Grit Removal – Identification and Removal Methods

ERIN FLANAGAN, P.E.

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Presentation Outline

• True Grit
• Particle Size
• Grit Material Comparison
• Settling Characteristics
• Grit Sampling
• Grit Removal Methods
• Q&A

50 Mesh  70 Mesh  100 Mesh  140 Mesh
True Grit

**Mattie Ross**: “Now I know you can drink whiskey and I saw you kill a rat, but all the rest has been talk. I'm not paying for talk.”

- Industry defines grit as heavy mineral matter consisting of a variety of particles including sand, gravel, cinder, and other heavy, discrete inorganic/organic materials in domestic sewage.
- Removal of particles $<$ **150 microns**
- Largest fraction of grit is between **50 and 100 mesh**
- SG Between **1.3 and 2.7**
- 0.5 to 27 ft$^3$ of grit per MG for sanitary sewers
Damage Caused by Grit

- Forms dense deposits in basins, pipelines, and channels
- Abrades and binds mechanical equipment
- Takes up process volume which reduces level of treatment (primaries, aeration, digesters)
- Results in over-burdening equipment, excessive maintenance, labor, and part replacement - $$$
When to Expect Grit

- Grit deposits in the collection system
- Average flows may only move a small portion of the grit load
- “First Flush” drastically increases grit load

![Graph showing Estimated Grit Increase vs. Peaking Factor]

- **Estimated Grit Increase vs. Peaking Factor**
  - Increased Grit (times)
  - Peaking Factor
  - Values range from 0 to 50, with increments of 10.
  - The graph shows a linear relationship between peaking factor and grit increase.
Particle Size – How Small?

- **Mesh vs. Microns**
  - Mesh is the number of openings per linear inch
  - Micron ($\mu$) is one-millionth of a meter (0.00004 in)

<table>
<thead>
<tr>
<th>Mesh</th>
<th>Microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>420</td>
</tr>
<tr>
<td>60</td>
<td>250</td>
</tr>
</tbody>
</table>
| 65   | 210     | 0.0084 in
| 80   | 177     |
| 100  | 149     |
| 120  | 125     |
| 140  | 105     |
| 200  | 74      |

The larger the Mesh number, the smaller the particle!
**Grit Material Comparison**

- Specific Gravity (SG) vs. Settling Velocity

<table>
<thead>
<tr>
<th>Specific Gravity of Various Materials</th>
<th>Quartz Sand</th>
<th>Sand, wet</th>
<th>Limestone</th>
<th>Gravel</th>
<th>Granite</th>
<th>Asphalt</th>
<th>Clay</th>
<th>Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG = 1.20</td>
<td>1.20</td>
<td>1.92</td>
<td>1.55</td>
<td>2.00</td>
<td>1.65</td>
<td>2.20</td>
<td>1.80</td>
<td>2.40</td>
</tr>
<tr>
<td>SG = 1.90</td>
<td>1.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG = 2.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Particle Size (microns)</th>
<th>Aggregate Class</th>
<th>Time Required to Settle 1’ SG = 2.65</th>
<th>Time Required to Settle 1’ SG = 1.35</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Fine Sand</td>
<td>38 Seconds</td>
<td>2 min. 48 sec.</td>
</tr>
</tbody>
</table>
KEY: Not all grit is created equal.

Silica Sand

Wastewater Grit
### Settling Characteristics

- **Actual Settling Velocities:**

<table>
<thead>
<tr>
<th>Material</th>
<th>Settling Velocity (cm/sec)</th>
<th>Particle Size Equivalency (Microns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Sand-Expected</td>
<td>2.8 – 4.0</td>
<td>212 – 300</td>
</tr>
<tr>
<td>Clean Sand</td>
<td>2.4 – 3.9</td>
<td>190 – 275</td>
</tr>
<tr>
<td>River Sand</td>
<td>2.4 – 3.9</td>
<td>190 – 275</td>
</tr>
<tr>
<td>Grit</td>
<td>&lt; 0.14 – 1.4</td>
<td>40 – 135</td>
</tr>
</tbody>
</table>
Settling Characteristics

• Modeling “Grit” as “Sand” (Settling Characteristics):

- Clean Sand Particle Settling Velocity (Fast)
- Same Size Particles
- Grit Particle Settling Velocity (Slow)
- Sand Equivalent Size (SES)
- Sand Particle With Same Settling Velocity

• Grit settling velocity affected by:
  - Shape
  - Specific Gravity
  - Fats, Oils & Grease
Method 1 – Cross Channel Sampling (CCS)

- Uses multiple siphoning ports to collect grit in the entire width and height of the water column.
- Attempts to minimize effects on existing channel velocities and currents.
Grit Sampling – VIS

- Method 2 – Vertical Integrated Sampling (VIS)
  - Single sampling location for full height of water column
  - Calculated slot width – Flow, Water Column W & H, Sample Pump Flow

Courtesy of Black Dog Analytical
Grit Characterization

• Estimate removal efficiency of existing systems
• Predict removal efficiency and volume for new systems/mods
• Used to determine SES
Components of Grit Removal Systems

• Grit Removal System
  1. Separation from Process Stream
  2. Washing and Classification
  3. Dewatering
Grit System Performance

• Capture efficiency in each process is critical.
• Example (150μ or 100 mesh):
  – Removal – 65%
  – Washing – 80%
  – Dewatering – 93%
• Net Effective Performance:
  – Grit Capture – 48%

Product of individual efficiencies provides total system performance.
Grit Removal Methods

- Aerated Grit
- Mechanical Vortex
- Multiple Stacked Trays
Aerated Grit

• Operational Principle: Introduction of air induces a rolling current.
  – Organics are encouraged to remain suspended
  – Grit particles are carried to the bottom of the tank for collection

• Performance:
  – 95% of 210 micron (65 mesh) particles and larger

• Recent innovations in blower technology help reduce energy requirements.

• CFD can be used to model existing or new systems for proper placement of baffles and introduction of influent flows and air
Aerated Grit

• Advantages
  – Consistent removal over a wide flow range
  – Low organics removal
  – Versatile process unit allowing for chemical addition, mixing, pre-aeration, etc.

• Disadvantages
  – Very energy intensive
  – High O&M demand on blowers and diffusers.
  – Large footprint
  – Low removal efficiency
  – Odor production
Mechanical Vortex

Courtesy of Hydro International
• Operational Principle: Hydraulics induce vortex and increase angular velocity of grit particles which causes them to reach the boundaries of the chamber and settle.

• Recent Innovations
  – Baffled designs exhibit much improved grit removal efficiencies across a wide range of flow
Mechanical Vortex

• Performance – Particle Removal Efficiencies

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>270 Vortex</th>
<th>360 Vortex</th>
<th>360 Vortex with Baffle</th>
</tr>
</thead>
<tbody>
<tr>
<td>300µm or 50 mesh</td>
<td>95%</td>
<td>95%</td>
<td>&gt;95%</td>
</tr>
<tr>
<td>210µm or 70 mesh</td>
<td>85%</td>
<td>85%</td>
<td>&gt;95%</td>
</tr>
<tr>
<td>150µm or 100 mesh</td>
<td>65%</td>
<td>65%</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>105µm or 140 mesh</td>
<td>&lt;40%</td>
<td>&lt;40%</td>
<td>95%</td>
</tr>
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From Smith & Loveless, Inc.

• Several Manufacturers

• Advantages
  – Smaller Footprint
  – Proven technology
  – Low headloss (< 1ft)
  – No submerged bearings or mechanical parts

• Disadvantages
  – Paddles may collect rags
  – Poor scalability and turn-down capability of the weir units (improved for baffled units)
Multiple Stacked Trays

Courtesy of Hydro International
Operational Principle: Design induces slow, hydraulic vortex which allows particles to settle and cascade down stacked trays.

One manufacturer (proprietary)
Particle Removal Efficiencies:

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<th>HeadCell™</th>
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<td>105μ or 140 mesh</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>75μ or 200 mesh*</td>
<td>95%</td>
</tr>
</tbody>
</table>

*As claimed by manufacturer

Advantages

- Smallest Footprint (easier to retrofit into existing structures)
- No moving parts
- High removal efficiencies
- Low Headloss (< 1ft)

Disadvantages

- Proprietary system
- Significant plant water demand for washing, classifying and dewatering equipment

Courtesy of Hydro International
• Reduces organics, odor, and vectors
• Aids in compliance with increasing landfill restrictions and more stringent regulations
• Efficient handling can help maintain high net grit capture
Grit Handling - Washing, Classification

- Grit Snail®
- TeaCup®
- SlurryCup™
- Grit Concentrator
- Grit Washer
- Conical Washer
- Dewatering Screw
Capture efficiency in each process is critical.

Example (150μ or 100 mesh):
- Removal – 65% → 95%
- Washing – 80% → 95%
- Dewatering – 93% → 95%

Net Effective Performance:
- Grit Capture – 48% → 86%

Product of individual efficiencies provides total system performance.
Questions & Answers

Erin Flanagan, P.E.
Freese and Nichols, Inc.
2711 North Haskell Avenue, Suite 3300
Dallas, Texas 75204
214-217-2261
ecf@freese.com