The four available polymer types are liquid solution coagulants, liquid solution flocculants, liquid emulsion flocculants, and dry flocculants.

Organic liquid solution coagulants are characterized by their lower molecular weights (5,000-300,000) and high cationic charge densities. The cationic charge is used to neutralize the negatively charged suspended solids in water. With this neutral charge, suspended solids no longer repel each other and are able to agglomerate and settle out of solution.

Organic flocculants are characterized by their higher molecular weights (1,000,000-10,000,000) and variety of charge densities. They can be either anionic (negatively charged), nonionic (no charge) or cationic (positively charged). Flocculants are used to bridge the neutralized or coagulated particles into larger agglomerates, resulting in more efficient settling. Flocculants are used in solids thickening, in sludge dewatering and as coagulation aids.

**LIQUID SOLUTION COAGULANTS**

Coagulants are available in liquid solution form in concentrations ranging from 6 to 50%. Molecular weight, viscosity and solution solubility are all characteristics that determine a product’s concentration.

Neat (product as shipped) organic coagulants generally have viscosities ranging from 20 to 5,000 cp at 70 °F (21 °C) and generally have complete freeze-thaw recovery. At typical temperatures of 40-100 °F (4-38 °C) most of these products can be stored up to one year in unopened drums and in bulk storage tanks. If stored at temperatures outside the recommended range, performance of the coagulant may diminish. Specific physical characteristics and handling recommendations are discussed in individual product bulletins, available from your Nalco sales engineer.

**Feeding**

Liquid solution coagulants should be fed as received, needing only dilution water to disperse the polymer into the water or wastewater being treated.
Figure 1 is a diagram of a typical coagulant feed system. A positive displacement gear pump and diaphragm pump are acceptable for pumping the neat polymer. Calibration cylinders are recommended for feeding organic coagulants and for all polymer feed systems so that the polymer delivery rate can be accurately monitored under varying service conditions.

A static-type in-line mixer is recommended for liquid solution coagulants to thoroughly intermix the denser polymer with the dilution water before it reaches the application point. As illustrated in Figure 1, a static mixer should be applied after the dilution water line.

To prevent contamination, check valves should be installed in the dilution water line as well as the line from the pump to the dilution water tee.

Optional Dilution Water Requirements

Dilution water of sufficient capacity to deliver 1 to 10% polymer concentration is recommended. Water should be free of insoluble solids, range from 50 to 100°F (38°C), and contain less than 0.5 ppm total chlorine residual. If optimum performance is to be achieved, these guidelines must be followed. Dilution water with a high level of hardness may cause precipitation in the dilution lines. If this occurs, feed the coagulant neat or use soft water for dilution.

LIQUID SOLUTION FLOCCULANTS

Liquid solution flocculants are available in concentrations ranging from 2 to 8%. As with all polymers, molecular weight, solution solubility and viscosity are all characteristics that determine a liquid solution flocculant's concentration. Nalco liquid solution flocculants are either cationically or anionically charged.

In neat form, liquid solution flocculants generally range in viscosity from 5,000 to 70,000 cp at 70°F (21°C) and generally have complete freeze-thaw recovery. To ensure optimum feeding performance, neat product should be stored indoors or in insulated storage tanks at temperatures of 70 to 80°F (21 to 27°C). If storage temperatures are below 70°F (21°C), pumping and handling problems may occur.

At temperatures above 80°F (27°C), product activity may deteriorate. Storage tanks located indoors should be vented outside to eliminate odors. Shelf life for liquid solution flocculants is generally three to six months in unopened drums and bulk tanks. For recommended storage limits, always refer to the individual product bulletins.
The flocculant feed system shown in Figure 3 uses the ValueLine or Nalco Polymer Feed Systems. These feeders (Figures 4 and 5) eliminate the need for in-line dilution water, static mixers and check valves. These feed systems automatically mix dilution water and polymer in a specially designed mixer within the feeder.

**Dilution Water Requirements**

Use sufficient water to make up the initial dilutions to 5-20% and application dilutions to 0.5-5%. Makeup and dilution water should be free of insoluble solids, range from 50 to 100°F (10 to 37°C), and have a total chlorine residual of less than 0.5 ppm.

Dilution water should be individually metered to each application point. Typically, a rotameter is used for this purpose.

**LIQUID EMULSION FLOCCULANTS**

Many liquid emulsion flocculants were developed, patented and licensed by Nalco. These emulsion products provide active polymer concentrations ranging from 25 to 75%. Liquid emulsion flocculants are available in cationic, nonionic and anionic charge forms.

In neat form, liquid emulsion flocculants range in viscosity from 200 to 700 cp at 70°F (21°C) and generally have complete freeze-thaw recovery. Shelf life for liquid emulsion flocculants is generally six months in unopened drums and bulk tanks. To minimize product separation, bulk tanks should be equipped with a recirculation pump. The tank contents should be recirculated only once a day. Drums should be mixed with drum mixers for 15 minutes prior to initial application. Bulk tanks should also be equipped with an air drier and breather vent to prevent premature activation (gelling). Figure 6 illustrates a fully equipped bulk tank. Polymer activity deterioration may occur at storage temperatures above 100°F (37°C). For specific physical characteristics and handling recommendations, refer to individual product bulletins.

**Feeding**

Water must be added and agitation applied to the neat emulsion flocculant to invert the product to solution form. This inversion process is necessary to achieve maximum activity. Following the inversion process, liquid emulsion flocculants must be subjected to a period of “aging”. Two common methods used to activate (invert and age) liquid emulsion flocculants are batch and continuous makeup. In batch systems, 15-30 minutes of mixing is typically sufficient to invert and age the polymer. Figure 7 illustrates a typical batch makeup system. The Nalco ValueLine Polymer Feeder with SS tank (Figure 8) is an automatic feed system specially designed for feeding liquid emulsion flocculants in small applications. For larger applications, the ValueLine or Nalco Polymer Feeders can be married with a broad selection of day tanks and gear or progressive cavity pump systems. When compared to typical batch systems, these systems will offer improved product activity.
Dilution Water Requirements

All these systems replace the calibration cylinder, metering pump, mix tank and transfer pump enclosed in the black square in Figure 7.

Dry flocculants have polymer concentrations ranging from 85 to 95% and are available in cationic, nonionic, and anionic charge forms. Typically, dry flocculants remain stable for one year when kept dry in unopened bags.

Feeding

When making up and feeding dry polymers, it is necessary to uniformly wet each solid particle to avoid “fish eyes”. Fish eyes are undissolved polymer particles that adhere to each other and do not function as active polymer. Once fish eyes are formed, it can take several hours to disperse them into a homogeneous solution.

A good dry feed system (Figure 9) should include a wetting device, an aging tank and a metering system. A common technique involves using some form of disperser and making up a primary solution. The solution should be mixed and aged from 30 to 60 minutes, depending on the dry flocculant.

Automatic dry feed systems are available. These systems provide automatic and continuous feed of polymer solutions. (See Figure 10.)

Dilution Water Requirements

Enough dilution water should be added to make up a 0.1-0.8% primary concentration. Secondary dilution water should be added in-line to reduce the application concentration to 0.01-0.5%. Dilution water should be free of insoluble solids and contain less than 0.5 ppm chlorine residual.
GUIDELINES

The following guidelines should be considered in the design of all polymer makeup and feeding systems.

1. **Technical assistance** – Always consult Nalco for specific polymer feeding recommendations and metallurgy information.

2. **Material compatibility** – Most polymers attack mild carbon steel, and some may be corrosive to stainless steel. Plastics such as polyvinyl chloride, polyethylene and polypropylene are generally suitable. Refer to the specific product bulletins for recommended materials of construction.

3. **Day tanks** – In general, do not store made-up diluted polymer solutions in day tanks for longer than 24 hours. Twelve hours is considered the maximum time for some polymers. Higher solution concentrations are less susceptible to polymer degradation than lower concentrations.

4. **Storage temperatures** – High ambient temperatures (in excess of 100°F (37°C)) can cause polymer degradation. Freeze protection should be provided for all neat and diluted polymers. If frozen, most polymers can be thawed, mixed and used with no activity reduction.

5. **Pump selection** – In general, gear pumps, diaphragm pumps and progressive cavity pumps are recommended for handling neat polymer and polymer dilutions.

6. **Feed system design** – Bench tests and in-plant evaluations should be performed before designing a complete polymer feed system.

7. **Polymer dilutions** – Table 1 summarizes typical target polymer makeup dilutions.

### Table 1 — Polymer dilution guidelines

<table>
<thead>
<tr>
<th>Polymer form</th>
<th>Primary makeup conc.</th>
<th>Application conc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Solution coagulant</td>
<td>— —</td>
<td>1 – 10%</td>
</tr>
<tr>
<td>Liquid solution flocculant</td>
<td>5 – 20%</td>
<td>0.5 – 5%</td>
</tr>
<tr>
<td>Liquid emulsion flocculant</td>
<td>0.5 – 2.0%</td>
<td>0.05 – 0.2%</td>
</tr>
<tr>
<td>Dry flocculant</td>
<td>0.1 – 0.8%</td>
<td>0.01 – 0.05%</td>
</tr>
</tbody>
</table>

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