CHAPTER 18
FLOW MEASUREMENT, SAMPLING, AND PROCESS CONTROL

18-1. General considerations.

a. In designing and constructing any wastewater treatment facility, a number of miscellaneous design details must be considered. They include water supply systems, lighting requirements, service buildings and equipment, landscaping, and proprietary processes and equipment. Requirements are given in other TM and AFM publications. Specific information may be obtained from HQDA (CEEC-EB) WASH DC 20314-1000 for Army projects and HQ USAF/LEEE WASH DC 20332 for Air Force projects.

b. Equipment for indicating, totalizing and recording the effluent wastewater flow will be provided for all secondary treatment plants with flows greater than 0.10 million gallons per day and smaller plants in special cases. For plants less than 0.10 million gallons per day, recording and totalizing equipment will be provided as required to assure effluent limitations within regulations imposed by the regulating authority. In plants requiring recirculation of wastewater, meters with means for indicating the rates of recirculation are required. Venturi meters, weirs, Parshall flumes, and magnetic flow meters are satisfactory for measuring wastewater flow; Parshall flumes being generally preferable for military projects when measuring influent or effluent. Measuring devices will be designed, or specified, with a view toward obtaining the maximum accuracy of measurement throughout the expected range of flow. Principles of design of such devices are covered in standard handbooks.

18-2. Flow measurement.

Monitoring is required by EPA when NPDES permits are issued to assure compliance with the permit. Additionally, certain operational monitoring is required to ensure that proper treatment plant performance is maintained. Refer to the EPA **Handbook for Monitoring Industrial Wastewater** for further information.

a. Continuous recording of flow. Wastewater flow rates will be monitored and recorded for purposes of evaluating treatment plant performance and will also be used when treatment changes are involved. Continuous flow measurement is necessary in order to monitor diurnal variations in flow which may affect treatment plant efficiency. Flow rates must also be taken into account when sampling wastewater quality (para 18-4).

b. Types of flow measuring devices. The following paragraphs describe the types that are suitable for use in wastewater treatment plants. For additional comments refer to table 18-1.

Table 18—1. Measurement devices.

Preliminary Measurement and Type of Device	Use	Limitations		
	Waste Disposal	General	Capacity[8]	Range[9]
Flow				
Open channels:				
Head area meters-				
Flume[1]	Plant influent, bypass lines,	More costly than weir.	13 gpm to 3,000 mgd	
Weir[2]	Primary effluent, plant effluent.	Produces greater had loss than flume.	Virtually unlimited.	
Velocity meters -				
Propeller	Clean liquids up to 2 percent solids.	Requires fixed cross-sectional area. Low head loss.	30 gpm to virtually unlimited, 0.9 to 20 fps	10 to 1
Pressure pipelines:				
Differential producers		Fluid must be under positive head at all times.		
Venturi tube[3]	All pipeline flows including raw sewage, plans effluent raw and digested sludge, and mixed liquors.	Long laying length.	160 to 160,000 to gpm	4 to 1 to 13 to 1

Table 18–1. (Con't)

Preliminary Measurement	Use	Limitations		
and Type of Device	Waste Disposal	General	Capacity[8]	Range[9]
Flow tube[4]	Clean liquids only.	May clog if used with suspended matter.	160 to 125,000 gpm	4 to 1 to 10 to 1
Orifice plate	Clean fluids only.	Use if head loss unobjectionable. Do not use with suspended matter.	10 to 60,000 gpm	4 to 1
Flow (continued)				
Orifice plate (continued)	Air and gas lines.	Use if rate indication required. Use for flows above 10,000 cfh.	Limit of pipe capacity for gas or air (cfh)	4 to 1
Flow nozzle	Clean liquids only.	Do not use with suspended matter.	10 to 160, 000 gpm	4 to 1
Direct measuring:				
Displacement meter	Plant water.	Use for flows up to 150 gpm maximum.	0.25 to 350 gpm	5 to 1
	Plant gas and sludge gas.	Use for flows up 10,000 cfh.	0 to 60,000 cfh	3 to 1
Compound meter		Use for flows greater than 150 gpm maximum.		50 to 1 and up

Table 18—1. (Con't)

Preliminary Measurement	Use	Limitations		
and Type of Device	Waste Disposal	General	Capacity[8]	Range[9]
Displacement	Plant water			
Velocity (propeller)	Clean liquids up to 2 percent solids		0.25 to 3.200 gpm	
Other types:				
Variable area Rotameter[5]	Gas feeders, Gas solution feeders,	Requires fairly constant temperature and pressure.	0.01 to 12,500 gpm	10 to 1
Magnetic meter[6]	Plant influent. sludge.	Costly	10 to 100,000 gpm	10 to 1
Open flow nozzle	Plant influent, plant effluent, sludge.	Use only with free fall from end of pipeline.	5 to 11,000 gpm	4 to 1
Rate of flow controller[7]			40 to 3,500 gpm	4 to 1
Level				
Staff gauge	Wet wells, floating cover digester.	Use for indication only. Location must be visible.	Unlimited	100 to 1

Table 18-1. (Con't)

Preliminary Measurement and Type of Device	Use: Waste Disposal	Limitations: General	Limitations: Capacity[8]	Limitations: Range[9]
Float	Wet wells.	Indication near tank.	Unlimited	100 to 1
Probes	Wet wells.	Do not use for indication. Fluid must be electrolyte.	Unlimited	100 to 1
Bubble tube		Requires air supply.	Limited by air pressure (psig)	10 to 1
Ultrasonic				
Pressure				
Pressure gauge	Digester gas, aeration air	Use in visible location	Vacuum to 1,500 psig	3 to 1
Loss of head gauge			Virtually unlimited	3 to 1

1 Suspended matter does not hinder operation.
2 Normally requires free fall for discharge.
3 May use short form tube to save space or expense, but has greater head loss.
4 May use for gas or air flows to minimize head loss.
5 Best suited for use where indicator only required.
6 Use for large flows where savings from reduced head loss justifies expenses and where no obstruction of pipe is allowed.
7 Self-contained unit; measures and controls flow rates.
8 Capacities shown are equipment capacities obtainable through various sizes of available equipment.

Table 18—1. (Con't)

[9] Range ratios shown are capacity ranges of individual measuring equipment. For example, equipment with a capacity of 50 gpm having a range of 10 to 1 means the range of that measuring device is 5 to 500 gpm.

[10] Refer to Chapter 7 of EPA's Handbook for Monitoring Industrial Wastewater for more information regarding flow-measuring equipment.

(1) **Venturi meters.** Venturi meters are not to be used for measuring wastewater or sludge flow unless sufficient hydraulic head is available , or unless the Venturi tube is so constructed as to prevent solids accumulation at the upstream side of the throat. Clogging of the pressure tubes is avoided by providing cleanout taps and discharging a stream of fresh water through them into the sewer. Positive separation of potable water supply from this connection must be assured.

(2) **Weirs.** Weirs will be located in a channel so that the flow will not be disturbed by turbulence and in such a manner that the depth of flow over the weir can be observed and recorded. When continuous recording is required, the float will be installed in a chamber separated from the main channel of flow but connected thereto by piping.

(3) **Parshall flumes.** The dimensions of a standard Parshall flume and a table of discharge rates are given in appendix C. This device has many advantages: the loss of head is minimal; it is self-cleaning; flow measurement can be made in open-channel flow; and it has no moving parts to malfunction. The downstream water-surface elevation above the flume approach floor must not exceed 65 percent of water elevation upstream of the flume. The flume will be designed with the narrowest throat practicable for the conditions under consideration. This is particularly important where a Parshall flume is utilized to control the velocity through a grit chamber.

(4) **Magnetic flow meters.** Magnetic flow meters can be used for flow measurement in wastewater treatment plants. There are many types of magnetic flow meters, however, and direct contact with the manufacturers is the quickest and generally most practical way to determine their application to specific wastewater measurements.

(5) **Ultrasonic meters.** Ultrasonic devices are being used to measure levels in Parshall flumes. A pulsing signal is bounced to the receiver where the level is related to the time elapsed. Since no components are in contact with the liquid, this device is applicable to many types of wastes and situations.

18-3. Monitoring equipment for process control.

Monitoring equipment will be used to indicate and/or record flow quantities and, if justified, pressure, temperature, liquid levels, velocities; and various quality parameters such as dissolved oxygen, biochemical oxygen demand, total suspended solids, ammonia, nitrate, and pH.

a. Monitoring at pumping stations. In sewage pumping stations, flow measurement is necessary to control periodic pump operation. Watt-hour meters and pump-time meters will be used to ensure uniform pump wear in multiple-pump installations.

b. Monitoring of primary treatment. Monitoring primary treatment processes will require only flow measurement and recording and perhaps grit level monitoring. When digestion of the primary sludge follows, raw sludge flow rates must be monitored and controlled. In digestion, gas flow rates, tank pressures and sludge temperatures will be monitored, and digester operation adjusted accordingly.

c. Monitoring of biological treatment. Trickling filter monitoring will include flow measurement of influent, effluent and recirculation lines, and also volume of sludge pumped to or from the digesters. These parameters are used in determining and controlling hydraulic and organic loading as well as in controlling settling tank efficiencies. Activated sludge treatment will require the same monitoring with the addition of mixed-liquor, volatile suspended solids and air supply monitoring.

b. Monitoring of sludge handling. In sludge elutriation, sludge and elutriant flows will be measured in order to determine required sludge conditioner quantities. Sludge filtration will require measurements and control of sludge and sludge-cake flows and chemical feed rates. All chemical feed lines will be monitored and controlled, whatever their function. Sludge incineration and drying processes will require temperature monitoring at various points, pressure gauges, and sludge weighing equipment. Fuel flow rates, whether waste gas or auxiliary fuel, must be measured and controlled.

e. Monitoring of other operations. For other treatment prcesses (advanced treatment), measurement of the appropriate performance parameters is required.

f. Instruments involved. The various instruments and meters used for monitoring are discussed in WPCF Manual of Practice No.8 under "Instrumentation and Control" and EPA handbook Monitoring Industrial Wastewater Table 18-1 describes the types of flow measuring devices applicable to wastewater treatment.

18-4. Sampling.

Wastewater sampling at various points in the sewage treatment process is useful in evaluating operation efficiency. This can be used internally to optimize the process and is also used by regulatory agencies to judge whether treatment plant regulations are satisfied. Sampling is also used to establish changes when treating industrial wastes. Provisions for sampling sites must be made in the plant design. The type of sampling provisions (flow proportional, composite, or grab-sample collection) will be dictated by the type of sampling required in the NPDES discharge permit. Forward flow, recycled flow, sludge flow, chlorine residual, pH and dissolved oxygen are some of the process control parameters that can be monitored on a continuous basis.

18-5. Odor control.

Odor arising from biological decomposition can be prevented by disinfecting the waste stream at appropriate points in the sewer system or treatment system. Chlorination is commonly used in this application, although supernatant return streams can upset odor control effectiveness. Other biological odors can be reduced by improved in-plant housekeeping practices. Ventilation and air washing can also reduce in-plant odors. Air washing is usually done with air scrubbers using hypochlorite or chlorine dioxide solution sprays. Oxidation by chlorine, hydrogen peroxide, potassium permanganate or ozone is effective in destroying certain odors such as hydrogen sulfide. Ozone also acts as an odor-masking agent, with ozone commonly being produced on-site. Dispersion can also reduce odors significantly but it is usually not good practice in urban areas. Plant design will provide for the retention, collection and disposal of any odorous gases produced in treatment processes when practical.