The Effect of Screen Design on Capture Rate and Plant Maintenance

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Agenda

- Problems Related to Low Capture Ratio
- Screen Technologies
- UKWIR Test Facility.
- Screen Details and Design Considerations
Poor Screening Systems

Material pulled from clarifiers after bypassing the screens
Material pulled from clarifiers after bypassing the screens
Poor Screening Systems

Clogged Pumps
Poor Screening Systems

Material from a clogged MBR system
Screen Technologies

An Overview
Types of Screens

- Spiral Screw
- Center Flow
- Trash Rake/Grab
- Perforated
- Step Screens
- Drum Screens
- Multi-Rake

...and more!
Filter Media – Bar Screens

- **Examples**
  - Multi-Rake
  - Catenary (single and double acting)
  - Climber / Grab
  - Step
  - Drum

- **Variations:**
  - Tapered Bar Field
  - Narrow Lamella Plates
  - Wedgewire

All are characterized by screening in 1 direction – Slotted Opening
Filter Media – Mesh Screens

- Examples
  - Spiral Screw
  - Perforated (belt)
  - Center Flow (band)
  - Drum

- Variations:
  - Perforated Plate
  - Plastic Filter Element
  - Steel Mesh

All are characterized by screening in 2 direction – Round or Rectangular Opening
Opening Size Options

- **BAR**
  - Bar
  - Brush Cleaned Perf
  - Perforated Plate
- **PERF**
- **SPIRAL**
- **STEP**
  - Bar
  - Perf
- **DRUM**
  - Wedgewire Mesh

Bar Size Options:
- 1/4” (0.635 mm)
- 0.060” (0.152 mm)
Independent Testing

UK Water Industry Research (UKWIR)

Equipment Comparison
National Screen Evaluation Facility (NSEF)

Opened in 1998 to provide process and mechanical type testing to establish minimum standards for screen

As of December 2015, over 70 different screens have been subjected to evaluation.
Each screen tested for two weeks under controlled conditions and operated to simulate differential operation.

For Example: FSM Flow Through Filter Screen – 6 mm

Screenings collected and weighed

Debris that passes screen is collected in Copa Sacs
UK Water Industry Research

Where:

- $X$ is the screenings load in the raw sewage;
- $Y$ is the screenings removed from the flow by the screen; and
- $Z$ is the screenings load in the screened sewage.

$$SCR = \left( \frac{Y}{Y + Z} \right) \times 100\%$$
Screen Details and Design Considerations
Screen Classification

- Bar/Slot Screens
- Step Screens (bar screen)
- Combination Screens
- Fine Screens – Flow Through
- Fine Screens – Band Screens
Heavy Duty coarse bar screens with 1 to 3 inch bar spacing.

Simple single cleaning rake mechanism.

One dimensional cleaning.

Removes large solids, bottles, wood, stones, and other debris.

Cannot remove fibrous material.
Coarse Bar Screen

- Traditional Bar Screens.
- Heavy Duty Carbon Steel Painted Frames.
- Very tall – requiring tall building with headspace.
- Very inefficient screenings capture rate (~30-35%).
Bar/Slot Screen

BAR OPENINGS: ¼” to 2”

Front Rake – Front Return

Catenary Style MultiRake

Climber Style
Multi-Rake Bar Screen

- Sturdy Structure
- High Flow Rate
- Perfect for the protection of fine screens
- Low Maintenance

.... BUT A LOW CAPTURE RATIO!

SCR with 6mm (1/4”) bar is ~35%
Continuous Belt Screens with Plastic Elements

- Slotted Opening
  - Increasing bar opening capture rates
  - Poplar Style Screen in the 70 and 80’s – revolutionized fine screen filtration.

- Plastic Elements weak – tend to break under heavy load.

- Replacement of the plastic elements – expensive and time consuming

- Problem with cleaning filter elements, which leads to high carry over of solids to the downstream process.

- Middle-Ground Capture Ratio: up to 71%
Screen Classification

- Bar/Slot Screens
- Step Screens (bar screen)
- Combination Screens
- Fine Screens – Flow Through
- Fine Screens – Band Screens
Step Screens – 3mm and 6mm

BAR OPENINGS: 1/8” to ¼”

Solids are elevated a step at time to the discharge point

SCR with 6 mm (¼”) bar is ~35% with 3 mm (3/8”) is between 50% and 56%
Step Screens

- Good low cost screen alternative.
- Small Footprint.
- Screenings Capture Ratio varies (35% at 6mm to ~53% at 3mm).
- Some problems with lifting heavy solids – roll back.
- Needs shallow channel.
- Does not react well to grit or stones.

“Step” shaped bar forms screening surface
Screen Classification

- Bar/Slot Screens
- Step Screens (bar screen)
- Combination Screens
- Fine Screens – Flow Through
- Fine Screens – Band Screens

Stationary Screens

Rotating Screens
Combination Screens – 6mm

Type 1. Stationary Screen Field

Rotating Screw - with brushes and **Perforated Plate Screen**

Rotating Cleaning Rake - with **Bar Screen**
Combination Screens – 6mm

Type 1. Stationary Screen Field

SCR with 6 mm (¼”) bar is ~32%

Rotating Cleaning Rake - with Bar Screen
Combination Screens – 6mm

Type 1. Stationary Screen Field

Rotating Screw - with brushes and Perforated Plate Screen

SCR with 6 mm (¼”) round holes is > 52%
Screw Screens

Flow Rates up to 9 mgd

- Excellent choice for small plants
- Best solution when an economical screen is required
- Stainless steel construction
- Screenings Capture Ratio – 52%
Vertical Screw Screens

Flow rate up to 2.5 MGD

Quick disconnect available

Up to 30 ft

In channel application available
Screen Classification

- Bar/Slot Screens
- Step Screens (bar screen)
- Combination Screens
- Fine Screens – Flow Through
- Fine Screens – Band Screens

Stationary Screens

Rotating Screens
Combination Screens – 6mm

Wastewater flows into the upstream side of the unit and debris is captured on the inside of the rotating drum.

As the drum rotates, a spray bar cleans the debris from the inside of the drum, depositing it into the auger trough. A nylon brush removes any additional material from the outside of the drum.

The screened material is washed, dewatered and discharged into a dumpster, conveyor or optional bagger.
Combination Screens – 6mm

Type 2. Rotating Screen Field

Flow Drum

66% - 6 mm
86% - 2 mm
92% - 1 mm

Twice the capture of a stationary bar screen!

SCR with 6 mm (¼”)
round holes is 66%
Screen Classification

- Bar/Slot Screens
- Step Screens (bar screen)
- Combination Screens
- Fine Screens – Flow Through
- Fine Screens – Band Screens
Filter Screens – Flow Through

High separation performance with a simple uncomplicated screen using perforated filter elements – up to 100% more retention than bar screen systems

85% Avg. Screenings Capture Ratio – Highest capture rate tested at UKWIR – National Screenings Testing Facility

SCR with 6 mm (¼”) round holes is 70% to 85%
Fine Screens – Flow Through

A screen that consists of:

- A series of perforated stainless steel screening panels which are joined together on heavy duty box conveyor chain
- The filter panels are of a stepped or curved design with some panels fitted with lifting tines for lifting material from the bottom of the channel
Filter Screens – Perforated Belt

POSITION OF THE BRUSH IMPACTS CLEANING EFFECTIVENESS
Filter Screens – Perforated Belt

New – Self Adjusting Cleaner Brush

- Optimal cleaning efficiency results in high capture efficiency
- Brush shaft can pivot
- Reduction in maintenance – no regular brush adjustments required
- No gradual degradation of cleaning performance
- Chain can be adjusted without necessitating readjustment of the brush
Screen Classification

- Bar/Slot Screens
- Step Screens (bar screen)
- Combination Screens
- Fine Screens – Flow Through
- Fine Screens – Band Screens
Fine Screens – Band Screens

Center and Dual Flow - Perforated Belt 6 mm

**SCR with 6 mm (¼”) round holes is 84%**
Center and Dual Flow

Applications in municipal and industrial WWTP

- Waste water pre-treatment / fine screening
- Membrane treatment plant – NO carryover.

Applications in power stations

- River or sea water screening

Applications in potable water treatment plants

- River or sea water screening
# Screen Capture Rates (SCR) by Product Type

<table>
<thead>
<tr>
<th>Screen Type</th>
<th>Cleaning Method</th>
<th>1mm Capture</th>
<th>2mm Capture</th>
<th>3mm Capture</th>
<th>6mm Capture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step Screen - Slotted</td>
<td>Self Cleaning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spiral Screw Screen - Perforated</td>
<td>Brush &amp; Water</td>
<td></td>
<td></td>
<td></td>
<td>52%</td>
</tr>
<tr>
<td>Filter/Element - Slotted</td>
<td>Self Cleaning, Brush &amp; Water</td>
<td></td>
<td></td>
<td>84%</td>
<td>71%</td>
</tr>
<tr>
<td>Perforated Filter Screen</td>
<td>Brush &amp; Water</td>
<td></td>
<td></td>
<td></td>
<td>71% - 85%</td>
</tr>
<tr>
<td>In Channel Cylindrical Bar Screen</td>
<td>Self Cleaning &amp; Water</td>
<td></td>
<td></td>
<td></td>
<td>32%</td>
</tr>
<tr>
<td>Perforated in channel Flo-Drum</td>
<td>Brush and Water</td>
<td>92%</td>
<td>86%</td>
<td></td>
<td>62% - 66%</td>
</tr>
<tr>
<td>Center Flow Screen - Perforated</td>
<td>Brush (FSM) and Water</td>
<td>93%</td>
<td></td>
<td>84%</td>
<td></td>
</tr>
</tbody>
</table>


See attached UKWIR Test Certificates
Choosing the Right Screen

| Highest Capture | • Center Flow  
|                | • Perf         
|                | • Drum         |

| Most Economical | • Screw Screen 
|                | • Step         |

| Smallest Footprint | • Vertical Screw Screen |

| Deep Channels [30’+] | • Grab Screen  
|                     | • Perf         
|                     | • Center Flow  |
Design Consideration

Fine screening in general requires more screen area than old coarse screens.

Flow velocity through the screen is important to reduce the chance of forcing solids through the screen openings.

- Channel Dimensions
- Screen Angle
- Downstream Water Level – Control with Parshall Flume, grit system, weir or water level in wet well. Maximizes wetted area.
- Maximum upstream water level
- Peak Flow Rate
- Percent of TSS in flow
- Screen Channels Velocity – Optimum between 2 and 3 feet per second
  - Low to peak flow range – 1 to 4.5 feet per second
A conventional screen installed in a channel calculates the “Screen Headloss” as the difference between USWL and DSWL (see below).
A Center Flow screen has many headloss points – headloss across the screen and the total hydraulic gradient across the screen system (see below).

EXAMPLE: CENTER FLOW SCREEN - Not your standard screen calculation
Overall fine screens are inexpensive and quickly pay for themselves. They represent about 4% of the equipment cost used in a WWTP.

However, they provide between 25 to 50% of the overall treatment.

Fine screening will improve any downstream process, prevent damage and clogging of equipment, reduce sludge dewatering costs and reduce overall maintenance of the plant.
Questions?
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