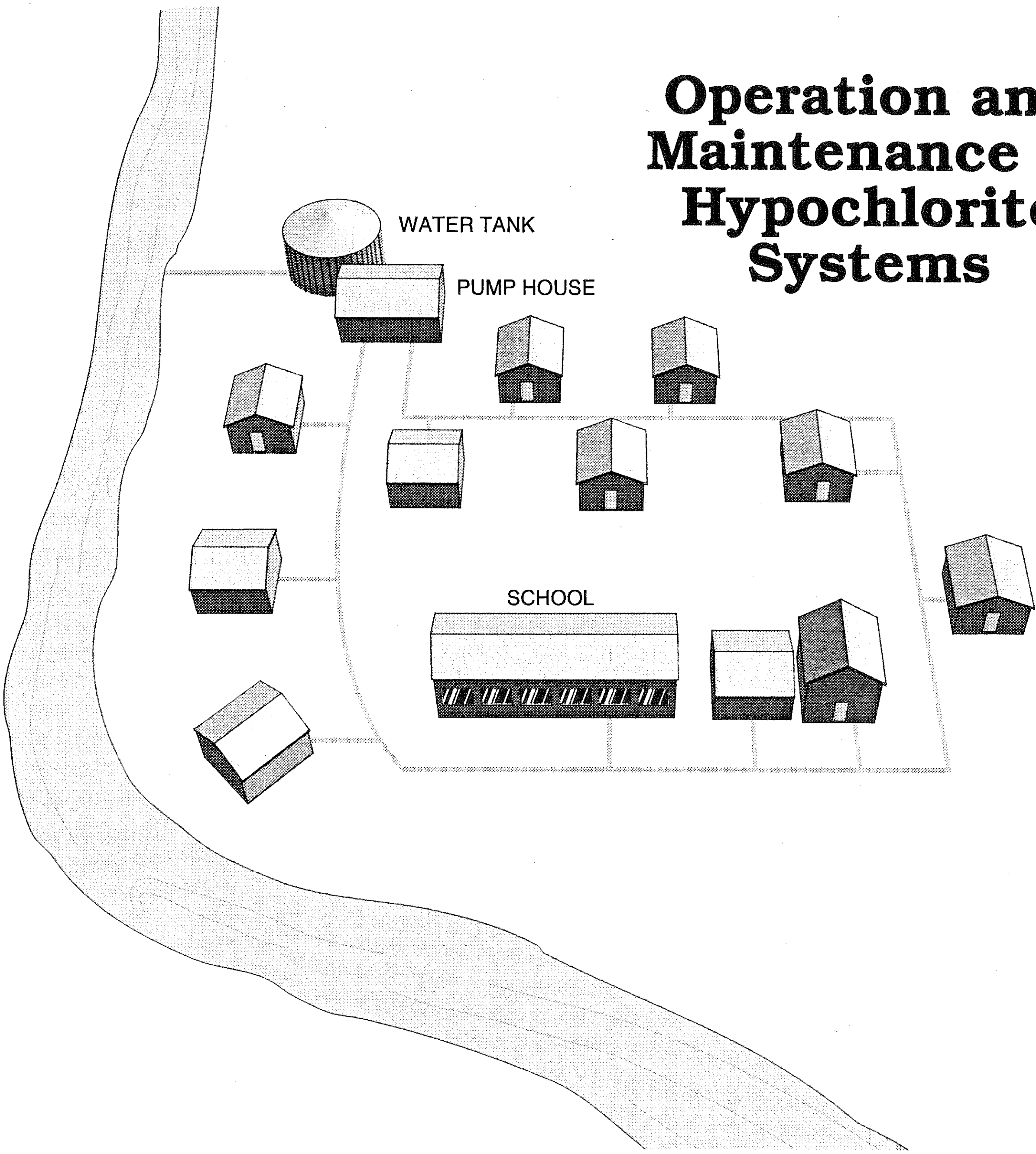
O & M of Small Water Systems



Operation and Maintenance of Hypochlorite Systems

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

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O & M OF HYPOCHLORITE SYSTEM

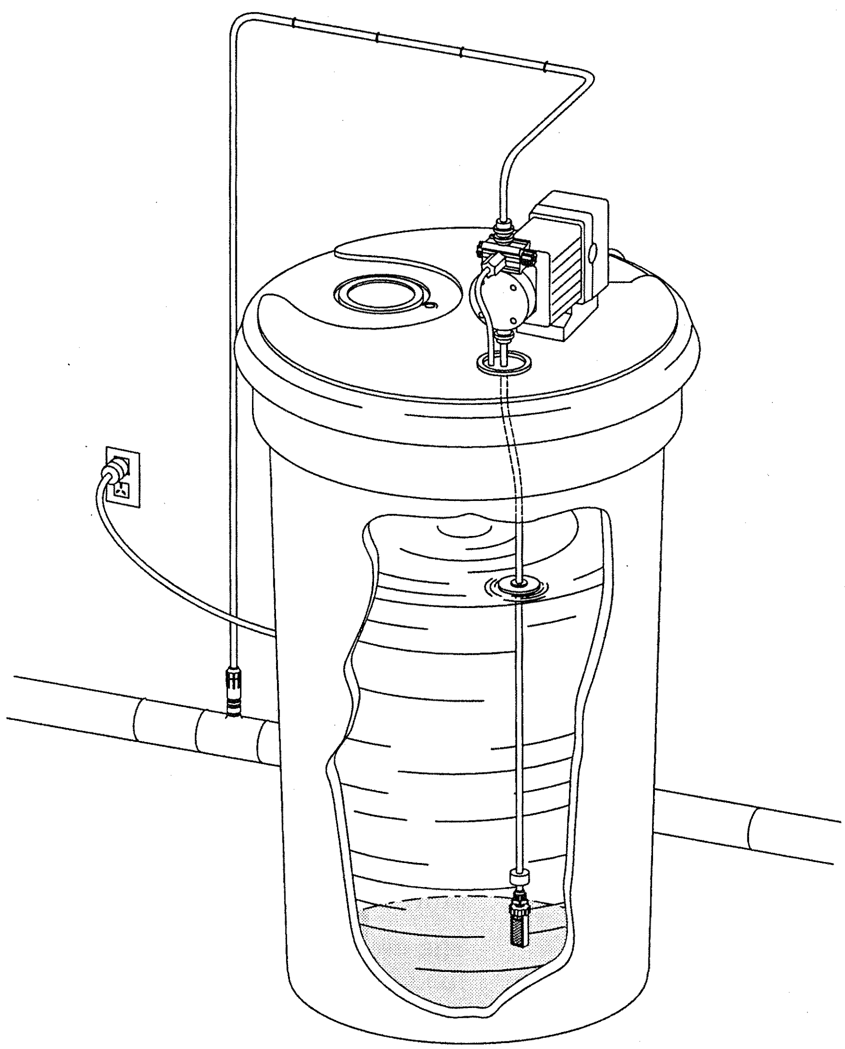
INTRODUCTION

Module Content

This module is designed for the level 1 operator. The focus is on the operation and maintenance of sodium and **calcium hypochlorite**[1] systems.

Theory

There is very little theory concerning the process of **disinfection**[2] in this module, since the focus of the module is on the operation and maintenance of **hypochlorite**[3] systems.



[1] **Calcium Hypochlorite** - A dry powder consisting of lime and chlorine ($Ca(OCl)_2$) combined is such a way that when dissolved in water, it releases active chloramine.
[2] **Disinfection** - The process used to control pathogenic organisms.
[3] **Hypochlorite** - Compounds containing chlorine that are used for disinfection. They are available as liquids or solids, in barrels, drums and cans.

FUNCTION

Reason For Adding Chlorine

Chlorine is added to a drinking water system to protect the health of the customers. Primarily it is used to reduce the number of pathogenic organisms. This process is called disinfection. The goal, of course, would be to kill all pathogenic organisms. While this is the goal, most health officials agree that this is not always possible. However, what is possible is to reduce the number of pathogenic organisms to a level that the users natural immune system can effectively deal with them. With recent changes in personal immune systems, this may change to the point that a complete kill is mandatory.

Dosage

In order to assure adequate disinfection, an adequate amount of chlorine must be added. The amount of chlorine added is called the chlorine **dosage**[4]. Typical dosages would be 2 to 5 mg/L for surface water and 1 to 30 mg/L for ground water.

Proper CT

The dosage needed is the amount necessary to provide the proper **CT**[5] value. The CT value required is depending on the source of the water (surface or ground), the presence or absence of filtration, the water **pH**[6] and temperature. Proper CT values are available from tables provided by EPA and/or the ADEC. A copy of these tables is provided in the module on regulations. The tables are based on the assumption that the **turbidity**[7] will be below 1 ntu and the feed of chlorine is continuous and proportional to the flow.

DETERMINING EFFECTIVENESS OF CHLORINE

Two Criteria

The effectiveness of disinfection is determined by the results of two tests, chlorine **residual**[8] and bacteriological analysis.

CT Requirements

Effective disinfection is assumed when the desired concentration is applied for the required contact time. This is reflected in the CT value for the system. Remember that the CT value takes into consideration: the free chlorine residual, contact time, water temperature and pH.

Residual

The proper dosage is assumed to have been applied if the free residual after proper contact time is 0.2 mg/L entering the distribution system and if a trace of chlorine must be maintained throughout the distribution system. For practical purposes, a residual of 0.2 mg/L

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

[5] **CT** - The produce of "residual disinfectant concentration" (C), in mg/L, determined before or at the first customer, and the corresponding "disinfectant contact time" (T), in minutes.

[6] **pH** - An expression of the intensity of the alkaline or acidic strength of a water. Mathematically, pH is the logarithm (base 10) of the reciprocal of the hydrogen ion concentration.

is about as low as can be read using a colormeteric device. Also, the residual of 0.2 mg/L entering the system is determined as a requirement under the assumption that proper contact time has been met.

Bac-T

The final test in determining if disinfection has taken place is to test for **Coliform bacteria**[9]. Proper disinfection is assumed to have taken place if the results of all tests performed during the month show an absence of all coliform bacteria. In fact, the **MCL**[10] allowed for a water system is zero coliform indicated in each and every test performed.

DISINFECTION PROCESS - USING HYPOCHLORITES

Overview

The typical hypochlorination process is accomplished by using a chemical feed pump to feed a concentration of sodium or calcium hypochlorite into the system flow. This solution is mixed with the flow and allowed to react for an appropriate length of time prior to the use by the first customer.

HYPOCHLORINATION SYSTEM

Introduction

A hypochlorination system can be divided into four distinct areas:

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

CHEMICAL STORAGE

Introduction

Chemical storage includes safety information concerning 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 chlorine equipment should be kept clean and dry. While dryness is not always possible, cleanliness is necessary in order to proved a safe working environment.

Building - Locked Door

In a small community the chlorine facility is seldom a separate facility. Normally, the chlorine equipment is maintained inside of the water treatment plant, well house or pumping station. Regardless of the setting, the building should be kept locked and vandal resistant.

[9] **Coliform Bacteria** - The coliform group of bacteria is a bacterial indicator of contamination. This group has as one of its primary habitats the intestinal tract of human beings. Coliforms also may be found in the intestinal tract of warm-blooded animals, and in plants, soil, air and the aquatic environment.

[10] **MCL** - Maximum Contaminant Level - The maximum permissible level of a contaminant in water delivered to a user of a public water system.

Chemicals

There are two chemicals used in hypochlorite system. Calcium hypochlorite ($Ca(OCl)_2$) and **sodium hypochlorite**[11]. Calcium hypochlorite is commonly purchased as a powder with a chlorine concentration of up to 67%. A common calcium hypochlorite brand is HTH (High Test Hypochlorite). Sodium hypochlorite (NaOCl), is typically a liquid. Liquid bleach is sodium hypochlorite. Sodium hypochlorite is available in concentrations of 4.75% to 15%. The most common industrial strength concentration is 12.5% chlorine. The safety and storage considerations for each chemical is unique to the chemical.

SODIUM HYPOCHLORITE - SAFETY & STORAGE

Out of the Sun

The deterioration rate of sodium hypochlorite is relative to the strength and temperature of the solution. The half life of a 12 to 15% solution is 100 days at 70°F or a deterioration rate of 2 to 4 percent per month. The table below gives the half life of various concentrations at specific temperatures.

Storage

Storing sodium hypochlorite in the sun reduces its concentration over time due to an increases in temperature and the effect of sunlight on the solution. The table above does not address the impact of sunlight.

OSHA Classification

Sodium hypochlorite (NaOCl), is classified by **OSHA**[12] as a Corrosive Liquid. The container should display the corrosive liquid placard.

UN Classification

The UN (United Nations) Classification for sodium hypochlorite is the number 8, a corrosive liquid. A table showing the various UN classifications is provided below.

NFR

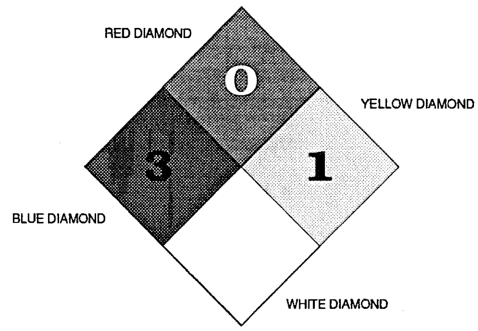
The NFR (National Fire Rating System developed by the National Fire Protection Association) provides the following classifications for sodium hypochlorite. (A table with explanations of the various ratings is provided below)

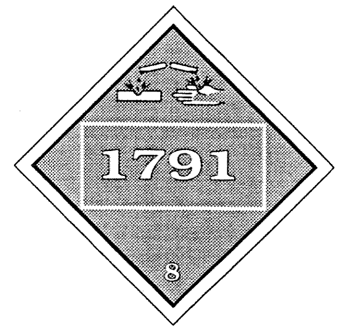
- Health rating - 3
- Flammability - 0
- Reactivity - 1
- Personnel protection requirements - CFR

DOT Identification

The DOT (Federal Department of Transportation) has given sodium hypochlorite a placard number of #1791. When determining how to handle a spill of sodium hypochlorite, the DOT has provided this information in their handbook under reference #60.

[11] **Sodium hypochlorite** - A water solution of sodium hydroxide and chlorine (NaOCl), in which sodium hypochlorite is the essential ingredient.
[12] **OSHA** - Occupational Safety and Health Administration.





Common Accidents & First Aid

Common sodium hypochlorite accidents and their associated first aid practices are:

- 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 hypochlorite spills.

- Small spills - clean up with vinegar & water (This is a recommendation of the author and not from DOT).
- Small spills - Can be taken up with sand or other noncombustible absorbent, place in a container for disposal - Reference is DOT 60.
- Large spills - dike for later disposal - Reference DOT 60

Fire

A fire involving sodium hypochlorite liquid can best be extinguished using dry chemical, Halon, water spray or standard foam.

CALCIUM HYPOCHLORITE - SAFETY & STORAGE

Cool and Dry

The storage area for calcium hypochlorite should be kept dry and cool. This is extremely important, calcium hypochlorite will explode and burn at a temperature of 350°F. Dryness is equally important, the addition of moisture in a calcium hypochlorite container may cause spontaneous combustion or hardening of the powder.

Deterioration Rate

Calcium hypochlorite ($Ca(OCl)_2$),when properly stored will deteriorate at a rate of 3 to 10% a year. In other words a concentration of 65% will be reduced to 55 to 62% at the end of one year.

OSHA Classification

OSHA classifies calcium hypochlorite as an Oxidizer. This means that its storage is restricted to facilities suitable for oxidizers.

UN Classification

The United Nations has given calcium hypochlorite a classification of 5. An explanation of this classification is provided in the table below.

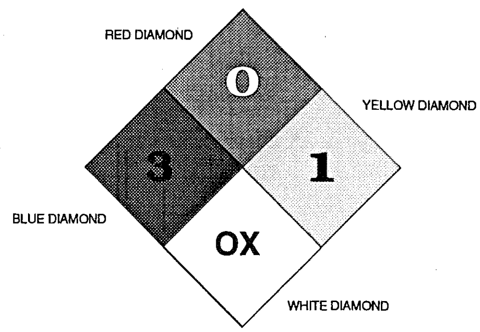
NFR

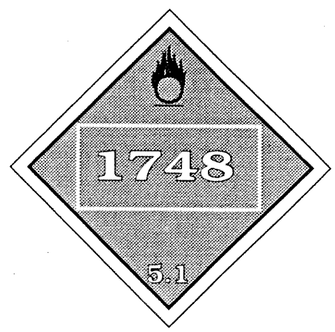
The NFR (National Fire Rating System developed by the National Fire Protection Association) has provided the following classification for calcium hypochlorite powder. An explanation of these classifications is provided in the table below.

- Health rating - 3
- Flammability - 0
- Reactivity - 1
- Special Notice - OX
- Personnel protection requirements - Safety goggles, face protection, respirator

DOT Rating

The DOT (Federal Department of Transportation) has given calcium hypochlorite a placard number of #1748. A description of how to handle spills and what first aid to provide is given in the DOT emergency response handbook under reference #45.





Common Accidents & First Aid

The DOT reference number 45 gives the following information on handling common calcium hypochlorite accidents and first aid requirements.

- Contact with skin or eyes - flush with clean water for 15 minutes, remove and isolate contaminated clothing and shoes.
- If victim is overcome - remove to fresh air - treat for shock - call for medical help.

Handling Spills

The following information is from the DOT reference number 45.

- Small spill - Pickup with shovel place material into clean, dry container and cover.
- Large spill - Contain with dike and pickup as in small leak.
- Fire - Water only; no dry chemical, CO_2 or Halon.

Calcium Hypochlorite Fires

The following information is from the DOT reference number 45.

- Fire or Explosion potential - May ignite other combustible materials - reaction with fuels my be violent - poison gas will be released.

Health Hazards

- If calcium hypochlorite fumes are inhaled, they may be harmful.
- Contact of calcium hypochlorite powder with skin and eyes may cause burns.
- A fire may that includes calcium hypochlorite may produce irritating or poisonous gases.

Table - UN Classifications

Number	Class Name/Hazard
1	Explosive
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:

Tank

The basic unit of the system is the 25 to 50 gallon corrosion resistant tank. The tank is used to hold a dilution of the chlorine solution. (In some cases the sodium hypochlorite solution is pumped directly from the shipping container.) The lid must fit snug to reduce the escape of chlorine gas, and holes in the lid should be plugged.

Concentrations

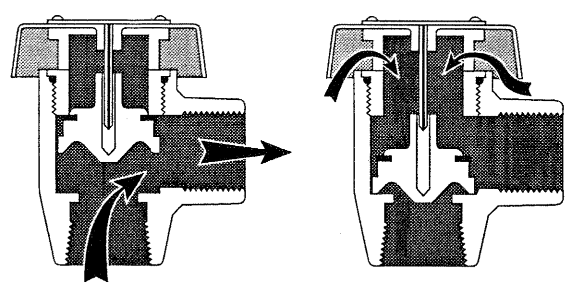
When the tank is used to hold a dilution, a typical dilution may range from 1/2 to 3%. This could be a sodium or calcium hypochlorite solution.

Job Aid

It is typical to have a device referred to as a"Job Aid" that is used to determine how much chlorine needs to be placed in the tank. Typically the "Job Aid" is marked off in five gallons segments. For each five gallons a set quantity of sodium or calcium hypochlorite is added. This procedure allows part time operators and full time staff to easily determine how much chlorine to add to the container in order to bring the volume back to the original level.

Fill Line

A **potable water**[13] fill line must be provided in order to mix and dilute the chlorine as well as for wash down in case of a spill. This line should be protected from **backflow**[14] by an **atmospheric vacuum breaker**[15]. The hose or line leading into the chlorine tank should stop a distance equal to twice the discharge line diameter or a minimum of one inch above the rim of the dilution tank.

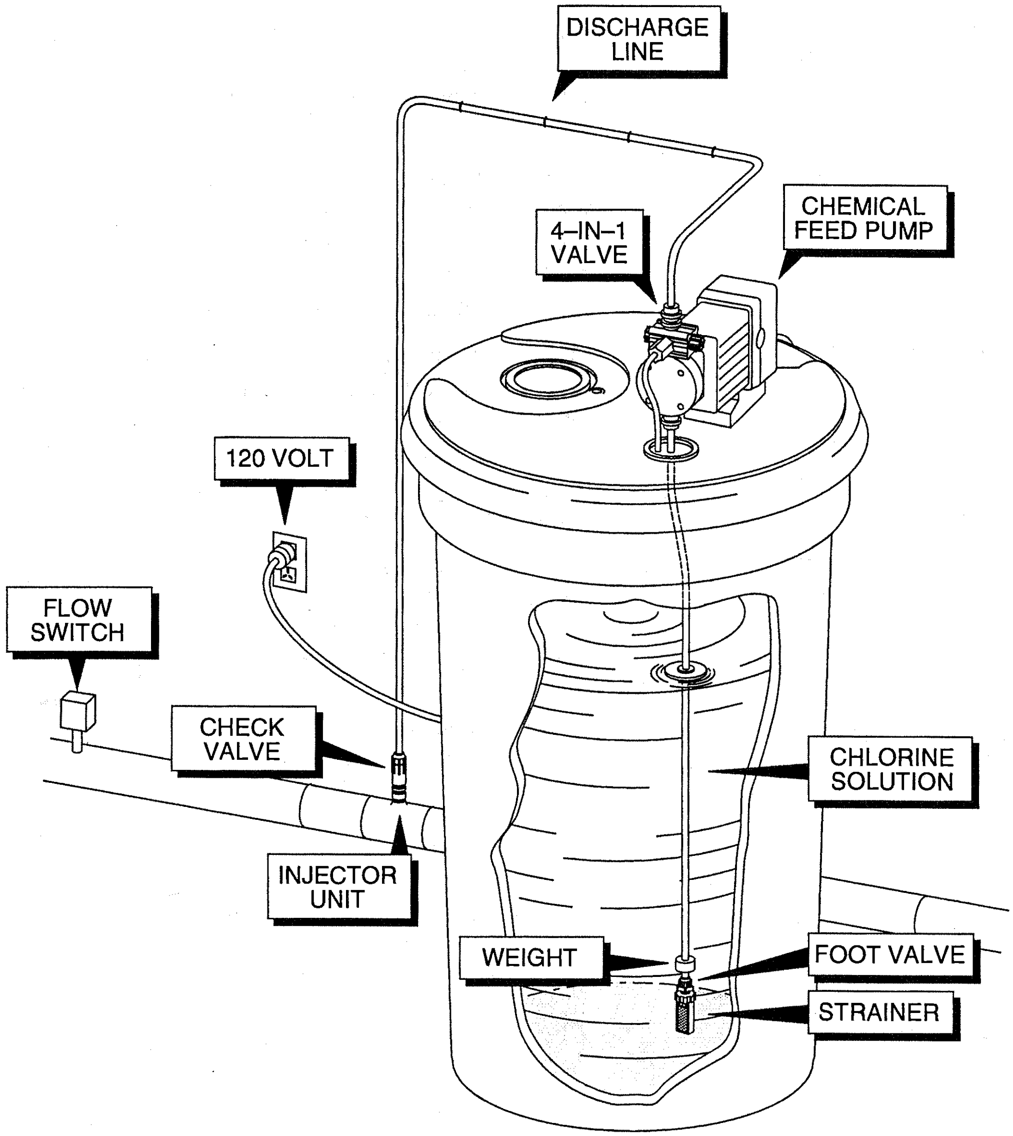


Flow condition   Non flow condtions

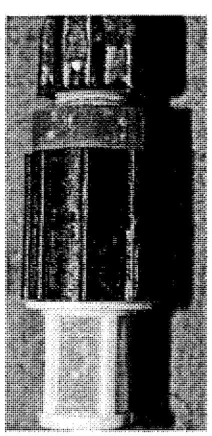
[13] **Potable Water** - Water satisfactory, safe for drinking purposes from the standpoint of its chemical, physical, and biological characteristic.

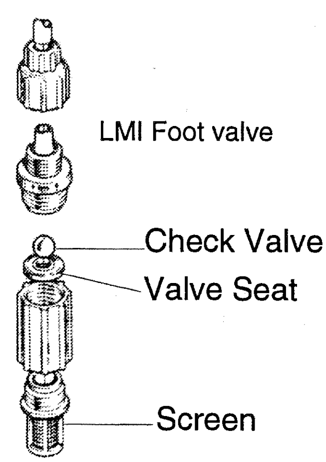
[14] **Backflow** - A reverse flow condition, created by a difference in water pressures, which causes nonpotable water to flow into a potable water system.

[15] **Atmospheric vacuum breaker** - A mechanical device that prevents backflow due to siphoning action created by a partial vacuum that allows air in to the piping system, breaking the vacuum.

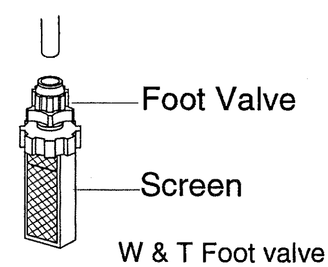


Foot Valve





At the bottom of the chemical feed pump suction line and 2 to 3 inches from the bottom of the tank is the 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.



PUMPING SYSTEM

Pump Piping

The piping on the suction and discharge of the pump is commonly polyethylene. 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 sunlight.

Pump

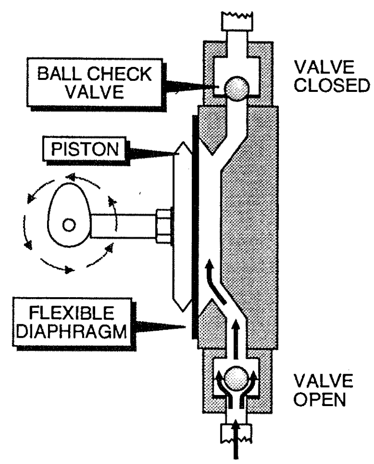
The most common pumps used in Alaska are LMI and W&T diaphragm, positive displacement pumps. This type of pump has a suction and discharge valve, valve seats and may have a spring on one or both of the valves to help them seat properly.

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.

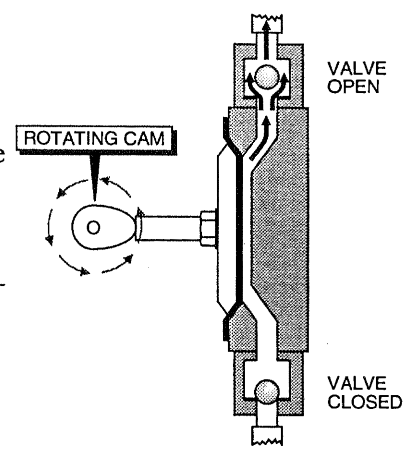
Pump Operation - Suction

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

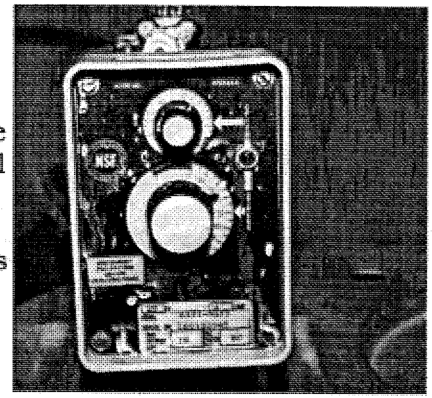
When the cam turns, it places pressure on the fluid inside of the pump head. This pressure forces the suction valve closed and the discharge valve open. Fluid is forced out of the pump and the pump is returned to normal operation. The pump cam then turns and starts the suction side of the cycle over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



Pump Adjustment

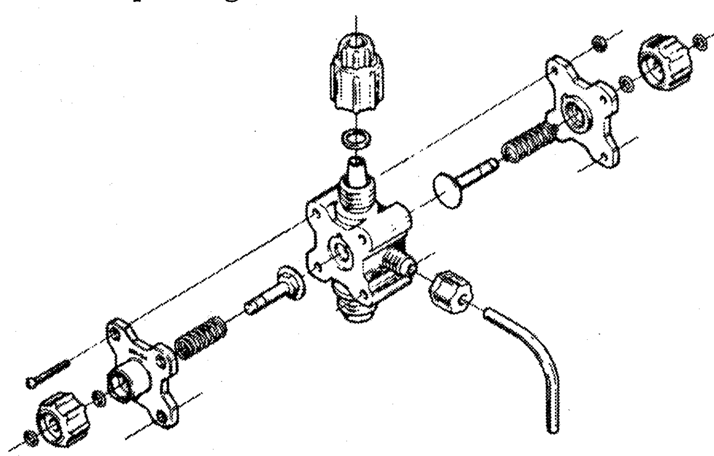
The chemical feed pumps used in Alaska allow two different adjustments of the feed rate. The length of the stroke and the frequency of the stroke can both be adjusted giving a high degree of flexibility. On the LMI feed pumps there is an additional adjustment or safety feature. On these pumps if the 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.

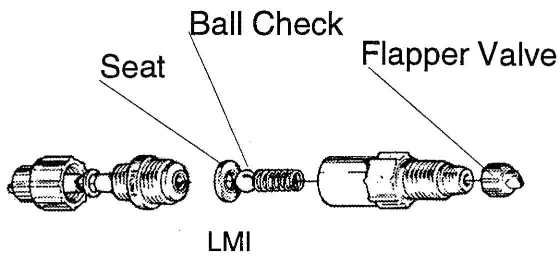
- Anti-siphon - the valve prevents the fluid from being siphoned from the tank should there be a below atmospheric pressure drop in the system pressure. This could happen if the system were set up to pump from a well and the foot valve on top of the submersible turbine failed. After pump shutdown, water 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**[16], siphoning fluid from the tank.



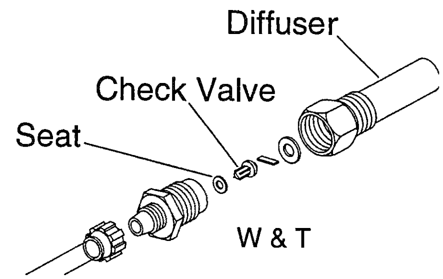
- Back pressure control. The valve maintains a positive discharge pressure of at least 25 psi on the discharge of the pump. This constant pressure exists even if the line pressure should drop to zero, helps to maintain the accuracy of the pump.
- Pressure relief - Should, for some reason, a valve on 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.

[16] **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 water 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

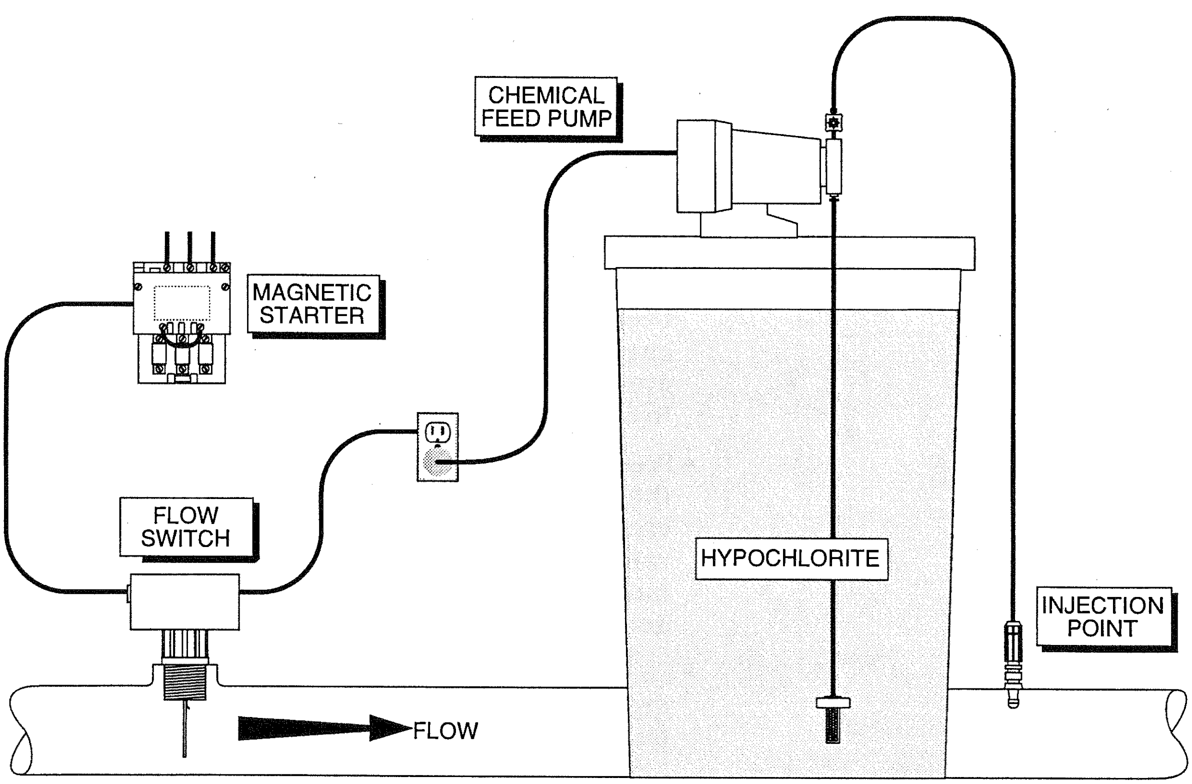
The electrical system starts at the **circuit breaker**[17]. The circuit breaker is designed to prevent a fire should there be a short in the wiring or the electric motor.

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 chlorine when it is not required.

Motor

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



17 **Circuit Breaker** - An electrical operated mechanical device used for over current protection.

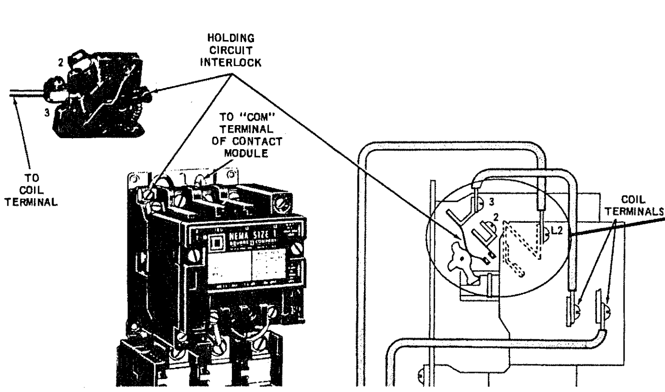
CONTROL SYSTEM

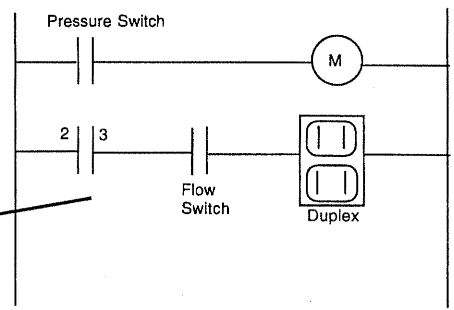
System Type

The type of control system found on chlorine 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 adjusts to system flow is normally associated with a gravity feed system.

Constant Flow

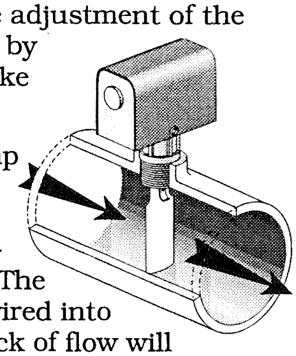
When the water that is to be chlorinated flows at a constant rate, as with a well, the chlorine feed pump is commonly connected electrically to the well pump control system. When there is a demand for the well pump to come on, power would be applied to the duplex plug that provides power to the chlorine feed pump. The electrical connection is either through a **contact relay**[18] or the **auxiliary contacts**[19] 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 were the pumping stroke frequency is controlled by a 4 - 20 ma signal. The signal is obtained from a flow meter. Fine adjustment of the chlorine 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**[20] is commonly installed 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.

18 **Contact relay** - An electrically operated mechanical device used to open and close a circuit.

19 **Auxiliary contact** - Contacts built into a mechanical starter and manually opened and closed by the magnetic starter.

20 **Flow Switch** - A switch that uses a metal read 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 describe above exists.

Sequence

In order to start a hypochlorite system do the following:

- Mix chemicals according the the procedure below. When handling the chemicals use the safety precautions described in the normal operations section.
- Prime the pump - see the procedure below.
- Check the chlorine residual every hour for the first eight hours of operation, and every four hours during the next 24 to 48 hours of operation. (No you do not have to check the residual during the night.)
- Adjust the feed rate to obtain proper residual
- Record the steps and their results.

Chemical Concentration

If the required concentration of chemicals for the tank is not known or provided, then use the procedure described below.

1. Estimate desired dosage. Typical dosages would be 2 to 5 mg/L for surface water and 1 to 30 mg/L for ground water.

2. Estimate the chlorine feed pump pumping rate in mL/min when the settings are 50/50. The feed pump rate can be estimated by either developing a calibration curve as described in the Normal Operations section or selecting from the pump list provided below.

3. Determine the plant flow rate in gpm.

4. Determine the concentration needed in the tank.

5. Determine the amount of HTH or bleach needed.

6. Determine how long a tank of solution will last.

Example:

The chemical feed pump used is a LMI A151-91FS with a maximum feed rate of 63 mL/min (see the table below). The flow rate through the plant is 50 gpm. A chlorine dosage of 3 mg/L is estimated to be needed to produce the desired residual for the contact time. The chlorinator system uses a 30 gallon tank. It is desirable to produce only 25 gallons of solution at a time.

- Determine the chemical feed pump rate, when the stroke and speed are both at 50%. 63 mL/min X 0.5 X 0.5 = 16 mL/min (step 2)
- Determine the concentration in the tank. (step 4)

$$\% = \frac{0.378 \text{ X } 3 \text{ mg/L X } 50 \text{ gpm}}{16 \text{ mL/min}} = 3.5\%$$

- Find the amount of 67% HTH necessary to make 25 gallons of this solution. (step 5)

$$\text{lbs} = \frac{3.5\% \times 25\ \text{gal} \times 8.34\ \text{lbs/gal}}{67\%} = 10.89 \text{ or } 11 \text{ lbs}$$

- Find how many days the tank will last if the total daily flow is 28,000 gallons. (step 6) Remember the pumping rate is 50 gpm, if the pump were running all day, 1,440 min, the total pumped would be 72,000 gallons. Since only 28,000 were pumped, the pump did not run 24 hours. Then how many hours did it run?

$$\text{Min of pumping time} = \frac{28{,}000\ \text{gal}}{50\ \text{gpm}} = 560\ \text{min}$$

560 min/day X 16 mL/min = 8,960 mL/day of solution needs to be pumped. The next step is to determine how many gallons will be pumped each day. Since there are 3,780 mL per gallon.

$$\text{gal} = \frac{8960\ \text{mL}}{3780\ \text{mL/gal}} = 2.37\ \text{gal/day}$$

$$\text{days} = \frac{25\ \text{gal}}{2.37\ \text{gal/day}} = 10.5\ \text{days}$$

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 gph	63 mL/min	110 psi
B121-91FS	2.5 gph	158 mL/min	100 psi
D121-71FS	4 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

Making Solutions

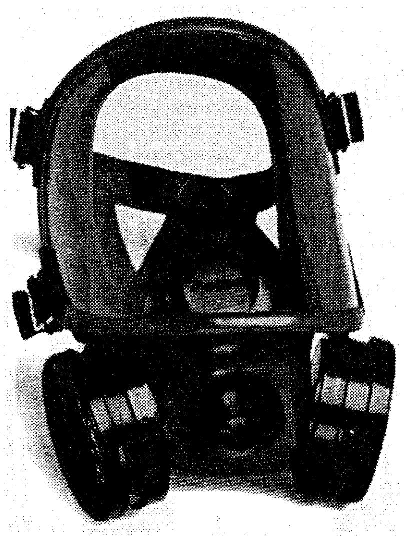
The concentration desired in a hypochlorite tank can be obtained from the formulas described later in this module or from the tables below.

Table for determining calcium hypochlorite requirements

Tank Vol	Solution Concentration				
gallons	1/2%	1%	2%	3%	4%
25 gal	1.5 lbs	3.0 lbs	6.0 lbs	9.0 lbs	12.0 lbs
50 gal	3.0 lbs	6.0 lbs	12.0 lbs	18.0 lbs	24.0 lbs

Table for determining sodium hypochlorite requirements using 5% bleach

Tank Vol	Solution Concentration		
gallons	1/2%	1%	2%
25 gal	2.5 gal	5 gal	10 gal
50 gal	5 gal	10 gal	20 gal



7. Fill tanks 1/2 full of clean potable water.

8. Put on safety equipment

- Goggles, gloves and apron for sodium hypochlorite
- Goggles, gloves and respirator for calcium hypochlorite.

9. Pour in powder or liquid

10. Mix the solution. This can be done with water, a plastic or wooden paddle or a mechanical mixer.

11. Finish filling the tank with clean potable water.

12. If calcium hypochlorite, allow to stand for 30 minutes to 1 hour. If there is an excessive amount of debris on the bottom of the tank or it is difficult to get the calcium hypochlorite to mix, see the sections on hypochlorite mixing and hard water later in this module.

13. Prime the pump - See the procedures below.

14. Adjust the pump to the proper setting.

15. Start feeding chlorine.

16. Take a residual each hour for the first four hours and then once every 4 hours for the first day then once a day. Make adjustments to feed rate as necessary.

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 chlorine 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 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 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 pump and 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 for desired CT value.

Priming W & T 45

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 chlorine solution.

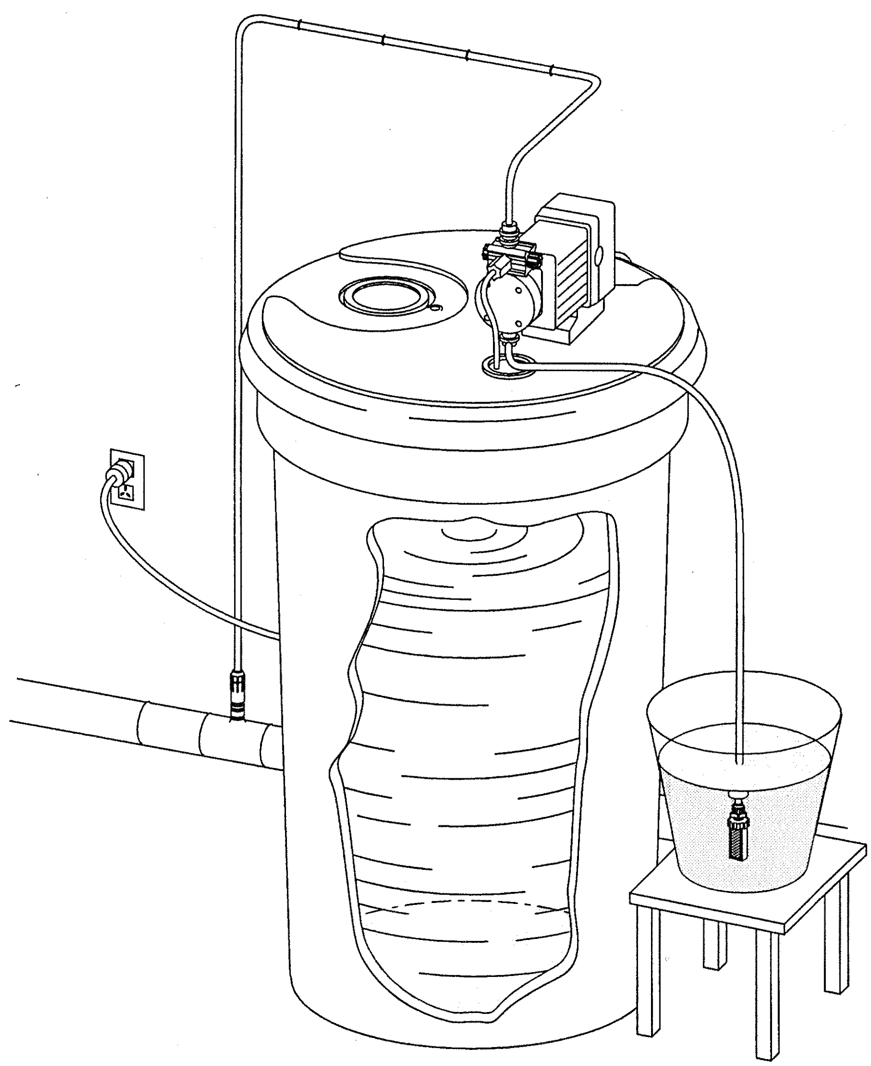
Equipment

• 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 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 INSPECTIONS

What to observe?

The chlorine installation should be inspected each day of operation. When inspecting the installation, look generally for proper operation. More specifically observe the following:

- Tank level - if below 6 inches - dump the remainder of the solution and replace with fresh solution. Is the tank level down from the previous visit?
- Age of solution - if the solution is older than 30 days - dump and replace with fresh solution.
- Operation of feed pump - look at the discharge line, Can you see fluid being pumped? Does everything look normal?
- Look for leaks.
- Test for residual. Must be at least 0.2 mg/L entering distribution system and a trace at all points in the system.

Data Collection

During the visit observe and record the following data:

- Level of liquid in the tank.
- If a standard 50 gallon tank is being used, there is approximately 45 gallons in tank. The typical tank contains 36 inches of solution when full. This is equivalent to 1.25 gallons per inch.
- Plant flow in gallons per day (gpd).

Calculations Needed

At the conclusion of each visit, calculate the dosage in mg/L. This is the best way to separate mechanical problems from contamination problems. If the dosage remains the same each day and the residual drops, then the chlorine demand has gone up indicating an increase in contamination in the supply. If the residual drops and the dosage drops by the same amount, then this is an indication of a problem with the feed system.

HOW MUCH CHEMICAL TO ADD?

Typical Problem

During the visit it is often necessary to replenish the chemical in the tank. If the tank is empty then determining how much chemical should be placed in the tank is very simple. However, one of the common problems facing operators of these systems is how to determine the amount of chemical that needs to be placed in the tank, when the tank is not completely empty.

Solution

The simplest way to resolve this problem is with a job-aid. A job aid is developed using this procedure:

- Cut a piece of 3/4 or 1 inch PVC pipe the height of the tank depth.

- Determine how much chemical will be required for five (5) gallons of water.
- Empty the tank.
- Place five gallons of water in the tank and, using a water resistant felt tip marker, place a mark on the piece of PVC.
- Continue this process until the tank is full.
- Make a note on the side of the piece of PVC, how many pounds, gallons, cups, etc of chemical is needed for each five gallons of water.
- When performing the routine inspection, hold the bottom of the piece of PVC even with the level of solution in the tank. Place a pencil mark on the tank at the nearest 5 gallon mark that you can fill to with out overfilling the tank.
- Place the chemical in the tank.
- Fill the tank to the mark with clean water.

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 chlorine used per month.
- Multiple 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 1.5 pounds of chlorine 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 1.5 lbs/day X 250 days = 375 pounds. A standard container of calcium hypochlorite is 70 pounds. The order should be for six containers.

HANDLING CHEMICALS

Sodium Hypochlorite Equipment

When handling sodium hypochlorite the following equipment should be worn:

- Chemical safety goggles - Lab Safety QB-14336 or equivalent.
- Rubber gloves that come to elbow - Neoprene or PVC.
- Rubber apron - Neoprene or PVC.

Calcium Hypochlorite Equipment

When handling calcium hypochlorite powder the following equipment should be worn:

- Chemical safety goggles - See respirator below.
- Rubber gloves that come to elbow - Neoprene or PVC.
- Rubber apron - Neoprene or PVC.
- Cartridge respirator - NIOSH/MSHA approved full face piece with chlorine cartridges and dust/mist filter- Lab Safety QB-9838 or equivalent.

Respirator Life

The cartridges on the respirators should be replaced at least every six months or anytime that chlorine odor can be detected when the respirator is being worn. Most operators find that the entire respirator should be replaced every three to five years.

Equipment Storage

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

Calcium Hypochlorite - Mixing

When it is necessary to mix a solution of calcium hypochlorite follow this procedure.

- Fill tank 1/2 full of water.
- Pour in powder.
- Mix - use plastic mixing device.
- Fill the tank with water.

Hard Water Problems

When the hardness of the water is above 125 mg/L, there is commonly difficulty with getting the powder to go into solution, and a lot of material settles to bottom. This problem can be solved by any one of the following means:

- Soften the water by adding an equal weight of calgon (1 lb of calgon for each 1 lb of calcium hypochlorite).
- Add one pound of soda ash to the tank for each one pound of of calcium hypochlorite added.
- Use a sequestering agent. A typical dosage would be 1.5 cups of **hexametaphosphate**[21] for each 5 gallons of water in the tank. This will keep the calcium in solution and reduce the amount of material in the bottom of the barrel.

[21] **Hexametaphosphate** - A common sequestering agent.

- After mixing, allow the solution to stand for 12 hours and then siphon off clear solution from the top of the tank into a second tank.

When to Replace Solution

The solution in a tank should be replaced when the level reaches six inches in the tank. At no time should a solution be kept that is older than 30 days.

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 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.

Considerations

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

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.

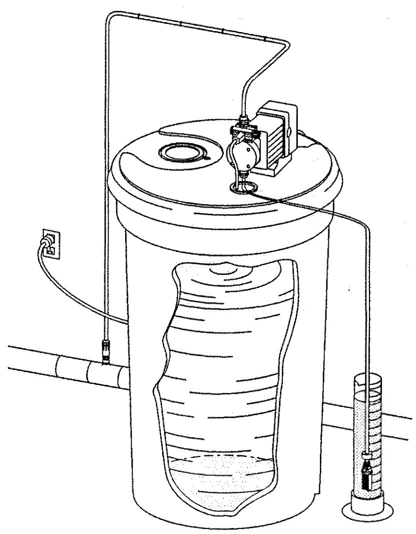
General Procedure

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

1. Calibrate the pump by observing amount pumped from 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 not be 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 - 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 in either 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, clean the cylinder.
17. Transfer the data to a graph.

Example

The following data was collected during a 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

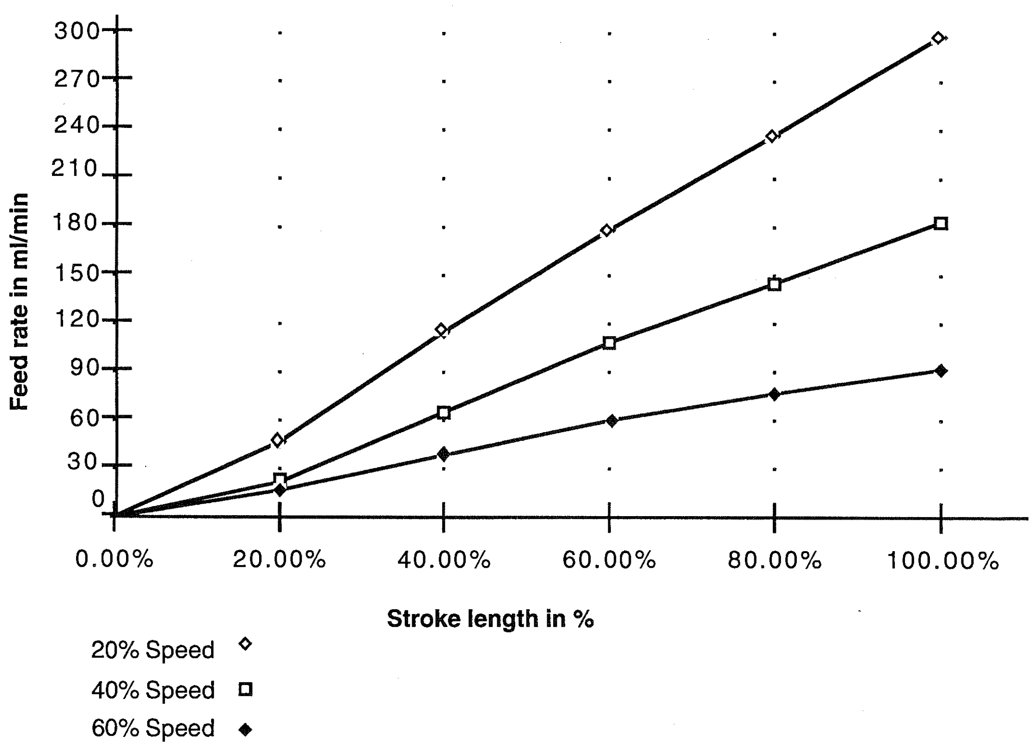
Stroke	Start level	Stop level	mL	mL/min
20%	1000	905	95	47.5
40%	875	645	230	115
60%	600	244	356	178
80%	1.0	9.8	475	237.5

90% Frequency - based on 1 minute sample

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, first 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 determine, 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 chlorine 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.

CALCULATION USED WITH HYPOCHLORINATION

Introduction

Depending on the situation, an operator may need one or more of the following formulas. There are ten formulas, divided into three groups. Group 1, formulas 1 through 3 are for calcium hypochlorite; group 2, formulas 4 & 5 are for sodium **hypochlorites**[22] and group 3, formulas 7 - 10 are for pump and dosage settings.

CALCIUM HYPOCHLORITE

Pounds for Set Concentration

The following formula can be used to determine the number of pounds of calcium hypochlorite needed to make a certain percent solution.

$$\_\_\_ \text{ lbs} = \frac{\_\_\_\_\_ \text{ \% Solution needed X } \_\_\_\_\_ \text{ gal in tank X 8.34 lbs/gal}}{\_\_\_\_\_ \text{ \% Calcium Hypochlorite}}$$

Example #1

Determine the number of pounds of 65% HTH needed to make 50 gallons of a 1% solution.

$$\text{Lbs} = \frac{1\% \text{ X 50gal X 8.34lbs/gal}}{65\%} = 6.4 \text{ lbs}$$

Example #2

Determine the pounds of 70 calcium hypochlorite necessary to make 50 gallons of a 2% solution.

$$\text{Lbs} = \frac{2\% \text{ X 50 gal X 8.34 lbs/gal}}{70\%} = 11.9 \text{ lbs}$$

22 **Hypochlorites** - Compounds containing chlorite that are used for disinfection. They are available as liquids or solids (powder, granules, and pellets) in barrels, drums, and cans.

No Scales

In many locations, there is no scales to measure out the amount of calcium hypochlorite powder. In these locations a cup marked in grams or ounces is commonly supplied and used.

Typical cups are 300 grams, 600 grams and 16 oz.

454 grams = 1 pound

16 oz = 1 pound

To convert the number of cups to pounds, divide the weight.

Example

Find the number of pounds in a 300 gram cup

300/454 = 0.66 lbs

Example

How many 300 gram cups are needed in example problem #1 above?

$$\text{Cups} = \frac{6.42 \text{ lbs}}{0.66 \text{ lbs/cup}} = 9.7 \text{ cups}$$

Example

How 300 gram cups are needed for the solution in example problem #2 above?

$$\text{Cups} = \frac{11.9 \text{ lbs}}{0.66 \text{ lbs/cup}} = 18 \text{ cups}$$

Finding Concentration

The formula for finding the concentration of calcium hypochlorite in a tank when the number of pounds of material added is known is:

$$\_\_\_\_\ \% \text{ in tank} = \frac{\_\_\_\_\ \text{lbs of powder} \times \_\_\_\_\ \% \text{ of } Cl_2 \text{ of powder}}{\_\_\_\_\ \text{gal of tank} \times 8.34 \text{ lbs/gal}}$$

Example #1

Find the concentration when 18 lbs of 67% HTH it is filled with water.

$$\% = \frac{18 \text{ lbs} \times 67\%}{50 \text{ gal} \times 8.34 \text{ lbs/gal}} = 2.89\%$$

Example #2

Find the concentration when three 700 gram cups of 65% calcium hypochlorite are placed in 25 gallons of water.

- Find the number of grams placed in the barrel.

700 grams X 3 = 2,100 grams

- Find the number of pounds added.

$$\text{lbs} = \frac{2100 \text{ g}}{454 \text{ g/lb}} = 4.6 \text{ lbs}$$

- Find the concentration in the tank.

$$\% = \frac{4.6 \text{ lbs} \times 65\%}{25 \text{ gal} \times 8.34 \text{ lbs/gal}} = 1.4\%$$

SODIUM HYPOCHLORITE

Gallons Needed

The following formula can be used to find the number of gallons of bleach needed to make a specific strength solution.

$$\text{Gal} = \frac{\_\_\_\_\ \%\ \text{solution needed in tank X}\ \_\_\_\_\_\ \text{gal of tank}}{\_\_\_\_\ \%\ \text{strength of bleach}}$$

Example #1

Find the amount of 5% bleach need to make 10 gallons of 1% solution.

$$\text{Gal of bleach} = \frac{1\%\ \text{X}\ 10\ \text{gal}}{5\%} = 2\ \text{gal}$$

Example #2

Find the amount of 12% bleach needed to make 25 gallons of 0.5% solution.

$$\text{Gal of bleach} = \frac{0.5\%\ \text{X}\ 25\ \text{gal}}{12\%} = 1\ \text{gallon}$$

Concentration In Tank

The formula below can be used for finding the concentration in a tank when the concentration of the sodium hypochlorite is known.

$$\_\_\_\_\ \%\ \text{in tank} = \frac{\_\_\_\_\ \%\ \text{bleach X}\ \_\_\_\_\ \text{gal bleach}}{\_\_\_\_\ \text{gal in tank}}$$

Example

Find the concentration of 50 gallons of solution if 10 gallons of 5% bleach were placed in the tank and then the tank filled to 50 gallons.

$$\%\ \text{solution} = \frac{5\%\ \text{X}\ 10\ \text{gal}}{50\ \text{gal}} = 1\%$$

PUMPS & DOSAGE

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% = 0.0289

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

Feed Rate

The following formula can be used to find the chemical pump feed rate when the system flow and the tank concentration are known.

$$\text{mL/min} = \frac{0.378 \text{ X } \_\_\_\_ \text{ mg/L (dosage) } \_\_\_\_ \text{ gpm (flow rate)}}{\_\_\_\_ \text{ \% in tank}}$$

Example

Find the feed rate in milliliters per minute for a feed pump that must pump a 2% chlorine solution into a 2 inch line that flows at 50 gpm. The desired dosage in 3 mg/L.

$$\text{mL/min} = \frac{0.378 \text{ X } 3 \text{ mg/L X } 50 \text{ gpm}}{2\%} = 28 \text{ mL/min}$$

Concentration @ Set Dosage

The following formula can be used to find the concentration needed to provide a set dosage at a specific chemical feed pump pumping rate.

$$\_\_\_ \text{\% Concentration} = \frac{0.378 \text{ X } \_\_\_\_ \text{ mg/L (dosage) X } \_\_\_\_ \text{ gpm (flow rate)}}{\_\_\_\_ \text{ mL/min (feed pump rate)}}$$

Example

Find the concentration needed to supply a dosage of 4 mg/L to a flow of 60 gpm when the chemical feed pump is producing 30 mL/min.

$$\% = \frac{0.378 \text{ X } 4 \text{ mg/L X } 60 \text{ gpm}}{30 \text{ mL/min}} = 3\%$$

Determining Dosage

The following formula can be used to find the dosage in mg/L, when the flow rate and the concentration of the solution are known

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

Example

Find the dosage in mg/L when 10 gallons was used from a 50 gallon tank to chlorinate a flow of 60,000 gallons. The concentration in the tank is 2%.

$$\text{mg/L} = \frac{10 \text{ gal/day X } 2\% \text{ X } 10{,}000}{60{,}000 \text{ gal/day}} = 3.3 \text{ mg/L}$$

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, 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.

W & T Series 45 Pump

The W & T series 45 pumps have oil cooled motors. With these pumps, you should do the following:

- Check oil level each month. The oil level should be just above solenoid coil or inside lower edge of fill hole when pump tilted 30°.

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 to for the proper chemical. There are three common wet ends used in small communities in Alaska, they are:

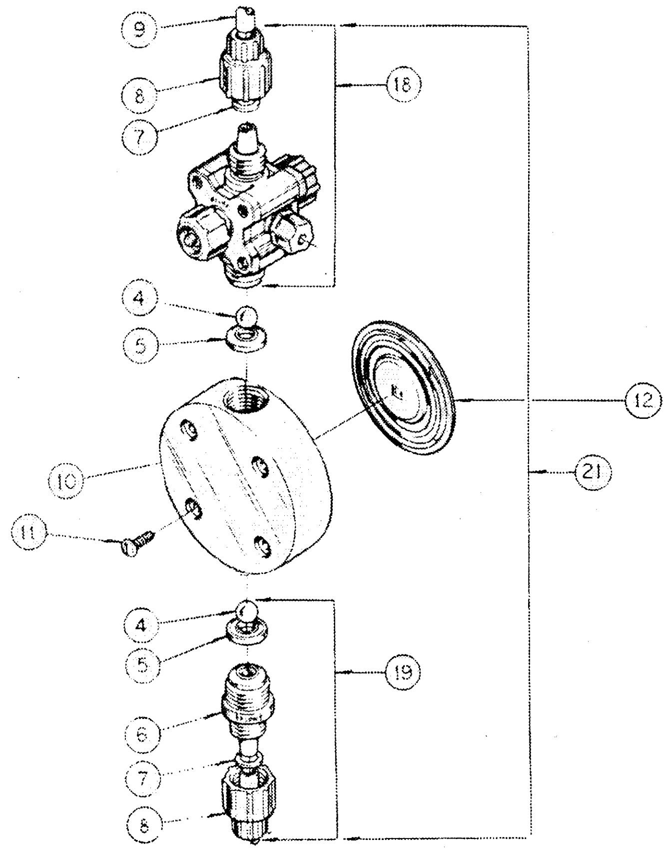
Model	Chemical it is designed for
91S	Chlorine
91T	Alum, $KMnO_4$, Soda Ash, etc.
91FS	Fluoride

Repair Kits

The repair kit required for a LMI pumping a chlorine application is **SP-U1**.

LMI PUMPS

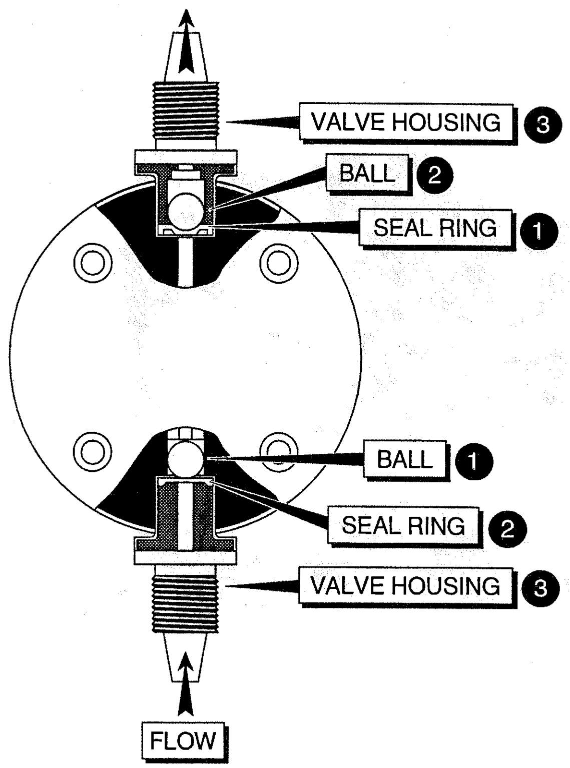
Key	Description
4	Check ball
5	Check seat
10	Pump head
12	Diaphragm
18	4 in 1 valve



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 pump.
2. Loosen hose fitting & remove hose.
3. Remove injection fitting.
4. Remove and replace, ball, spring seat and seal 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.
5. Clean and replace 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.



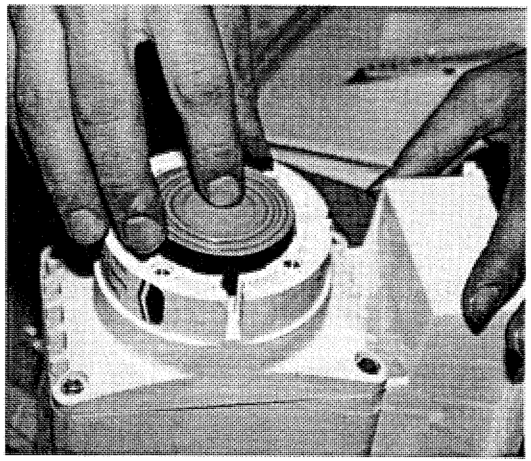
Proper order of installation of LMI discharge and suction valves

LMI Suction Valve

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

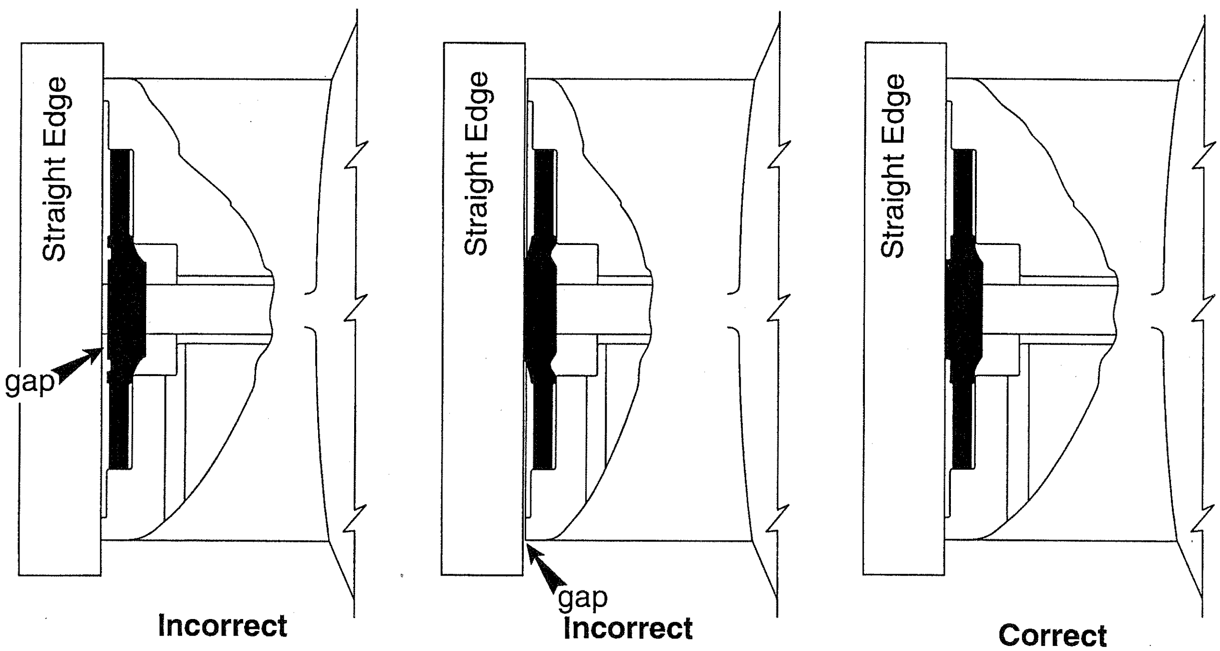
1. Shut off and depressurize pump.
2. Loosen hose fitting & remove hose.
3. Remove coupling nut.
4. Remove suction valve seat.
5. Remove and replace ball, seat and seal ring. No Teflon tape should be used on the fitting or threads. Instead use silicon lube on threads (Dow 33 Moleycoat). Tighten the fitting 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 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 pump head.
5. Remove diaphragm. Grasp other edge and rotate counter clockwise.
6. Restart pump.
7. Adjust stroke to 90%.
8. Screw on diaphragm until center begins to buckle.
9. Stop pump.
10. Check position with straight edge. Adjust as necessary.



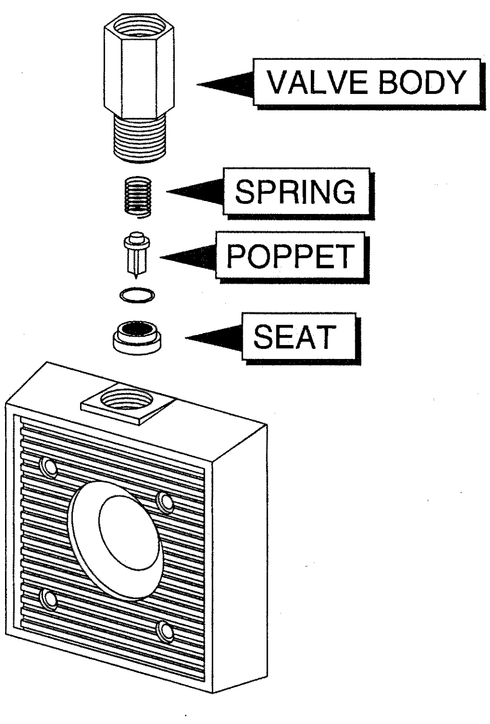
11. Replace head. Tighten the head bolts using a criss-cross pattern.

W & T PUMPS

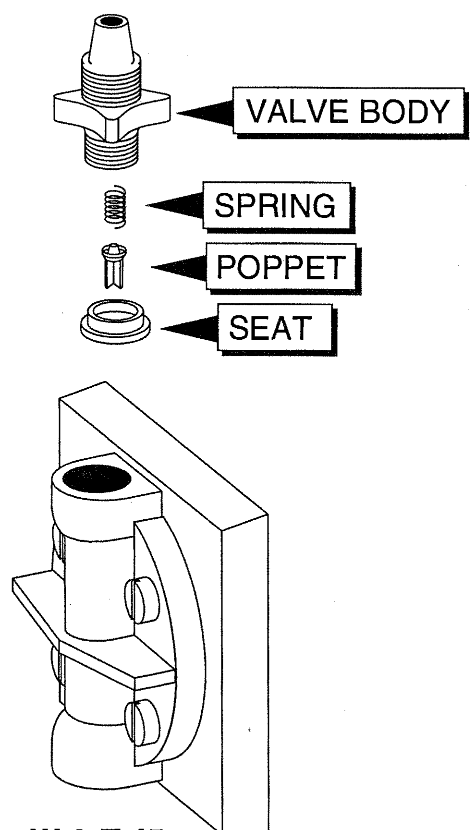
Discharge & Suction Valves

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



W & T 94

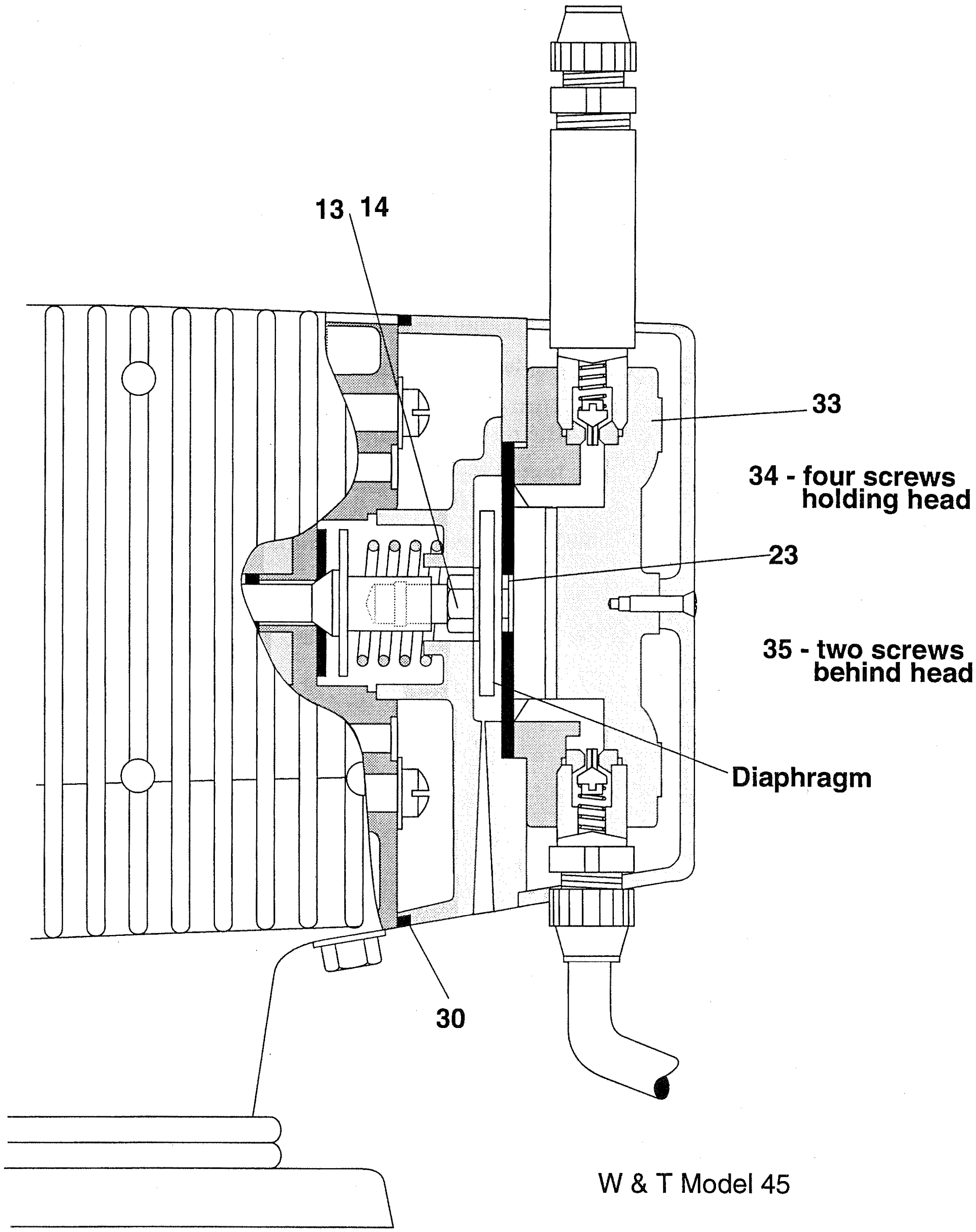


W & T 45

Replace Diaphragm on W & T Pump

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 & lock-out or unplug.
4. Remove screws (34) from pump head (33).
5. Lift diaphragm by edge, turn counterclockwise.
6. Hold hub (23), remove nut (13), lock washer (14) and diaphragm..
7. Remove two screws (35)
8. Hold washer with pliers & turn diaphragm counter-clockwise.
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 groove. 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.

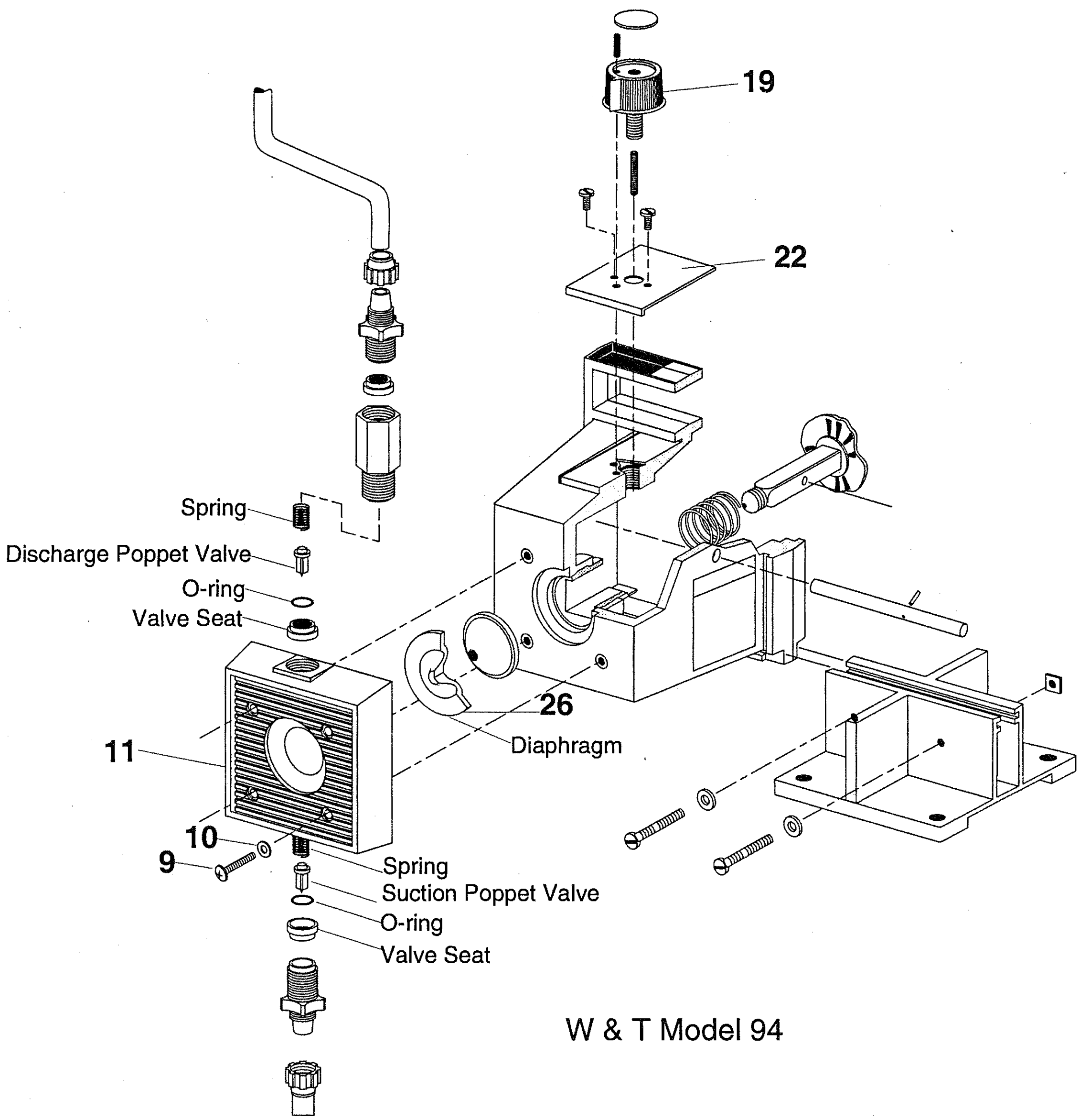

13, 14
33
34 - four screws
holding head
23
35 - two screws
behind head
Diaphragm
30

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 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, 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 anytime 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

Problem

Low Residual	
Causes	**Check and/or Solution**
No solution in tank	Add solution
Pump airbound	Check foot valve
Increased demand	Check dosage rate
Suction &/or discharge valves not working correctly	Check dosage rate
Ruptured diaphragm	Inspect & replace
Stroke length not correct	Adjust

Will not prime	
Causes	**Check and/or Solution**
Not plugged in	Plug in
Not turned on	Turn on
Speed and stroke not set properly	80% speed 100% stroke
Suction lift to 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 to high	Check pressure
Suction screen plugged	Replace

Lost Prime **Causes**	**Check and/or Solution**
Solution tank dry	Refill
Foot valve not in vertical position	Adjust
Suction lift to great	Maximum 5 feet suction lift
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

Will not run **Causes**	**Check and/or Solution**
Power off	Check outlet
EPU failure on LMI pumps	See manufacturers info
Pulser failure	See manufacturers info

Excessive output **Causes**	**Check and/or Solution**
Siphoning	Replace anti siphon valve
Loss of discharge pressure	Needs to be at least 25 psi
Excessive stroke frequency	Replace pulser

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

CHLORINE DATA FORM

City of ______________________________ Month ____________

Tank Volume ______ gal 1 inch = ______________ gal

Day	Time	Tank Level Inches	Inches used	Gallons used	Flow for day, gallons	Dosage	Residual	Operator
31								
30								
29								
28								
27								
26								
25								
24								
23								
22								
21								
20								
19								
18								
17								
16								
15								
14								
13								
12								
11								
10								
9								
8								
7								
6								
5								
4								
3								
2								
1								
Total								
Average								

O & M OF HYPOCHLORITE SYSTEMS WORKSHEET

1. The proper chlorine dosage would be one that would produce a residual entering the system of at least ________.

   _______ a. A trace of chlorine

   _______ b. 5 mg/L

   _______ c. 1%

   _______ d. 0.2 mg/L

   _______ e. 0.1 mg/L

2. A properly disinfected water distribution system maintains a chlorine residual at all points in the system of ___________.

   _______ a. A trace of chlorine

   _______ b. 5 mg/L

   _______ c. 1%

   _______ d. 0.2 mg/L

   _______ e. 0.1 mg/L

3. The amount of chlorine added to a system is called..

   _______ a. Demand

   _______ b. Residual

   _______ c. CT

   _______ d. Dosage

   _______ e. Disinfection

4. The effectiveness of disinfection is measured by the presence of a chlorine residual and the absence of ____________________.

   _______ a. Turbidity

   _______ b. Coliform Bacteria

   _______ c. pH

   _______ d. Microorganisms

   _______ e. Combined residuals

5. Calcium hypochlorite ($Ca(OCl)_2$) is available in concentrations of up to ________.

_______ a. 67%

_______ b. 45%

_______ c. 15%

_______ d. 65 mg/L

_______ e. 12 mg/L

6. Sodium hypochlorite (NaOCl), is available in concentrations up to __________.

_______ a. 67%

_______ b. 12.5%

_______ c. 15%

_______ d. 45%

_______ e. 20%

7. A small spill of sodium hypochlorite can be contained by:

_______ a. Call an emergency response team

_______ b. Flush with water and vinegar

_______ c. Use dry alum powder

_______ d. Dike and call for help

_______ e. Call CEMTREX

8. Calcium hypochlorite will burn at temperatures above _______ °F.

_______ a. 100

_______ b. 250

_______ c. 400

_______ d. 350

_______ e. 212

9. For storage purposes, calcium hypochlorite is classified by OSHA as an________.

_______ a. Poison

_______ b. Flammable liquid

_______ c. Oxidizer

_______ d. Explosive

_______ e. Corrosive

10. If a hypochlorite solution is spilled or splashed onto your hands you should ...

_______ a. Flush with water for 15 minutes

_______ b. Call a doctor

_______ c. Flush with water and cover the area with a clean dry bandage & seal in plastic

_______ d. Cover the area with a salve and see a doctor

_______ e. Do nothing, hypochlorites will not harm you

11. Identify the components identified below

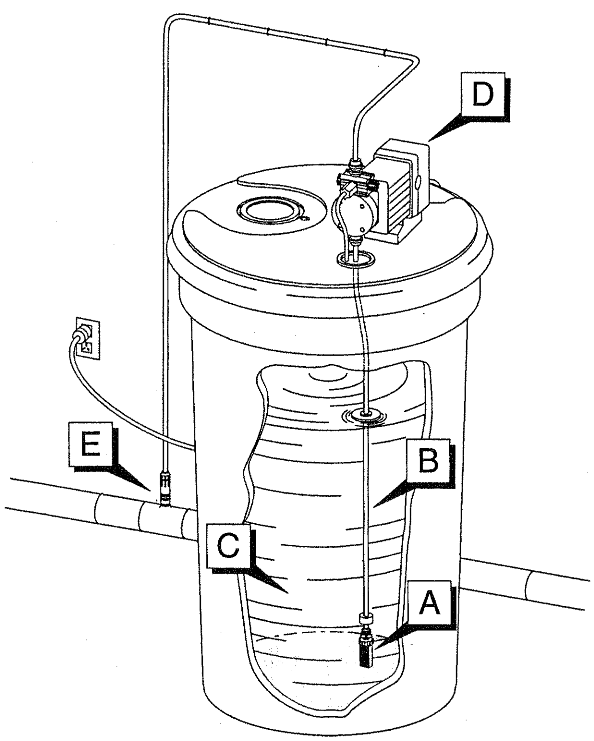
a. ______________________________ f. ______________________________

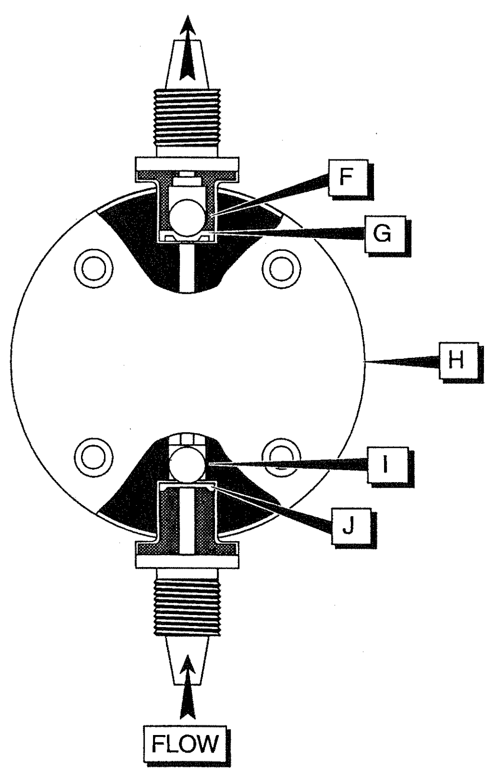
b. ______________________________ g. ______________________________

c. ______________________________ h. ______________________________

d. ______________________________ i. ______________________________

e. ______________________________ j. ______________________________





12. A chemical feed pump should be wired so that..

_______ a. It will start anytime the pump motor starter is engaged.

_______ b. It will start only when the pump starter is engaged and the flow switch is closed.

_______ c. It will start only when the contact relay is closed, the auxiliary contacts are closed and the tank is above the half way point.

_______ d. It will start only when the pump is actually pumping water and there is a residual below 0.2 in the incoming water.

_______ e. It will start only when the fluoride system is off line.

13. When mixing a calcium hypochlorite system you should

_______ a. Always allow 24 hours of settling before feeding the solution.

_______ b. Always place the powder into the empty tank and then add the water.

_______ c. Always wear hearing protection.

_______ d. Always place the powder into the water.

_______ e. None of the above.

14. If the maximum feed rate of a pump is 63 mL/min, what will the feed rate be if the stroke is set at 40% and the speed at 75%?

_______ a. 35 mL/min

_______ b. 22 mL/min

_______ c. 54.8 mL/min

_______ d. 118 mL/min

_______ e. 18.9 mL/min

15. In a properly operated chlorination system which pieces of data should be collected or determined on a daily basis?

_______ a. Plant flow

_______ b. Gallons of chlorine used

_______ c. Dosage in mg/L

_______ d. pH of water

_______ e. Temperature of water

16. Handling calcium hypochlorite requires one piece of safety equipment not required when handling sodium hypochlorite. That piece of safety equipment is?

_______ a. Goggles

_______ b. Cartridge respirator

_______ c. Apron

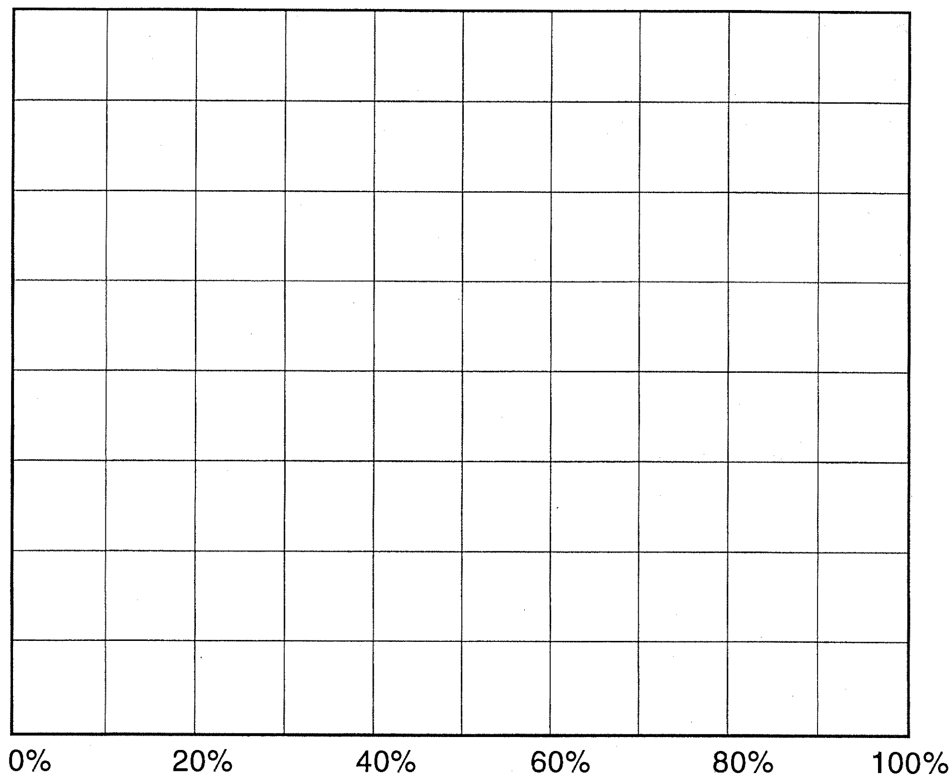
_______ d. Rubber gloves

_______ e. Rubber boots

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. Determine the number of pounds of 65% HTH needed to make 50 gallons of a 1% solution.

_______ a. 0.77 lbs

_______ b. 32.5 lbs

_______ c. 6.4 lbs

_______ d. 5.75 lbs

_______ e. 271 lbs

19. Determine the number of 700 gram cups of 67% calcium hypochlorite necessary to make 50 gallons of a 2% solution.

_______ a. 8

_______ b. 10

_______ c. 871,500

_______ d. 12

_______ e. 4.6

20. Find the concentration when four 700 gram cups of 65% calcium hypochlorite are placed in 25 gallons of water.

_______ a 1.44mg/L

_______ b.16 mg/L

_______ c. 0.96 mg/L

_______ d. 3.75 mg/L

_______ e. 2 mg/L

21. Find the amount of 12% bleach needed to make 50 gallons of 0.5% solution.

_______ a. 2 gal

_______ b. 8.33 gal

_______ c. 17.4 gal

_______ d. 6 gal

_______ e. 6.25 gal

22. Find the concentration of 50 gallons of solution, if 10 gallons of 5% bleach were placed in the tank and then the tank filled to 50 gallons.

_______ a. 0.5 %

_______ b. 2 %

_______ c. 2.5 %

_______ d. 3.5 %

_______ e. 1 %

23. Find the feed rate in milliliters per minute for a feed pump that must pump a 2% chlorine solution into a 2 inch line that flows at 50 gpm. The desired dosage in 2.5 mg/L.

_______ a. 283 mL/min

_______ b. 15.1 mL/min

_______ c. 0.04 mL/min

_______ d. 23.6 mL/min

_______ e. 80 mL/min

24. Find the concentration needed to supply a dosage of 3 mg/L to a flow of 60 gpm when the chemical feed pump is producing 30 mL/min.

_______ a. 2.3%

_______ b. 0.567%

_______ c. 11%

_______ d. 27%

_______ e. 1%

25. Find the dosage in mg/L when 8 gallons was used from a 50 gallon tank to chlorinate a flow of 60,000 gallons per day. The concentration in the tank is 2%.

_______ a. 14 mg/L

_______ b. 1.5 mg/L

_______ c. 2.7 mg/L

_______ d. 4 mg/L

_______ e. 3.3 mg/L