Cryogenic Testing – Prepared for Highland International, LLC  
December 2014

Short Term Cryogenic Testing Procedure

Designated panels were subjected to 4 x 24 hour cycles of cryogenic temperatures (-300°F). All panels were removed mid cycle and submerged in boiling water. The immediately cooled water bath was allowed to return to a boil for 5 minutes, afterwards, the panels were placed back in the cryogenic chamber (-300°F) for the remainder of each 24 hour cycle. At the end of each cycle, the panels were allowed to return to ambient temperatures (approx 72°F) for 24 hours.

All testing was conducted by 300° Below Cryogenic Tempering Services, 2999 E. Parkway Drive, Decatur IL 62526.

All test panels (304L Grade Stainless Steel) were prepared and provided by Highland International, Inc.

Short Term Panel Preparation

<table>
<thead>
<tr>
<th>Group</th>
<th>Panel ID</th>
<th>Surface Prep (On 304L SS)</th>
<th>Coat 1</th>
<th>Coat 2</th>
<th>Cure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highland 827-HB Series</td>
<td>A1</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
</tr>
<tr>
<td></td>
<td>A3</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
</tr>
<tr>
<td></td>
<td>A4</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>24 Hours @ 500°F</td>
</tr>
<tr>
<td></td>
<td>A5</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>24 Hours @ 500°F</td>
</tr>
<tr>
<td></td>
<td>A6</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>24 Hours @ 500°F</td>
</tr>
<tr>
<td>Competitor #1</td>
<td>B1</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
</tr>
<tr>
<td></td>
<td>B3</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>24 Hours @ 500°F</td>
</tr>
<tr>
<td>Competitor #2</td>
<td>C1</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>24 Hours @ 500°F</td>
</tr>
</tbody>
</table>
Short Term Post-Test Panels

Group “A” Panels Represent Highland International, Inc. 827-HB Series
(Magnification represents x20 zoom)

A1 – Highland 827-HB
Ambient Cure

A2 – Highland 827-HB
Ambient Cure

A3 – Highland 827-HB
Ambient Cure

A4 – Highland 827-HB
Heat Cured @ 500°F

A5 – Highland 827-HB
Heat Cured @ 500°F

A6 – Highland 827-HB
Heat Cured @ 500°F
Short Term Post-Test Panels (Continued)

Group “B” Panels Represent Competitor #1 Multipolymeric Matrix Coating
(Magnification represents x20 zoom lens)

- B1 – Competitor #1 Ambiant Cure
- B2 – Competitor #1 Ambiant Cure
- B3 – Competitor #1 Heat Cured @ 500°F

Group “C” Panels Represent Competitor #2 CUI Coating
(Magnification represents x20 zoom lens)

- C1 – Competitor #2 Ambiant Cure
- C2 – Competitor #2 Ambiant Cure
- C3 – Competitor #2 Heat Cured @ 500°F
Short Term Post-Test Panels (Adhesion Results)
ASTM D4541 Test Method for Pull-Off Strength using Portable Adhesion Tester
ASTM D3359 Test Method for Measuring Adhesion by Tape Test

Group “A” Panels Represent Highland International, Inc. 827-HB Series
All pull offs were noted as 100% cohesive failure at given psi.

<table>
<thead>
<tr>
<th>Panel</th>
<th>Pull Off</th>
<th>Cross Hatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>350 PSI</td>
<td>3A</td>
</tr>
<tr>
<td>A2</td>
<td>400 PSI</td>
<td>3A</td>
</tr>
<tr>
<td>A3</td>
<td>300 PSI</td>
<td>4A</td>
</tr>
<tr>
<td>A4</td>
<td>450 PSI</td>
<td>3A</td>
</tr>
<tr>
<td>A5</td>
<td>450 PSI</td>
<td>3A</td>
</tr>
<tr>
<td>A6</td>
<td>450 PSI</td>
<td>3A</td>
</tr>
</tbody>
</table>
Group “B” Panels Represent Competitor #1 Multipolymeric Matrix Coating
All pull offs were noted as 100% cohesive failure at given psi.

B1
Pull Off: 50 PSI
Cross Hatch: 3A

B2
Pull Off: 50 PSI
Cross Hatch: 4A

B3
Pull Off: 50 PSI
Cross Hatch: 3A

Group “C” Panels Represent Competitor #2 CUI Coating
All pull offs were noted as 100% cohesive failure at given psi.

C1
Pull Off: 400 PSI
Cross Hatch: 3A

C2
Pull Off: 100 PSI
Cross Hatch: 3A

C3
Pull Off: 400 PSI
Cross Hatch: 4A
Short Term Post-Test Panels (Salt-Fog Results)
ASTM B117 Practice for Operating Salt Fog

Group “A” Panels Represent Highland International, Inc. 827-HB Series
(Top and bottom areas of each panel have been taped to protect from salt-fog affect)

A1
No rusting in the field

A2
No rusting in the field

A3
No rusting in the field

A4
No rusting in the field

A5
No rusting in the field

A6
No rusting in the field
Group “B” Panels Represent Competitor #1 Multipolymeric Matrix Coating

B1
No rusting in the field

B2
No rusting in the field

B3
No rusting in the field

Group “C” Panels Represent Competitor #2 CUI Coating

C1
No rusting in the field

C2
No rusting in the field

C3
No rusting in the field
Short Term Cryogenic Evaluation

After the cryogenic test procedure was complete, all panels were evaluated for micro-cracking (via visual and magnified inspection), adhesion differences, and performance in salt fog to further evaluate effects, if any, from cryogenic and thermal shock cycles.

Short Term Cryogenic Testing - Summary

<table>
<thead>
<tr>
<th>Group</th>
<th>Panel ID</th>
<th>Visual Inspection</th>
<th>Micro-cracking (20 x zoom inspection)</th>
<th>Micro-cracking Pass/Fail</th>
<th>Adhesion (via Elcometer)</th>
<th>Adhesion (via Tape Test)</th>
<th>Salt-Fog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highland 827-HB Series</td>
<td>A1</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>350 psi</td>
<td>3A</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>400 psi</td>
<td>3A</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>A3</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>300 psi</td>
<td>4A</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>A4</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>450 psi</td>
<td>3A</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>A5</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>450 psi</td>
<td>3A</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>A6</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>450 psi</td>
<td>3A</td>
<td>Pass</td>
</tr>
<tr>
<td>Competitor #1</td>
<td>B1</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>50 psi</td>
<td>3A</td>
<td>Pass</td>
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<td></td>
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<td>4A</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>B3</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>50 psi</td>
<td>3A</td>
<td>Pass</td>
</tr>
<tr>
<td>Competitor #2</td>
<td>C1</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>400 psi</td>
<td>3A</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>100 psi</td>
<td>3A</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>Excellent</td>
<td>None</td>
<td>Pass</td>
<td>400 psi</td>
<td>4A</td>
<td>Pass</td>
</tr>
</tbody>
</table>

Excellent = No visual abnormalities  
Good = Some visual abnormalities, no visual failure  
Poor = Visual abnormalities and visual coating failure

All panels passed visual and magnified inspections for micro-cracking as well as salt fog testing. Adhesion for all coatings evaluated via cross-hatch (ASTM D3359) averaged between a 3-4A. Adhesion evaluated via Elcometer Pulls (ASTM D4541) showed the following averages/rankings:

#1 – Highland 827-HB Series with average pull-off strength of 400psi  
#2 – Competitor #2 with average pull-off strength of 300psi  
#3 – Competitor #1 with average pull-off strength of 50psi
Long Term Cryogenic Testing Procedure

Designated panels were subjected to 4 x 1 week cryogenic cycles (1 week = 7 days @ -300°F). All panels were removed from the cryogenic chamber on the 3\textsuperscript{rd} day of each cycle to be submerged in boiling water. The immediately cooled water bath was allowed to return to a boil for 15 minutes, afterwards, the panels were placed back in the cryogenic chamber (-300°F) for the remainder of each 1 week cycle. At the end of each 1 week cycle, the panels were allowed to return to ambient temperatures (approx 72°F) for 24 hours.

All testing was conducted by 300° Below Cryogenic Tempering Services, 2999 E. Parkway Drive, Decatur IL 62526.

All test panels (304L Grade Stainless Steel) were prepared and provided by Highland International, Inc.

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<th>Coat 2</th>
<th>Cure</th>
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<tbody>
<tr>
<td>Highland 827-HB Series</td>
<td>A-L7</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
</tr>
<tr>
<td></td>
<td>A-L8</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
</tr>
<tr>
<td>Competitor #1</td>
<td>B-L4</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
</tr>
<tr>
<td>Competitor #2</td>
<td>C-L4</td>
<td>SSPC-SP 1 w/ MEK</td>
<td>5-6 mils DFT</td>
<td>5-6 mils DFT</td>
<td>7 Days Ambient</td>
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Long Term Panel Evaluation

After the long-term test procedure was complete, all panels were evaluated for microcracking (via visual and magnified inspection), adhesion differences, and performance in salt fog to further evaluate effects, if any, from longer term cryogenic cycles.
Long Term Post-Test Panels

Group “AL” Panels Represent Highland International, Inc. 827-HB Series
(Magnification represents x20 zoom)

Group “BL” Panel Represents Competitor #1 Multipolymeric Matrix Coating
(Magnification represents x20 zoom)
Group “CL” Panel Represents Competitor #2 CUI Coating
(Magnification represents x20 zoom)

Long Term Post-Test Panels (Adhesion Results)
ASTM D4541 Test Method for Pull-Off Strength Using Portable Adhesion Tester
ASTM D3359 Test Method for Measuring Adhesion by Tape Test

Group “AL” Panels Represent Highland International, Inc. 827-HB Series
All pull offs were noted as 100% cohesive failure at given psi.
Group “BL” Panel Represents Competitor #1 Multipolymeric Matrix Coating

All pull offs were noted as 100% cohesive failure at given psi.

B-L4
Pull Off: 0 PSI
Cross Hatch: 3A

Group “CL” Panel Represents Competitor #2 CUI Coating

All pull offs were noted as 100% cohesive failure at given psi.

C-L4
Pull Off: 300 PSI
Cross Hatch: 3A
Long Term Post-Test Panels (Salt-Fog Results)
ASTM B117 Practice for Operating Salt Fog

Group “AL” Panels Represent Highland International, Inc. 827-HB Series
(Top and bottom areas of each panel have been taped to protect from salt-fog affect)

- A-L7
  No rusting in the field

- A-L8
  No rusting in the field

Group “BL” Panel Represents Competitor #1 Multipolymeric Matrix Coating
(Top and bottom areas of each panel have been taped to protect from salt-fog affect)

- B-L4
  No rusting in the field
Group “CL” Panel Represents Competitor #2 CUI Coating
(Top and bottom areas of each panel have been taped to protect from salt-fog affect)

![Image of group panel]

C-L4
No rusting in the field

Long Term Cryogenic Testing - Summary

<table>
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<tr>
<th>Long Term Test Panel Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>Highland 827-HB Series</td>
</tr>
<tr>
<td>Highland 827-HB Series</td>
</tr>
<tr>
<td>Competitor #1</td>
</tr>
<tr>
<td>Competitor #2</td>
</tr>
</tbody>
</table>

Excellent = No visual abnormalities
Good = Some visual abnormalities, no visual failure
Poor = Visual abnormalities and visual coating failure

All panels passed visual and magnified inspections for micro-cracking as well as salt fog testing. Adhesion for all coatings evaluated via cross-hatch (ASTM D3359) was found to be equal at 3A. Adhesion evaluated via Elcometer Pulls (ASTM D4541) showed the following averages/rankings:

#1 – Highland 827-HB Series & Competitor #2 with average pull-off strengths of 300psi
#2 – Competitor #1 had 0 psi pull-off strength
Cryogenic Testing Conclusions

Highland 827-HB Series is suitable for cryogenic service temperatures, in that such temperatures reached in these tests do not affect the overall performance of the product. Furthermore, it can be inferred that while all coatings tested may be suitable for cryogenic services, Highland 827-HB may perform as well or better than the 2 competitor products tested alongside 827-HB in these trials.