

# Product Testing Report

## HR1 Getter Test and Data Analysis update

Version 1.1

Date: 15 December, 2020

By:

Dr. H. Xia – Chief Scientist

D. DeWire – VP Business Development

Hermetic Solutions Group, LLC

## Version History

This report is intended to provide an up to date test and data analysis of the performance of Hermetic Solutions Group's Hydrogen Getter product titled HR1, a Palladium Foil based getter for use in hydrogen gettering applications in hermetically sealed electronic packages and/or microelectronic enclosures.

HR1 Version History					
Version #	Implemented by	Revision Date	Approved By	Approval Date	Reason
1.0	D. DeWire	7 Oct, 2020	Hua Xia	9 Oct. 2020	Initial Release
1.1	D. DeWire	15 Dec, 2020	Hua Xia	15 Dec, 2020	Release for Publication

**HR1 Getter Test and Data Analysis update**

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## **HR1 Getter Test and Data Analysis update**

### **1.0 Introduction:**

#### **1.1 Purpose:**

This project was implemented to provide our customer base with greater detail on the efficacy of our HR1 Hydrogen gettering system. This novel system consists of the use of a pure Palladium foil attached to the inside of a hermetic enclosure. The use of this novel system allows for the capture or removal of hydrogen gas that is typically outgassed from the constituents and components of and within the hermetic enclosure.

### **2.0 Test Results Summary:**

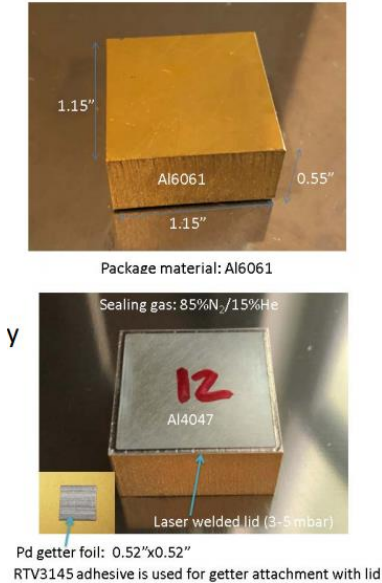
- RGA Analysis - **PASS**
- Thermal Cycling - **PASS**
- Random Vibration Testing - **PASS**
- Mechanical Shock – **PASS**

### **3.0 Test Elements, Overview and Analysis**

#### **3.1 RGA Analysis**

##### **Test Elements:**

- Test housings parts were prepared (6061 Aluminum) to ~10cc volume
- Test Lids were prepared (4047 Aluminum)
- HR1 preforms were built using Pd foils 0.5"x0.5"x.004" (100µm)
- 4 Epoxy materials were ordered for the test
- Test Housings and lids were plated with Electrolytic Sulphamate Nickel and Gold on all surfaces
  - With the exception of the lid to housing weld/ seal area and the outside top of the lid (see pictures **FIG 1** below).
- Packages laser sealed using a standard cover gas of 90%N<sub>2</sub> and 10% He



**FIG 1.**



**FIG 2.**

### 3.1 (cont.) RGA Testing Overview

RGA Test was performed to evaluate worst case assembly/ build test scenario. Epoxy systems and test housings were NOT baked out prior to welding of the Aluminum Lid to the Aluminum housing. Bake in occurred AFTER the lid was attached to the housing with the HR1 getter inside. Parts were baked at 125C for 168 hours to produce H<sub>2</sub> and moisture within the sealed hermetic enclosure. **FIG 2 above.**

**3.1 RGA Test Results:** Tests indicate substantive reduction of H<sub>2</sub> in packages containing the HR1 getter, where all control packages (packages sealed without getters showed significantly high levels of H<sub>2</sub>. **See Fig. 3 below. Note: Samples 2, and 9 are CONTROL.**

### Internal Vapor Analysis - Test Report

ORS Report: 252554-001  
Date Tested: 04 Aug 2020  
Manufacturer: HERMETIC SOLUTIONS GROUP  
Package Type: PLATING SAMPLE  
Device Type: UNKNOWN  
Part No.: UNKNOWN  
Lot/Date Code: UNKNOWN/UNKNOWN  
Qty. Tested: 6  
P.O. /Release No.:601464

Dr. Hua Xia  
Hermetic Solutions Group  
6934 Kinsmen Court  
Niagara Falls, L2H 0Y5  
Canada

SAMPLE ID		1	2	3	4	5	9
Inlet Pressure	torr	N/A	N/A	N/A	N/A	N/A	N/A
Sys. Pressure	torr	1.2e-4	2.4e-5	2.5e-5	2.5e-5	3.0e-5	2.4e-5
Sample Temp.	°C	99.7	99.5	99.5	99.5	99.5	99.5
Volume	atm cc	>20	>20	>20	>20	>20	>20
Nitrogen	ppmv	895,874	904,655	899,319	896,630	899,066	898,586
Oxygen	ppmv	ND	ND	ND	ND	ND	ND
Argon	ppmv	160	149	160	163	162	151
Carbon Dioxide	ppmv	168	98	148	173	213	260
Moisture	ppmv	4,031	650	3,661	4,812	4,129	1,342
Hydrogen	ppmv	228	1,421	147	174	130	1,609
Methane	ppmv	ND	ND	ND	ND	ND	ND
Ammonia	ppmv	ND	ND	ND	ND	ND	ND
Helium	ppmv	98,925	93,027	96,398	97,854	96,142	98,052
Fluorocarbon	ppmv	ND	ND	ND	ND	ND	ND
UNKNOWN	ppmv	244	ND	167	194	158	ND
Methanol	ppmv	369	ND	ND	ND	ND	ND

Tested by: A. Sandoval    Package Thinned: Yes    Future #: N/A    ND: None Detected    1 %v = 10,000 ppmv

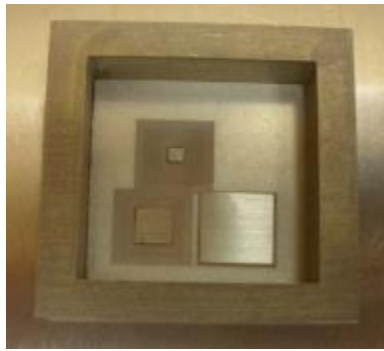
Procedure	ORS SOP MEL-1053 "Internal Vapor Analysis"
Prebake	No prebake performed. Test at 100°C.
Test System	HR-IVA® 210s System 6 (EQ-D11-005)
Comments	UNKNOWN: Unidentified organic compound(s). Additional analysis by IVA/GC/MS may be necessary to identify the unknown organic(s).

**FIG 3.**

### 3.2 Thermal Cycling Testing

#### Test Elements:

- Aluminum Test Rings Al6061 - 5 pieces each of 2.0" sq. and 4.5" sq. **(FIG 4)**
- Aluminum Test Lids AL4047 - 5 pieces each of 1.5" sq. and 4.0" sq. **(FIG 4)**
- HR1 preforms were built using rolled Pd foils 0.5"x0.5"x.004" (100µm)
- 4 Epoxy materials **(Figure 5)**
- Test Lids were prepared with Chem Film and later ablated in areas decided for getter attach.
- Laser Welding of Lids to Ring post getter attach to lids.



**FIG 4**

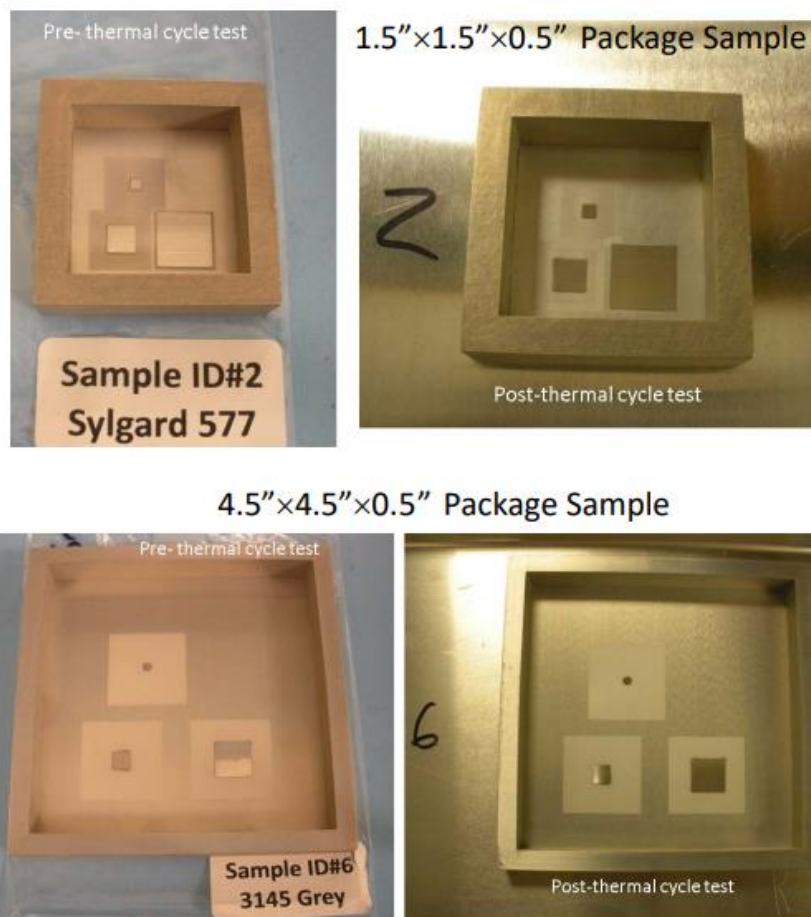
<p><b><u>LOCTITE ABLESTIK 286 Adhesive</u></b></p> <ul style="list-style-type: none"> <li>- Low-temperature: -55°C (-67°F)</li> <li>- High-temperature: 105°C (221°F)</li> <li>- Tap shear strength: 2200 psi</li> </ul>	<p><b><u>Supreme 12AOHT-LO Adhesive</u></b></p> <ul style="list-style-type: none"> <li>- Fully meets ASTM E595 for low outgassing</li> <li>- Low-temperature: 4K</li> <li>- High-temperature: 260°C (500°F)</li> <li>- High tap shear strength: 3400-3600 psi</li> </ul>
<p><b><u>Sylgard® 577 Adhesive</u></b></p> <ul style="list-style-type: none"> <li>- MIL-PRF-23586F tested</li> <li>- Low-temperature: -45°C (-49°F)</li> <li>- High-temperature: 200°C (392°F)</li> <li>- Tap shear strength: 984 psi</li> </ul>	<p><b><u>Dow Corning RTV3145 Grey Adhesive</u></b></p> <ul style="list-style-type: none"> <li>- MIL-A-46146 tested</li> <li>- Low-temperature: -45°C (-49°F)</li> <li>- High-temperature: 200°C (392°F)</li> <li>- Tap shear strength: 1035 psi</li> </ul>

**FIG 5**

### 3.2 Thermal Cycling Testing Results

All 1.5" and 4" square lid assemblies, welded to 2.0" sq. and 4.5" sq. rings, built using the 4 test epoxy materials were subjected to Thermal Cycling conditions according to MIL-STD-883-1 Condition 1010.9. Parts were tested at -55 to +125C for 110 cycles using a 15 minute dwell. All parts subjected to the test passed with no visual damage observed. **FIG's 6 and 7**

#### Pre and Post Pictures from Package Samples



**FIG 6**



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## CERTIFICATE OF TEST



**CERTIFICATE NUMBER:** 253617-001

**CLIENT:** Hua Xia, Ph. D  
Hermetic Solutions Group  
434 Olds Station Road  
Wenatchee, WA 98801

**TEST:** Temperature Cycle - (ATA) DLA Suitability

**REFERENCE:**  
MIL-STD-883-1  
Method 1010.9

**PURCHASE ORDER:** 601638

**ISSUED:** 09/14/2020

**RECEIVED:** 09/11/2020

**TEST START:** 09/11/2020

**COMPLETION:** 09/14/2020

**MFR:** Hermetic solutions group

**PART NO.** Various

**DATE CODE:** Unknown

**DEVICE TYPE:** Getter

**PACKAGE TYPE:** Epoxy attached getter

**LOT NUMBER:** Various

### CONDITIONS:

- Condition B: -55 to +125C, 110 cycles, 15 minute dwells

### EQUIPMENT USED:

- ESPEC, Temp Cycle Chamber Model ETS04 (SC0979); cal due 01/15/2021

- Keysight, DLOG2 Data Acquisition System Model DAQ970A (SC1204); cal due 03/06/2021

### SERIAL NUMBERS:

- 2 - Sylgard 577, 1.5"x1.5"
- 4 - Sylgard 577, 4"x4"
- 5 - RTV 3145 Gray, 1.5"x1.5"
- 6 - RTV 3145 Gray, 4"x4"
- 7 - Supreme 12AOHT-LO, 1.5"x1.5"
- 8 - Supreme 12AOHT-LO, 4"x4"
- 9 - Ablestik 286 WH PTA, 1.5"x1.5"
- 10 - Ablestik 286 WH PTA, 4"x4", one getter detached prior to receipt.

### RESULTS:

No visual damage observed as a result of the above test.  
Pre and post pictures sent to the customer.

This document certifies that these devices have completed the test as shown.

Charles Cobuzza  
Manager

FIG 7

### 3.3 Random Vibration Testing Overview

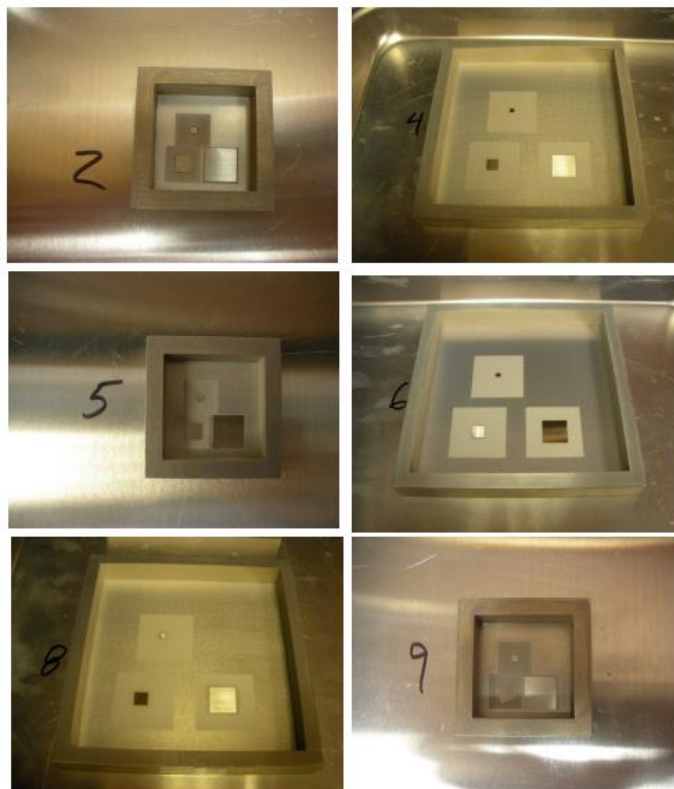
Test Elements:

- Aluminum Test Rings AL6061 - 5 pieces each of 2.0" sq. and 4.5" sq. (**FIG 6**)
  - Assemblies used in 2.2 Thermal Testing
- Aluminum Test Lids AL4047 - 5 pieces each of 1.5" sq. and 4" sq. (**FIG 6**)
  - Assemblies used in 2.2 Thermal Testing

### 3.3 Random Vibration Testing Results

All 1.5" and 4" square lid assemblies, welded to 2.0" sq and 4.5" sq. rings, used in the Thermal Cycling tests conducted and reported on in section 2.2 were subjected to Vibration testing conditions according to MIL-STD-883-2, Method 2026, Conditions B and F. Parts were subjected to Vibrations of 50 – 2000 Hz in 3 Axis' at 15 minutes per Axis. No Visual damage was observed as a result of the above test. **FIG's 8 and 9**

#### Post Package Samples after Vibration Tests



**FIG 8**

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### CERTIFICATE OF TEST



**CERTIFICATE NUMBER:** 253854-003

**CLIENT:** Hua Xia, Ph. D  
Hermetic Solutions Group  
434 Olds Station Road  
Wenatchee, WA 98801

**TEST:** Random Vibration - DLA

**REFERENCE:**  
MIL-STD-883-2  
Method 2026  
Table I

**PURCHASE ORDER:** 601696

**ISSUED:** 09/24/2020

**RECEIVED:** 09/21/2020

**TEST START:** 09/21/2020

**COMPLETION:** 09/23/2020

**MFR:** Hermetic solutions group

**PART NO.** Various

**DATE CODE:** Unknown

**DEVICE TYPE:** Getter

**PACKAGE TYPE:** Epoxy attached getter

**LOT NUMBER:** Various

#### CONDITIONS:

- Condition F: Psd = 0.3, 20 Grms, 50-2000 Hz
- 3 axes, 15 minutes per axis

#### EQUIPMENT USED:

- Ling Dynamics Systems, LTD Air Cooled Vibrator Model 721 (SC0709)
- PCB, Accelerometer Model 353B03 (SC1142); cal due 04/07/2021
- LDS, Power Supply Model FP-10L (SC0715)
- PCB, Accelerometer Model 353B03 (SC1151); cal due 05/06/2021
- LDS, Dactron Comet Shaker Control System Model COM-200 (SC1041); cal due 02/11/2021
- LDS, Power Amplifier Model PA-1000L (SC0716)

#### SERIAL NUMBERS:

- 4 - Sylgard 577, 4"x4"
- 5 - RTV 3145 Gray, 1.5"x1.5"
- 6 - RTV 3145 Gray, 4"x4"
- 7 - Supreme 12AOHT-LO, 1.5"x1.5"
- 8 - Supreme 12AOHT-LO, 4"x4"
- 9 - Ablestik 286 WH PTA, 1.5"x1.5"
- 10 - Ablestik 286 WH PTA, 4"x4", one getter detached prior to receipt.

#### RESULTS:

No visual damage observed as a result of the above test.  
Pre and post pictures and plots sent to the customer.

This document certifies that these devices have completed the test as shown.

Charles Cocuzza  
Manager

FIG 9

### 3.4 Mechanical Shock Testing Overview

Test Elements:

- Aluminum Test Rings AL6061 - 5 pieces each of 2.0" sq. and 4.5" sq. **(FIG 8)**
  - Assemblies used in 2.2, 2.3 Thermal and Vibration Testing
- Aluminum Test Lids AL4047 - 5 pieces each of 1.5" sq. and 4" sq. **(FIG 8)**
  - Assemblies used in 2.2, 2.3 Thermal and Vibration Testing

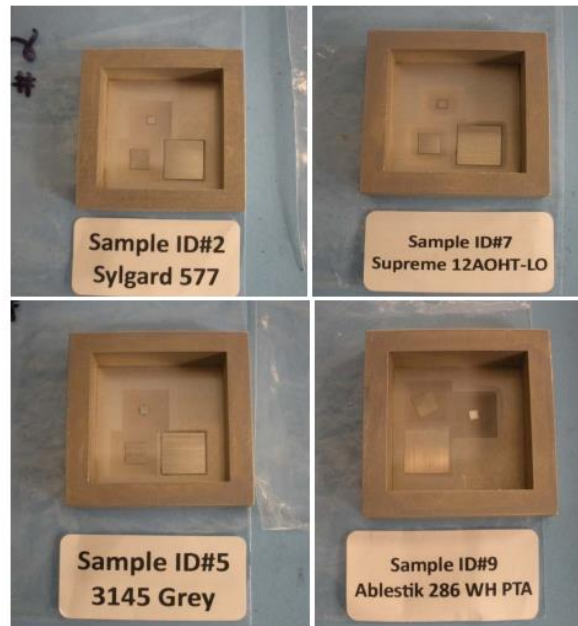
### 3.4 Mechanical Shock Testing Results

All 1.5" and 4" square lid assemblies, welded to 2.0"sq and 4.5" sq. rings, used in the Thermal Cycling and Vibration tests conducted and reported on in sections 2.2 and 2.3 were subjected to Mechanical Shock testing conditions according to MIL-STD-883-2, Method 2002.5, Condition B. Parts were subjected to two test conditions as follows with 5 drops in each of 6 directions:

<u>Test condition</u>	<u>g level (peak)</u>	<u>Duration of pulse (ms)</u>
A	500	1.0
B	1,500	0.5

No Visual damage was observed as a result of the above test. **FIG's 10 and 11**

### 4 Adhesives Attached HR1 Getter with Al-alloy lid post thermal, vibration and mechanical shock tests



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FIG 10




 4201 Pottsville Pike, Reading, PA 19605 1 855 ORS-LABS • www.orslabs.com		<b>CERTIFICATE OF TEST</b>		 CERT #2910.01	
<b>CERTIFICATE NUMBER:</b> 254074-001		<b>PURCHASE ORDER:</b> 601740			
<b>CLIENT:</b> Hua Xia, Ph. D Hermetic Solutions Group 434 Olds Station Road Wenatchee, WA 98801		<b>ISSUED:</b> 09/30/2020 <b>RECEIVED:</b> 09/29/2020 <b>TEST START:</b> 09/29/2020 <b>COMPLETION:</b> 09/30/2020 <b>MFR:</b> Hermetic Solutions Group <b>PART NO.</b> Various <b>DATE CODE:</b> Unknown <b>DEVICE TYPE:</b> Getter <b>PACKAGE TYPE:</b> Epoxy Attached Getter <b>LOT NUMBER:</b> Various			
<b>TEST:</b> Mechanical Shock - DLA					
<b>REFERENCE:</b> MIL-STD-883-2 Method 2002.5					
<b>CONDITIONS:</b> - Condition B: 1500G, 0.5ms Half-sine, 5 drops in each of 6 directions					
<b>EQUIPMENT USED:</b> - Endevco, Signal Conditioner Model 133 (SC0237); cal due 07/28/2021 - Lansmont Corp., Shock Test System Model 23 (SC0748) - Tektronix, Oscilloscope Model 794D (SC0907); cal due 07/30/2021 - ENDEVCO, Piezo. Accelerometer Model 2225 (SC1212); cal due 04/29/2022					
<b>SERIAL NUMBERS:</b> 2 - Sylgard 577, 1.5"x1.5" 4 - Sylgard 577, 4"x4" 5 - RTV 3145 Gray, 1.5"x1.5" 6 - RTV 3145 Gray, 4"x4" 7 - Supreme 12AOHT-LO, 1.5"x1.5" 8 - Supreme 12AOHT-LO, 4"x4" 9 - Ablestik 286 WH PTA, 1.5"x1.5" 10 - Ablestik 286 WH PTA, 4"x4", one getter detached prior to receipt					
<b>RESULTS:</b> No visual damage observed as a result of the above test.					
This document certifies that these devices have completed the test as shown.					
 Charles Cocuzza Manager					
254074-001 This test certificate shall not be reproduced except in full without the written approval of Oneida Research Services, Inc. Page 1/1					

FIG 11

## 4.0 Acknowledgements

Hermetic Solutions Group would like to thank several of our Business units without whose contributions this effort could not have been possible. Specifically:

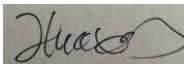
- Hi-Rel Alloys
- Hi-Rel Products
- And the Litron Division

Hermetic Solutions Group would also like to thank **Oneida Research Services, Inc.** for their recommendations, expert analysis and contributions to this product qualification effort.



## Appendix A: Test Report Approval

The undersigned acknowledge they have reviewed the HR1 Test Report and agree with the approach and results it presents. Changes to this test report will be coordinated with and be approved by the undersigned or their designated representatives.

Signature: \_\_\_\_\_  \_\_\_\_\_

Print Name: \_\_\_\_\_ Hua Xia \_\_\_\_\_

Title: \_\_\_\_\_ Chief Scientist \_\_\_\_\_

Role: \_\_\_\_\_ R&D for Global Business Development \_\_\_\_\_

Date: \_\_\_\_\_ 15 December, 2020 \_\_\_\_\_

## Appendix B: Figures

Figure	Courtesy of	Description
1	Litron Corp	Image of plated and weld/ sealed packages for RGA testing
2	Dr. H. Xia	Image of HR1 getter attached to plated lid and RGA tested packages with punctured lids
3	ORS	RGA Test analysis of internal vapors present in enclosed packages
4	ORS	Welded Rings and Lids with Epoxy attached HR1 getter material (Note Chem coat removal in areas of epoxy/ getter attach)
5	Dr. H. Xia	Overview of Epoxy materials used in the study
6	ORS	Images of rings and lids with getter attached prior to and post Thermal Cycle Testing
7	ORS	Certificate of Test indicating results of Thermal Cycle Testing
8	ORS	Images of rings and lids with getter attached prior to and post Vibration testing
9	ORS	Certificate of Test indicating results of Random Vibration testing
10	ORS	Images of Rings and Lids with getter attached prior to and post Mechanical Shock Testing
11	ORS	Certificate of Test indicating results of Mechanical Shock Testing



**Appendix B: Key Terms**

<b>Term</b>	<b>Definition</b>
HR1	Hydrogen Getter element consisting of rolled, stamped pure Palladium foils of various form factors
Chem Film	The process of coating aluminum materials to protect the Aluminum from corrosion. Sometimes called Alodine or Iridite.
Ablate	To remove the Chem Film from specific areas of the coated aluminum materials. Used to enhance adhesion of epoxies to the base aluminum.