Rehabilitating Gravity Filters
Using the Dual Parallel Lateral Underdrain

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PRESENTATION OUTLINE

• Types of Rehabilitation
• Filtration Theory
• Underdrain Types
• Water to Air/water Backwash Comparison
• Mal-Distribution
• Flume Types and Air Introduction
• Rehabilitation
Gravity Granular Filters

Typical Filter in Filtration Mode
Types of Filter Rehabilitation

• Media replacement
• Component repair
  - Rebuilding agitators; replacing valves, actuators, etc.
• Updating instrumentation
  - Automating, adding particle counters, etc.
• Converting from water only backwash to air/water backwash
• Complete replacement
  - New underdrain, media, valves, actuators, troughs, instrumentation, etc.
Granular Media Filtration

Filtration

• The passage of water through a porous medium for the physical removal of suspended solids
• Sometimes with biological removal

Filter Process: Semi-Batch Operation

• Filling and clogging of the interstitial voids of the media and then washing the solids out
  - Void volume is approximately 45%
  - Maximum void volume available for removal of particles is approximately 10% for hydroxide flocc
  - Example: 100 cubic centimeters \times 0.45 \times .10 = 4.5 \text{ cubic centimeters}
Methods of Particle Removal

Straining
- particle removal size 20% of smallest media grains
- 500 microns (0.5 mm) x 0.20 = 100 micron removal (0.004”)

Nonstraining (non-settleable)
- particles must be coagulated and properly condition
- color, silt, microscopic organisms & organic matter
- Giardia & Cryptosporidium cysts - 3 to 15 microns
- Colloidal dispersions - 1 to 500 millimicrons (0.5 micron)
Particle Size Comparison

Filter Media Grain
0.5mm diam

1 micron
10 microns
100 microns
Particle Removal Mechanisms

**Mechanical**
- Raw Water
- Large Particles Become Lodged Between Media

**Adsorption**
- Raw Water
- Particles Stick to the Media

**Biological Growth**
2014 Safety Awards
5th Place
Single Pass Systems

Dual Parallel by Leopold
Dual Parallel Lateral Underdrains
ADVANCEMENT OF LEOPOLD® FILTRATION TECHNOLOGY

1926 Duplex Concrete
1945 Superblock® Clay Tile
1977 Universal® HDPE
1991 I.M.S® Cap HDPE
1995 Type S® HDPE
1998 Type SL® HDPE
2012 I.M.S® 200 & 1000 Media Retainers
2013 Type XA™

Over 8,000 installations with over 25,000 filters
How the Dual Parallel Lateral Works
Water Recovery Channel

3 to 5 scfm/sf required Air Range
Old Universal

1 to 5 scfm/sf Air Range
Type S Universal Underdrain

LEOPOLD
a xylem brand
Baffle Reduces Level Sensitivity
2014 Safety Awards- 4th Place
Underdrain Videos!
Air-water Interface
Type SL
Nozzle Air Pattern
Nozzles with Sand/Anthracite
16’ Type SL with IMS Cap
Types of Backwash

- Water only - least effective is fluidize and flush
- Water only with surface agitators
- Sequential air then water
- Concurrent air with water then high rate water
- Sustained air/water - must be careful to not degrade media or get it too clean to cause long ripening times
Typical Water Only Backwash

Fluidize and flush
Surface agitators to break up mud balls
Agitators increase scrubbing action
  1-2 gpm/sf surface wash rate
  15 to 20 gpm/sf backwash rate
20 to 30 percent bed expansion (check that existing backwash system is adequate)
Typical Air/Water Backwash

Minimizes formation of mud balls
Concurrent wash has air/water combined step followed by high water-considered the best backwash method
Sequential wash has air followed by high rate water
3-4 scfm/sf typical air rate
5 gpm/sf typical water rate with air
~20 gpm/sf typical backwash rate (check that existing backwash system is adequate)
## Backwash Comparison at Decatur, IL

### Air & Water

<table>
<thead>
<tr>
<th>Description</th>
<th>Flow Rate</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Only</td>
<td>5 scfm/sf</td>
<td>2 min</td>
</tr>
<tr>
<td>Air/Water</td>
<td>5 scfm/5 gpm</td>
<td>2 min</td>
</tr>
<tr>
<td>Water Purge</td>
<td>5 gpm/sf</td>
<td>2 min</td>
</tr>
<tr>
<td>Water Wash</td>
<td>20 gpm/sf</td>
<td>6 min</td>
</tr>
<tr>
<td>Low Wash</td>
<td>5 gpm/sf</td>
<td>1 min</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>145 gal/sf</strong></td>
</tr>
</tbody>
</table>

### Water Only

<table>
<thead>
<tr>
<th>Description</th>
<th>Flow Rate</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Wash</td>
<td>20 gpm/sf</td>
<td>13.5 min</td>
</tr>
<tr>
<td>High Wash</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Wash</td>
<td>5 gpm/sf</td>
<td>1 min</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>275 gal/sf</strong></td>
</tr>
</tbody>
</table>

45% Less
2014 Safety Awards - 3rd Place
Underdrain Installation
Lowering into Filter Cell
Underdrain Installation
Air Header Piping and Anchor Rods
Underdrain Installation
Laterals Stacked Waiting for Installation
Underdrain Installation
Installing the Laterals
Filter Maldistribution

Definition

• It is the percent difference in flow from one part of a filter to another

Recommended Maldistribution Limits

• Backwash Water: +/- 5% across the filter
• Air Scour: +/- 10% across the filter

Sources of Maldistribution

• Backwash Inlet Pipe
• Flume
• Underdrain
• Filter Media
Filter Maldistribution
Before Correction
Filter Maldistribution After Correction

BACKWASH RISE RATE CONTOURS
In Inches Per Minute (IPM)
With Baffle Set No. 3
Average Rate 31.0 IPM

EAST FILTER HALF

Phoenix, Arizona
Deer Valley WTP
Wheeler 5 – Ball Bottom
Backwash Inlet & Flume Velocity Recommendations

- **Equalized Flume Velocity (at inlet)**: 2 ft/sec or less
- **Reducer**: 4 f/s or less
2014 Safety Awards-2\textsuperscript{nd} Place
Austin, TX

**Challenge**

Unique filter layout with distribution problems

Requirement for <5% total variation in flow distribution

**Solution?**
CFD to validate solution

Contours of Velocity Magnitude (ft/s)

Apr 02, 2004
FLUENT 6.0 (3d, segregated, ske)
Backwash Pipe Inlet Baffle

High Inlet Velocity Energy Reduction
Underdrain Maldistribution

WATER TEMP. = 55° – 65°F

MALDISTRIBUTION (±%)

WATER FLOW (gpm/sf)
Filter Media & Underdrain Headloss
Effect of Backwash Mal-distribution on Filter Media Cleaning in Backwash Mode
Effect of Backwash Maldistribution on Filter Performance in Filtering Mode

- Down Flow
- Media Surface
- Effluent Pipe
- Combining Flow
Air Introduction
Air Introduction
“H” Flume
Flat Bottom Flume
What is a Flat Bottom Flume?
Center Flume
Air Introduction
FILTER AIR SYSTEM LOSSES

FILTER AIR SYSTEM COMPONENT (LOSS)  EXAMPLE OF TYPICAL LOSSES

<table>
<thead>
<tr>
<th>Component</th>
<th>PSI</th>
<th>FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLOWER INLET</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>AIR SUPPLY PIPE</td>
<td>0.5</td>
<td>1.1</td>
</tr>
<tr>
<td>AIR HEADER = (RISER HEIGHT + 9&quot;)+</td>
<td>1.4±</td>
<td>3.2±</td>
</tr>
<tr>
<td>UNDERDRAIN = (8&quot;)</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>STATIC WATER DEPTH ABOVE UNDERDRAIN (WL)</td>
<td>3.5</td>
<td>8.0±</td>
</tr>
<tr>
<td></td>
<td>6.0±</td>
<td>13.7±</td>
</tr>
</tbody>
</table>

QUICK TOTAL LOSS ESTIMATE = D/2.31 + 2 psi = 6.6± 15.3±

MAX. AIR RATE HEADLOSS. CONTACT THE LEOPOLD APPLICATION ENGINEERING GROUP WHEN THE FILTERS ARE DESIGNED TO OPERATE OVER A RANGE OF AIR RATES.
2014 Safety Awards- 1st Place
Rehabilitation

LEOPOLD F.R.P. WASHWATER TROUGH WITH S/S END HANGER

LEOPOLD ANCHOR RODS TO BE EMBEDDED IN NEW FLOOR SLAB ON 12" CENTERS FOR LEOPOLD UNDERDRAIN INSTALLATION

AREA BETWEEN SUPPORT PIERS TO BE FILLED WITH CONCRETE AND LEVELLED WITH TOP OF PIERS

SUPPORT PIERS TO BE REMOVED OVER WASH WATER FLUME OPENING

LEOPOLD UNIVERSAL UNDERDRAIN, (X) LATERAL RUNS REQ'D. PER FILTER

TYPICAL REHABILITATED FILTER BASIN
Rehab of Wheeler Filter

Wilson WTP, Little Rock, Arkansas
Cored Holes for Air

Shelf Support Angle

2'

Wilson WTP, Little Rock, Arkansas
Air & Water Wall Feed

“L” Flume Block with External Anchors
Existing Wall Openings

size, spacing and elevation
Orifice Plate and Offset Wall
Orifice plate with variable openings

1 2 3 4 5

Flume Entry

Direction of Flow
FILTER REHABILITATION OPTION

AIR HEADER PIPE with DROP PIPES

FLUME BLOCK

IMS Cap

FILL

INLET DISPERSION BOX

EFFLUENT/BACKWASH ENTRY PIPING
BEER CAN SAVE LIVES!!!
Questions??

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