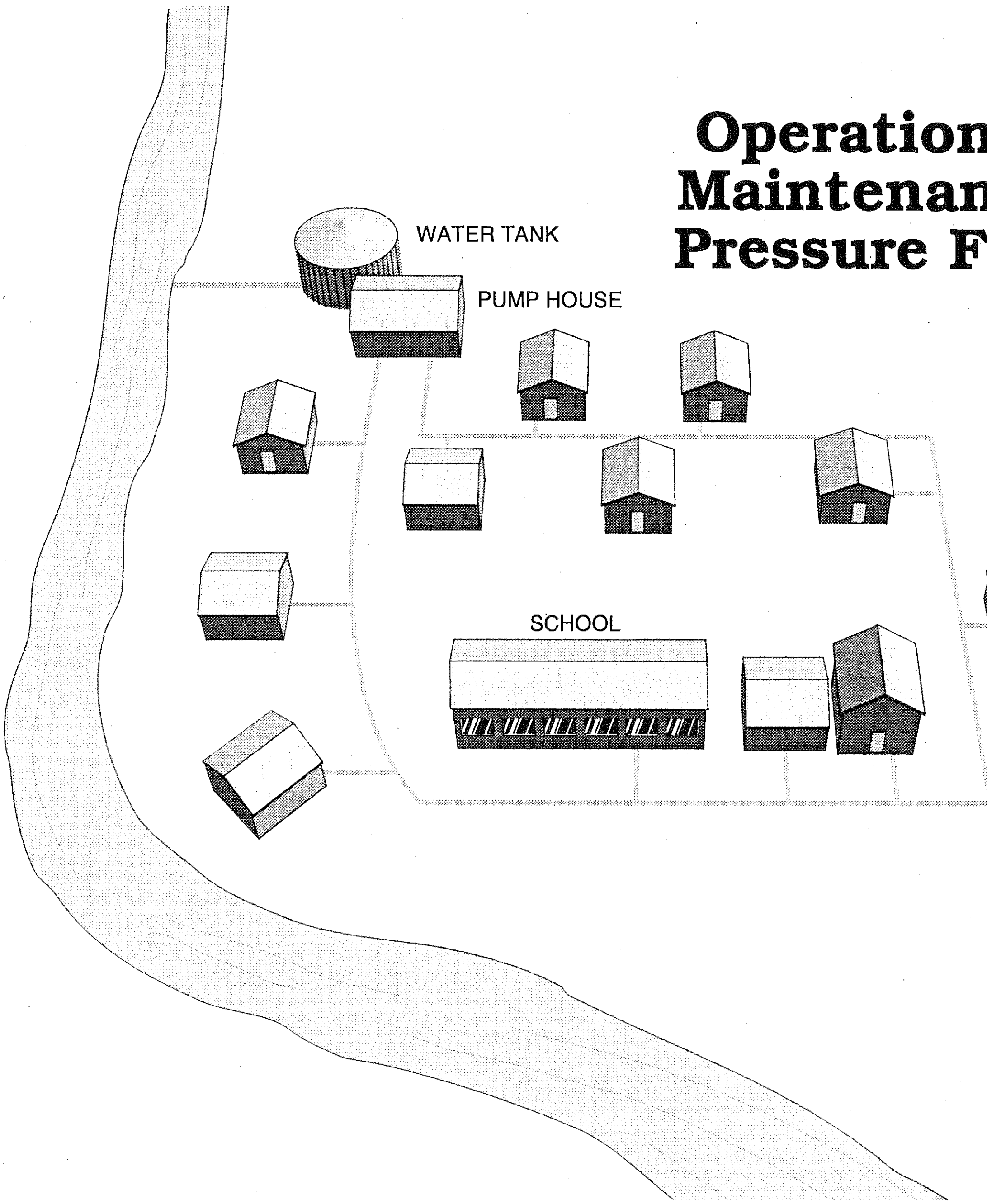
# O & M of Small Water Systems




## Operation and Maintenance of Pressure Filters


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

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1298 Elm Street SW
Albany, Oregon
(503) 928-5211

# TABLE OF CONTENTS

O & M of Pressure Filters

# O & M OF PRESSURE FILTERS

## WHAT IS IN THIS MODULE?

1. A review of the filtration process and equipment.
2. Typical uses of pressure filters.
2. The hydraulic flow through a typical pressure filter plant.
3. Detention times for each process unit in a typical pressure filter plant.
4. How rate of flow control works on a typical pressure filter plant.
5. How the headloss indicator works on a filter plant.
6. Safety consideration for handling alum and soda ash.
7. The proper mixing method for alum and soda ash.
8. Normal operations for each process unit on a small pressure filter water plant.
9. Typical inspection routine for a small pressure filter water plant.
10. Operation and process control testing required for a small water plant.
11. Typical maintenance routine for a small water plant.
12. Example shut down procedure for a small water plant.

## KEY WORDS

- Alkalinity
- Alum
- Backwash
- Breakthrough
- Coagulation
- Color
- Conventional treatment
- Detention time
- Direct filtration
- DOT
- Filter media
- Filtration
- Filtration rate
- Flocculation
- Headloss
- Iron salts
- Lime
- OSHA
- pH
- Polymers
- Sludge
- Soda Ash
- Turbidity
- Underdrain

## MATH CONCEPTS DISCUSSED

- Filtration rates
- Dosage
- Detention time
- Velocity
- Flow
- Differential pressure
- Backwash rates

# SCIENCE CONCEPTS DISCUSSED

- Coagulation
- Settling
- Hydraulic expansion
- Specific gravity
- Headloss
- Straining
- Anaerobic conditions
- Oxidation

# SAFETY CONSIDERATIONS

- Handling Alum
- Confined space entry
- Handling Soda Ash

# MECHANICAL EQUIPMENT DISCUSSED

- Static mixer
- Chemical feed pumps
- Surface wash arms
- Headloss indicators
- Flash mixers
- Electric operated valves
- Wide body globe valves
- Solo valves

# O & M OF PRESSURE FILTERS

## INTRODUCTION

### Lesson Content

In this module on the O & M of pressure filter treatment plants the focus will be on the theory of coagulation, and the physical process found in a small pressure treatment plant. The emphasis of this module will be on pressure filters using the typical treatment process for reduction of color and turbidity in Alaska. Where appropriate, information concerning the operation of the direct filtration systems will be included.

### Small System

While most of the concepts and mechanical equipment discussed in this module are used in small and large systems the focus of the module will be on small systems. Primarily those systems with a population of less than 500 and located in Rural Alaska.

## FILTRATION PROCESS

### Three Process

There are three pressure filtration processes used in Alaska. The most common is the PHS and VSW filter only system which, historically, has not included chemical feed, **flocculation**[1] or sedimentation. **Conventional treatment**[2] using pressure filters and **direct filtration**[3], which is conventional treatment without sedimentation are the other two processes.

## PRESSURE FILTERS - ADVANTAGES & DISADVANTAGES

### No Headloss

One of the primary advantages of the pressure filter system is the ability to pump from the sources directly through the filter. A conventional filtration system would require pumping into the plant and then pumping out of the plant. The pressure filter system thus reduces pumping cost.

### Media Observation

One of the primary disadvantages of the pressure filter system is the operators inability to observe the **filter media**[4]. This makes it difficult to identify filter problems and observe the quality of the **backwash**[5].

### Operations

The inability to obtain visual feedback on filtration operation, flocculation development and general appearance of the water makes the pressure filter system more difficult to operate than the gravity filter system. The lack of visual feedback will require frequent jar tests in order to determine proper dosage.

### Capital Cost

In most cases, pressure filter systems are less costly to build than gravity filter systems.

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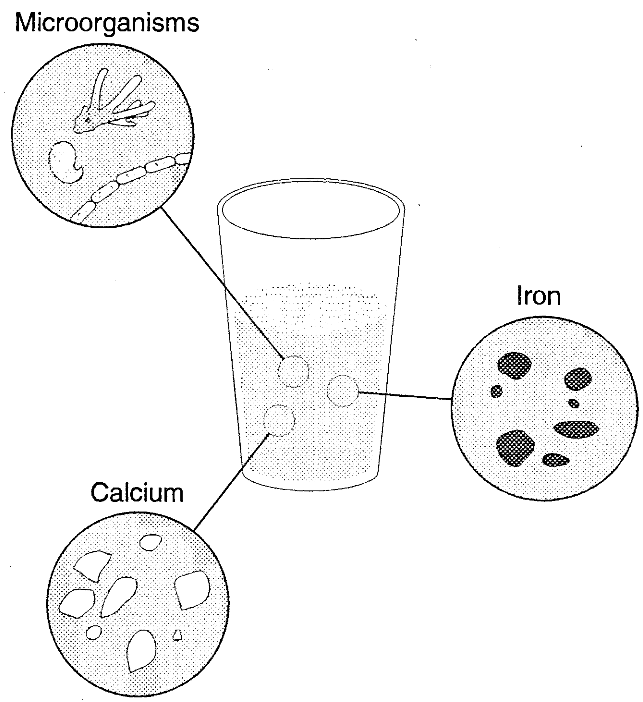
[1] **Flocculation** - The agglomeration of colloidal and finely divided suspended matter after coagulation by gentle stirring by either mechanical or hydraulic means.
[2] **Conventional Treatment** - A standard treatment process involving, coagulation, flocculation, sedimentation, filtration and disinfection.
[3] **Direct Filtration** - A gravity or pressure filter system involving coagulation, flocculation, filtration and disinfection.
[4] **Filter Media** - Silica sand, garnet sand and anthracite coal that is prepared according to detailed specifications for use in water filters.
[5] **Backwash** - The reversal of flow through a filter in order to clean the filter by removal of material trapped by the media in the filtration process.

# REASONS FOR TREATMENT

**Introduction**

Treatment systems are primarily installed for two general reasons, to protect health and to deal with substances in the water that create nuisances. The type of treatment facility and chemicals used is dependent on the quantity and type of substances found in the water. The procedures discussed here are for turbidity and color removal as well as the reduction and/or removal of viruses and protozoa such as Giardia and Cryptosporidia. The removal or reduction of turbidity and color are considered indirect health related considerations. The removal or inactivation of virus and protozoa are considered health related treatment considerations.




## TURBIDITY

**Why Remove Turbidity?**

One of the primary health related treatments is associated with the removal of **turbidity**[6]. Turbidity itself is not a health hazard but makes the water aesthetically unpleasant. However, it is an indirect health hazard. First of all, drinking water that is high in turbidity causes people to seek other water that may be **palatable**[7] but not **potable**[8] (looks good but not safe to drink). Second, turbidity particles provide a hiding

[6] **Turbidity** - A condition in water caused by the presence of suspended matter, resulting in the scattering and absorption of light rays.

[7] **Palatable** - In relation to drinking water, it is that water which does not give off unpleasant taste and odors, is cool in temperature, has low color and low turbidity. Water which is pleasant to drink.

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

place for **microorganisms**[9] reducing the possibility that they will be killed by a disinfectant such as chlorine. Finally, turbidity increases the amount of chlorine required (**demand**[10]) and reduces the amount of chlorine that is available to kill disease causing (**pathogenic**[11]) microorganisms.

**Turbidity Requirements**

In order to reduce the health impacts of turbidity performance standards have been established depending on the type of filtration system being used. Generally these standards range from 0.5 NTU to 1.0 NTU.

**Turbidity Reduction Goals**

Most conventional water treatment plants have the ability to produce water with turbidity below 0.1 NTU. It is commonly considered in the waterworks industry that 0.1 NTU is good water and 0.2 NTU is cause for making corrections to a water treatment plant.

## COLOR

**Not a Direct Health Hazard**

**Color**[12] like turbidity, is not in itself a health hazard. However, like turbidity, colored water is an **aesthetic**[13] problem causing people to seek unsafe water that has less color and possibly resulting in illness. Because of this secondary effect, a secondary MCL standard of 15 color units has been established for drinking water.

**Indirect Health Problems**

A secondary health problem has to do with the compounds that makeup color. The compounds that come from decaying vegetation and create color can, when mixed with chlorine, produce chemicals that we call Trihalomethanes (**THM's**[14]). Some of these compounds can contribute to cancer. While the current regulations on THM's do not apply to small systems they could in the future. Nonetheless, if the system has high color in the raw water and uses chlorine as a disinfectant there could be an obvious health concern that would cause the owner to check the finished water for THM's.

## WATER TREATMENT GOAL

**Basic Goal**

The basic goal is to protect pubic health. However, the more acceptable goal is to provide potable and palatable water. That is, water that is safe to drink and is pleasant in appearance, taste and odor.

---

[9] **Microorganisms** - Minute organisms, either plant or animal, invisible or barely visible to the naked eye.
[10] **Demand** - When related to chlorine, the amount of chlorine utilized by iron, manganese, algae, and microorganisms in a specified period of time.
[11] **Pathogenic Organisms** - Bacteria, virus and protozoa which can cause disease.
[12] **Color** - Primarily, organic colloidal particles in water.
[13] **Aesthetic** - Concerning an appreciation of the beauty. With water it means pleasant in appearance, odor and taste.
[14] **THM's** - Trihalomethanes, also referred to as TTHM's or Total Trihalomethanes - (1) Regulations - The sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane, and trichlormethane. (2) Compounds formed when natural organic substances from decaying vegetation and soil (such as humic and fulvic acids) react with chlorine.

# TURBIDITY AND COLOR REMOVAL PROCESS

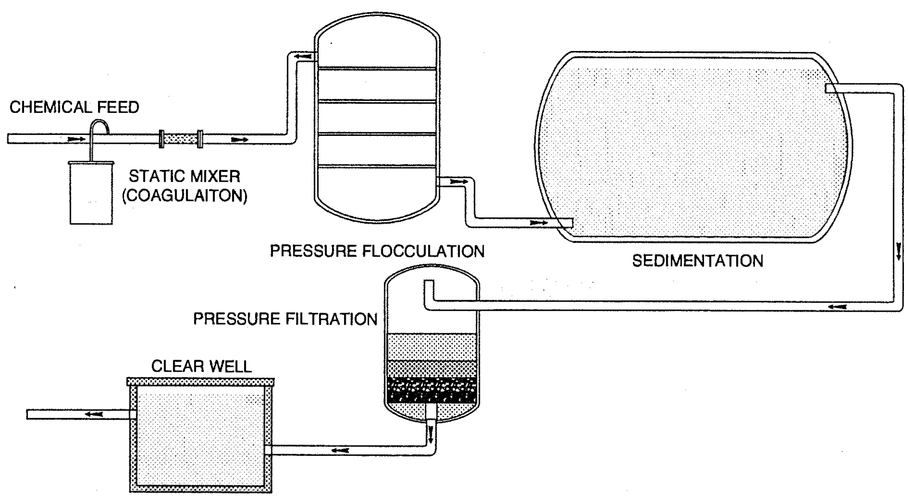
**Introduction**

The control of turbidity, color, microorganisms and to some extent taste and odor is commonly accomplished through some type of **filtration**[15]. The Surface Water Treatment Rule describes five different types of filtration systems, **conventional treatment**[16], **direct filtration**[17], **slow sand filters**[18], **diatomaceous earth filters**[19], and alternate filtration systems such as cartridge filters. The basic system used in this discussion is one of the conventional treatment types called rapid gravity filtration.

**Sequence**

The conventional treatment plant is composed of four processes;

- **coagulation**[20] a process where chemicals are added to destabilize small particles suspended in the water.
- **flocculation**[21] a slow mixing process where the coagulated particles are formed into feather-like material called **floc**[22],
- sedimentation is a physical process that allows the majority of the floc to settle, removing a large portion of the material in the water, and
- filtration, the process of straining the remaining floc from the water.




15 **Filtration** - The process of passing through a filtering medium (which may consist of granular material such as sand, magnetite, or diatomaceous earth, finely woven cloth, unglazed porcelain, or specially prepared paper) for the removal of suspended colloidal matter.
16 **Conventional Treatment** - A standard treatment process involving, coagulation, flocculation, sedimentation, filtration and disinfection.
17 **Direct Filtration** - A gravity or pressure filter system involving coagulation, flocculation, filtration and disinfection.
18 **Slow sand filters** - A filter composed of 24 to 42 inches of filter media, used to remove turbidity from waters with raw water turbidities of less than 10 ntu's. No chemicals are used in slow sand filters. Filtration rates range from 0.016 gpm/ft$^2$ to 0.16 gpm/ft$^2$.
19 **Diatomaceous Earth Filter** - A pressure filter utilizing a media made from diatoms.
20 **Coagulation** - In water treatment, the destabilization and initial aggregation of colloidal and finely divided suspended matter by the addition of a floc-forming chemical.
21 **Flocculation** - The agglomeration of colloidal and finely divided suspended matter after coagulation by gentle stirring by either mechanical or hydraulic means.
22 **Floc** - Small gelatinous masses formed in a liquid by the reaction of a coagulant added thereto.

**What is Removed**

These processes are used to remove or reduce organic and inorganic material that form turbidity, color and cause odor and taste.

**Organic Contaminants**

The organic component of this material contributes to color, odor, taste and disease. The organic component includes microorganisms, (viruses, bacteria, protozoa), algae, and organic material from plants and animals.

**Inorganic Contaminates**

The inorganic portion of this material is the primary contributor to turbidity. The inorganic portion includes silt, sand and inorganic chemical complexes.

**The Contribution to Settling**

Most organic and inorganic material is suspended in the water and not dissolved and therefore will settle out if given enough time. However, the main materials that contribute to color and turbidity are too small to settle. The basic problem comes from solids that are less than one micron in size, called **colloidal**[23]. The Greek letter "μ", called "mu" is used to identify a micron. One micron would be written 1μ.

**Colloids**

For instance, a particle 0.01 mm in diameter will settle 1 foot in 33 minutes but a particle 0.0001 mm in diameter (a colloid) will only settle 1 foot in 230 days. This is hardly a reasonable settling time.

**Why Colloids Don't Settle**

Colloids do not settle in a reasonable length of time due to electrical charges on their surface. At one micron in size the influence of the surface charges offsets the attraction due to gravity and the particles stay suspended.

| Particle Diameter mm | Representative Particle | Time Required to Settle in 1 ft. (0.3 m) Depth |
|---|---|---|
| | | Settleable |
| 10 | Gravel | .03 sec |
| 1 | Coarse Sand | 3 sec |
| 0.1 | Fine Sand | 38 sec |
| 0.01 | Silt | 33 min |
| | | Considered Nonsettleable |
| 0.001 | Bacteria | 55 hours |
| 0.0001 | Color | 230 days |
| 0.00001 | Collodial Particles | 6.3 years |
| 0.000001 | Collodial Particles | 63 year minimum |

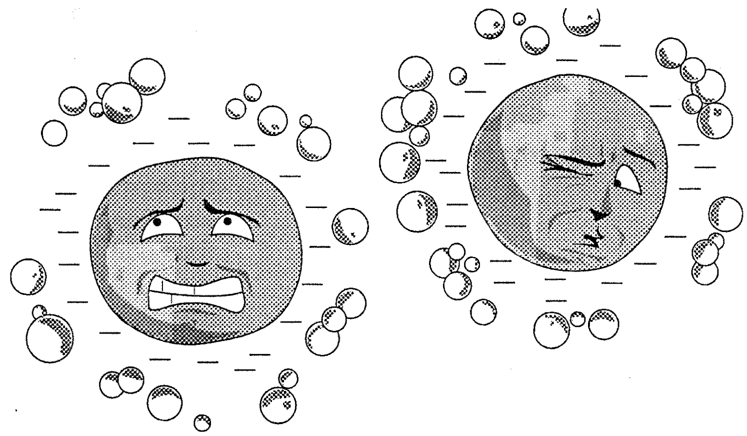
[23] **Colloidal** - Any substance in a certain state of fine division in which the particles range in diameter from about 0.2 to 0.005 micron.

**Types of Colloidal Material**

There are generally two types of colloidal material **Hydrophobic**[24] and **hydrophilic**[25].

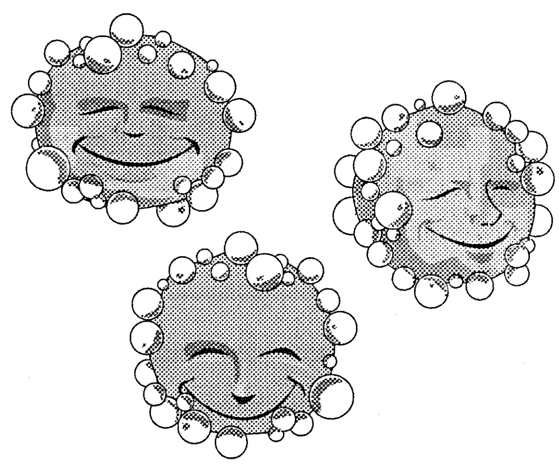
**Hydrophobic**

Hydrophobic means water fearing. Hydrophobic colloidal material is basically inorganic material that contributes to turbidity. Hydrophobic colloidal material generally carries a negative electrical charge.



**Hydrophilic**

Hydrophilic means water loving. Hydrophilic colloidal material is basically composed of organic material that is the common source for color. Hydrophilic compounds are surrounded by water molecules and because of their polarization, they tend to make these particles negatively charged.



**Opposing Forces**

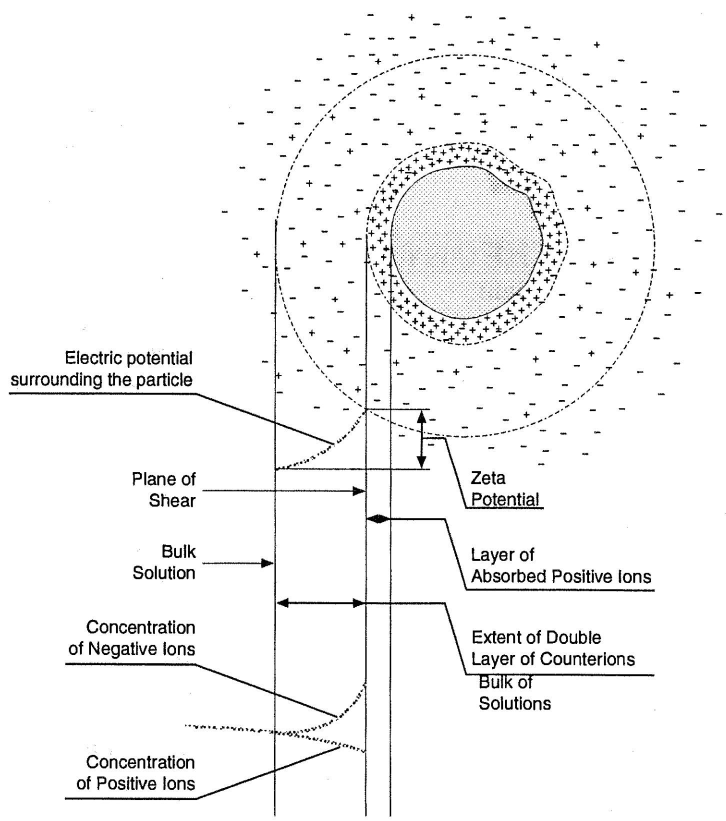
There are two opposing forces that impact the removal of colloidal material. These are stability factors and instability factors. Stability factors are those factors that help to keep colloids suspended, instability factors are those that contribute to the natural removal of colloids.

**Stability Factors - Hydrophobic**

The stability factors associated with hydrophobic, inorganic clay are its electrical charges. Basically hydrophobic particles have a negative charge on the surface of the clay. This attracts a layer of water to the

[24] **Hydrophobic** - Water fearing. In water hydrophobic refers to inorganic colloidal particles that contribute to turbidity.
[25] **Hydrophilic** - Water loving. In water hydrophilic refers to organic colloidal particles that contribute to color.

clay. This layer is called a boundary layer because it moves with the particle. This boundary layer attracts a second layer of water molecules that include various compounds. The overall charge of the particle remains negative. The phenomena is referred to as the electrical double layer. The electrical charge is called the **Zeta potential**[26]. The result is that the particle remains negatively charged. Since like charges repel, these negative charged particles keep one another in motion in the water and thus do not settle.




From Riddick 1968

**Stability Factors - Hydrophilic**

Hydrophilic, color causing, organic particles are kept in solution due to the layer of water molecules around them. This prevents the particles from colliding. If they were to collide they might stick together and become large enough to settle. The water layer contains chemicals that are combined with the water molecule. The most important of these chemicals are the carboxyl ion and **Hydroxyl ion**[27] that contribute to **alkalinity**[28]. While the chemical compounds contained in the water may be either negative or positive, most are negative. The negative charges, like the ones on the hydrophobic particles along with the layer of water keep the hydrophilic particles from colliding.

26 **Zeta Potential** - A measurement (in millivolts) of the particle charge strength surrounding colloidal solids. The more negative the number, the stronger the particle charge and the repelling force between the particles.

27 **Hydroxyl ion** - The monovalent ($OH^-$) radical characteristic of hydroxides, and oxygen acids.

28 **Alkalinity** - The buffering capacity of water to retard the change in pH by an acid. Alkalinity is composed of bicarbonates, carbonate and hydroxide.

**Instability Factors**

There are two instability factors; the **Brownian movement**[29] and the London-Van der Waals forces. When particles are very small their collision with a water molecule will impart enough energy to keep the particle in motion. Particles in motion are more likely to collide with one another. If the particles collide the **London - Van der Waals Forces**[30] will cause them to stick together. If this happens enough times the particles will become large enough and heavy enough to settle.

**Natural Waters**

Natural waters contain colloids that are neither purely hydrophobic or hydrophilic, but are a heterogeneous; a mixture of hydrophobic and hydrophilic particles. The net result is a fluid containing negatively charged particles and microorganisms which are also negatively charged. These charges allow us to use chemicals to remove the material.

## TREATMENT THEORY

**Introduction Materials**

The general theories concerning coagulation, flocculation, sedimentation and filtration are discussed in the "Introduction to Small Water Systems" training manual. Because the coagulation theory is the most important of these, only it will be reviewed and expanded in this module.

## COAGULATION - THEORY

**The Chemicals**

The process of decreasing the stability of the colloids in water is called coagulation. Coagulation results from adding salts of iron or aluminum or polymers to the water. Common coagulants are:

- **Alum**[31] - Aluminum Sulfate $Al_2(SO_4)_3 \cdot 18H_2O$
- Sodium Aluminate - $NaAlO_2$
- Ferric Sulfate - $Fe_2(SO_4)_3$
- Ferrous Sulfate - $FeSO_4 \cdot 7H_2O$
- Ferric Chloride - $FeCl_3$
- **Polymers**[32]

**Coagulation**

The reaction between one of these chemicals and water is called coagulation. The simplest coagulation process to follow is the reaction between alum and water. When alum is placed in water a chemical reaction occurs that produces:

- a weak acid,
- an insoluble molecule of aluminum hydroxide that is positive charged,

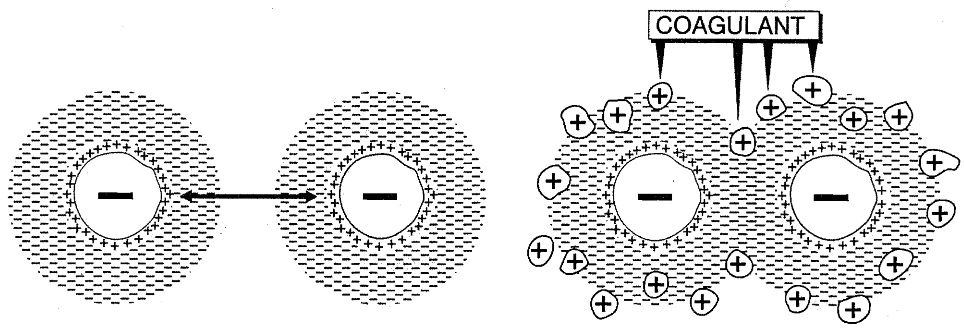
[29] **Brownian Movement** - The erratic movement of colloidal particles, due to the collisions of the molecules of water.

[30] **London - Van der Waals Forces** - The attractive force existing between colloidal particles that causes colloids that collide to stick together.

[31] **Alum** - Trade name for the common coagulant aluminum sulfate, $Al_2(SO_4)_3 \cdot 18H_2O$.

[32] **Polymer** - High-molecular-weight synthetic organic compound that forms ions when dissolved in water. Also called polyelectrolytes.

- and consumes 0.5 mg/L of alkalinity for each 1 mg/L of alum that is introduced. (If an iron salt is used, the active compound that is produced is a positive charged ion of ferric hydroxide.) Without alkalinity this reaction could not occur.
- The typical way to indicate this insoluble ion is with the symbol $Al^{+++}$.
- The reaction will have a tendency to drive the **pH**[33] down.




**Alkalinity Reactions**

The following are the reactions with various alkalinity producing compounds and how they react with 1 mg/L of alum.

| | |
|---|---|
| Natural alkalinity | 0.5 mg/L |
| 85% Quick **Lime**[34] (CaO) | 0.33 mg/L |
| 95% hydrated lime $Ca(OH)_2$ | 0.39 mg/L |
| **Soda Ash**[35], $Na_2CO_3$ | 0.54 mg/L |

**Reaction - Hydrophobic Particles**

The positive charged ions ($Al^{+++}$) reduce the negative charge of the hydrophobic particles by being adsorbed onto the surface of the particle and by being in the vicinity of the negatively charged particle. This is referred to as the physical portion of the reaction.

**Reaction - Hydrophilic Particles**

The positive charged ions ($Al^{+++}$) combine chemically with the alkalinity that is attached to the water molecules which in turn are attached to the particle. The result is a sticky substance and a reduction in the negative electrical charge.

**Combined Reaction**

The overall result is the reduction of electrical charges and the formation of a sticky substance. These two destabilizing factors are the major contributions that coagulation makes to the removal of turbidity, color and microorganisms.

33 **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. pH may range from 0 to 14, where 0 is the most acid, 14 most alkaline, and 7 neutral. Natural waters usually have a pH between 6.5 and 8.5.

34 **Lime** - A common term used to describe a caustic powder containing calcium oxide (CaO). The term is used to identify quick lime CaO and hydrated lime $Ca(OH)_2$. Lime is used in water treatment to add alkalinity in the coagulation process, reduce pH and reduce corrosion for corrosive and aggressive waters.

35 **Soda Ash** - Trade name for Sodium carbonate $Na_2CO_3$ - a chemical used to add alkalinity to water, adjust pH and/or improve the stability of the water. 1 mg/L of alum will combine with 0.54 mg/L of soda ash.

## FACTORS THAT INFLUENCE COAGULATION

**Overview**

There are a number of factors that influence the coagulation process, five of the most important are; pH, the amount of turbidity, the temperature of the water, the amount of alkalinity and the use of polymer. The degree to which these factors influence coagulation is dependent upon the coagulant used. The following discussion is based on the use of alum as the coagulant.

**Least Soluble pH**

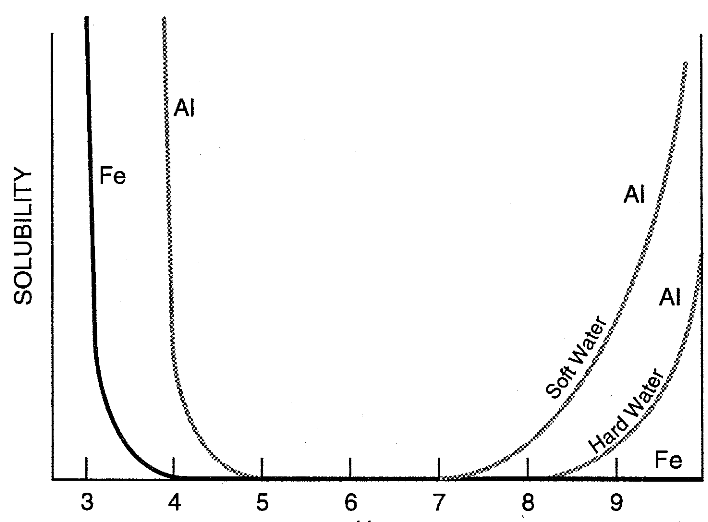
One of the major keys to effective coagulation with alum is to maintain the pH in the range where alum is least soluble. It is not intended or desirable for the alum to be dissolved. Quite the reverse, what is needed is for the alum to be in suspension and be removed in the treatment process so that the amount of $Al^{+++}$ in the finished water is very low. The amount of aluminum in the finished water is called alum carry through.

**Desirable pH**

When the goal is to reduce turbidity, it is generally agreed that a pH between 6.0 and 7.8 is best. However, the proper pH for any specific water must be determined by testing. When the goal is to reduce color the desirable pH range is between 4 and 6. This low pH will require the addition of soda ash or lime after the color is removed, in order to raise the pH to an acceptable level.

**Solubility Curve**

The curve below is taken from a series of tests and shows that the solubility of iron and aluminum salts in relationship to pH. The most desirable pH range is the range of least solubility. This will give the lowest aluminum carry through. Notice that the iron curve is flat from pH 4 up past pH 10.




Solubility curves for ferric and aluminum hydroxides

**Impact of Turbidity**

Generally, the greater the turbidity the greater the alum **dosage**[36] required. However, there is commonly a point where an increase in turbidity does not require a corresponding increase in alum. This is because the increased number of particles increases the collision probability and improves the treatment naturally.

**Low water Temperatures**

In theory a few degrees drop in water temperature should not affect the amount of coagulant needed. However, in actual practice, as the water temperature drops below 40°F the water becomes very difficult to treat. For most cold water it has been determined that the optimum pH is shifted downward as the water temperature drops.

## ALKALINITY

**Function**

From our discussion above about hydrophilic particles you should remember that the chemical reaction between alum and water is actually between the alum and the alkalinity in the water.

**Alkalinity Requirements**

Some natural water, especially those in coastal streams of the Pacific Northwest and Southeast Alaska are very low in alkalinity and therefore very difficult to coagulate. When the natural alkalinity is below 80 mg/L the water is said to have a low alkalinity. Such water may require the addition of alkalinity in order for a floc to be formed. The waters in Southeast Alaska will typically have alkalinity much lower that 80 mg/L. The combination of low temperature, low alkalinity and low winter turbidities make these waters very difficult to treat.

**Lowering the pH**

A secondary problem with low alkalinity waters is the addition of a coagulant such as alum may drive the pH down below the point of least solubility. This is an operational problem in Southeast and South-central Alaska where the natural pH is below 7.

**Alkalinity Chemicals**

The two most common chemicals used to add alkalinity to water are soda ash and hydrated lime. The relationship between these two chemicals and alum is; 1 mg/L of alum will combined with 0.54 mg/L of soda ash or 0.39 mg/L of hydrated lime. What that means is that a dosage of 20 mg/L of alum would combine to form a floc with approximately 11 mg/L of alum or 8 mg/L of lime.

**Other Considerations**

The raw water conditions, optimum pH for coagulation and other factors must be considered before deciding which chemical is to be fed and at what levels.

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

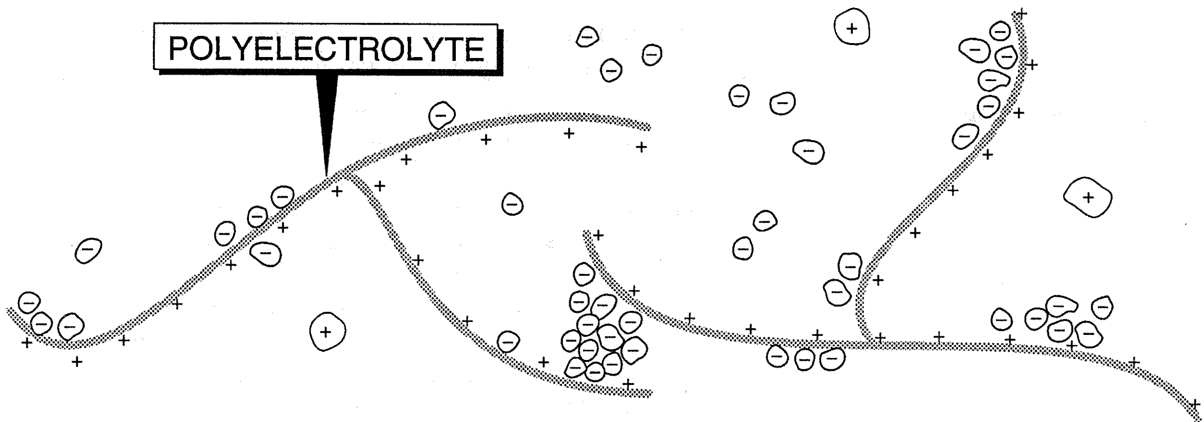
**POLYELECTROLYTES**

**Common**

Polyelectrolytes or polymers as they are commonly called can be used as an aid to coagulation. In some waters they have been successfully used as the primary coagulant instead of alum or one of the **iron salts**[37]. The practice of using a polymer as a primary coagulant is not always successful.

**What are Polymers**

Polymers are long, string-like chain molecules with charges placed along the string. There are three common types of polymers; positive charged polymers called cationic polymers, negative charged polymers called anionic polymers, and polymers with no charge called nonionic polymers. The correct charge is selected depending on the use of the polymer, filter aid, coagulation air or primary coagulant.




**Determining Chemical Dosage**

In order to determine the correct chemical dosage a device called a jar test is used. The most common of these is composed of six stirrers connected together and six one-liter beakers. A sample of the water along with the coagulation chemicals is poured into the jars. The jars are stirred in an attempt to approximate the flash mix of the plant and then slowly stirred to approximate the flocculation portion of the plant. The proper dosage is determined by observing the best forming floc, the pH and the turbidity of a filtered sample of the water. This procedure is explained in detail in the Process Control Module.

37 **Iron Salts** - Iron based chemical compounds containing trivalent ions of Fe. These salts are used as primary coagulants. Common iron salts including ferric chloride $FeCl_3$, Ferric sulfate $Fe_2(SO_4)_3 \cdot 9H_2O$, and Ferrous sulfate $FeSO_4 \cdot 7H_2O$.

# SYSTEM COMPONENTS

**Introduction**

The following discussion is based on a conventional treatment, gravity filter plant.

**Five Systems**

The conventional treatment gravity filter process can be divided into five systems:

- The building and chemical storage
- The chemical feed system
- The hydraulic system
- The electrical system
- The control system

**Sequence**

The next portion of this module is used to identify the various components of the five systems and follow the hydraulic flow through the system. Details on routine operations is found in the text. Process control and trouble shooting are in companion modules. Information on the theory and chemistry of the process is described above and in the "Introduction to Small Water Systems" training manual.

## BUILDING AND 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 normal operations.

**Building - Clean and Dry**

The interior of the building in the vicinity of the chemical feed and filter equipment should be kept clean and dry. While dryness is not always possible, cleanliness is necessary in order to provided a safe working environment.

**Building - Locked Door**

In a small community the chemical feed is seldom a separate facility. Normally, the chemicals and feed equipment are located inside of the water treatment plant building next to the filters. Regardless of the setting the building should be kept locked and vandal resistant.

## CHEMICALS

There are three chemicals commonly used by small gravity filter systems in Alaska — alum, soda ash and various polymers. The alum and polymers are commonly used as primary coagulants. In many facilities additional polymers are used as coagulant aids, flocculate aids and filter aids. Soda ash is used to add alkalinity to the water and to raise the pH. Each of these chemicals requires a unique set of handling procedures. The following is designed to give general guidelines on handling these three chemicals.

## ALUM - ALUMINUM SULFATE

### Storage

Alum is purchased as a dry crystal and is delivered in 110 pound paper bags. The crystals are 100% aluminum sulfate. The bags should be stored in a clean cool dry place. It is OK to store dry powdered alum in the same room with $KMnO_4$ and soda ash. **Do not** store alum with oxidizers such as chlorine or fluoride.

### Properties

Tends to cake under high relative humidity. Acidic, hydroscopic, mildly corrosive if wet.

### OSHA Classification

Alum is classified by **OSHA**[38] as a Corrosive. The container should display the dry-corrosive placard.

### UN Classification

The UN (United Nations) Classification for alum is 8G226, indicating a mild corrosive material. A table showing the various UN classifications is provided below.

### NFPA Ratings

The National Fire Protection Association (NFPA) provides the following classifications for alum. (A table with explanations of the various ratings is provided below).

- Health Hazard — 1
- Flammability — 0
- Reactivity — 1

### DOT Identification

The **DOT**[39] (Federal Department of Transportation) has given alum a placard number of #9078. When determining how to handle a spill of alum the DOT has provided this information in their handbook under reference #31.

### Common accidents and Recommended First Aid

Common alum accidents and related first aid practices are:

- Contact with eyes - flush for 15 minutes with fresh clean water - Reference DOT 31.
- Contact on skin - wash with soap and water - Reference DOT 31.

### Handling Spills

DOT describes the following methods of handling Alum spills.

- Small Dry Spills - With clean shovel place material into clean, dry container, cover and remove from area.
- Small liquid spills - Pick up with dry sand, place in clean dry container and remove from area.
- Large spill, dike liquid, cover dry material with plastic sheet.

38 **OSHA** - Occupational Safety and Health Administration.
39 **DOT** - Federal Department of Transportation

**Fire Control**

The following methods are identified as recommended procedures for dealing with a fire involving alum.

- Dry chemical $CO_2$, Halon, water spray or standard foam.

**Health Hazards**

- Irritating to skin and mucous tissues. Can cause serious eye damage.

**SODA ASH - SODIUM CARBONATE**
$Na_2CO_3$

**Storage**

Alum is purchased as a dry powder and is delivered in 80 and 100 pound paper bags. The crystals are 100% $Na_2CO_3$. The bags should be stored in a clean cool dry place. It is OK to store dry powdered soda ash in the same room with $KMnO_4$ and alum. Soda ash is very stable and is not considered to be either toxic or hazardous. However, the dust can dry the mucus membranes and be an extreme irritation to the eyes.

**Properties**

Tends to lump and is mildly corrosive if wet. Depending on the amount of water contained in the crystal, the weight of soda ash can vary. However, the most common concentration used in water treatment has a weight of 60 $lbs/ft^3$.

**OSHA Classification**

Soda ash is classified by OSHA as a Mild Corrosive. The material is not classified as either hazardous or toxic. The container should display the dry corrosive placard.

**UN Classification**

The UN (United Nations) Classification for soda ash is 8, indicating a mildly corrosive material. A table showing the various UN classifications is provided below.

**NFPA Ratings**

The National Fire Protection Association (NFPA) provides the following classifications for soda ash. (A table with explanations of the various ratings is provided below).

- Health Hazard — 2
- Flammability — 0
- Reactivity — 0

**DOT Identification**

Because soda ash is neither hazardous nor toxic the DOT (Federal Department of Transportation) has not provided a placard number and does not list the material in their emergency response guidebook.

**Common accidents and Recommended First Aid**

Common soda ash accidents and related first aid practices are:

- Contact with eyes - flush for 15 minutes with fresh clean water - Reference - AWWA Safety Training package.

- Contact with skin - wash with large quantities of water - Reference - AWWA Safety Training package.

**Handling Spills**

Spills are cleaned-up with a liberal use of water.

**Fire Control**

Soda ash will not burn or support combustion.

**Health Hazards**

- Irritation to respiratory tract and mucous membranes and eyes.

## POLYMERS

**Introduction**

There are several hundred polymers available for water treatment. They are shipped as liquids and as powders. They may be fed directly or mixed with water. Each polymer has its own unique properties regarding mixing, aging and feed concentration recommended by the manufacturer.

**Handling**

To find the proper procedure for handling a specific polymer carefully read the MSDS. If the MSDS is not available contact the supplier before mixing the polymer.

**Storage**

Dry polymers should be stored in a cool dry location. Liquid polymers should be stored in a location that prevents freezing.

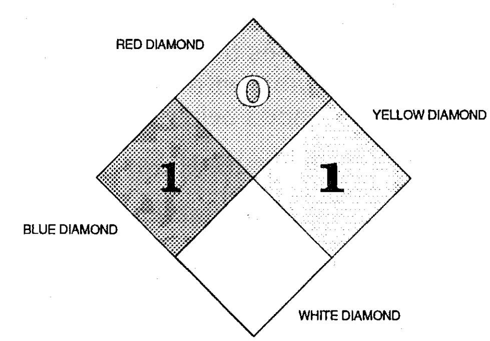
**Neat Polymers**

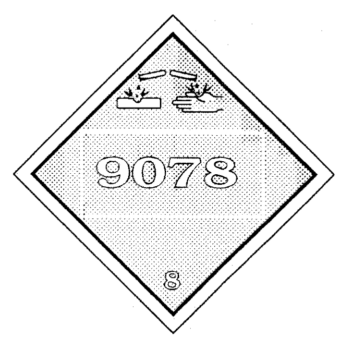
A polymer that is not diluted with water is called a "Neat" polymer.

**Clean-up of spills**

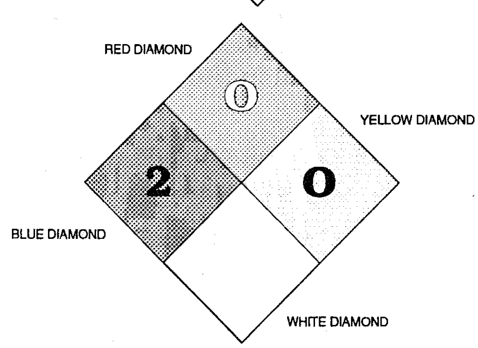
In most cases a polymer spill can be cleaned up with liberal amounts of water. Neat polymers will have a tendency to swell and become slick prior to dilution. Continue to apply water until the material dilutes and is washed away.

**Alum**




**Soda Ash**




DOT placard not required for soda ash

## 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 etrologic (infectious) material. |
| 7 | Radioactive materials. |
| 8 | Corrosives. |
| 9 | Miscellaneous hazardous materials. |

## NFPA 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 ini tiating force or heating under confinement.
2 Normally unstable but will not detonate.
1 Normally stable. Unstable at high temperature and pressure. Reacts with wate.r
0 Normally stable. Not reactive with water.

**Special Notice Key**

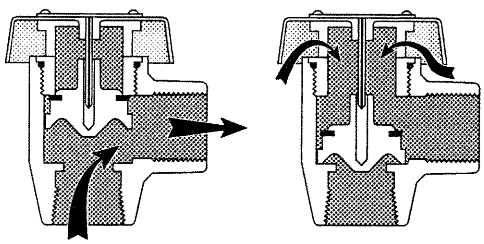
~~W~~ Water reactive.
OX Oxidizing agent.

## CHEMICAL FEED SYSTEM

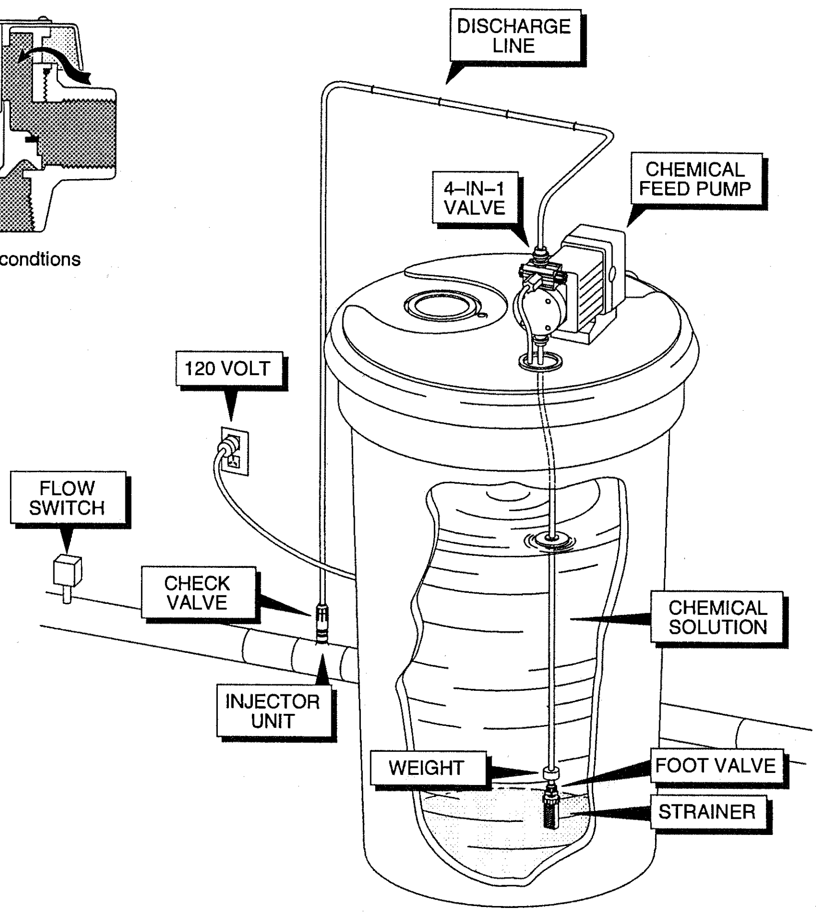
There are three common chemicals fed in small gravity filter plants, polymers, alum and soda ash. Polymer feed systems may be dry or liquid feeders. In some small plants soda ash is fed directly into the facility with a dry chemical feeder. This module will provide information on only the more common batch feed system. The most common alum and soda ash chemical feed system is composed of the following components:

### Tank

The basic unit of the system is the corrosion resistant mixing tank. The tank may range is size from 50 gallon to 800 gallons. The tank is used to hold dilution of the powdered chemical.



Flow condition    Non flow condtions




### Fill Line

A potable water fill line must be provided in order to mix and dilute the alum or soda ash. This line should be protected from **backflow**[40] by an **atmospheric vacuum breaker**[41]. 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.

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

41 **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.

**Foot Valve**

At the bottom of the 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.

**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**

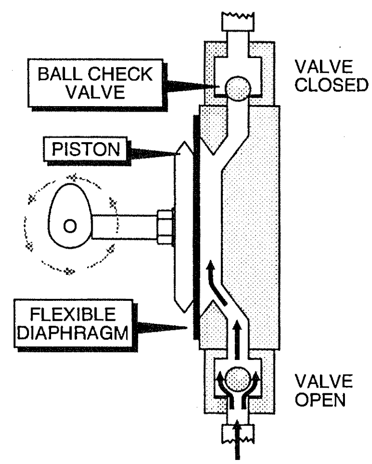
The most common pumps used in Alaska are LMI and W&T diaphragm, positive displacement pumps. This type of pump has a suction and discharge valve, valve seats and may have a spring on one or both of the valves to help them seat properly.

**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.

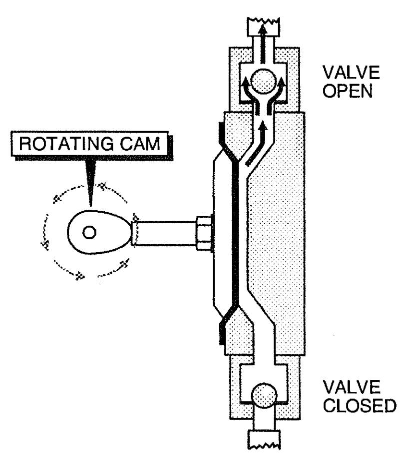
**Pump Operation - Suction**

The diaphragm pump operates on a two stroke sequence. 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.



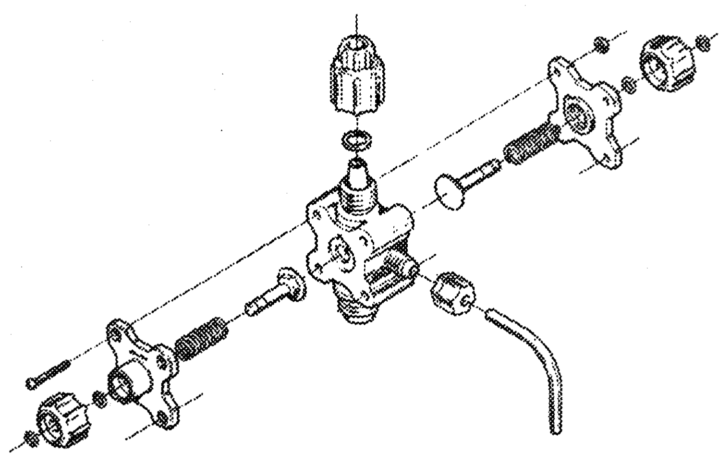

**Pump Adjustment**

Most of 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**

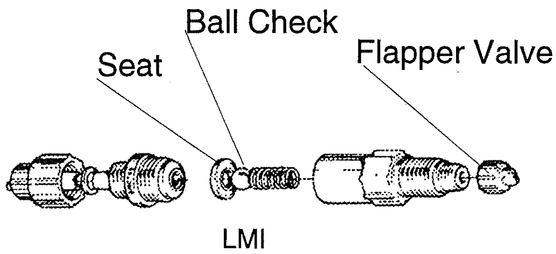
The LMI pumps can be installed with a special valve on the discharge line called a 4 in 1 valve. This valve serves four functions.

- Anti-siphon - This 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 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**[42], 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 and 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.

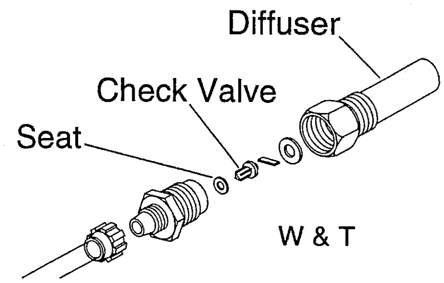


42 **Diffuser** - A section of pipe or porous plates used to mix a gas or liquid with the flow of water.

**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.




**Chemical Separation**

The sequence that chemicals are added to water can impact the rate of coagulation and floc production. Typically soda ash is added first followed by the alum. The polymer may be added before or after the other chemicals. However, it may respond differently depending upon when it is added. It is not desirable to add chlorine or fluoride prior to coagulation. If potassium permanganate is added for odor control it should be injected into the line at least five (5) minutes before the soda ash alum injection point

# HYDRAULIC SYSTEM

## REVIEW OF SYSTEMS

### VSW & PHS SYSTEMS

**Use**

In the past, the typical Alaskan pressure filter system, as designed by PHS or VSW is a filter only system, primarily used to reduce turbidity and sometimes color. Filtration rates with this type of system are controlled by the raw water pumping rate.

**Polymers**

On occasion **polymers**[43] are added prior to filtration to help with turbidity and/or color removal. In the Southeast PHS has reported success with color reduction by adding low concentrations of polymers.

**Not Direct Filtration**

The pressure filter system using a polymer, or another coagulant is often referred to as "Direct Filtration". However, industry's definition of direct filtration usually includes flash mix and flocculation steps.

**Additions to System**

In a few cases, experiments have been completed that indicate that the efficiency of these facilities can be drastically improved by the addition of a static mixer and a flocculation chamber. In Homer, a pressurized flocculation vessel with baffles that cause constant mixing has proven to be very successful in the reduction of color.

[43]**Polymer -** High-molecular-weight synthetic organic compound that forms ions when dissolved in water. Also called polyelectrolytes.

**DIRECT FILTRATION**

**Components**

A direct filter system is identical to a conventional filter except the direct filter system does not have a sedimentation basin. The lack of the sedimentation basin reduces capital cost while increasing operational requirements. A direct filtration system could employ either pressure or gravity filters.

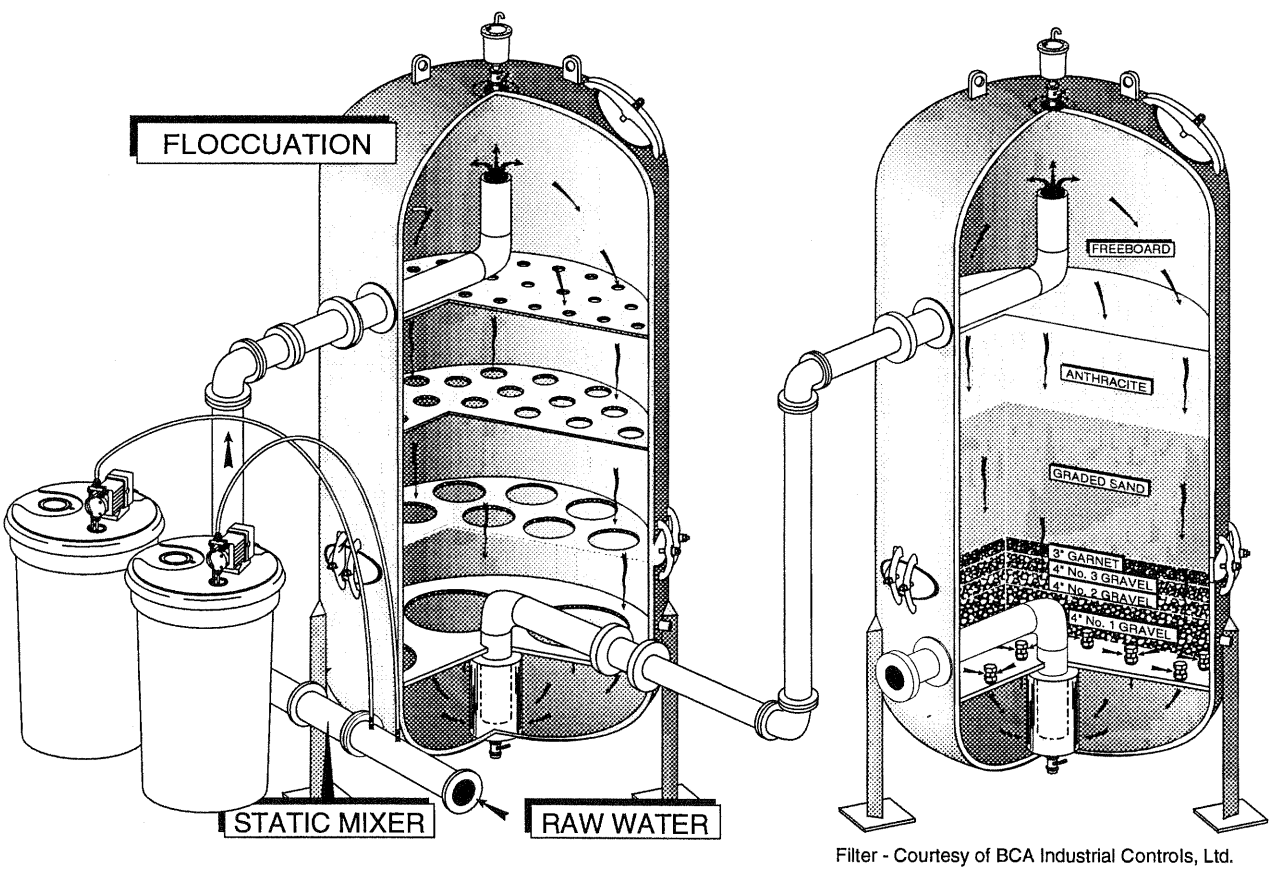
**CONVENTIONAL TREATMENT**

**Components**

The conventional pressure filter system contains the same components and operates essentially the same as the conventional gravity filter system. The standard components are the chemical feed system, the coagulation system (typically a static mixer), the flocculation chamber, the sedimentation chamber and the filtration system.

**Direct is Most Common**

The most common pressure filter systems are those that do not contain a sedimentation chamber. Pressurized sedimentation chambers are seldom efficient. Therefore, most pressure filter system designs either do not have a sedimentation chamber or use an open basin for sedimentation. These open basin systems pump the water from the sedimentation basin through the filter into a storage tank. As previously stated, many pressure filter system installations in Alaska may not include the flocculation step.




Filter - Courtesy of BCA Industrial Controls, Ltd.

# TYPICAL PRESSURE FILTER - COMPONENTS & HYDRAULICS

## FLOW CONTROL

**Hydraulics**

The following discussion attempts to follow the water flow through a typical pressure filter system with a static flocculator.

**Control System**

The raw water flow rate entering a pressure filter system can be controlled in a number of ways. Since most pressure filter systems are fed by a pumping unit, the most common flow control is a variable flow where the pump responds to the system pressure. As the pressure of the system increases the flow decreases. The filter is protected from damage by a flow restrictor that prevents flows above some maximum level to be pumped through the filter.

**High Flows**

Should a discharge line of the filter break, the system head could drop to near zero. This would allow the raw water pump to provide maximum flows and could cause premature filter **breakthrough**[44]. The flow restrictor discussed above prevents this condition.

**PHS & VSW Facilities**

A was mentioned above the facilities designed and installed by PHS and VSW commonly have no formal flow control system. This system relies on the raw water pump to control flow rates. Care should be taken in the replacement of the raw water pump to assure that the design flow rate is not exceeded.

## CHEMICAL ADDITION

The first unit that the water encounters upon entering the treatment plant is the chemical addition and coagulation system.

**Common Chemicals**

The most common water treatment chemicals used in small Alaskan communities are:

- Aluminum Sulfate (Alum)
- Iron salts ( Ferrous and Ferric Sulfate)
- Polymers

**PHS**

(PHS is presently working with a number of polymers in order to determine their flexibility. Using polymers reduces a number of handling and storage problems and thus warrants the research cost.) In many of these cases dosage rates of less than 1.0 mg/L have proven to be very successful.

**Common Alaskan Coagulants**

The most popular coagulants used in rural Alaska are alum and cationic polymers. The polymers have proven to be very effective, however, it is difficult to control the proper dosage in the clean, clear, cold waters that are found during late fall to spring in many Alaskan communities.

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44 **Breakthrough** - The point in a filtering cycle at which trubidity causing material starts to pass through the filter.

**Alkalinity**

Many waters, such as in Southeast Alaska are very low in natural alkalinity. Therefore, it is difficult to develop an adequate floc. In order to obtain proper treatment, the alkalinity must be enhanced by adding chemicals such as soda ash, lime or sodium bicarbonate. In small plants soda ash is the most popular used chemical for alkalinity enhancement.

**Batch Mix**

The most common chemical dosage system is the batch mix system. With this system dry or liquid chemical (in the case of some polymers) is mixed into a tank that contains 50 to 800 gallons. Standard positive displacement chemical feed pumps are used to pump the solution into the raw water.

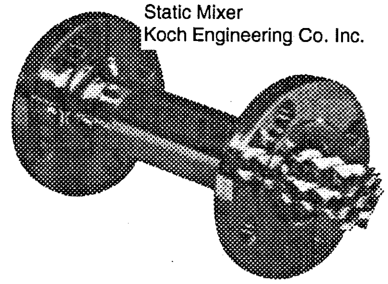
## COAGULATION

**Chemical**

The coagulation process is referred to as a chemical process. Coagulation is the process of reducing the impact of the negative electrical charges on hydrophobic particles and developing a sticky substance on the surface of hydrophilic particles.

**Equipment**

The two most common coagulation components are static mixers and mechanical mixers. With small pressure filter systems the in-line static mixer is the most efficient.



Static Mixer
Koch Engineering Co. Inc.

**Time Frame**

Coagulation is very fast taking 2 to 15 seconds.

## FLOCCULATION

**Review**

Water flows from the coagulation system to the flocculation basin or chamber. Flocculation is a physical process of slowly stirring the water in order to enhance the possibility of collision between coagulated particles. This process develops a light appearing white feather like material called floc. When a polymer is used as the primary coagulant the floc formed is often too small to see with the unaided eye. This type of floc is referred to as pin floc.

**Mixer Types**

With conventional gravity filters the flocculation basin is either a hydraulic system of nozzles or a slow mechanical mixer. The most effective flocculation basin for fully contained pressure systems is a pressure vessel with baffles and hydraulic nozzles.

**Detention Time**[45]

Regardless of the system used flocculation can take from 20 to 60 minutes. Normally, the colder and cleaner the water the longer the coagulation time required.

[45] **Detention time** - The theoretical time required to displace the contents of a tank or unit at a give rate of discharge or flow.

## SEDIMENTATION

**Not Normal**

From the flocculation basin water flows to the sedimentation basin. Sedimentation basins are not normally part of a typical pressure filter system. Therefore, most pressure filter systems are "direct filtration" systems. In order to use a sedimentation basin in a classic pressure filter system the vessel would need to be under pressure. This process has proven to make **sludge**[46] removal difficult.

**Loss of Head**

When a sedimentation basin is used it is typically used on a system where all of the process units are open to the atmosphere except the filter. With this system water is pumped from the sedimentation basin through the filter and into a storage tank. With this process the head provided by the raw water pump is lost and the water must be pumped a second time, increasing pumping cost. One exception are those systems with enough elevation head to transport the water from the intake to the plant without pumping.

## FILTER

**Vessel**

Depending upon the type of system, water flows from the raw water supply, flocculation basin or sedimentation basin to the pressure filter. Pressure filters are housed in a vertical or horizontal steel vessel. Entrance hatches allow access to the vessel and are used to inspect the media and make repairs. A filter vessel is a confined space. Entrance requires following the OSHA and Alaska Department of Labor requirements for confined space entry.

**Inspection Port**

One of the new renditions available from some pressure filter manufacturers is a glass viewing port and interior light in the filter. These allow the operator to view the filter media during normal operation and backwash.

**Underdrain**[47]

At the bottom of the vessel is the collection piping called the underdrain system. This may be lateral pipes with slots or nozzles. In the small systems in Alaska lateral pipes with slots are the most common.

**Support Gravel**

Placed over the nozzles or laterals is six to eighteen (6 to 18) inches of support gravel. This gravel may be up to three (3) inches in diameter and will be graded from large to small in the direction of the top of the filter. The support gravel supports the filter media.

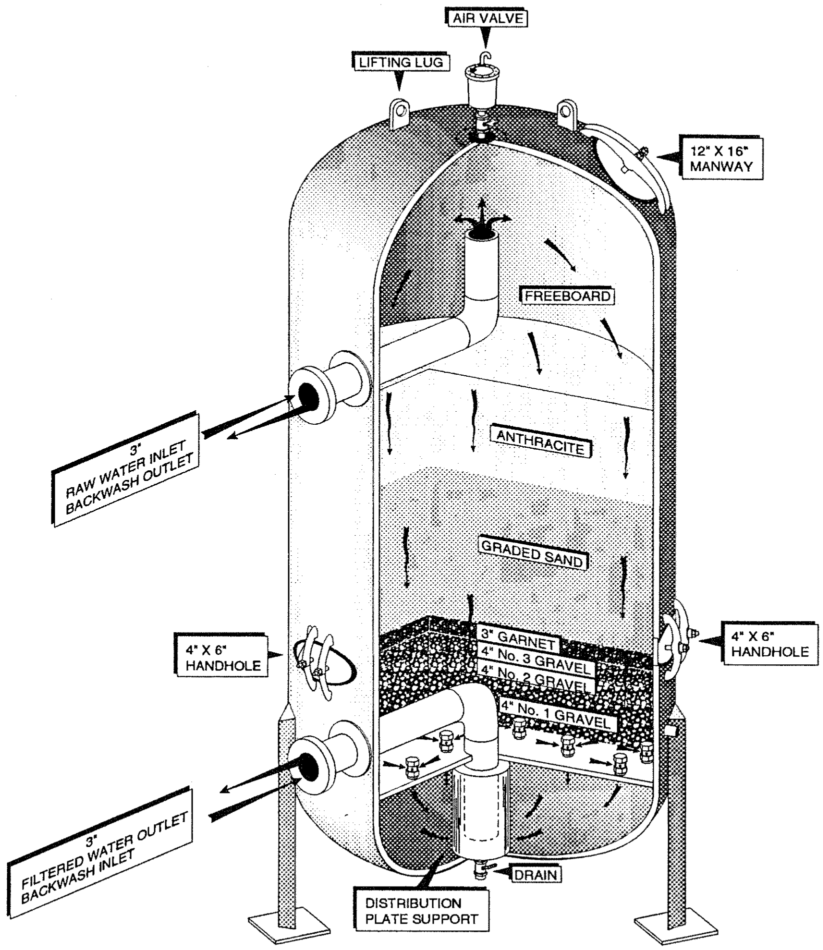
**Media**

Depending upon design the filter media will range from twenty four (24) to forty two (42) inches of material that ranges in size from 0.25 to 1.2 mm in diameter. Filter media may be silica sand, garnet sand or anthracite coal. The most common size range for the

[46] **Sludge** - The accumulated solids separated from water during treatment.
[47] **Underdrain** - The bottom part of a filter that collects the filtered water and uniformly distributes the backwash water.

filter media for color or turbidity removal is:

- Silica sand - 0.4 to 1 mm
- Garnet sand - 0.2 to 1.4 mm
- Anthracite coal - 0.4 to 1.4 mm




Courtesy of BCA Industrial Controls, Ltd.

**Multi-media**

The ideal filter process would be to have the material that escapes the sedimentation basin, start to collect on the top of the media and then slowly work its way down the media like the roots of a tree. Therefore, the most effective filter would be one that is graded with the largest diameter particles on the top and the smallest diameter particles on the bottom. In order to do this the large diameter particles would need to have a specific gravity (weight) less than the small diameter particles. Mulit-media filters, those using silica and garnet sand as well as anthracite coal show the best results in approaching this ideal filter.

**Example**

The following is an example of media layers on a two media filter. The size and type of filter media is selected by the engineer and/or manufacturer of the plant to meet a specific water condition.

**Filter media**

| Material | Size | Depth |
|---|---|---|
| Coal | 1.0 - 1.2 mm | 24 inches |
| Sand | 0.45 - 0.55 mm | 7 inches |
| Sand | 0.80 - 1.20 mm | 4 inches |
| Sand | 2.0 mm | 4 inches |
| Gravel | 3/8 x 1/4 inch | 6 inches |
| Total | | 45 inches |

## HYDRAULIC CONSIDERATIONS

**Normal Flow**

Water enters the at the top of the filter. Most filters direct the water toward the top of the vessel dissipating the influent energy against the vessel. Water then flows down through the media and out through the underdrain into the clear well, the distribution system or storage tank.

**Filtration Rates**

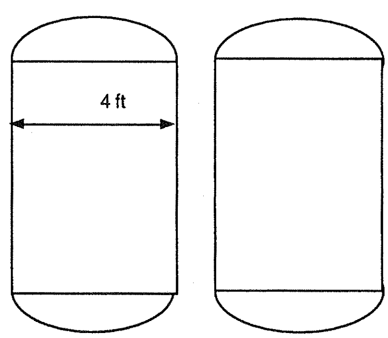
Pressure filters are commonly designed to filter water at 2 to 4 gpm/ft$^2$. Village Safe Water uses 1.5 gpm/ft$^2$ as their design criteria. With multi-media filter media the most common filtration rate is 4 gpm/ft2. The filtration rate should be checked at least once a year. This is accomplished by dividing the flow rate in gpm by the surface area of the filters.

**Frequency**

It is desirable to check filtration and backwash rates every three months. These simple tests will give you valuable information on the performance of the plant and the backwash pump.

**Math Practice**

The City of Noorvik uses two pressure filters, each is four feet in diameter. The raw water pump produces a flow of 110 gpm. What is the filtration rate in gpm/ft$^2$?




Find the surface area of the filters

$$A = \pi r^2 = \pi (2ft)^2 = \pi X 4 ft^2 = 12.6 ft^2$$

This is the surface area of one filter. To obtain the total surface area this value must be muliplyied by 2.

12.6 ft$^2$ x 2 filters = 25.2 ft$^2$

Find the filtration rate

$$\frac{110\,\text{gpm}}{25.2\,\text{ft}^2} = 4.4\,\text{gpm/ft}^2$$

**Piping**

Common piping on a pressure filter include:

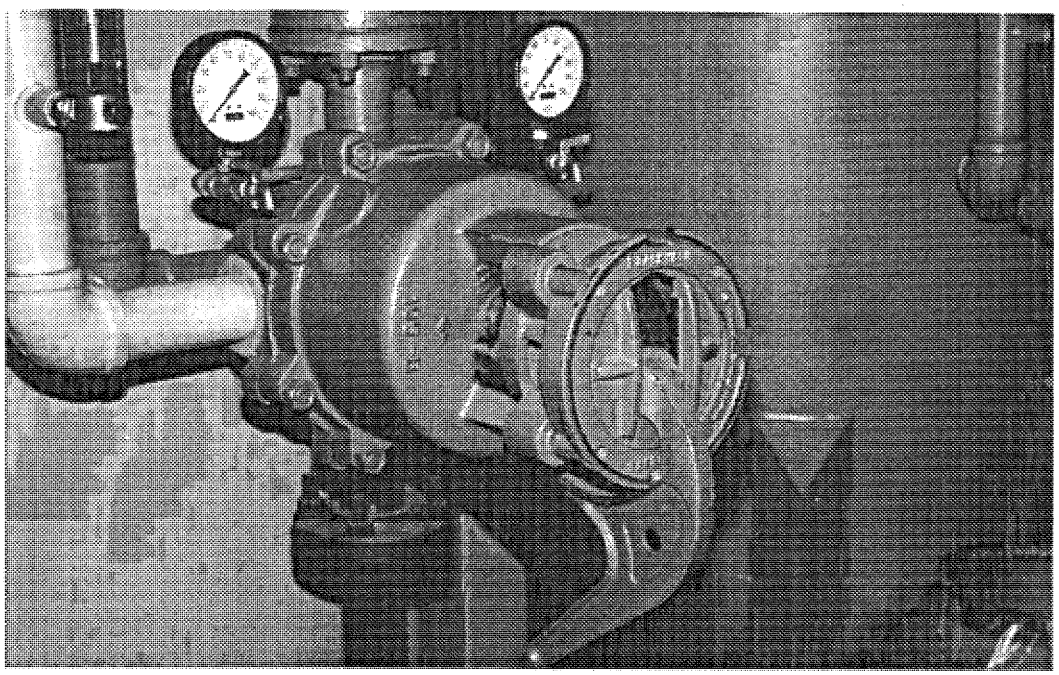
- Inlet piping
- Outlet piping, connected to the underdrain
- Backwash piping
- Filter to waste piping

**Cross-Connection**

It is important that the backwash filter to waste lines be separated from the waste line by an appropriate air gap. If the air gap is not at least twice the diameter of the discharge pipe there is a potential cross connection between the filtered water and the wastewater system.

**Control Valves & Piping**

The flow of water through the filter is controlled by various isolation and control valves. Most plants have isolation valves (gate or butterfly) on the raw water inlet, filtered water, filter to waste and backwash.



**Filter to Waste**

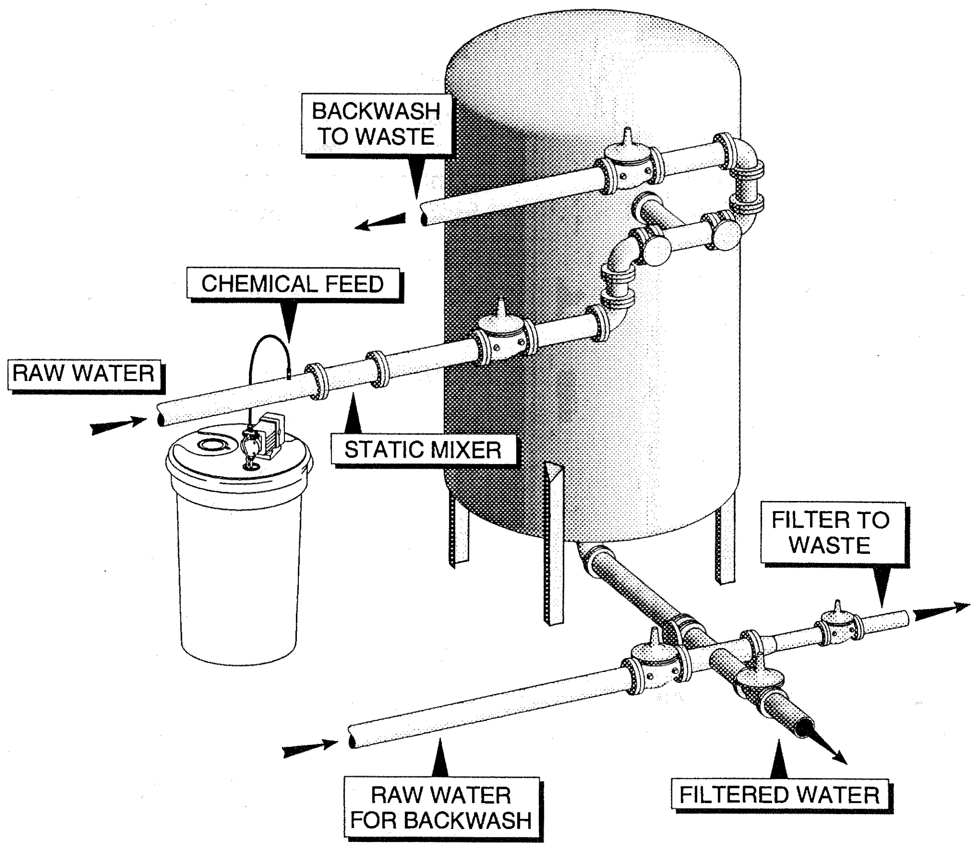
After a filter has been backwashed, it is desirable to waste the first water that is filtered. This is because the first water normally contains high turbidity. As the filter bed compresses, the quality of the finished water will improve. The compression, (aging) of the filter can take from 5 to 15 minutes.

**Filter Control**

Most pressure filters used in Alaska use a multi-port valve that reduces the number of actions that the operator must perform in order to switch the plant from normal flow to backwash. The most common of these valves is the Solo™ valve. Some of the multi-port control valves have very small openings creating a high velocity. This high velocity can cause high head-loss and floc shear.

**Air Relief**

It is normal for a pressure filter to accumulate air in the vessel. Therefore, an air release valve is installed on the top of the vessel. The most common valve is the combination valve that allows air out of the filter and air in under the rare conditions where a vacuum could develop in the filter vessel.




BACKWASH SYSTEM

**Pump**

With small water systems the most common back-wash pump is a close coupled end-suction centrifugal. The backwash pump is used to pump finished water back through the filter in order to remove debris that have collected during filtration.

**Control Valves**

When the backwash pump is started the head on the pump is usually low, which allows a high flow. This high flow can damage the filter media, support gravel and underdrain system. For this reason backwash flow control valves are often placed on the discharge of the pump. There are two types, one restricts flow to a set gpm, the second is a wide body globe valve that slowly opens after the pump starts.

**No Control Valve**

With a large number of pressure filter systems the control valve system can be eliminated. The backwash cycle sequence is designed to maintain pressure on the filter and thus reduces the normal flow inrush that is associated with starting the backwash pump.

**Surface Wash**

Surface wash systems are installed on pressure filters to breakup the surface accumulation of mud and debris on top of the filter. The most common surface wash system utilizes a rotating arm with nozzles. Because of the need for high pressures, usually at least 75 psi, the system is usually operated with its own pump. Because, surface wash systems require additional control valves and piping they are often not installed in very small system. When the filter lacks a surface wash system the media should be inspected at least once a quarter. Accumulation of mud and debris should be removed with a small flat shovel. Lack of removal of this debris could cause mud balls to be formed which can eventually work down into the media and plug the support gravel.

**Flow Sequence**

The normal backwash sequence with a surface wash is:

- Surface wash comes on for 2 to 5 minutes
- Backwash pump comes on
- Surface wash continues to run 3 to 5 minutes before the backwash pump shuts down.
- Backwash water flows up through the filter and out the same pipe that was used as an inlet. The valving is used to direct the backwash water to the sewage system or some other disposal site.

**Hydraulic Considerations**

Backwash rates are based on water temperature. The lower the temperature the denser the water and thus the lower the backwash rates. Details on backwash rates are provided in the section on Normal Operations. Typical backwash rates for small systems in Alaska are between 15 and 17 gpm/ft$^2$. The backwash rate should be checked at least once a year. For an example of how to check the backwash rate see the section on Normal Operations.

**Bed Expansion**

The backwash rate needs to be sufficient to provide a fifty percent (50%) hydraulic expansion. This is a 20 to 35% physical expansion. A method of determining backwash rates and physical expansion is described in the "Typical Filter Plant Problems" module.

**Backwash Rates**

The following table was taken from the AWWA Standard on Filtering Material B100-80 and can be used to determine typical backwash rates.

**Maximum Backwash Rates**

| Water Temperature, °F | Maximum Backwash Rate, gpm/ sq ft |
|---|---|
| 50 or less | 15 |
| 51-55 | 16 |
| 56-60 | 17 |
| 61-65 | 18.5 |
| 66 - 70 | 20 |
| 71-75 | 21 |
| Above 75 | 22.5 |

**Backwash Time**

In most small and packaged treatment plants the backwash lasts from six to 15 minutes.

**Math Practice**

The City of Noorvik uses two pressure filters, each is four feet in diameter. The backwash pump pumps water into a tank. The tank is 46" X 46". It took 3 minutes to fill 27 inches of the tank. What is the backwash rate in gpm/ft$^2$?

**Convert inches to feet**

46" /12" per foot = 3.8'

27"/ 12" per foot = 2.25 ft

**Find volume in cubic feet**

3.8' X 3.8' x 2.25' = 32.49 ft3

**Find volume in gallons**

32.49 ft3 x 7.48 gal/ft$^3$ = 243 gal

**Find flow rate in gpm**

243 gal/3 min = 81 gpm

**Find backwash rate**

$$\frac{81\text{ gpm}}{12.6\text{ ft}^2} = 6.4\text{ gpm/ft}^2$$

**Conclusion**

The normal backwash rate should be between 15 and 17 gpm/ft$^2$. At the time that this test was performed the filter was inspected and approximately one half to three eights of an inch of mud was found on the filter. The mud accumulation was the result of low backwash rates. The conclusion was to replace the backwash pump with one that would produce at least 215 gpm.

## SLUDGE HANDLING

The material backwashed from the filter must be disposed of. The two most common disposal methods are to the sanitary sewer or to a lagoon. With a separate lagoon a state or NPDES permit for the effluent may be required. When utilizing the lagoon system, the normal process is to have two lagoons. When enough sludge has accumulated in the bottom, it is allowed to dry and be removed for disposal as landfill. One of the problems with water treatment plant sludges is that they may contain heavy metals. As such, the water purveyor is responsible for any short or long term damage caused by the disposal of this sludge.

## CONTROL SYSTEM

**Subsystems**

The control system is composed of 5 subsystems;

- Plant rate control system
- Filtration rate control system
- **Headloss**[48] control system
- Backwash control system
- Chemical feed control system

**Control System Combinations**

The type of control system selected for a plant is based on engineering decisions about what will be most effective. There are several different combinations of plant flow rate and filtration rate systems. Different combinations are selected for constant head influent, pumped influent, variable head influent, automatic or manual backwash and constant or declining filtration rates.

## RATE OF FLOW CONTROL

The most common flow rate control used with small pressure filter systems is the one described above in the section on raw water. The flow control is based on the pumping rate and a flow restriction valve. Unlike the gravity pressure filter systems where more than one system is used, the pressure filter systems primarily use a modified declining rate process. With this process the maximum flow is restricted by an influent valve. As the filter plugs the differential in head will increase, thus decreasing flow rates. If the raw water pump is selected properly, with a flat curve, the flow rate will change only slightly.

**Filter Banks**

When the system is composed of several filters that backwash at different times, the control system must be designed to maintain the proper inlet pressure and flow rate to each filter. The system must be able to do this regardless of how many filters are on line.

**Dual Filters**

With a two filter system, the most common method of preventing over pressure or high flow during backwash, is to shut down both filters and backwash each of them independently. After backwash, both filters are returned to service.

### INSTRUMENTATION

**Headloss Indicator**

As floc descends into the filter media it partiality plugs the media and thus increases headloss across the media. Under normal conditions it is desirable to backwash the filter before the floc has penetrated the media and caused breakthrough. In order to deter-

[48] **Head loss - Filter** - As it applies to a water filter, the difference between the pressure or head on the top of a filter and the pressure or head on the underdrain of the filter.

mine this point the differential across the filter (headloss) must be measured and observed.

**Simple System**

The most common headloss systems are the differential pressure gauges and the dual pressure gauges. The differential pressure gauges provide headloss in psi and are read directly. Unfortunately, in most small pressure filter systems there are two gauges, one on the inlet and one on the outlet. The pressure differential must be determined by the operator. Two gauges give twice the possibility of error that is obtainable with one gauge.

**Turbidity**

Because turbidity is a measure of plant performance, monitoring the turbidity of the plant effluent can yield valuable data about when to backwash. Continuous monitoring turbidimeters with strip chart recorders allow the operator the opportunity to backwash prior to breakthrough. The exact point where backwash should occur can only be determined by experimentation with a specific plant. However, this point is normally where there is a sudden upward movement in the effluent turbidity.

**Alarms**

In some small plants where continous recording turbidimeters have been installed without continuous recording, a built in alarm system that senses turbidity above a certain point and shuts down the plant if this level is exceeded has been a successful operational alternative preventing breakthrough.

## CHEMICAL FEED CONTROL

### CONSTANT RATE PLANTS

**General System**

The chemical feed system is connected to and controlled by the electrical system. With most small plants the flow rate is either constant or variable. With constant flow rates the chemical feed adjustments need only be based on raw water and finished water quality. Typically, turbidity or color are selected as control parameters. The chemical feed system is then adjusted manually by the operator or electrically by a signal from a turbidimeter or streaming current meter.

### VARIABLE FLOW PLANTS

**Turbidimeters**

There are several reliable continuos measuring turbidimeters. A standard 4 to 20 ma signal from the turbidimeter can be used to adjust the chemical feed system. With most of the small treatment plants using either an LMI or W & T chemical feed pump, the stroke length of the pump is set manually by the operator and the frequency of the stroke adjusted by the electrical signal. There are systems that measure the raw and finished water turbidities and use the differential to develop a signal that controls chemical feed rates.

**Streaming Current Meter**

A relatively new instrument that has proven to be very effective in controlling large and small treatment plants is the streaming current meter. This device obtains a sample of the water just after the static mixer. The instrument detects the electrical potential of the water. The addition of alum or other primary coagulants changes this electrical potential. As a result, a specific electric potential can be observed that corresponds to low turbidity water. This value can then be used as a set point and a 4 to 20 ma signal produced around this set point. The signal is then used to control the chemical feed pumps in the same way as a turbidimeter.

## ELECTRICAL SYSTEM

**Subsystems**

The electrical system, like the control system is composed of several subsystems. Some of the more common systems are:

- Plant operation system,
- Backwash system, and
- Alarm system.

## PLANT OPERATIONS

**Plant Operations using PLC's**

While a water plant is basically a hydraulic device it is most often controlled electrically. The heart of most new water plants is the PLC (programmable logic controller). This device takes the place of most of the contactor relays that have been used in the past. Its primary advantage is the ease with which changes can be made in the control process.

**Example Plant**

In our example plant, the plant influent valve is manually controlled and the flow, backwash and backwash to waste sequence is controlled by a multi-port Solo™ valve.

## BACKWASH SYSTEM

**Components**

In our example plant, the backwash system is composed of a pump, and the multi-port valve.

**General Operation**

When the operator notices that the differential in pressure between the inlet and outlet pressures exceeds the maximum, the backwash sequence is started. This is accomplished by manually turning on the backwash pump and changing the position of the multi-port valve.

**Time Control**

The only time control is that offered by the operator.

## ALARM SYSTEM

**High Turbidity**

Most newer plants have some type of high turbidity alarm system. The most common system is composed of a turbidimeter that measures finished water turbidity. If the turbidity exceeds some predetermined point, the plant is shut down and an alarm is sent to a control panel light, horn or auto dialer phone system.

**Pump Failure**

Many plants have alarms that shut down the plant and send a visual or audible alarm if the prime is lost or the backwash pump, a chemical feed system or the finished water pumps fail to operate. Pump failure alarm systems may also be associated with high or low pressures.

# START-UP

**Assumptions**

The following start-up sequence is based on the assumption that the system being used is a pressure filter plant as described below. The chemical feed is composed of powdered alum and soda ash. Each chemical is mixed in a 100 gallon container. A final assumption is that this is a functioning system that has been off line and is being restarted. (If your plant does not use chemicals, then skip the various discussions on chemical feed equipment).

**Sequence**

Starting any pressure filter plant requires starting the chemical feed system, the pumping system and the filter hydraulics system. There are many correct sequences that can be used to bring the plant on-line. The O & M manual should be followed for a specific plant. The following is a suggested generic sequence.

- Mix chemicals according to the procedure below. When handling chemicals use the safety precautions described in the normal operations section.
- Prime the chemical feed pump - see the procedure below.
- Run jar test to determine proper chemical dosages.
- Make preliminary chemical feed pump settings.
- Check the raw water pumps and backwash pumps for proper operation. If the system is so designed, pump each pump to waste to assure that proper flow and pressure is possible.
- Backwash the filter.
- Start the raw water pump and filter to waste for 10 to 15 minutes or until the chemical feed is adjusted enough to produce turbidity below 0.5 ntu's.
- Check flow meter, note if the flow rate is normal.
- Check chemical feed during this period.
- Check finished water turbidity.
- Adjust chemical feed - see process control procedure for more details.
- If all systems are in working order, change control valve to normal operating position.

• Record the steps and their results.

**Chemical Concentration**

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

1. Estimate desired dosage. Typical alum dosages range from 5 to 30 mg/L. Soda Ash dosages are typically 1/2 of the alum dosage.
2. Run sufficient jar tests to be assured that the chemical feed settings are reasonable.
3. Determine the concentration of chemical needed or if there is a standard mixture, determine the concentration in the dilution tank.
4. Determine the plant flow rate in gpm.
5. Determine the chemical feed pump pumping rate in mL/min.
6. Determine the pump setting to obtain this feed rate. Set the feed pumps and check their output with a graduated cylinder.
7. Determine how long each tank of solution will last.

**Example:**

The chemical feed pump used is a LMI B121-91T with a maximum feed rate of 158 mL/min (see the table below). The flow rate through the plant is 175 gpm. The chemical feed tanks are each 100 gallon.

**Steps 1 & 2**

• A jar test was conducted and it was determined that the alum dosage would need to be 12.5 mg/L. A dosage of 5 mg/L of soda ash in the raw water was needed for coagulation.

**Step 3**

The maximum amount of alum that can be easily dissolved in water is about 1 pound per gallon. This is a concentration of just under 12%. The standard mixture of soda ash at this plant has been 50 pounds of soda ash in a 100 gallon tank, this is approximately a 6% solution. (Under ideal conditions soda ash can be mixed to a concentration of 49.5%. However, the preferred maximum concentration is 4 to 7%.)

• Determine the exact concentration of the alum solution.

$$\% \text{ Conc} = \frac{100 \text{ lbs X } 100}{100 \text{ gal X } 8.34 \text{ lbs/gal}} = 11.99\% \text{ or } 12\%$$

Since 1% is equal to 10,000 mg/L

11.99% = 119,900 mg/L

• Determine the exact concentration of the soda ash solution.

$$\% \text{ Conc} = \frac{50 \text{ lbs X } 100}{100 \text{ gal X } 8.34 \text{ lbs/gal}} = 5.99 \text{ or } 6\,\%$$

Since 1% is equal to 10,000 mg/L

5.99 % = 59,900 mg/L

**Step 4** The plant flow is 175 gpm

**Step 5** Determine the chemical feed pump feed rate in mL/min.

$$\text{Alum feed rate} = \frac{0.378 \text{ X } 12.5 \text{ mg/L X } 175 \text{ gpm}}{12\,\%} = 68.9 \text{ or } 69 \text{ mL/min}$$

$$\text{Soda Ash} = \frac{0.378 \text{ X } 5 \text{ mg/L X } 175 \text{ gpm}}{6\%} = 55 \text{ mL/min}$$

**Step 6**

- There are two choices of how to determine the pump setting. 1) use the PHS chart provided at the end of this module or 2) assume some stroke setting and calculate the frequency.

From the chart for alum - stroke 50% and frequency between 80 and 90%.

From the chart for soda ash - stroke 50% and frequency 70%.

From the calculation for alum. The pump has a maximum feed rate of 158 mL/min. If the stroke is set at 50% the feed would be: 158 x 0.5 = 79 mL/min. What should the frequency setting be to obtain 69 mL/min.

$$\text{Frequency} = \frac{69 \text{ mL/min}}{79 \text{ mL/min}} \text{ X } 100 = 87\,\%$$

By using the calculation process determine the soda ash pump feed setting. Assume that the stroke is to be set at 50% or 79 mL/min

$$\text{Frequency} = \frac{55 \text{ mL/min}}{79 \text{ mL/min}} \text{ X } 100 = 69.9\,\%$$

**Step 7** Determine the number of days that the tanks will last if the flow is 175 gpm for 14 hours a day.

- Total time 14 hrs x 60 min/ hr = 840 min
- 1 gallon = 3,785 mL

For Alum

- Alum - 840 min/day x 69 mL/min = 57,960 mL/day

$$\text{Gallons/day} = \frac{57{,}960 \text{ mL/day}}{3{,}785 \text{ mL/gal}} = 15.3 \text{ gal/day}$$

$$\text{Days} = \frac{100\,\text{gal}}{15.3\,\text{gal/day}} = 6.5\,\text{days}$$

For Soda Ash

- Soda ash, 840 min/day x 55 mL/min = 46,200 mL/day

$$\text{Gal/day} = \frac{46{,}200\,\text{mL/day}}{3{,}785\,\text{mL/gal}} = 12.2\,\text{gal/day}$$

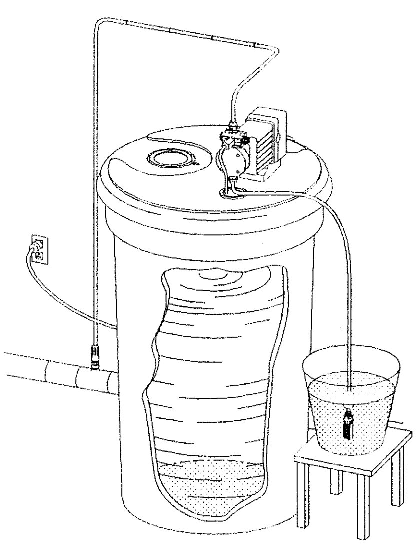
$$\text{Days} = \frac{100\,\text{gal}}{12.2\,\text{gal/day}} = 8.2\,\text{days}$$

**Pumping capacities of various chemical feed pumps**

| | Model | Capacity gph | Capacity mL/min | Max psi |
|---|---|---|---|---|
| **LMI Pumps** | | | | |
| | A141-150S | 0.2 gph | 13 mL/min | 150 psi |
| | A171-151T | 0.4 gph | 26 mL/min | 140 psi |
| | A151-91T | 1 gph | 63 mL/min | 110 psi |
| | B121-91T | 2.5 gph | 158 mL/min | 100 psi |
| | D121-71T | 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 |

## PRIMING THE PUMP

### Priming LMI



If the pump is new, 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 pump.
6. Adjust feed to 80% speed and 100% stroke.

7. With the 4 in 1 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 in 1 valve to normal - the pump should pump into the bucket.
10. Shut off the 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 residual.
15. Adjust the feed rate to obtain the proper residual for desired CT value.

**Priming W & T 45**

If the pump is new, use clear water for the prime. If this is 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 the 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 the feed rate to obtain the proper residual.

# NORMAL OPERATIONS

## ROUTINE OPERATIONS

**General Description**

The normal operation of a water filtration plant involves; data collection, observations, mixing chemicals, adjusting process control, cleaning, testing and performing routine preventive maintenance activities. The following are general guidelines involving these activities with each of the typical process units found in a small or package water treatment plant.

**Raw Water**

The raw water system may contain such equipment as pumps, basket strainers and control valves. The pumps will require observation for leakage, vibration and noise. Suction and discharge pressure as well as amperage and voltage readings should be gathered on a regular basis and the pump analyzed for proper performance

**Basket Strainers**

If the raw water system contains a basket strainer or other similar device, the differential pressure should be monitored daily and the device backwashed or cleaned when the differential pressure exceeds the manufacturer's recommendation.

**Control Valves**

The inlet and outlet pressures on control valves should be monitored daily. The valve should receive annual maintenance consisting of disassembly, cleaning and replacement of gaskets, and worn parts.

**Flow Measurement**

In order for a water treatment plant to operate properly and in order to properly perform process control the plant must have a flow meter. This meter must be read each day. If the meter is used to pace chemical feed equipment, it must be calibrated at least once each year.

**Coagulation**

The chemical feed rate should be observed and tested on at least a monthly basis. The feed rate in mL/min and the dosage in mg/L should be calibrated each month.

**Flocculation**

If the plant contains a flocculator, samples should be collected before and after the flocculator and the floc observed. The effluent sample should be compared with jar test results.

**Sludge in the Flocculator**

Valves at the bottom of the floc chamber should be opened and the accumulation of sludge observed at least once a week. The preference is there be little or no sludge accumulation. The chamber should be drained and cleaned every three to six months.

FILTRATION PROCESS

**Normal Process**

As has been mentioned before, as the filtration process proceeds through its cycle the floc penetrates the filter bed. The key to proper operation is to backwash the filter bed before this breakthrough occurs.

**Filtration Rate**

The filtration rate should be checked at least twice a year and maintained within the design limitations. Commonly this is between 2 and 8 gpm/ft2.

**Filter Run**

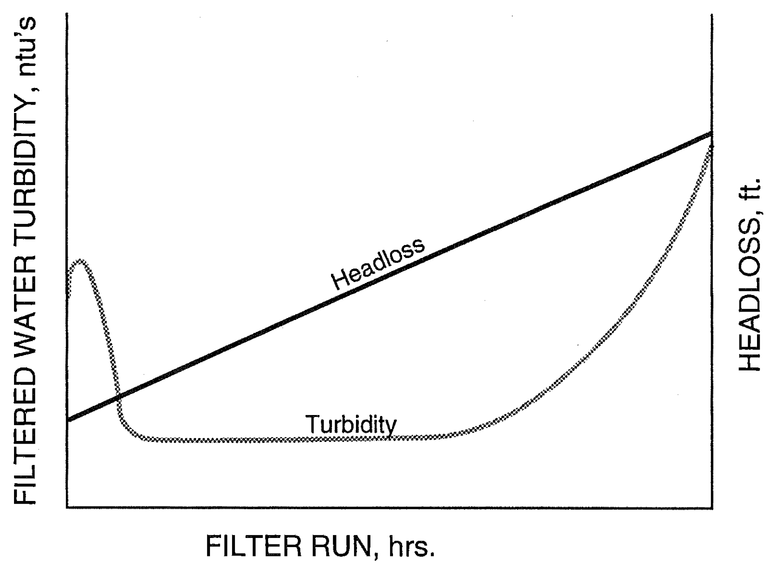
At the start of a typical filter run the headloss of the clean filter should be approximately 1 foot. When the headloss reaches 6 to 8 feet, or the finished water turbidity begins to climb, it is time to backwash the filter. A typical filter run should last from 12 to 72 hours. Filters should not be operated longer than 72 hours without backwashing, regardless of finished water turbidity. The bed can become contaminated with biological growth after this length of time.

**Turbidity**

When a filter is backwashed and placed into service, the finished water turbidity will rise sharply and then drop off. This rise and drop should only take a few minutes. During this period the filter is compacting and said to be aging. This process should only take a few minutes. After compaction the filter effluent should remain below 0.1 ntu during most of the filter run. When the turbidity rises to 0.2 ntu a backwash cycle should be considered.

**Graph of Turbidity & Headloss**

The graph below shows what happens to turbidity and headloss during a typical filter run.




## BACKWASH PROCESS

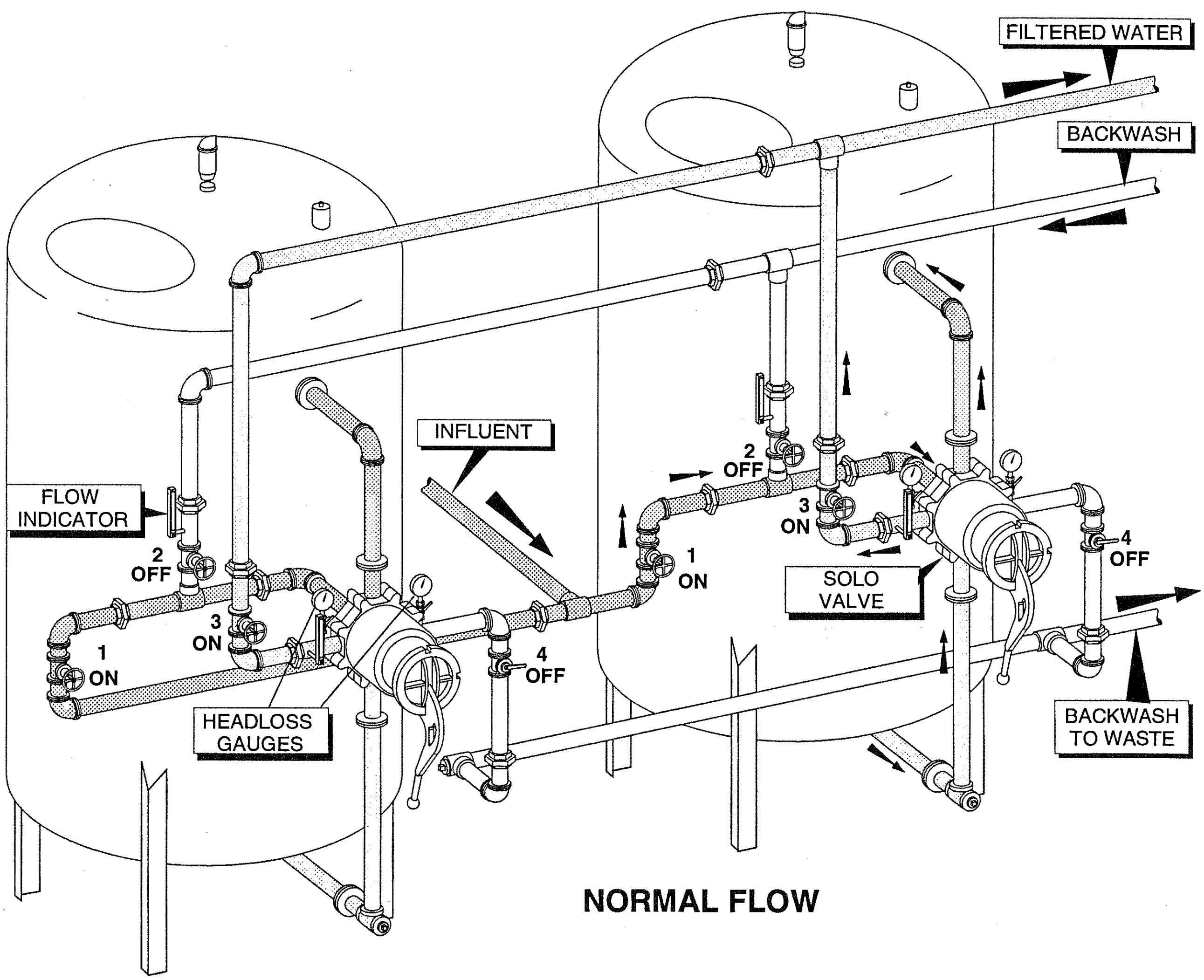
**Control Valves**

While backwash control can be accomplished manually and with various brands and styles of butterfly and wide body globe automatic control valves, the most common pressure filters in Alaska use the single valve process. The most common single control valve is the Solo™. The following discussion will be based on the Solo™ control valve. However, the sequence would be the same with any combination of manual and/or automatic control valves.

**Sequence**

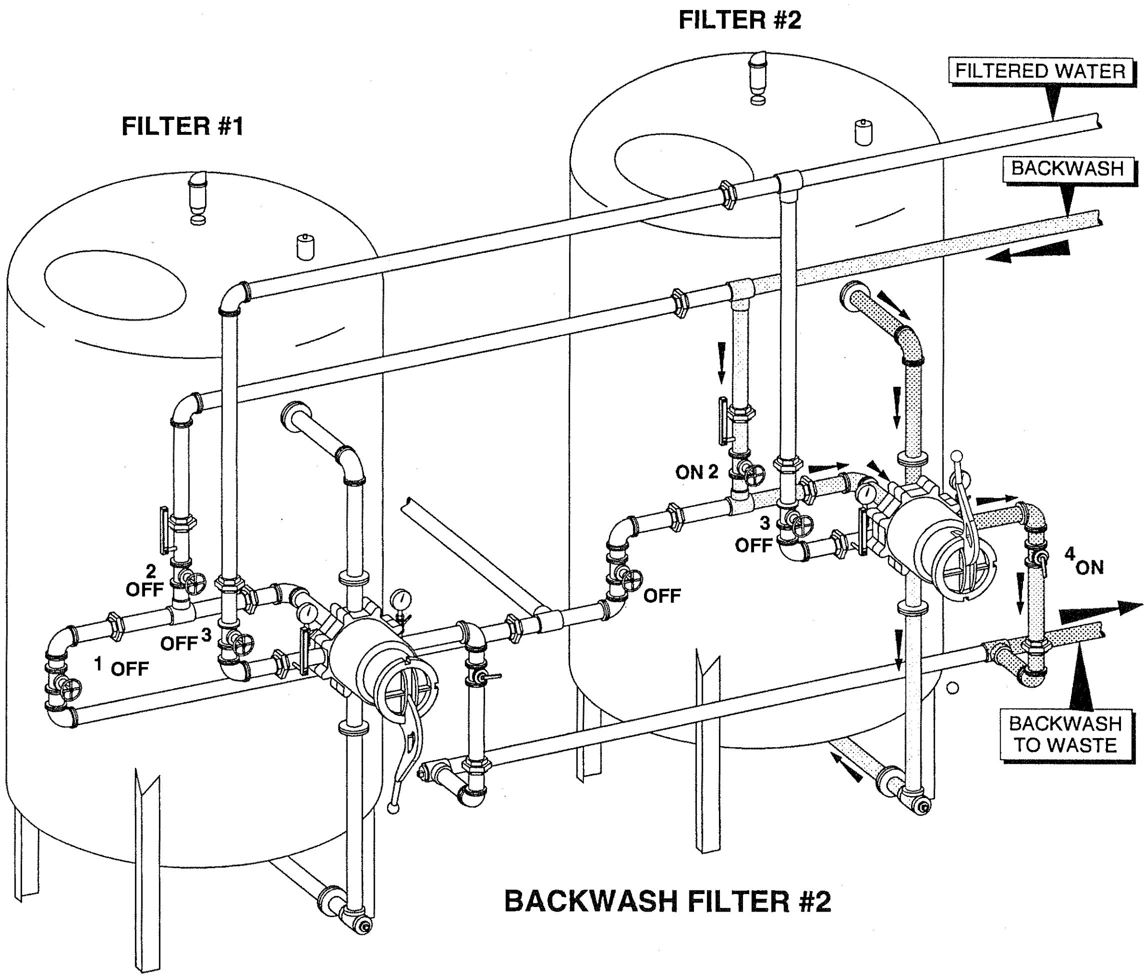
When it is time to backwash the filter the following sequence is typically followed:

- Close the inlet supply valve (valve #1).
- Close the finished water valve (valve #3).
- The pressure differential across the filter should slowly become zero.
- Open the backwash valve (valve #4).
- Move the Solo™ valve to the backwash position
- Turn on the backwash pump. *There may be a automatic control valve in the backwash system that slowly opens, preventing a surge on the filter media. If this is so this valve will open slowly, usually takingat least 1 minute.*




**NORMAL FLOW**

- If there is surface wash the surface wash valve will open and run for 30 seconds to 1 minute before the backwash valve opens. With the surface wash running the backwash valve will open.
- Backwash for six to 15 minutes or until the backwash water comes clear. Taking grab samples during the backwash is the best method of determining the clarity of the backwash water. When observing the sample, look for media, if media is present then the backwash rate is to high.




**BACKWASH FILTER #2**

**Process**

During the backwash the media in the bed will expand 50% hydraulically (the distance between any two particles is one-half the average diameter of the particles), this represents a 20 to 35% physical expansion. Unfortunately, in most pressure filter systems the operator is not able to observe the expansion.

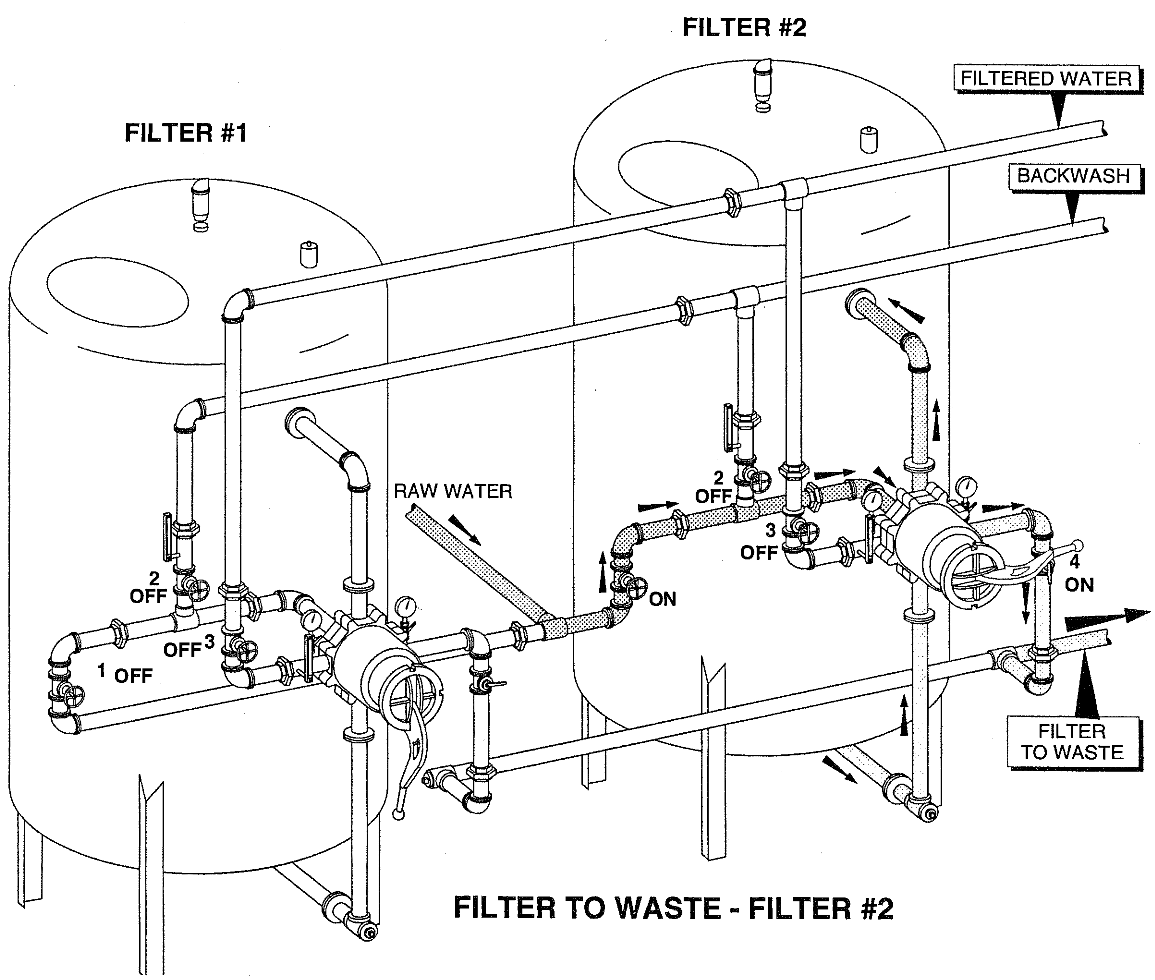
**Rate**

The backwash rate is dependent on the temperature of the water. The warmer the water the greater the backwash rate needs to be. This is because the warmer the water the lower the water density. The following backwash rate table was taken from the AWWA Standard on Filtering Material B100-80 and can be used to determine proper backwash rates.

**Maximum Backwash Rates**

| Water Temperature, ° F | Maximum Backwash Rate, gpm/ sq ft |
|---|---|
| 50 or less | 15 |
| 51-55 | 16 |
| 56-60 | 17 |
| 61-65 | 18.5 |
| 66 - 70 | 20 |
| 71-75 | 21 |
| Above 75 | 22.5 |

- At the conclusion of the backwash cycle the surface wash system should shut down 2 to 3 minutes before the backwash pump shuts off.
- Shut off the backwash pump.
- Close backwash line control valve (valve #2).
- Wait 20 to 30 seconds for the filter to become stable.
- Rotate the Solo™ valve to "Filter to Waste" position. *On some valves this position is called Regeneration.*




**FILTER TO WASTE - FILTER #2**

- Open the influent valve (valve #1). The first water though the filter will be exited to waste. During this period the filter is compressing (aging) and becoming more efficient. If you were able to observe the effluent turbidity you would see a spike at the start of this process and then the turbidity should fall quickly down to normal. This prevents microorganisms that are still in the filter from being pushed into the finished water.
- Run the filter to waste for 4 to 6 minutes.
- Close the waste valve (valve #4).
- Rotate the Solo™ valve to Normal. Water should now be routed to the clear well or storage tank.

## ROUTINE INSPECTION

**What to Observe?**

A filter plant should be visited once each day of operation. During the visit the equipment and water should be observed and tested to assure proper operations. More specifically the following should be checked:

- Level of chemicals in each tank.
- Leaks - observe all piping, the tank and chemical feed pump for leaks. If there is a leak, shut down the 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.
- Filter system - Observe the operation of the filter by checking flow rate, headloss, floc appearance, tube settlers for plugging, floc carry over onto the filter, raw and finished water turbidity.
- During the visit collect the data described below.

## DATA COLLECTION

**Raw water**

Test and/or record daily:

- pH
- Alkalinity
- Temperature
- Turbidity
- Pressure
- If you are removing Mn or Fe the levels in the raw water should be tested daily
- Flow

Monthly

- Fluoride

**Chemicals & Coagulation**

Daily observe, record and calculate:

- Level of liquid in each tank
- Calculate quantity used
- Calculate dosage - daily

Quantity on hand - need six months' supply

**Flocculation**

Test and record daily:

- Alkalinity
- pH - daily
- Turbidity of sample that has settled for 1 hour - compare with sedimentation sample. Should be close to the same

**Sedimentation**

Test and record daily:

- Alkalinity
- pH - daily
- Turbidity as water flows to filter

**Filter**

Test and record:

- Turbidity - continuous or at least daily
- Alkalinity - daily
- pH - daily
- Calculate filtration rates - every 3 months
- Check backwash rates - every 3 months
- Inspect filter media for mud balls - every year
- Initial clean filter headloss

**Finished water**

Test and record daily:

- Turbidity
- Alkalinity
- pH
- Aluminum - Iron if you are feeding iron salts

## CALCULATIONS

### Calculation Needed

As a result of the daily visit to a filtration plant, dosage should be calculated for each chemical added to the water. While a low turbidity in the finished water is a key to determining proper dosage, the dosage calculation is important to understanding what is happening with the plant and the raw water quality. A change in dosage can give information on why there is a change in finished water quality. The formula for calculating dosage is given in the section topic titled "Calculations needed for Alum and Soda Ash."

Example Check list from a automated package plant

## Daily Check List

- ❑ Collect data as per data collection form.
- ❑ Has there been a use of chemicals in the last 24 hours? This can be determined by comparing your level readings with the previous readings.
- ❑ If you enter the data into the computer compare dosage and use to history.

- ❑ Check all plant thermostat settings _____ ° F.
- ❑ Check rest room thermostat setting ______ ° F.
- ❑ Check office and lab thermostat setting ______ °F.

- ❑ Alum - power light on ________.
- ❑ Alum % feed on panel _______ %.
- ❑ Alum dilution water rotometer setting _______.
- ❑ Alum feed pump, stroke on pump ______ % and frequency ______%.
- ❑ Alum alarms _________.

- ❑ Soda ash - power light on ______.
- ❑ Soda ash feed rate _____ %.
- ❑ Soda ash feed pump, stroke on pump ______% and frequency _______%.
- ❑ Soda ash mixer motor temperature _______.
- ❑ Soda ash alarms _________.

- ❑ Chlorine pump stroke setting _______ %.
- ❑ Chlorine pump frequency light flashing _______ strokes/min.

- ❑ Fluoride crystal level _____ inches.
- ❑ Fluoride pump stroke setting ____ %.
- ❑ Fluoride pump frequency light flashing ________ strokes/min.

- ❑ Poly feed pump stroke _____ % and frequency ______ %.

- ❑ Flow rate _____ gpm.

- ❑ Initial filter head loss ______ psi.
- ❑ Headloss________ psi.
- ❑ Check for leaks.

# MIXING & FEEDING CHEMICALS

## ALUMINUM SULFATE - $Al_2(SO_4)_3$

**Properties**

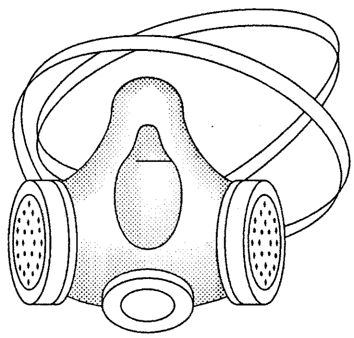
Tends to cake under high relative humidity. Acidic, hydroscopic, mildly corrosive if wet.

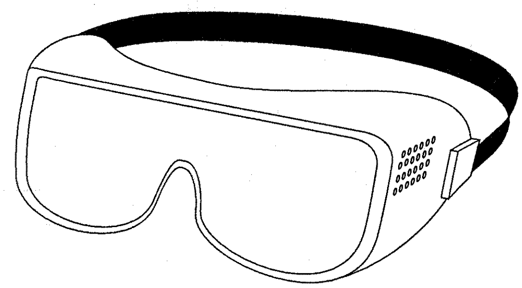
**Storage Requirements**

Clean, dry area.

**Safety equipment required when handling as a powder**

- Cartridge dust mask.
- Splash proof chemical safety goggles.





- Loose, denim-quality, dust-proof, long-sleeved clothes with bandanna and cap. Trousers and sleeves tied at ankles and wrist.

**Mixing Concerns**

- Maximum concentration. Under normal conditions it is difficult to maintain an alum solution of greater than 1 pound of alum per gallon of water, approximately a 12% solution. In order to develop a solution using dry alum an electric mixer is required.

## SODA ASH - SODIUM CARBONATE $Na_2CO_3$

**Properties**

- Tends to lump and is mildly corrosive if wet. Soda ash is neither a toxic or hazardous material.

**Safety equipment required when handling as a powder**

- Cartridge dust mask.
- Splash proof chemical safety goggles.
- Loose, denim-quality, dust-proof, long-sleeved cloths with bandanna and cap. Trousers and sleeves tied at ankles and wrist.
- Rubber gloves.
- Cover exposed skin with cream or petroleum jelly.

**Mixing Concerns**

Under ideal conditions soda ash can be mixed to a concentration of 49.5%. However, the preferred maximum concentration is 4 to 7%. Soda ash is difficult to maintain in a solution without an electric mixer.

## MIXING PROCESS

**Normal Conditions**

It is typical to make an alum solution of 1 to 12% and a 4 to 7% soda ash solution. In some facilities the soda ash is fed directly into the water as a dry powder. While this process is efficient it usually does not provide the process control necessary for a well run filter plant. Both alum and soda ash are considered to be 100% concentrated when in a powered or crystal form. In this form, two pounds (2) of powder are required for each 25 gallons of water for each 1% concentration that is required.

| Volume | lbs for each 1% of solution |
|---|---|
| 25 gallons | 2 lbs |
| 30 gallons | 2.5 lbs |
| 50 gallons | 4 lbs |
| 100 gallons | 8 lbs |
| 150 gallons | 12 lbs |
| 200 gallons | 16 lbs |

**Conversions**

1 lb = 16 oz = 454 grams

**Assumptions**

The following procedure is provided with the assumption that alum and/or soda ash are being mixed in a batch solution and a dry feeder **is not** being used.

**Procedure**

When making up a new solution batch the following procedure can be adapted to local conditions.

- Put on personal protective equipment.
- Fill container 1/2 full of water.
- Start mixer.
- Dump dry chemical in container.
- Fill with water - continue to mix.

**Soda Ash**

With soda ash the mixer should run continuously.

**Polymers**

Some polymers require aging before they can be used. Check with the manufacturer to determine if aging is necessary.

## CHEMICAL FEEDING PROCESS

**Control of Feed Rates**

It is important for proper plant operation to match the chemical feed rate with the plant performance. This is accomplished by relating the turbidity or color levels, temperature, pH and flow to the chemical feed rate.

**Automatic Feed Rate Control**

Some water treatment plant chemical feed systems are controlled by a signal from the raw water flow meter. This system provides one of the most precise methods of changing feed rates to match flow rates.

**Calibration**

Calibration of chemical feeder and calculations for determining chemical concentrations are to be found in the process control module.

**Using Polymers**

If a polymer is being used, the following guidelines can be used in jar tests to determine the most effective feed rate;

| **Use** | **Typical Dosage range** |
|---|---|
| Primary Coagulant | 1 -5 mg/L |
| Coagulant aid | 0.1 - 1 mg/L |
| Floc aid | 0.1 - 1 mg/L |
| Sedimentation aid | 0.1 - 1 mg/L |
| Filtration Aid | 0.01 - 0.1 mg/L |

Colored water - Primary coagulant. The PHS has shown considerable success in the reduction of color in the cold, turbidity-free, low alkalinity waters of Southeast Alaska with dosages of less than 1 mg/L.

## ADDING CHEMICALS

**Typical Problem**

During the visit to the treatment plant it is often necessary to replenish the alum or soda ash in the feed solution tank. If the tank is empty, then determining how much chemical to place 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.

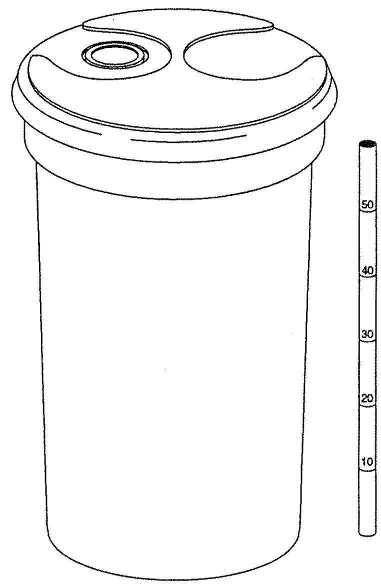
**Solution**

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 ten (10) gallons of water.
- Empty the tank.
- Place ten 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 10 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 six months 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 alum and/or soda ash 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 chemical supply is at the six month point, order the amount necessary for the next six months, plus shipping time plus one week lead time.

**Example:**

The City of Waterhome uses and average of 15 pounds of alum 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 15 lbs/day x 250 days = 3,750 pounds. A standard container of alum is the 100 pound bag. The City of Waterhome order should be for 38 bags.

# CALCULATIONS USED WITH ALUM, SODA ASH & POLYMER

**Introduction**

Depending on the situation an operator may need one or more of the following formulas.

## MAKING SOLUTIONS

**Pounds for Set Concentration**

It is assumed that dry alum and soda ash are a 100% concentrated product. Therefore, the following formula can be used to find the number of pounds of chemical needed to make a set concentration.

Start by converting the percent desired to a decimal (2% = 0.02, 4% = 0.04, etc.)

____ lbs = ___ % solution needed X ____ gal in tank X 8.34 lbs/gal

**Example**

Determine the number of pounds of alum needed to make 50 gallons of a 6% solution.

lbs = 0.06 x 50 gallons x 8.34 lbs/gal = 25 pounds

**No Scales**

In many locations there are no scales to measure out the amount of chemical needed. In these locations a standard household cup is often used. The following conversions can be used in order to determine the correct chemical concentration.

1 cup = 8 oz

16 oz = 1 pound, therefore 2 cups = 1 pound

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

**Finding Concentration**

The formula for finding the concentration of alum or soda ash in a tank when the number of pounds of material added is known is:

$$\_\_\_ \text{ \% in tank} = \frac{\_\_\_ \text{ lbs of powder X 100}}{\_\_\_\_ \text{ gal of tank X 8.34 lbs/gal}}$$

**Example**

Find the concentration when 16 lbs of soda ash are placed in a 50 gallon barrel that is filled with water.

$$\% = \frac{16 \text{ lbs X } 100}{50 \text{ gal X } 8.34 \text{ lbs/gal}} = 3.8\%$$

## MIXING LIQUID

In most small plants the only liquid chemical that is used is a polymer. In most cases the formula for mixing the polymer will be provided. If it is not available, assume that the polymer is 100% concentrated (neat solution) and use the following formula.

**Gallons Needed**

The following formula can be used to find the volume of poly needed to make a specific strength solution.

$$\text{Gal} = \frac{\_\_\_\_ \text{\% solution needed in tank X } \_\_\_ \text{ gal of tank}}{\text{100\% concentrated (neat) solution}}$$

**Example**

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

$$\text{Gal of poly} = \frac{1\% \text{ X } 10 \text{ gal}}{100\%} = 0.1 \text{ gal of poly}$$

There are 3,780 mL in a gallon so:

0.1gal x 3,780 mL/gal = 378 mL of solution

## PUMPS & DOSAGE

**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% solution into a 2 inch line that flows at 50 gpm. The desired dosage is 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 in a flow of 60,000 gallons. The concentration in the tank is 2%.

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

**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 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

## PROCESS CONTROL

**Additional Data**

Additional information on process control can be found in the module titled "Process Control - Water Filter Plants."

**Process Control Tools**

The keys to proper operation of a water filtration system with chemical feed is the proper adjustment of the chemical feed rate. This can only be accomplished by maintaining the proper balance between pH, alkalinity, turbidity and chemical feed rate. If there is enough alkalinity (usually at least 80 mg/L is desired, when using Alum) then pH is the most important control parameter. This balance can best be determined using the jar test procedure and then passing the solution from the jar test through a filter to determine its filterability.

**Floc Formation & Filterability**

One of the common operational errors is to concentrate on the development of the best looking and best settling floc. With a pressure filter there is usually no settling basin, therefore the best floc is the one that will filter best. This means that it will produce the highest quality filtrate (low turbidity) and give the longest filter runs. Filtration capabilities are normally estimated by using a standard Whatman #1 filter and a vacuum device. The procedure for using this process is described in the section on "Process Control."

**Typical pH Values**

When using Alum for color removal the best pH is usually between 4 and 6 and for turbidity removal a pH of between 6.8 and 7.2 is normally best. While these pH values are considered normal, each water supply will react in its own way. You must use the jar test procedure to determine the best pH, alkalinity and chemical dosage to obtain the best color removal. A detailed discussion of these procedures can be found in the section on "Process Control."

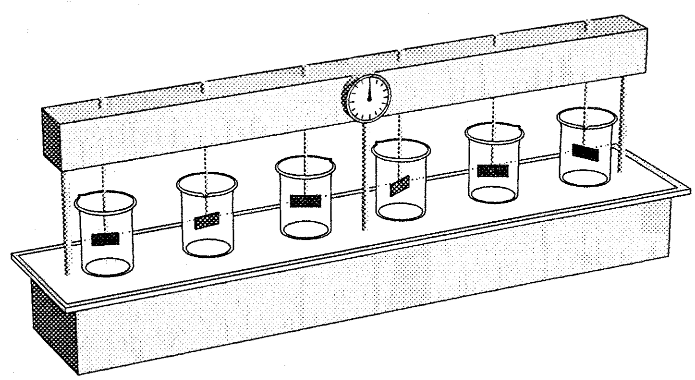
**Lab Equipment**

In order to determine the proper chemical feed rates there is a need for specific laboratory equipment. The minimum equipment would include:

- pH meter
- Jar test kit
- Alkalinity test kit
- Turbidimeter

**Jar Test - Plant Performance**

One of the most difficult operational task is to interpolate the jar test results and make chemical feed adjustments in the pant so that the jar test results can be duplicated by the plant. In most instances, once the pH, coagulant dosage, and soda ash dosage (if used) have been determined, simple adjustments of the chemical feed rates should place the plant in the "ball park."



**Routine Operations**

Once the chemical feed rates have been set and verified, test the pH of the water to see if it matches the jar test results. If not, adjust the chemical feed. Always watch final effluent turbidity. The correct dosage is the one that produces the lowest turbidity while maintaining normal filter runs.

## FLOCCULATION

**Pressure Tank**

The most common flocculation chamber associated with the pressure filter system is the baffled tank. Collect a sample after flocculation and test for pH, alkalinity and filter ability. Some operators find that performing a turbidity analysis on the flocculated water will give them good information about how well the water will filter.

**Trend Charts**

The chemical makeup of water has a tendency to change with the seasons but repeat with the return of a season. The same is true of turbidity or color readings, once a chemical dosage is determined for a specific turbidity and/or color that dosage can be repeated , with success, anytime this same turbidity and/or color occurs. In order to reduce the amount of testing required, successful operators plot the water quality against dosages and keep track of the results. For instance the following data would normally be placed on a trend chart:

- Raw water temperature
- Raw water alkalinity
- Raw water turbidity (or color)
- Raw water pH
- Chemical dosages
- Finished water turbidity (or color)
- Finished water pH
- Finished water alkalinity

**Routine Maintenance**

Daily collect a sample from the end of the flocculation chamber and compare its appearance to the jar test results. Perform the chemical analysis discussed above. At least once a week, open the drain valve and determine the amount of sludge accumulation, the preference is that there be no sludge accumulation. Every three to six (3 to 6) months drain and clean the flocculation chamber. *This is a confined space and the confined space permit and entry procedure must be followed.*

## FILTRATION

**Process**

Water enters on top of the filter and moves downward through the media. As the filtration time continues material that is collected on top of the filter, works down through the media, much like the roots of a tree. The filter must be backwashed before the "roots" have penetrated the bottom of the media. Penetration is called breakthrough. Breakthrough can bring the microorganisms that we were attempting to remove into the final effluent.

**Filtration Rates**

The filtration rate should remain within the design parameters. Remember this should be between 1.5 and 4 gpm/ft$^2$. Once the filtration rate has been determined the influent flow meter should be monitored for changes in flow rates. Any significant change, especially upward, would require recalculating the filtration rate. If for some reason the designed filtration rate is exceeded the plant should be shut down and the problem resolved.

**Normal Filter Run - Headloss**

Under normal conditions, after backwash a pressure filter should have headloss of between 1 and 2 psi. As the filter run continues the headloss will rise. Backwash is usually started when the headloss is between 6 and 9 psi.

**Normal Filter Run - Turbidity**

When returning the filter to operation, assuming there is a filter to waste cycle, the turbidity of the filtered water will rise initially. After a few minutes the turbidity should drop quickly and then flatten. As the filter run continues the turbidity should continue a slight downward trend. Just before it is time to backwash a slight increase in turbidity will be noted. Properly operated filter systems that use a coagulant should be capable of producing a turbidity below 0.1 ntu's during the majority of the filter run. Should the turbidity exceed 0.2 ntu the filter should be backwashed or the chemical feed adjusted.

**Normal Filter Run - Time**

A typical filter run is 12 to 72 hours. However, this may change drastically during the year. When the raw water turbidity is high the filter runs will shorten, when the raw water turbidity is low the filter runs will be longer.

**Filtration Rates**

As was described above the normal process for pressure filter flow control is the utilization of a flow restrictor valve on the inlet and in some cases also on the outlet.  In a few instances, flow control is accomplished in a more traditional manner, using a flow control valve on the outlet. With this process the inlet valve is set at the maximum filtration rate. An effluent valve is controlled by headloss. The valve starts in a partiality closed position. As the filter plugs, the increased pressure above the media is transmited to the effluent valve which opens maintaining a constant flow through the filter. Should the effluent valve fail the influent control valve will prevent damage to the filter.

## ROUTINE OPERATIONS

- Check the effluent quality daily.
- Check the raw water quality daily.
- Inspect the media once each year. Remove the top 1 inch and replace with new media. If polymer is being fed the filter media should be checked for mud balls and cracking at least once a quarter.

**Finished Water**

Usually very little is done to the finished water in a pressure filter system. Chlorine and fluoride may be added as well as chemicals such as soda ash for corrosion and pH adjustments.

# SUMMARY OF ROUTINE MAINTENANCE

There are four major components of a filter plant that require scheduled, routine maintenance: the pumps, control valve(s), filter media and chemical feed pumps

## PUMPS

Once a year, efficiency tests should be run on the raw water and backwash pumps. Once every three months the amperage, voltage and flow should be tested and recorded.

## FILTER

- Clean floc basin every 3 to 6 months.
- Clean sedimentation basin every 3 to 6 months.
- Inspect filter media every year.
- Check filtration and backwash rates every 3 months.
- Check chemical feed pump calibration every month.
- Disassemble, clean and replace gaskets on all control valves - each year.
- If valve contains a pilot valve - change seat, spring and valve each year.

## CHEMICAL FEED PUMPS

The chemical feed pumps should be calibrated once each year. The process of calibration is described above in the section on normal operation.

**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.
- 4 in 1 valve.

**About 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**

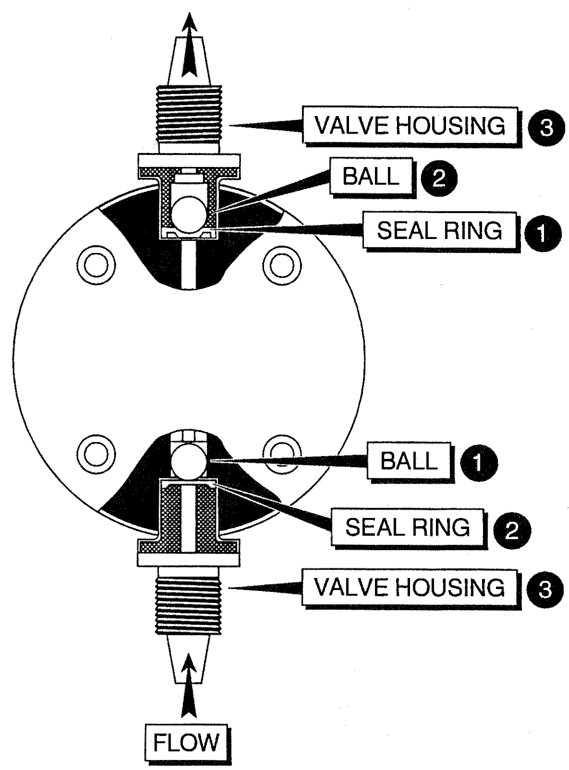
The repair kit required for a LMI pumping alum or soda ash is SP-U3.

## 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 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.

**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.

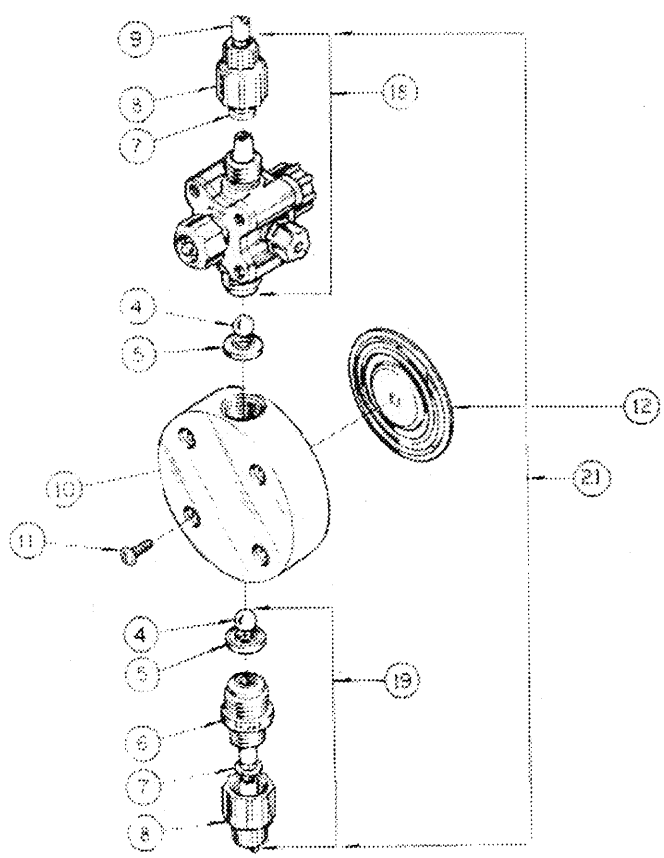
3. Remove coupling nut.
4. Remove suction valve seat.
5. Remove and replace ball, seat and seal ring. No Teflon tape should be used on the fitting or threads. Instead use silicon lube on threads (Dow 33 Moleycoat). Tighten the fitting by hand. If a wrench must be used do not tighten more than 1/8 turn.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

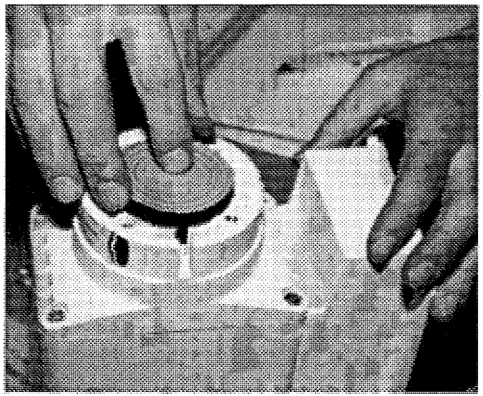
**Replace Diaphragm - LMI**

The following procedure can be used for the annual replacement of the diaphragm on LMI feed pumps.

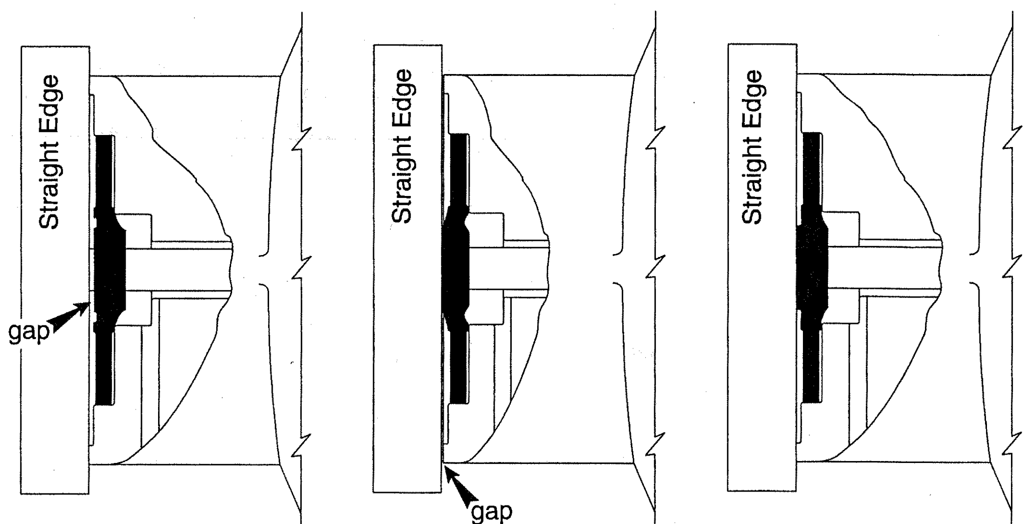
1. Flush pump by pumping clean water 10 min with stroke & frequency at 100%.
2. Turn settings to Zero.
3. Shut off pump.
4. Remove pump head.
5. Remove diaphragm. Grasp other edge and rotate counter clockwise.

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





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.



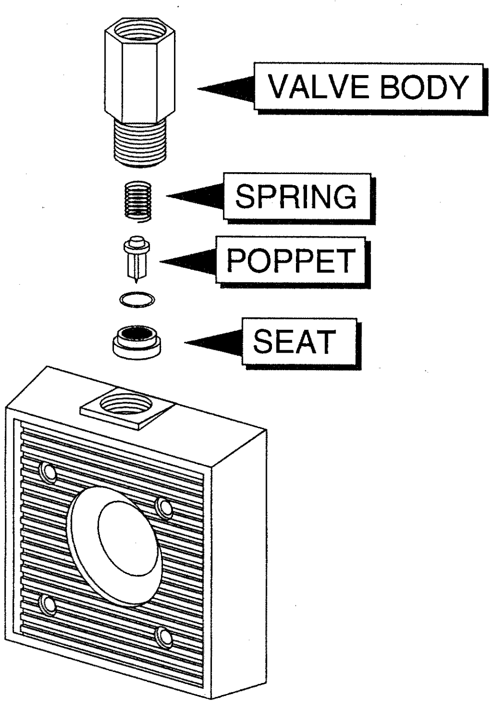

11. Replace head. Tighten the head bolts using a criss-cross pattern.

## W & T PUMPS

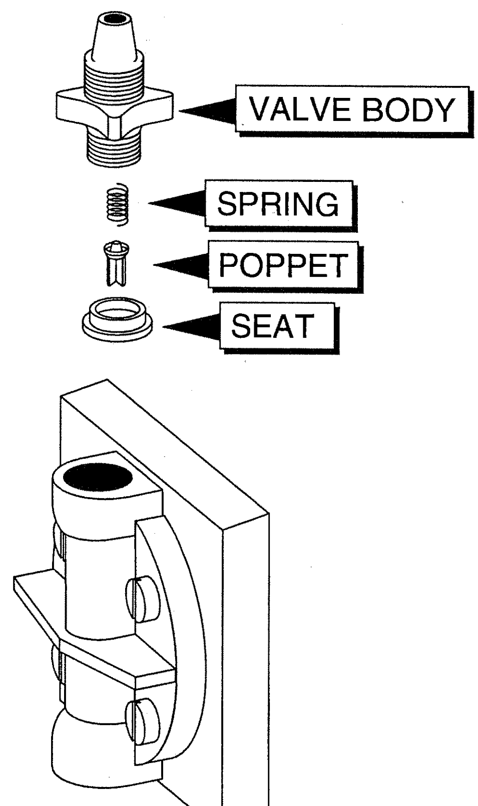
### Discharge & Suction Valves

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

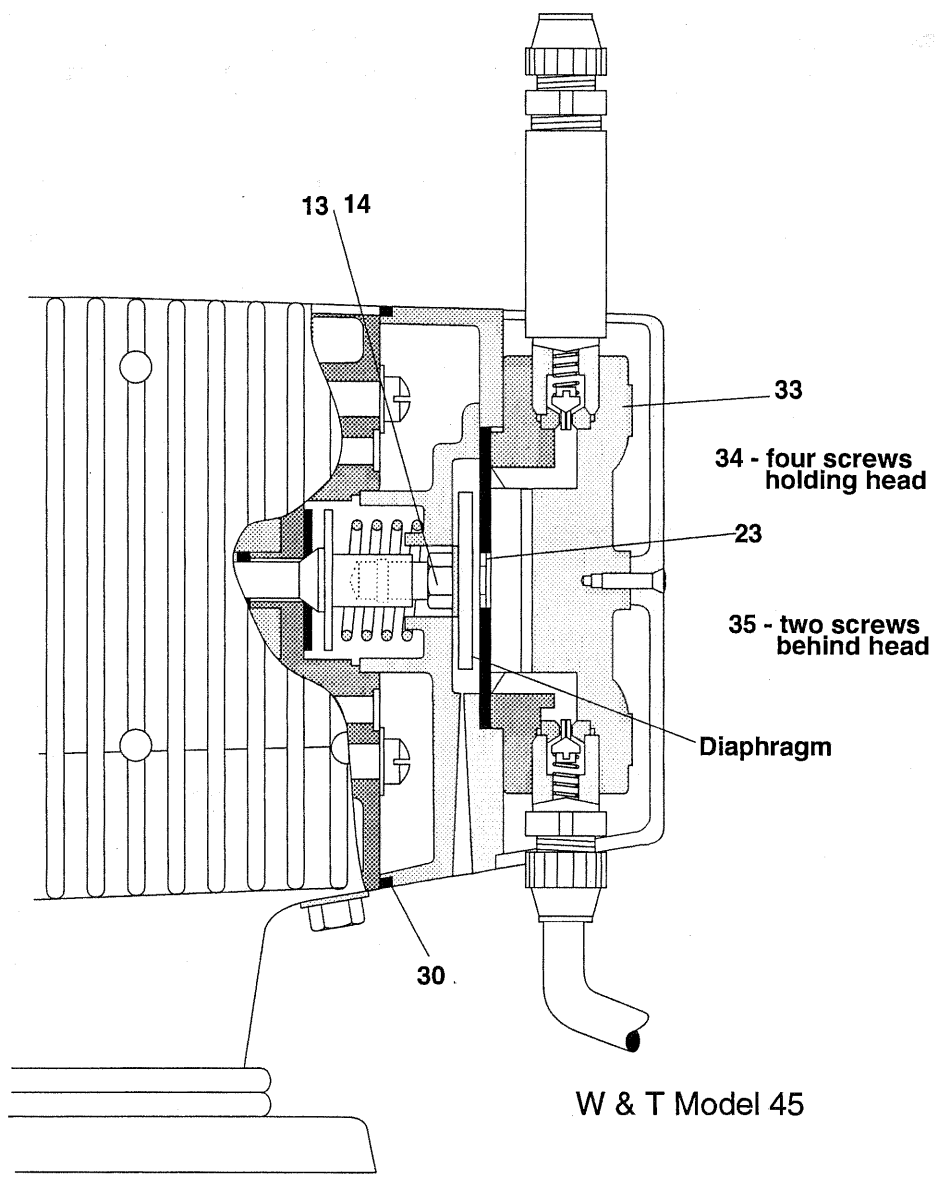



W & T 45

**Replace Diaphragm on W & T 45**

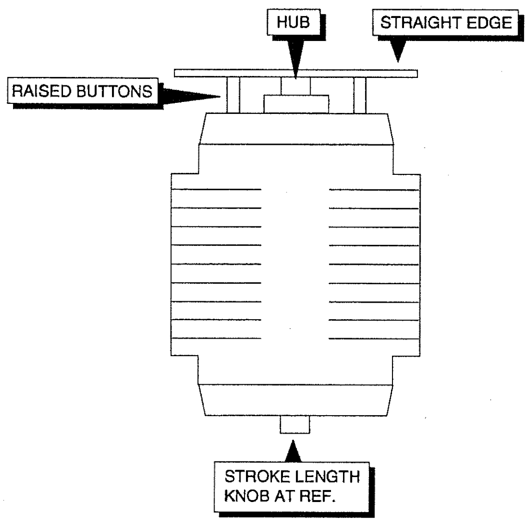
The following procedure can be used for the annual replacement of the diaphragm on a W & T model 45.

1. Flush pump by pumping clear water at maximum stroke.
2. Adjust stroke length to REF.
3. Turn pump off & lock-out or unplug.
4. Remove screws (34) from pump head (33).
5. Lift diaphragm by edge, turn counter clockwise.
6. Hold hub (23) and remove nut (13) and lock washer (14) and diaphragm.
7. Remove two screws (35).
8. Hold washer with pliers & turn diaphragm counter-clockwise.




W & T Model 45

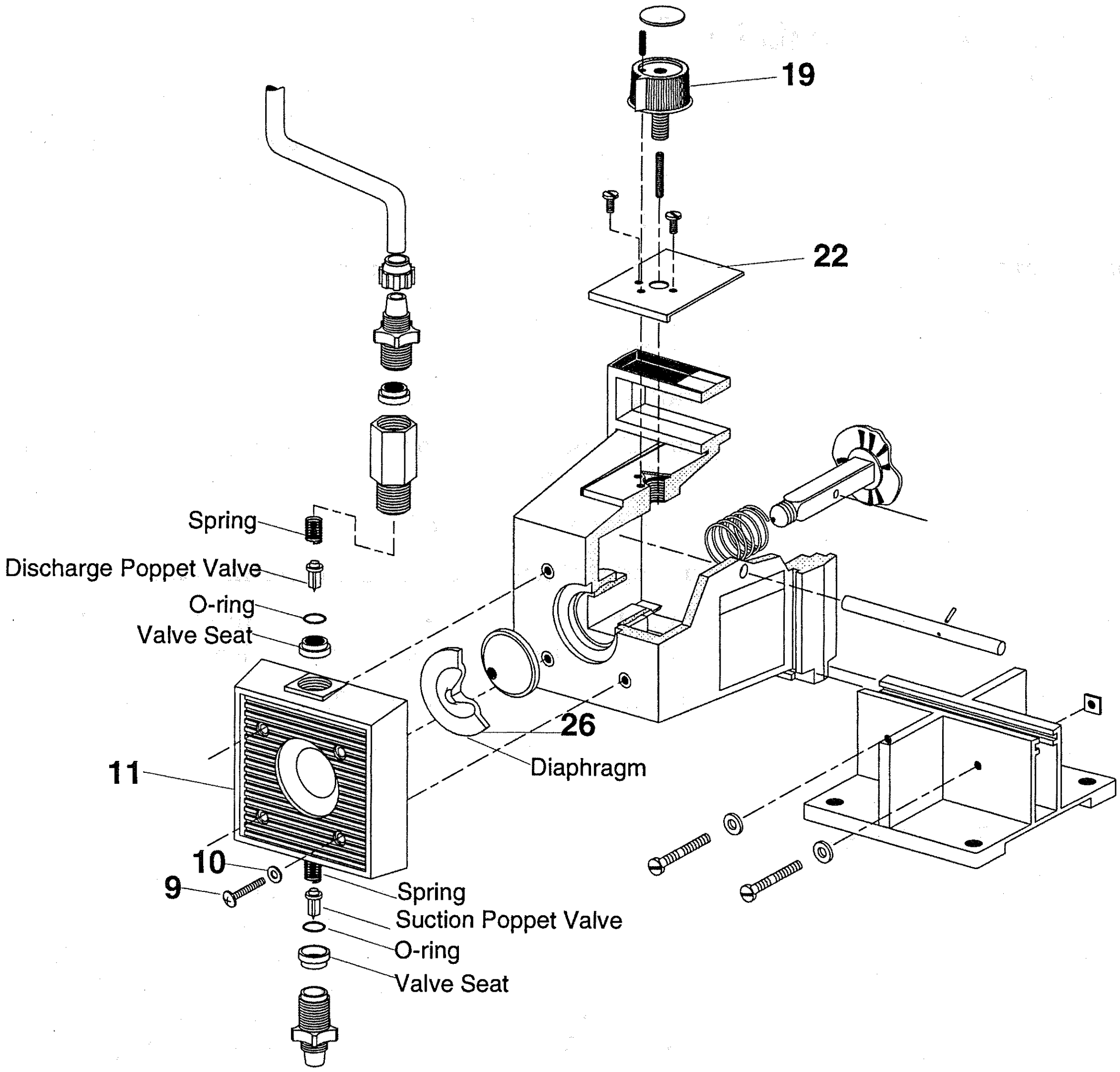
9. Replace diaphragm, lock washer and nut.
10. Tighten nut 30 inch pounds for 1 gph & 100 inch pounds for 5 & 10 gph.
11. Replace return spring into counter bore on inside of head adapter.
12. Clean internal threads of extension shaft.
13. Place extension shaft on top of spring - cone end out.
14. Place 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.




**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, turn counter clockwise.
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

# EXAMPLE OF TYPICAL SHUTDOWN

## SHUTDOWN

**Introduction**

Shutting this plant down is a relatively simple process. Just shut the equipment off in the following order.

### Backwash

Backwash filters

**Main Plant Control**

Turn the plant selector control knobs to off.

**Automatic Valves**

Observe the plant influent and effluent valves to see that they close.

**Raw water**

Shutdown raw water valve.

**Chemicals**

Turn the power selector switches on the alum and soda ash feed systems to off.

**Polymer**

Unplug the feed pumps and the make-up pump.

**Chlorine**

Unplug the power cord to the chlorine pump.

**Fluoride**

Shut off the inlet water supply and unplug the chemical feed pump and the inlet solenoid valve power supply.

**Backwash Pump**

Turn the power selector to off.

**High Service pumps**

Turn the power selector to off.

## EXTENDED OUT OF SERVICE NOTES

**Plants**

If you intend for any one plant to be off line for more than 24 hours, the floc basins and sedimentation basins should be drained. This will keep the sludge from going septic. The filter should be backwashed with chlorinated water, the chlorine dosage should be increased until a residual is present in the backwash.

**Chemicals**

If you intend for the chemicals to be off line several days you should drain and clean the tanks and flush the feed pumps with clean water.

**Soda Ash**

Because soda ash will take on water and become hard, it should not be left in the hopper if the unit is to be off line for more than 24 hours.

## PROBLEMS - SEE THE MODULE ON TYPICAL PLANT PROBLEMS

## 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

# O & M OF PRESSURE FILTERS WORKSHEET

1. The difference between conventional filtration and direct filtration is a direct filtration system does not have a __________.

   ______ a. Flocculation chamber

   ______ b. Chemical feed system

   ______ c. Sedimentation chamber

   ______ d. Surface wash system

   ______ e. Influent control valve

2. One method that has been successful in the removal of color in cold waters is to add a special coagulant called a ___________.

   ______ a. Iron salt

   ______ b. Lime

   ______ c.Soda Ash

   ______d. Nonionic sulfur

   ______e. Polymer

3. When turbidity shows up in the finished water prior to the end of the filter run the most probable cause is......

   ______ a. Breakthrough

   ______ b. Underfeeding alum

   ______ c. Excessive mud balls in filter media

   ______ d. The lack of proper coagulation

   ______ e. Low water temperatures

4. Alum is another name for .....

   ______ a. Ferric Sulfate

   ______ b. Alkalinity

   ______ c. Soda Ash

   ______ d. Aluminum Sulfate

   ______ e. Sodium Aluminate

5. A pressure filter should be backwashed when the headloss is between ____ and ____ psi.

_______ a. 6 and 9

_______ b. 1 and 5

_______ c. 8 and 10

_______ d. 6 and 12

_______ e. 10 and 15

6. A multimedia filter contains which three medias?

_______ a. Silica sand

_______ b. Coal

_______ c. Fine gravel

_______ d. Garnet sand

_______ e. Anthracite coal

7. A typical pressure filter has a media bed that is _____ to ____ inches deep.

_______ a. 12 to 24 inches

_______ b. 48 to 54 inches

_______ c. 36 to 60 inches

_______ d. 24 to 60 inches

_______ e. 24 to 42 inches

8. Typical filtration rates for pressure filters are between _____ and _____ $gpm/ft^2$.

_______ a. 1 to 5

_______ b. 2 to 4

_______ c. 3 to 6

_______ d. 1.5 to 4

_______ e. 4 to 8

9. Typical backwash rates on pressure filters should be between _____ and ______ gpm/ft2.

_______ a. 15 to 17

_______ b. 2 to 4

_______ c. 10 to 20

_______ d. 6 to 15

_______ e. 9 to 12

10. Identify the valves and piping on the pressure filter below by matching the numbers with the list provided.

_______ Influent

_______ Finished water

_______ Waste line

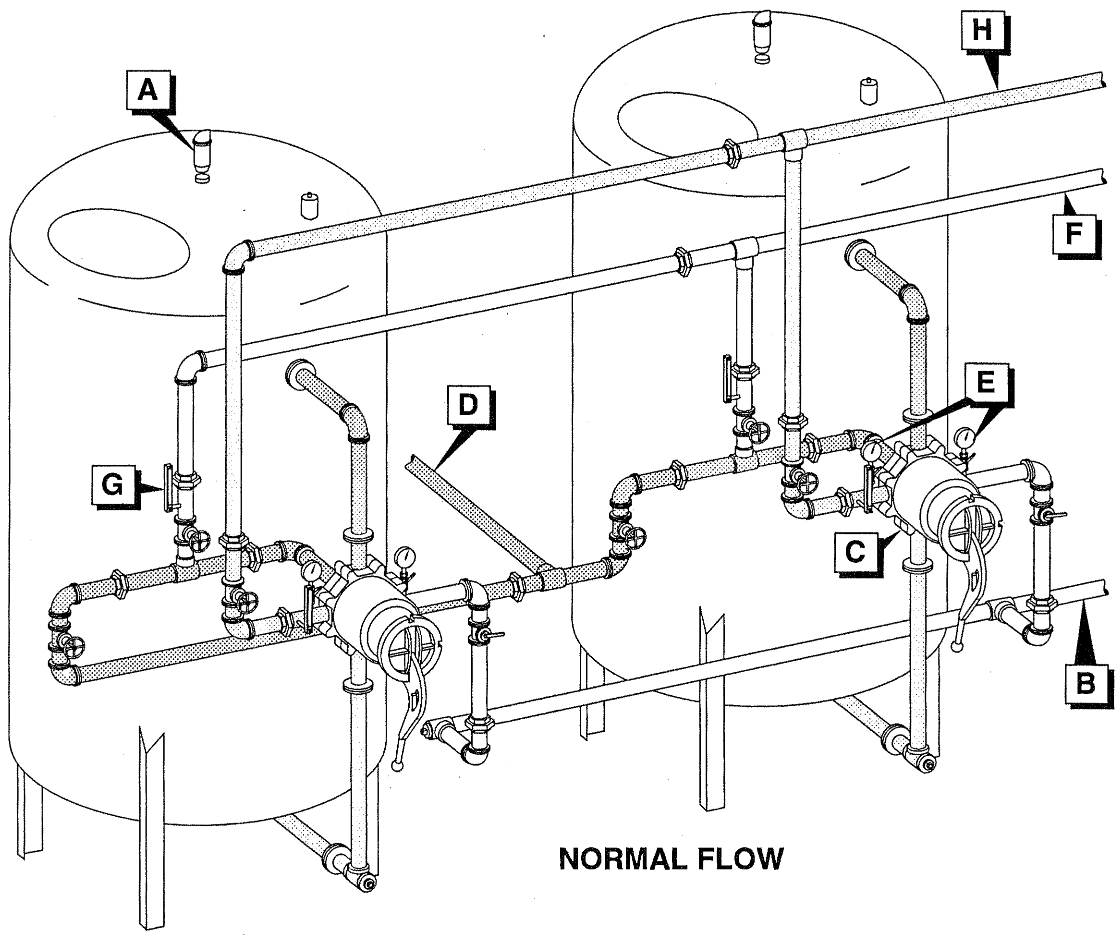
_______ Backwash supply

_______ Control valve

_______ Vent

_______ Headloss gauges

_______ Flow inicator




11. There are two pressure filters each four feet in diameter. The flow rate is 120 gpm. What is the filtration rate?

_______ a. 2.4

_______ b. 6.8

_______ c. 1.5

_______ d. 3.8

_______ e. 4.8

12. There are two pressure filters each four feet in diameter. What would the backwash pumping rate be if it were necessary to backwash the filter at 17 gpm/ft$^2$?

_______ a. 55

_______ b. 107

_______ c. 214

_______ d. 321

_______ e. 86

13. What type of breathing protection is required when handling alum?

_______ a. Dust mask

_______ b. Full face cartridge respirator

_______ c. SCBA

_______ d. None

_______ e. Cartridge dust mask

14. The two most common chemicals used in small water treatment plants are alum and soda ash. Both are a powder. Which is the most hazardous to handle.

_______ a. Alum

_______ b. Soda Ash

15. Which is the recommend material for handling a fire associated with alum?(Mark the most correct answer (s))

_______ a. Dry chemical

_______ b. $CO_2$

_______ c. Halon

_______ d. Water

X e. All of the above

16. When using a polymer as a primary coagulant the most common dosage range is between______ and _________ mg/L.

_______ a. 4 and 10

_______ b. 17 and 24

_______ c. 0.1 and 0.4

_______ d. 1 and 5

_______ e. 12 and 20

17. 50 pounds of alum was placed into a 50 gallon container to make 45 gallons of solution. Find the concentration of the solution in percent.

_______ a. 6%

_______ b. 13%

_______ c. 25%

_______ d. 95%

_______ e. 54 %

18. 12 gallons of an 8% solution of alum was pumped into a flow of 34,000 gallons. What is the dosage in mg/L?

_______ a. 13 mg/L

_______ b. 17 mg/L

_______ c. 21 mg/L

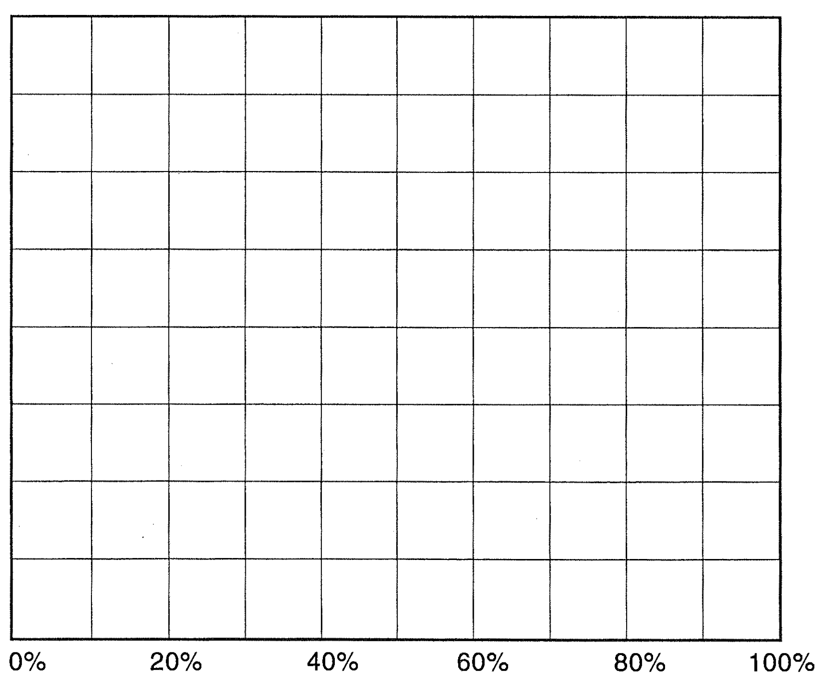
_______ d. 3 mg/L

_______ e. 28 mg/?

19. 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 | ____________ |



20. A typical backwash should take approximately ________ min.

_____ a. 5 min

_______ b. 30 min

_______ c. 15 min

_______ d. 45 min

_______ e. 4 min