Hydrogen Vent Ground Umbilical Quick Disconnect – Flight Seal Advanced Development

Prepared by:
Doug Girard – Team ESC
Fred Jankowski – Team ESC
Mark C. Minich – Team ESC
Weiping Yu – NASA NEM
Objective

• This project is a team effort between NASA Engineering (NE) and Team QNA Engineering personnel to provide support for the Umbilical Systems Development project which is funded by Advanced Exploration Systems (AES) and 21st Century Launch Complex.

• Specifically, this project seeks to develop a new interface between the PPBE baselined Legacy SSP LH2 Vent Arm QD probe and SLS vent seal.
Scope of effort:

- Utilize existing SSP hardware, GSE and test fixtures
- Correct inherent design issues of SSP LH2 vent
- Utilize NASA analysis tool
- Develop self-aligning hardware interface
- Design new seal configurations for analytical evaluation
- Determine a more balanced spring rate relationship between QD – flight seal
- Optimize the mating position engagement with umbilical arm loads accounted
- Determine the affects of cryogenic operating temperatures on this relationship
- Down select proposed seal designs to best candidates and optimize configurations
GH2 Vent Interface - Alignment

Ground Side

Flight Side

QD Body

Seal Interface

Poppet

Seal Center Line

Section View
GH2 Vent Interface - Alignment

**Test 14 - One Piece Worst**

- Pressure [psi]

**Test 14 - “Best Fit”**
- Offset 0.010” @ 8:00
- GUCP Restrained

**SSP Spider Chart**
- Requirement
- Offset < 0.050”
GH2 Vent Interface – Alignment Hardware

<table>
<thead>
<tr>
<th>Max Offset</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 to 6</td>
<td>0.002</td>
</tr>
<tr>
<td>11 to 5</td>
<td>0.014</td>
</tr>
<tr>
<td>10 to 4</td>
<td>0.023</td>
</tr>
<tr>
<td>9 to 3</td>
<td>0.024</td>
</tr>
<tr>
<td>8 to 2</td>
<td>0.018</td>
</tr>
<tr>
<td>7 to 1</td>
<td>0.010</td>
</tr>
</tbody>
</table>

SLS Recommendation – Develop Concentricity Tool
GH2 Vent Interface – Alignment Recommendations

SLS Recommendation – Parallelism Retainer Clips
An installation GSE bolt with a retainer clip should be considered. This fastener would help maintain parallelism during the installation process by capturing the QD flange on the inside face until QD guide pin removal.
GH2 Vent Interface – Alignment Hardware

SLS Recommendation – Self-Aligning Probe
## GH2 Vent Interface – Analysis Tool

<table>
<thead>
<tr>
<th>Part</th>
<th>Material Description</th>
<th>Young's Modulus (psi)</th>
<th>Poisson's Ratio (in/in)</th>
<th>Yield Strength (psi)</th>
<th>Ultimate Strength (psi)</th>
<th>Elongation at Break</th>
<th>Mass Density (lbf/in³)</th>
<th>CTE (10⁻⁶ in/in/F°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-Piece Seal</td>
<td>FEP-Fluorocarbon</td>
<td>70,000</td>
<td>0.46</td>
<td>1700</td>
<td>2500 – 3500</td>
<td>300.00%</td>
<td>0.011</td>
<td>70°: 125, -130°: 75, -417°:</td>
</tr>
<tr>
<td>Two-Piece Seal</td>
<td>Polytetrafluoroethylene (PTFE or Teflon)</td>
<td>70,000</td>
<td>0.46</td>
<td>1700</td>
<td>3,500</td>
<td>400.00%</td>
<td>0.078</td>
<td>70°: 12.65, -130°: 11.8, -417°: 8.3</td>
</tr>
<tr>
<td>Retainer</td>
<td>AL 6061 T6511 (Shapes Extruded)</td>
<td>9,900,000</td>
<td>0.33</td>
<td>35,000</td>
<td>38000 ~ 42000</td>
<td>6.00%</td>
<td>0.098</td>
<td>70°: 12.2, -130°: 11.3, -417°: 8</td>
</tr>
<tr>
<td>Spring</td>
<td>ELGILOY S4-71A (Elgiloy® AMS 5876)</td>
<td>27,500,000</td>
<td>0.226</td>
<td>75400</td>
<td>125000</td>
<td>38.00%</td>
<td>0.3</td>
<td>70°: 8.428, -130°: 6.2, -417°: 4.8</td>
</tr>
<tr>
<td>ETCA</td>
<td>AL 2219 T851-ULTR</td>
<td>10,500,000</td>
<td>0.33</td>
<td>46000</td>
<td>62,000</td>
<td>6.00%</td>
<td>0.103</td>
<td>70°: 12.8, -130°: 6.2, -417°: 4.8</td>
</tr>
<tr>
<td>Probe</td>
<td>Inconel 718 (seam welded to bellow)</td>
<td>29,400,000</td>
<td>0.29</td>
<td>145,000</td>
<td>180,000</td>
<td>15%</td>
<td>0.297</td>
<td>70°: 12.8, -130°: 6.2, -417°: 4.8</td>
</tr>
<tr>
<td>Bellow</td>
<td>Inconel 718 (3 ply welded together)</td>
<td>29,400,000 (3,396,000)</td>
<td>0.29</td>
<td>145,000</td>
<td>180,000</td>
<td>15%</td>
<td>0.297</td>
<td>70°: 12.8, -130°: 6.2, -417°: 4.8</td>
</tr>
</tbody>
</table>
GH2 Vent Interface – Analysis Tool

One-Piece Seal (Previous Design)

Two-Piece Seal (Current Design)
GH2 Vent Interface – Analysis Tool

(BELLOWS PROBE GROUND SECTION) ET SECTION

OLD ET SEAL

OLD SEAL RETAINER

(WAS) ONE-PIECE SEAL

NEW ET SEAL (JACKET/SPRING)

NEW SEAL RETAINER

(NOW) TWO-PIECE SEAL
GH2 Vent Interface – Analysis Tool

Contact Normal Force

Contact Normal Stress

1pc-Seal (1.06", 524 lb)

2pc-Seal (1.06", 359 lb)

2pc-Seal (1.12", 539 lb)
Figure 6.3.5.0. Effect of temperature on the physical properties of Inconel 718.
GH2 Vent Interface – Analysis Tool

**2219 Aluminum Alloy**

-\( \alpha \) - Between 70 °F and indicated temperature
- \( K \) - At indicated temperature
- \( C \) - At indicated temperature

**6061 Aluminum Alloy**

-\( \alpha \) - Between 70 °F and indicated temperature
- \( K \) - At indicated temperature
- \( C \) - At indicated temperature
GH2 Vent Interface – New Seal Development

Proposed Seal Design #1 – Pressurized “V”
GH2 Vent Interface – New Seal Development

Proposed Seal Design # 2 – Raised Radius
GH2 Vent Interface – New Seal Development

Proposed Seal Design #1 – SSP One Piece Chamfer
GH2 Vent Interface – New Seal Testing

Existing Equipment:
• SSP Carrier Plate
• SSP QD (Stiff / Weak Spring Rate)
• QD Hardware (inc. QD/GUCP spacers)
• QD Pressure Test Fixture
• ET Test Fixture
• Pressure Panel
• Cryogenic Testing Hardware
GH2 Vent Interface – New Seal Testing

Preliminary Discussion have happened with SLS (Boeing) Core (Boeing) and full briefing during TIM (April 10-12)