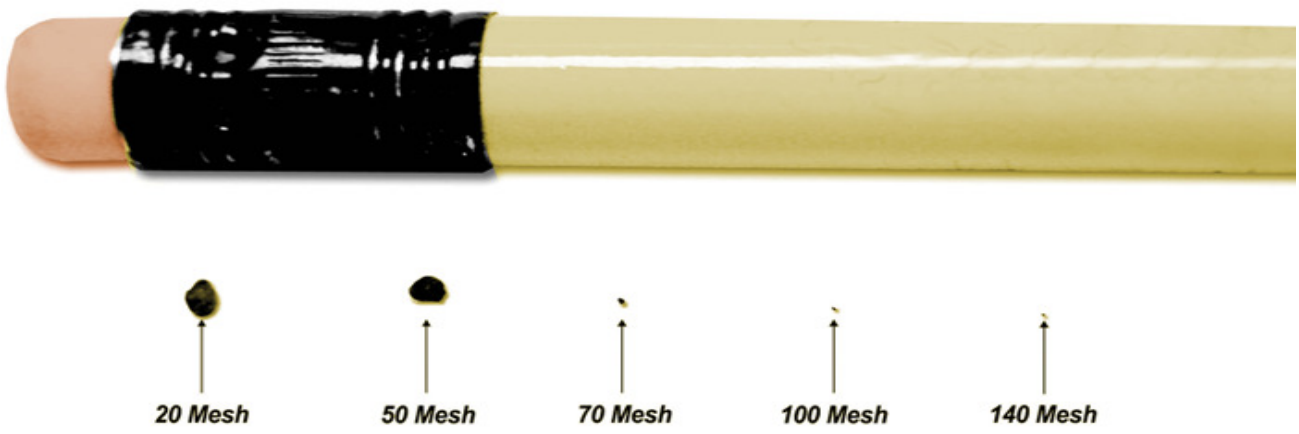
Grit Removal Essentials

By Frank Weis, P.E., Senior Engineering Consultant, Smith & Loveless Inc.

More companies offer mechanized grit removal systems and services than ever before, underscoring the increasing grit removal focus in the industry. The rising application of membrane bioreactors (MBRs), specialized pumping equipment, and fine bubble diffusers in wastewater treatment plant infrastructure require protective equipment up front to maximize service life and operation. A properly designed and operated grit removal system prevents grit buildup in unit processes, scouring and plugging in lines, and fouling of diffusers and membranes. In times when funding sources are tighter and dollars are scarcer, protecting plant infrastructure proves critical. As the stakes increase, it's wise to take a closer look at the dynamics of grit removal to achieve optimal outcomes.



Typical WWTP grit sizes range from 50 to 100 mesh. These course particles cause the most problems in downstream equipment. At 140 mesh, particles begin to take on silt-like, buoyant properties.

It's important to define relevant terms and provide a brief overview of factors affecting how grit "behaves" in collected wastewater.

Grit consists of a variety of particles including sand, gravel, cinder, and other heavy, discrete inorganic materials found in domestic sewage. The Environmental Protection Agency's *Wastewater Technology Fact Sheet* (Screening & Grit Removal), defines grit "as particles larger than 0.21 mm (.008 in.) (65 mesh) and with a specific gravity of greater than 2.65."[1]

Mesh sizing is a common way to classify grit particle sizes, particularly for influent grit profiling and performance testing. Mesh values correlate to the scale of measuring pan screens that sieve collected

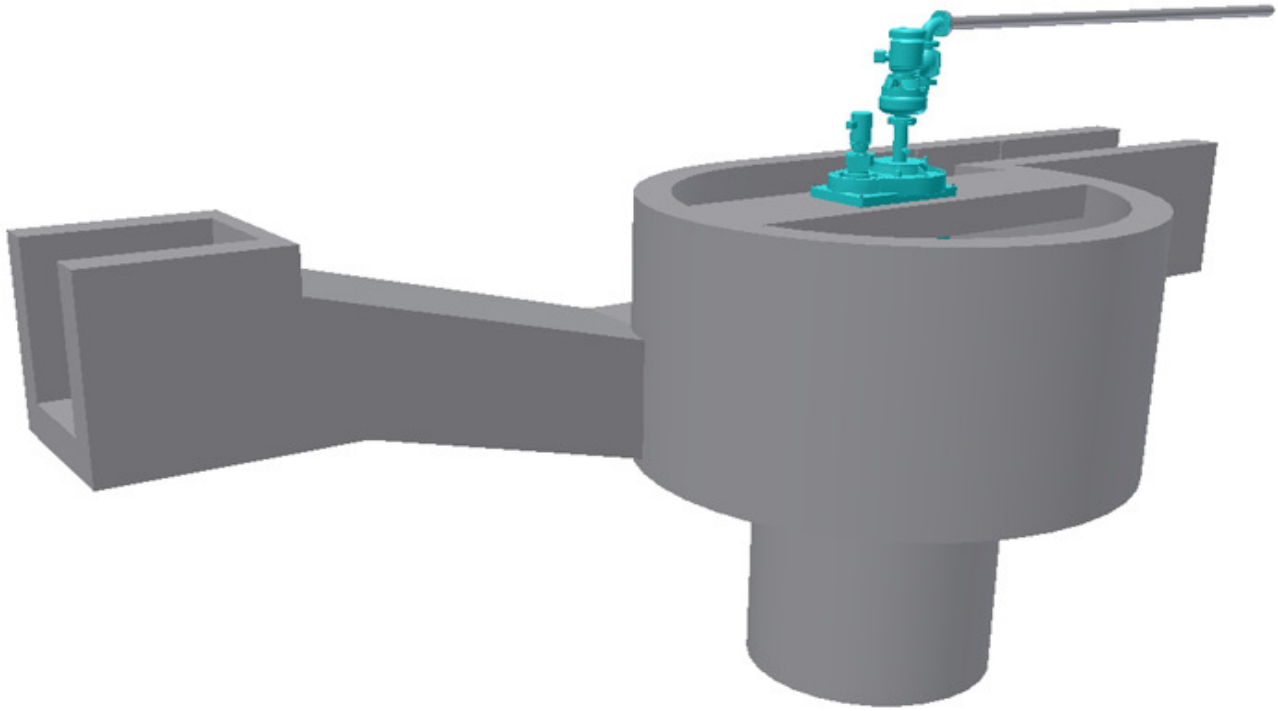
grit samples. Increasing mesh values translates into smaller grit particle diameters. Typical domestic sewage grit ranges from 20 to 140 mesh with the strong majority of grit (more than 90 percent) ranging between 50 and 100 mesh (the quantity will vary somewhat based on geographic location). Abrasive grit particles 100 mesh and larger create the greatest problems with downstream equipment. Particles smaller than 140 mesh begin to take on buoyant, silt-like characteristics, meaning they will rarely settle in a WWTP flow stream with any measure of velocity. Another unit of measure applied for grit particle sizing is microns. Typically 50 mesh particles convert nominally to 300 microns in length while 100 mesh particles, which are smaller, are nominally 150 microns.

Velocity plays a key role in grit travel through a collection system and WWTP flume. Ideal rates range between 2-3.5 ft./second (fps) in the flume leading to the inlet. At this rate, the flow will cause grit concentrations to travel like a moving bed along the bottom of the flume. At higher velocities, the flow becomes turbulent dispersing the grit bed. When the overall velocity dips below 2 fps, grit will settle in the flume. Multiple straight currents exist within a flume, each with varying velocities. Grit will always be found where the lowest velocities of the flume occur. Basic physics demonstrates that the lowest velocities occur along the sides and bottom corners of an open flume because of friction, which slows the water. Therefore, grit will typically be found along the bottom corners of the flume. Understanding this is especially helpful for grit profiling and performance testing.

The PISTA Grit Removal System by Smith & Loveless Inc.

Grit removal system performance is measured by *removal efficiency*. Removal efficiency is simply the percentage of grit continually removed from the influent. For example, high-performance grit removal systems achieve greater than 90 percent removal efficiency when properly designed and applied. Removal efficiencies can be attributed to individual particle sizes as well. However, the bottom-line is obtaining sufficient removal efficiency for all influent grit at normally encountered flows. Peak flow conditions caused by wet weather events bring more grit into the plant, which means systems must handle surges in flow and grit quantity.

The above terms provide important insight when designing a new grit removal system, evaluating an existing system, or performing a grit profile. When apprehended, other standard factors for implementing enhanced grit removal include factors like *head loss*, *grit system sizing/footprint*, *maintenance*, and *energy-efficiency*. Head losses through various grit removal devices can vary substantially, from as little as 0.25" to more than 12'. Be sure to review the effects of these differences, including requirements for higher heads. Likewise, examine the space requirements for your grit removal system and the corresponding capital costs, particularly with respect to excavation depth (if necessary) and the amount of concrete required. The same goes for on-going maintenance and energy-efficiency concerns. Appraisal questions include: *how will on-going operation and maintenance contribute to annual expenditures*? and *What are the energy demands for operating this system*? Some grit removal devices require frequent cleaning while others may require periodic mechanical inspection and lubrication. Concerning energy use, some grit chambers may assert no integral moving parts or power draw, but they may require power for ancillary pumping equipment used for head losses, velocity control, or continuous fluidizing.



Example of a true vortex grit removal system with flat floor basin.

In today's market, three types of grit removal systems dominate the landscape: vortex grit chambers (including forced hydraulic vortex and vortex settlers), centrifugal separators, and to a lesser degree, aerated grit chambers. Grit chambers and separators supply a basin or channel that reduces flow velocity, allowing inert grit particles to be hydraulically removed or settled out. Understanding the primary *means* by which grit chambers physically remove grit – *hydraulic* vs. *settling* – provides fundamental insight for system procurement and evaluation because the removal dynamics differ significantly.

Ironically, most self-described vortex and separator grit chambers rely on settling as the primary means of grit removal despite inducing tacit measures of centrifugal action, usually by way of integral cylindrical flow paths and/or rotating paddles. Sloped or cone-shaped chamber flooring is the key indicator of a primary settling device, the design of which depends on detention time and settling rates. Meanwhile, vortex systems that integrate an inlet flume, flat-floor circular basin with a center opening, and flow baffles generate a hydraulically forced vortex to efficiently remove grit. Flat chamber flooring visually distinguishes a forced hydraulic vortex from a closely resembling settling device, but the velocities and the required detention time inside the chamber also remain different. Forced vortex systems incorporate rotating paddles, but the purpose is to separate organics from the grit particles, not creating a vortex. It's important to note that settling rates do not apply at all to forced hydraulic vortex grit chambers.

Despite key process differences, these systems often appear together as approved equals on bid lists for new projects. When this happens, consultants and end-users must sort out the differing prerequisites and operational nuances of each system type. By doing this, they champion contractor bids and reduce costly time delays and hassles during the equipment submittal and testing phases, not to mention receive a more robust system.

The key to successful grit removal begins with understanding the nature of grit and the means by which it is systematically removed from a waste stream. How grit moves within the flow channel at varying velocities provides insight for enhanced grit capture. It's incumbent upon consultants and plant operations staffs to augment their understanding of grit removal systems. This brings clarity to industry jargon, system supply and testing methods evolving from increased market activity. With these basics established, end-users and consultants can ask the tough questions and make wise decisions regarding system selection for the betterment of the overall plant.

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Mr. Weis' distinguished career in the water and wastewater industry spans more than 50 years and includes more than 55 patents to his credit. Mr. Weis is the recipient of the American Society of Mechanical Engineers (ASME) 1999 Henry R. Worthington Medal, awarded for his career achievements in the realm of grit removal and pumping technology. He also has been awarded the Missouri Honor Award for Distinguished Service in Engineering by the University of Missouri-Columbia School of Engineering.