

# CHAPTER 13

## Plant Flow Measurement and Sampling

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## PLANT FLOW MEASUREMENT AND SAMPLING

### 13.1 Purpose

Complete and accurate flow measuring and sampling are essential in the proper treatment of wastewater. Compliance with discharge limits requires proper flow measurement and sampling. They provide the operator with the information to optimize process control and operational costs, as well as providing an accurate data base of flows and process performance which can be used to analyze changes in operational strategy or assist future plant design.

### 13.2 Flow Measurement

#### 13.2.1 General Considerations

13.2.1.1 Facilities for measuring the volume of sewage flows should be provided at all treatment works.

13.2.1.2 Plants with a capacity equal to or less than 100,000 gallons per day (gpd) shall be equipped, as a minimum, with a primary metering device such as: a Parshall flume having a separate float well and staff gauge, a weir box having plate and staff gauge, or other approved devices. Continuous recording devices may be required where circumstances warrant.

13.2.1.3 Plants having a capacity of greater than 100,000 gpd shall be provided with indicating, recording, and totalizing equipment using strip or circular charts and with flow charts for periods of 1 or 7 days. The chart size shall be sufficient to accurately record and depict the flow measured.

13.2.1.4 Flows passed through the plant and flows bypassed shall be measured in a manner which will allow them to be distinguished and separately reported.

13.2.1.5 Measuring equipment shall be provided which is accurate under all expected flow conditions (minimum initial flow and maximum design peak flow). The accuracy of the total flow monitoring system (primary device, transmitter, and indicator) must be acceptable. The effect of such factors as ambient temperature, power source voltage, electronic interference, and humidity should be considered. Surges must be eliminated to provide accurate measurement.

Two primary devices and flow charts may be required in some cases.

- 13.2.1.6 Metering devices within a sewage works shall be located so that recycle flow streams do not inadvertently affect the flow measurement. In some cases, measurement of the total flow (influent plus recycle) may be desirable.
- 13.2.1.7 All clarifiers must be provided with a means for accurate flow measurement of sludge wasting and sludge return lines so that solids handling can be controlled. Sludge digesters, thickeners, and holding tanks should be provided with some way to determine the volume of sludge added or removed. This can be accomplished by a sidewall depth scale or graduation in batch operations.
- 13.2.1.8 Flow meter and indicator selection should be justified considering factors such as probable flow range, acceptable headloss, required accuracy, and fouling ability of the water to be measured. For more detailed information the consultant is encouraged to read the EPA Design Information Report "Flow Measurement Instrumentation"; Journal WPCF, Volume 58, Number 10, pp. 1005-1009. This report offers many installation details and considerations for different types of flow monitoring equipment.
- 13.2.1.9 Flow splitter boxes shall be constructed so that they are reliable, easily controllable, and accessible for maintenance purposes.
- 13.2.1.10 Where influent and effluent flow-proportional composite sampling is required, separate influent and effluent flow measuring equipment is required.
- 13.2.1.11 Consideration should be given to providing some types of flow meters with bypass piping and valving for cleaning and maintenance purposes.

## 13.2.2 Parshall Flumes

Parshall Flumes are ideal for measuring flows of raw sewage and primary effluents because clogging problems are usually minimal.

The properly sized flume should be selected for the flow range to be encountered. All Parshall Flumes must be designed to the specified dimensions of an acceptable reference.

The following requirements must be met when designing a Parshall Flume.

13.2.2.1 Flow should be evenly distributed across the width of the channel.

13.2.2.2 The crest must have a smooth, definite edge. If a liner is used, all screws and bolts should be countersunk.

- 13.2.2.3 Longitudinal and lateral axes of the crest floor must be level.
- 13.2.2.4 The location of the head measuring points (stilling well) must be two-thirds the length of the converging sidewall upstream from the crest. Sonar-type devices are only acceptable when foaming or turbulence is not a problem.
- 13.2.2.5 The pressure tap to the stilling well must be at right angles to the wall of the converging section.
- 13.2.2.6 The invert (i.e., inside bottom) of the pressure tap must be at the same elevation as the crest.
- 13.2.2.7 The tap should be flush with the flume side wall and have square, sharp corners free from burrs or other projections.
- 13.2.2.8 The tap pipe should be 2 inches in size and be horizontal or slope downward to the stilling well.
- 13.2.2.9 Free-flow conditions shall be maintained under all flow rates to be encountered by providing low enough elevations downstream of the flume. No constrictions (i.e., sharp bends or decrease in pipe size) should be placed after the flume as this might cause submergence under high flow conditions.
- 13.2.2.10 The volume of the stilling well should be determined by the conditions of flow. For flows that vary rapidly, the volume should be small so that the instrument float can respond quickly to the changes in rate. For relatively steady flows, a large-volume stilling well is acceptable. Consideration should be given to protecting the stilling well from freezing.
- 13.2.2.11 Drain and shut-off valves shall be provided to empty and clean the stilling well.
- 13.2.2.12 Means shall be provided for accurately maintaining a level in the stilling well at the same elevation as the crest in the flume, to permit adjusting the instrument to zero flow conditions.
- 13.2.2.13 The flume must be located where a uniform channel width is maintained ahead of the flume for a distance equal to or greater than fifteen (15) channel widths.  
The approach channel must be straight and the approaching flow must not be turbulent, surging, or unbalanced. Flow lines should be essentially parallel to the centerline of the flume.

### 13.2.3 Sharp Crested Weirs

The following criteria are for V-notch weirs, rectangular weirs with and without end contractions, and Cipolletti weirs. The following details must be met when designing a sharp crested weir:

- 13.2.3.1 The weir must be installed so that it is perpendicular to the axis of flow. The upstream face of the bulkhead must be smooth.
- 13.2.3.2 The thickness of the weir crest should be less than 0.1 inch or the downstream edge of the crest must be relieved by chamfering at a 45° angle so that the horizontal (unchamfered) thickness of the weir is less than 0.1 inch.
- 13.2.3.3 The sides of rectangular contracted weirs must be truly vertical. Angles of V-notch weirs must be cut precisely. All corners must be machined or filed perpendicular to the upstream face so that the weir will be free of burrs or scratches.
- 13.2.3.4 The distance from the weir crest to the bottom of the approach channel must be greater than twice the maximum weir head and is never to be less than one foot.
- 13.2.3.5 The distance from the sides of the weir to the side of the approach channel must be greater than twice the maximum weir head and is never to be less than one foot (except for rectangular weirs without end contractions).
- 13.2.3.6 The nappe (overflow sheet) must touch only the upstream edges of the weir crest or notch. If properly designed, air should circulate freely under and on both sides of the nappe. For suppressed rectangular weirs (i.e., no contractions), the enclosed space under the nappe must be adequately ventilated to maintain accurate head and discharge relationships.
- 13.2.3.7 The measurement of head on the weir must be taken at a point at least four (4) times the maximum head on the crest upstream from the weir.
- 13.2.3.8 The cross - sectional area of the approach channel must be at least eight (8) times that of the nappe at the crest for a distance upstream of 15-20 times the maximum head on the crest in order to minimize the approach velocity.  
The approach channel must be straight and uniform upstream of the weir for the same distance, with the exception of weirs with end contractions where a uniform cross section is not needed.

13.2.3.9 The head on the weir must have at least three (3) inches of free fall at the maximum downstream water surface to ensure free fall and aeration of the nappe.

13.2.3.10 All of the flow must pass over the weir and no leakage at the weir plate edges or bottom is permissible.

13.2.3.11 The weir plate is to be constructed of a material equal to or more resistant than 304 Stainless Steel.

#### 13.2.4 Venturi and Modified Flow Tube Meters

The following requirements should be observed for application of venturi meters:

13.2.4.1 The range of flows, hydraulic gradient, and space available for installation must be suitable for a venturi meter and are very important in selecting the mode of transmission to the indicator, recorder, or totalizer.

13.2.4.2 Venturi meters shall not be used where the range of flows is too great or where the liquid may not be under a positive head at all times.

13.2.4.3 Cleanouts or handholes are desirable, particularly on units handling raw sewage or sludge.

13.2.4.4 Units used to measure air delivered by positive - displacement blowers should be located as far as possible from the blowers, or means should be provided to dampen blower pulsations.

13.2.4.5 The velocity and direction of the flow in the pipe ahead of the meter can have a detrimental effect on accuracy. There should be no bends or other fittings for 6 pipe diameters upstream of the venturi meter, unless treated effluent is being measured when straightening vanes are provided.

13.2.4.6 Other design guidelines as provided by manufacturers of venturi meters should also be considered.

#### 13.2.5 Other Flow Metering Devices

Flow meters, such as propeller meters, magnetic flow meters, orifice meters, pitot tubes, and other devices, should only be used in applications in accordance with the manufacturer's recommendations and design guidelines.

## 13.2.6 Hydrograph Controlled Release (HCR) Systems

For plants utilizing HCR systems, accurate stream flow measurements are required. Detailed plans must be submitted outlining the construction of the primary stream flow measuring device and the associated instrumentation. The following factors should be emphasized in the design.

13.2.6.1 Accuracy over the flow range required for effluent discharge limiting purposes.

13.2.6.2 Operational factors such as cleaning and maintenance requirements.

13.2.6.3 Cost

The use of sharp crested weirs as described in Section 13.2.3 will not be allowed due to the installation requirements such as approach channel details and upstream pool depth and since entrapment and accumulation of silt and debris may cause the device to measure inaccurately. Parshall Flumes may be used due to their self-cleaning ability but field calibration will be required. Self-cleaning V-notch weirs are recommended due to their accuracy in low flow ranges. The weir can be made self-cleaning by sloping both sides of the weir away from the crest. The top portion of the crest shall be covered with angle-iron to prevent its breakdown. The angle of the V-notch should be determined by the stream characteristics; however, a smaller angle will increase accuracy in the low flow range. The primary device shall be built with sufficient depth into the stream bed to prevent undercutting and sufficient height to cover the required flow range.

It is recommended that the wastewater system director, engineer, or other city official contact the U.S. Geological Survey (USGS), Water Resources Division, in Nashville, Tennessee, for assistance with the design and installation of the flow measuring device. They offer a program which shares much of the costs for designing and maintaining the device. After visiting the site, they can assist with the design of a self-cleaning weir for the stream. They provide the consultant with a field design that shows the proper location and installation of the weir. From this field design, the consultant must provide detailed plans to the State.

The wastewater system is responsible for constructing the weir at their own cost. The flow measuring station is installed, maintained, and calibrated by USGS personnel so that accurate results are insured.

The primary device will record continuous flow of the stream and can be designed to send a feedback signal to the WWTP for other purposes such as controlling plant discharge rates.

This program benefits both the local wastewater system, the State of Tennessee, and the USGS, as it adds to stream flow data bases archived for public use. Cost sharing allows the flow measuring station to be built and operated at a lower cost for all parties concerned.

### **13.3 Sampling**

#### 13.3.1 Automatic Sampling Equipment

The following general guidelines should be adhered to in the use of automatic samplers:

- 13.3.1.1 Automatic samplers shall be used where composite sampling is necessary.
- 13.3.1.2 The sampling device shall be located near the source being sampled, to prevent sample degradation in the line.
- 13.3.1.3 Long sampling transmission lines should be avoided.
- 13.3.1.4 If sampling transmission lines are used, they shall be large enough to prevent plugging, yet have velocities sufficient to prevent sedimentation. Provisions shall be included to make sample lines cleanable. Minimum velocities in sample lines shall be 3 feet per second under all operating conditions.
- 13.3.1.5 Samples shall be refrigerated unless the samples will not be effected by biological degradation.
- 13.3.1.6 Sampler inlet lines shall be located where the flow stream is well mixed and representative of the total flow.
- 13.3.1.7 Influent automatic samplers should draw a sample downstream of bar screens or comminutors. They should be located before any return sludge lines or scum lines.
- 13.3.1.8 Effluent sampling should draw a sample immediately upstream of the chlorination point. This will eliminate the need to dechlorinate and then re-seed the sample.

#### 13.3.2 Manual Sampling

Because grab samples are manually obtained, safe access to sampling sites should be considered in the design of treatment facilities.



### 13.3.3 Long Outfall Lines

Many wastewater systems are constructing long outfall lines to take advantage of secondary or equivalent permit limits.

Due to possible changes in effluent quality between the treatment facility and the outfall, a remote sampling station will be required at or near the confluence of the outfall line and the receiving stream on all outfall lines greater than one mile in length.

Dissolved oxygen, fecal coliform, and chlorine residual may have to be measured at the remote sampling station for permit compliance purposes.

### 13.3.4 Sampling Schedules

Samples must be taken and analyzed for two purposes: permit compliance and process control. Any time a new permit is issued, a sampling schedule for permit compliance will be determined by the Division of Water Pollution Control. An additional sampling program needs to be set up for process control purposes. This would include all testing required for completing the monthly operational report, as well as any other tests that might aid the operation of the plant. This schedule can be determined by the Division of Water Pollution Control, Wastewater Treatment Section or the appropriate field office once final plans are approved. The designer shall provide safe access points to collect representative influent and effluent samples of all treatment units and to collect samples of all sludge transmission lines. This makes it possible to determine the efficiency of each treatment process. Additional information about methods of analyses can be obtained from the Federal Register 40 CFR Part 136. Information about sampling locations and techniques can be obtained from the EPA Aerobic Biological Wastewater Treatment Facilities Process Control Manual and EPA's NPDES Compliance Inspection Manual.