Report on Sweeping
by Duncan Silversides

Introduction
In the 2015/16 curling season, there was a lot of controversy about the different types of broom heads. 22 Canadian and international teams signed a statement stating they will not sweep with brooms that have 'directional fabric.' Curling Canada released a guideline stating that the fabric covering the broom head may not be embossed, sealed, textured or modified from its original woven form. That includes waterproofing the fabric with materials such as polyurethane. As well, teams can't use "stiffening" inserts where a hard piece of plastic has been placed between the outer fabric and the inside pad.

There's been lots of discussion and theorizing about what curlers see happening on the ice. Previous tests by the Gushue team demonstrated the issue by throwing a rock at a set speed, sweeping with different brooms and seeing what happens. Unfortunately, this type of testing doesn't provide a way to measure and compare different types of brooms, beyond looking at where the rock stops.

The purpose of this project is to find a way to measure how brooms effect the ice, and quantify the difference between the different broom heads. I believe that it is possible to measure the difference in broom heads using photos and image analysis.

Procedure
Materials: PVC rail stand, Cannon 1DS mark 2 Camera with a 100mm macro lens, camera mount for rail stand, notebook, two sensor brooms, synthetic broom head, EQ broom head, hair broom and Hardline broom with IcePad (waterproof fabric) and plastic insert

1. Have the ice maker prepare a sheet of ice for regular play.
2. Put the camera stand on the ice and take photos of each location to be used in the experiment and assign a specific broom for each photo location (see photo below).
3. For each location, sweep in front of a moving rock using the specified broom. The sensor brooms were used as a check that the pressure (100 lbs) and brush head speed (4 strokes per second) was consistent. The first location was only a rock traveling over it as a control.
4. After each time a rock was swept, I replaced the camera stand and took a set of photos. Each image is of approximately a 7cm x 5cm section of ice at 5,000 x 3,200 pixels.
5. Repeat steps 3 and 4 ten times in each photo location to show the impact of multiple rocks throughout a game.
6. Match and crop photos for each broom type. An example of photos for the hair broom are included in Appendix A.
7. Use image analysis software to measure the ice change caused by the brooms.
Results

When I analyzed the photos, the rock only changed the ice in the photo 2 percentage points from the first rock to the tenth rock. With the EQ head, there was a 5 percentage point difference. The hair broom caused a 9 percentage point difference. Finally, the Hardline broom caused a 15 percentage point difference.

The average change in the difference between the first sweep and the fifth sweep was 3.27 percentage points, with a standard deviation of 2.67. The average change in the difference between the first sweep and the 10th sweep was 6.33 with a standard deviation of 5.56.

The first 5 sweeps cause more change in the ice than the last 5 sweeps with the exception of the Hardline broom. The Hardline broom seems to change the ice the same or slightly more with repeated sweeping. The values for the Hardline broom are significantly higher than the mean at the 95% confidence interval.

From the results for the Synthetic broom head, there appears to be a problem with the data since sweeping and a rock should change the ice more than just a rock. The data is within the range of 1 standard deviation, so it could be at the edge of the range of valid results.
In the graph, Indexed Results of Sweeping Tests, you can see from the slope of the lines that they all go up in the first section, and most of them, with the exception of the Hardline, level off or decline in the second section.

### Indexed Results of Sweeping Tests

<table>
<thead>
<tr>
<th>Number of Sweeps</th>
<th>Base(1)</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQ</td>
<td>100</td>
<td>103</td>
<td>104</td>
</tr>
<tr>
<td>Hardline</td>
<td>100</td>
<td>102</td>
<td>101</td>
</tr>
<tr>
<td>Hair</td>
<td>107</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>Synthetic</td>
<td>113</td>
<td>117</td>
<td>117</td>
</tr>
<tr>
<td>Rock</td>
<td>129</td>
<td>129</td>
<td>129</td>
</tr>
</tbody>
</table>

**Conclusion**

Photo analysis did show that the ice changes as a result of sweeping the rocks, and that it is possible to measure those changes. The image analysis showed that the Hardline broom caused significant changes to the ice surface proving my hypothesis. For this report, the Hardline broom with waterproof fabric was the only banned broom available for testing. The intent of this testing is to demonstrate that it is possible to measure the change in ice due to sweeping and should not be used to single out a specific broom.

The different types of broom heads change the ice in different ways. For example, with the hair broom, it is easy to see the scratches on the ice.

Curling rules already prohibit the use of equipment which damages the ice. This type of testing can be used to evaluate brooms and identify which brooms, if any, are damaging to the ice.

**Next Steps**

If there’s interest in continuing this approach to testing brooms, the next step would be to repeat the tests with a larger selection of allowed brooms, as well as different banned brooms. The tests could be done on a variety ice surfaces, including arena ice, to make sure the results would apply to any type of event.

A complete set of photos is available on request.
Appendix A – Sample of photos

Hair Broom after a rock and sweeping once

Hair Broom after 10 rocks and sweeping 10 times