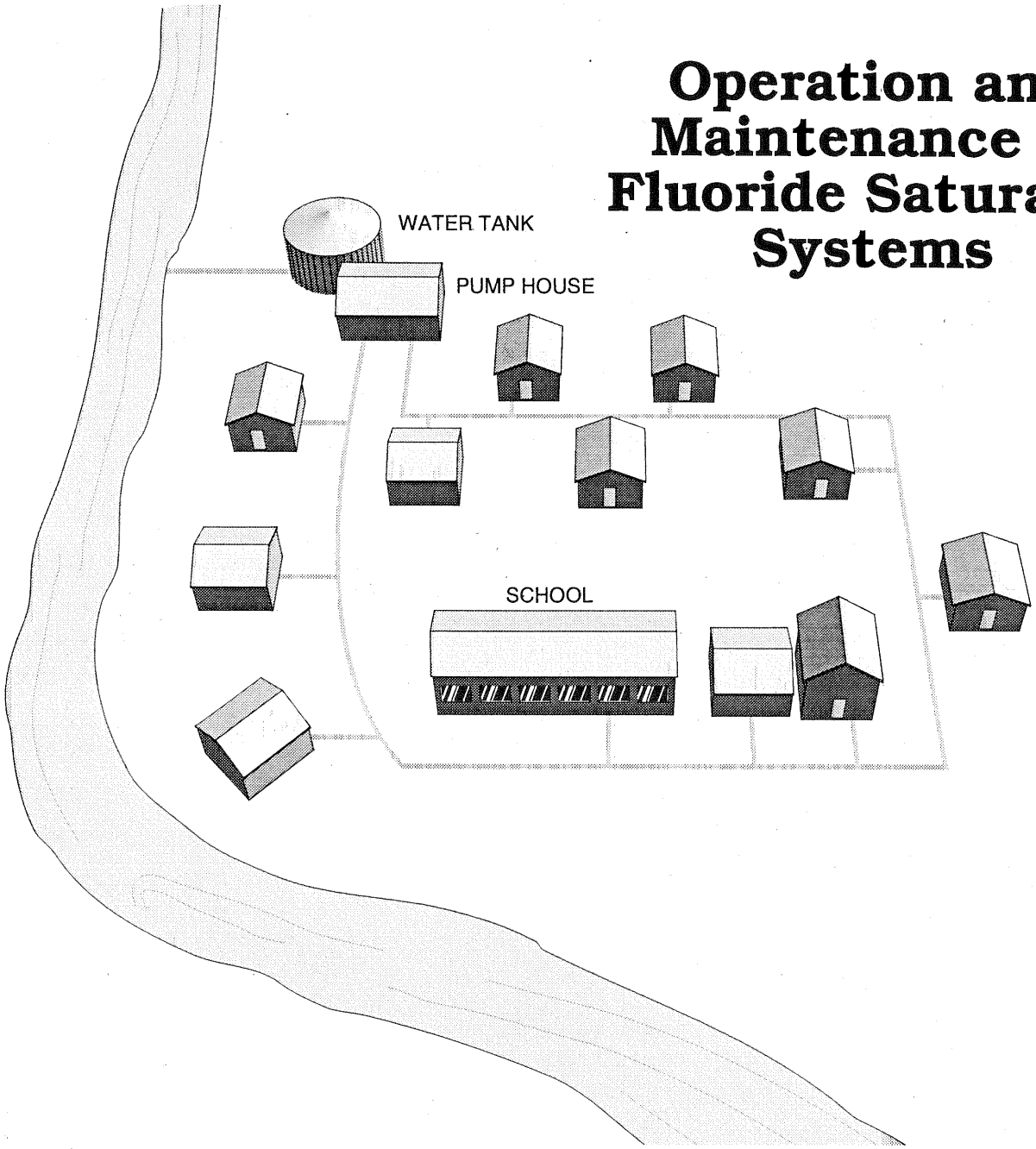
O & M of Small Water Systems



Operation and Maintenance of Fluoride Saturator Systems

Alaska Department of Environmental Conservation
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O & M of Small Water Systems

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KEY WORDS

- Atmospheric vacuum breaker
- Diffuser
- Dosage
- Fluoridation
- OSHA
- Positive displacement pump
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- Upflow saturator
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O & M OF FLUORIDE SATURATOR SYSTEMS

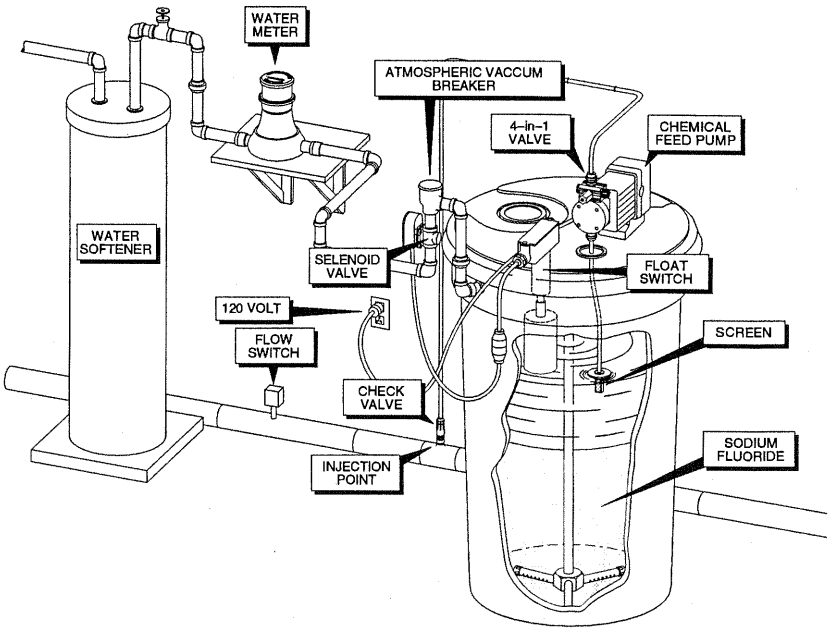
INTRODUCTION

Lesson Content

This module is designed for the level 1 operator. The focus is on the operation and maintenance of **sodium fluoride**[1] **upflow saturator**[2] systems.

Theory

There is no information associated with the theory or chemistry of fluoride discussed in this module.



FUNCTION

Reason for Adding Fluoride

Fluoride is added to drinking water system to adjust the natural fluoride in the drinking water. Studies associated with fluoridated water systems indicate that the optimum dose of fluoride can reduce tooth decay by as much as 60%.

Optimum Dosage

In Alaska the optimum **dosage**[3] ranges from 1.1 mg/L to 1.7 mg/L. The optimum dosage is dependent upon the amount of water being consumed by each individual. It is assumed that the amount of water consumed will vary with air temperature. When the air temperature is hot or extremely cold water consumption will go up.

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[1] **Sodium Fluoride** - A chemical compound with the chemical formula NaF. The compound is commonly used in a crystal form in a fluoride saturator. Sodium fluoride is designated by OSHA as a Poison, it has a UN designation of 6, its DOT placard number is 1690.

[2] **Upflow Saturator** - A device which produces a fluoride solution for the fluoridation process. The device is usually a cylindrical container with granular sodium fluoride on the bottom. Water flows upward through the sodium fluoride to produce the fluoride solution.

[3] **Dosage** - The amount of a chemical applied to the water. Commonly expressed in mg/l.

MCL

Fluoride is the only chemical with two MCL's. There is a Secondary MCL and a Primary MCL. The Secondary MCL is 2.0 mg/L and the Primary is 4.0 mg/L. This means that if the fluoride concentration in the water system reaches 2.0 mg/L there is cause for concern and DEC must be notified, if the concentration reaches 4.0 mg/L a health risk is considered to exist and the fluoride system should be shut-down and DEC notified. These levels are established under the assumption that fluoride is being feed on a continuous basis.

Primary MCL
2.0 mg/L

Secondary MCL
4.0 mg/L

Theory

Bacteria that naturally exist in the mouth consume sugar and produce an acid that destroys the enamel of the teeth. It is believed that when fluoride at the proper concentration is provided to children between birth and eight to ten years of age, the teeth are hardened and thus reduce the acids impact.

Determining Effectiveness

The effectiveness is assumed to exist if the fluoride concentration remains within the optimum range. The best measure of effectiveness is from local dental records.

USING A FLUORIDE SATURATOR

Overview

There are serval methods employed to add fluoride to drinking water. Only one method will be described in this module, the use of an upflow saturator. Basically the upflow saturator uses a chemical resistant tank to hold sodium fluoride (NaF) crystals that produce a 4% solution of sodium fluoride. This solution is fed into the system at the water plant or well site to provide the proper **residual**[4].

UPFLOW SODIUM FLUORIDE SYSTEM

Introduction

The upflow fluoride saturator system can be divided into four distinct areas:

- Chemical storage
- Hydraulic system
- Electrical system
- Control system

CHEMICAL STORAGE

Introduction

Chemical storage includes safety information on the chemical, storage requirements and concerns and building considerations. Proper methods of handling and mixing chemicals is discussed in the section on start-up.

Building - Clean and Dry

The interior of the building in the vicinity of the **fluoridation**[5] equipment should be kept clean and dry. While dryness is not always possible, cleanliness is necessary in order to provide a safe working environment.

Chemical

Sodium fluoride is commonly purchased as a dry powdered crystal containing 5 to 12.5% fluoride (F). The crystals are typically purchased in 54 pound plastic buckets or paper bags.

OSHA Classification

Sodium fluoride is classified by **OSHA**[6] as a poison. Each container should display a placard with a skull and cross bones and the letters POISON. At the bottom of the placard will be the UN classification number 6.

UN Classification

The UN (United Nations) Classification for sodium fluoride is the number 6, a poisonous and infectious material. A table showing the various UN classifications is provided below.

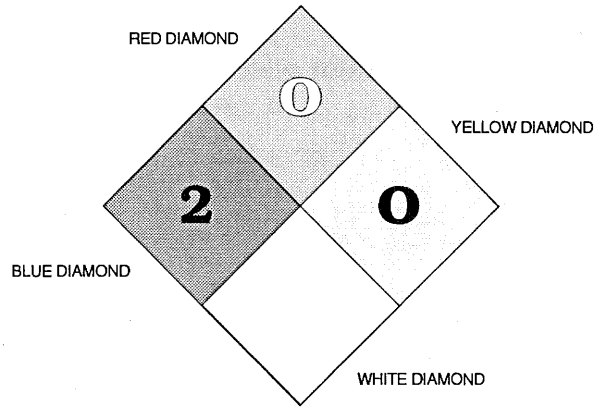
---

[4] **Residual** - What is remaining in the water after a set period of time.
[5] **Fluoridation** - The treatment process involving the addition of fluoride to a water supply in order to obtain an optimum fluoride concentration in the drinking water of 1.1 to 1.7 mg/l.
[6] **OSHA** - Occupational Safety and Health Administration.

NFR

The NFR (National Fire Rating system developed by the National Fire Protection Association) has provided the following classification for sodium fluoride. An explanation of these classifications is provided in the table below.

- Health rating - 2
- Flammability - 0
- Reactivity - 0



DOT Identification

The DOT (Federal Department of Transportation) has given sodium fluoride a placard number of #1690. When determining how to handle a spill of sodium fluorides, the DOT has provided this information in their handbook under reference #54.

Common Accidents and First Aid

First aid for common sodium fluoride, provided below, was taken from the DOT reference #54.

- Contact with skin - flush with running water for 15 min.
- Contact with eyes - flush with running water for 15 min.

Handling Spills

DOT describes the following methods of handling sodium fluoride spills.

- Dry spill - A dry spill can be picked up using a non-metallic device. The powder should be stored in plastic for later disposal. Handling powdered sodium fluoride requires that a cartridge respirator be worn.
- Small Liquid Spill - A spill of less than 5 gallons can be disposed of by being washed to waste with liberal use of water. Rubber boots, rubber gloves and chemical goggles are recommended.
- Large Liquid Spill - A large liquid spill should be contained with booms and pumped into plastic containers for later disposal. Rubber boots, rubber gloves, rubber apron and chemical goggles are recommended.

Fire Control

There is no fire hazard associated with liquid or powdered sodium fluoride.

Table - UN Classifications

Number	Class Name/Hazard
1	Explosives
2	Gases
3	Flammable liquids
4	Flammable solids, spontaneously combustible material, materials dangerous when wet
5	Oxidizers and organic peroxides
6	Poisonous and etiologic (infectious) material
7	Radioactive materials
8	Corrosives
9	Miscellaneous hazardous materials

NFR System

Health hazard

4 Can cause death or major injury despite medical treatment
3 Can cause serious injury despite medical treatment
2 Can cause injury. Requires prompt treatment
1 Can cause irritation if not treated
0 No hazard

Flammability hazard

4 Very flammable gases or very volatile flammable liquids
3 Can be ignited at all normal temperatures
2 Ignites if moderately heated
1 Ignites after considerable preheating
0 Will not burn

Reactivity (Stability) hazard

4 Readily detonates or explodes
3 Can detonate or explode but requires strong initiating force or heating under confinement
2 Normally unstable but will not detonate
1 Normally stable. Unstable at high temperature and pressure. Reacts with water
0 Normally stable. Not reactive with water

Special Notice Key

W Water reactive
OX Oxidizing agent

HYDRAULIC SYSTEM

The hydraulic system is composed of the following components:

SATURATOR

Tank

The basic unit of the system is the 25 to 50 gallon corrosion resistant tank. This tank and its related piping is referred to as a saturator. The tank is used to hold 10 to 20 inches of sodium fluoride crystals, which produce a dilution of sodium fluoride.The lid should fit snug to reduce the escape of fluoride gas and holes in the lid should be plugged.

Concentrations

A fluoride saturator maintains a solution with a 4% concentration of sodium fluoride (NaF), giving a 1.74% solution of fluoride ion (F). The water is at its saturation point with fluoride when these concentrations are reached. Because this is the maximum amount of fluoride that will come into solution under normal water temperatures, this type of fluoridator is called a fluoride saturator.

Fill Line

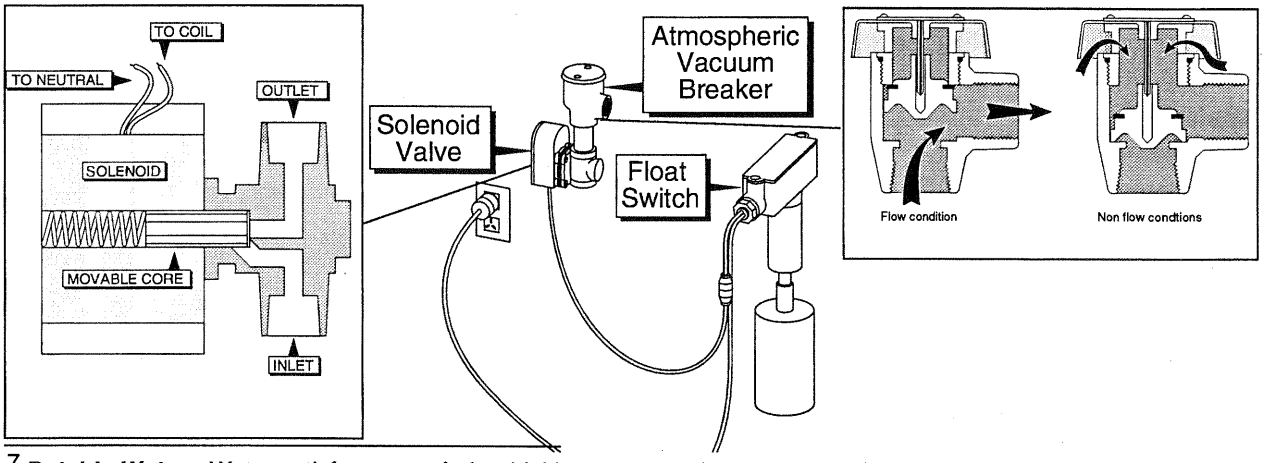
A **potable water**[7] fill line must be provided in order to develop the fluoride solution as well as for wash down in case of a spill. Water enters the saturator through a standard domestic water meter. The meter is used to determine the amount of fluoride used.

Flow Rate Control

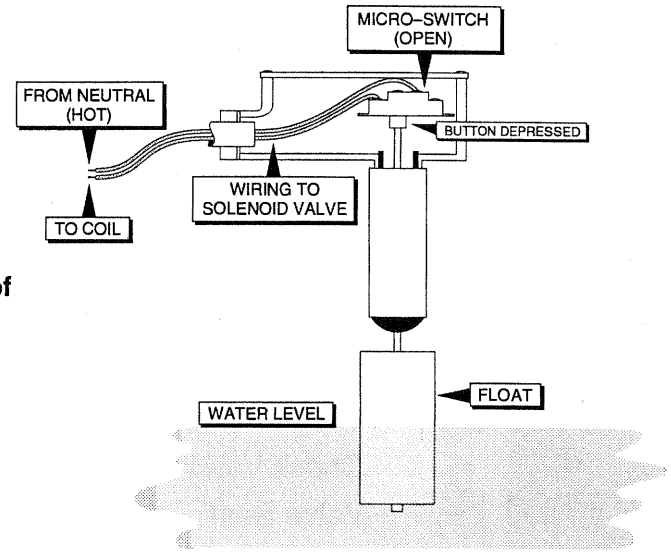
To prevent excessive flow through the saturator a **Dole valve**[8] is placed in the inflow line. This valve is commonly placed just after the meter. Normally flow is restricted by this valve to 2 gpm or less.

Water Level Control

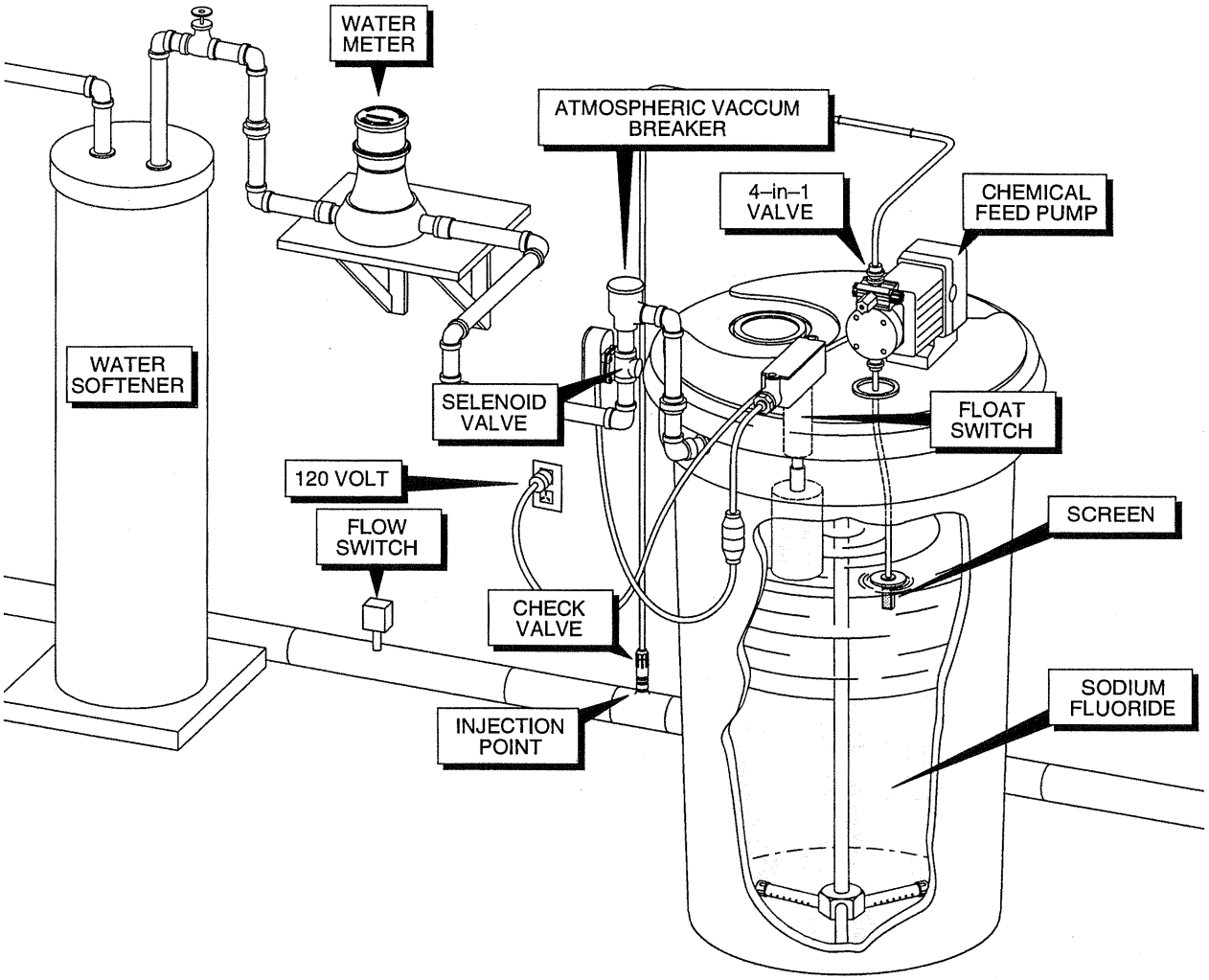
Control of flow into the tank is obtained by a liquid level switch, operated by a float in the tank. The switch operates a **solenoid valve**[9] that sets between the tank and the water meter. The level of the water in



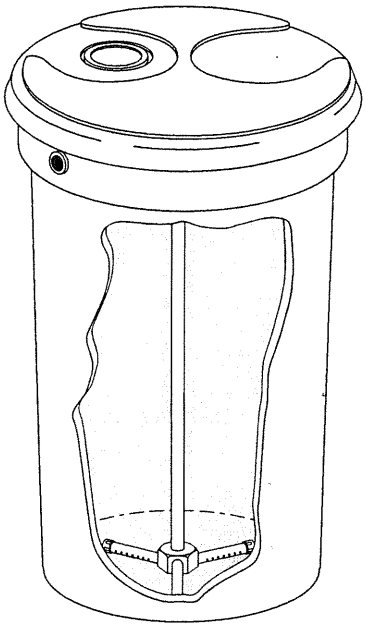
[7] **Potable Water** - Water satisfactory, safe for drinking purposes from the standpoint of its chemical, physical, and biological characteristics.
[8] **Dole Valve** - A valve designed to control the rate of flow at a specific level.
[9] **Solenoid Valve** - A valve, usually a globe type, operated by an electro magnet.



Cross-section of Float Switch

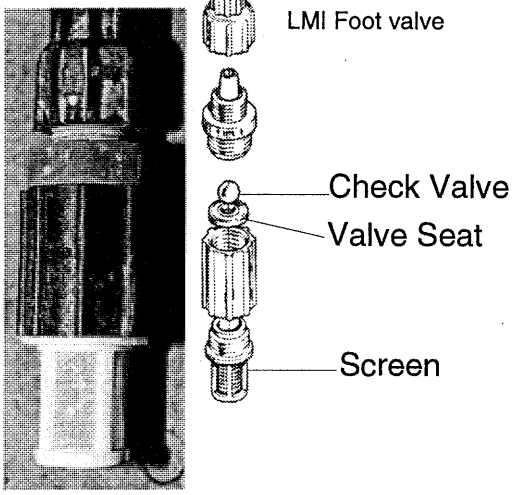


the tank only varies approximately 4 inches.



Backflow Protection

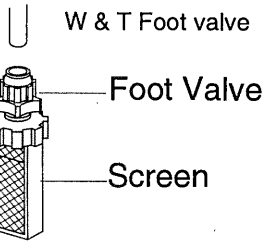
This line should be protected from **backflow**[10] by an **atmospheric vacuum breaker**[11]. The line leading to the tank, goes to the bottom of the tank and into a distribution manifold (called a distributor) on the bottom of the tank. The distributor is made of 1/2 or 3/4 inch PVC with small holes drilled along the top of each leg of the distributor. Water flows upward from these holes, through the crystals and into the solution zone above the crystals. This upward flow is where the saturator gets the upflow portion of its designation.



PUMPING SYSTEM

Components

A typical pumping system, as found in Alaska utilizes an LMI diaphragm type chemical feed pump and related valves, piping and fittings. In a few cases a W & T model 94 chemical feed pump is used.



Foot Valve

At the bottom of the pump suction line, 2 to 3 inches from the surface of the solution and held in place by a float, is a foot valve and screen. The foot valve reduces the possibility of loss of prime to the feed pump and the screen prevents large debris from entering the pump and damaging the pump diaphragm or valves.

Pump Piping

The piping on the suction and discharge of the pump is commonly **polyethylene**[12]. This material is flexible but has an approximate one year life span.The life of the piping can be reduced if it is exposed to sun light.

Pump

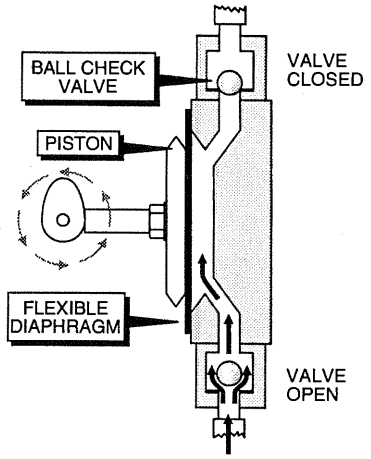
The most common pumps used in Alaska are LMI model A 101 with a 91FS pumping unit and W&T model 94-100 diaphragm, **positive displacement pumps**[13]. This type of pump has a suction and dis-

[10] **Backflow** - A reverse flow condition, created by a difference in water pressures, which causes nonpotable water to flow into a potable water system.
[11] **Atmospheric vacuum breaker** - A mechanical device that prevents backflow due to siphoning action created by a partial vacuum that allows air into the piping system, breaking the vacuum.
[12] **Polyethylene** - One of a group of thermoplastics, lightweight and varying in flexibility and having high resistance to chemicals, and good insulating properties.
[13] **Positive Displacement Pump** - Pumps in which energy is added to the water periodically and the water is contained in a set volume.

charge valve, valve seats and may have a spring on one or both of the valves to help them seat properly.

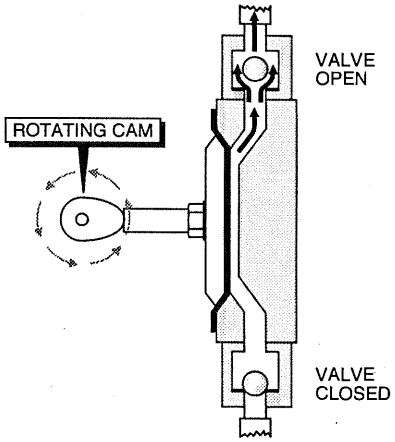
Pump - Diaphragm

The energy input device of the pump is the diaphragm, made of a flexible material and operated by some type of electric or mechanical cam. The diaphragm operates inside of the pump head. The pump head forms a chamber that holds fluid during the pumping cycle.



Pump Operation - Suction

The diaphragm pump operates on a two stroke operation. When the diaphragm is pulled back a vacuum is developed inside of the pump head. Atmospheric pressure pushes fluid from the tank, through the foot valve, past the suction valve and into the pump head cavity. Discharge backpressure holds the discharge valve closed.

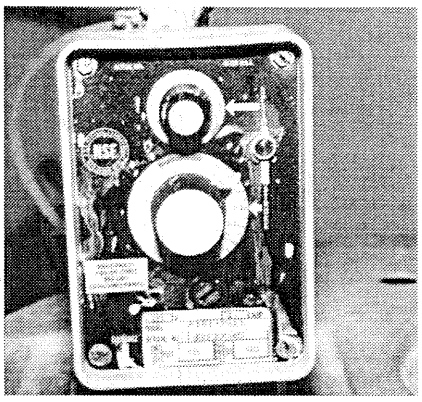


Pump Operation - Discharge

When the cam turns it places pressure on the fluid inside of the pump head. This pressure forces the suction valve closed and the discharge valve open. Fluid is forced out of the pump and the pump is returned to normal operation. The pump cam then turns and starts the suction side of the cycle over again.

Back Pressure Requirement

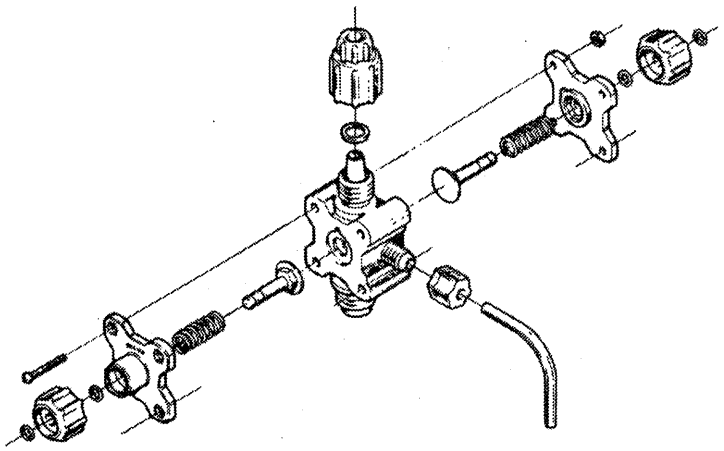
In order for the chemical feed pump to operate properly a backpressure of 15 to 20 psi is required. If the backpressure drops below this point it is possible to feed an excessive amount of fluoride, because the pump has a tendency to siphon and provide a continuous feed rather than the pulsing feed that is normal.



Pump Adjustment

The chemical feed pumps used in Alaska

allow two different adjustments of the feed rate. The length of the stroke and the frequency of the stroke can both be adjusted giving a high degree of flexibility. On the LMI feed pumps there is an additional adjustment or safety feature. On these pumps if the discharge pressure exceeds a set point the pump will fail to pump without damaging the pump.



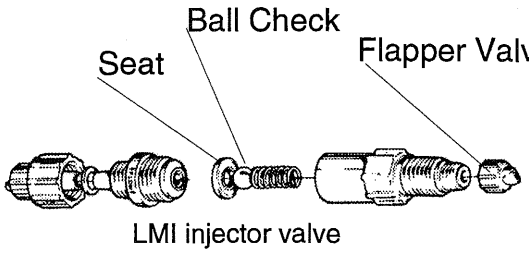
Anti-Siphon Valve

The LMI pumps can be installed with a special valve on the discharge line called a 4 in 1 valve. This valve serves four functions.

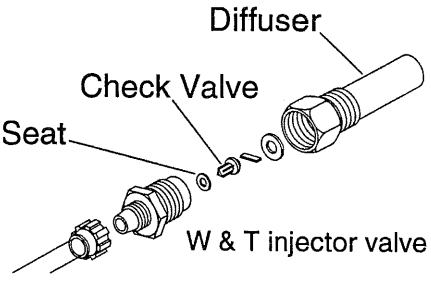
- Anti-siphon - The valve prevents the fluid from beginning siphoned from the tank should there be a below atmospheric pressure drop in the system pressure. This could happen if the system were set up to pump from a well and the foot valve on top of the submersible turbine failed. After pump shut down, water would fall down the riser pipe and cause a reversal in flow in the discharge pipe of sufficient velocity to cause a venturi action at the **diffuser**[14], siphoning fluid from the tank.
- Back pressure control - The valve maintains a positive discharge pressure of at least 25 psi on the discharge of the pump. This constant pressure exists even if the line pressure should drop to zero, helping to maintain the accuracy of the pump.
- Pressure relief - Should for some reason a valve on the discharge line be closed or the line pressure exceed the safety rating of the pump, the 4 in 1 valve will open and discharge the fluid back to the tank. This prevents damage to the pump diaphragm and head.
- Line depressurization - To prevent fluid from spraying onto the operator when starting to repair the pump, the 4 in 1 valve allows the discharge pressure to be relieved.

[14] **Diffuser** - A section of pipe or porous plates used to mix a gas or liquid with the flow of water.

Injection Point



At the point where the solution is injected into the system there is a one way valve that reduces the possibility of backflow from the system into the solution tank. Just past the one-way valve and inserted into the main line is a diffuser. This is a PVC or silver tube extending one third the diameter into the line. The diffuser is inserted into the line a distance that allows for maximum mixing of the solution with the flow of the plant.



ELECTRICAL SYSTEM

Breaker

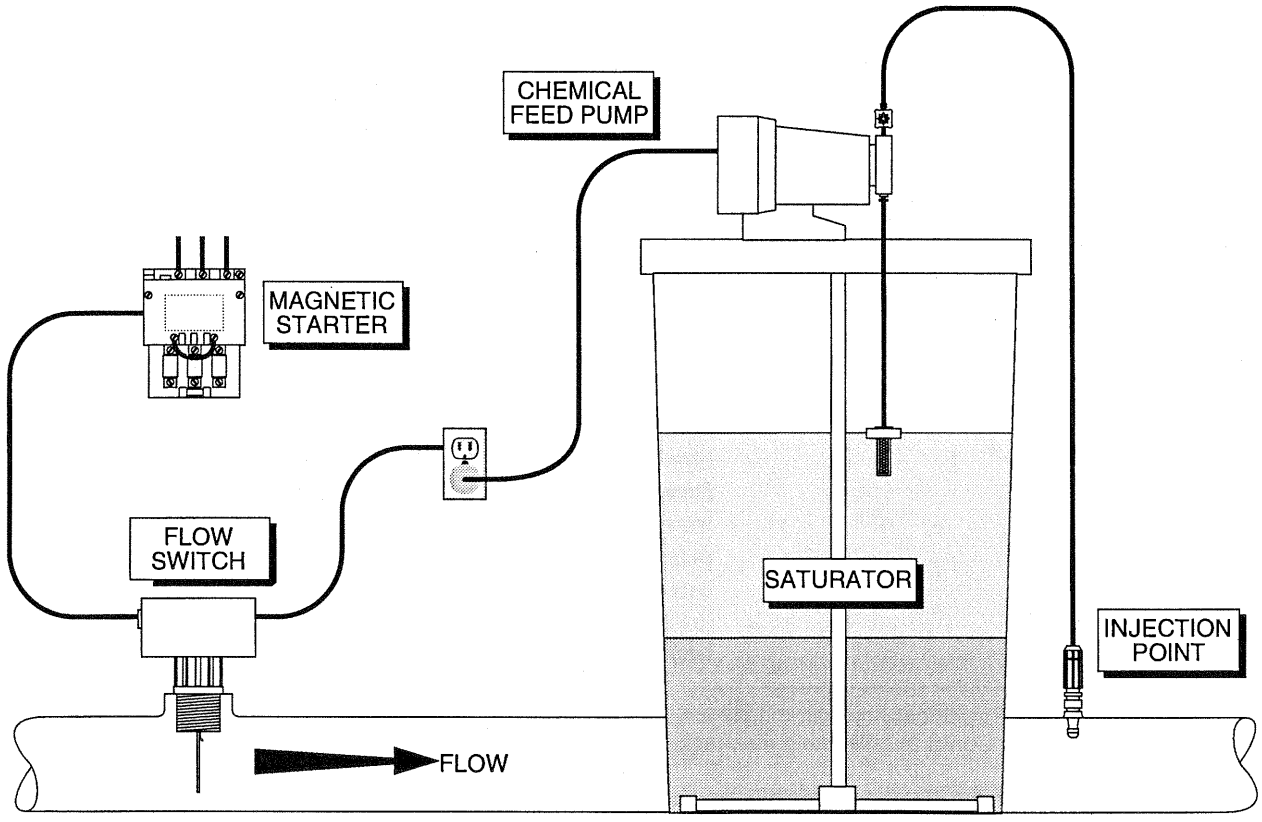
The electrical system starts at the **circuit breaker**[15]. The circuit breaker is designed to prevent a fire should there be a short in the wiring or the electric motor.

Duplex Plug

The pump motor is connected to the electric system via a standard electrical cord and a duplex plug. Recently it has been common practice to change this plug to a three prong twist plug. This prevents the pump from accidently being plugged into the wrong pump and feeding fluoride when it is not required.

Motor

The LMI and the W & T chemical feed pumps are operated by a 120 volt constant speed motor.



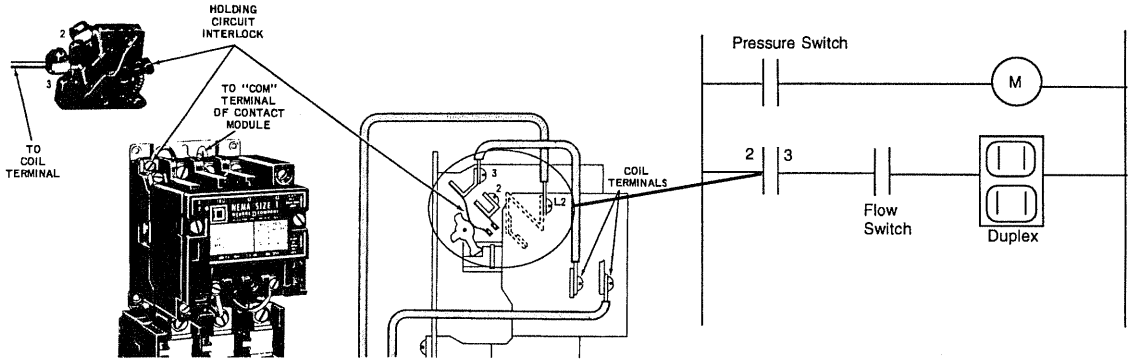
CONTROL SYSTEM

System Type

The type of control system found on fluoride saturator systems varies widely with system design. However, the two most common systems are those associated with a constant delivery pump such as a well system and those that adjust the feed rate based on system flow. The system that automatically adjust to system flow is normally associated with a gravity feed system.

Constant Flow

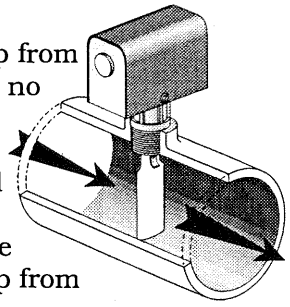
When the water that is to be fluoridated flows at a constant rate, as with a well, the fluoride feed pump is commonly connected electrically to the well pump control system. When there is a demand for the well pump to come on power would be applied to a duplex plug that provides power to the fluoride feed pump. The electrical connection to the duplex plug is either through a **contact relay**[16] or the **auxiliary contacts**[17] on the well pump motor starter. (See the wiring diagram below.)



Variable Flow

When the system flow varies over time, as with a gravity flow system, the chemical feed pump must automatically adjust the feed rate in proportion to the changes in the system flow. This type of system utilizes a feed pump where the pumping stroke frequency is controlled by a 4 - 20 ma signal. The signal is obtained from a flow meter. Fine adjustment of the fluoride dosage can be obtained by manually varying the pump stroke length.

Fail Safe



In order to prevent the feed pump from accidently running when there is no flow of water in the system, a **flow switch**[18] is commonly inserted in the flow line. The feed pump electrical control is wired into the control circuit so that the lack of flow will prevent the pump from being energized.

---

16 **Contact relay** - An electrically operated mechanical device used to open and close a circuit.
17 **Auxiliary contact** - Contacts built into a mechanical starter and manually opened and closed by the magnetic starter.
18 **Flow Switch** - A switch that uses a metal reed placed into a line to determine the presence or absence of forward velocity of fluid.

START-UP

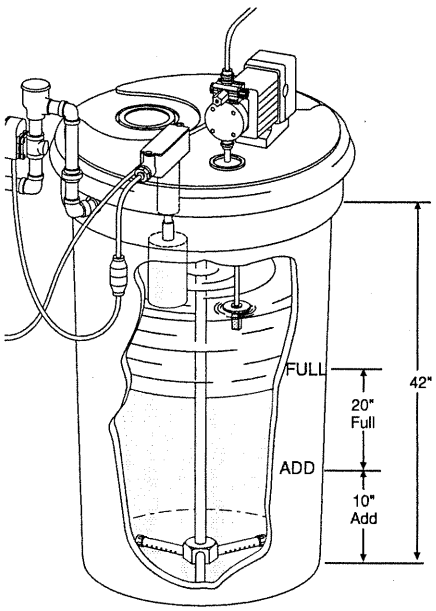
Assumptions

The following start-up sequence is based on the assumption that a system similar to the one described above exists.

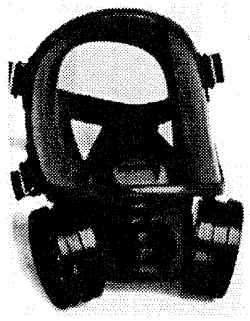
Sequence

In order to start a sodium fluoride upflow saturator system do the following:

The pump and inlet solenoid valve should be unplugged or the breaker supplying power to them should be in an off position.



1. Center the distributor on the bottom.
2. Mark the tank at two positions on the outside with indelible marker. The two points are:
   - Up 10 inches from the bottom write "Add Sodium Fluoride".
   - Up 20 inches from the bottom write - "Fluoride Full".
3. Fill tank 1/2 full of clean potable water.
4. Check for leaks in saturator.
5. Check the appearance of the water. If the water is dirty - dump and start over.



6. Place the cover on the tank.
7. Remove access hatch on cover.
8. Put on safety equipment:
   - Goggles
   - Respirator
   - Gloves
9. Fill with sodium fluoride to "Full" level.
10. Allow the water to stand for 30 min.
11. Turn power on to the solenoid valve. *(If the valve obtains power from a standard household duplex plug then plug it back in. If power is supplied directly through a breaker and the power cord to the solenoid valve is hard wired into the circuit, then turn on the breaker and make sure the chemical feed pump is unplugged.)* Allow the tank to fill with water until LLS (Limit Level Switch) turns the solenoid off.
12. Allow the solution to stand for 2 hours.
13. Prime feed pump - see instructions below.
14. While the solution is standing, determine the feed rate and the pump settings for frequency and stroke. The formulas and tables needed to perform this task are described later in this module. However, for convenience we offer the following example using these formulas and tables.

Example & Assumptions

Assume that the system flow is 19,000 gallons per day. The sodium fluoride solution contains 1.74% fluoride ion (F). The fluoride concentration in the raw water was measured at 0.2 mg/L. The decision has been made to maintain a 1.2 mg/L fluoride concentration in the distribution system. The chemical feed pump being used is an LMI model A141-150S with a maximum feed rate of 13 mL/min. This is a well system and the well pump only operates 12.7 hours per day. The following steps can be used to determine the feed pump setting:

- Find the flow rate in gpm.

- Find the chemical pump feed rate in mL/min.

Formula for finding pump feed rate.

$$\text{gpm} = \frac{19{,}000 \text{ gpd}}{12.7 \text{ hrs} \times 60 \text{ min/hr}} = 24.9 \text{ gpm or } 25 \text{ gpm}$$

$$\text{mL/min} = \frac{0.378 \times (\text{Desired F, mg/L} - \text{Natural F, mg/L}) \times \text{gpm}}{1.75 \% \text{ F (solution)}}$$

$$\text{mL/min} = \frac{0.378 \times (1.2 \text{ mg/L} - 0.2 \text{ mg/L}) 25 \text{ gpm}}{1.74 \% \text{ F}} = 5.4 \text{ mL/min}$$

- The feed pump being used has a maximum feed rate of 13 mL/min. What is needed is the setting of the stroke and speed to obtain the feed rate of 5.4 mL/min. Since it is desirable to have the stroke be above 50%, we are assuming that a desirable stroke length would be 80%. To determine the feed rate at 80% stroke length and 100% frequency, multiply the maximum feed rate times the new stroke setting.

13 mL/min X 0.8 = 10.4 mL/min

- Next, find the speed setting to bring the feed rate down to 5.4 mL/min. This is done by dividing the desired rate by the new feed rate.

$$\% \text{ setting} = \frac{5.5 \text{ mL/min}}{10.4 \text{ mL/min}} = 0.519 \times 100 = 52 \%$$

- Set the stroke at 80% and the speed at 52% and the feed pump should produce 5.4 mL/min. This can be tested with a graduated cylinder or you can just go ahead and make final adjustments based on the fluoride residual.

15. Set frequency and stroke to desired level.

16. Plug in the chemical feed pump or turn on the feed pump breaker.
17. Start system flow - fluoride feeder should come on.
18. Collect a sample of water down stream and check for fluoride. The sample collection point need only be 20 feet or so away from the fluoride injection point.
19. Check every 5 min during first 1 hour and adjust the feed pump as necessary to obtain the desired residual.
20. Check and record the fluoride residual twice a day for the next 10 days.
21. Check and record daily after first 10 days.
22. Record pump settings, flow and residuals daily.

Pumping capacities of various chemical feed pumps

LMI Pumps

Model	Capacity gph	Capacity mL/min	Max psi
A141-150S	0.2 gph	13 mL/min	150 psi
A171-151FS	0.4 gph	26 mL/min	140 psi
A151-91FS	1.0 gph	63 mL/min	110 psi
B121-91FS	2.5 gph	158 mL/min	100 psi
D121-71FS	4.0 gph	253 mL/min	100 psi

W & T Pumps

45-010	1 gph	63 mL/min	150 psi
45-050	5 gph	315 mL/min	100 psi
45-100	10 gph	630 mL/min	50 psi

PRIMING THE PUMP

Priming LMI

If the pump is a new pump, use clear water for the prime. If this is an existing pumping situation and you are just re-priming the pump, then use the fluoride solution. When handling components of the feed system that have been in the fluoride solution wear chemical goggles and rubberized gloves.

Equipment

- Clean water - at least 2 gallons
- Bucket - 2 to 3 gallon size

1. Remove the suction line from the tank and from the pump.
2. Place the suction line into the bucket.
3. Fill the suction line with clear water.
4. Disconnect discharge line and add a section of pipe that allows you to discharge the pump into a bucket.
5. Start the pump.
6. Adjust feed to 80% speed and 100% stroke.
7. With a 4-FV valve - turn yellow and black knobs 1/4 turn or pull and hold.
8. Once a small amount of fluid starts out of the bypass line the pump is primed.
9. Release or turn the 4-FV valve to normal - the pump should pump into the bucket.
10. Shut off the pump, reconnect the discharge piping and place the suction line into the tank.
11. Restart the pump.
12. Adjust speed and stroke.
13. Wait appropriate time.
14. Check the residual.
15. Adjust feed rate to obtain proper residual.

Priming W & T 94

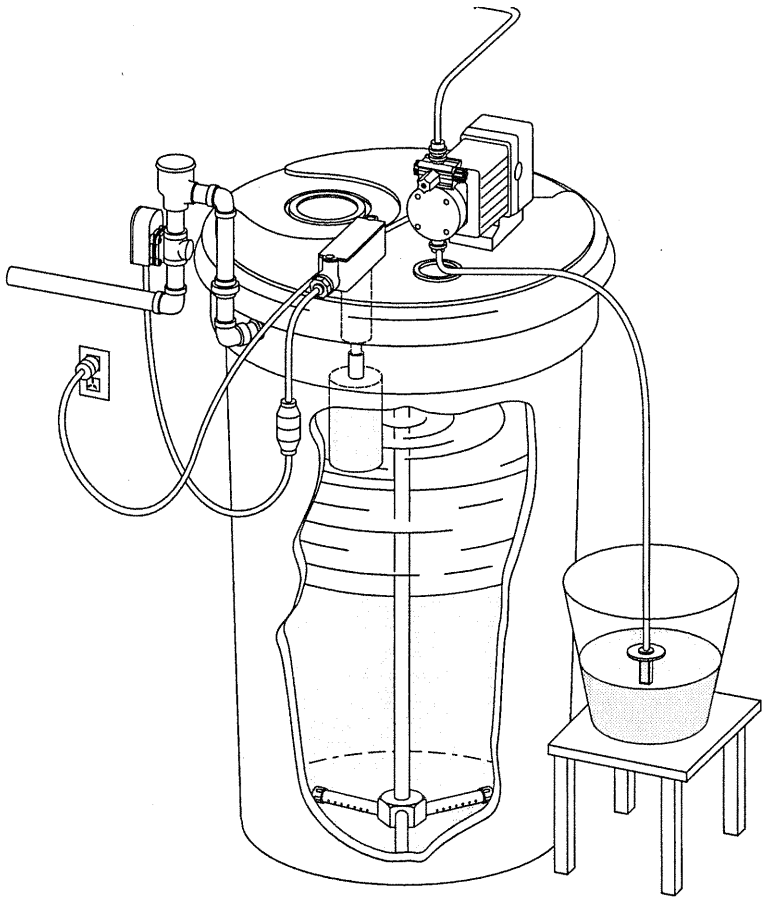
If the pump is a new pump, use clear water for the prime. If this is an existing pumping situation and you are just re-priming the pump, then use the fluoride solution.

Equipment

- Clean water - at least 2 gallons
- Bucket - 2 to 3 gallon size

1. Remove the suction line from the tank and from the pump.
2. Place the suction line into the bucket.

3. Fill the suction line with clear water.
4. Disconnect discharge line and add a section of pipe that allows you to discharge the pump into a bucket.
5. Start the pump.
6. Adjust feed to 80% speed and 100% stroke.
7. Once liquid starts to flow from the discharge piping the pump is primed.
8. Shut off pump, reconnect the discharge piping and place the suction piping back into the tank.
9. Restart the pump.
10. Adjust speed and stroke.
11. Wait appropriate time.
12. Check the residual.
13. Adjust feed rate to obtain proper residual.



NORMAL OPERATIONS

ROUTINE OPERATION

Sequence

The normal operation of the fluoride saturator is accomplished by placing approximately 1/2 the volume of the fluoride saturator tank with sodium fluoride crystals. The tank is then filled with water. The solution above the crystals will saturate with sodium fluoride (NaF) to a concentration of 4% and a fluoride ion (F) concentration 1.74%.

This solution is then pumped using a diaphragm pump into the system flow. As fluid in the tank drops to a predetermined level a liquid level switch (LLS) is tripped by a float in the tank. This opens a solenoid valve allowing the tank to fill until the LLS determines the proper level has been reached. At this point the LLS shuts off the solenoid valve and the cycle starts over again. The quantity of fluoride solution used is determined by reading a meter on the inflow line to the saturator tank.

ROUTINE INSPECTIONS

What to observe?

The fluoride installation should be visited each day of operation. When visiting the installation look generally for proper operation. More specifically observe the following:

- Level of crystals in the tank. The level should never fall below the "Low Level" mark. On a 50 gallon tank this mark is 10 inches from the bottom of the tank.
- Liquid level - The liquid level should not fall below the normal low level. This is the point at which the liquid level switch should open the inlet solenoid valve.
- Leak - observe all piping, the tank and chemical feed pump for leaks. If there is a leak, shut down the saturator system, wash down the area and fix the leak.
- Observe pump - Observe the operation of the chemical feed pump to be sure that solution is being pumped.
- Flow switch operation - Compare the feed pump operation with the system flow. Make sure that when the system flow is off the feed pump is not operating. If you find the feed pump operating when there is no system flow, the fluoridator should be unplugged and the problem identified before the resumption of fluoride feed. **Not feeding fluoride is not a health hazard. Feeding too much fluoride is a health hazard.**

Data Collection

During the daily visit to the fluoride station collect the following data:

- Water meter reading - observe and record this data. This will be used to determine the fluoride dosage.
- Plant flow or system flow for the day. Observe and record this data. This is used with the above information to determine the fluoride dosage.
- Residual - The fluoride residual should be tested and recorded at least once each day.

Calculation Needed

As a result of the daily visit to the fluoride station the fluoride dosage should be calculated. The fluoride residual is the most important reading in the system. A change in fluoride dosage can give information on why the residual is changing. The formula for calculating dosage is given below under the topic title of Calculations.

ORDERING CHEMICALS

Six Months Supply

In rural Alaska it is best to keep at least a six month supply of chemicals on hand. This means that each order must be for a six months supply plus shipping time. A typical procedure would be:

- Determine the amount of fluoride used per month.
- Multiply times six.
- This is the amount that needs to be on the shelf when you order.
- Set up a procedure to inventory the chemicals each month.
- When the supply is at six months, order the amount necessary for six months, plus shipping time plus one week lead time.

Example:

The city of Ambler uses an average of 0.75 pounds of fluoride per day. Shipping time is 60 days. Therefore the total amount needed would be for 183 days (six months) + 60 days + 7 day = 250 days.The amount of chlorine needed in the order would be 0.75 lbs/day X 250 days = 188 pounds. A standard container of Sodium fluoride is 54 pounds. The order should be for 4 containers.

HANDLING CHEMICALS

Sodium Fluoride Equipment

When handling sodium fluoride the following equipment should be worn:

- Chemical safety goggles - Lab Safety QB-14336 or equivalent.
- Rubber gloves that come to the elbow - Neoprene or PVC.
- Rubber apron - Neoprene or PVC.
- Cartridge respirator - Wilson Half Mask - Lab Safety QB-7523 or equivalent. The full face mask used for calcium hypochlorite can also be used.

Equipment Storage

The goggles and respirator should be stored in a sealed baggy. At no time should they be left hanging or laying in an open area.

Mixing Process

After filling or refilling wait 2 hours for the solution to come to saturation.

Hard Water Problems

When the **hardness**[19] of the water is above 75 mg/L (as $CaCO_3$) crystals will be formed in the bottom of the saturator and the sodium fluoride could be crystallized into a single large crystal. Under these conditions it is difficult if not impossible to obtain the desired concentration of fluoride in the saturator and the crystals deteriorate the suction and discharge valves on the chemical feed pump. Therefore, when the hardness is above 75 mg/L, a water softener is required on the feed water for the saturator.

Replacing Solution

Once a year the tank should be drained, the crystals removed and a new, fresh batch of sodium fluoride made.

Disposal of Old Fluoride

Disposal of the fluoride crystals is accomplished by placing the liquid and crystals into plastic pails. The pails should be filled one-half full of the material from the saturator. The remainder of the pail should be filled with lime. This will neutralize the fluoride and allow for proper disposal.

CALIBRATION OF FEED PUMPS

When to Calibrate

Chemical feed pumps should be calibrated at start-up and then quarterly.

Why Calibrate

The calibration of the chemical feed pump is the only reliable method of determining the actual feed rate of the pump. It is from this data that we are most able to properly set the pump. The second reason for calibrating the pump is to obtain data that allows us to develop a calibration curve. It is from the calibration curve

[19] **Hardness** - A characteristic of water, caused primarily by the salts of calcium and magnesium. Hardness causes deposits and scale to form on pipes and fixtures.

that we can determine the proper setting to obtain the desired dosage.

Equipment

The following equipment is necessary in order to complete the calibration.

1. Five gallon bucket.
2. 1000 mL graduated cylinder.
3. Stop watch.
4. Writing pad.
5. Pen or pencil.
6. Latex gloves.
7. Safety goggles.n

Considerations

When calibrating a auto paced chlorinator, shut off the auto pacing. That is, change the local/remote switch to local.

Speed & Stroke

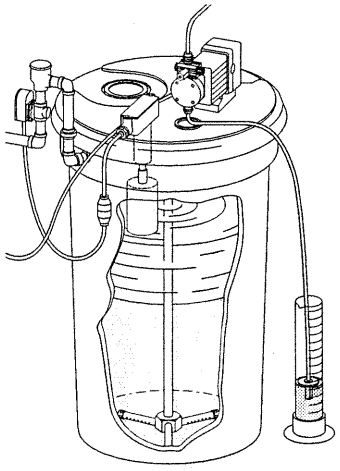
With pumps that have both speed and stroke length settings a series of calibrations will need to be made for each major stroke length setting, i.e. 20%, 40%, 60%, 80% and 100%.

Assumption

In proceeding with the calibration process described below it is assumed that feed pumps with stroke length and stroke frequency are being calibrated. When the pump is auto paced to flow the flow signal will adjust the frequency. The stroke is set manually. It is best to calibrate the pump at the low, normal and high frequency ranges.

General Procedure

The calibration of a chemical feed pump is accomplished in four general steps.



1. Calibrate the pump by observing the amount pumped from the suction side of the pump. Calibrating from the suction side is much more accurate that calibrating from the discharge side of the pump. The discharge rate will vary with an increase in discharge pressure. Therefore, the amount that is measured during calibration may be more than what is actually pumped when the pump is pumping against a high head.
2. The greatest accuracy is obtained by manually setting the stroke length and making a series of readings at various stroke frequencies.
3. The data is recorded in a table.
4. The data from the table is then transferred to a graph.

PROCEDURE - SPECIFIC

1. Adjust the speed to 10 percent and the stroke length to 20%.
2. Shut off the pump.

3. Fill the graduated cylinder to 800 mL with solution from the tank.
4. Set the cylinder on the floor beside the tank.
5. Remove the suction line from the tank and place it in the cylinder.
6. Fill the cylinder to 1000 mL.
7. Start the pump.
8. After running 1 min, observe level in cylinder and start the stop watch.
9. Run the pump for at least 1 min - a 3 min is better.
10. At end of time, observe reading.
11. Record the data.
12. Adjust the stroke frequency to the next step (commonly this is either in 10 or 20 percent increments).
13. Refill the cylinder to 1000 mL.
14. Repeat steps 9 through 13 for each setting.
15. Adjust the stroke length to the next increment (10 or 20% increments) and repeat steps 9 through 14.
16. Upon completion - return the suction line to the tank and clean the cylinder.
17. Transfer the data to a graph.

Example

The following data was collected during calibration of a fluoride feed pump.The pump being tested is auto paced from a series of raw water pumps. When one pump is running the flow signal will set the frequency at 20%, when two pumps are running the signal is at 40% and so on.

20% Frequency - based on 1 minute samples

Stroke	Start level	Stop level	mL	mL/min
20%	1000	993	16	16
40%	985	947	38	38
60%	920	860	60	60
80%	800	724	76	76

40% Frequency - based on 1 minute samples

Stroke	Start level	Stop level	mL	mL/min
20%	1000	978	22	22
40%	950	885	65	65
60%	850	742	108	108
80%	700	555	145	145.8

60% - based on 2 minute samples

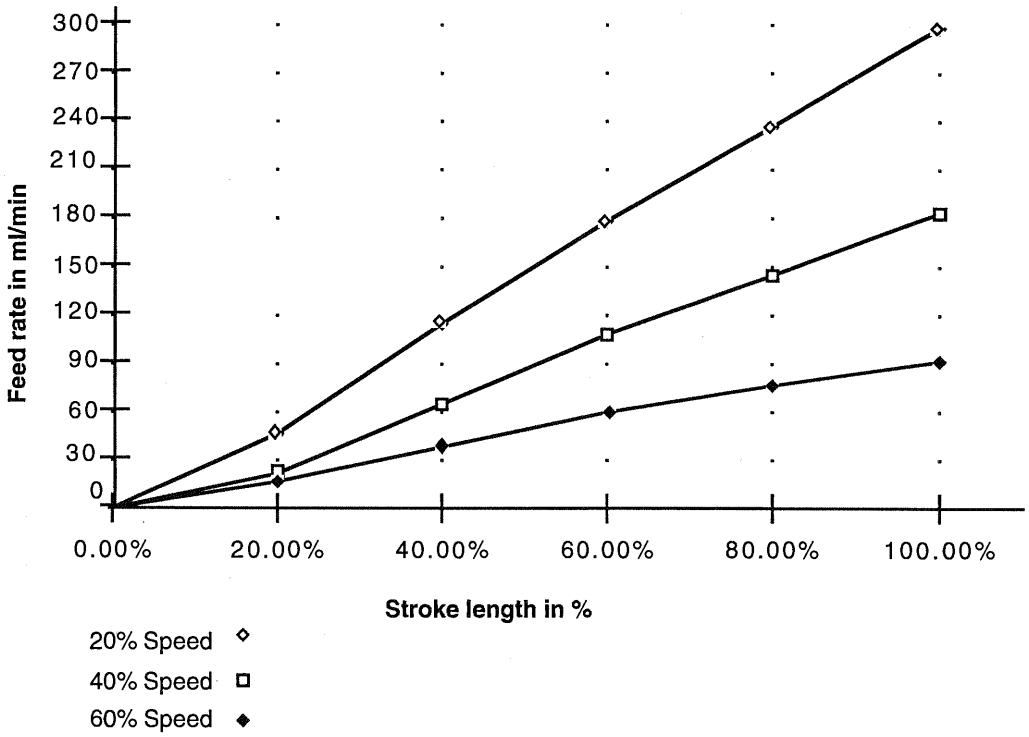
Stroke	Start level	Stop level	mL	mL/min
20%	1000	905	95	47.5
40%	875	645	230	115
60%	600	244	356	178
80%	1.0	9.8	475	237.5

90% Frequency - based on 1 minute samples

Stroke	Start level	Stop level	mL	mL/min
20%	1000	967	33	33
40%	900	803	97	97
60%	775	617	158	158
80%	600	442	232	232

Curve

The following family of curves were plotted from the data in the 20%, 40% and 60% frequency settings above.



Using the Curve

To use the curve, fist find your desired dosage in mg/L, then calculate the fluoride feed rate in mL/min. (These calculations are found in the calculation section of this text.) Once the feed flow rate is determined, enter the chart on the left and proceed to the right until you touch the appropriate speed curve. Then extend a line down until you read the stroke length setting. Adjust the fluoride feed pump to this setting.

Checking Feed Rate

After adjustment it is best to check the actual feed rate with a graduated cylinder. Fill the cylinder with fluoride solution, and place the pump suction line in the solution. Start the pump. Observe the amount pumped in a three minute time period and divide by three. This is the feed rate in mL/min. If this does not match the desired rate then make the adjustments to the stroke length.

Alternate

An alternate to performing the calculations is to use the table at the end of this module.

CALCULATIONS USED WITH SODIUM FLUORIDE SATURATOR SYSTEMS

Introduction

The following four formulas can be used to determine milligrams per liter concentration from a percent solution, feed pump setting in milliliters per minute, fluoride dosage in milligrams per liter and feed rate for chemical feed pumps with frequency and stroke settings.

Percent to mg/L

The following formula can be used in converting percent concentration of chlorine to a concentration in mg/L. The base of this process is the fact that one percent is equal to ten thousand milligrams per liter.

1% = 10,000 mg/L

Percent concentration is a percent of 1,000,000. Thus, 1% is equal to 0.01 and therefore 0.01 X 1,000,000 = 10,000 mg/L.

Example

What is the concentration in mg/L of 2.89%?

2.89% = 0.029

0.0289 X 1,000,000 = 28,900 mg/L

Fluoride Concentration

Since a fluoride saturator nearly always produces a 4% sodium fluoride (NaF) and a 1.74% fluoride ion (F) concentration, these conversions need only be made once.

4% sodium fluoride (NaF) is equal to 40,000 mg/L.

1.74% fluoride (F) is equal to 17,400 mg/L.

Feed Pump Rate

The following formula can be used to find the chemical pump feed rate when the system flow rate in gpm and the system natural fluoride level are known.

$$\text{mL/min} = \frac{0.378 \text{ X (Desired F, mg/L - Natural F, mg/L) X gpm}}{\text{1.74\% F (solution)}}$$

Example

Find the feed rate in milliliters per minute for a feed pump that must pump fluoride into a 2 inch line that flows at 50 gpm. The desired dosage 1.1 mg/L and the natural fluoride is 0.2 mg/L.

Fluoride Dosage

The following formula can be used to find the fluoride dosage in mg/L, when the plant flow is known.

$$mg/L = \frac{\text{\_\_\_\_ gal of solutin used X 1.74\% X 10,000}}{\text{\_\_\_\_\_ gal, plant flow for day}}$$

Example

Find the dosage in mg/L when 3.5 gallons of solution was used from a 50 gallon tank to fluoridate a flow of 60,000 gallons.

$$mg/L = \frac{3.5\,\text{gal X 1.74\% X 10,000}}{60{,}000\,\text{gpd}} = 1\,\text{mg/L}$$

Feed Rate for Dual Control Pumps

When a pump has both speed and stroke adjustments the feed rate can be estimated if the maximum feed rate is known. The maximum feed rate is often either given by the pump manufacturer or is part of the model number. When this information is known the feed rate can be estimated by doing the following:

Feed rate = Max pump output X % speed X % stroke

Example

Find the feed rate of a pump with a maximum feed rate of 158 mL/min and the speed set at 65% and the stroke at 55%.

Feed mL/min = 158 mL/min X 0.65 X 0.55 = 56.5 mL/min

PREVENTIVE MAINTENANCE ROUTINES

Annual Procedures

On all pumps once each year replace:

- All suction and discharge lines
- Foot valve and screen
- Injection valve
- Pump suction and discharge valves, seats and springs
- Pump diaphragm

LMI Pump

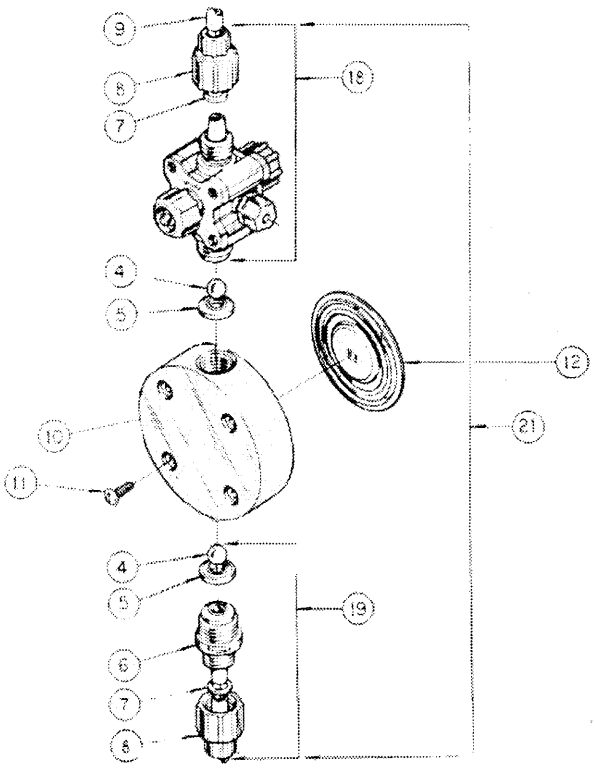
The LMI pumps are composed of two units, the electrical unit and the pumping unit (also called the liquid end). The model number includes indicators for both ends. For instance with the model A101-91FS, the A101 is the electrical end and the 91FS is the liquid end. The electrical end may be used to pump all chemicals, however, the wet end must be selected for the proper chemical. There are three common wet ends used in small communities in Alaska. They are:

Model	Chemical it is designed for
91S	Chlorine
91T	Alum, $KMnO_4$, Soda Ash, etc.
91FS	Fluoride

Repair Kits

The repair kit required for a LMI pumping a fluoride application is **SP-U3**.

Key	Description
4	Check ball
5	Check seat
10	Pump head
12	Diaphragm
18	4 in 1 valve

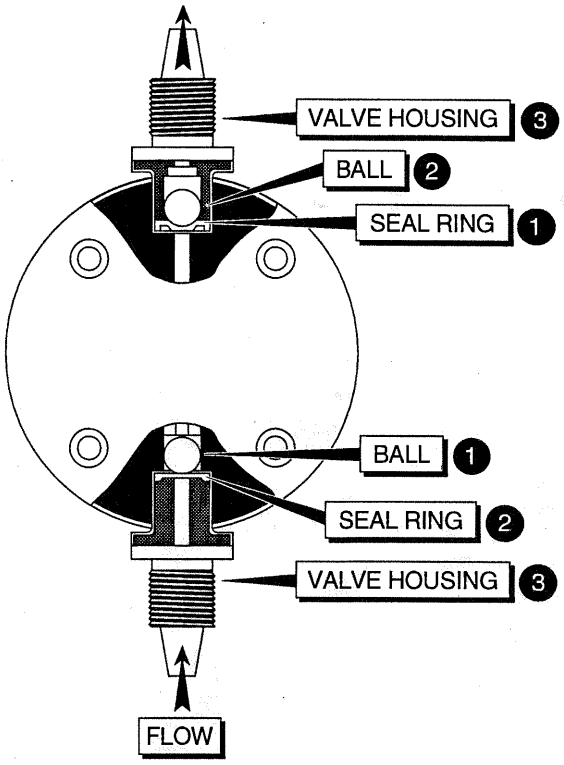


LMI PUMPS

LMI Discharge Valves

The following procedures can be used to make the annual replacement of the discharge valves on an LMI feed pump.

1. Shut off and depressurize the pump.
2. Loosen hose fitting & remove the hose.
3. Remove the injection fitting.
4. Remove and replace ball, spring seat and seal ring.



Proper order of installation of LMI discharge and suction valves

No Teflon tape should be used on the fitting or threads. Instead use silicon lube on threads (Dow 33 Moleycoat). Tighten the fitting by hand. If a wrench must be used do not tighten more than 1/8 turn.

5. Clean and replace the injection fitting. No Teflon tape should be used on the fitting or threads. Instead use silicon lube on threads (Dow 33 Moleycoat). Tighten the fitting by hand. If a wrench must be used, do not tighten more than 1/8 turn.
6. Replace discharge piping.

LMI Suction Valve

The following procedure can be used for the annual replacement of the suction valve on a LMI chemical feed pump.

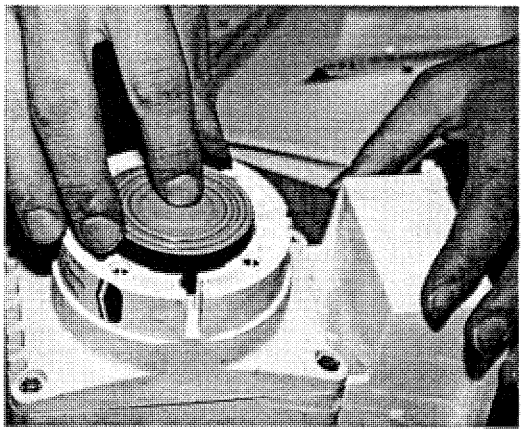
1. Shut off and depressurize pump.
2. Loosen hose fitting and remove hose.

3. Remove coupling nut.
4. Remove suction valve seat.
5. Remove and replace ball, seat and seat ring. No Teflon tape should be used on the fitting or threads. Instead use silicon lube on threads (Dow 33 Moleycoat). Tighten the fitting by hand. If a wrench must be used do not tighten more than 1/8 turn.
6. Clean and replace coupling nut. No Teflon tape should be used on the fitting or threads. Instead use silicon lube on threads (Dow 33 Moleycoat). Tighten the fitting by hand. If a wrench must be used, do not tighten more than 1/8 turn.
7. Replace discharge piping.

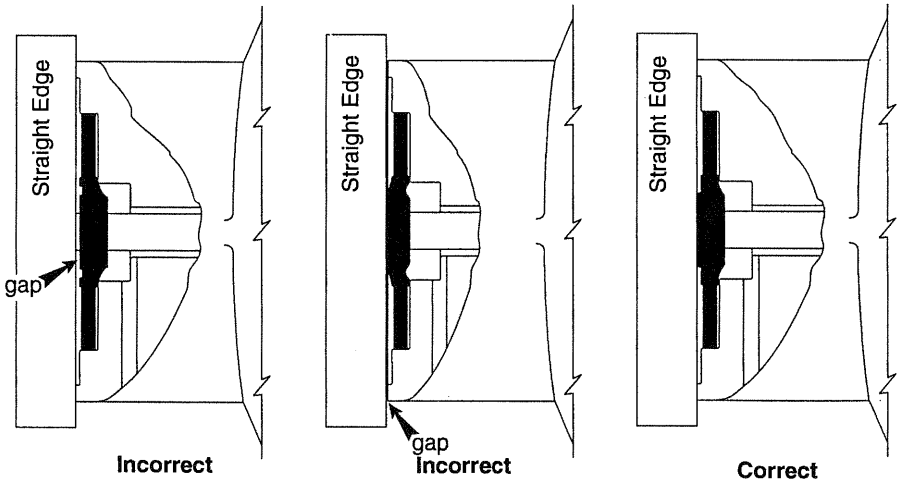
Replace Diaphragm - LMI

The following procedure can be used for the annual replacement of the diaphragm on a LMI feed pump:

1. Flush pump by pumping clean water 10 min with stroke & frequency at 100%.
2. Turn settings to Zero.



3. Shut off pump.
4. Remove the pump head.
5. Remove diaphragm. Grasp other edge and rotate counter clockwise.
6. Restart the pump.
7. Adjust stroke to 90%.
8. Screw on diaphragm until center begins to buckle.
9. Stop the pump.
10. Check position with a straight edge. Adjust as necessary.



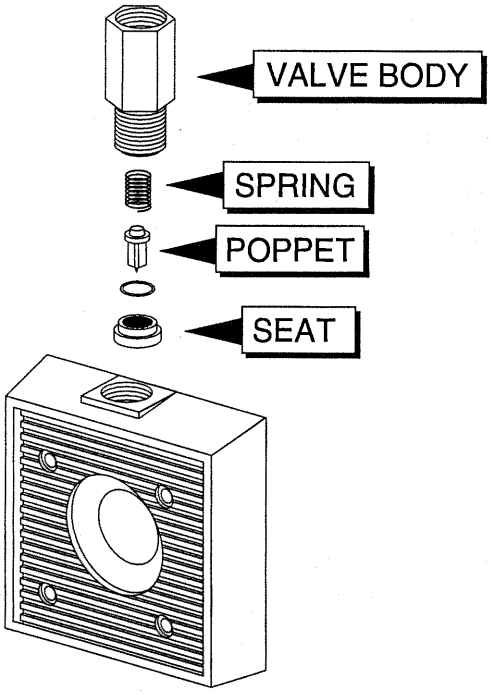
11. Replace head. Tighten the head bolts using a criss-cross pattern.

W & T PUMPS

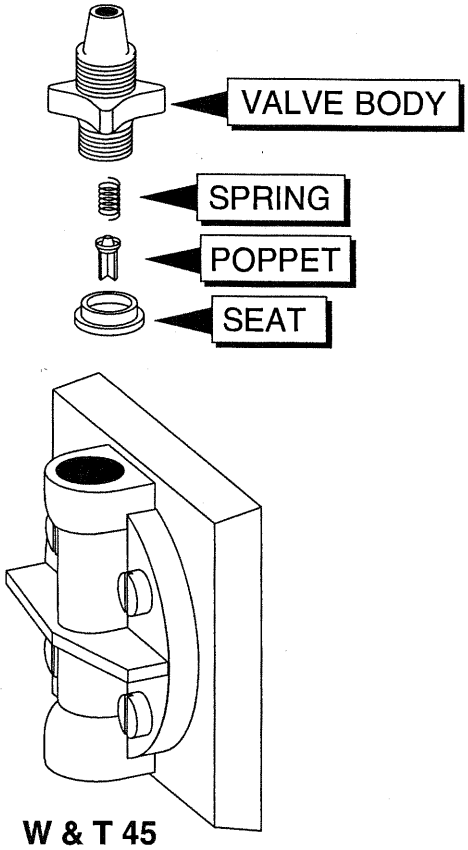
Discharge & Suction Valves

The following procedure can be used for the annual replacement of discharge & suction valves on a W & T chemical feed pump.

1. Shut off pump and depressurize.
2. Remove union nut.
3. Remove half union.
4. Remove and replace spring, poppet, gasket and valve seat. There may or may not be a spring on the suction side.



W & T 94



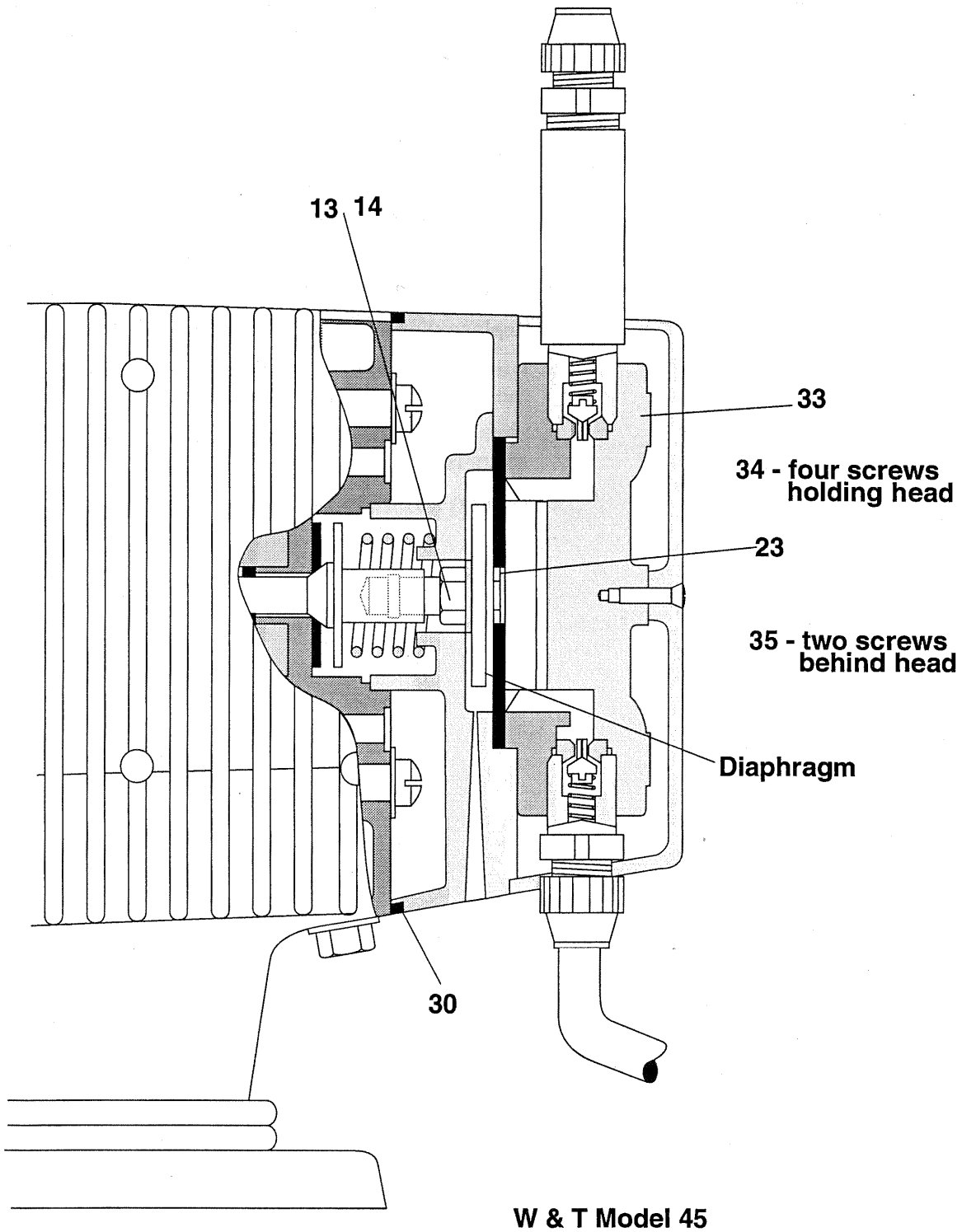
W & T 45

5. Replace half union. Use Teflon tape on the threads.
6. Replace union nut. No Teflon tape should be used on the fitting or threads. Instead use silicon lube on threads (Dow 33 Moleycoat). Tighten the fitting by hand. If a wrench must be used, do not tighten more than 1/8 turn.

Replace Diaphragm on W & T 45

The following procedure can be used for the annual replacement of the diaphragm on a W & T model 45.

1. Flush pump by pumping clear water at maximum stroke.
2. Adjust stroke length to REF.
3. Turn pump off and lock-out or unplug.
4. Remove screws (34) from pump head (33).
5. Lift diaphragm by edge and turn counterclockwise.
6. Hold hub (23) and remove nut (13), lock washer (14), and diaphragm.
7. Remove two screws (35).
8. Hold washer with pliers and turn diaphragm counterclockwise.
9. Replace diaphragm, lock washer and nut.
10. Tighten nut 30 inch pounds 1 gph & 100 inch pounds for 5 & 10 gph.
11. Replace return spring into counter bore on inside of head adapter.
12. Clean internal threads of extension shaft.
13. Place extension shaft on top of spring - cone end out.
14. Place assembly on pump housing Engage the cone with the recess on the solenoid shaft. A thin rod inserted through the head side of the adapter plate into the female thread of the extension shaft will help hold the parts together while assembling.
15. Replace screws (35).
16. Stretch O-ring (30) around the gap between head adapter and pump housing. Loosen the two screws (35) enough to allow the O-ring to tuck into the grove. Tighten screws lightly to snug assembly together.
17. Place a drop of loctite on the thread of the diaphragm.
18. Screw on the new diaphragm. Correct position is when a straight edge laid across center of diaphragm hub just touches the top of the two studs. (For 1 gpm tighten until there is 0.020 inch gap between diaphragm and straight edge.
19. Install head & screws. Tighten screws to 28 inch pounds.

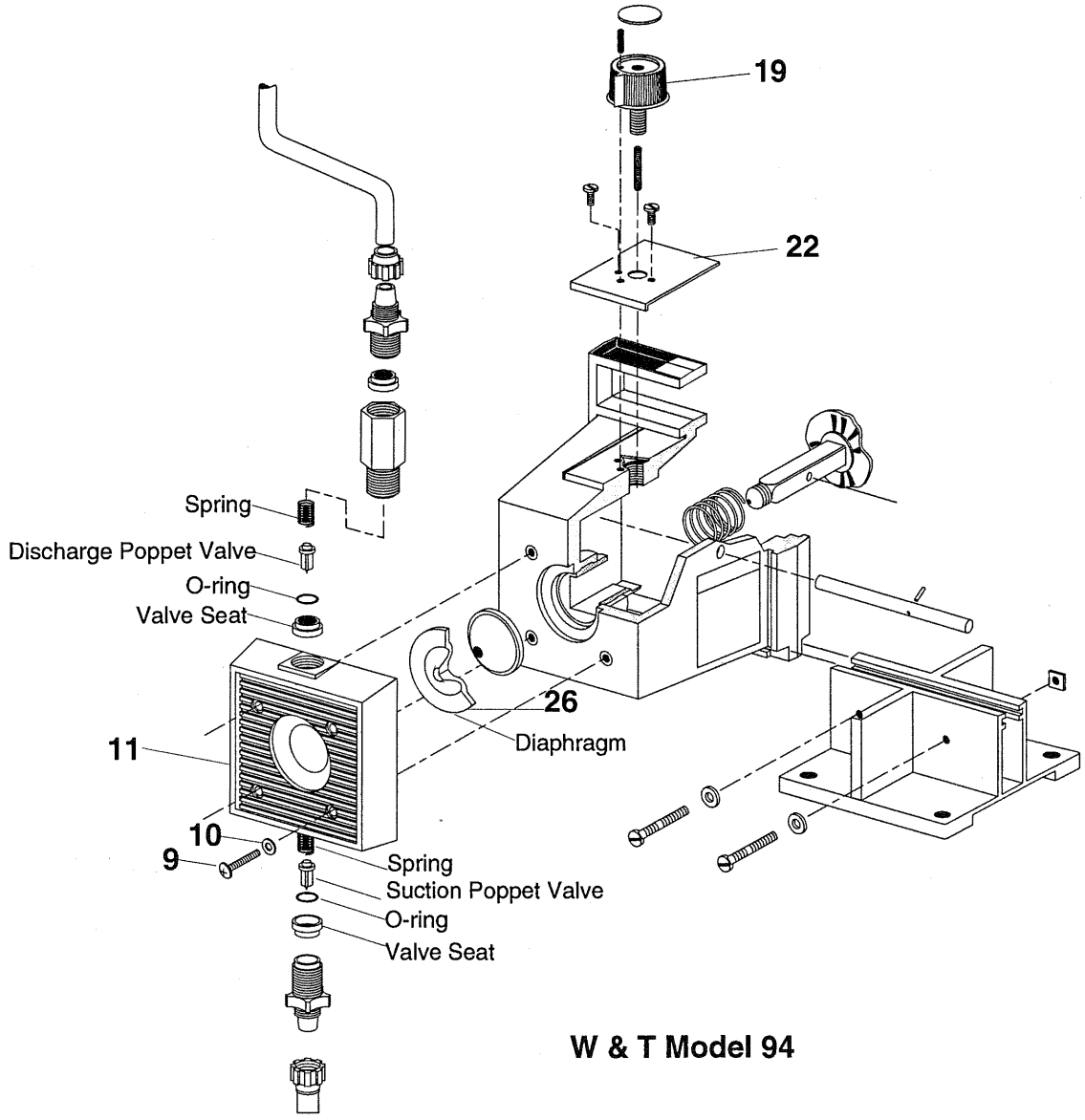

13 14
33
34 - four screws holding head
23
35 - two screws behind head
Diaphragm
30

W & T Model 45

Replace Diaphragm on W & T 94

The following procedure can be used for the annual replacement of the diaphragm on a W & T model 94.

1. Flush pump by pumping clear water at maximum stroke.
2. Turn pump off & lock-out or unplug.
3. Remove four screws (9) from pump head (11).
4. Turn knob (19) to zero with dial (22) in order to advance the diaphragm (26).
5. Lift diaphragm by edge and turn counterclockwise.
6. Replace diaphragm (26) onto cam unit.
7. Turn knob (19) to 10 on dial (22) this will position the pump mechanism to fully retract diaphragm.
8. Install pump head (11) with four screws (9) and washers (10).
9. Tighten screws to 14 in-lbs.


19
22
Spring
Discharge Poppet Valve
O-ring
Valve Seat
26
Diaphragm
11
10
9
Spring
Suction Poppet Valve
O-ring
Valve Seat

W & T Model 94

SHUTDOWN PROCEDURE

Overview

This procedure should be used any time the feed pump is to remain off line for more than 1 month.

1. Pump clear water through the pump for 30 min.
2. Pump 1 qt of vinegar through pump.
3. Pump 1 gallon of clear water through pump.
4. Shut pump off.
5. Release pressure from discharge piping.

TYPICAL PROBLEMS

Low Fluoride Reading

Causes	Check and/or Solution
• Less than 8 inches of sodium fluoride in tank	• Add sodium fluoride
• Makeup water line inside saturator top leaking	• Tighten connections • Install PVC vertical tube straightener
• Bottom diffuser connection rides up off bottom of saturator, channels visible in sodium fluoride during fill cycle	• Check electrical make-up solenoid valve for blockage, may require upstream strainer.
• Pump air bound	• Check slotted strainer assembly for blockage
• Short circuiting of make-up water through diffuser assembly, channels visible in sodium fluoride during fill cycle, only rise on one side	• Check float assembly for proper operation
• Insufficient contact time with sodium fluoride during fill cycle	• Clean and inspect bottom diffuser, clean out slots , tighten connections
• Make-up water moving too fast through NAF	• Lumpy sodium fluoride used. Check rate of make-up water addition. How long to fill tank? Should not exceed 2 gpm
• Wrong type of fluoride used (Sodium Silicofluoride is the wrong material)	• Add Dole valve to system or replace with dole valve rated at 1 gpm

High Fluoride reading

• Sodium fluoride added within 1 to 24 hours	• Add smaller amounts at greater frequency
• High fluoride in make-up water	• Previous backflow or backsiphonage. Flush to waste. Replace or repair vacuum breaker
• Solution being mixed	• Do not mix solution with paddle or mechanical mixer
• Pump setting too high	• Adjust fluoride feed pump
• Decreased pump rate through plant	• Adjust fluoride feed pump
• Flow switch stuck	• Replace - check for correct size, model and electrical connection

Will not prime	
• Not plugged in	• Plug in
• Not turned on	• Turn on
• Speed and stroke not set properly	• 80% speed 100% stroke
• Suction lift too high	•Maximum of 5 feet
• Suction line out of solution	• Check solution level
• Fittings over tightened	• Can cause seals to distort and not seal
• Air trapped in suction valve and tubing	• Suction line not vertical
• Discharge pressure too high	• Check pressure
• Suction screen plugged	• Replace
Lost Prime	
• Solution tank dry	• Refill
• Foot valve not in vertical position	• Adjust
• Suction lift to great	• Maximum 5 feet
• Fittings over tightened	• Can cause seals to distort and not seal
• Air trapped in suction valve and tubing	• Suction line not vertical
• Air leak in suction fittings	• Check for cracked fitting
Motor will not run	
• Power off	• Check outlet
• EPU failure on LMI pumps	• See manufacturers info
• Pulser failure	• See manufacturers info
Excessive output	
• Siphoning	• Replace anti-siphon valve
• Loss of discharge pressure	• Needs to be at least 25 psi
• Excessive stroke frequency	• Replace pulser
Saturator tank does not fill up automatically	
• No power	• Check load center
	• Check output voltage
• Solenoid valve does not open	• Valve shut tight - remove and replace
	• Level switch not operating, replace
	• Solenoid defective, replace
NaF solution overflows tank	
• Solenoid valve does not close	• Valve open tight, remove & clean
	• Adjust float in saturator
	• Add air to pressure switch pipe in older models of LMI and Precision saturator
	• Solenoid defective, replace

Pump Setting Table

This table is applicable for any solution and any concentration. The table is used to determine the frequency and stroke settings on a LMI chemical feed pump, once the feed rate in mL/min is known. **F = Frequency, S = Stroke**

Pump Rate mL/min	LMI/Z141 -152S	LMI* A101-91FS	LMI/A171 -150FS	W & T 94-100	LMI** A151-91FS	LMI B121-91FS	LMI D1221-71FS
2	S=50% F=30%						
4	S=50% F=60%						
6	S=65% F=70%	S=50% S=30%	S=50% S=45%				
8	S=80% F=90%	S=50% F=40%	S=50% F=60%				
10	S=85% F=90%	S=50% F=55%	S=50% F=75%				
12		S=50% F=65%	S=70% F=65%		S=50% F=40%		
14		S=50% F=75%	S=70% F=75%		S=50% F=45%		
16		S=50% F=85%	S=70% F=90%	S=3.0	S=50% F=50%		
18		S=70% F=50%	S=80% F=85%	S=3.5	S=50% F=55%		
20		S=70% F=75%	S=90% F=85%	S=4.0	S=50% F=65%		
25		S=80% F=80%		S=5.0	S=50% F=80%		
30		S=90% F=90%		S=6.0	S=70% F=70%	S=50% F=40%	
35				S=6.5	S=70% F=80%	S=50% F=45%	
40				S=7.5	S=90% F=90%	S=50% F=50%	
50						S=50% F=65%	S=50% F=40%
60						S=50% F=75%	S=50% F=45%
70						S=50% F=90%	S=50% F=55%
80						S=70% F=70%	S=50% F=65%
90						S=70% F=80%	S=50% F=70%
100						S=70% F=90%	S=50% F=80%
120							S=70% F=70%
130							S=70% F=75%
140							S=70% F=80%
150							S=70% F=85%

* A101-91FS has been replace by A171-150FS

** A151-91FS replaces A122-91FS

Table originally produced by USPHS - Alaska

Fluoride Pump Setting Table
This table can be used to select the initial setting of a chemical feed pump when pumping a4% NaF saturated solution to obtain a 1.4mg/L F- dosage and assuming proper pump operation.

Flow GPM	Pump Rate mL/min	LMI/Z141 -152S	LMI* A101-91FS	LMI/A171 -150FS	W & T 94-100	LMI** A151-91FS	LMI B121-91FS	LMI D121-71FS
5	1.5	S=50% F=25%						
10	3.0	S=50% F=45%						
15	4.6	S=50% F=70%						
20	6.1	S=70% F=70%	S=50% F=35%	S=50% F=45%				
25	7.6	S=70% F=85%	S=50% F=45%	S=50% F=60%				
30	9.1	S=80% F=85%	S=50% F=50%	S=50% F=70%				
40	12.2		S=50% F=65%	S=70% F=65%		S=50% F=40%		
50	15.2		S=50% F=80%	S=70% F=85%	S=3.0	S=50% F=50%		
75	22.8		S=70% S=85%		S=4.5	S=50% S=70%		
100	30.4				S=6.0	S=70% F=70%	S=50% F=40%	
125	38.0				S=7.5	S=70% F=85%	S=50% F=50%	
150	45.6				S=9.0	S=90% F=80%	S=50% F=60%	
175	53.2						S=50% F=65%	S=50% F=40%
200	60.8						S=50% F=75%	S=50% F=50%
250	76.0						S=70% F=70%	S=50% F=60%
300	91.2						S=70% F=85%	S=50% F=70%
350	106.4						S=80% F=85%	S=50% F=85%
400	121.6							S=70% F=70%
450	136.8							S=70% F=75%
500	152							S=70% F=85%

* A101-91FS has been replace by A171-150FS
** A151-91FS replaces A122-91FS

Table originally produced by USPHS - Alaska

O & M OF SODIUM FLUORIDE SYSTEMS WORKSHEET

1. The most common fluoride addition system used in Alaska is the...

_____ a. Upflow diffuser

_____ b. Downflow saturator

_____ c. Upflow concentrator

_____ d. Upflow saturator

_____ e. Downflow diffuser

2. Sodium fluoride when placed in a water solution will reach a concentration of...

_____ a. 1%

_____ b. 2%

_____ c. 3%

_____ d. 4%

_____ e. 5%

3. Sodium fluoride saturation in water ...

_____ a. varies little with water temperature

_____ b. varies widely with water temperature

_____ c. is dependent on the pH of the water

_____ d. is dependent on the alkalinity of the water

_____ e. is dependent on the hardness of the water

4. Fluoride is fed into a water system to...

_____ a. Improve water quality

_____ b. Remove turbidity

_____ c. Remove color

_____ d. Reduce alkalinity in the water

_____ e. Reduce tooth decay

5. The primary MCL for fluoride is...

_____ a. 0.5 mg/L

_____ b. 5 mg/L

_____ c. 2 mg/L

_____ d. 4 mg/L

_____ e. 0.03 mg/L

6. The secondary MCL for fluoride is ...

_____ a. 0.5 mg/L

_____ b. 5 mg/L

_____ c. 2 mg/L

_____ d. 4 mg/L

_____ e. 0.03 mg/L

7. The chemical formula for sodium fluoride is ...

_____ a. NaF

_____ b. $CaCO_3$

_____ c. FNa

_____ d. F

_____ e. $KMnO_4$

8. Sodium fluoride is classified by OSHA as a ...

_____ a. Non-combustible gas

_____ b. Poison

_____ c. Corrosive

_____ d. Oxidizer

_____ e. Non regulated material

9. A small liquid spill of sodium fluoride can be cleaned-up by ...

_____ a. Flushing with water

_____ b. Adding lime and then pick up with a non-metallic device

_____ c. Call an emergency response team

_____ d. Use a boom to contain and then call an emergency response team

_____ e. Just ignore the spill, small spills are not a health risk

10. Two safety controls that prevent the over feeding of a fluoride solution are:

_____ a. Flow switch

_____ b. Atmospheric vacuum breaker

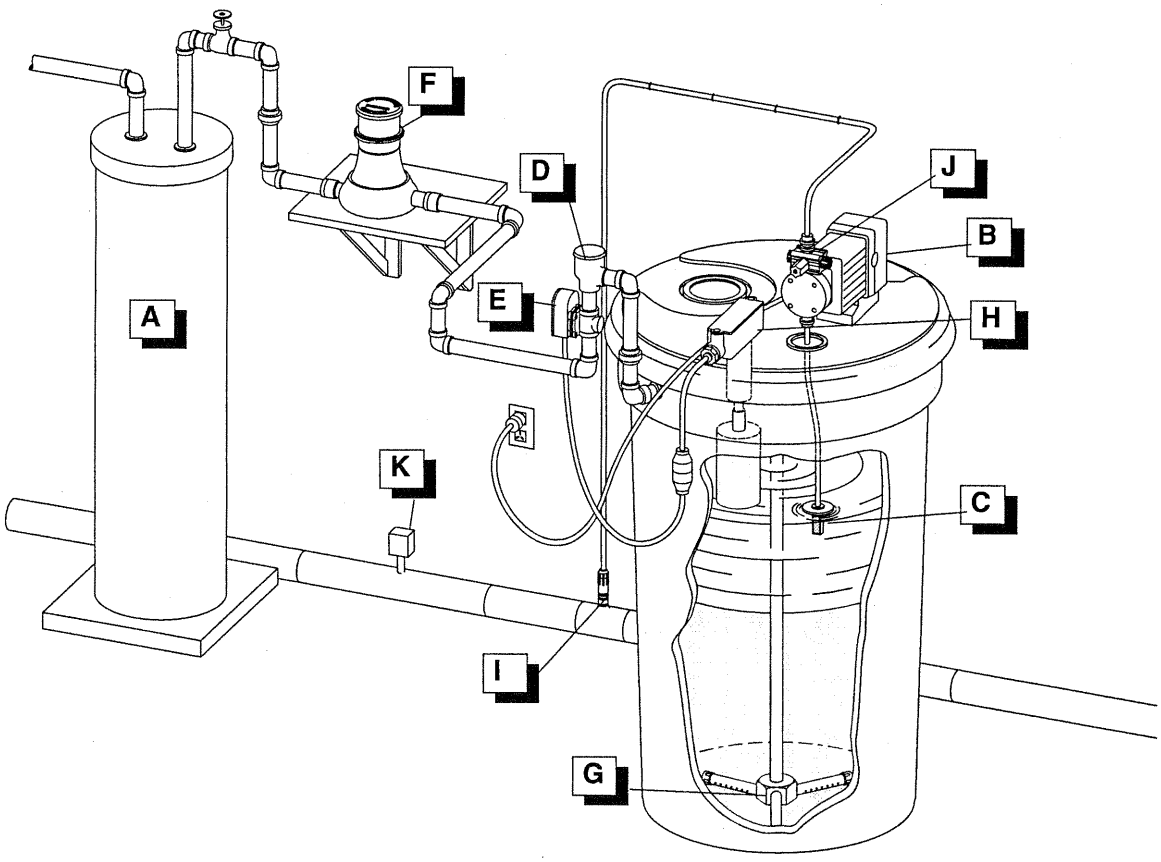
_____ c. Dole valve

_____ d. Using motor starter auxiliary contacts

_____ e. Solenoid valve

11. Identify the components in the fluoride system shown below.

a. _____
b. _____
c. _____
d. _____
e. _____
f. _____
g. _____
h. _____
i. _____
j. _____
k. _____



12. When filling a fluoride saturator using a 50 gallon tank the sodium fluoride level should be...

_____ a. 5 inches
_____ b. 10 inches
_____ c. 20 inches
_____ d. 1/3 of the depth of the tank
_____ e. 3/4 of the depth of the tank

13. How long should a new batch of sodium fluoride set before you can be assured that it has reached saturation?

_____ a. 30 min

_____ b. 1 hour

_____ c. 2 hours

_____ d. 15 minutes

_____ e. 1.5 hours

14. What is the required feed rate for a fluoride pump when the system flow is 55 gpm, the natural fluoride is 0.1 mg/L and the desired residual is 1.4 mg/L?

_____ a. 23 mL/min

_____ b. 55 mL/min

_____ c. 63 mL/min

_____ d. 17.75 mL/min

_____ e. 15.5 mL/min

15. The maximum flow rate of a LMI A 151 is 63 mL/min. What would the flow rate be if the stroke were set at 60% and the frequency set at 45%?

_____ a. 37.8 mL/min

_____ b. 28 mL/min

_____ c. 23 mL/min

_____ d. 17 mL/min

_____ e. 32 mL/min

16. At what level of hardness is it desirable to use a water softener on the feed water for a fluoride saturator?

_____ a. 25 mg/L

_____ b. 75 mg/L

_____ c. 150 mg/L

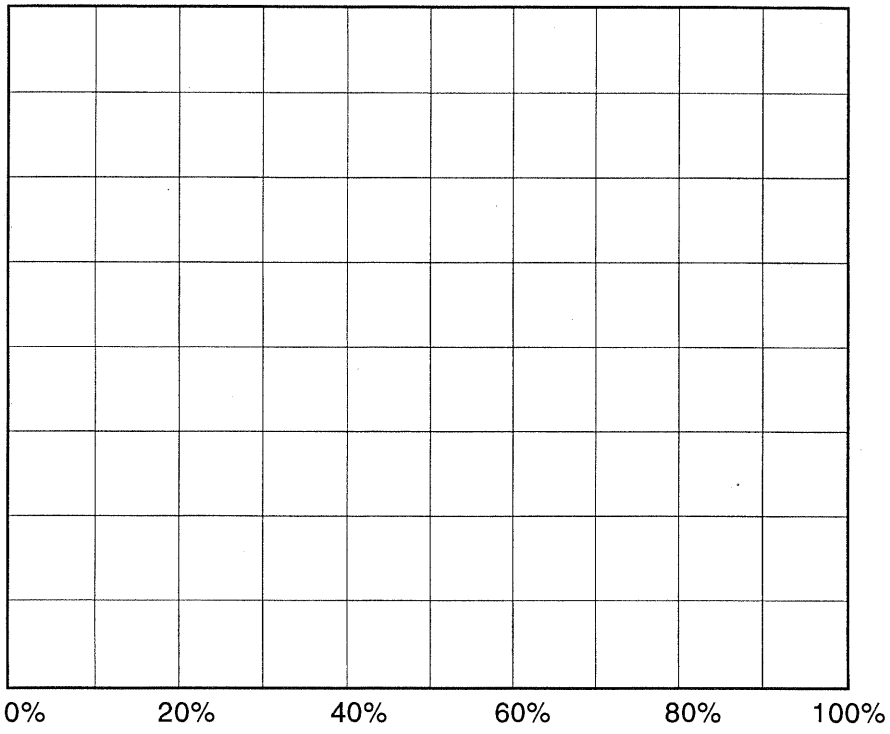
_____ d. 200 mg/L

_____ e. 250 mg/L

17. Complete the last column and develop a curve for the following chemical feed pump calibration data.

20% Frequency - based on 2 minute samples

Stroke	Start level	Stop level	mL	mL/min
20%	1000	993	32	_____
40%	985	947	76	_____
60%	920	860	120	_____
80%	800	724	152	_____



18. Find the dosage in mg/L when 5 gallons of solution was used from a 50 gallon tank to fluoridate a flow of 80,000 gallons per day.

_____ a. 1.7 mg/L

_____ b. 1.1 mg/L

_____ c. 1.4 mg/L

_____ d. 0.9 mg/L

_____ e. 1.3 mg/L