POLYMER SYSTEMS FOR WATER & WASTE WATER TREATMENT 101

Introduction

Polyelectrolytes used in water & waste water treatment systems have certain storage, handling, feeding, and dilution requirements. It is imperative that these materials be fed accurately to prevent underfeeding and overfeeding, which can result in wasted chemical treatment and poor system performance.

Polymer Types

Polymers are available as powders, liquids, and emulsions. Each form has different feeding, handling, and storage requirements.

Water Quality

Fresh clean water should be used for the makedown of all polymers. The temperature range should be between 60-90 F. Warmer water allows faster makedown and dilution than colder water. Avoid waters having high temperature (120 F), High hardness (>300 ppm $CaCO_3$), high alkalinity (>75 ppm alkalinity), or high chlorine residual (>2 ppm) as these can rapidly deteriorate polymers. Made down or diluted polymers should not be stored over 24 hours.

Chemical Concentrations

The maximum, minimum and suggested solution strengths are listed in the following table. ***Please note: This should be used as a guideline only. All polymers should be prepared according to the chemical vendors' specific instructions.*** Failure to meet these conditions could lead to a poor polymer program.

These solution strengths are required to ensure complete dissolution of dry polymers and a complete inversion of emulsion polymers. These concentrations are dictated by the eventual solution viscosity and the required concentration of the inversion surfactant. Time is also necessary to allow for dissolution and uncoiling of these polymers.

Secondary Dilution

After the polymer has been mad down to the proper concentration, additional dilution water (minimum 10:1) should always be used. This ensures proper dispersion of the polymer at the point of application. Fresh water or clarified process water can be used at the point of polymer feed for secondary dilution.

POLYMER MAKEDOWN EQUIPMENT

Different types of equipment are required for liquid, emulsion, and dry polymer makedown. To dissolve in water, each individual polymer molecule must be wetted. Polymer ionizes in water; and in doing so, the molecules uncoil as a result of natural repulsion of similar charges along the length of the polymer chain.

DRY POLYMERS

Both cationic and anionic high molecular weight polymers are available in powdered form. These products have the advantage of being 100% polymer, which can minimize shipping and handling costs.

It is absolutely essential that dry polymer materials be handled and diluted properly to prevent quality problems, underfeeding and overfeeding. If dry polymer particles are not individually wetted, clumps of undissolved polymer, often called fisheyes, will form. Since fisheyes are unusable polymer, they lower the cost effectiveness of the application. The plugging of ball check valves and filters are additional problems that result from improperly dissolved polymers.

Polymer System Makedown Concentration Requirements

Product	Recommended Makedown Concentration, %	Makedown Concentration % Max & Min	Recommended Mix time (min)	Minimum Mix time (min)	Typical Viscosity @ 0.5%, (cPs)	Molecular Wt X 10^6
Cationic Liquid (solution polymer)	10:1 dilution (a)	(b)	-	-	250-5000 (neat solution)	0.01-0.50
Cationic Liquid Mannich sol'n polymer	20:1 dilution	10/20:1 dilution (b)	-	-	17000-40000 (neat solution)	1.00-2.00
Cationic Emulsion 'A'	0.75	1.50-0.75	30 (c)	15 (c)	1000-6000	8.0-10.0
Cationic Emulsion 'B'	1.00	1.50-0.75	30 (c)	15 (c)	500-2000	4.0-8.0
Cationic Powder 'A'	0.50	0.75 (b)	90	60	700-2000	9.0-14.0
Cationic Powder 'B'	0.50	0.75 (b)	45	20	1100	3.0-8.0
Anionic Emulsion	0.75	1.00-0.50	30 (c)	15 (c)	1100-4000	3.5~23.0
Anionic Powder	0.25	0.50 (b)	60	45	1500-3000	3.5-5.0
Organic Particulate (emulsion)	1.00	2.00-0.50	30 (c)	15 (c)	(d)	(d)

a) Dilution is recommended but not required. These polymers may be fed neat to areas with extremely good mixing
b) No lower limits exist. Determine by evaluating tank size and pump capacity
c) With automatic makedown units, emulsion polymers need 15-30 min aging time. Additional mixing is recommended but not required. No aging or additional mixing is necessary for clarification applications.
d) Data not available

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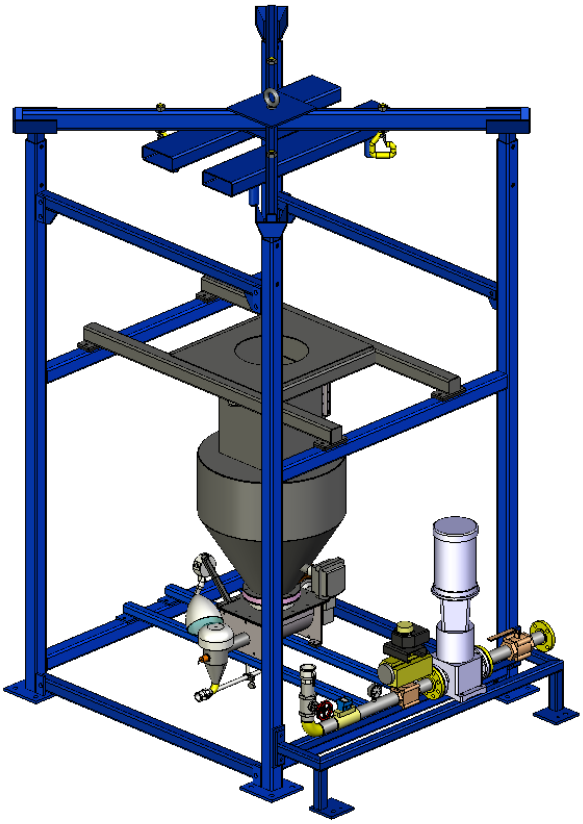
Storage

Dry polymers are susceptible to caking if stored under highly humid conditions. Caking is undesirable because it interferes with the polymer make-down and dilution process. Dry polymers should be kept in areas of low humidity, and opened containers of dry material should be sealed prior to re-storage. In general, polymer products begin to lose their activity after 1 year of storage. Although this process is gradual, it ultimately affects the cost of chemical treatment. It is highly recommended that polymers be used before their expiration dates.

Dilution and Feeding

Dry polymers must be diluted with water before use. Automatic dry polymer dilution systems can be used to perform the wetting, diluting, and mixing functions however, the system must be manually recharged with dry polymer periodically. These systems can save appreciable time for plant personnel, and operations are usually more consistent when automatic make-down units are used.



The contents of the hopper are conveyed to the mixing tank through a polymer eductor. The eductor is a device that uses water pressure to create a vacuum and is designed so that dry polymer particles are wetted individually by the water as they pass through the eductor assembly. If dry polymer particles are not wetted individually before introduction into the dilution tank, "fisheyes" (undissolved globules of polymer) will form in the solution tank. Fisheyes represent wasted polymer and cause plugging in chemical feed pumps.

Dry polymer solution strengths must be limited to approximately 0.5-1% or less by weight, depending on the product used. This is necessary to keep the solution viscosity to a manageable level. The mixer employed in the solution tank should not exceed 350 rpm, and mixing should proceed only until all material is dissolved. Normally, a batch of diluted dry polymer should be used within 24 hr of preparation, because the diluted product begins to lose activity after this amount of time.

It is usually desirable to provide secondary dilution water capabilities to polymer feed systems, because these products tend to be most effective when fed at approximately 0.1% solution strength.

EMULSION POLYMERS

Both cationic and anionic high molecular weight polymers are available as emulsions. An emulsion product allows the manufacturer to provide concentrated liquid polymer formulations that are not in a water solution form. The active polymer in emulsion products is tightly coiled in droplets called micelles. These droplets are polymer emulsified in an oil phase. It is only after the emulsion polymer has "inverted" with water that the polymer is available in its active form. Therefore, these products must be diluted properly prior to use.

Storage

Because emulsion polymers are not true solutions, they separate if allowed to stand for a prolonged period of time. Therefore, emulsion polymers must be mixed prior to use with a drum mixer, tank mixer, or tank recirculation package.

A bulk tank or bin recirculation package should be designed to recirculate the tank's contents at least once per week for 30-60 minutes to prevent separation. Emulsion polymers contained in drums or totes should also be mixed regularly. Tote mixing packages complete with timers are available from Hayward Gordon. See below.

Tote Mounted Mixing Bridge with Timer & DC Controller

Neat emulsion polymer must be protected from water contamination, which causes gelling of the product and can make pumping difficult or impossible. In areas of high humidity, tank vents should be outfitted with a desiccant in order to prevent water condensation within the emulsion storage tank. Even small amounts of condensation can cause significant amounts of product gelling. As with liquid products, emulsion polymers must be protected from freezing and should be stored at temperatures below 120°F.

Dilution and Feeding

Emulsion polymers must be diluted before use. Dilution allows the emulsion product to invert and "converts" the polymer to its active state. Proper inversion of emulsion polymers is rapid and effective. Improper inversion of the emulsion polymer can result in loss of activity due to incomplete uncoiling and dissolution of the polymer molecules. ***Do not add water to polymer. Always add polymer to water.***

Drum, semi-bulk, or bulk supply of emulsion polymer is typically made down with an automatic inversion system. Hayward Gordon manufacturers and markets continuous emulsion polymer make-down and feed systems. These systems pump neat polymer directly from the storage container into a dilution chamber, where the polymer is combined with water and fully activated. The polymer-water solution then flows by water pressure to the point of application. Provision is made for secondary in-line dilution water to dilute the polymer further prior to use. These

polymer feed systems are by far the easiest and best ways to feed emulsions continuously. They provide superior ability to invert the polymer molecule over batch tank dilution systems. A commercially available continuous emulsion polymer makedown system is shown in Figure (right).

It is not typically acceptable to use in-line static mixing alone for dilution of emulsion polymers. However, in-line static mixing can be employed for blending secondary dilution water with diluted emulsion product prior to application. Initial dilution of emulsion polymers should be 1% or 2% by weight. This solution strength ensures proper particle-to-particle interaction during the inversion step, which aids in complete inversion.

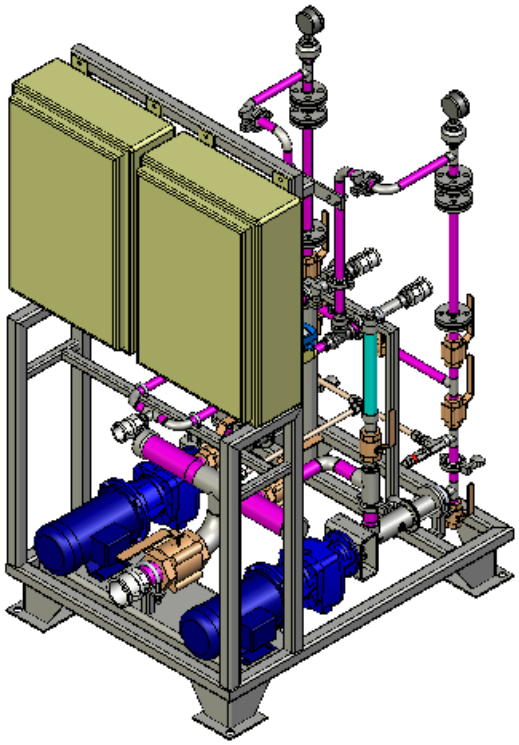
It is usually desirable to provide secondary dilution water capabilities to emulsion polymer feed systems because these products tend to be most effective when fed at approximately 0.1% solution strength.

SOLUTION POLYMERS

Solution polymers are usually cationic, low molecular weight, high charge density products, and are usually used for clarification of raw water. Solution polymers are easier to dilute, handle, and feed than dry and emulsion polymers. In many cases, pre-dilution of a solution polymer is unnecessary, and the product can be fed directly from the shipping container or bulk storage tank. Solution polymers offer the convenience of neat feed, and they can be diluted to any convenient strength consistent with chemical feed pump output.

Storage

Solution polymers should be stored in an area of moderate temperature to protect them from freezing. Some solution products are susceptible to irreversible damage when frozen. Others exhibit excellent freeze-thaw recovery. In no case should solution polymers be stored at temperatures above 120°F. As solutions, these polymers do not require periodic mixing (to prevent separation) before use. However, some solution polymers have a short shelf life, and inventory should be adjusted accordingly.



Dilution and Feeding

Solution polymers may be diluted prior to use or fed neat from a shipping container, bin, or bulk storage tank. Dilution of these products becomes necessary if there is insufficient mixing available to combine the polymer with the water being treated. In-line static mixer dilution systems are acceptable for solution polymers and are the simplest method of solution polymer dilution and feed. Solution polymers can be pumped most easily with progressing cavity or gear pumps. However, some solution polymers have a viscosity low enough to be pumped by diaphragm chemical metering pumps.

General Recommendations

In addition to the above, some general guidelines apply to the feeding and handling of all water treatment polymers. In areas where the temperature routinely drops below freezing, it is good practice to insulate all polymer feed lines so that feed line freezing does not occur.

For tank batches of diluted polymers, tank mixer speeds of over 350 rpm should not be used. On large tank systems where there can be high impellor tip speeds, lower rpm mixers should be considered to avoid excessive shear to the polymer. In the preparation of diluted batches of polymer, water should always be added to the tank first. Then, the mixer should be started and the polymer added on top of the water.

Do not uses high shear pumps (centrifugal pumps) to transfer or feed made down polymer solutions. Instead use gear, progressing cavity, Waukesha, Jabsco flexible impellor or diaphragm pumps to transfer solutions to a day tank.

Plastic piping can be used in polymer feed systems; stainless steel is also commonly used for wetted parts. Most polymers are corrosive to mild steel and brass. Extra precautions should be taken to prevent spilling of polymers, because wet polymer spills can become extremely slippery and present a safety hazard. Spills should be covered with absorbent material, and the mixture should be removed promptly and disposed of properly.
