			DATE ENTERED 1		2 16.3.1
DATE RECEIVED	FACILITY NAME 9-8-06	COUNTY No.	PROGRAM AREA CODE	FACILITY TYPE CODE	SUBJECT AREA CODE
3 1/22/87	4 ATALISSA	5 70	6 CP	7 C04	8 325

RULE REFERENCE	DESIGN STANDARD REFERENCE	DECISION / DATE	APPEAL ACTION / DATE
567-64.2(9)	10 16.3.1	11 Approved ~~2-20-87~~ 3/5/87	12

ENGINEER	VARIANCE RULE
13 Hawkeye	14 IAC CHAP. 64.2(9)c

15. DESCRIPTION OF VARIANCE REQUESTED:

modular settling unit proposed as an innovative technology system utilizes a depth of 6' in lieu of the 12' standard

16. ENGINEERS JUSTIFICATION: the system meets the 20% life cycle energy savings to qualify for EPA innovative technology consideration. the facility has been approved and constructed in Missouri under this program.

17. DEPARTMENTS JUSTIFICATION: the SWD requirements of the standard are assumed to be related to the fact that the floc following extended aeration periods are very light and have a potential to become re-suspended as a result of normal flow variations. the physical configuration of the settler unit tends to be less sensitive to these variations, as text book values of surface settling rates may be several times greater than those for conventional units, while accomplishing effective settling. it does not appear that this design should require the additional heighth of water to hold the blanket, as is the apparent guiding rationale behind the standard, as a means of compensating for flow variation.

18. PRECEDENTS USED:

19. STAFF REVIEWER:

20. SUPERVISOR:

21. AUTHORIZED BY: 2/20/87

peak overflow rate controls. The diameter is given by $(\pi/4)(D^2) = 5357\ ft^2$ or

$D = 82.59$ ft   Use 85.0 ft for standard size.

The peak weir loading = (7,500,000 gal/day)/(π)(85.0 ft) or

Peak weir loading = 28,086 gal/day-ft.

Chemical Treatment Sedimentation

The peak overflow rates used for coagulation in tertiary treatment or for coagulation of raw municipal wastewaters and secondary effluents depend mainly upon the type of coagulant employed. Recommended peak overflow rates are shown in Table 3.7.

Table 3.7. Peak Overflow Rates for Various Coagulants

Coagulant	Peak Overflow Rates (gal/day-ft²)
Alum	500–600
Iron Salts	700–800
Lime	1400–1600

EPA, *Suspended Solids Removal*, EPA Process Design Manual, January 1975.

A detention time of at least two hours based on the average daily flow should be provided. Alum or iron salt coagulated wastewaters should not have a weir loading greater than 10,000 to 15,000 gal/day-ft based on the average daily flow. Lime coagulated wastewaters should not have an average weir loading greater than 20,000 to 30,000 gal/day-ft. The expected performance from chemical coagulation of wastewaters can best be determined from pilot plant studies. Chemical sludges produced from chemical coagulation may vary from 0.5 to more than 1.0 percent of the plant capacity and have solids concentrations from 1 to 15 percent, depending on the chemical used and basin efficiency.

Lime-feed or lime-sludge drawoff lines should be glass-lined or PVC pipe to facilitate cleaning of encrustations. Also, recycling of sludge from the bottom of the clarifiers to the rapid-mix tank should be provided to assist in coagulation. For lime-settling basins the mechanical sludge rakes should be the bottom scraper type and not the suction pick-up type due to the dense sludge to be removed.

Inclined Settling Devices

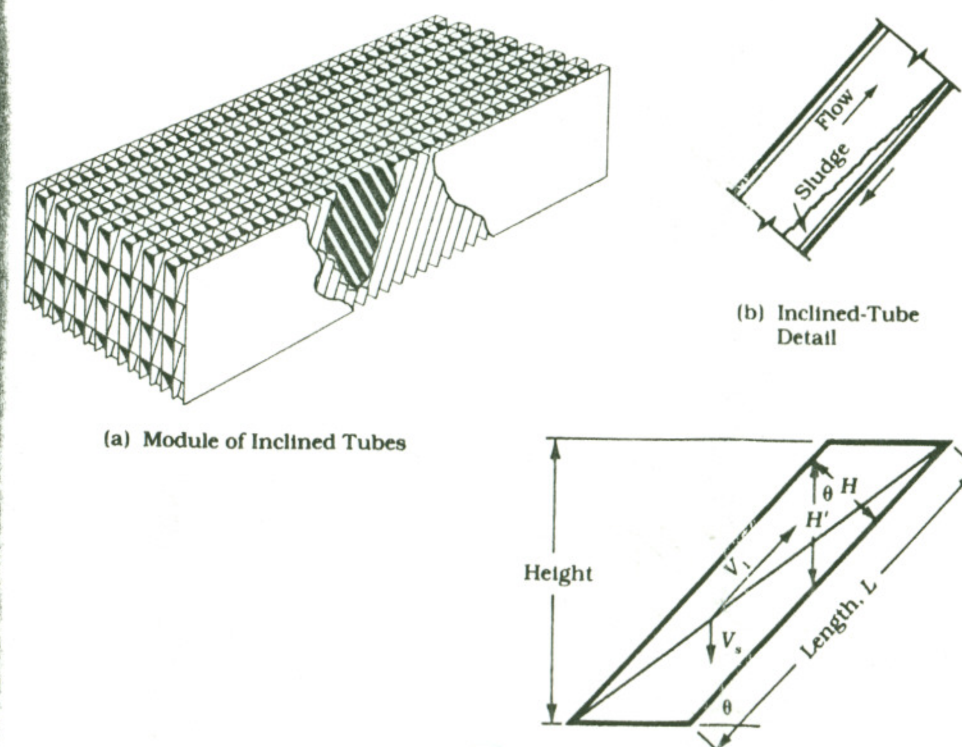
Inclined settling devices include inclined-tube settlers and the Lamella separator, both of which have overflow rates much higher than conventional settling basins.

Inclined-Tube Settlers

Figure 3.36 (a) shows a module of inclined-tube settlers. Figure 3.37 shows the modules installed in a circular clarifier, whereas Figure 3.38 shows the modules installed in a rectangular clarifier. The water to be clarified passes upward through the tubes, and as settling occurs the solids are collected on the bottom of the tubes, as shown in Figure 3.36 (b). The tubes are inclined at an angle of 45 to 60 degrees, which is steep enough to cause the settled sludge to slide down the tubes. The sludge falls from the tubes to the bottom of the clarifier, where it is removed by the sludge rakes. The tube cross section may be of numerous geometric shapes; however, a square or rectangular cross section is the most common type.

Figure 3.36.* *Inclined-Tube Settler

Part (a) courtesy of Neptune Microfloc, Inc.

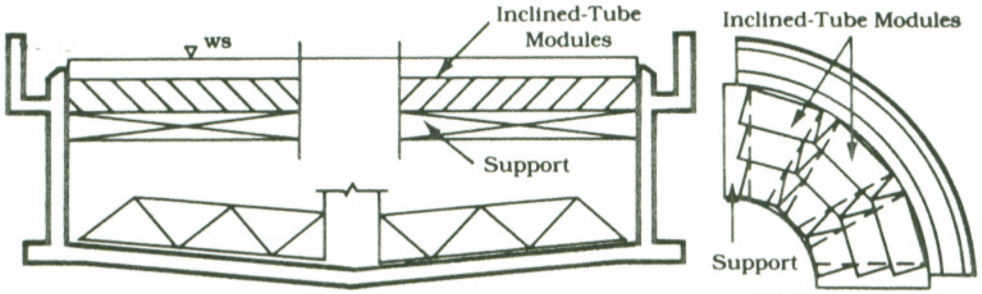


(a) Module of Inclined Tubes

(b) Inclined-Tube Detail

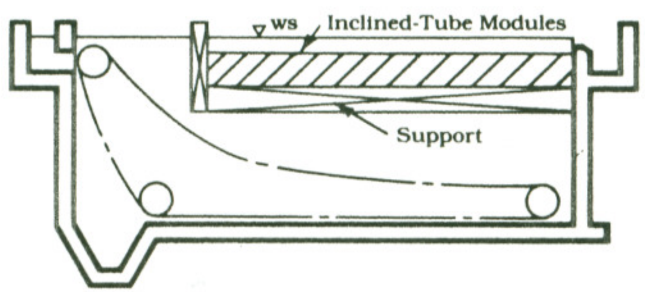
(c) Inclined-Tube Detail

Figure 3.37. Inclined-Tube Settlers in a Circular Clarifier



(a) Section (b) Plan

Figure 3.38. Inclined-Tube Settlers in a Rectangular Clarifier



The advantage of a tube settler over a conventional tank can be illustrated using the ideal settling theory and a theoretical problem. If the flow to a conventional rectangular settling tank is 1.0 MGD, the detention is 2 hr, the overflow rate is 1,000 gal/day-ft^2, and the length to width ratio is 4:1, then the dimensions of the tank will be 63.25 feet long, 18.81 feet wide, and 11.1 feet deep. The overflow rate of 1,000 gal/day-ft^2 corresponds to a settling velocity of 5.55 ft/hr. According to the ideal settling basin theory, a settling particle must intersect the sludge zone before it reaches the outlet end of a settling chamber in order to be removed. Thus, if V_s is the settling velocity, H is the depth, V_1 is the horizontal velocity, and L is the chamber length, the critical trajectory of a settling particle is such that the following relationship holds true:

$$\frac{V_1}{L} = \frac{V_s}{H} \tag{3.48}$$

or

$$V_1 = V_s L/H \tag{3.49}$$

Applying Eq. (3.49) to the hypothetical problem gives

$$V_1 = \left(5.55\,\frac{\text{ft}}{\text{hr}}\right)\left(\frac{63.25\ \text{ft}}{11.10\ \text{ft}}\right) = 31.6\ \text{ft/hr}$$

Thus, the horizontal velocity is 31.6 ft/hr. For an inclined-tube settler, a particle must settle through the distance H', as shown in Figure 3.36 (c). Thus, for an inclined tube, Eq. (3.48) becomes

$$\frac{V_1}{L} = \frac{V_s}{H'} \tag{3.50}$$

Assume, for the hypothetical problem, that modules of tube settlers are to be placed in the rectangular tank. The modules are 3.0 feet high and the tubes are 2 inches deep and inclined at a 45° angle. The value of H' is given by

$$H' = \frac{H}{\cos\theta} \tag{3.51}$$

or

$$H' = \left(\frac{2\ \text{in.}}{\cos 45°}\right)\left(\frac{\text{ft}}{12\ \text{in.}}\right) = 0.236\ \text{ft}$$

The value of L is

$$L = \text{module height}/\sin\theta \tag{3.52}$$

or

$$L = 3.0\ \text{ft}/\sin 45° = 4.24\ \text{ft}$$

Now applying Eq. (3.50) to get the velocity through the tube gives the following:

$$V_1 = \left(\frac{L}{H'}\right)V_s = \left(\frac{4.24}{0.236}\right)\left(\frac{5.55\ \text{ft}}{\text{hr}}\right) = 99.7\ \text{ft/hr}$$

Thus, the velocity through the inclined-tube settler can be 99.7 ft/hr and still have the same degree of solids removal as the horizontal settling unit. This is 99.7/31.6, or 3.2 times as much flow as the conventional basin can accommodate. Thus, the advantages of the inclined-tube settlers are readily apparent.

Usually, the overflow rates used for inclined-tube settlers are from three to six times as great as those used for conventional settling tanks. Laminar flow is necessary for efficient settling since turbulent flow would scour the set-use of tubes with small hydraulic radii.

Figures 3.37 and 3.38 show modules of inclined-tube settlers installed in a new or existing circular or rectangular clarifier. In either type clarifier, a large portion of the plan area, usually 67 to 80 percent, is occupied by the tube modules. New settling tanks using inclined-tube settlers will have much less area requirements than conventional settling tanks; however, one of the most common uses of inclined tubes is to increase the capacity of existing clarifiers.

In water treatment where the water temperature is above 50°F, it has been reported that effluent turbidities from 1 to 7 JTU (Jackson Turbidity Unit) may be achieved, depending upon the overflow rate, if the raw water turbidity is less than 1000 JTU (Culp, G. L. & Culp, R. L., 1974). When the water temperature is below 40°F, expected turbidities are from 1 to 10 JTU if the raw water turbidity is less than 1000 JTU. Since the settling velocity is dependent upon the water temperature, better results are obtained with warm waters. The usual overflow rates based upon the area covered by the tube modules are from 3600 to 6000 gal/day-ft^2. The tube settlers are ideal for increasing the capacity of existing clarifiers.

In wastewater treatment, tube settlers have been successfully used in secondary settling for activated sludge and trickling filter plants and for settling of coagulated wastewaters. They are not well suited as primary clarifiers because biological growths develop within the tubes. In particular, they are useful in increasing the capacities of existing final clarifiers. When used for final clarifiers, the activated sludge mixed liquor or trickling filter effluent is discharged below the tube modules. Some sludge settles and the final effluent is clarified as it passes upward through the tube settlers. The sludge from the settlers falls from the modules to the bottom of the clarifier and is removed with the other sludge. Overflow rates as high as 4000 gal/day-ft^2 have been used, which is about five times the overflow rates normally used for conventional settling tanks. Some installations have had microbial slime buildups inside the tube settlers. This can be minimized by installing an air grid underneath the modules and using air scouring to periodically clean off the growths.

Lamella Separator

The Lamella separator is similar to the inclined-tube settlers except that inclined plates are used to form the settling compartments and the sludge and water flow is cocurrent instead of countercurrent. The manufacturer recommends it only for use with coagulated waters and wastewaters.

Inlet and Outlet Hydraulics

To prevent short circuiting and basin instability, it is essential that the influent flow enter a sedimentation basin uniformly and also that the effluent flow leave uniformly. Figure 3.39 (a) shows the plan of a typical rectangular basin with an influent orifice flume and an effluent weir channel. Figure 3.39 (b) shows a cross-section through the influent flume, and Figure 3.39 (c) shows a cross section through the effluent channel. Figure 3.40 (a) shows a profile of the influent flume, whereas Figure 3.40 (b) shows a profile through the effluent channel. Although the profile shows the influent flume with circular orifices, square orifices are also used. The effluent weir may be a suppressed weir or a series of 90-degree V-notch weirs, as shown in Figure 3.40 (b) for a portion of the channel. If V-notch weirs are used, they are usually at about 8-in. centers. The elevation of the water surface in the effluent box, shown in Figure 3.40 (b), is set by the elevation of the water surface in the next downline treatment unit and the total head loss between the two water surfaces.

Figure 3.39. Inlet and Outlet Details for a Rectangular Tank