Grit
It’s Not Just for Breakfast Anymore

Rusty Schroedel, P.E., BCEE, WEF Fellow
Topics

– What is Grit?
– Why Do We Care?
– How Do We Remove Grit?
– Case Histories
– Conclusions and Recommendations
What is Grit?
What is Grit?

- Grit is inorganic settleable solids ranging in size from 50 to 1,000 microns.
- Grit removal is necessary to protect downstream equipment from wear and avoid grit accumulation in downstream unit processes.
- Grit is identical in size to sand and the design guidelines for many years have been based on 90% removal of 210 micron particles with a specific gravity of 2.65 (like sand).

Studies at the Hyperion Plant in California found that 10 times more grit was being removed in the anaerobic digesters than in the grit chambers. The grit chambers were only removing 6% of the grit.
Grit Sedimentation Rates

Sedimentation Rates
Sand, 2.65 Sp. Gr. in Water at 68° F

Theoretical gpm/sq ft

Surface Loading, gpm/sq ft

1000
0.1
10
1
0.1
10
100
1000
Sand Equivalent Size, Microns
In Reality:

Grit is not sand and most grit particles settle slower than sand.

East Bay Municipal Utility District WWTP, CA
SG: 1.24 – 1.61, Average 1.35
> 1mm 1.04 SG

Deer Island Treatment Plant, Boston, MA
SG: 1.22

Green Bay WWTP, WI
SG: 1.53

<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>Very Fine Sand</td>
<td>38 Seconds</td>
<td>2 min. 48 sec.</td>
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Physical Size Distribution

Compiled Particle Size Distribution from Treatment Plants

Design Criteria
90% removal of sand based on 210 Micron particle size

Chicago, Illinois
85% of grit > 210 micron

Orlando, Florida
15% of grit > 210 micron
Impact of surface active agents (SAAs)

Clean Sand Particles

Settling velocity of clean sand particles depend on size

Grit coated with SAAs

Settling velocity of grit coated with SAAs is independent of particle size

Sand Equivalent Size (SES)
Sediment Transport Basics

- Grit remains in the collection system until transported to the plant
- Flow/velocity suspends grit
- Low flow moves only small and light grit
- First flush significantly increases grit load

**Effective grit removal systems must function at peak flow and peak grit load**
Impacts of Poor Grit Removal

• Many of the older systems have been proven to be ineffective.

• Designed to remove 210 micron SAND, 210 micron GRIT is much lighter and passes through the grit chamber.
Today’s Design Criteria

1. When possible, conduct grit characterization study

2. If not possible, use regional data.

3. If not possible, base removal on 106 micron particle size. The expected results are 80 to 90% depending on location.
Why Do We Care?
Impacts of Poor Grit Removal

If grit is not captured in the grit removal units, biological activity will strip the organic SAAs from the inorganic core.
Impacts of Poor Grit Removal

With Primary Settling – You have a digester cleaning problem!

Without Primary Settling – You have an aeration tank cleaning problem!
How Do We Remove Grit?
Trends in Grit Removal Technology Selection

• Better understanding of grit characteristics and grit system removal performance

• Manufacturers have developed some new technologies that treat grit removal as a total process that includes:
  • Removing grit from the wastewater
  • Separating organics from the inert grit particles of the collected grit
  • Drying collected grit

<table>
<thead>
<tr>
<th>Earlier Technologies</th>
<th>More Recent Technologies</th>
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<tbody>
<tr>
<td>• Horizontal-Flow Grit Chambers</td>
<td>• Vortex Grit Removal Units</td>
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<tr>
<td>• Constant Velocity</td>
<td>• Multi-Plate Grit Removal Units</td>
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<tr>
<td>• Detritors</td>
<td></td>
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<tr>
<td>• Aerated Grit Chambers</td>
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</table>
Modern Grit Removal Systems

INFLUENT → GRIT REMOVAL UNIT → EFFLUENT

GRIT CLASSIFIER / DRIER

Collected Grit
Volatile Content $\leq 20\%$
Solids Content $\geq 60\%$

EFFLUENT Contains no Settleable Grit
Grit Removal Units

- Horizontal Flow
  - Rectangular (Constant Velocity)
  - Detritor (Square Type)
- Aerated
  - Conventional
  - w/ Grease Removal
- Vortex Type
  - Hydraulically Induced
  - Mechanically Induced
  - Accelerated Gravity
  - Multi tray
Rectangular (Constant Velocity Grit Chamber)

- Long narrow settling tank
- Velocity controlled by proportional weir or flume
- Length governed by depth required for settling velocity
- Cross sectional area governed by flow rate
Horizontal Flow Grit Tanks

Controlled Velocity Disadvantages

• Difficult to maintain velocity of 1 fps over wide range of flows

• Mechanically cleaned system have submerged chain and sprockets

• Washing of grit may be required where flow control is an issue

• Bottom scour can occur using proportional weirs

• High headloss
Square Horizontal Flow (Detritus Tank)
Square Horizontal Flow (Detritus Tank or Detritor)

Adjustable deflectors

Grit collection Pocket

Screw Conveyor

Reciprocating Rake

Issues

• Difficult to get uniform flow
• Mechanisms obstructs flow pattern
• Typically removes large amounts of organics and washing and classifying is critical

Grit Container
Aerated Grit Chambers

- Flow enters from side to start spiral
- Air is introduced along one side of a rectangular tank
- Grit particles settle to the bottom and the spiral roll sweeps grit to the collection channel
- The velocity of roll governs the size of particles removed and moves grit to hopper
- Grit removed by clamshell buckets, screw conveyor, grit pumps or airlift

- **Air must be carefully controlled** – Too much air washes out grit
- **Aeration can strip out H₂S** – Covers may be necessary
- **Difficult to effectively remove grit from tank**
- **Grit can have high organic content attracting insects**
Aerated Grit Chambers – Grit Removal Techniques:

Removal Mechanisms
- Chain and Bucket
- Bottom Screw and Bucket Elevator
- Clamshell Bucket
- Screw Conveyor
- Traveling Bridge with Pumps
  - Air Lift
  - Submersible Recessed Impeller
  - Cantilever Recessed impeller
- Traveling Bridge with Scraper and External Pumps

Clamshell Bucket
Traveling Bridge w/ Cantilever Pumps
Traveling Bridge w/ Submersible Pumps
Traveling Bridge Aerated Grit Chambers
Grit and Grease Removal:

Grit Removal Mechanisms
✓ Air Lift Pump
✓ Submersible Recessed Impeller Pump
✓ Cantilever Recessed impeller Pump

Grease Removal Mechanisms
✓ Air Lance and Screw Conveyor
✓ Surface Collector and Screw Conveyor
✓ Surface Collector w/ Hopper and Pumps
Centrifugal Separator (Vortex type w/ Mixer)

- Influent Channel tangentially feeds grit chamber
- Mixer to mechanically induce vortex and lift and separate organics
- Grit Removal
  - Air Lift Pumps
  - Vacuum Primed Recessed Impeller Pumps
  - Self Priming Pumps
  - Dry Pit Recessed Impeller Pumps
- Low headloss
- Scouring of grit hopper required
- Small space requirements

Disadvantages
- Have proven to be effective in smaller sizes but larger sizes may have reduced performance
- Baffling system reported to improve performance
Centrifugal Separator (Hydraulically Induced Vortex)

- Influent channel tangentially feeds grit chamber
- Internal non rotating mechanism
- Grit Removal
  - Air Lift Pumps
  - Submersible Recessed Impeller Pumps
- Low headloss
- Small space requirements
Centrifugal Separator (Accelerated Gravity)

Flow enters the unit by a downward sloping ramp that increases the downward velocity above simple gravity settling.

Based on these modification the manufacturer claims higher grit removals than conventional mechanically induced vortex units.
Centrifugal Separator (Hydrodynamic Multiple Tray Type – Head Cell)

- Influent Channels tangentially feeds multiple vortex grit trays
- Internal non rotating mechanism
- Grit Removal
  - Recessed Impeller Pumps
  - Self-Priming Pumps
- Small space requirements
Centrifugal Separator (Hydrodynamic Multiple Tray Type – Head Cell)
Centrifugal Separator (Hydrodynamic Multiple Tray Type – Head Cell)
Secondary Grit Separators

- Used for grit separation after vortex type chambers
- Hydrocyclone type or hydrodynamic type
- Provides grit washing and organics removal
- 2% to 5% of forward flow

Typical pressure required at inlet: 5 to 15 psi
Grit Treatment – Grit Washers

Receives grit slurry from the grit chamber
• Performance: Less than 3% organics in washed grit
• Enclosed for odor control
Primary Sludge Degritting - Centrifugal Separator & Classifier

Used for primary sludge degritting but sludge must be pumped at about 1% solids.
Grit Pump and Piping Systems

- Keep suction piping as short as possible, approximately 10 to 15 feet (3 to 4.5 meters)
- Pipeline Velocity: 6 to 8 fps (1.8 to 2.4 m/sec)
- Provide cleanouts and flushing connections
- Provide flushing water in pump suction piping
- Avoid the use of check valves
- For isolation valves use full port abrasion resistant pinch valves
- Use hard metal recessed impeller pumps for pumping abrasives
- Use 4” (100 mm) minimum diameter piping
- Use a piping system that is abrasion resistant like glass lined ductile iron or abrasion resistant and light enough for removal such as ceramic lined FRP
- Use long radius 90 deg bends or 45 deg bends
- Use dedicated suction and discharge piping runs for multiple pump systems
Case Histories
Spiral roll pattern resulted in high velocity during high flow.

Conduits Abandoned

New Metal Workshop

New Headworks Building

Existing Grit Tank Building

Existing Screen Building

New BioFilter
CFD modeling for hydraulic analysis

Ashbridges Bay WWTP, Toronto, Canada
Naperville IL Springbrook WRC

Existing aerated grit tanks
Grit technologies considered:

A – Vortex Tanks (example shown: Smith & Loveless)
B – Aerated Tanks (example shown: WSG)
C – Headcells (example shown: Hydro International)
Option A, Vortex Tanks Recommended
Urbana Champaign IL Sanitary District

Start of construction of new grit tanks

Existing grit tanks
New tanks include compartments w/ FRP baffles

Planned phasing required bulkheads to minimize time for bypass pumping to complete tie-ins and demolition
Kansas City, MO Blue River WWTP

Existing aerated grit tanks

Retrofit with vortex grit tanks
Kansas City, MO Blue River WWTP

Vortex grit tanks constructed within existing aerated grit tanks

Dry-pit grit pumps in lower pump room
Genesee County MI proposed expansion

- Proposed vortex tank outside of building
- Existing vortex tank inside of building
Conclusions and Recommendations
Analysis of Existing Grit Systems

– Evaluate records of grit quantities, if available
– Assess quality of grit including seasonal variations
– Sample primary sludge for grit carry over
– Assess build up in channels, aeration tanks, and digesters
– Assess hydraulic velocities and flow patterns
Considerations for Grit Removal Criteria

– Percent of fine grit particles
– Seasonal variations
– Organic material from industrial sources
– Is removal of fine grit necessary?
Typical Improvement Alternatives

– Physical modifications to improve performance
– New system for average flow with existing process for supplement at high flow
– New processes retrofitted within existing processes
– Space permitting consider entirely new process to simplify construction
# Grit System Considerations

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<th>Discussion</th>
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<tr>
<td>Understand the collection system</td>
<td>Combined or separate sewers</td>
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<tr>
<td>Understand flow patterns</td>
<td>Hydraulics and flow splitting. First flush effect?</td>
</tr>
<tr>
<td>Understand the grit type implications</td>
<td>Grit characterization or use regional data. If no data available, design to remove 106 micron grit particle.</td>
</tr>
<tr>
<td>Assess and quantify existing grit problems</td>
<td>Excessive digester or aeration tank cleaning.</td>
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<tr>
<td>Identify downstream processes (existing and future) impacted by grit</td>
<td>Membrane bioreactors, anaerobic digesters, aeration tanks.</td>
</tr>
<tr>
<td>Assess performance of existing grit removal equipment</td>
<td>Upgrade with new technology or re-purpose (Capture First Flush)</td>
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Conclusions and Recommendations

– Grit characteristics – Determine if removal of fine grit is appropriate

– Assess hydraulics – Laminar flow and equal flow distribution optimize performance

– Carefully analyze retrofits to avoid features that may compromise performance

– Consider impacts on future processes such as BNR or membrane systems
Credits

– Paul Moulton – AECOM – Chelmsford, MA
– Bill Pfrang – AECOM – New York, NY
– Bob Kulchawik – AECOM – Chicago, IL
Thank You

rusty.schroedel@aecom.com

February 12, 2019