of hardness, how many gallons of water will total exhaust the softener?

   b. How many gallons of water will exhaust 2/3 the capacity of the softener?

   c. How many pounds of salt will be required regenerate a totally exhausted softener?

   d. How many pounds of salt will be required to regenerate a 2/3 exhausted softener?

CLASS PROBLEM #4

1. A water to be zeolite softened has the following chemical and physical characteristics:

   Hardness = 360 mg/l as $CaCO_3$
   Alkalinity = 300 mg/l as $CaCO_3$
   Calcium = 180 mg/l as $CaCO_3$
   Total Dissolved Solids = 800 mg/l
   pH = 7.3
   Temperature = 60°F

   a. What percentage of water will have to be bypassed to achieve a stable water?

   b. What will be the chemical and physical characteristics of the blended water?

   c. What pH should the blended water be adjusted to achieve a stable water?

CLASS HANDOUT

for

Training Module II2SWS

I. Introduction
   A. What is Hardness
      1. Chemical Components
         a) Ca
         b) Mg
         c) Other
      2. Types
         a) Carbonate
         b) Noncarbonate
      3. Typical Hardness in U.S.
      4. Typical Hardness in Iowa
   B. What is Softening
      1. Removal of Hardness
      2. Types of Softening
         a) Chemical precipitation
         b) Ion exchange
   C. Why Soften
      1. Advantages
         a) Consume less soap and detergent.
         b) Increase the life of clothing and other articles being cleaned.
         c) Increase the life of pipes and fixtures, heating systems, and boiler shells and tubes for depositing water.
         d) Certain industrial processes require it.
         e) Some indications that hard water may be the cause of certain cardiovascular diseases.
         f) Remove radioactive nuclides.
      2. Disadvantages
         a) With improper control, softened water may be more corrosive or scaling than the raw water.
         b) If ion exchange softening is used, the sodium content of the water is greatly increased with a potential cardiovascular health hazard to certain people.
         c) If ion exchange softening is used, the total dissolved solids of the product water is increased.
         d) With both processes, a waste sludge or waste brine has to be disposed of.

II. Principles of Ion Exchange Softening
   A. Softening Reactions

$$\begin{Bmatrix} Ca^{++} \\ Mg^{++} \end{Bmatrix} \begin{Bmatrix} HCO_3^- \\ SO_4^{=} \\ Cl^- \end{Bmatrix} + Na\,R \longrightarrow$$

$$Na^+ \begin{Bmatrix} HCO_3^- \\ SO_4^{=} \\ Cl^- \end{Bmatrix} + \begin{Bmatrix} Ca \\ Mg \end{Bmatrix} R$$

B. Regeneration Reactions

$$\left\{ \begin{matrix} Ca^{++} \\ Mg^{++} \end{matrix} \right\} R + 2\,NaCl \longrightarrow$$

$$Na_2R + \left\{ \begin{matrix} Ca^{++} \\ Mg^{++} \end{matrix} \right\} Cl_2$$

III. Components of Ion Exchange Softener
- A. Softener
  (See Figure 1)
- B. Brine Tank
  (See Figure 2)

IV. Basic Operation of Ion Exchange Softener
- A. Regeneration
  1. Backwash softener for five minutes or until washwater is clear, which ever one is longer.
  2. Add the required amount of brine to the softener from the brine saturator.
  3. Continue adding water at a slow rate until a salt taste is noticed at the waste.
  4. Discontinue water addition and allow brine to remain in softener for 15-30 minutes.
  5. Start slow rinse until all salt taste is gone.
  6. Start fast rinse for 10-15 minutes.
  7. Place unit into service.
- B. Salt Dosage
  1. Full exhaustion - .5 lbs/1000 grains removed
  2. 2/3 exhaustion - .3 lbs/1000 grains removed

V. Water Stabilization
- A. Factors affecting water stabilization
  1. Temperature
  2. Calcium
  3. Total Dissolved Solids
  4. Alkalinity
  5. pH
- B. Reizener Index
  S.I. = 2 pHs - pH
- C. Saturation pH
  (See Figure 3)

VI. Preventative Maintenance
- A. Accurate record of performance
  1. Periodic capacity checks
  2. Periodic brine flow checks
- B. Keep all parts well painted to prevent corrosion.
- C. Properly treat units when they are laid up
  1. For above freezing temperatures
     a) Backwash and regenerate
     b) Leave a valve open to release any pressure buildup
  2. For below freezing temperatures
     a) Backwash
     b) Fill tank with strong brine
     c) Leave a valve open to release any pressure build up

VII. Safety

A. Electrical Safety

1. Always use grounded or double insulated electrical tools when working on softeners.
2. If softener has automatic controls always connect to a appropriately grounded outlet. Replace any worn or frayed power cords.

B. Lifting heavy salt bags

1. Always lift from the knees to prevent personal injury.

C. Eye protection

1. Always wear eye protection when handling salt or working around the brine tank.
2. If salt gets into your eye, flush with a large quantity of fresh water.

VIII. Laboratory Control

A. Physical

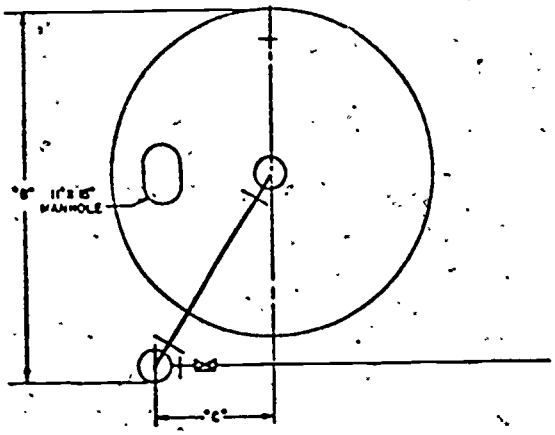
1. Temperature - Final
2. Pressure loss through softener

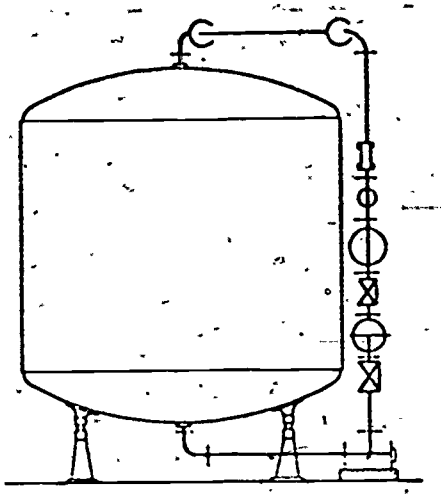
B. Chemical

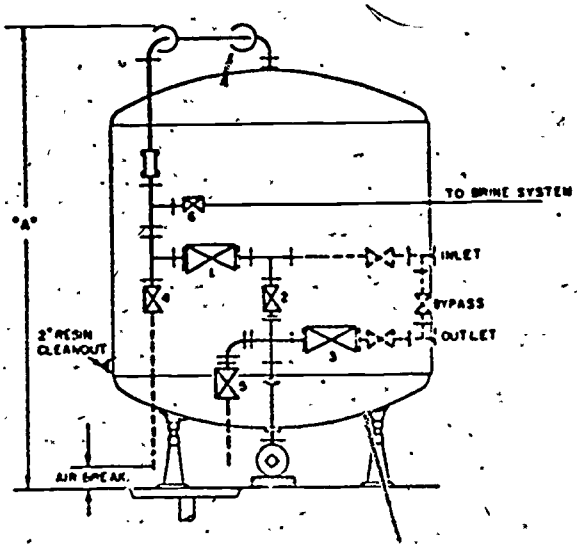
1. Alkalinity - Final
2. Total and Calcium Hardness - Raw and Final
3. Total Dissolved Solids - Final
4. pH - Final
5. Soap Test - Final

BASIC COMPONENTS OF A SOFTENER

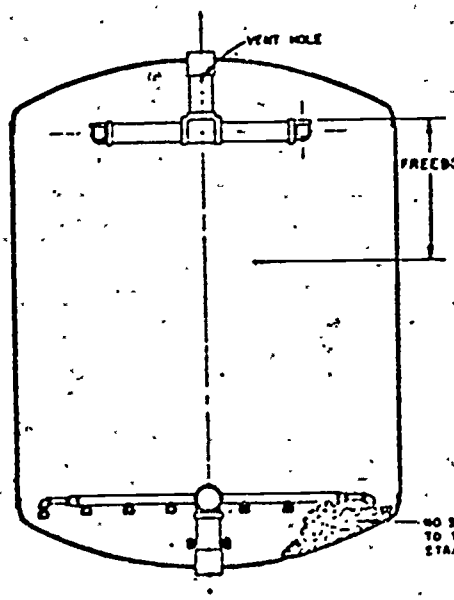
1. Inlet valve
2. Backwash control valve
3. Outlet valve
4. Backwash outlet valve
5. Brine to waste valve
6. Brine control valve
7. Bottom manifold
8. Top manifold

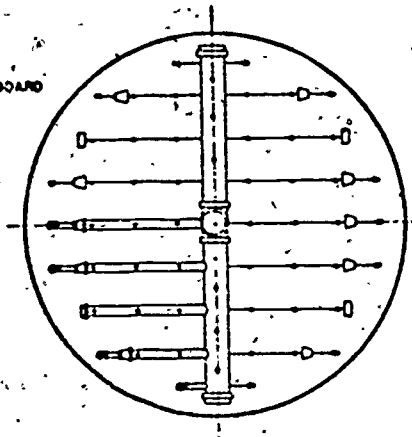


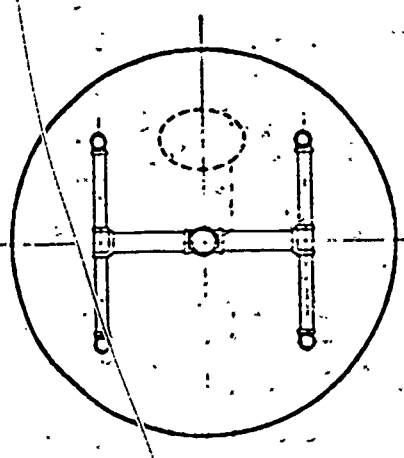




SOFTENER EXTERNAL VIEW







SOFTENER INTERNAL VIEW

FIGURE II2SWS - #1

BASIC COMPONENTS OF A BRINE TANK

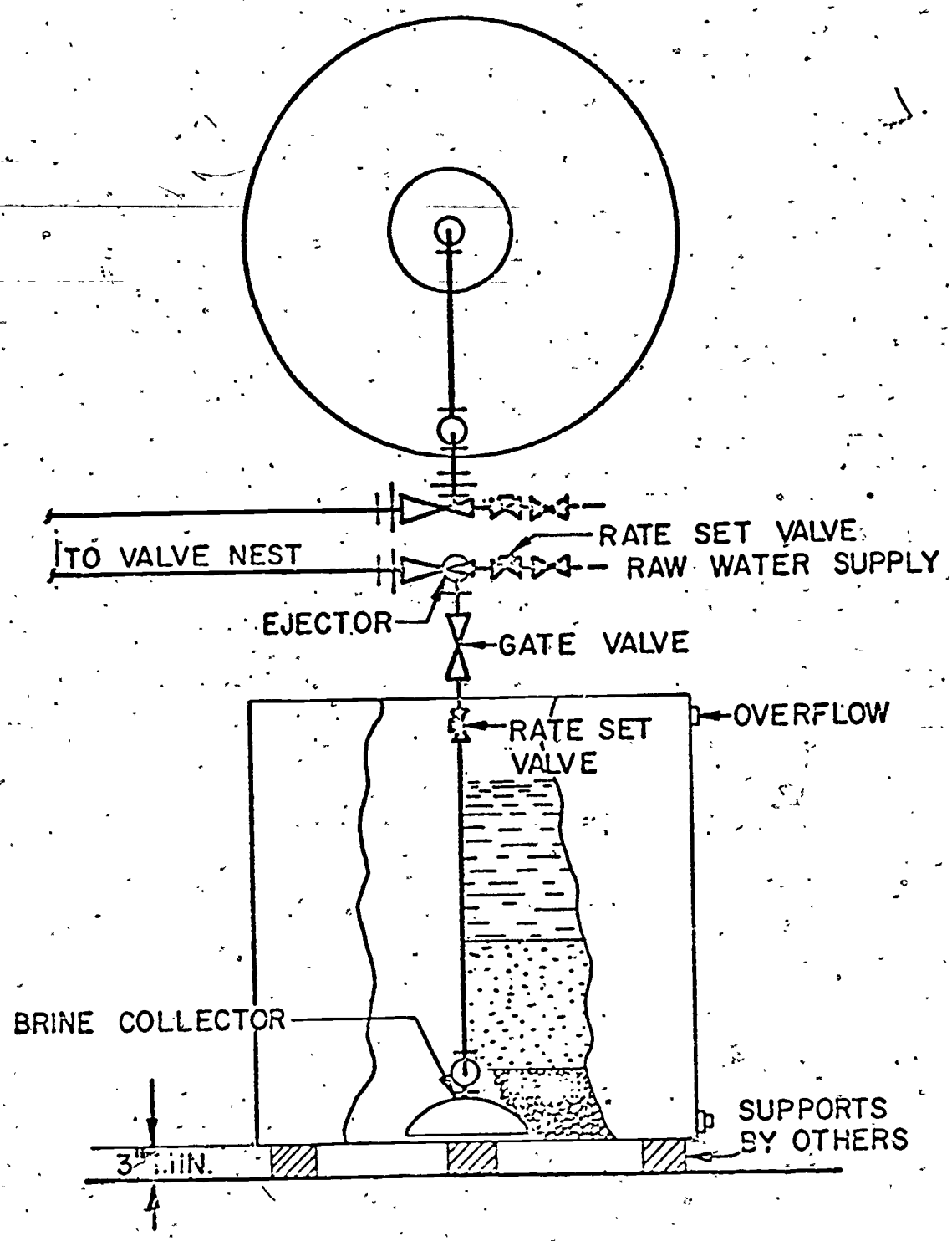


FIGURE II2SWS - #2

EXAMINATION

for

Training Module II2SWS

Examination for II2SWS - Basic Ion Exchange Softening

1. Hardness in most waters is caused by _____ and _____ divalent cation ions.

2. Hardness ions that are matched with bicarbonate anions is called _____ hardness.

3. Softening is defined as _____

_____

4. List three advantages of softening:
   a.
   b.
   c.

5. List three disadvantages of ion exchange softening:
   a.
   b.
   c.

6. In ion exchange softening, hardness ions are removed and replaced with _____ ions.

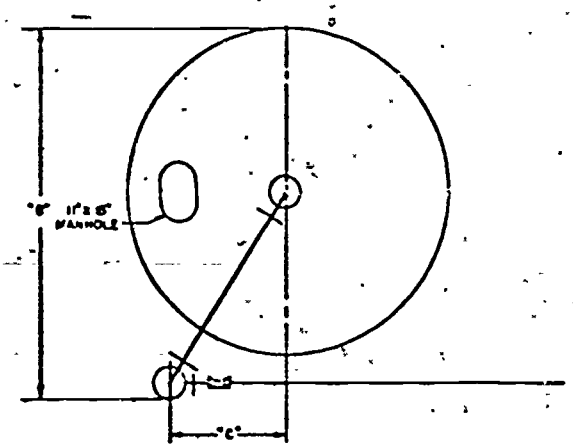
7. When a softener is fully exhausted, it requires _____ lbs of salt per 1000 grains of hardness removed.

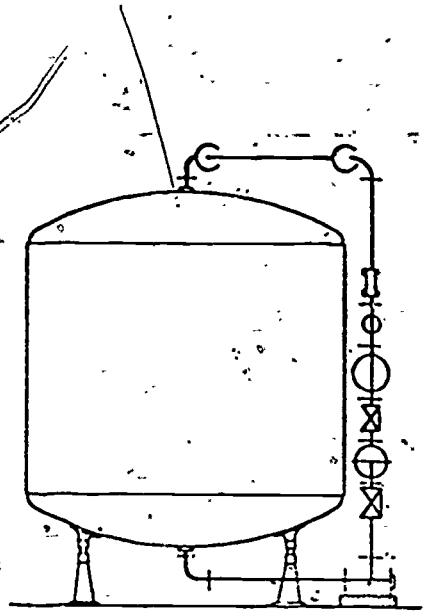
8. When a softener is 2/3 exhausted, it requires _____ lbs of salt per 1000 grains of hardness removed.

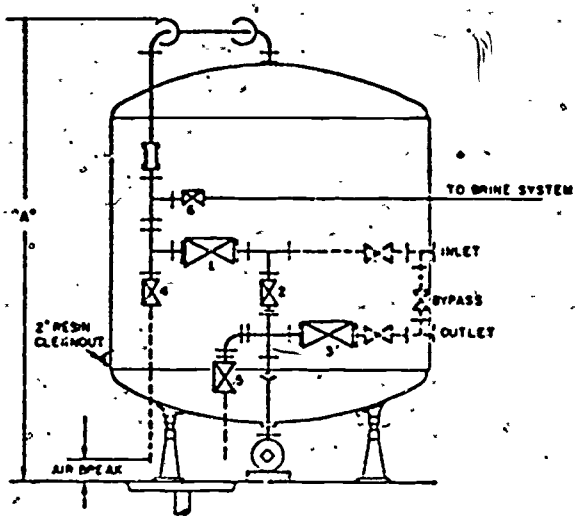
9. List the five factors affecting water stabilization.
   a.
   b.
   c.
   d.
   e.

10. Match each number with the correct component.

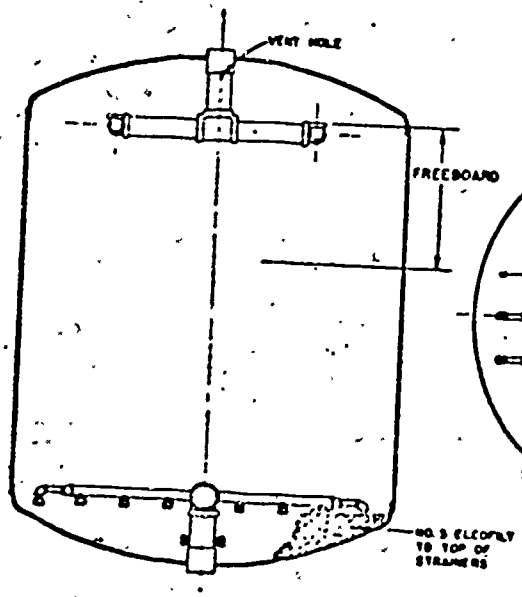
Top Manifold_____
Outlet Valve_____
Backwash outlet valve_____
Brine to waste valve_____
Bottom manifold_____
Backwash control valve_____
Inlet valve_____
Brine control valve_____

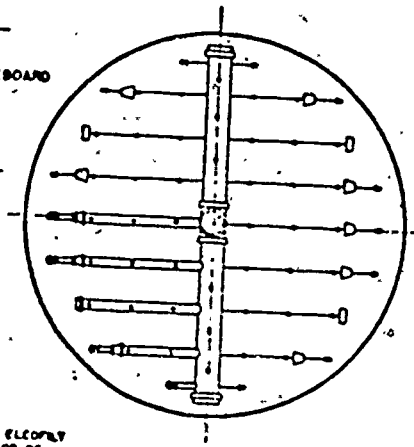




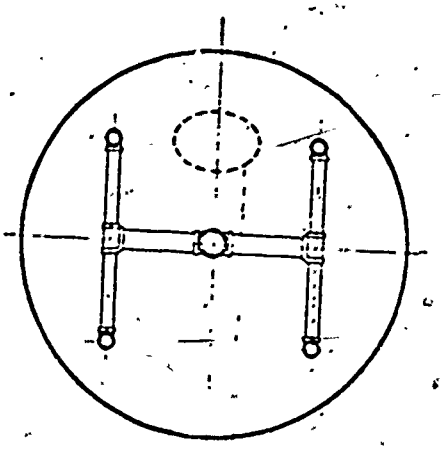


SOFTENER EXTERNAL VIEW





BOTTOM VIEW
7



TOP VIEW
8

SOFTENER INTERNAL VIEW

TRUE OR FALSE - CIRCLE THE CORRECT ANSWER

T or F 11. When a softener is regenerated, the brine should never be allowed to sit in contact with the resin for any length of time.

T or F 12. A properly stabilized water always has a pH of 7.0.

T or F 13. When a softener is laid up in freezing temperatures it should always be left with brine in the tank.

T or F 14. The soap test can give a quick determination for headloss across the softener.

T or F 15. When water contains $CaSO_4$ it is considered noncarbonate.

T or F 16. Radioactive particles are removed by ion exchange softening.

T or F 17. Total dissolved solids always decrease with ion exchange softening.

T or F 18. The majority of ion exchange reactions occur inside the resin particles.

T or F 19. It is cheaper to operate a softener at full exhaustion than at 2/3 exhaustion.

T or F 20. Zero soft water is always stable and never needs any chemical adjustment.