# Lamellas in Grit Removal

## Applying Lamella Principles to Grit System Design

Space saving technology can economically remove fine grit and protect downstream processes when applied correctly.

### Lamella Benefits

Lamella type separators can be beneficial due to the space saving feature of increased settling area in a small footprint. Inclined plates or trays are arranged in parallel stacks that shorten the settling distance particles need to travel to be removed. The plates or trays are stacked resulting in an effective settling area that can be more than ten times greater than the vertically projected area of a traditional settling tank. In addition to its smaller footprint, the advantages of a lamella separator over a conventional separator are lower capital, installation, and operating costs, and the potential for higher capacity. Some of the key design criteria for lamella separators include:

- ***Surface Area.*** Projected surface area of the plate or tray is defined as the vertically-projected 2D area (Fig. 2). Therefore, the angle of incline influences projected surface area, with shallower angles of incline producing larger projected areas. Projected surface area is used to calculate surface overflow rate. When projected surface area is used to calculate surface overflow rate, the area of the surface of the water above and the area of the floor below the settling plates is neglected as that area is already included in the calculations.
- ***Plate/Tray Inclination Angle.*** Plates or trays are installed at an angle greater than the angle of repose for the target particles. Most are set to an incline angle 45-60 degrees from horizontal.[2]
- ***Flow Distribution.*** Traditional lamella separators utilize submerged orifice holes or v-notch weirs on the effluent launder to ensure equal hydraulic loading to each surface (Fig 3). This results in a typical pressure drop (headloss) of 2”-3” (5-8 cm) (minimum).[3]
- ***Minimize Clogging.*** In municipal applications, traditional lamella separators are typically used in processes that do not contain large solids and little to no stringy materials (i.e. potable water filter backwash). When used in processes with large solids and stringy materials, care must be taken to guide the flow through the lamella plates while avoiding the sharp leading edges of the plates and their supporting structures.

***Effective headworks screening now allows the use of lamella principals to achieve high efficiency grit removal.***

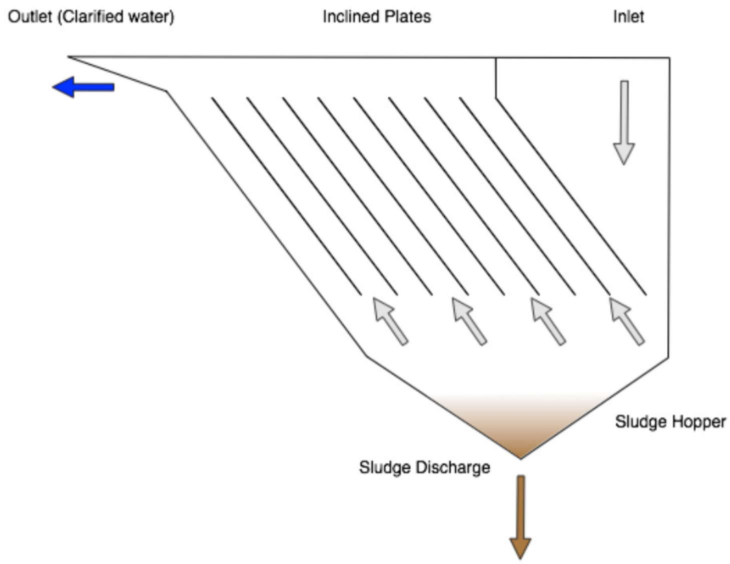


*Fig. 1. “Lamella Clarifier.” Wikimedia Foundation. Last Modified June 25, 2022. https://en.wikipedia.org/wiki/Lamella_clarifier*

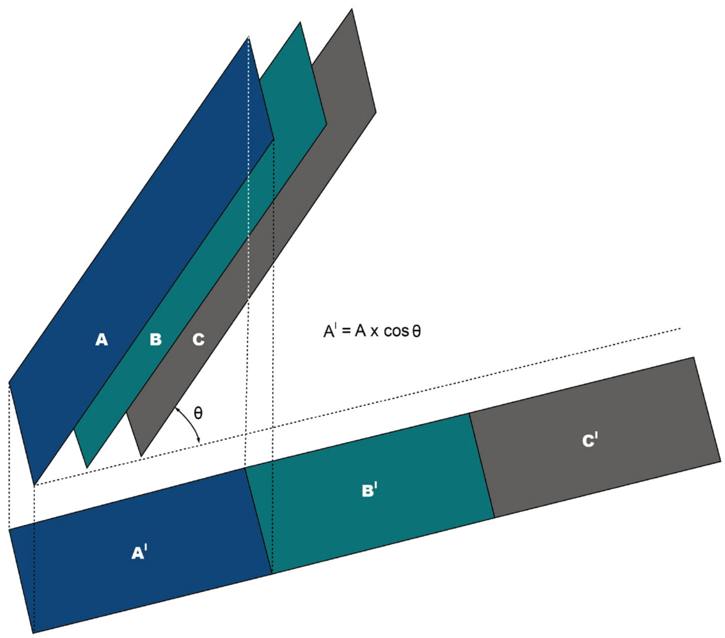


*Fig. 2. Horizontal projection of equivalent surface area in lamella systems*

## History of Lamellas in Grit Removal

Grit removal systems utilizing lamella separation principals have been commercially available since the introduction of the HeadCell® stacked tray separator in the late 1990's. The stacked tray grit separator combines lamella separation and vortex flow features (to effectively achieve the desired surface overflow rate across all flows) with self-cleaning rotary flow patterns which contain no moving parts. Recently, other lamella type grit separators have become commercially available. Each uses different designs, yet all are sized based on a specific target particle size and specific gravity, utilizing settling velocity and the surface overflow rate required to remove the target particle size.

Surface overflow rate was used in grit removal systems long before the stacked tray separator was introduced into the industry. The use of surface overflow rate to size grit removal systems dates to the 1950's with Detritor tanks. Sizing of Detritor tanks included consideration of velocity and surface overflow rate as well as flow distribution. Detritor tanks typically used flow directing vanes on the inlet and outlet which were angled to aid even flow distribution across the surface area of a square tank. Even flow distribution was critical to ensuring adequate settling time for the grit particles to drop to the bottom of the tank where they could be removed by rotating rake arms. Detritor tanks eventually fell out of favor due to the space required and mechanical complexity.

***Historically, conventional lamella technologies for primary clarification fell out of favor in north America due to their tendency for clogging. Stacked tray grit separator designs have been adapted to overcome these challenges.***

As mentioned previously, one of the key design considerations for lamella separators is ensuring that the design surface overflow rate is consistently achieved across all flows through effective flow distribution so that the target particles are removed. Even flow distribution is typically achieved by creating headloss either upstream or downstream of the plates/trays.[1] Traditional lamella separators designed to remove flocculated solids utilize orifice holes (0.5"-2" diameter (13-50 mm) typical) or v-notch weirs on the effluent launder to create headloss which ensures equal hydraulic loading to each surface. Because grit separation does not include flocculation, the headloss required to distribute flow equally may be accomplished upstream of the plates/trays.

In applying lamella principals to grit separation technology, one must consider how the system will perform given the nature of the influent. Lamella separators have been used in primary clarification applications at municipal wastewater treatment plants with limited success in North America. The tendency for rags, sanitary wipes, hair, and other coarse material to clog spacing between the plates is typically the biggest challenge. In a similar manner, lamella grit separator design must address the presence of this material to avoid plugging and allow long term operation.

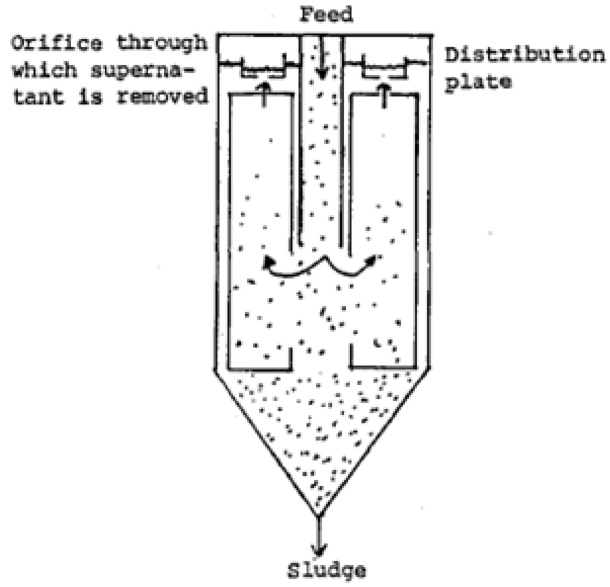


*Fig. 3. Brown, Deborah J. 2018. "Design of Lamella Separators. Part 2". figshare. https://hdl.handle.net/2134/36469.*

## Comparing Lamella Grit Removal Technologies

A comparison of the three commercially available Lamella type grit separators allows stakeholders to evaluate each technology. Ultimately the goal is to protect downstream assets by maximizing total grit removal. Properly implementing the key design principles will yield the desired performance and operate dependably.

## Traditional Lamella Design (Linear Lamella)

Traditional (or linear) lamella type grit separators utilize rectangular plates mounted in a rectangular basin. Flow is introduced perpendicular to the plates which are submerged side by side in a 20' long (6 m) "plate pack". Effluent exits by a weir located at the downstream end of the basin. This design closely resembles the original lamella gravity separators but omits some of the key design criteria:

- ***Surface Area.*** Surface area is provided by rectangular plates that are mounted in "packs" that are assembled, one plate at a time by the installing contractor. A typical basin size is 10'x32' (3-10 m). While sufficient surface area may be provided, limitations in the flow distribution prevent utilization of the provided surface area.

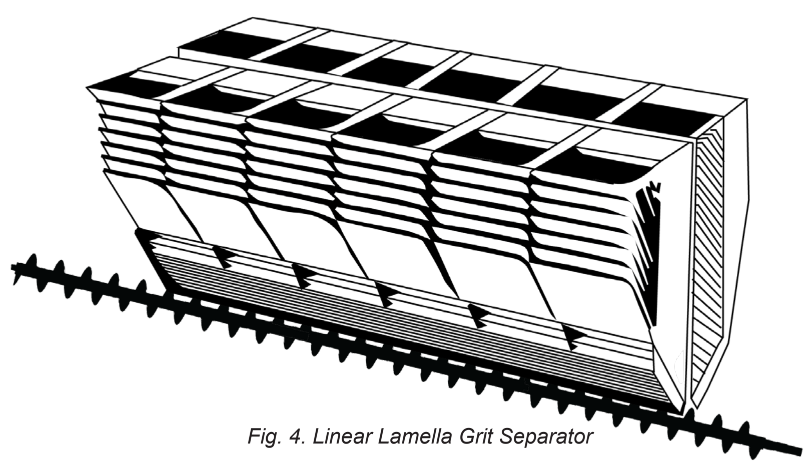

*Fig. 4. Linear Lamella Grit Separator*

- ***Minimize Clogging.*** Plates are normally inclined at a 60º angle with 3" (7.6 cm) spacing. Trays are supported by a stainless steel support frame with many snag points.

- ***Flow Distribution.*** Flow is pre-aerated to bring floatables to the surface. Wastewater enters the plates perpendicular to the narrow plate edge and supporting frame, with effluent exiting via a 10' (3 m) weir at the far end of the basin. No pressure drop, other than the depth of flow over the effluent weir is provided. This leads to potential maldistribution and short circuiting of flow, especially across the top of the submerged plate packs. The use of 3" (7.6 cm) plate spacing and perpendicular plate feed in an application where rags and other coarse material are present may lead to significant clogging.

- ***Municipal Wastewater Application.*** Traditional lamella separators are very effective in separating flocculated solids in industrial and municipal drinking water applications where coarse debris is not common. The use of lamella separators for primary clarification at North American municipal wastewater treatment plants is highly uncommon due to the propensity for clogging with coarse debris. Increasing the plate spacing to 3" (7.6 cm) may improve the design but clogging is to be expected from the larger solids and stringy materials. Another challenge is the overall basin length. Captured grit settles in a V-shaped hopper bottom with a cross collector screw (30'+ (9 m) long) used to transfer grit to the suction point of a pump that operates intermittently. The use of cross collector screws in grit applications have been used in the past with aerated grit chambers, with most seen as problematic, as maintenance is challenging due to the basin depth and limited access.

## Mechanical Vortex Lamella Separators

Another version of lamella grit separator combines a flat bottom mechanically induced vortex design with plastic cone segments. A circular tank with tangential influent/effluent channels incorporates cones where influent is introduced at the bottom of the separator. Flow then rises though a combination of layered plates and cones and then exits via a tangential effluent channel.

- ***Surface Area.*** Surface area is provided by placing layered plates and cone segments in the circular tank. The cone segments are assembled and installed, one at a time by the installing contractor. Typical basin sizes are 6'-24' (1.8-7.3 m) diameter. The surface overflow rate applied is based on Stokes Law but does not incorporate the impacts of non-laminar flow regimes found in rotary flow devices.

- ***Tray Inclination.*** Cones slope at approximately 75° towards the center hole which transitions the settled grit vertically to the lower area. A labyrinth of layered plates further collect grit that ultimately must pass through a perforated plate that sits over the collection hopper. Cone spacing is currently unknown as there are no commercially operating units installed.

- ***Flow Distribution.*** A 30º downwards sloping influent ramp feeds the chamber tangentially, while flow travels upward through the same layered plates that the grit must pass through to reach the grit hopper. The layered plates sit at a shallow incline angle to minimize height requirements. Flow exits at the periphery of the layered plates and the unit does not include any features to evenly distribute the flow across the cone segments. Effluent exits via a tangential effluent channel while flow is expected to travel across the surface area of all the cones, despite there being no means to ensure this is accomplished. The supports for the cone segments and layered plates provide many locations for rags and coarse solids to snag. The effluent channel is typically 3'-6' wide which is expected to accelerate velocity in this area and the adjacent cones. Captured grit settles through a perforated plate into the lower hopper and is pumped away intermittently.

- ***Municipal Wastewater Application.*** While the cone-based system offers more surface area than a traditional mechanically induced vortex separator, flow distribution and clogging are significant challenges with the design. The upward velocity of flow passing through the layered plates below the cones is estimated to far exceed the settling velocity of the 75 micron grit the technology claims to remove. Velocities throughout the unit will increase as portions of the plates and cones are clogged with rags and other coarse material. There are no grit separators of this type in commercial operation currently.

***Minimizing moving parts and snag points significantly improves trouble free operation.***

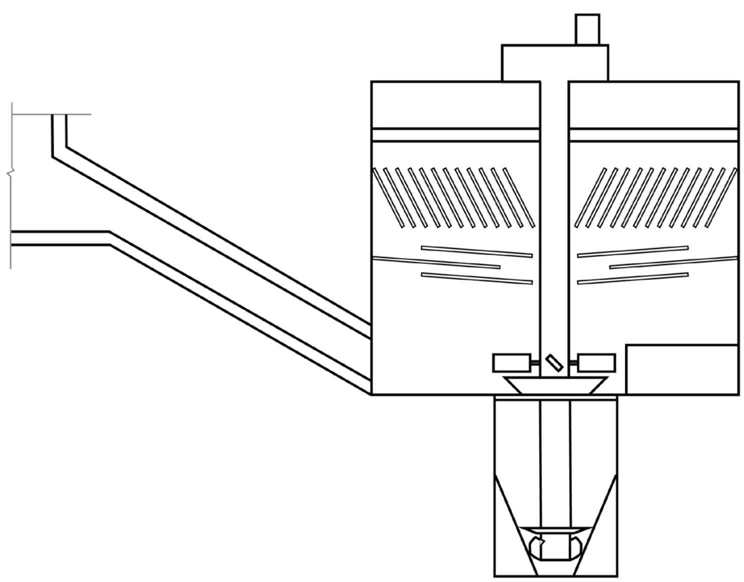

*Fig. 5. Lamella Mechanically Induced Vortex (MIV) Grit Separator*

***Lamella type grit separators can be a highly effective solution for grit removal if designed and implemented correctly.***

## HeadCell® Stacked Tray Grit Separator

The HeadCell stacked tray grit separator uses a patented influent duct with rectangular nozzles attached to each tray to create headloss which ensures equal flow distribution and surface overflow rate across the entire surface area of each tray. This allows for consistent/predictable removal of target particles. Key lamella design principles are followed in all areas of the design:

- ***Surface Area.*** Surface area is maximized in a small footprint by stacking circular conical trays vertically. Trays are supported by a stainless steel support frame on the effluent of the trays, designed to minimize snag points. Typical basin size is 12'x12' (4x4 m) or 16'x16' (5x5 m). The surface overflow rate applied incorporates the impacts of non-laminar flow regimes found in rotary flow devices.

- ***Tray Inclination.*** Trays slope at a 45º to the center hole which transitions the settled grit vertically to the lower collector.

- ***Minimize Clogging.*** Trays are spaced at a minimum of 8" (20 cm) to prevent clogging. Flow is introduced into the interior of the tray to prevent materials hanging up on the periphery of the trays and to minimize the amount of rags which reach the surrounding support structure. Trays are rotomolded in one piece to eliminate fasteners or intermediate supports which can snag.

- ***Flow Distribution.*** A patented influent duct splits flow equally to each tray throughout all flow ranges resulting in a maximum headloss of 12" (31 cm) while delivering consistent surface loading and performance. Smooth transitions and rounded corners ensure no snag points for rags are presented to the influent wastewater. A circular baffle on the top of each tray directs flow around the perimeter of the tray creating a stable circular flow path, which then exits radially through spaces between the trays and finally carries over a fixed effluent weir. The effluent weir is typically 12'-16' (4-5 m) wide which minimizes exit velocity. Captured grit settles in the lower collector and is pumped away continuously. No moving parts are located within the basin.

- ***Municipal Wastewater Application.*** There are over 800 HeadCell stacked tray separators currently in operation since first introduced in 1999. The design has been optimized to deal with the coarse debris typically found in the headworks area of today's wastewater treatment plants. The rotary flow path through the HeadCell allows self-cleaning while the transition areas within the patented influent duct eliminate snag points.

***HeadCell is specifically designed to prevent clogging and ragging issues by using large clearances and rounded edges to prevent clogging and downtime.***

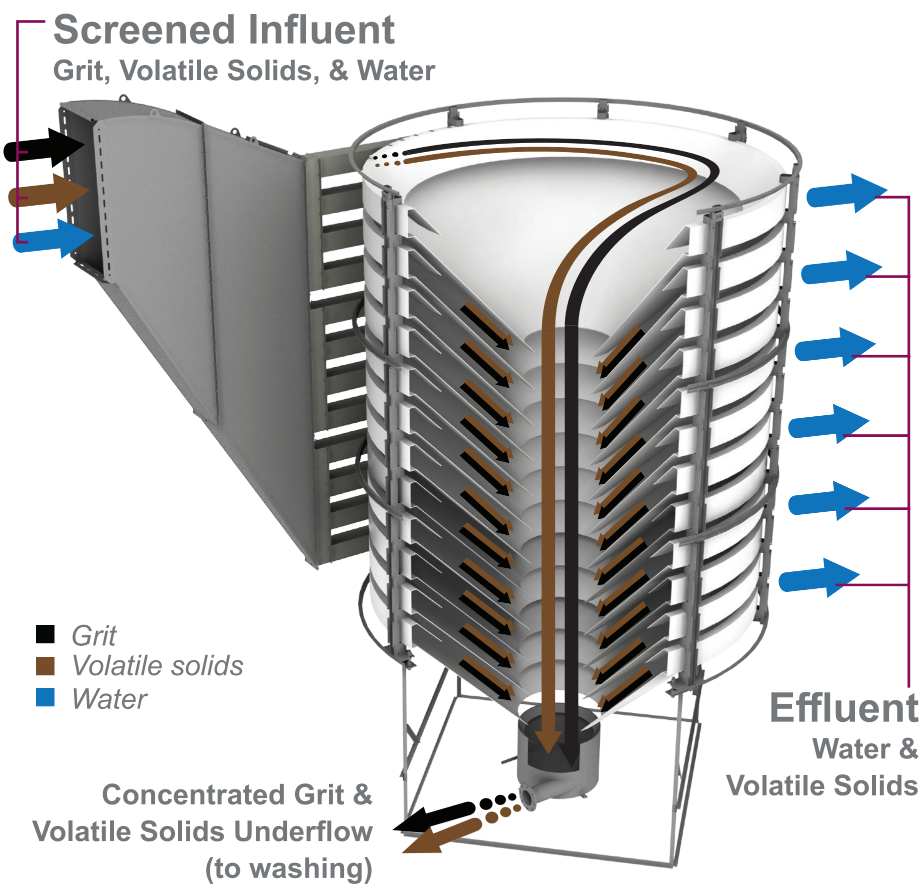


*Fig. 6. HeadCell® Stacked Tray Grit Separation System*

*Fig. 7. Installed HeadCell® Stacked Tray Grit Separation System*

*Fig. 8. Installed HeadCell® Stacked Tray Grit Separation Systems*

## Conclusions & Comparisons

Applying lamella principles to grit removal processes can be a very effective solution for modern wastewater treatment plants where fine and slow settling grit removal is desired. To achieve predictable and consistent grit removal using lamella separation, designers must ensure that the required surface overflow rate is maintained. Flow distribution and preventing blockages are key factors in achieving target surface overflow rates. With 800+ HeadCell stacked tray grit separators in operation for 23+ years, this proven design delivers the performance needed to protect downstream assets in modern water reclamation facilities. The HeadCell® is the only lamella type grit separator to have been independently verified at dozens of sites to achieve the fine grit removal advertised.

**HeadCell® - Stacked Tray Grit Separation**

| Pros | Cons |
|---|---|
| Proven technology with 800+ units installed with good operational history | Proprietary design |
| Independently verified to achieve 95% removal of grit ≥ 75 micron at rated flow | Basin depth |
| No moving parts within basin | Cannot be retrofit into existing MIV tank |
| Patented influent duct ensures even flow distribution | |
| Rounded corners and smooth transitions within influent duct prevents snagging | |
| Small footprint | |
| Can be retrofit into existing basins (aerated grit & others) | |
| Square tank makes for simple forming and construction | |

**Linear Lamella Grit Separation**

| Pros | Cons |
|---|---|
| Fits most aerated grit basins (retrofit) | No independent test results to support performance claim |
| Available in pre-packaged headworks skid for small plants | No long term operational history – less than 5 units installed |
| | Small plate spacing and sharp edges create opportunity for clogging/ snagging |
| | Lack of flow distribution results in bypass and uneven surface overflow rates |
| | 5 total mechanical components: blower motor, screw, screw drive, skimmer carriage, skimmer drive (several below water level) |
| | Bottom mounted screw difficult to access |
| | Skimmer mechanism not reliable |
| | Cannot be retrofit into existing MIV tank |
| | Large footprint |

**Lamella Mechanically Induced Vortex Separation**

| Pros | Cons |
|---|---|
| Variable inlet and outlet configuration options | No independent test results to support performance claim |
| Available in pre-packaged headworks skid for small plants | No long term operational history – less than 5 units installed |
| | Small plate spacing and sharp edges create opportunity for clogging/ snagging |
| | Shallow flow distribution cones prone to clogging |
| | Lack of flow distribution results in bypass and uneven surface overflow rates |
| | Segmented cone has seams with fasteners which results in hair pinning and clogging |
| | Cannot be retrofit into existing MIV tank |
| | Long influent & effluent channels requires large footprint and a complicated concrete forming with multiple pours |
| | High headloss, typically up to 2 feet (0.6 m) |
| | Proprietary design |

## Learn more

To learn more about how our **Grit Removal Systems** can improve your plant, visit **hydro-int.com**, or contact us:

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