SOLAR ORBITER ENERGETIC PARTICLE DETECTOR

MLI Standoff Bonding Qualification Test Procedure

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Written	Checked	Approved configuration control	Approved QA	Approved Experiment Manager	Approved Principal Investigator
M.L.Richards	Cesar Martin	Cesar Martin	W.Boogaerts		
Signature and date	Signature and date	Signature and date	Signature and date	Signature and date	Signature and date

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DISTRIBUTION LIST

The following list indicates the individuals and agencies in receipt of review copies of the present document:

Agency / Organization	Name & Title	Contact information
SRG-UAH	Javier Rodriquez-Pacheco EPD-Principal Investigator	javier.pacheco@uah.es
SRG-UAH	Manuel Prieto, EPD Project Manager	manuel.prieto@uah.es
SRG-UAH	Teresa Isabel Varela Jeraldo EPD Configuration Control Responsible	teresa.varela@uah.es
CAU	Michael Richards Walter Boogaerts EPD Kiel PA/QA	mlr@richards-consulting.eu WBoogaerts@gmx.net
CAU	EPD-Solar Orbiter Kiel Team	solo_kiel@physik.uni-kiel.de

CHANGE RECORD

Issue	Revision	Date	Modified by	Section / Paragraph modified	Change implemented
1	0	2017-10-13	M.L.Richards	All	First draft
1	1	2018-01-19	M.L.Richards W.Boogaerts Kiel team	This page 1 4 8 9	Changed dist. list Add fig 1 Change number of sample types Removed tables, added step-by-step Added test result section
1	2	2018-02-15	M L Richards		TRR related changes and additions

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1 INTRODUCTION

1.1 Purpose

This procedure is to qualify the Kiel bonding process for MLI standoffs as used for the Solar Orbiter EPD. It is in response to Action #8 of SO.SC.ASTR.NCR/00700 in NRB#3:

"…EPD team to update the RFA to explicitly state the full coverage including metal to metal bonding and coupon level test planning…" [AD3].

This procedure follows the specification for a standoff rupture test as outlined in [AD1]. The RFA referred to is SO-EPD-KIE-RA-0002 [AD2].

Further background can be found in §3 of [AD5], the report of MLI standoff bonding test on EPT-HET PQM.

1.2 Scope

This procedure is for the Kiel MLI Standoff bonding process.

It comprises test coupon manufacture and inspection, workmanship test, TVAC cycling and rupture test. Testing in pull and shear is performed on representative sample and interface types.

Following ESA comments (AD-08) on the Kiel plan and internal discussions (2017-12-20), it was agreed to keep a baseline set of samples that would not be thermally cycled. The general plan is outlined here in Figure 1.

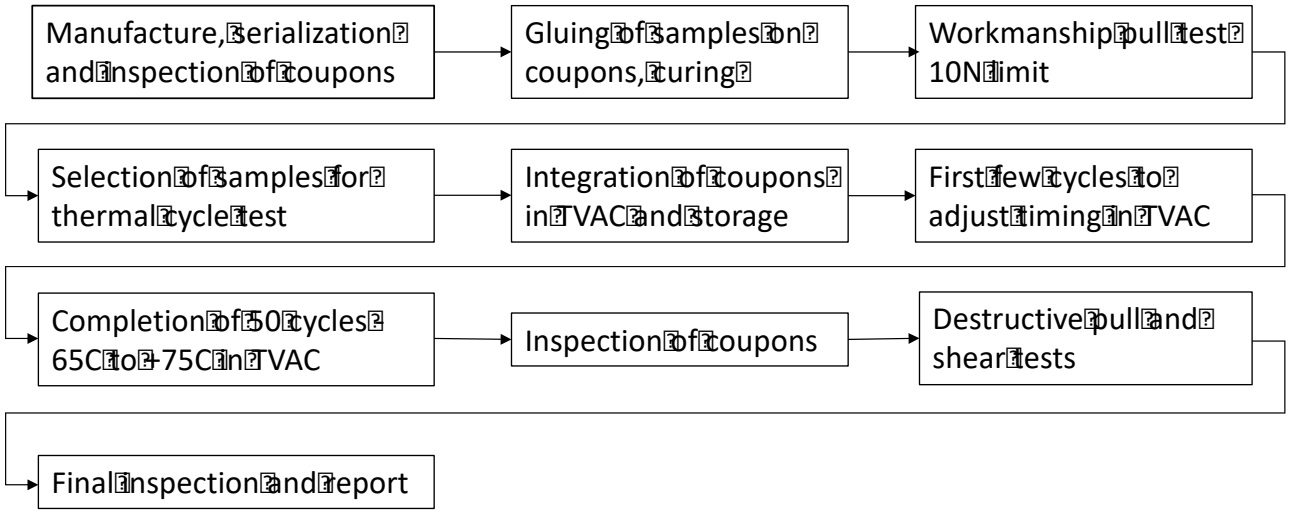

Figure 1 Test flow diagram

The EPD Kiel procedure [AD4] describes the preparation of 3M Scotch Weld 2216 B/A, its use in staking wires to a PCB surface or aluminum electronics box, and the curing. Preparation of the surface is by cleaning with Isopropanol.

This method of surface preparation has been used for bonding all MLI standoffs to the EPD flight units EPT-HET1, EPT-HET2 and STEP. However, the method is not recommended in either the Scotch Weld data sheet [ND2] or the ECSS standard [ND1] and is to be qualified by this coupon test specifically for these EPD flight units.

1.3 Response to ESA comments to test plan

ESA comments on the Kiel plan (AD-08) have been discussed (2017-12-20) and implemented in this revision.

First, the number of types of sample to be tested has been reduced from the total number as listed, e.g., in [AD05]. These are described and listed in section 4, together with the coupon layout.

Second, in the Kiel plan some changes were made to the thermal cycling parameters with respect to the ESA specification. The justifications for number of cycles and lower temperature limit are summarized in the following paragraphs.

Reduction from 100 thermal cycles to 50 has been made with the argument that the flight units are expected to experience less than 40 cycles during environmental testing and in-flight orbital environmental changes. These include:

ON-GROUND cycles

6 during instrument acceptance testing

3 during S/C level tests

IN-FLIGHT cycles (orbits)

4 during phases LEOP + NECP + CP

8 during nominal phase

8 during extended phase

10 during type 1 maneuvers (K. Wirth, 2018-02-12)

The number of S/C environmental cycles and IN-FLIGHT orbits may be subject to change, but it is expected the total will be about 40 cycles. Then, the 50 cycles proposed would provide a margin of 20%.

The change of temperature range at the lower point from -75C to -65C is based on the best estimate for efficient operation of the TVAC system. In addition, thermal analysis shows the coldest housing parts of EPT-HET 1&2 to be HET housing during cold NonOp cold phase to be -47degC [SO-EPD-KIE-RP-0039_iss3_rev1]. For STEP the coldest housing part would be the Ebox Ti cover during CNOC at -61degC [SO-EPD-KIE-RP-31_iss4_rev1]. An acceptance margin of -5degC would require testing to -66C, which is possible for the TVAC system.

Third, for each type of sample, one reference coupon with ten samples will be produced extra to, but identically with, the test coupons. These will undergo the workmanship pull test and then be put in ISO class 8 storage while the test samples are in TVAC. The reference coupons will be available for later destructive testing if necessary.

2 GLOSARY AND DEFINITIONS

2.1 Acronyms and Abbreviations

CIDL	Configuration Item Data List
CIL	Critical Item List
DCL	Declared Components List
DML	Declared Materials List
DMPL	Declared Mechanical Parts List

DPL	Declared Processes List
EICD	Experiment I/F Control Document
EPD	Energetic Particles Detector
EPT	Electron, Proton Telescope
FM	Flight Model
HET	High Energy Telescope
MOC	Molecular Contamination
NA	Not Applicable / No applicable
NR	Normative Requirement
PA	Product Assurance
PAC	Particulate Contamination
QA	Quality Assurance
RfA	Request for Acceptance
RfD	Request for Deviation

3 REFERENCE DOCUMENTS

3.1 Applicable Documents

ID.	Title	Reference	Iss./Rev.	Date
AD-01	Standoff Rupture Test Outline	Email Kristin Wirth		2017-06-23
AD-02	Use of EPO-TEK H20E and Scotch Weld B/A Grey	SO-EPD-KIE-RA-0002		2017-06-01
AD-03	Summary NRB#3, SOL.SC.ASTR.NCR/00700	Email Andrew Ewbank		2017-05-30
AD-04	EPT-HET & STEP FM/FS Application Procedure of 3M Scotch Weld 2216 B/A	SO-EPD-KIE-PR-0027	1 / 0	2015-11-26
AD-05	EPT-HET PQM MLI Stand-off Bond-strength Test-Report	SO-EPD-KIE-TR-0044	1 / 1	2017-07-07
AD-06	MLI standoff bonding EPT-HET and STEP instruments	SO-EPD-KIE-PR-0045	1 / 1	2015-03-01
AD-07	EPT-HET PQM MLI Stand-off Bond Strength Test Plan and Procedure	SO-EPD-KIE-TP-0060	1 / 1	2017-06-22
AD-08	MLI Standoff Rupture Test Re-Plan	Email Kristin Wirth		2017-12-11
AD-09	EPD Instrument MLI standoff bond integrity check - test specification	SOL-SP-ADSS-1000264089	1	

Table 1 Applicable documents

3.2 Normative documents

ID.	Title	Reference	Iss. / Rev.	Date
ND-01	Space engineering: Adhesive bonding handbook	ECSS-E-HB-32-21A	A	2011-03-20
ND-02	3M Scotch Weld Epoxy Adhesive 2216 Technical data		C	2009-Dec
ND-03	Space product assurance: Thermal testing for the evaluation of space materials, processes, mechanical parts and assemblies	ECSS-Q-ST-70-04	C	2008-11-15

Table 2 Normative documents

4 TEST COUPONS

The following paragraphs summarize the selection of standoff types and bonding interface types to be used in coupon manufacture, and how they relate to the implementation on the flight units.

4.1 Coupon

Each coupon comprises an aluminum substrate with samples bonded to it.

Surface treatment of the substrate is Iridite, the same as for the EPD FM units.

Sample number per coupon is 10.

Bracket samples are surface treated with Iridite.

The bonding method is [AD4] as extended in [AD6], with a curing time of 1 week at room temperature, in class 8 clean room.

4.2 Bonding types as implemented on flight units

Two kinds of bonding interface are to be tested, Vespel to aluminum and aluminum to aluminum. In the RFA [AD2, Annex E] these are termed Type A where the samples are Vespel standoffs, and Type B where the samples are aluminum brackets.

4.2.1 Nominal sample types

The Vespel standoffs are of two nominal sizes, with circular base diameters of 10mm or 15mm, called “Simple-short” and “Simple” in [AD5]. In [AD5] the standoff types are listed for EPT-HET PQM (Fig 7) and STEP PQM (Fig 9).

The brackets are of three nominal sizes, with contact areas 10x15mm^2 (Normal A), 10x10mm^2 (Normal B) and 10x2mm^2 (Small).

4.2.2 Off-nominal sample types

In addition to the standard sizes of standoff, some were clipped for awkward fastening locations. And, in addition to the nominal bracket sizes, one Normal A size was bonded over a slot in the instrument frame.

4.2.3 Selected types for bonding test

Following ESA comments on the Kiel plan (AD-08) and internal discussions (2017-12-20), the types of sample have been reduced from the above nominal types to the set listed in Table 3, eliminating the larger bonding areas. It is stressed that these include worst case geometries, small standoff base, clipped standoff base, narrow and bridging aluminium/aluminium bonding contacts.

I/F Type	Size mm	Bonding area mm^2	Materials
A	10	78	Vespel to aluminum
B	10x10	100	aluminum to aluminum
B	10x4	40	aluminum to aluminum

Table 3 Nominal sample types

Off-nominal types have been reduced to the set listed in Table 4.

I/F Type	Size mm	Bonding area mm^2	Materials
A	10, clipped	48 (approx)	Vespel to aluminum
B	10x15, bridging	90 (approx)	aluminum to aluminum

Table 4 Off-nominal sample types

4.3 Reference samples

Following ESA comments on the Kiel plan (AD-08) and internal discussions (2017-12-20), it was agreed to include additional coupons, one for each of the types, nominal and off-nominal. That makes a total of five coupons, with ten samples each.

These reference samples would follow all steps in the procedure (i.e., Figure 1) except the TVAC test.

4.4 Sample and Coupon count

There will be two coupons for each type listed in the tables above, one for pull tests and one for shear tests. In addition, there will be one coupon per type for reference samples, making a total of 15 coupons.

The table below provides a cross reference between the sample tables and coupon integration for TVAC or reference, including serialization and coupon/sample coding.

Both sample and coupon shall be marked for serialization, the samples serially 1 through 150, and the coupons with the 15 sample types as specified in the third column of Table 5.

Test result sheets are provided in §9.

Coupon	Code	Sample type	Serial numbers	Glued (date)	10Nm test (date)	Pull/Shear	Rupture (date)
1		A-10	1, …, 10			Pull	

2		A-10	11, …, 20			Shear	
3		B-100	21, …, 30			Pull	
4		B-100	31, …, 40			Shear	
5		B-40	41, …, 50			Pull	
6		B-40	51, …, 60			Shear	
7		A-10-c	61, …, 70			Pull	
8		A-10-c	71, …, 80			Shear	
9		B-150-b	81, …, 90			Pull	
10		B-150-b	91, …, 100			Shear	
11		A-10-r	101, …, 110			As needed	
12		B-100-r	111, …, 120			As needed	
13		B-40-r	121, …, 130			As needed	
14		A-10-cr	131, …, 140			As needed	
15		B-150-br	141, …, 150			As needed	

Table 5 Coupon definition

4.5 **TVAC setup (out of date)**

Several geometries are under consideration. The photo Figure 2 shows the setup for a pretest run of one cycle for one horizontal and two vertical coupons. Each had two PT1000 attached. One vertical coupon had thermal filler at the base plate interface, the other not.

For the horizontal layout, a limitation is the diameter of the base plate (245mm), and therefore the number of coupons that can be placed side-by-side per run.

For the vertical layout, a constraint is the time delay of the limiting temperature at the upper PT1000 with respect to the lower PT1000. The thermal filler had no effect.

The complete cycle required 193 minutes for the vertical coupon without filler (191min with), and 183 minutes for the horizontal coupon. Dwell times were three minutes at -65°C and +75°C, with temperature stability of <1°C/h.

In the vertical layout, the test would require 6 days 16 hours and 50 minutes, and with a more conservative additional 20 minutes at dwell the test would require 8 days 2 hours and 10 minutes.

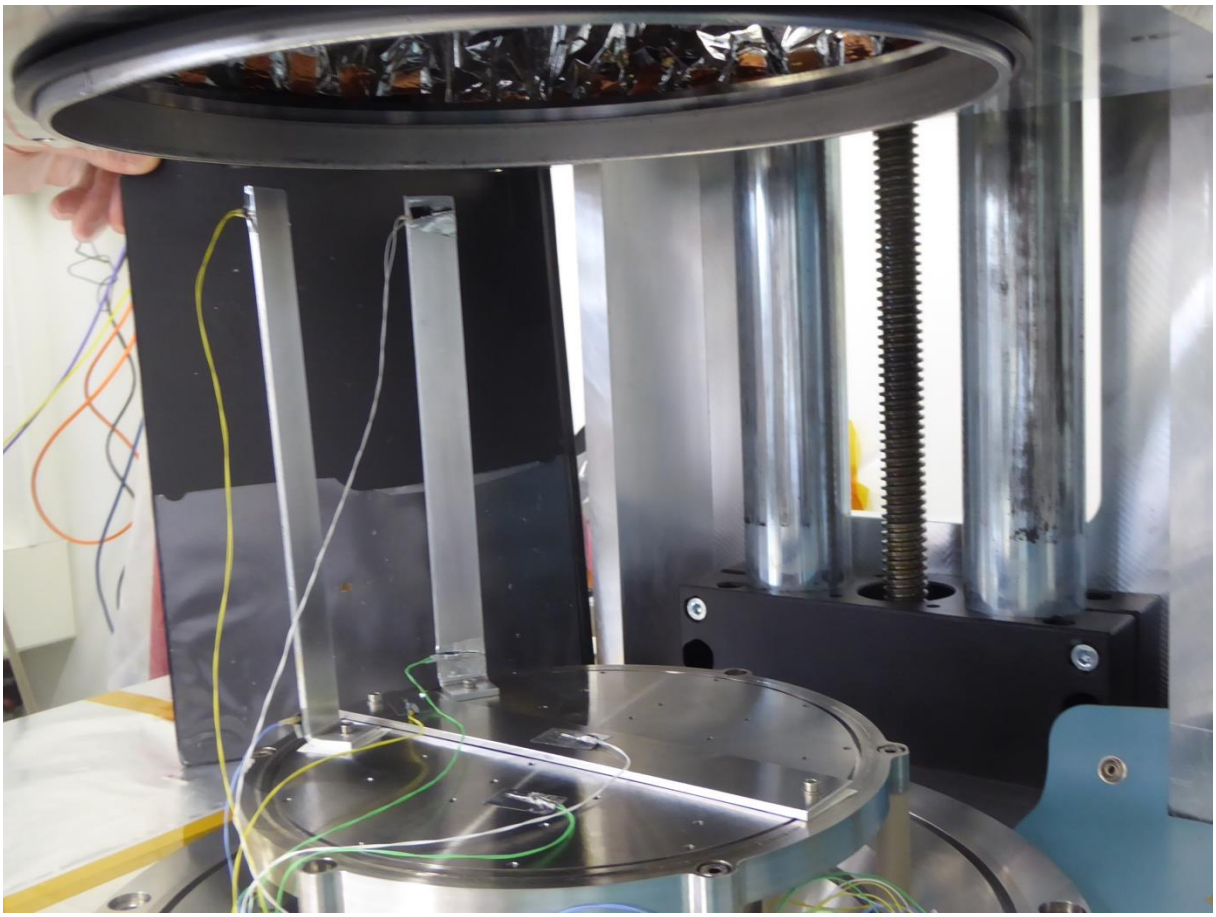

Figure 2 Coupon setup on TVAC baseplate

The geometry will be fit checked prior to testing.

5 TEST SEQUENCE

5.1 Overall view of sequence

The MLI standoff bonding test shall follow the steps specified in [AD1] and illustrated in Figure 1:

1. Preparation of coupons, including serialisation
2. After one week curing interval, workmanship test of each sample with pull of 10N for 10s
3. Visual inspection of each bonding joint and conformity with Table 5
4. TVAC test, 50cycles, (-65C±5) °C to (+75±5) °C, at 5 °C per minute (maximum), vacuum 10^{-7} bar
5. Visual inspection for bonding cracking, with photos
6. Rupture test, recording final force at rupture and with photos

5.2 Acceptance criteria:

Step 3, samples remain bonded and there are no cracks

Step 5, all bonds intact, no cracks

Step 6, final rupture force > 10N, and if not ruptured, up to a maximum of 20N without cracks; for selected aluminium/aluminium bonds the test will go to rupture or the facility maximum (450N)

6 TEST FACILITY

The gluing and curing will be performed in CAU/IEAP clean room which is ISO class 8.

The workmanship pull test will be performed with the CAU equipment of [AD6] with appropriate setup of the force gauge system. Alternatively, a smaller, hand-held gauge may be acquired.

The TVAC test will be performed in the same chamber as used for EPD bake-out and for qualification and acceptance testing. The chamber is in ISO class 8 clean room, and the facility provides for temperature and pressure monitor. TQCM will not be used.

The rupture test will be made with the CAU equipment used for EPT-HET PQM pull test [AD6], in the same clean room as TVAC, workmanship and gluing activities.

7 DOCUMENTATION AND QA

This procedure shall provide the as-run report of inspection results and rupture data. Photos will be provided separately. TVAC temperature and pressure recordings will be attached to the as-run procedure.

Comments such as deviations from procedure shall be noted in the as-run procedure

There shall be QA participation at inspections, pull and shear tests.

Failed bonds will be cause for an NCR.

8 STEP-BY-STEP PROCEDURES

This section consists of four parts:

Bonding process – this is a check sheet to record the serial number (SN) for each sample

Workmanship test – the same check sheet is used to record after curing time the pass/fail result for each sample

TVAC thermal cycling procedure

Post thermal cycling inspection – a check sheet to record pass/fail for each sample bond

Rupture test – a check sheet to record the final rupture force

8.1 Gluing procedure

The following steps are adapted from section 5 in the procedure for bonding MLI stand offs [AD6|.

Step	Description	Date	Sign.
1	Prepare working place in ISO class 8 area. Assemble coupon(s) and MLI standoff samples to be glued. Clean coupon(s) and standoffs thoroughly with IPA. Use template and marker to transfer standoff locations to coupon(s) with marks to guide sample positioning.		
2	Coupon Number(s): _____ Sample Numbers: _____		
3	Serialize the samples by marking either sample or coupon location as per coupon definition in Table 5. These must be visible throughout testing. Thoroughly wipe gluing areas with IPA.		
4	Mix glue and record in Table 6 of as-run version of this procedure.		
5	Apply scotchweld to base of standoff. Cover a maximum of the base area from center to half of the radius. Control by eye.		
6	Use tweezers to hold standoff.		
7	Position standoff between marks on coupon and press firmly.		

	Rotate standoff to form a homogeneous, uniform layer of glue under standoff base, until a visible bead forms around the edge of base.		
8	Repeat for all samples for the coupon(s)		
9	Apply a strict 8 hour pre-curing at room temperature before moving the coupon.		
10	The full 7 day room temperature curing must be allowed before any structural loading may be applied. The end of curing will be on _____		

8.2 **Workmanship test**

The document SO-EPD-KIE-TR-0044_1_1 [AD05] reports pull and shear tests of MLI standoffs on the EPT-HET PQM and STEP PQM. In total 7 shear tests and 12 pull tests were performed on EPT-HET PQM, and 22 shear tests on STEP PQM. The force in pull was 10N for 2 to 5 seconds (see Figure 4), and the force in shear 10, 15, 20 and 50N (for example Figure 3). No failure was observed.

The same test setup, replacing the units by test coupon, will be used for workmanship test.

The workmanship test shall be performed in pull only on samples on coupons designated for pull destructive testing and in shear for the other coupons. Maximum force shall be 10N.

See [AD05] for workmanship procedure, and [AD09] for the Airbus test carried out on flight units.

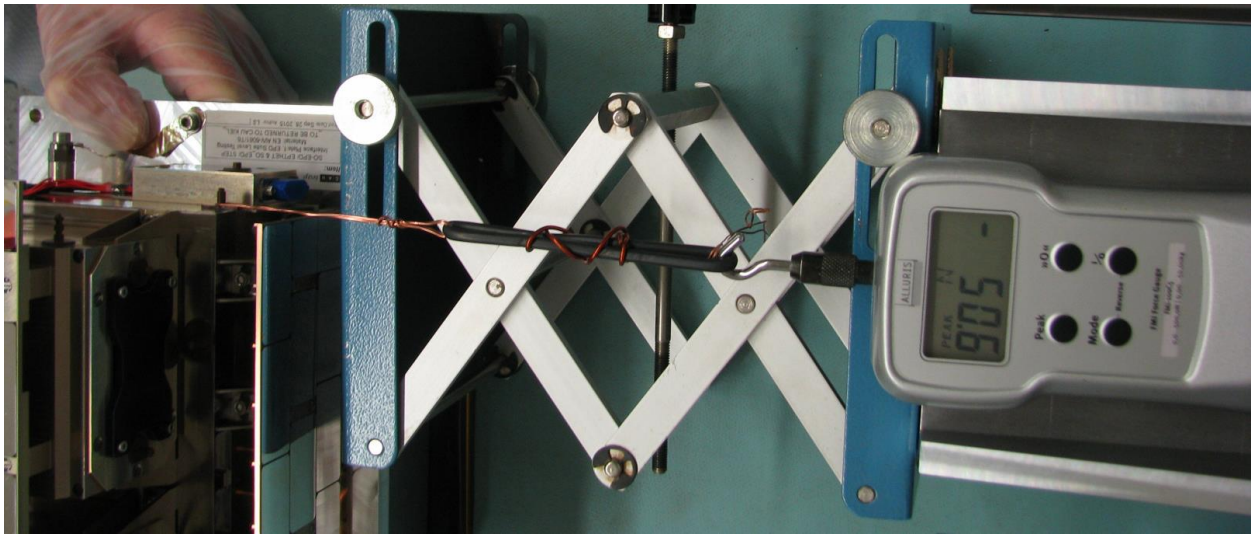

Figure 3 Example of workmanship shear test as performed on STEP PQM

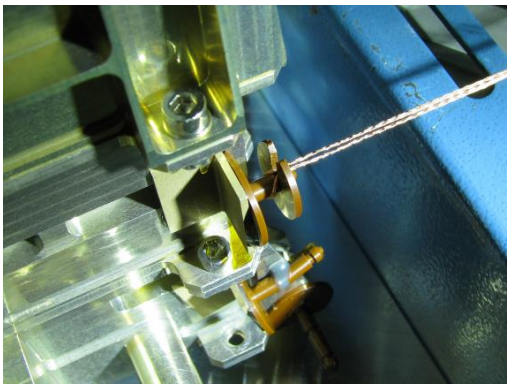

Figure 4 Example of workmanship pull test on STEP PQM

8.3 **TVAC thermal cycling procedure**

The boundary conditions are: 50 cycles, -65C to +75C range, less than 5degC/min rate (max), and one minute dwell.

The dwell is assumed to be a short interval during which the chamber temperatures are reversed and the sample temperatures attain the required limit within a ±5 °C range before continuing the next phase of the cycle. Limiting factor is the thermal inertia: base plate, shroud and coupon.

Depending on the dwell criterion and heating/cooling rate, a single cycle would require one hour, so for planning purposes the 50 cycles could be performed in two days and two hours. More conservatively, a run would need three days, and two runs could be made in one week. This would make the option of mounting the coupons flat on the base plate more practical. The final test setup (horizontal or vertical) as well as number of test runs will be decided at the time of the test.

Parameters to monitor are: sample temperature, chamber pressure and temperature. Sample temperature shall be monitored at coupon surface having bonded samples

8.3.1 Procedure flow diagram

Following [ND03] and the boundary conditions for this procedure, the procedure will follow the flow in diagram

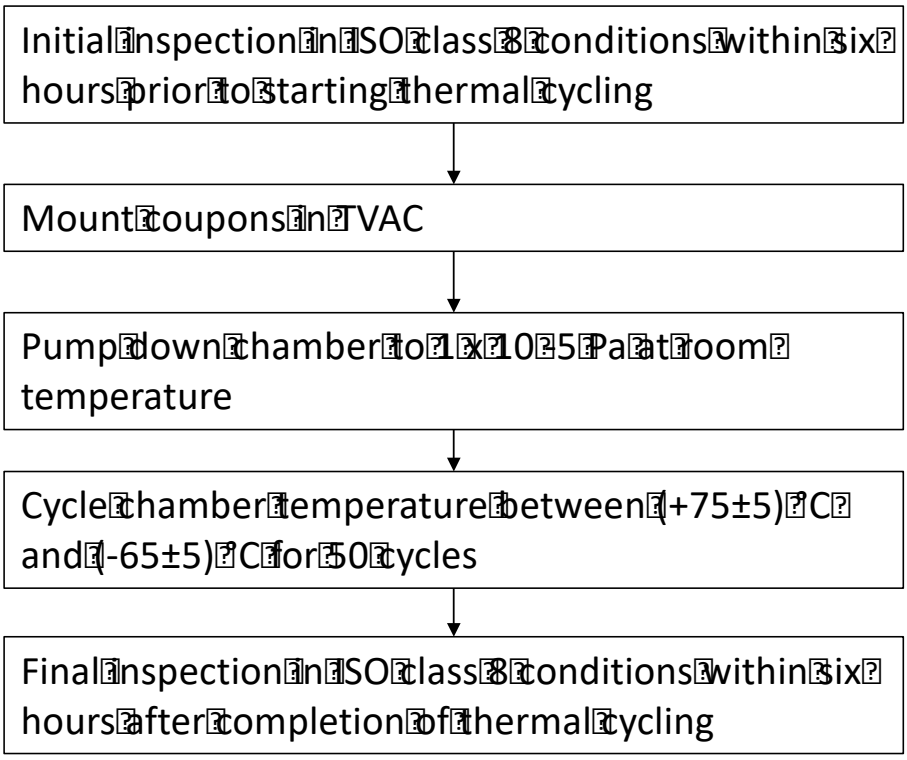

Figure 5 Thermal cycling procedure

8.3.2 Post-TVAC inspection

Post thermal cycling test inspection and review will include:

Visual inspection, also under magnification where indicated

Photographs

Internal post test review

8.4 Rupture test

The current plan is to use the same or similar setup as for the workmanship proof of bonding. However, the apparatus has not been tested to rupture. During the PQM MLI standoff test one standoff on a spare bracket (EPT-HET PQM) was loaded to 100N without failure of the bond. The maximum force for the Alluris FMI Force Gauge used in the PQM testing [AD5] is 500N.

An alternative setup at the Max Planck Institute for Solar System Research has been proposed. This is a load machine (Zwick/Roell Type 8397.50.00) with data acquisition system.

9 BONDING, WORKMANSHIP AND RUPTURE TEST RESULTS

Glue Mixing Record		Date	Sign
Glue:	Scotch-Weld A/B 2216, two component, mix ratio A:B :: 7:5 by weight		
Serial No.:			
Expiry date:			
Weights [g]:	A = __________, B = _____________		
Coupon No's:			

Glue Mixing Record		Date	Sign
Glue:	Scotch-Weld A/B 2216, two component, mix ratio A:B :: 7:5 by weight		
Serial No.:			
Expiry date:			
Weights [g]:	A = __________, B = _____________		
Coupon No's:			

Glue Mixing Record		Date	Sign
Glue:	Scotch-Weld A/B 2216, two component, mix ratio A:B :: 7:5 by weight		
Serial No.:			
Expiry date:			
Weights [g]:	A = __________, B = _____________		
Coupon No's:			

Glue Mixing Record		Date	Sign
Glue:	Scotch-Weld A/B 2216, two component, mix ratio A:B :: 7:5 by weight		
Serial No.:			
Expiry date:			
Weights [g]:	A = __________, B = _____________		
Coupon No's:			

Table 6 Glue mixing records for procedure SO-EPD-KIE-0045

I/F Type	Size mm	Bonding area mm^2	Materials
A	10	78	Vespel to aluminum

Nr.	Code	Gluing Date	Photos	10Nm test result	Post TVAC photos (1)	Pull / Shear	Rupture test result
1	A-10.01					Pull	
2	A-10.02					Pull	
3	A-10.03					Pull	
4	A-10.04					Pull	
5	A-10.05					Pull	
6	A-10.06					Pull	
7	A-10.07					Pull	
8	A-10.08					Pull	
9	A-10.09					Pull	
10	A-10.10					Pull	
11	A-10.11					Shear	
12	A-10.12					Shear	
13	A-10.13					Shear	
14	A-10.14					Shear	
15	A-10.15					Shear	
16	A-10.16					Shear	
17	A-10.17					Shear	
18	A-10.18					Shear	
19	A-10.19					Shear	
20	A-10.20					Shear	

[1] As required to document anomalies
Table 7 Sample type A-10 test results

I/F Type	Size mm	Bonding area mm^2	Materials
B	10x10	100	aluminum to aluminum

Nr.	Code	Gluing Date	Photos	10Nm test result	Post TVAC photos (1)	Pull / Shear	Rupture test result
1	B-100.21					Pull	
2	B-100.22					Pull	
3	B-100.23					Pull	
4	B-100.24					Pull	
5	B-100.25					Pull	
6	B-100.26					Pull	
7	B-100.27					Pull	
8	B-100.28					Pull	
9	B-100.29					Pull	
10	B-100.30					Pull	
11	B-100.31					Shear	
12	B-100.32					Shear	
13	B-100.33					Shear	
14	B-100.34					Shear	
15	B-100.35					Shear	
16	B-100.36					Shear	
17	B-100.37					Shear	
18	B-100.38					Shear	
19	B-100.39					Shear	
20	B-100.40					Shear	

[1] As required to document anomalies
Table 8 Sample type B-100 test results

I/F Type	Size mm	Bonding area mm^2	Materials
B	10x4	40	aluminum to aluminum

Nr.	Code	Gluing Date	Photos	10Nm test result	Post TVAC photos (1)	Pull / Shear	Rupture test result
1	B-40.41					Pull	
2	B-40.42					Pull	
3	B-40.43					Pull	
4	B-40.44					Pull	
5	B-40.45					Pull	
6	B-40.46					Pull	
7	B-40.47					Pull	
8	B-40.48					Pull	
9	B-40.49					Pull	
10	B-40.50					Pull	
11	B-40.51					Shear	
12	B-40.52					Shear	
13	B-40.53					Shear	
14	B-40.54					Shear	
15	B-40.55					Shear	
16	B-40.56					Shear	
17	B-40.57					Shear	
18	B-40.58					Shear	
19	B-40.59					Shear	
20	B-40.60					Shear	

[1] As required to document anomalies
Table 9 Sample type B-40 test results

I/F Type	Size mm	Bonding area mm^2	Materials
A	10, clipped	48	Vespel to aluminum

Nr.	Code	Gluing Date	Photos	10Nm test result	Post TVAC photos (1)	Pull / Shear	Rupture test result
1	A-10-c.61					Pull	
2	A-10-c.62					Pull	
3	A-10-c.63					Pull	
4	A-10-c.64					Pull	
5	A-10-c.65					Pull	
6	A-10-c.66					Pull	
7	A-10-c.67					Pull	
8	A-10-c.68					Pull	
9	A-10-c.69					Pull	
10	A-10-c.70					Pull	
11	A-10-c.71					Shear	
12	A-10-c.72					Shear	
13	A-10-c.73					Shear	
14	A-10-c.74					Shear	
15	A-10-c.75					Shear	
16	A-10-c.76					Shear	
17	A-10-c.77					Shear	
18	A-10-c.78					Shear	
19	A-10-c.79					Shear	
20	A-10-c.80					Shear	

[1] As required to document anomalies

Table 10 Sample type A-10, clipped test results

I/F Type	Size mm	Bonding area mm^2	Materials
B	10x15, bridging	90	aluminum to aluminum

Nr.	Code	Gluing Date	Photos	10Nm test result	Post TVAC photos (1)	Pull / Shear	Rupture test result
1	B-150-b.81					Pull	
2	B-150-b.82					Pull	
3	B-150-b.83					Pull	
4	B-150-b.84					Pull	
5	B-150-b.85					Pull	
6	B-150-b.86					Pull	
7	B-150-b.87					Pull	
8	B-150-b.88					Pull	
9	B-150-b.89					Pull	
10	B-150-b.90					Pull	
11	B-150-b.91					Shear	
12	B-150-b.92					Shear	
13	B-150-b.93					Shear	
14	B-150-b.94					Shear	
15	B-150-b.95					Shear	
16	B-150-b.96					Shear	
17	B-150-b.97					Shear	
18	B-150-b.98					Shear	
19	B-150-b.99					Shear	
20	B-150-b.100					Shear	

[1] As required to document anomalies

Table 11 Sample type B-150, bridging, test results

I/F Type	Size mm	Bonding area mm^2	Materials
A	10, reference	78	Vespel to aluminum

Nr.	Code	Gluing Date	Photos	10Nm test result	Pull / Shear	Rupture test result
1	A-10-r.101					
2	A-10-r.102					
3	A-10-r.103					
4	A-10-r.104					
5	A-10-r.105					
6	A-10-r.106					
7	A-10-r.107					
8	A-10-r.108					
9	A-10-r.109					
10	A-10-r.110					

Table 12 Sample type A-10, reference, test results

I/F Type	Size mm	Bonding area mm^2	Materials
B	10x10, reference	100	aluminium to aluminum

Nr.	Code	Gluing Date	Photos	10Nm test result	Pull / Shear	Rupture test result
1	B-100-r.111					
2	B-100-r.112					
3	B-100-r.113					
4	B-100-r.114					
5	B-100-r.115					
6	B-100-r.116					
7	B-100-r.117					
8	B-100-r.118					
9	B-100-r.119					
10	B-100-r.120					

Table 13 Sample type B-100, reference, test results

I/F Type	Size mm	Bonding area mm^2	Materials
B	10x4, reference	40	aluminum to aluminum

Nr.	Code	Gluing Date	Photos	10Nm test result	Pull / Shear	Rupture test result
1	B-40.121					
2	B-40.122					
3	B-40.123					
4	B-40.124					
5	B-40.125					
6	B-40.126					
7	B-40.127					
8	B-40.128					
9	B-40.129					
10	B-40.130					

[1] As required to document anomalies

Table 14 Sample type B-40, reference, test results

I/F Type	Size mm	Bonding area mm^2	Materials
A	10, clipped, reference	48	Vespel to aluminum

Nr.	Code	Gluing Date	Photos	10Nm test result	Pull / Shear	Rupture test result
1	A-10-c.131					
2	A-10-c.132					
3	A-10-c.133					
4	A-10-c.134					
5	A-10-c.135					
6	A-10-c.136					
7	A-10-c.137					
8	A-10-c.138					
9	A-10-c.139					
10	A-10-c.140					

[1] As required to document anomalies
Table 15 Sample type A-10, clipped, reference, test results

I/F Type	Size mm	Bonding area mm^2	Materials
B	10x15, bridging, reference	90	aluminum to aluminum

Nr.	Code	Gluing Date	Photos	10Nm test result	Pull / Shear	Rupture test result
1	B-150-b.141					
2	B-150-b.142					
3	B-150-b.143					
4	B-150-b.144					
5	B-150-b.145					
6	B-150-b.146					
7	B-150-b.147					
8	B-150-b.148					
9	B-150-b.149					
10	B-150-b.150					

[1] As required to document anomalies
Table 16 Sample type B-150, bridging, reference, test results

10 SUMMARY AND CONCLUSIONS