CMSE 2017
21st Components for Military & Space Electronics

THE NEW TIGHTER HERMETICITY LEAK TEST REQUIREMENTS - EUROPEAN OVERVIEW.

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THE NEW TIGHTER HERMETICITY LEAK TEST REQUIREMENTS - EUROPEAN OVERVIEW.

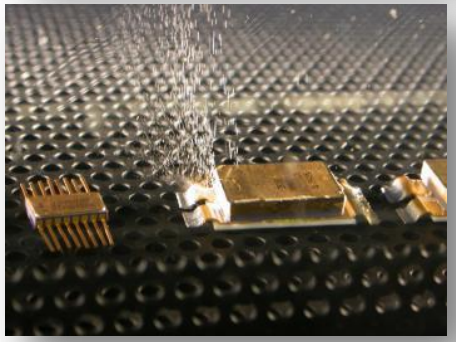
OUTLINE:

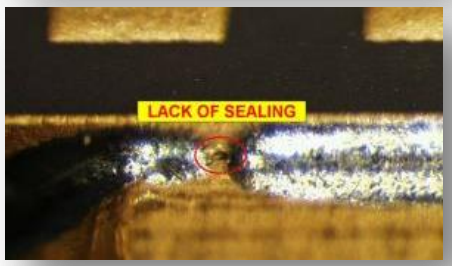
1. *Introduction.*
2. *Normative and test methods review.*
3. *Data collection and European assessment.*
4. *ESCC temporary position.*
5. *Ongoing activities and further works:*
    1. *Technical assessment*
    2. *Inter-comparative study*
    3. *ESCC leak test method?*
6. *Summary and conclusions.*

1.- INTRODUCTION

The recent modifications made in the seal test requirements under the MIL system are affecting the European space component community: manufacturers, space agencies, users, institutions, test labs,…etc.

- There are not European Space standards / normative related to hermeticity test on EEE components, thus MIL system is used as a reference.
- Lack of field failure. No hermeticity field failures on ESCC parts were recorded on devices tested during screening using the old MIL test failure criteria. Doubts on the need to change requirements.
- Other factors:
  - Why large differences between 750 versus 883 method?
  - Limited test resource covering all leak test conditions in Europe, with cost & lead time impacts.
  - governmental regulations influence the implementation of some techniques, like ^{85}Kr…
  - Different physical principles on different test conditions, test techniques correlation concerns, technical doubts…





2.- NORMATIVE AND TEST METHODS REVIEW.

There are different standards linked with leak test. Some generic (not focus on EEE components) and some specific to EEE components.

MIL	MIL-STD-883 TM 1014.	"Test Method Standard. Microcircuits". Seal Test Method TM 1014.
	MIL-STD-750 TM 1071.	"Test Method Standard. Test Methods for Semiconductor Devices. Method for Discrete Semiconductor Devices". Hermetic Seal Test Method 1071
JEDEC	JESD22-A109-B.	"Hermeticity".
ASTM	ASTM F2391-05 (2011).	Standard Test Method for Measuring Package and Seal Integrity Using Helium as the Tracer Gas.
	ASTM E432-91 (2011).	ASTM E432-91 (2011) Standard Guide for Selection of a Leak Testing Method.
	ASTM E499/E499M-11.	Standard Practice for Leaks Using the Mass Spectrometer Leak Detector in the Detector Probe Mode1, 2.
	ASTM E493/E493M-11	Standard Practice for Leaks Using the Mass Spectrometer Leak Detector in the Inside-Out Testing Mode.
	ASTM E498/E498M-11	Standard Practice for Leaks Using the Mass Spectrometer Leak Detector or Residual Gas Analyzer in the Tracer Probe Mode1, 2
IEC	IEC 60749-8: 2002.	Semiconductor devices - Mechanical and climatic test methods - Part 8: Sealing.
	IEC 60068-2-17:1994,	Environmental testing – Part 2: Tests – Test Q: Sealing.

Currently the MIL leak test methods look like the most detailed and updated document to carry out leak test on EEE components for High reliability application. Nevertheless there are still doubts and technical concerns to be solved.

3.- DATA COLLECTION AND EUROPEAN ASSESSMENT

- The different test conditions are based on different physical principles, and often, the leak rate is obtained through an indirect measurements, like happens with the OLT method, which needs correlation factors, that may be, are not constant for all test cases, making difficult the comparison.

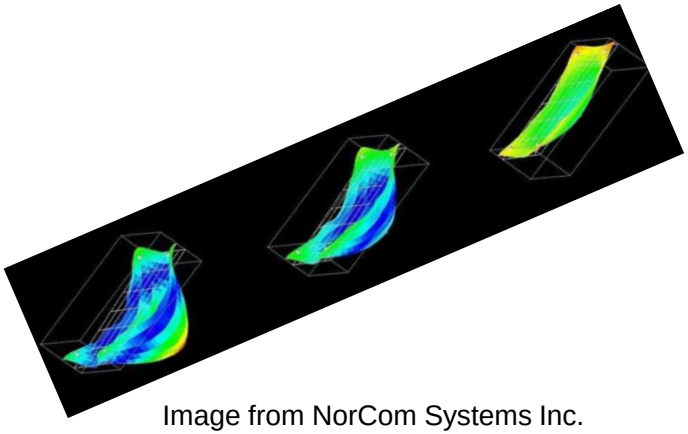
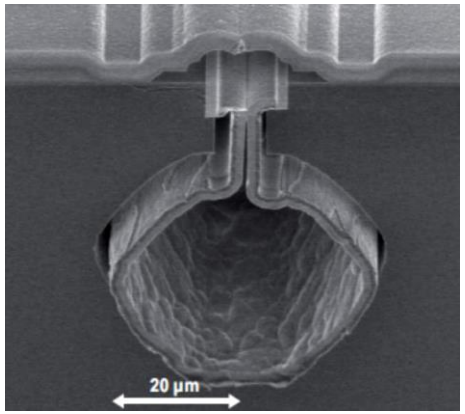


Image from NorCom Systems Inc.

- There are other promising techniques based on in-situ measurements: MEMS structures,…, etc., but detailed calibration processes are mandatory to correlate measurement, and there are not any available standard.



MEMS Thin Film Encapsulation. Fabio Santagata Ph.D. Thesis (Delft University of Technology).

3.- DATA COLLECTION AND EUROPEAN ASSESSMENT

- Example of leak test collected data from a qualified MIL manufacturer.
- Assessment on the available DLA lab suitability for Leak test.
- Hermeticity Test Method Survey. At European Level.

3.- DATA COLLECTION AND EUROPEAN ASSESSMENT

KR^{85} JANS LEAKAGE STATUS

2016 NOV 14TH

PN	Screening	Reject1	Groups	Reject2	Total	Total Reject
JANS2N2222AUB	[illegible]	0	89	0	[illegible]	0
JANS2N2907AUB	526	0	89	0	615	0
JANS2N3700UB	524	1	201	0	725	1
JANS2N5401UB	542	0	201	0	743	0
JANS2N2907AUB	1088	0	156	0	1244	0
JANSR2N2907 AUB	598	0	44	0	642	0
JANS2N2222AUB	530	0	156	0	686	0
JANSR2N2222AUB	531	0	44	0	575	0
JANS2N5551UB	516	0	201	0	717	0
JANSM19500/773-01	1060	0	201	0	1261	0
JANSR2N2222AUB	1094	0	156	0	1250	0
JANSR2N2907 AUB	1270	0	156	0	1426	0
JANSR2N5401UB	600	0	156	0	756	0
JANSR2N5551UB	570	0	156	0	726	0
JANSR2N2907AUB	250	0			250	0
JANSR2N2907AUB	250	0			250	0
JANSR2N2907AUB	510	0			510	0
JANSR2N2222AUB	531	1			531	1
JANSR2N2222AUB	680	0	156	0	836	0
JANSR2N5401UB	260	0			260	0
JANSR2N3700UB	818	1	156	1	974	2
JANSR2N3700UB	270	0			270	0
JANSR2N2907AUB	1173	0	156	0	1329	0
JANS2N3700UB	1137	0			1137	0
JANSR2N2222AUB	912	1	44	0	956	1
JANS2N3700UB	260	0			260	0
JANS2N2222AUB	260	0			260	0
JANS2N2222AUB	[illegible]	0			[illegible]	0
Total	**17538**	**4**	**2518**	**1**	**20056**	**5**

3.- DATA COLLECTION AND EUROPEAN ASSESSMENT

MIL-STD-883 TM 1014 DLA Commercial Lab Suitability

Laboratory	Test Methods (Conditions)	TEST CONDITIONS																
		A1	A2	A4	B1	B2	B3	C1	C2	C3	C4	C5	DYE PEN	GT	CH1	CH2	Z
Analytical Solutions LLC	Mil-std-883 TM 1014	X	X														
CORWIL	Mil-std-883 TM 1014	X	X					X									
Cobham Environmental Test Services (San Diego)	Mil-std-883 TM 1014							X									
Cobham RAD Solutions	Mil-std-883 TM 1014	X	X														
Criteria Labs	Mil-std-883 TM 1014							X									
DPA Components	Mil-std-883 TM 1014	X	X								X	X					
ECR Laboratories, Inc.	Mil-std-883 TM 1014	X	X					X									
Golden Altos	Mil-std-883 TM 1014	X	X					X									
Hi-Reliability Microelectronics	Mil-std-883 TM 1014	X	X					X									
ISE Labs Inc.	Mil-std-883 TM 1014		X					X									
Intersil Corporation	Mil-std-883 TM 1014							X									
IsoVac Engineering Incorporated	Mil-std-883 TM 1014				X	X											
Micross Components, Orlando	Mil-std-883 TM 1014	X	X					X									
Oneida Research Services Inc.	Mil-std-883 TM 1014	X	X		X	X	X										
Oneida Research Services Inc.	Mil-std-883 TM 1014	X	X		X	X	X										
Pantronix Corporation	Mil-std-883 TM 1014	X	X					X									
Pernicka Corporation	Mil-std-883 TM 1014														X	X	
Precision Test Solutions	Mil-std-883 TM 1014				X	X											
Silicon Turnkey Solutions	Mil-std-883 TM 1014	X	X					X									
Six Sigma	Mil-std-883 TM 1014	X	X					X									
e2v Aerospace and Defense	Mil-std-883 TM 1014							X									

- 16 laboratories perform the leak test using the classic He fine leak test conditions A1 and A2, and per-fluorocarbon gross leak test conditions C1.
- Four labs have capabilities to run ^{85}Kr testing using the conditions B1, B2 or B3.
- Only one lab is certified for OLT and CH testing, being these two techniques less popular.

3.- DATA COLLECTION AND EUROPEAN ASSESSMENT

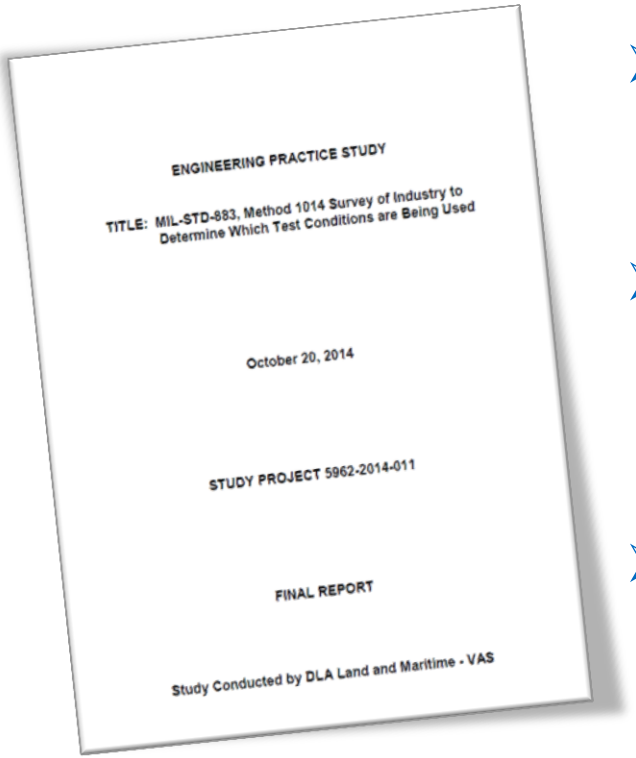
MIL-STD-750 TM 1071 DLA Commercial Lab Suitability

Laboratory	Test Methods (Conditions)	Test Conditions																
		A	B	C	D	E	J	K	L1	Gt	G1	G2	CH1	CH2	H1	H2	L2
Aeroflex-Metelics	Mil-std-750 TM 1071	X	X			X					X						
Cobham RAD Solutions	Mil-std-750 TM 1071	X	X								X	X					
Hi-Reliability Microelectronics	Mil-std-750 TM 1071														X	X	
IsoVac Engineering Incorporated	Mil-std-750 TM 1071	X	X								X	X					
Oneida Research Services Inc.	Mil-std-750 TM 1071	X	X								X	X			X	X	
Pernicka Corporation	Mil-std-750 TM 1071												X	X			
Precision Test Solutions	Mil-std-750 TM 1071	X		X		X						X					
Product Testing Center-Electronic	Mil-std-750 TM 1071																
Semitronics Corporation	Mil-std-750 TM 1071		X								X	X					
Tektronix Service Solutions	Mil-std-750 TM 1071			X	X										X		

- Only 10 certified laboratories.
- 5 perform ^{85}Kr following different test conditions (A, B, G1 or G2).
- Classical Fine He test conditions (H1, H2) are only covered by three certified lab.
- CHLD conditions are only offered by one laboratory.
- There is not any certified lab offering OLT test conditions for discrete devices.

3.- DATA COLLECTION AND EUROPEAN ASSESSMENT

Engineering Practice Study: “MIL-STD-883, Method 1014 Survey of Industry to Determine Which Test Conditions are Being Used”. October 20, 2014.



ENGINEERING PRACTICE STUDY

TITLE: MIL-STD-883, Method 1014 Survey of Industry to Determine Which Test Conditions are Being Used

October 20, 2014

STUDY PROJECT 5962-2014-011

FINAL REPORT

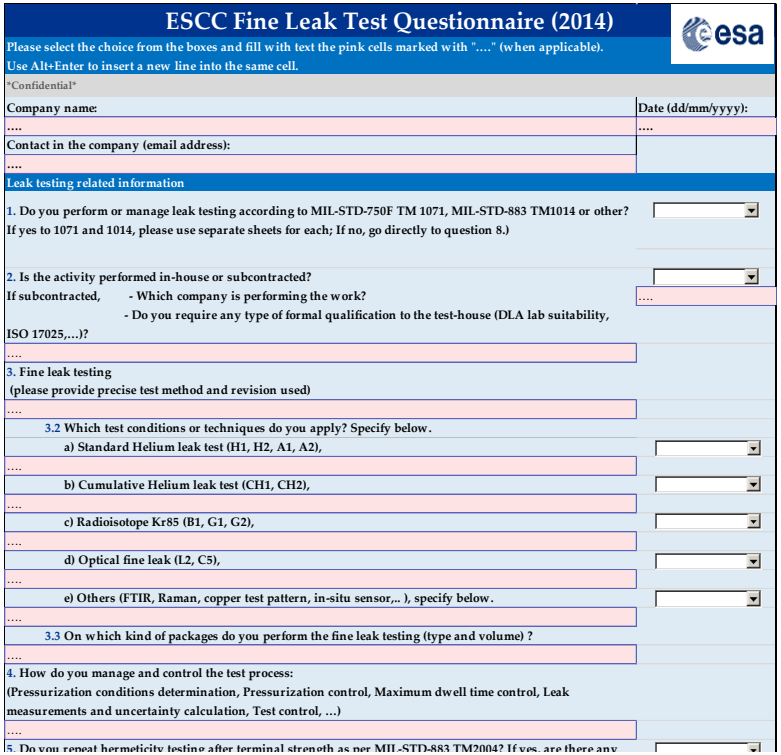
Study Conducted by DLA Land and Maritime - VAS

- The study outcome determines that most, if not all, of the Test Conditions existing in MIL-STD-883, method 1014 are being used.
- Additionally, method 1014 may not be simplified by moving any unused Test Conditions to an appendix in the method at this time.
- DLA Land and Maritime recommends that no changes be made to MIL-STD-883, method 1014, based on the results of the survey responses to this EP Study.

3.- DATA COLLECTION AND EUROPEAN ASSESSMENT

ESA performed a survey:

Hermeticity Test Method Survey (ESA-QES-ESCC-TN-003 PSWG).
First a questionaire was prepared and delivered:



ESCC Fine Leak Test Questionnaire (2014)

Please select the choice from the boxes and fill with text the pink cells marked with "...." (when applicable).
Use Alt+Enter to insert a new line into the same cell.

Confidential

Company name:	Date (dd/mm/yyyy):
....	....
Contact in the company (email address):	
....	

Leak testing related information

1. Do you perform or manage leak testing according to MIL-STD-750F TM 1071, MIL-STD-883 TM1014 or other?
If yes to 1071 and 1014, please use separate sheets for each; If no, go directly to question 8.)

2. Is the activity performed in-house or subcontracted?
If subcontracted, - Which company is performing the work? ....
- Do you require any type of formal qualification to the test-house (DLA lab suitability, ISO 17025,...)?
....

3. Fine leak testing
(please provide precise test method and revision used)
....

3.2 Which test conditions or techniques do you apply? Specify below.
a) Standard Helium leak test (H1, H2, A1, A2),
....
b) Cumulative Helium leak test (CH1, CH2),
....
c) Radioisotope Kr85 (B1, G1, G2),
....
d) Optical fine leak (L2, C5),
....
e) Others (FTIR, Raman, copper test pattern, in-situ sensor,..), specify below.
....

3.3 On which kind of packages do you perform the fine leak testing (type and volume) ?
....

4. How do you manage and control the test process:
(Pressurization conditions determination, Pressurization control, Maximum dwell time control, Leak measurements and uncertainty calculation, Test control, ...)
....

5. Do you repeat hermeticity testing after terminal strength as per MIL-STD-883 TM2004? If yes, are there any

Questionnaire content:

- Do you perform leak test?
- The activity is done in-house or subcontracted?
- Which test conditions are applied?
- How the leak test process is managed?
- Leak failures: during manufacturing, customer returns,…
- …, etc

3.- DATA COLLECTION AND EUROPEAN ASSESSMENT

The questionnaire was delivered to different European entities: component manufacturers, assembly houses, and test labs:

3D PLUS	LEACH EUROPE (SARRALBE)	ORS ONEIDA RECHERCHE SERVICES	SAGEM	TESAT SPACECOM	OPTOI MICROELECTRONICS
RUAG	IMT	STMICROELECTRONICS	ALTER TECHNOLOGY TÜV NORD	ATMEL	TAS FRANCE
AEROFLEX GAISLER	LEWICKI	PEREGRINE UK	SERMA TECHNOLOGIES - HCM	TT SEMELAB	RF2M MICROWAVE
AXTAL GMBH	MICROSEMI IRELAND	RAKON FRANCE	SPUR ELECTRON	TYNDALL	RHE (CICOR)
HIREX ENGINEERING	OMIC	REL STPI	SYFER TECHNOLOGY LTD	UMS	TAS BELGIUM ETCA
MASER ENGINEERING	KVG QUARTZ CRYSTAL TECHNOLOGY	KONGSBERG NORSPACE AS	EADS ASTRIUM FRANCE	E2V	COMEPA
INFINEON TECHNOLOGIES A.G.	OPTOCAP	ROOD-MICROTEC	TAS ITALY	COBHAM MICROWAVE	

50% offered responses

3.- DATA COLLECTION AND EUROPEAN ASSESSMENT

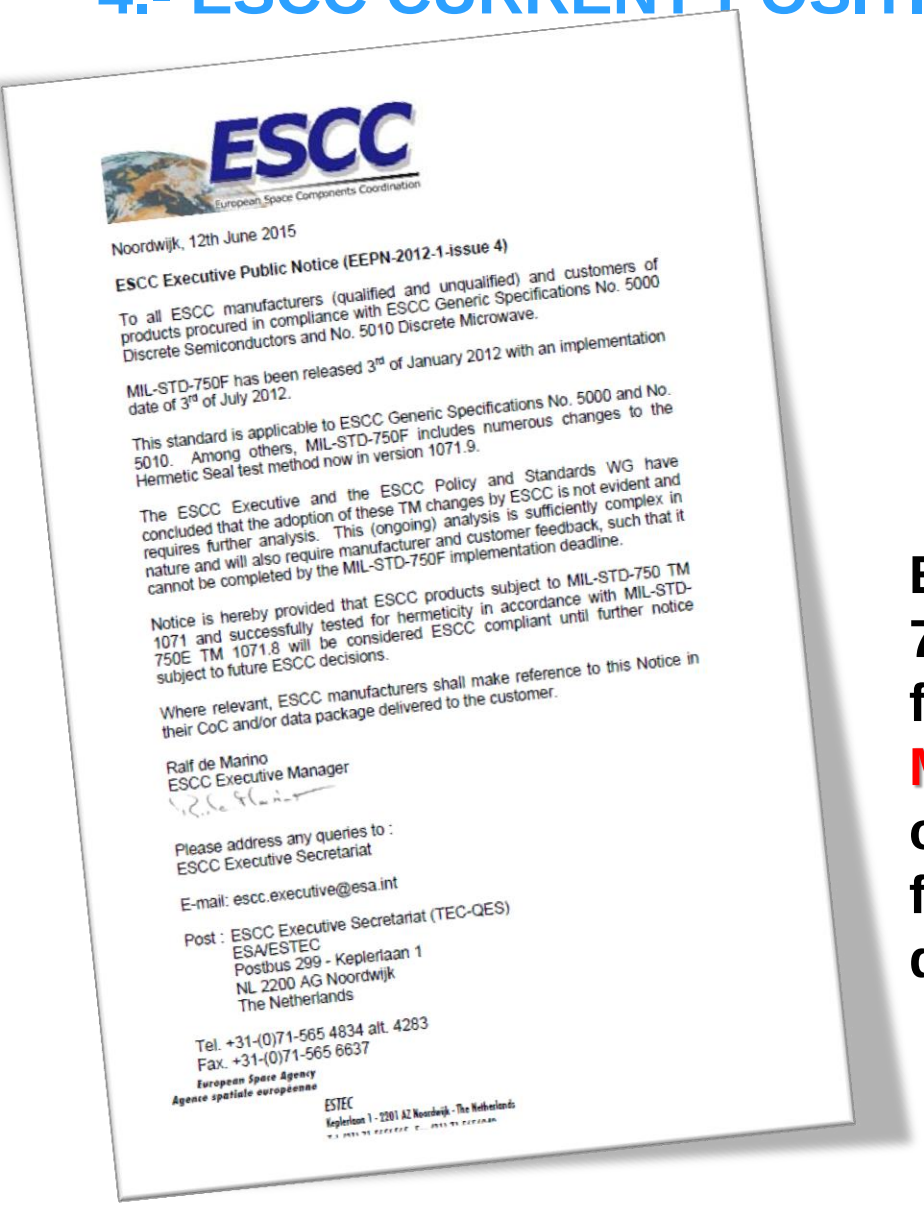
Most of the companies of this survey confirmed the following:

- To use the previous versions of test methods MIL-STD-883H 1014 and MIL-STD-750D 1071.
- Previous version of test methods are sufficient to ensure good reliability in terms of hermiticity.
- To have less than 1% of failure rate for hermeticity
- To have no field failure return due to hermeticity failure.
- To find the challenges to implement the new test method too demanding (impossible for complex packages).

The received answers show that the failure rates for hermeticity is very low (<1%) and no customer return is reported due to leak failures nor to component failures associated to a loss of hermeticity.

According to the surveyed companies, the current test methods are sufficient to insure good reliability in term of hermeticity. The satisfactory usage of the previous version associated with the difficulties to implement the new ones make them **recommend to not migrate to the updated requirement** indicated in the MIL-STD-750F method 1071.12 and MIL-STD-883 Method 1014.9 conditions.

4.- ESCC CURRENT POSITION



ESCC
European Space Components Coordination

Noordwijk, 12th June 2015

ESCC Executive Public Notice (EEPN-2012-1-issue 4)

To all ESCC manufacturers (qualified and unqualified) and customers of products procured in compliance with ESCC Generic Specifications No. 5000 Discrete Semiconductors and No. 5010 Discrete Microwave.

MIL-STD-750F has been released 3rd of January 2012 with an implementation date of 3rd of July 2012.

This standard is applicable to ESCC Generic Specifications No. 5000 and No. 5010. Among others, MIL-STD-750F includes numerous changes to the Hermetic Seal test method now in version 1071.9.

The ESCC Executive and the ESCC Policy and Standards WG have concluded that the adoption of these TM changes by ESCC is not evident and requires further analysis. This (ongoing) analysis is sufficiently complex in nature and will also require manufacturer and customer feedback, such that it cannot be completed by the MIL-STD-750F implementation deadline.

Notice is hereby provided that ESCC products subject to MIL-STD-750 TM 1071 and successfully tested for hermeticity in accordance with MIL-STD-750E TM 1071.8 will be considered ESCC compliant until further notice subject to future ESCC decisions.

Where relevant, ESCC manufacturers shall make reference to this Notice in their CoC and/or data package delivered to the customer.

Ralf de Marino
ESCC Executive Manager

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Agence spatiale européenne

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Keplerlaan 1 - 2201 AZ Noordwijk - The Netherlands

ESCC
European Space Components Coordination

ESCC products subject to MIL-STD-750 TM 1071 and successfully tested for hermeticity in accordance with MIL-STD-750E TM1071.8 will be considered ESCC compliant until further notice subject to future ESCC decisions.

5.- ONGOING ACTIVITIES / FURTHER WORKS

1. Technical assessment

He

^{85}Kr

CHLD

OLT

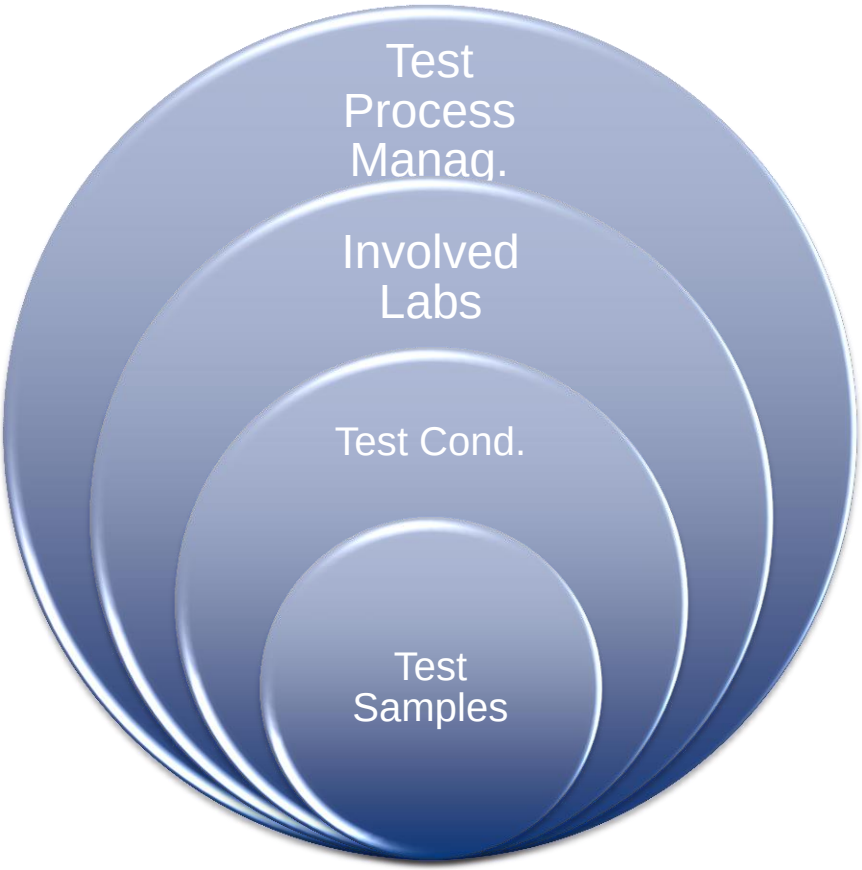
HSHLD

Fine Leak Test	Helium Leak Detection
	Cumulative Helium Leak detection (CHLD)
	Radiosotope ^{85}Kr
	Optical Leak Detection (OLT)
	High Sensitivity Helium Leak Detector (HSHLD)
New Test Techniques	Q-Factor MEMS structures.
	Micro pirani
	FTIR Leak detection
	Raman Spectroscopy

Test Methodology	Advantages	Drawbacks
Classical He Leak Test	Process standard.	Not appropriate on devices with glass, polymers, epoxies,…
	Well-known technique.	He sorption characterization.
	Various equipment suppliers.	Low sensitivity for very small cavity devices.
	Available test methods.	
Cumulative Helium Leak Detection	Simultaneous Gross and Fine leak test (in the same test process).	Not valid for devices with He sorption, and He sorption management.
	Higher sensitivity level than standard He test.	Limited equipment suppliers (Two identified)
	Available test methods.	Not very efficient test cycle time.
Radioisotope ^{85}Kr	Can perform simultaneous Gross and Fine leak test in the same test process.	Handling radioactive elements which have some safety concern and severe installation rules, especially in Europe. Equipment not European certified.
	Fast test cycle time.	^{85}Kr tested Leak failures became radioactive material. Must be handled under special procedures.
	High test sensitiveness reaching detectability levels 1×10^{-12} atm.cm^3/s and better.	Only one equipment supplier: "ISOVAC", located in USA. Limited service outside USA.
	Minimal gas absorption to glass and other materials, but still need to evaluate for very low leaks levels.	Only one recognized equipment installed in Europe.
	Available test methods	Limited supplier sources of ^{85}Kr gas and also under export-import regulations.
OLT	No pre-bombing requirements	Is not possible to use this test when the devices have not metal lid or flexible case.
	Can perform simultaneous Gross and Fine leak test in the same test process.	Not demonstrated capabilities below leak levels 1×10^{-11} atm.cm^3/s
	Is adequate to perform Leak test on packages with helium absorbing / emitting materials.	Only one equipment supplier, located in USA, and limited service outside USA.
	The technique allows the leak test when the devices are already mounted in the board even after application of conformal coating layers.	
	The test can be performed in automatic mode, reducing cost and improving the test process.	
	Available test methods	
HSHLD	Fine and Gross Leak detection	Not valid for devices with He sorption, and He sorption management.
	Minimum Fine Leak detection: < $1.0\text{x}10^{-12}$ atm.cm^3/s He.	Only one equipment supplier.
	Spectrometer mass range 1-100 amu. Allowing the use of several gasses.	Technique new. Pending to demonstrate performance.
	2 point Linear Calibration (as low as $1.0\text{x}10^{-11}$ atm.cm^3/s He)	
	Faster cycle time than standard He leak test	
Q-factor monitoring Micro Pirani	No surface sorption	No available test method.
	High theoretical sensitivity	Need of pre-calibration before leak measurements.
		Not available dedicated test equipment.
		Complex implementation on existing products.
FTIR spectroscopy Raman Spectroscopy	No surface sorption	No available test method
	High theoretical sensitivity	Need of calibration against other technique.
		Not available dedicated test equipment, lab instruments used.
		Complex test set-up.
		Requirements on specific device packaging properties: infrared transparent, …, etc.

5.- ONGOING ACTIVITIES / FURTHER WORKS

2. Inter-comparative study



- Test samples: 70 devices, with small cavity devices, from 4 different qualified sources and with various leak rates will be used as test vehicles.
- Test conditions: He, CHLD, ^{85}Kr and HSHLD.
- Laboratories: ALTER, INFINCON, Leybold, ORS, ISOVAC,…(pending to confirm the final list)
- Test process management: fixed test conditions and under ISO 17025 framework.

5.- ONGOING ACTIVITIES / FURTHER WORKS

3. ESCC leak test method

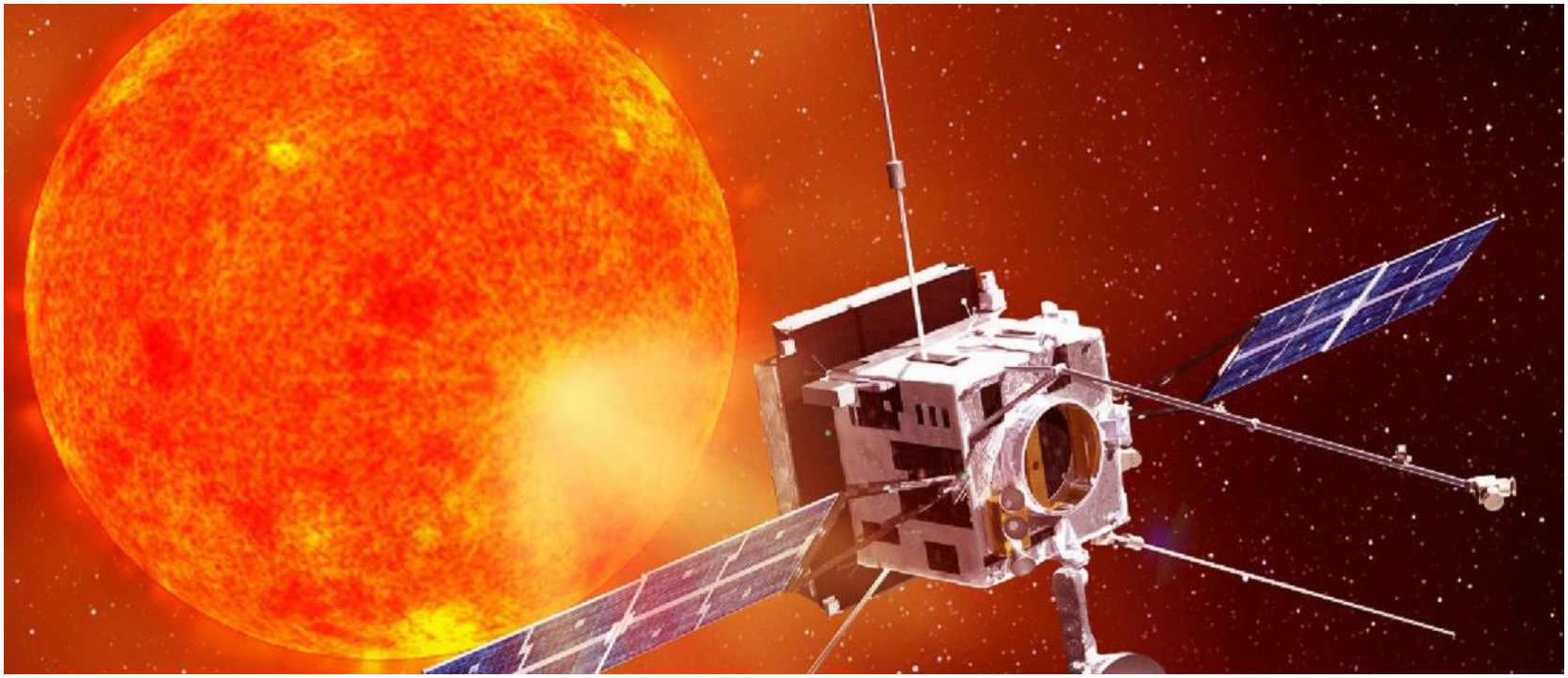
- ✓ The subject was discussed by a dedicated ad hoc CTB-PSWG working group.
- ✓ A decision was made to create an European ESCC leak test requirement document.
- ✓ The basic requirements will be based on the old requirements and failure criteria with some corrections.

THE NEW TIGHTER HERMETICITY LEAK TEST REQUIREMENTS - EUROPEAN OVERVIEW.

SUMMARY AND CONCLUSIONS:

1. Each test technique has its own advantages and drawbacks and are somehow complementary, although the He and ^{85}Kr look like the most versatile tools.
2. The correlation levels are still under concern and some additional investigation must be performed to understand the differences.
3. The introduced tighter requirements seems not justified as a general rule, although could be required in specific cases.
4. The new In-situ leak test techniques, based on different MEMS structures, and other new techniques offer promising characteristics but further work need to be done before using them as standard test methods.

ACKNOWLEDGMENT: "This work has been partially developed with the European Space Agency support and under the contract (ESA Contract: 400011075/15/NL/PS): Hermeticity Testing Procedures".



THANK YOU FOR YOUR ATTENTION

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