

# Product Information Bulletin

## Inclined Plate Clarifiers

PIBE1011

### Technology

Removal of suspended and precipitated solids from water and wastewater is required prior to use, reuse/recycle, or discharge. Typical technologies used for solids removal include gravity clarification, hydrocyclones, pressure filtration, centrifuges, and a variety of membrane methods such as micro and ultra filtration. **Gravity clarification is the process of choice for removal of suspended and precipitated solids where the solids loading is heavy, flows are high, simplicity of operation is important, low capital and operating cost are major factors, and a robust, highly reliable process is desired.**



Gravity clarification is based upon Stoke's Law, which relates the size and density of the solid particle and liquid viscosity to settling rate of the particle by the following equation:

$$V = 54.5 (SGP-1/0.01)(D \times D)$$

where V = settling velocity in cm/s

SGP = specific gravity particle  
in g/cc

D = diameter of particle in cm

A shape correction of  $V/0.75$  must be applied to the result of this calculation to account for the fact that most particles are not round.

In practice, we generally do not know either the diameter of the particle, or its density, so a simple laboratory settling rate procedure is undertaken to determine the settling rate of the target particle(s). Once the particle settling rate is known, a gravity clarifier can be designed based on the fact that the settling rate of the particle must allow it to reach the bottom of the settling device before it is carried out in the discharge. Thus the flow rate (velocity) at which a clarifying device can be operated is directly proportional to its length and inversely proportional to its depth. From this relationship we find that the surface area of the clarifier required to remove the target particle from the liquid stream can be easily calculated by:

$$\text{surface area sq ft} = \text{flow rate (cu ft/sec)} / \text{settling rate (ft/sec)}$$

This equates to the common design parameter of **gpm flow/square foot**.

Application of this equation to removal of particles from typical water, or wastewater, results in substantial surface area requirements at flow rates over 5 gpm. In many industrial settings, space is a high cost item and large areas cannot be used for water or wastewater treatment. The inclined plate clarifier design addresses this problem by substituting the vertical distance between inclined plates for clarifier depth, which substantially increases the amount of surface area that can be packaged into a given space. Using inclined plates set at a 60 degree angle, which essentially makes them self cleaning, the settling area is thus equal to 50% of the actual surface area of the inclined plate.

This is generally referred to as the projected surface area and for design purposes is equal to the surface area of a conventional gravity clarifier. In practice, we find that an inclined plate clarifier will use less than 25% of the floor space of a conventional gravity clarifier at the same flow rate with generally better particle removal.

Review of our extensive treatability data and the literature shows that light particles, such as metal hydroxides, can generally be removed with at a design flow rate of 0.25 gpm/square ft of surface area. Heavier particles, such as carbon, ceramics, and those resultant from sludge recirculation and crystal growth processes, can often use a much higher design flow rate, resulting in even smaller clarifiers. It is generally recommended that laboratory settling tests followed by on-site pilot testing be conducted if there is any question concerning settling rates.

### **Custom Inclined Plate Clarifiers**

While in theory inclined plate clarifier design is simple, a solid understanding of coagulation, flocculation, and hydraulics is needed to design, build, and operate inclined plate clarifiers. Due to our extensive chemical application activity in the water and wastewater treatment field, we have substantial experience working with inclined plate clarifiers manufactured by every major supplier in the field. Based on numerous observed problems with existing clarifier designs, we decided to custom design and manufacture our own inclined plate clarifiers in 1988.



We have determined that the following items are of critical importance in design of an inclined plate clarifier and thus incorporated them into our designs.

#### **- Zero head loss entry into the plate pack flocculation/stilling well**

We have discovered through observation and experimentation that a major variable in the performance of an inclined plate clarifier is the velocity with which the wastewater enters the flocculation/stilling well of the unit. Any head loss entering the unit will cause floc shear which produces very small particles which will not be removed in the clarifier. ProChemTech clarifiers are designed so that attached flocculation mix tanks have zero head loss entry into the stilling well.

#### **- Stilling well discharge throat area and location**

The discharge from the stilling well to the bottom of the plate pack must have sufficient area and baffling to maintain a minimal flow velocity so as to prevent re-suspension of settled particles.

The stilling well throat must also be located at sufficient distance above the sludge hopper to prevent any “jetting” effect on settled sludge.

**- Flat, short length (maximum length 36”), hard glossy (polished) finish plates**  
Plates longer than 3 feet (36”) have been found to re-suspend settled particles due to sludge movement down the plate, degrading system performance. This is of note as many manufacturers use plates up to 12 feet in length to get the maximum surface area in the smallest package. We manufacture our plates of hard, polished fiberglass, with PVC spacers, to minimize buildup with a maximum length of 3 feet (36”).

**- 60 degree slope on plates for self cleaning**

A polished plate set at a 60 degree angle is self cleaning, many of our clarifiers have been operated for periods exceeding five (5) years with no plate cleaning required.

**- No moving parts below the water line, 45 degree slope pyramid shape sludge hopper**

Moving parts below the water line, such as a sludge rake, are maintenance problems waiting to happen. We have found that a 45 degree slope, pyramid shape sludge hopper is ideal for consolidation and removal of sludge from an inclined plate clarifier.



**- Adjustable V notch effluent weirs set above plate packs**

Due to floor irregularities, inclined plate clarifiers should be equipped with fully adjustable weirs so that flow through all the plate packs can be balanced. To prevent corrosion on this critical portion of the clarifier, our adjustable weirs are constructed of stainless steel with the v notch weir plate of the same polished fiberglass used to make our plates.

**- An inclined plate clarifier should be operated with a minimal retained sludge volume or bed**

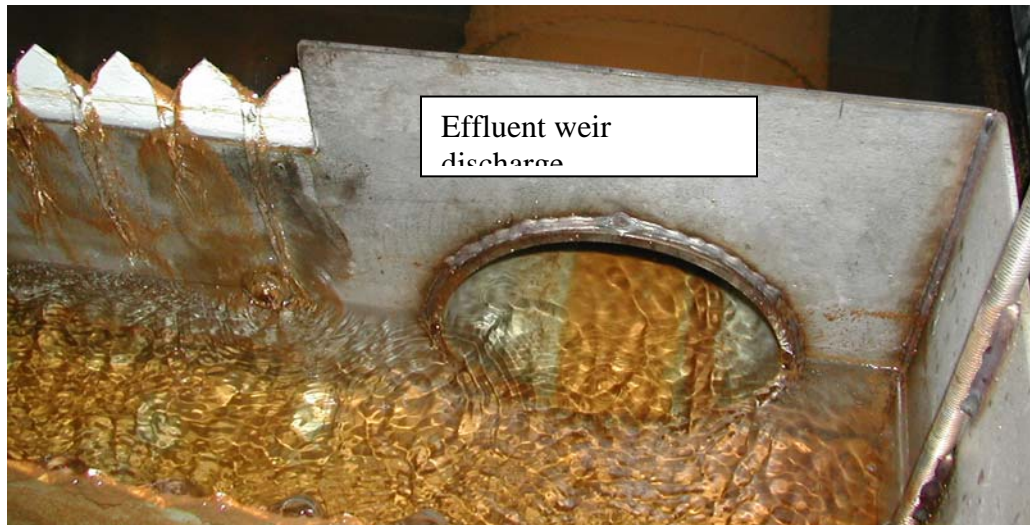
Many clarifiers, such as traditional “solids contact” upflow units, operate with a sludge bed, which in reality functions as a particle filter. Since inclined plate clarifiers are not designed to use, or need, a solids contact bed to obtain rated performance, retention of sludge is not needed.

**- Individual plates for easy plate pack removal**

We have noted that many competitor inclined plate clarifiers are constructed with “unitized” plate packs, removal of these large heavy plate packs for inspection is a major undertaking, sometimes requiring use of a crane. Our plates are individual and can be removed one at a time, often by a single person.

## Chemistry Integration

Our years of working with many waters and wastewaters, and just about every clarifier design known, has also taught us that the chemistry utilized prior to the clarifier is of great importance to the actual performance obtained from the clarifier installation. Many pollutants must first be precipitated from solution, or coagulated into larger solids, then flocculated, to obtain optimum performance from a gravity clarifier. When the proper pretreatment chemistry is combined with good clarifier design, the results are astounding. For instance, our clarifier installation at the Blue



Valley Fish Culture Station, where the clarifier is utilized to treat abandoned mine drainage for use as makeup water to a trout rearing facility, consistently maintains a clarifier effluent discharge (shown above) of less than 0.3 ntu, **without any filtration.**

While we are happy to provide inclined plate clarifiers to specification, the vast majority of our inclined plate clarifiers are supplied as a complete, custom designed system, which incorporates specific chemistry and all pretreatment steps. Our systems commonly integrate mix tanks for pH and ORP adjustment, precipitation, coagulation, and flocculation; complete with mixers, feed systems, and a single control center. Use of a single supplier for both the chemistry and complete system design and provision eliminates potential integration problems from use of several suppliers and gives the customer a single responsible party to work with.

Our clarifier based systems have been used to successfully treat water and wastewaters for such pollutants as arsenic, lead, zinc, copper, iron, manganese, barium, aluminum, cobalt, nickel, mercury, antimony, selenium, chromium, silver, tin, carbon/graphite fines, emulsified oils, fluoride, MBAS, flexographic wastewater, various chemical manufacturing wastewaters, hardness, and suspended solids. Many systems incorporate either recycle of the treated wastewater back to the generating process or reuse of the treated water for such things as cooling tower makeup or fish culture. Chemical pretreatment followed by clarification is a viable process for removal of any pollutant that can be converted into a solid particle or absorbed on a particle such as silica, clay, or carbon. Please note that we have developed many specialized chemistries over the years which permit use of clarifier technology on formerly difficult, or impossible, to treat waters and wastewaters.

## Engineering Specifications

While each ProChemTech inclined plate clarifier, or clarifier based system, is custom designed to customer requirements and needs, the following design factors, specifications, and features are generally applicable.

### Materials of Construction

- Clarifier and mix tank wetted areas are welded carbon steel, white sand blasted, primed, and epoxy finished. Optional stainless steel or PE construction.
- Clarifier and mix tank support structures are welded carbon steel, white sand blasted, primed, and coated with industrial enamel. Optional stainless steel construction.
- Clarifier plates are constructed of a special high density, flat polished finish fiberglass, stainless steel is an option.
- Clarifier plate spacers are constructed of PVC plastic angle secured with nylon bolts, optional is stainless steel angle with stainless steel bolts.
- Mixer blades and shafts are stainless steel.
- V notch weirs of welded stainless steel, weir plates of polished fiberglass, bolts of stainless steel.

### Engineering Design Specifications

- Standard flow rate at 0.25 gpm/square foot of projected surface area, other flow rates used based on laboratory determination of settling rate.
- Inclined plates set at 60 degree angle.
- Maximum inclined plate length, direction of flow, is three feet (36 inches).
- Plate spacing set at 1.5 inch, other spacings optional based on treatability testing.
- Sludge hopper side walls at 45 degree angle, pyramid shape.
- Reagent addition (pH, ORP, precipitation, and coagulation) tanks designed to square dimensions with a typical detention time of 5 minutes. High speed mixing at 1 to 5 hp power input per 1000 gallons of tank volume.
- Flocculation tanks designed to square dimensions with a typical detention time of 10 minutes. Low speed mixing, VFD drive, with typical power input of 1 to 3 hp per 1000 gallons.
- Equipment of welded construction, bolt and gasket assembly of multiple units or special constructed units optional.
- Dual sludge draw ports at bottom of sludge hopper.
- Valved drain ports on all chambers.
- Adjustable effluent weir assemblies set at a minimum distance of 6" above the top of the plate pack.
- Valved sludge blanket location ports on sludge hopper.
- Plate assemblies are single units capable of being removed by one person.
- Flow through unit is by gravity only.

### Typical Options

- Catwalks, ladders, and stairs for access.
- Complete system control panel, various stages of control from manual to fully automatic.
- Sludge holding tanks and dewatering devices.
- Polymer makedown subsystems from manual to fully automatic
- Pre-design laboratory treatability studies with certified laboratory analysis.
- Complete on-site pilot unit, nominal 5 gpm, available.

Due to limits on the dimension of truck shipments, individual clarifier modules are limited to a maximum design flow of approximately 300 gpm, higher flows are obtained by placing modules in parallel. Typical installation of any unit sized above 50 gpm will generally utilize separate mix tanks.

A typical installed combination system with aeration, chemical feed, flocculation, clarification, and sludge recirculation, providing 500 gpm at the Blue Valley Fish Culture Station, is shown at the right. Note that the aeration/flocculation tank is set between two 250 gpm inclined plate clarifiers. This system was supplied as a “turn key” installation, from design through complete commissioning.



Unlike other suppliers of water and wastewater treatment equipment, ProChemTech manufactures water and wastewater treatment chemicals, and provides extensive on-site applications assistance. Our ability to custom design chemical products for specific applications enables us to provide the highest performance inclined plate clarifier based systems on the market. Continued support of our systems, tied to supply of treatment chemicals, allows us to monitor system performance over many years and develop the detailed knowledge needed to design and construct the best inclined plate clarifiers in the world.

While inclined plate clarifiers are the appropriate technology to treat many waters and wastewaters, we have noted in the past few years a tendency by many consultants, engineers, and industry suppliers to recommend other “more innovative” technologies, such as membranes. In many cases this has saddled the customer with costly to operate and maintain systems that are simply inappropriate for the job to be accomplished.

If you have a difficult to treat water or wastewater or need to replace an existing system due to corrosion damage, higher flows, high maintenance costs, or inadequate performance; we would welcome the opportunity to discuss inclined plate clarifiers and systems based upon this proven, cost effective technology.

**ProChemTech International, Inc.**  
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**“Innovation in Water Management”**  
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**“The fish like it!”**

Fish tank at the Blue Valley Fish Culture Station, 100% of the makeup water is abandoned coal mine drainage treated by a ProChemTech designed, built, and installed inclined plate clarifier system in 2005.