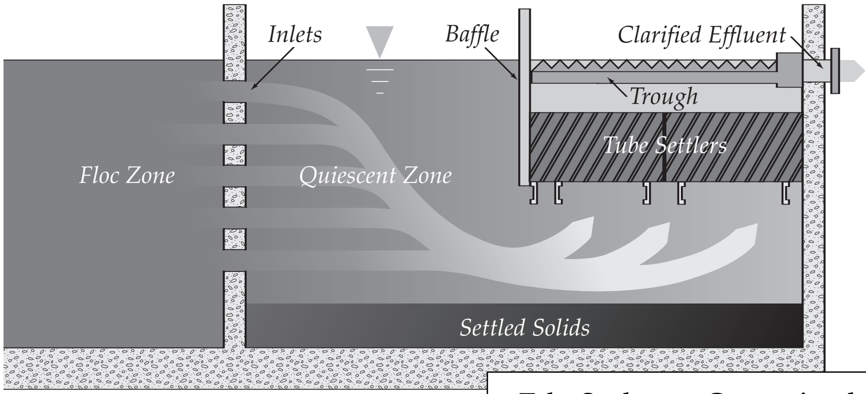
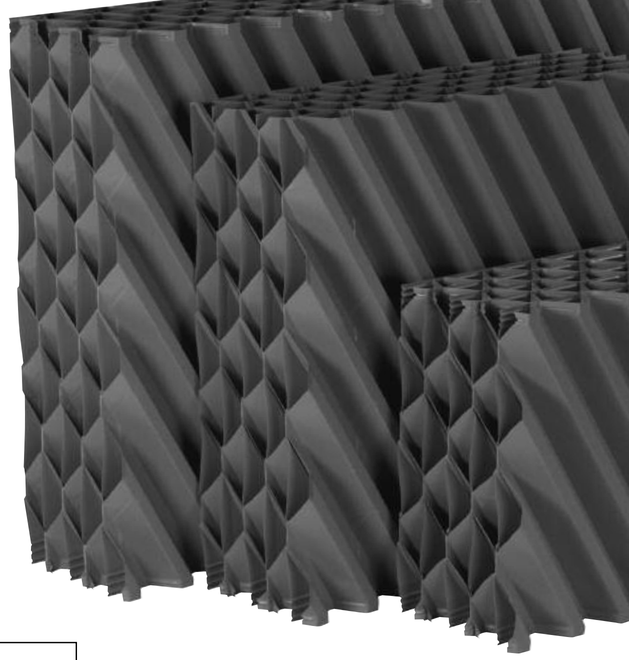
Tube Settlers

Tube settlers and parallel plates increase the settling capacity of circular clarifiers and/or rectangular sedimentation basins by reducing the vertical distance a floc particle must settle before agglomerating to form larger particles.





Tube settlers use multiple tubular channels sloped at an angle of 60° and adjacent to each other, which combine to form an increased effective settling area. This provides for a particle settling depth that is significantly less than the settling depth of a conventional clarifier, reducing settling times.

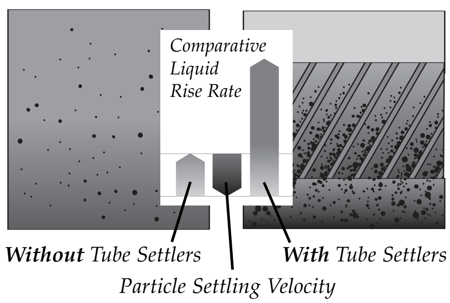
Tube settlers capture the settleable fine floc that escapes the clarification zone beneath the tube settlers and allows the larger floc to travel to the tank bottom in a more settleable form. The tube settler's channel collects solids into a compact mass which promotes the solids to slide down the tube channel.

WHY TUBE SETTLERS?

Tube settlers offer an inexpensive method of upgrading existing water treatment plant clarifiers and sedimentation basins to improve performance. They can also reduce the tankage/footprint required in new installations or improve the performance of existing settling basins by reducing the solids loading on downstream filters.

Made of lightweight PVC, tube settlers can be easily supported with minimal structures that often incorporate the effluent trough supports. They are available in a variety of module sizes and tube lengths to fit any tank geometry, with custom design and engineering offered by the manufacturer.

Tube Settlers vs. Conventional Settling



ADVANTAGES OF TUBE SETTLERS

The advantages of tube settlers can be applied to new or existing clarifiers/basins of any size:

- Clarifiers/basins equipped with tube settlers can operate at 2 to 4 times the normal rate of clarifiers/basins without tube settlers.
- It is possible to cut coagulant dosage by up to half while maintaining a lower influent turbidity to the treatment plant filters.
- Less filter backwashing equates to significant operating cost savings for both water and electricity.
- New installations using tube settlers can be designed smaller because of increased flow capability.
- Flow of existing water treatment plants can be increased through the addition of tube settlers.
- Tube settlers increase allowable flow capacity by expanding settling capacity and increasing the solids removal rate in settling tanks.

> ***"Clarifiers equipped with tube settlers can operate at 2 to 4 times the normal rate of clarifiers without tube settlers."***

> ***"The City of Westminster, CO used alum as their water treatment plant flocculant. After the installation of tube settlers, they cut the alum dosage from 30 ppm to 16 ppm, and the filter influent turbidity was still decreased by 25%. Since the filter influent turbidity had decreased, this enabled a savings of over 27% water used for filter backwashing[1]."***

[1] *Innovative Plant Operations Yield Bonuses, Opflow,* Vol. 6 No. 10 (Oct. 1980)

System Design Criteria

According to the technical review entitled *Tubular Settlers*[2], written by Mr. Roderick M. Willis in 1978, there are three basic requirements essential for successful performance of tube settlers.

1. There must be laminar (or viscous) flow conditions within the tubes at the maximum flow rate required. Laminar flow is essential so that each slowly-settling floc particle within a tube maintains a steady descent to the collecting surface of the tube and is not intermittently swept upward by turbulent currents within the tube.

2. The residence time within each tube must be ample so that a floc particle entering at the extreme upper edge of the tube will have sufficient time to settle to the collecting surface a vertical distance below. (Once the particle reaches the collecting surface, the coalescing tendency between particles creates a steady sludge formation).

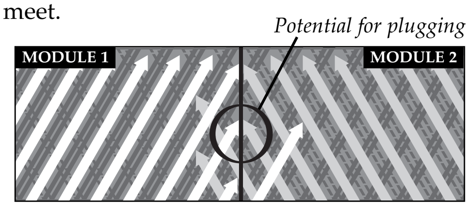
3. The velocity of flow through the tubes must not exceed a critical maximum that would cause the settled sludge to lose stability and be swept out of the tube in the direction of normal flow. As a corollary, the volume of the tube must be ample to allow either accumulation or a continual discharge backward of all sludge, without critically changing the normal flow rate through the tube

Size, Shape, and Configuration

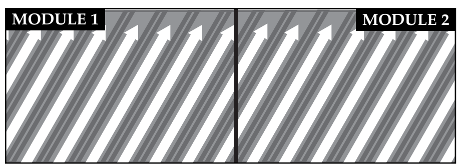
In addition to system design criteria, size, shape, and configuration need to be evaluated when choosing a tube settler module design. The vertical settling height within a tube should be kept as short as possible, within the restraints of cost and plugging potential, to minimize the settling distance for the particles. A V-groove base should be provided to allow for the rapid accumulation of solids into a compact mass, which slides continuously down the tube.

When selecting a tube settler, careful consideration should also be given to the vertical height of the modules. There are several different size tube settlers, each having a specific application rate. *(See chart under System Design for more info.)* Tube settlers with a vertical height of 24” and a tube length of 28” are the most commonly used size. 3’ and 4’ tube heights, because of longer residence time, are advantageous in many applications as well, such as high flow/high turbidity applications and where existing basins need improved settling capabilities to increase the plants total capacity.

Tube settlers manufactured with the tubes aligned in the same direction avoid the formation of crossing points that crossflow tubes promote. Many manufacturers compromise tube settler flow-through with “criss-crossing” tubes in order to achieve module rigidity. Crossing points can re-suspend the floc particles, affecting process performance. Tube modules that have flow in only one direction are easier to clean and have less chance for plugging, particularly where ends of modules meet.



CRISS-CROSSING TUBES



UNI-DIRECTIONAL TUBES

Also, the tube module design should incorporate features that would prevent gaps along the installed modules. These gaps allow short-circuiting of unclarified water to pass around the tube settlers. A module design which allows nesting with adjacent modules is ideal because it maximizes available area and increases the total module strength.

Tube Settlers vs. Plate Settlers

Plate settlers (Lamella Plates) are often compared to tube settlers when evaluating options for upgrading plants. They are more expensive than tube settlers because of the material of construction, and the wide plates in operation tend to be hydraulically unstable. Tube settlers eliminate cross-flows and eddy currents and allow for the use of corrosion-resistant, lighter-weight PVC, resulting in a 50% cost savings. Tube settlers are a common, economically-viable alternative/solution to parallel plates (plate settlers).

Material of Construction

Tube settler modules should be constructed of evenly-spaced sheets of PVC which are solvent-welded to form a durable bond between sheets and channels. The PVC material is inert and resistant to deterioration from naturally-occurring constituents in water or wastewater.

Material and finished modules to be used for potable water treatment plant should be Certified to ANSI/NSF-61 Standard for drinking water.

NSF
Certified to ANSI/NSF 61

Any material used for either water or wastewater should include an ultraviolet radiation inhibitor.

Some tube settler modules are constructed of ABS, which is a highly flammable material. A spark from welding, drilling, or a cigarette, etc. could ignite the ABS tube settlers, causing injury to personnel and damage to the tube settlers and surrounding structures.

PVC modules (unlike ABS and other materials) have a specific gravity considerably greater than water and will not float. ABS modules have a specific gravity only slightly higher than water and require a tie-down system. This results in greater costs for material and installation. A tube settler module constructed of PVC will not require any hold-down system or clips.

The mechanical properties of PVC exceed those of ABS, resulting in a more structurally sound installation. The most important mechanical property of PVC, flexural modulus, is 30% greater then that of ABS. PVC is denser, has greater tensile strength, higher impact strength, and is much less flammable then ABS.

“The Paducah WTP increased their total plant capacity by 4.0 MGD (12.0 MGD to 16.0 MGD) by replacing their existing 20” high tube settlers with new, extended tube settlers having a vertical height of 36”. This allowed the plant to meet the increased demand without building a new settling basin, saving the City of Paducah hundreds of thousands of dollars.”

Comparison of Physical and Mechanical Properties of PVC and ABS

PROPERTY	TEST METHOD	PVC	ABS
Specific Gravity	D792	1.45 gram/cm^3 max.	1.06 gram/cm^3 max.
Tensile Strength	D638/D882	6,000 psi min.	5,100 psi min.
Flexural Modulus	D790	425,000 psi min.	300,000 psi min.
Flexural Strength	D790	11,000 psi min.	8,500 psi min.
Impact Strength	D256	10.0 ft-lbs/in min.	6.3 ft-lbs/in min.
Heat Deflection	D648	158°F @ 264 psi min.	180°F @ 264 psi min.
Flammability	UL94	Grade Count = 22 (self-extinguishing)	Grade Count = 135 (extremely flammable)

[2] Willis, R.M. *Tubular Settlers-A Technical Review, Journal AWWA*, 331:335 (June 1978)

Tube Settler System Design

Tube Settler System design is based on these three criteria:

Flow (gpm): Required hydraulic flow capacity through the basin

Area (ft²): Plan area of tank for tube settlers.

Design Application Rate: Flow/Area (1.5 to 3.5 gpm/ft²)

Tube settlers handle maximum application rates from 2.5 to 4.5 gpm/ft². The recommended application rate for design purposes is 1.5 to 3.5 gpm/ft². This design application rate should be verified in accordance with local design standards for allowable flows, application rates, etc. Consideration of the influent water chemistry, settleability, and basin hydraulics should also play a role in selecting the proper application rate.

TUBE SETTLER	VERTICAL HEIGHT	TUBE LENGTH**	TYPICAL DESIGN APPLICATION RATE	EQUIVALENT SETTLING AREA
20″	20.00″	23.09″	1.50 gpm/ft²	10.3 ft²/ft
IFR-6024*	24.00″	27.71″	2.00 gpm/ft²***	12.3 ft²/ft
30″	30.00″	34.64″	2.50 gpm/ft²	15.4 ft²/ft
IFR-6036*	36.00″	41.57″	3.00 gpm/ft²	18.5 ft²/ft
40″	40.00″	46.19″	3.50 gpm/ft²	20.5 ft²/ft
IFR-6041*	41.00″	47.34″	3.50 gpm/ft²	21.0 ft²/ft

* Brentwood Tube Settlers
** Tube length is based on an angle of 60°
*** Some states are limited by the 10 States Standards application rate of 2.0 gpm/ft²

The top of the tube settler modules should be submerged approximately 18″ to 30″ below the water surface. To prevent high velocities and short circuiting of tubes, the velocities through the sedimentation basin should be verified. This can be calculated by dividing the flow through the tank (ft³/s) by the cross sectional area (height x width) perpendicular to flow under the tube settler area, where the height is the distance between the bottom of the tube settlers and the basin floor.

Basin Velocity = Flow (ft³/s) /Area (ft²) ≤ 0.05 fps

The velocities under the tube settler area generally should not be greater than 0.05 fps. To avoid problems with longitudinal velocity, either the tank width or height should be modified. If this is not feasible, consideration of decreasing the flow is an option. Note that this figure is a general guideline and, if the velocity is a concern, a more detailed hydraulic analysis should be performed. When designing the layout of tube settlers within a basin, care should be given to avoid installation near entrance areas where turbulence could impact the performance of the tubes. In a horizontal basin it is recommended that approximately one-third of the basin length should remain tube-free to act as a quiescent zone. Generally, this is easy to implement because the required area of tube settler coverage will occupy a smaller portion of the basin.

Support System Design

Tube settler module support systems should have a bearing surface of approximately 2″. Bearing surfaces of more than 2″ will cause blockage of the tubes that are in contact with the structural members. Supports less than 2″ wide can create loading forces that could crush the modules and reduce their effectiveness. Tubular supporting structures are not recommended because they create point loads, which can severely damage the tube settlers.

The support system can be made of stainless steel, painted carbon steel, or aluminum.

Supports for the modules must be located a minimum of 1′-0″ from the end of each module for modules less than 8′-0″ in length and 1′-6″ for modules greater than 8′-0″ in length.

The support system must be designed with consideration of both live loads (human traffic) and dead loads (Dead loads include the weight of the PVC tube settlers, floc build-up, troughs, baffles, protective surface grating, etc.). The dry weight of PVC tube settlers is approximately 1.75 to 2.00 lbs/ft³. The support system should be designed in accordance with a maximum 8′-0″ unsupported span of the tube settler. This design will support both dead and live loads with an adequate safety factor. Some manufacturers will design based on a 10′-0″ unsupported span that limits operator access and can be potentially dangerous.

In rectangular tanks, the supports should span the full width of the tank. If this is not possible, intermediate support columns may be used. However, the support system should not impact any sludge-collecting device operations or other basin operations. Often concrete center columns are available for use in attachment of the tube settler support system.

Circular clarifiers can use supports that span from the outside diameter to the center well, creating pie shape tube settler areas. If complete coverage is not required for circular clarifiers, cantilevered support frames can be attached to the outer wall to provide the required coverage area.

Trough Design

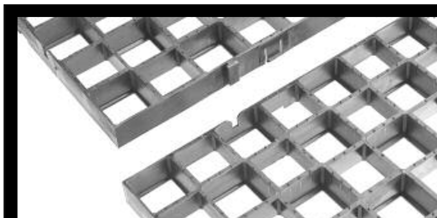
Troughs and weirs for the tube settler system must be designed to handle peak flows and meet local regulatory requirements. Generally, a flow of 20,000 gpd per linear foot of weir (10 States Standards) is sufficient. Material of construction for troughs and weirs is commonly UV-inhibited, NSF-certified fiberglass or stainless steel. The layout of the troughs should be equally-spaced so flow distribution is realized throughout the tube settler area. A general rule of thumb is that trough spacing should not be more than four times the tube submergence.

Baffle Design

Baffles located at the tube settler/quiescent zone interface are required to direct water through the tube settlers area. They should be constructed of UV-inhibited fiberglass, PVC, or stainless steel. The design of the baffle system should be integrated with the support system.

Tube Settler Access

During basin design, consideration must be given to operator access for cleaning and for servicing of the effluent troughs/weirs, as required, within the tube settler area. Like any type of equipment, tube settlers will require periodic cleaning and maintenance and it is unreasonable to deny access for plant operators. A basin walkway design and/or a protective covering on the tube settlers should be provided to allow for a safe walking surface. A plastic or fiberglass grating is ideal because it not only allows access to the tubes, troughs, and weirs, but also adds a protective layer to the tube settlers. Any type of grating must be specifically designed not to hinder the tube settler performance and to be structurally sufficient without causing damage to the tube settlers.



Brentwood AccuGrid® Protective Surface Grating

Brentwood has developed a unique, cost-effective means of providing additional protection to a tube settler system. Our potable-grade NSF-certified AccuGrid provides a protective layer from foot traffic and from the repeated hydraulic impact which occurs during routine wash-downs. The one-piece, interlocking panels are strong, lightweight, economical, and easy to install. AccuGrid protective surface grating will extend the useful life of the tube settlers by 2-3 times.

WHY BRENTWOOD TUBE SETTLERS?

Brentwood provides complete engineered systems, including tube settlers, supports, baffles, troughs & weirs, and protective surface grating. The advantages of a Brentwood installation are:

- **Single source responsibility.** Avoid problems with coordination of engineering, installation, and pricing of different components.
- **Save money** by purchasing an economical packaged system.
- **Exclusive products and features** like AccuGrid Protective Surface Grating and integrated structural ribs provide unique benefits to the tube settler system.
- **Extensive engineering experience** in both plastics design and water treatment technologies are utilized in every system design.

Project Customization

Brentwood tube settler modules can be "custom fit" for either rectangular or circular tanks. Standard lengths available are 6′, 8′, 10′, or 12′, with standard widths of 1′ or 2′. Other sizes are available upon request.

Every tube settler system is different due to project requirements, tank configuration, etc. Please contact us to provide detailed budget pricing, schematic system layouts, and specifications for your particular system design.

Project Pricing

The following case studies are representative of Brentwood's economic performance within the water industry. The figures shown, adjusted for inflation, are from actual projects. System budget prices will vary considerably based on structural requirements and the scope of the project.

CASE STUDY #1:

IFR-6024 System vs. Plate Settler System

8 basins, 20′x52′ tube settler area, Project allowed cost add for plate settler system.

Plate Settler System	Bid Cost = $1,000,000
IFR-6024 System	**Bid Cost = $400,000**

CASE STUDY #2:

Retrofit w/Tubes vs. Build New Basin

2 basins, 17′x32′ tube setter area.

New Tank Cost*	Budget Cost = $300,000
IFR-6036 System	**Budget Cost = $95,100**

CASE STUDY #3:

New Tank w/o Tubes vs. w/Tubes

1 basin 20′x50′ without Tubes,
1 basin 15′x30′ with Tubes

Without Tubes*	Budget Cost = $375,000
IFR-6041 System	**Budget Cost = $250,000**

Does not include new inlet piping, flocculation chamber, troughs, weirs, outlet piping. Includes only site grading, excavation, concrete tank

The City of Myrtle Beach Surface Water Treatment Facility has 5 settling tanks, each with an original design flow capacity of 5 MGD. Each tank is 60′ wide x 120′ long x 15.5′ deep, divided into three 20′ passes.

The sedimentation process was a major component that needed to be upgraded or expanded to increase the plant's rated capacity to meet current and future flow predictions. Enhanced settling was required because the 4-hour detention time was not being met at 30 MGD. After reviewing all available options, the City of Myrtle Beach SWTF decided to purchase and install Brentwood IFR-6024 Tube Settlers in each of the 5 settling basins.

"After less than a year in operation, our Brentwood Tube Settler System:

- *Increased our flow capability (approved plant capacity) from 30 to 40 MGD*
- *Contributed significantly to historically-low settled water turbidity*
- *Reduced chemical coagulant usage*
- *Improved overall filter performance*
- *Allowed us to reduce the state Dept. of Health and Environmental Control (DHEC) mandated basin retention times from 4 hours to approximately 2.5 hours*
- *Allowed greater operating flexibility for the plant staff"*

Sam Scialdone
Plant Superintendent

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