

Grit Chamber Design Considerations

A look at the slow settling rates of grit particles demonstrates why grit separation is so difficult.

U.S. Mesh Size	Diameter, Microns	Diameter, mm	Settling Rate, ft/sec
50	295	0.295	0.13
100	147	0.147	0.05
140	104	0.104	0.03
200	74	0.074	0.02
325	43	0.043	0.01

The actual settling rate is even slower than these ideal rates, because the particles attach to oil or grease and because of particle interference while settling. Conventional aerated grit chambers create updrafts which tend to keep particles suspended. The rise rate of small bubbles is about one foot per second.

A. Available Systems

A 50 mesh size particle is the largest normally selected for design. Some engineers select the 140 or 200 mesh size as their design basis. Clearly, conventional aerated grit chambers would have to be extremely large and expensive to capture a particle whose settling rate is 0.05 feet per second or less. For this reason, the much smaller and less expensive centrifugal designs have become popular. Systems for grit separation fall into one of the following three categories.

(1) The cyclone is effective in separating grit particles. It is small, inexpensive and has no moving parts. However, it has two major disadvantages. First, the cyclone requires high energy input because of the 10 to 15 psi of headloss required to operate it. Second, the grit is discharged with a large volume of water in a fairly dilute slurry. Cyclones are often used as part of a complete grit removal system to reduce the volume of grit slurry entering the grit slurry settling basin. Manufacturers of grit cyclones include Wemco, Krebs and AerResearch.

(2) The open centrifugal chamber design can be as effective as the cyclone. Plus, it has little headloss. The concept of the open centrifugal chamber was developed by a European company named PISTA. Manufacturers of open centrifugal chambers include Jones and Atwood, Munier, Smith & Loveless, and AerResearch with its “AerCyclone” design.

(3) Static centrifugal chambers are large-diameter chambers without internal mechanisms. They fall between the cyclone and open centrifugal chambers in their energy usage and slurry concentration. Manufacturers of static chambers include Eutek, Grit King, and AerResearch with its “Nautilus” design.

B. Open Centrifugal Design Concepts

The open centrifugal chamber begins its work (See attached drawing) by taking advantage of the kinetic energy of the particle in the water stream. The particle and water move at the same velocity as they enter the chamber. The particle has more kinetic energy than the water it displaces because it has more mass (It’s specific gravity is 2.65 times that of water). Greater kinetic energy means that the particle is harder to turn, so, as flow enters the upper chamber tangentially, grit particles become isolated against the wall. At the same time, gravity works on the particles to move them downward.

The mechanisms of all open centrifugal systems are designed (in concept, at least) to create an updraft at the center of the chamber. This draws the slurry across the tank bottom toward the center where grit can fall into the center hopper and be isolated from the flow. Many manufacturers use paddles to accomplish this center upflow. The problem with paddles occurs when the paddles turn too fast and actually push the particles outward rather than pulling them inward. The adjustment of paddle speed and angle is critical, and it must be changed often to compensate for changes in flow. The constant adjustment necessary with a paddle design makes it impractical to operate.

Some of the manufacturers of paddle systems, especially on their larger grit chambers, position their paddles at the surface so that the flow is directed outward at the surface. This is a great improvement, since it accomplishes the goal of directing the flow toward the center at the bottom.

The *AerResearch* AerCyclone grit separation chamber creates an updraft with an airlift system. This system never needs to be adjusted. It is not possible to cause an outward flow at the bottom with this system. It is mechanically more simple and less expensive than a paddle system. Plus, it adds oxygen to control odors and corrosive gases in the plant influent. And, as a bonus, the mechanism is retrievable without bypassing the basin, so duplicate grit chambers are not necessary.

C. Grit Slurry Removal

Some manufacturers recommend airlifts to remove concentrated grit slurry from the center hopper. Airlifts are low velocity devices which are not well suited for the movement of grit. However, they are often used based on owner preference or for their apparent simplicity. Many “failures” of grit systems are due to the airlift being unable to remove grit from the sump. When the sump becomes filled with packed grit, the operator has a major problem, because (1) the sump is difficult to clean, (2) the suction end of the airlift becomes blocked and (3) the air diffusion device at the bottom of the airlift becomes packed and inoperable.

For these reasons, *AerResearch* recommends that a minimum of two airlifts be provided (*AerResearch* designs allow up to four) and that the airlifts be removable from the basin without interrupting operation of either the basin or the other airlift. With this system, at least one operable airlift is always in service. The operator has the option of operating either or both airlifts, operating one while the second is operated in reverse as a sump agitation device or removing one for cleaning while the second remains in operation. *AerResearch* also recommends that the airlift be operated by a removable air lance rather than an air dispersion ring, since air dispersion rings become inoperable when packed with grit. In either case, *AerResearch* recommends that the airlift be operated by a solenoid valve on an adjustable timer.

A strongly recommended alternate to airlifts is an abrasion-resistant vortex pump to remove slurry from the sump. To avoid plugging, we recommend the use of a 3" minimum (4" preferred) pump operated on an adjustable timer. Such a pump will flow approximately 300 gallons per minute at head conditions typical for grit systems.

AerResearch recommendations always show the pump suction pipe entering the grit slurry sump vertically downward. Other configurations would allow grit to pack into the pipe. Open slurry pumps have a low suction capability and are unable to start flow when the suction is packed with grit.

With either airlifts or centrifugal pumps, the sump should be provided with a bottom cleanout and an air connection or a water connection. If the sump becomes packed with grit, the operator will greatly appreciate these inexpensive aids. Keep in mind that most of the grit enters a plant during periodic high flows which "flush" grit accumulations from the collection system. Packing of the grit slurry sump can occur quickly if such a flush takes place at the same time that the grit pump or airlift is out of service.

D. Final Disposal Of Grit

A grit chamber does not dry the grit and prepare it for disposal. It simply concentrates grit into a smaller volume of water. This grit slurry must be concentrated further prior to final disposal. Simple systems, such as sludge drying beds, are obvious and inexpensive choices. Mechanical dewatering is often desired, and it is usually accomplished in a settling basin with a dewatering screw or other conveyor. Typical units are the Wemco Hydrogritter and the Eutek Snail.

A common design problem, and the cause of many "failures", is an undersized grit classifier. The settling basin of the classifier must function effectively as a clarifier for the slow settling grit particles. Therefore, the settling basin must be sized the way that any clarifier is sized - by surface loading rate and weir loading rate. *AerResearch* recommends no more than 8,300 gallons per day per foot of weir for the weir loading rate and no more than 2.88 gallons per minute per square foot for the surface loading rate. Remember that this is based on the flow actually entering the classifier - not the plant flow.

A second major cause of grit system failures is operating the conveyor too fast so that it stirs the settling tank. This stirring re-suspends the grit and allows it to re-enter the wastewater stream with the return flow. AerResearch recommends that a screw conveyor be designed to turn at no more than two revolutions per minute. Many manufacturers recommend around ten revolutions per minute.

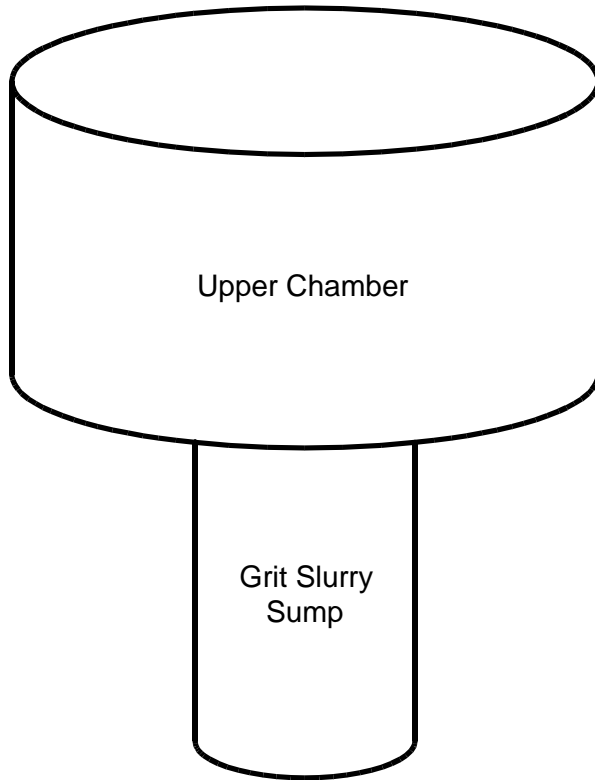
A grit classifier sized by these criteria to receive a typical grit pump discharge of 300 gallons per minute is very large and expensive. For this reason, **AerResearch** recommends that a cyclone be used on the pump discharge to reduce flow to the classifier to about 18 gallons per minute. This will result in a classifier with about an 18" diameter screw conveyor, about 3.1' of weir and about 10 square feet of surface area in the settling basin.

E. Summary

A grit chamber is only one component of a grit system. A system is successful only when all components are properly designed. Careful design considerations are often neglected, and unsatisfactory designs result. However, a properly designed system can be both effective and easy to operate.

The **AerResearch** AerCyclone and Nautilus chambers are easy to operate and inexpensive to build. They require no daily or seasonal adjustments. As a part of a properly designed system, they save many times their cost in parts wear and basin cleaning.

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PARTICLE ISOLATION STEPS:

- A. Centrifugal push to wall
- B. Gravity pull to floor
- C. Mechanical sweep to center
- D. Heavy particles fall into sump
- E. Light material stays in suspension

