Designing A Grit Removal System That Works

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Executive Summary

SITUATION

Grit is often treated as an afterthought.

Meeting regulatory requirements for treated effluent and solids quality has been the major focus for wastewater treatment facilities.

Yet, wastewater treatment plants are significantly impacted by grit. Grit is a nuisance material which causes abrasive wear to mechanical equipment and increases maintenance and operational costs.

Grit also accumulates in processes throughout the plant, reducing processing capacity and efficiency over time.

PROBLEM

Current assumptions about grit are wrong.

Conventional design guidelines target removal of grit larger than 210 µm while minimizing organic content, but many wastewater treatment plants find that over 50% of their influent grit is smaller than 210 µm.

In addition, conventional engineering practices assume that municipal grit behaves like clean sand particles in clean water when, in reality, wastewater grit is comprised of silica sand as well as asphalt, limestone, concrete and various other materials that do not behave like sand.

Finally, grit particles are not typically spheres and are exposed to fats, oils, greases, and soaps in the collection system which coat the grit and alter its settling velocity.

SOLUTION

Improved grit removal is possible through improved design.

Grit removal systems can work as intended when designed with an accurate understanding of the nature and characteristics of the grit arriving at the treatment plant and how this grit actually behaves in wastewater.

An effective system addresses size as well as settleability, produces a clean dry product for landfill and minimizes deposits and accumulations in the plant.

Grit causes abrasive wear to mechanical equipment and increases maintenance and operational costs.

RESULT

Improved grit removal reduces operational costs.

The most significant impact of grit is in damaging and reducing the effectiveness of downstream systems and equipment, necessitating increased maintenance, repair and replacement frequencies.

Grit removal systems that are designed with reference to the accurate characteristics of grit remove grit with greater effectiveness, reducing the amount of grit that reaches and impacts on downstream systems.

This reduces the amount of maintenance and repair required for those systems – saving money on operations.
Wastewater treatment plants are significantly impacted by grit.

Grit is a nuisance material, depositing in treatment processes and causing abrasive wear to mechanical equipment. In addition to the abrasive effects, grit accumulates in processes throughout a plant, reducing processing capacity over time.

The reduction in processing capacity can affect the plant’s ability to achieve process design goals, such as reduced methane production or increased alkalinity in digesters, and increase operational costs, such as horsepower requirements in aeration basins.¹

Accumulation happens gradually and continuously, and often goes unnoticed until a process is completely overwhelmed and needs to be shut down to manually remove the deposited grit.

This is a costly, labor-intensive and hazardous operation.

When a process must be taken offline the flow to the entire process train must be diverted. This requires building excess plant capacity to use as grit storage, which can significantly increase the size and cost of the plant.

As plants move toward higher performing processes, effective grit removal becomes an even more important criterion in treatment plant designs – and the growing acceptance of Membrane Bio-Reactors (MBR) technology brings the need for advanced grit management systems into consideration for effective pretreatment processes.

MBR technology requires extensive screening pretreatment, which often allows elimination of primary clarification.

Without the protection of primary clarification, advanced grit removal should also be part of an effective MBR pretreatment system design² otherwise grit entering a MBR plant can damage the membranes, which are often the most expensive equipment in the plant.


While grit is a nuisance and increases both maintenance and operational costs, it is often treated as an afterthought.

The main focus in the design of wastewater treatment plants is meeting regulatory requirements for treated effluent and solids quality. Traditionally, the design intent of grit removal systems – based on Metcalf & Eddy, WEF MOP #8 and other trade manuals – has been to target 210 µm grit and larger, with a specific gravity of 2.65.

The results of these design criteria, however, are more likely to produce a product with low organic content in order to make it acceptable at a landfill rather than to eliminate the grit that is causing problems for the plant.

Reviewing the design criteria more closely, one nonetheless finds descriptions of materials in addition to silica sand and a recommendation that settling velocity be considered. Despite this, however, the industry continues to target large grit in order to produce a product that is easy to landfill.

Though producing a low organic content grit is an important goal to keep in mind when designing a grit removal system – as organics create odor issues as well as increasing volume and water content, which can make the product unacceptable at a landfill – the primary goal of any grit removal system should be to eliminate the grit that is causing problems at a plant.

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The principle reason that conventional grit removal systems do not work effectively is a failure to apply everything that has been learned about how municipal grit actually behaves in wastewater.

Since grit is not well understood, it is often erroneously treated as clean sand particles. This is a major reason why most grit removal systems fail to capture the quantity and sizes of grit for which they were designed.

Understanding the actual characteristics of grit at a particular plant helps to determine the size and type of grit removal system that is needed to remove it.

Conventional design criteria caution that settling velocities are important, yet grit systems are typically designed with the assumption that grit is simply spherical silica sand having a 2.65 specific gravity.

In other words, each particle is assumed to be a perfect sphere settling in a quiescent basin of clean water.

Ideal assumptions rarely work in municipal wastewater, however; in reality, industry faces a variety of potentially damaging materials with a variety of specific gravities.

The particles vary in shape, and many plants have noted that much of their larger grit is flat. A flat particle will display much different settling characteristics than a sphere.

While in the collection system, the grit particles are exposed to fats, oils, greases, soaps and scum which attach to the grit particles and alter the particles’ settling characteristics.

In addition regional aspects, such as the local geography, winter degritting regime and activities and the type of collection system can also impact the characteristics of grit.

IN PRACTICE

At the East Bay MUD wastewater treatment plant in the Oakland, California area it was determined that the specific gravity of the plant’s influent grit ranged from 1.95-1.6 and had an average of 1.35.3

While the textbook 210 µm particle with specific gravity of 2.65 would settle at 2.39 cm/s at 15ºC (59ºF), a 210 µm particle with a specific gravity of 1.35 would settle at a rate of 0.62 cm/s at the same temperature.

In other words, the hypothetical higher specific gravity particle settles almost four times faster than the particles observed in the actual working plant.

Conventional grit removal systems predominately rely on gravity as the main separation method – and if system design conditions differ from reality then they will not operate as intended.

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Grit in wastewater is a complex phenomenon.

The commonly used assumption that grit behaves in an equivalent manner to clean sand particles in clean water is critically flawed.

Looking strictly at size and comparing distributions of grit from a variety of plants it can be seen that in many cases 50% of the incoming grit is smaller than the conventional design cut point of 210 µm. Therefore, based solely on size distribution, by design, half of the incoming grit will continue on to damage downstream equipment.

Modifying design criteria to remove 90% of the incoming grit requires changing the design cut point to somewhere between 75-150 µm, depending on the grit gradation.

The conventional design criterion of 210 µm removal has allowed passage of a large quantity of small grit into wastewater treatment plants.

Larger material is also often found downstream of the grit removal process. The larger material that passes must be accounted for based on different criteria.

One reason is that municipal grit is comprised of various materials and is not only silica sand.

Since conventional design guidelines continue to prove ineffective, more comprehensive design guidelines should be used.

Several factors should be considered when designing a grit removal system, starting with a full characterization of the endemic grit including grit load, size distribution and settling velocity or effective specific gravity.

CRITICAL DESIGN FACTORS

Define design requirements:
- Grit particle size analysis
- Settling velocity or specific gravity
- Required system removal Efficiency
- Screening requirements

Evaluate Equipment:
- Removal efficiency/performance
- Equipment design/features
- Space
- Headloss
- Cost: capital, installed, operational
- Maintenance Requirements

With good data on the endemic grit, a cost-benefit analysis can be determined, evaluating grit removal efficiency as compared to cost. Other considerations include upstream screening requirements, maintenance requirements, space, and headloss.

In the absence of site-specific information, it is better to err on the side of caution. In this regard, design should be based on the smallest practicable particle size – which would typically be in the 75-106 µm size range.
Conclusion

It is not uncommon to find operator dissatisfaction with installed grit removal systems.

Many systems fail to keep depositable grit out of the plant, and the reality is that many systems fail to remove the sizes and amounts of grit that they were intended to capture.

Grit system failure happens primarily due to a faulty assumption that municipal grit behaves like clean sand particles in clean water.

The failure of many traditional grit removal systems has led to the misconception that grit removal systems cannot work, and that the only option is to deal with grit deposits downstream of the headworks and to deal with abrasive wear from grit by increasing maintenance and operational budgets.

This need not be the case. Effective grit removal systems may be designed as long as effective, appropriate design guidelines are used.

Design Principles for an Effective Grit Removal System

Don’t treat grit like sand

In order to design an effective system, design guidelines are required that go beyond treating the complexity of grit as equivalent to simple spherical particles of sand.

Understand your specific grit requirements

A clear understanding of the grit entering the plant is required, including grit load, size distribution, effective specific gravity and settling velocity.

Only with a clear understanding of the material to be removed can an effective system be designed to achieve specified results.

Think smaller

Without site-specific information, in order to protect equipment from damage caused by fine grit it is advisable to design based on the smallest practicable particle size – typically 75-106 µm.
Visit advancedgritmanagement.com to learn more about how advanced grit management can help you to improve grit removal and reduce wastewater treatment operational costs.