Designation: D 4188 – 82 (Reapproved 2003)

An American National Standard

Standard Practice for Performing Pressure In-Line Coagulation-Flocculation-Filtration Test [1]

This standard is issued under the fixed designation D 4188; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the procedure used to perform pressure in-line coagulation-flocculation-filtration of water and waste water. It is applicable to water and waste water with relatively low suspended solids (<30 mg/L). The practice is applicable for any size filter greater than 100 mm (4 in.) in diameter.

1.2 This practice can be used to determine the effectiveness of flocculants or coagulants, or both, and filter medium(a) in removing suspended and colloidal material from water and waste water.

1.3 Interval between filter backwashing, backwash requirements, rinse requirements, and effect of filtration rate on effluent quality can also be obtained with this practice.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 1129 Terminology Relating to Water

D 1888 Test Methods for Particulate and Dissolved Matter, Solids, or Residue in Water[3]

D 1889 Test Method for Turbidity of Water

D 2035 Practice for Coagulation-Flocculation Jar Test of Water

D 3370 Practices for Sampling Water from Closed Conduits

D 4187 Test Methods for Zeta Potential of Colloids in Water and Waste Water[3]

D 4189 Test Method for Silt Density Index (SDI) of Water

3. Terminology

3.1 *Definitions:* For definitions of terms used in this practice, refer to Definitions D 1129.

4. Summary of Practice

4.1 A flocculant or coagulant, or both, is added to a pressurized flowing water or waste water stream, and the floc that forms is removed, using a filter medium(a).

4.2 The effectiveness of the system in removing suspended and colloidal matter is determined by monitoring the quality of the filter effluent.

4.3 A holding tank for floc formation or floc growth is optional.

4.4 The practice also provides information on interval between filter backwashing, backwash requirements, rinse requirements and effect of filtration rate on effluent quality.

5. Significance and Use

5.1 Pressure in-line coagulation-flocculation followed by filtration is an effective process to remove suspended and colloidal matter from water and waste water.

5.2 The effectiveness of this process is dependent on the type and concentration of the flocculant or coagulant, or both, the pH, the temperature, the filtration medium(a), and the filtration rate. This practice permits the evaluation of these various parameters.

5.3 This practice can also be used to determine filter backwash and rinse requirements.

5.4 The results obtained from this practice can be used for plant design of large systems.

6. Apparatus

6.1 *Installation*:

6.1.1 To prevent contamination by corrosion products, use stainless steel, plastic, or coated (rubber or epoxy-lined) steel for all wetted parts.

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[1] This practice is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.03 on Sampling of Water and Water-Formed Deposits, Analysis of Water for Power Generation and Process Use, On-Line Water Analysis, and Surveillance of Water.

Current edition approved Oct. 29, 1982. Published March 1983.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Withdrawn.

6.1.2 Take care to ensure that no contamination will occur from oil films on new metal piping, release agents on raw plastic components, or from solutions previously used in the system. Thoroughly clean or degrease, or both, any materials that are suspect.

6.1.3 Design all pressurized components based on the manufacturer's working pressure rating. Review the manufacturer's rating for compliance with standard engineering practice.

6.1.4 Assemble the system as shown in Fig. 1. The holding tank just preceding the filter is optional. Use a manual flow control valve to regulate the filter effluent flow.

NOTE 1—Since the filter is intended to be operated at constant flow with differential pressure changes across the filter, manual flow adjustments may be required periodically. For streams that yield a high filter loading rate, an automatic flow control valve might be required.

NOTE 2—If a holding tank is used, it should be designed to obtain uniform flow to minimize stagnant zones and to keep the floc suspended. It should also be sized to obtain the desired retention and contain an air vent.

6.1.5 Operate the apparatus by drawing water from the water supply and pumping it through the system under pressure. Use a gage pressure of 275 to 345 kPa (40 to 50 psi) as the filter inlet pressure.

NOTE 3—If the water supply is already sufficiently pressurized, the pressurizing centrifugal pump is not required.

6.1.6 Use a single calibrated pressure gage equipped with a" quick-connect" fitting to measure the filter inlet pressure and filter pressure drop. Individual gages are also satisfactory but not as reliable as a single "quick-connect" pressure gauge.

6.1.7 Use either a flowmeter or a calibrated volume container and stopwatch to measure the filter effluent flow.

6.1.8 Use an accurate metering pump to inject the flocculant or coagulant, or both. Use an injector with a check valve and locate the teat of the injector in the center of the flowing stream and in the vertical position.

6.1.9 Use a calibrated volume container and stopwatch to measure the injection pump rate.

NOTE 4—If the suction line of the metering pump is placed into the volume container, it is necessary to subtract the volume displaced by the suction line.

6.1.10 With small inside diameter piping (½-in. nominal), use five or six right-angle elbows for mixing. With large inside diameter piping, use in-line static mixing to obtain good mixing.

6.1.11 Valve the filter so the raw water supply can be used for backwashing.

6.1.12 To protect the pump, install a flow-sensor switch to shut the system down if the water supply to the pump is interrupted.

NOTE 5—If a centrifugal pump is used, excessive pressure is usually no problem provided the pump or piping or both are properly sized. Either a high-pressure limit control switch or a pressure-relief device can be installed after the pump, if there are any doubts about excessive pressure.

6.1.13 If the system pressure fluctuates by more than ± 35 kPa (±5 psi), install a pressure regulator immediately downstream of the pressure control valve.

6.2 To minimize wall effects, use a filter with a minimum diameter of 100 mm (4 in.).

7. Reagents

7.1 For a list of typical coagulants and the preparation of polyelectrolyte solutions, refer to Practice D 2035.

8. Procedure

8.1 *Start-Up Procedure*:

8.1.1 First, backwash the filter with the supply water to thoroughly clean the filter medium. Use the backwash rate recommended by the filter medium supplier, which is usually 20 to 50 $m^3/(h{\cdot}m^2)$ of filter area (8 to 20 $gal/(min{\cdot}ft^2)$). Backwash the filter until the turbidity (as determined by Test Method D 1889) of the backwash is equal (within 10 %) to the

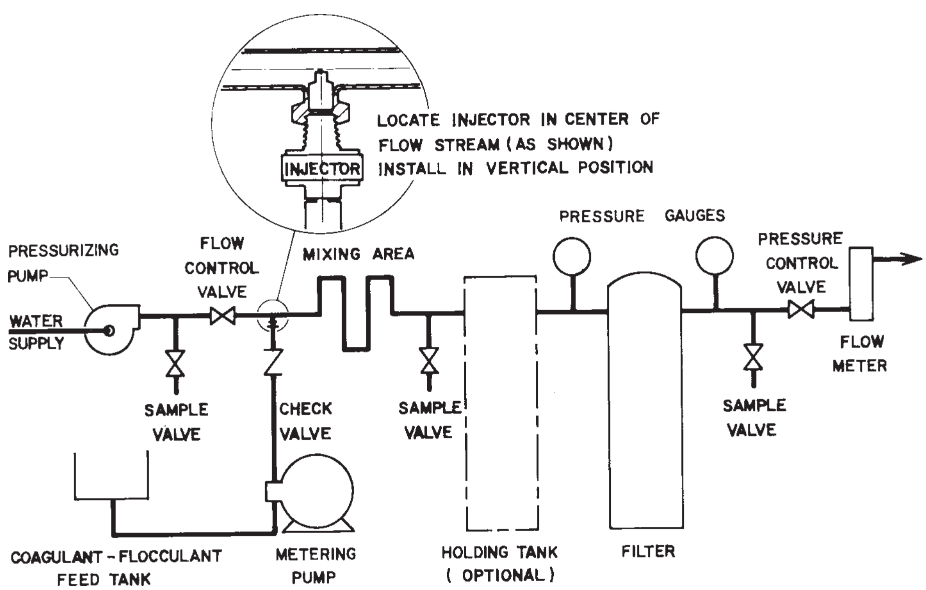

FIG. 1 Typical Pressure In-Line Coagulation-Flocculation Filtration System

turbidity of the supply water. For all sampling follow the procedure given in Practices D 3370.

NOTE 6—New medium usually contains many fines which need to be removed for the best filter performance. During backwash approximately 2 to 3 % of the medium can be siphoned off at the top of bed to remove fines.

8.1.2 After backwashing, operate the filter in the service mode and adjust the flow rate and pressure by adjusting both the flow control valve and the pressure control valve.

8.1.2.1 Set the inlet pressure to the filter at a gage pressure of 275 to 345 kPa (40 to 50 psi).

8.1.2.2 Set the flow rate based on filter medium supplier's recommendation, which is usually 5 to 15 $m^3/(h \cdot m^2)$ of filter area (2 to 6 $gal/(min \cdot ft^2)$).

8.2 *Operating Procedure*:

8.2.1 To determine the effectiveness of the filter medium in removing colloidal and suspended particles with addition of flocculants or coagulants, or both, proceed to 8.2.3. To determine the ability of the filter medium in removing colloidal and suspended particles without addition of flocculants or coagulants, or both, operate the filter for 30 min. Then, measure the water quality of the filter effluent and compare it to the quality of the supply water. Use turbidity (Test Method D 1889), suspended solids analyses (Test Methods D 1888), or silt density index (Test Method D 4189) to measure the water quality. Repeat the water quality measurements every 30 min until results indicate equilibration of the filter.

8.2.2 Repeat 8.1.1 and 8.1.2.

8.2.3 Start the flocculant or coagulant injection pump to inject a previously prepared solution. Initially, set the injection pump rate to obtain 2 mg/L of the flocculant or coagulant in the supply water.

8.2.3.1 Set the concentration of flocculant or coagulant in the supply water using the injection pump curves (pumping rate against back pressure), concentration of flocculant or coagulant in the chemical feed tank, and the flow rate of water through the filter. For example, for a 250-mm (10-in.) diameter filter operating at 3.785 L/min (1 gal/min) and a polyelectrolyte feed solution concentration of 200 mg/L, the injection pump should be adjusted to the following rate to obtain 2 mg/L in the supply water: Dilution of polyelectrolyte feed solution of 100 to 1 will give 2 mg/L.
Therefore,

$$(3.785\text{ L/min.})/(X\text{ L/min}) = 100$$

$$X = 0.03785\text{ L/min} = 37.85\text{ mL/min}$$

Therefore, set injection pump rate at 37.8 mL/min.

8.2.3.2 If polyelectrolyte from supplier is a liquid, assume 100 % active ingredient.

8.2.4 After the injection rate has been set, measure the injection rate (see 6.1.9).

8.2.5 Allow 5 min of operation to equilibrate the mixing section then obtain a water sample just after the mixing section and measure the zeta potential (Test Methods D 4187), if applicable.

NOTE 7—For most natural waters, optimum coagulation-flocculation will occur at a zeta potential of 0 ± 2 mV. Zeta potential measurements are only useful for cationic polyelectrolytes and inorganic coagulants (alum and iron). If a nonionic or anionic polyelectrolyte is used, omit the zeta potential measurement.

NOTE 8—For waters with high total dissolved solids, for example, seawater, zeta potential measurements are not meaningful.

8.2.6 Adjust the concentration of flocculant or coagulant, or both, either up or down to obtain the desired zeta potential.

8.2.7 After the desired zeta potential has been obtained, allow the system to operate for 15 to 20 min, and then measure the filter effluent water quality and compare to the supply water quality (before flocculant or coagulant, or both, addition) using turbidity, suspended solids, or silt density index. Repeat measurements (both effluent water quality and zeta potential) every 30 to 45 min until equilibration of the system has occurred.

8.2.8 If the desired zeta potential value is unknown or if zeta potential measurements are not made, then the coagulant concentration must be varied and equilibrated values of the effluent water quality obtained at each concentration to determine the optimum concentration, that is, that concentration of flocculant or coagulant, or both, which gives acceptable effluent water quality.

NOTE 9—Exercise care since excess coagulant or flocculant, or both, can be adsorbed by the filter medium, and several hours may be required before true equilibration of the system occurs.

8.2.9 Measure the pH and the temperature of the filter effluent for future reference.

NOTE 10—For some coagulants, for example, alum, the pH is an important parameter and control of the pH within certain limits is usually desirable.

8.2.10 In operating the system, periodically measure and make appropriate adjustment of the filter inlet pressure, filter flow rate, and injection pump rate.

8.2.11 To determine the effect of filtration rate on effluent water quality, repeat 8.1.1 to 8.2.9 but set the flow rate in 8.1.2.2 at different values.

8.2.12 To determine the effect of different flocculants or coagulants, or both, on the effluent water quality, repeat 8.1.1 to 8.2.9, using different flocculants or coagulants, or both.

8.2.13 To evaluate different medium, replace filter or filter medium with new medium and repeat 8.1.1 to 8.2.9.

8.2.14 To determine the need for backwashing for a given medium, and flocculant or coagulant, or both, operate the system as in 8.2.7 for extended time periods and monitor the effluent quality. When the effluent quality deteriorates or when the pressure drop across the filter reaches the supplier's recommended maximum limit, backwash the filter.

NOTE 11—The interval between backwashings can vary from a few hours to several weeks, depending on the quantity of suspended and colloidal material in the supply water, the filter flow rate, the type of flocculant or coagulant, or both, used, and the filter design.

8.2.15 To determine the filter rinse time, first determine the optimum concentration of flocculant or coagulant, or both, at a given filter flow rate. Then backwash the filter as in 8.1.1. After backwashing operate the filter in the service direction with the addition of the optimum flocculant or coagulant, or both, concentration and monitor the effluent water quality versus time to obtain acceptable water quality. Depending on the desired water quality and nature of colloidal material in the supply water, the rinse time can vary from 15 min to several hours.

8.3 *Shutdown Procedure*:

8.3.1 Shut off the injection pump and push the stop button on the pressurizing pump motor.

8.3.2 Allow the pressure to reach zero before disconnecting the system or carrying out maintenance on the piping system.

9. Calculation and Report

9.1 Report the following data and information:

9.1.1 Filter medium(a), depth of medium, filter area, filter flow rate, filter backwash rate, filter rinse rate, rinse time, backwash time, time between backwashings (service run time), pressure of filter influent, and pressure drop across filter during service run.

9.1.2 Flocculant or coagulant, or both used, concentration of flocculant or coagulant, or both in chemical feed tank, concentration of flocculant or coagulant, or both in filter influent, injection pump flow rate, and zeta potential (if applicable) of filter influent.

9.1.3 Filter effluent temperature and filter effluent pH; turbidity, suspended solids, or silt density index of raw water and filter effluent.

9.2 Calculate and report the volume of water used for backwashing (volume = backwash flow rate × backwash time).

9.3 Calculate and report the volume of water used for rinsing (volume = rinse flow rate × rinse time).

9.4 Calculate and report the volume of water obtained during service cycle (volume = service flow rate × service time).

9.5 Calculate and report the percent of raw water converted to clarified water as:

$$\left(\% = \frac{\text{volume of water from service run}}{\text{total volume of raw water}} \times 100\right).$$

The total volume of raw water is the sum of the volumes calculated in 9.2, 9.3, and 9.4.