NATIONAL SCREEN EVALUATION FACILITY, CHESTER LE STREET STW

EVALUATION OF THE HAIGH ACE SCREENER

THOMPSON RESEARCH - PROJECT MANAGEMENT LTD

for

HAIGH ENGINEERING CO LTD

REPORT REFERENCE : TRPM – REP241
AUTHOR : BARRY THOMPSON / MARTIN GRAY
VERSION : 1.0
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EXECUTIVE SUMMARY

A Haigh ACE Screener was tested at the National Screen Evaluation Facility, Chester-le-Street STW, Co Durham during October & November 2010. The screen was tested with screen curtain aperture sizes of 6 mm, 3 mm and 2 mm diameter, with the screen curtain plates being changed between each test series.

A total of 12 SCR (Screenings Capture Ratio) tests were conducted on each aperture size, comprising six ‘ON’ tests and six ‘OFF’ tests.

The average SCR for the screen with 6 mm apertures has been found to be 64%.

The average SCR for the screen with 3 mm apertures has been found to be 86%.

The average SCR for the screen with 2 mm apertures has been found to be 94%.

The SCR value of 64 % found for the 6 mm Haigh ACE Screener is very similar to other “Brush Screens” previously tested at the NSEF, and is therefore considered reasonable, representative, and within the expected range.

No direct comparisons are possible however for the SCR values of 86% and 94% found for the 3 mm and 2 mm screens respectively, as no similar screens have ever been tested at the NSEF.

All the screens appeared to remove all gross solids (ie solids greater than 6 mm in any two dimensions) from the flow.

The pattern of the SCR / Flow graphs (Figures 1, 2 and 3) indicate that the trend is for the SCR to increase slightly as flow increases.

The pattern of the Headloss / Flow graphs (Figures 4, 5 and 6) indicate that headloss increases with flow.
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1.2 The UK National Screen Evaluation Facility (NSEF)
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1.0 INTRODUCTION

1.1 The Importance of Efficient Screening

Inlet Screens purchased for STWs / WwTWs that do not function efficiently increase operational expenditure because:

- poor reliability increases screen maintenance costs
- solid material passing through, over or around screens can block downstream equipment
- screens which require excessive wash-water / drive power increase energy costs, and
- poor screen performance can reduce effluent quality, increasing the risk of Consent failure

Specifically, failure of screens to adequately remove solids to the required level can result in:

- visible debris and blockages / fouling in downstream processes
- visible and offensive debris in final effluent, and
- sanitary product debris on beaches and riverbanks

Aesthetic requirements within consented discharges and the desire for reduced operational expenditure throughout the wastewater process have driven UK Water Industry trends towards finer screening. As a result, a considerable variety of “finescreens” are available from numerous suppliers and purchasers have a wide choice of options when considering new screens.

To assist in making this choice, the UK Water Industry, via its collaborative research initiative UKWIR, funded the construction and subsequent operation of a National Screen Evaluation Facility (NSEF), based at Northumbrian Water’s Chester-le-Street STW.

1.2 The UK National Screen Evaluation Facility (NSEF)

The NSEF was commissioned in March 1998 and to date (November 2010) approximately 40 different screens from various manufacturers in the UK, Europe and the USA have been subjected to evaluation.

The Facility is used to ‘type-test’ screens using raw sewage. The aim of this ‘type-testing’ is to confirm that screens meet minimum standards of process effectiveness during service. The intention is not to issue a ‘pass or fail’ certificate for a particular screen but to provide a quantitative measure of process effectiveness known as the Screenings Capture Ratio (SCR) - a value derived by sampling screen discharges and downstream gross solids loading (see Section 2.0, below).

The ‘Average SCR’ value for any particular screen has been accepted world-wide as the comparator for process performance when considering new screens. For example, the value is recognised by the UK Water Industry Mechanical & Electrical Specifications (WIMES) Initiative, and features in WIMES 5.03 – “Screens for Sewage Treatment” (Issue 3, dated May 2008).

Test results are reported immediately to the equipment supplier concerned and remain their property. TRPM do not disseminate results to any third party without the prior permission of the supplier. Suppliers are however offered the opportunity to have their results included in occasional comparative reports published via UKWIR – the most recent being UKWIR Report Ref 03/WW/06/5 – “NSEF, Inlet Screen Evaluation - Year 5 Comparative Report”, published in July 2003. All screen test results up to this date are included in this report.

Since the publication of the above report, the development of new fine screen technologies has slowed, with seven further completed tests to date, including the ACE Screener, the subject of this report.
1.3 The Haigh ACE Screener

The ACE Screener is manufactured and supplied in the UK by Haigh Engineering Co Ltd, Ross-on-Wye. The screen tested at the NSEF comprises of a twin curved perforated stainless steel plate screen curtain, mounted in a stainless steel fabricated body, nominally 490 mm wide. The screen curtain comprises of two interchangeable curved panels, 196 mm wide by 1 mm thick. The panel curves up and out of the flow from the inlet end to the outlet end. The screen structure, manufactured from Gr 304 stainless steel, is normally bolted to the channel floor and rubber seals are used between the unit and the adjacent channel walls. Alternatively, prefabricated tank mounted versions are available with flanged inlet and outlet connections.

Sewage flows through the screen and screenings are collected on the two screen curtain panels. Screenings are removed from the curtain by a LISAB brush, arm-mounted on a reciprocating mechanism. When the motor (0.25 KW) operates, the brush assembly sweeps the screenings up the screen curtain and out of the flow. In normal operations the screenings would be deposited into a hopper and then pumped by a macerator pump to a Liquid Separator, but for this test the screenings were transferred directly into a perforated plate collection basket.

Haigh have advised that the screen is available for channel widths of 500 mm, 750 mm and 1000 mm with standard curtain aperture diameters of 6 mm, 3 mm and 2 mm. The nominal aperture size of 6 mm, gives a 44% open area, with the 3 mm having a 33% open area and the 2 mm a 40% open area.

The screen installed at the NSEF for evaluation had interchangeable panels with the structure remaining in situ, thus the three different aperture sizes were tested sequentially.

Photograph 1 – Haigh ACE Screener – NSEF
2.0 SCREEN EVALUATION – METHODOLOGY

2.1 Screenings Capture Ratio (SCR)

The test procedure used for evaluating a screen SCR value was initially developed by Northumbrian Water as part of their Screen Evaluation Programme, and subsequently adopted by all the UK Water Companies for use at the NSEF. A line diagram of the screening process is shown below:

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.

The screenings load removed from the sewage flow by the screen (Y) is obtained by inserting a collection tray below the screen discharge. This is made from 3 mm diameter perforated plate to permit drainage of excess liquid.

The screenings load in the raw sewage (X) and / or the screened sewage (Z) is obtained by inserting a number of 4 mm - 6 mm Copasacs into a fabricated mounting plate placed in the sewage flow.

The screen SCR is calculated as follows:

\[ SCR = \left( \frac{Y}{X} \right) \times 100\% \]

It is not practical, however, to sample X simultaneously with Y and Z as all solids would be removed at X, but given that in theory \( X = Y + Z \), the formula can be revised, to remove the requirement for upstream sampling at X, to:

\[ SCR = \left( \frac{Y}{Y+Z} \right) \times 100\% \]

This method is used where screenings are discharged virtually instantaneously following removal from the flow (ie Y and Z are recorded simultaneously). A modified method is used for screens which do not discharge screenings instantaneously, such as “Spiral Screens”, which is:

\[ SCR = \left( \frac{X - Z}{X} \right) \times 100\% \]

With this variation, Copasacs are used to sample the flow at X, but X and Z are not sampled simultaneously as all solids would be removed at X. X is sampled for a timed period before and after the sampling at Z and the average of the two values used in the above equation.
2.1 Screenings Capture Ratio (SCR) (Cont)

During an SCR evaluation, the performance of the screen is measured with the screen running continuously (an ‘ON’ test), or with the screen stationary and blinding (an ‘OFF’ test).

An ‘ON’ test simulates screen performance during storm conditions, ie full time operation due to the high flows arriving at the WwTW, whilst an ‘OFF’ test simulates screen performance during normal dry weather conditions, ie only very occasional operation, allowing screen blinding and the formation of a “mat” of screenings on the screen face.

The target number of individual tests is 12 per evaluation, being six ‘ON’ Tests and six ‘OFF’ Tests, with the combination of all tests being seen as replicating the usual intermittent operation of a screen under automatic control conditions.

To prevent overflow during an ‘OFF’ test, the screen may be operated for a few seconds if necessary to reduce screen curtain blinding and lower the upstream-downstream head differential.

The collection tray and Copasacs used for assessing the X (if required), Y and Z values are weighed prior to testing and their “self-weights” noted on a datasheet. Following a test, the collection tray and Copasacs are allowed to “drip-dry” for 30 minutes prior to weighing.

The X (if required), Y and Z values may be expressed in units of g/m$^3$ of flow or Kg/min. All values are absolute - ie the total flow is sampled.

2.2 Headloss / Flow Relationship Assessment

To determine the relationship between screen capacity (flow rate) and resistance (headloss), values of upstream and downstream depth (and hence headloss) are recorded at different flow rates.

The facility inlet control valve setting is manually varied to give a range of flows.

To simulate the effect of downstream flow control structures in real installations, steel plate weirs with different crest heights are inserted in the channel downstream of the screen.

Headloss versus flow rate data is then generated with no weir, and then with weirs having crest heights of 100 mm, 225 mm and 350 mm.
3.0 RESULTS

3.1 Screenings Capture Ratio (SCR)

3.1.1 6 mm Screen Apertures

The results from each SCR test are shown in the following table:

<table>
<thead>
<tr>
<th>DATE</th>
<th>TEST REF</th>
<th>ON/OFF</th>
<th>AV. FLOW (l/sec)</th>
<th>TRAY – MASS (kg)</th>
<th>COPASACS – MASS (Kg)</th>
<th>SCR (% Y/Y+Z)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GROSS</td>
<td>SELF</td>
<td>NET</td>
</tr>
<tr>
<td>25/10/10</td>
<td>1</td>
<td>ON</td>
<td>49</td>
<td>6.2</td>
<td>4.2</td>
<td>2</td>
</tr>
<tr>
<td>25/10/10</td>
<td>2</td>
<td>OFF</td>
<td>50</td>
<td>6.25</td>
<td>4.2</td>
<td>2.05</td>
</tr>
<tr>
<td>26/10/10</td>
<td>3</td>
<td>OFF</td>
<td>45</td>
<td>7.9</td>
<td>4.2</td>
<td>3.7</td>
</tr>
<tr>
<td>26/10/10</td>
<td>4</td>
<td>ON</td>
<td>49</td>
<td>7.7</td>
<td>4.2</td>
<td>3.5</td>
</tr>
<tr>
<td>26/10/10</td>
<td>5</td>
<td>OFF</td>
<td>48</td>
<td>5.8</td>
<td>4.2</td>
<td>1.6</td>
</tr>
<tr>
<td>27/10/10</td>
<td>6</td>
<td>ON</td>
<td>43</td>
<td>8.2</td>
<td>4.2</td>
<td>4.0</td>
</tr>
<tr>
<td>27/10/10</td>
<td>7</td>
<td>OFF</td>
<td>44</td>
<td>7.25</td>
<td>4.2</td>
<td>3.05</td>
</tr>
<tr>
<td>27/10/10</td>
<td>8</td>
<td>ON</td>
<td>46</td>
<td>8.1</td>
<td>4.2</td>
<td>3.9</td>
</tr>
<tr>
<td>27/10/10</td>
<td>9</td>
<td>OFF</td>
<td>45</td>
<td>6.4</td>
<td>4.2</td>
<td>2.2</td>
</tr>
<tr>
<td>28/10/10</td>
<td>10</td>
<td>ON</td>
<td>49</td>
<td>8.85</td>
<td>4.2</td>
<td>4.65</td>
</tr>
<tr>
<td>28/10/10</td>
<td>11</td>
<td>OFF</td>
<td>44</td>
<td>7.65</td>
<td>4.2</td>
<td>3.45</td>
</tr>
<tr>
<td>28/10/10</td>
<td>12</td>
<td>ON</td>
<td>49</td>
<td>7.9</td>
<td>4.2</td>
<td>3.7</td>
</tr>
</tbody>
</table>

AVERAGE SCR (%) = 63.5

On the basis of this data, the average SCR value for the screen with 6 mm screen apertures was found to be 64%.
3.1.1 6 mm Screen Apertures (Cont)

The average SCR value based on the results from all 12 tests is 64%.

This result is comparable to other Brush Screens with 6 mm screen apertures previously tested at the NSEF.

The variation of SCR against flow is shown as Figure 1 below:

![Figure 1 – SCR v Flow](image)

This shows that the trend is for the SCR to increase slightly as flow increases.
3.1 Screenings Capture Ratio (SCR) (Cont)

3.1.2 3 mm Screen Apertures

The results from each SCR test are shown in the following table:

<table>
<thead>
<tr>
<th>DATE</th>
<th>TEST REF</th>
<th>ON/OFF</th>
<th>AV. FLOW (l/sec)</th>
<th>TRAY – MASS (kg) = ‘Y’ VALUE</th>
<th>COPASACS – MASS (Kg) = ‘Z’ VALUE</th>
<th>SCR (Y/Y+Z)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GROSS</td>
<td>SELF</td>
<td>NET</td>
</tr>
<tr>
<td>29/10/10</td>
<td>1</td>
<td>ON</td>
<td>41</td>
<td>11.55</td>
<td>4.2</td>
<td>7.35</td>
</tr>
<tr>
<td>29/10/10</td>
<td>2</td>
<td>OFF</td>
<td>34</td>
<td>9.2</td>
<td>4.2</td>
<td>5.0</td>
</tr>
<tr>
<td>1/11/10</td>
<td>3</td>
<td>ON</td>
<td>36</td>
<td>10.0</td>
<td>4.2</td>
<td>5.8</td>
</tr>
<tr>
<td>1/11/10</td>
<td>4</td>
<td>OFF</td>
<td>29</td>
<td>7.7</td>
<td>4.2</td>
<td>3.5</td>
</tr>
<tr>
<td>1/11/10</td>
<td>5</td>
<td>ON</td>
<td>34</td>
<td>7.2</td>
<td>4.2</td>
<td>3</td>
</tr>
<tr>
<td>1/11/10</td>
<td>6</td>
<td>OFF</td>
<td>33</td>
<td>7.05</td>
<td>4.2</td>
<td>2.85</td>
</tr>
<tr>
<td>2/11/10</td>
<td>7</td>
<td>ON</td>
<td>38</td>
<td>8.55</td>
<td>4.2</td>
<td>4.35</td>
</tr>
<tr>
<td>2/11/10</td>
<td>8</td>
<td>OFF</td>
<td>30</td>
<td>7</td>
<td>4.2</td>
<td>2.8</td>
</tr>
<tr>
<td>2/11/10</td>
<td>9</td>
<td>ON</td>
<td>38</td>
<td>7.15</td>
<td>4.2</td>
<td>2.95</td>
</tr>
<tr>
<td>2/11/10</td>
<td>10</td>
<td>OFF</td>
<td>32</td>
<td>6.05</td>
<td>4.2</td>
<td>1.85</td>
</tr>
<tr>
<td>3/11/10</td>
<td>11</td>
<td>ON</td>
<td>33</td>
<td>7.2</td>
<td>4.2</td>
<td>3.0</td>
</tr>
<tr>
<td>3/11/10</td>
<td>12</td>
<td>OFF</td>
<td>28</td>
<td>10.2</td>
<td>4.2</td>
<td>6</td>
</tr>
</tbody>
</table>

AVERAGE SCR (%) = 86.42

On the basis of this data, the average SCR value for the screen with 3 mm screen apertures was found to be 86%.
3.1.2 3 mm Screen Apertures (Cont)

The average SCR value based on the results from all 12 tests is 86%.

No other Brush Screens with 3 mm screen apertures have been tested at the NSEF, thus it is not possible to make a direct comparison between this and other results.

The variation of SCR against flow is shown as Figure 2 below:

![Figure 2 – SCR v Flow](image)

This shows that the trend is for the SCR to increase slightly as flow increases.
3.1 Screenings Capture Ratio (SCR) (Cont)

3.1.3 2 mm Screen Apertures

The results from each SCR test are shown in the following table:

<table>
<thead>
<tr>
<th>DATE</th>
<th>TEST REF</th>
<th>ON/OFF</th>
<th>AV. FLOW (l/sec)</th>
<th>TRAY – MASS (kg) = ‘Y’ VALUE</th>
<th>COPASACS – MASS (Kg) = ‘Z’ VALUE</th>
<th>SCR (Y/Y+Z) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/11/10</td>
<td>1</td>
<td>ON</td>
<td>39</td>
<td>13.0</td>
<td>430</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>OFF</td>
<td>31</td>
<td>7.7</td>
<td>386</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>ON</td>
<td>34</td>
<td>7.75</td>
<td>406</td>
<td>94</td>
</tr>
<tr>
<td>8/11/10</td>
<td>4</td>
<td>ON</td>
<td>30</td>
<td>12.55</td>
<td>592</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>OFF</td>
<td>25</td>
<td>8.2</td>
<td>412</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>OFF</td>
<td>26</td>
<td>10.1</td>
<td>464</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>ON</td>
<td>32</td>
<td>9.10</td>
<td>370</td>
<td>96</td>
</tr>
<tr>
<td>9/11/10</td>
<td>8</td>
<td>ON</td>
<td>32</td>
<td>8.85</td>
<td>406</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>OFF</td>
<td>25</td>
<td>7.15</td>
<td>410</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>OFF</td>
<td>27</td>
<td>7.05</td>
<td>382</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>OFF</td>
<td>29</td>
<td>8.0</td>
<td>400</td>
<td>94</td>
</tr>
<tr>
<td>10/11/10</td>
<td>12</td>
<td>ON</td>
<td>34</td>
<td>10.9</td>
<td>480</td>
<td>96</td>
</tr>
</tbody>
</table>

AVERAGE SCR (%) = 94.42

On the basis of this data, the average SCR value for the screen with 2 mm screen apertures was found to be 94%.
3.1.3 2 mm Screen Apertures (Cont)

The average SCR value based on the results from all 12 tests is 94%.

No other Brush Screens with 2 mm screen apertures have been tested at the NSEF, thus it is not possible to make a direct comparison between this and other results.

The variation of SCR against flow is shown as Figure 3 below:

![Figure 3 – SCR v Flow](image)

This shows that the trend is for the SCR to increase slightly as flow increases.
3.2 Headloss / Flow Relationship Assessment

3.2.1 6 mm Screen Apertures

The results of the Headloss / Flow assessment for each controlled downstream condition are shown as Figure 4 below:

The pattern of the Headloss / Flow graph (Figure 4) indicates that headloss increases with flow as could be expected.

3.2.2 3 mm Screen Apertures

The results of the Headloss / Flow assessment for each controlled downstream condition are shown as Figure 5 below:

The pattern of the Headloss / Flow graph (Figure 5) indicates that headloss increases with flow as could be expected.
3.2.3 2 mm Screen Apertures

The results of the Headloss / Flow assessment for each controlled downstream condition are shown as Figure 6 below:

![Figure 6 – Headloss v Flow](image)

The pattern of the Headloss / Flow graph (Figure 6) indicates that headloss increases with flow as could be expected.

3.2.4 Headloss / Flow Assessment with 350 mm Downstream Weir

Due to the depth of the screen support structure it was not possible to conduct a Headloss / Flow Assessment utilising the 350 mm downstream weir.

This creates flow depths in excess of 350 mm downstream of the screen, which when ‘backed-up’ submerged the screen curtain.
4.0 CONCLUSIONS

A Haigh ACE Screener was tested at the National Screen Evaluation Facility, Chester-le-Street STW, Co Durham during October & November 2010. The screen was tested with screen curtain aperture sizes of 6 mm, 3 mm and 2 mm diameter, with the screen curtain plates being changed between each test series.

A total of 12 SCR (Screenings Capture Ratio) tests were conducted on each aperture size, comprising six ‘ON’ tests and six ‘OFF’ tests.

The average SCR for the screen with 6 mm apertures has been found to be 64%.

The average SCR for the screen with 3 mm apertures has been found to be 86%.

The average SCR for the screen with 2 mm apertures has been found to be 94%.

The SCR value of 64% found for the 6 mm Haigh ACE Screener is very similar to other “Brush Screens” previously tested at the NSEF, and is therefore considered reasonable, representative, and within the expected range.

No direct comparisons are possible however for the SCR values of 86% and 94% found for the 3 mm and 2 mm screens respectively, as no similar screens have ever been tested at the NSEF.

All the screens appeared to remove all gross solids (i.e. solids greater than 6 mm in any two dimensions) from the flow.

The pattern of the SCR / Flow graphs (Figures 1, 2 and 3) indicate that the trend is for the SCR to increase slightly as flow increases.

The pattern of the Headloss / Flow graphs (Figures 4, 5 and 6) indicate that headloss increases with flow.