NASA Electronic Parts and Packaging (NEPP) Hermeticity Task

NEPP Program Task 13-294: MSFC/GSFC Joint Hermeticity Instrument Correlation Study of TO-5, TO-18, and UB Style Packages

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AGENDA

I. Introduction

II. Purpose

III. Instrument Correlation Study

A. Test Plan

B. Data & Results (TO-5, TO-18, UB)

C. Plugging

D. Lessons Learned

IV. Future Work

INTRODUCTION

NEPP Hermeticity task is a collaborative effort between GSFC/MSFC to address the following:

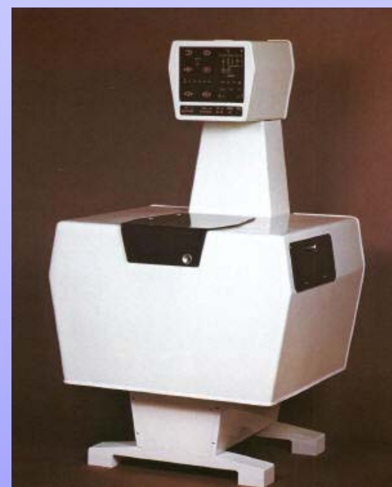
- Determine CHLD test equipment capability between NASA centers as well as correlation of test results with other equipment used for hermeticity testing (OLT, Krypton-85, IGA)
- Provide input to DLA Land & Maritime to optimize hermeticity specifications based on the knowledge gained during correlation study, part testing, and research efforts
- Gain understanding of the influence of component part material on resultant leak rate data
- Design, fabricate, and test gross leak hermeticity standards

Purpose

What was the purpose of this study?

Test non-hermetic parts to determine CHLD test equipment capability between NASA centers as well as correlate test results collected using other pieces of hermetic test equipment (OLT, Krypton-85, IGA)

CHLD
(Pernicka 700H System)



Krypton-85
(IsoVac Mark V Bomb Station)

OLT System
(NorCom 2020 Optical Leak Test System)

Test Plan

Step 1

Secure Non-Hermetic Parts

- *Obtained 3 sets 10 parts each of MIL-STD-750 gross/fine leakers from IsoVac, Inc. which were go/no go tested (Pre-requisites: Nitrogen sealed, no fluorocarbon/red dye testing)*
- *The 3 package styles used were TO-18, TO-5, and UB*

Step 2

Confirm GSFC/MSFC CHLD Performance

- *Used 2 calibrated helium leak standards to verify high/low leak range accuracy*
- *Verified empty chamber values to confirm analyzer sensitivity to detect fine leaks and set GLT to detect gross leaks*

Step 3

Test Parts Using CHLD, OLT, and Kr85 Equipment

- *Order of testing was CHLD-MSFC, CHLD-GSFC, OLT - NorCom, Kr85–IsoVac, Kr85–MSFC, Kr85 Red Dye-IsoVac (if applicable)*
- *(Note: Set 1 T0-18 gross leakers were tested by CHLD-MSFC after OLT-NorCom)*

Step 4:

Test Parts With IGA to Confirm Parts Selected Were Non-Hermetic

- *Testing was done for final confirmation of part hermeticity and to ensure fluorocarbons were not present which could skew test results*

Test Specifics

CHLD

- MSFC/GSFC tested in accordance with MIL-STD-750 TM1071 Test Condition CH_2
- Both used identical bombing conditions, equipment setup, and comparable wait times prior to testing each sample
- CHLD test conditions and system setup are summarized in a backup chart

OLT

- NorCom, Inc. tested in accordance with MIL-STD-750 TM1071 Test Condition L_2
- OLT test and bombing conditions were determined by NorCom
- Testing was observed by GSFC
- OLT test conditions and system setup are summarized in a backup chart

Kr85

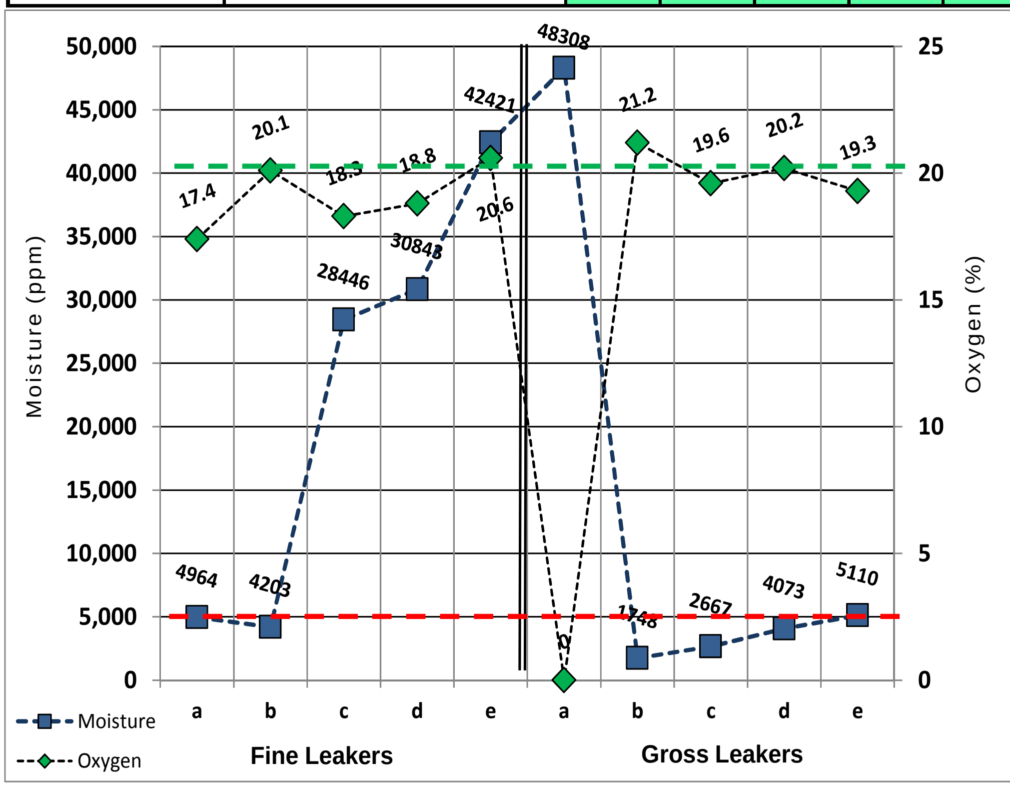
- MSFC/IsoVac Eng., Inc. tested in accordance with MIL-STD-750 TM1071
- Gross leak was performed using Test Condition B
- Fine leak was performed using Test Condition G-1
- Red dye testing was performed by IsoVac Eng., Inc. in accordance with Test Condition A
- Test conditions and system setup are summarized in a backup chart.

IGA

- ORS, Inc. tested in accordance with MIL-STD-750 TM1018
- TO-5, TO-18 IVA was performed using a quadropole mass spectrometer. TO-18 required special mounting (<0.7cm diameter)
- UB High Resolution HR-IVA was performed using a time of flight mass spectrometer. (volume <0.01)
- All samples were prebaked 16-24hrs @100°C and tested at 100°C

Data & Results: Set 3 UB

System	Order of Testing	Fine						Gross					
		a	b	c	d	e	Results	a	b	c	d	e	Results
Kr85	IsoVac (Pass/Fail)						5/5						5/5
CHLD	MSFC	P	P	P	P	P	0/5						5/5
	GSFC	P	P	P	P	P	0/5						5/5
OLT	Norcom	Package Type Cannot Be Tested With OLT											
Kr85	IsoVac	P	P	P	P	P	0/5						5/5
	MSFC	P	P	P	P	P	0/5						5/5
	IsoVac (Red Dye)	P	P	P	P	P	0/5	N/A					
RGA	ORS						5/5						5/5



Test Result Summary

Gross:

- All instruments identified gross leakers per Mil-STD-750 TM's
- 5/10 RGA moisture under ppm failure criteria but indicated atmospheric exchange (Note: 883 would have passed these 4)
- 100% correlation btwn Kr85, CHLD, IVA.

Fine:

- Parts are plugged. Initially Kr85 was able to detect leakers subsequent CHLD, OLT, Kr85 testing could not.

Plugging

Handling & Testing

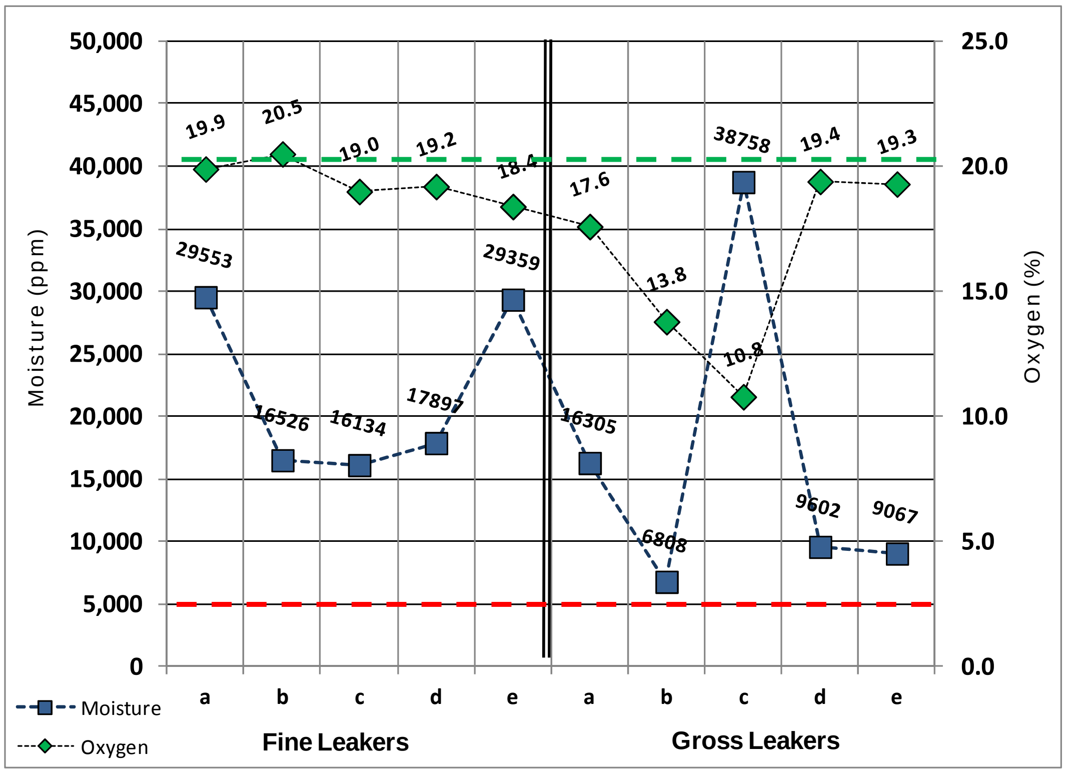
- *Increased handling can increase the chances of devices coming into contact with particles that can plug leak paths.*
- *Increased handling can damage protective oxidation coatings on the outside of the package which can expose metal surfaces.*
- *When non-hermetic parts are handled/tested outside of a clean room environment atmospheric particle counts are higher and can plug existing leak paths.*

Storage

- *Parts stored in ambient conditions provides a suitable environment for oxidation. Metal compounds used in the sealing process and device construction can rust and plug existing leak paths.*
- *Storage conditions that allow moisture ingress or internal moisture to form inside the device cavity can cause one way leakers.*

Data & Results: Set 2 TO-5

System	Order of Testing	Fine a	Fine b	Fine c	Fine d	Fine e	Fine Results	Gross a	Gross b	Gross c	Gross d	Gross e	Gross Results
Kr85	IsoVac (Pass/Fail)						5/5						5/5
CHLD	MSFC	2.5E-08	G	G	G	1.6E-08	5/5				1.2E-08	1.2E-08	5/5
	GSFC	2.5E-08	G	3.4E-08	2.5E-08	1.8E-08	5/5	3.7E-08	3.8E-08		1.5E-08	1.6E-08	5/5
OLT	Norcom	P	2.9E-08	P	8.3E-09	P	2/5	P	P		P	P	1/5
Kr85	MSFC	P	1.6E-08	P	4.1E-08	P	2/5	1.7E-08	P		P	P	2/5
	IsoVac (Final)	P	2.4E-08	P	3.9E-08	P	2/5	1.7E-08	P		P	P	2/5
RGA	ORS						5/5						5/5



Test Result Summary

Gross:

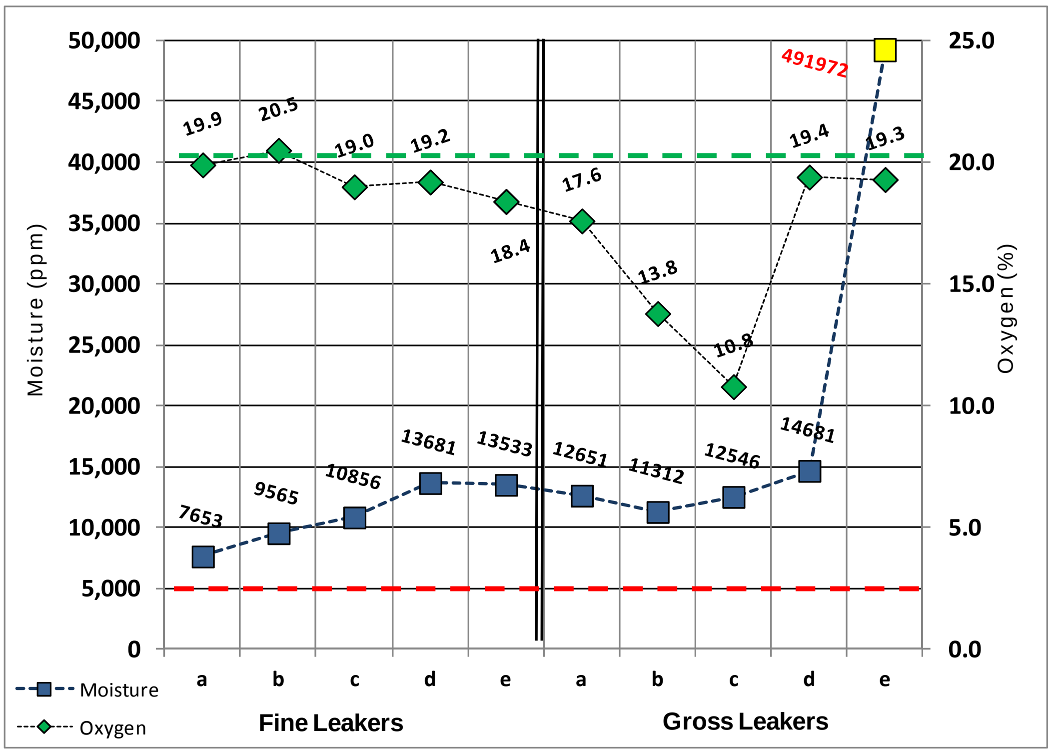
- MSFC/GSFC CHLD failed all 5 parts
- 3 parts plugged after CHLD testing
- Of 2 remaining parts, OLT passed 1 failed part and failed 1 part.
- Kr85 failed 2 parts which correlates with CHLD and conflicts with OLT
- RGA data confirms that all 5 parts were leakers

Fine:

- CHLD failed all 5 parts
- 3 parts plugged after CHLD GSFC testing allowing Kr85 to only fail 2 parts
- RGA data confirms that all 5 parts were leakers

Data & Results: Set 1 TO-18

System	Order of Testing	Fine a	Fine b	Fine c	Fine d	Fine e	Results	Order of Testing	Gross a	Gross b	Gross c	Gross d	Gross e	Results
Kr85	IsoVac (Pass/Fail)						5/5	IsoVac (Pass/Fail)						5/5
CHLD/OLT	CHLD:MSFC	P	P	G	P	G	2/5	CHLD: GSFC	P		P		P	2/5
	CHLD: GSFC	P	P	P	P	P	0/5	OLT: Norcom			9.2E-08	1.3E-08	P	3/5
	OLT: Norcom	G	1.2E-08	1.9E-08	P	G	4/5	CHLD: MSFC	P		P	P	P	1/5
K85	IsoVac	P	P	P	P	P	0/5	IsoVac	P	P	P	P	P	0/5
	MSFC	P	P	P	P	P	0/5	MSFC	P	P	P	P	P	0/5
	IsoVac (Red Dye)	P	P	P	P	P	0/5	IsoVac (Red Dye)	N/A	P	N/A	N/A	P	0/2
RGA	ORS						5/5	ORS						5/5



Test Result Summary

Gross:

- All samples exhibited plugging
- CHLD GSFC passed one failed part that NorCom identified as a fine leak.
- One part shifted during OLT testing and would require retesting (?? Wait time and 5 hr rebomb)

Fine:

- All samples exhibited plugging
- GSFC identified all parts as passed. MSFC indicated 2 parts failed. OLT indicated 4 parts failed. Several scenarios unable to make a conclusion due to lack of correlation.

Lessons Learned

Plugging

- **Leakers must be identified during screening and qualification!** This data shows that pass/fail Kr85 testing in the early lifetime of the device was able to segregate leakers based on IGA confirmation. Results from this test provides supporting evidence that non-hermetic parts can gradually and/or completely plug at anytime.

Correlation CHLD

- For the UB, TO-5 parts, and TO-18 gross leak packages, GSFC and MSFC were able to fail the same devices when plugging did not occur.
- For TO-18 fine packages, if the OLT data was excluded and plugging is considered , CHLD correlates with Kr85.
- When both identified a fine leak, the leak rates correlated within < 1/4 magnitude

Correlation OLT

- There is a lack of correlation between OLT and CHLD/Kr85 data for TO-18 packages and 1 TO-5 package.
- If OLT data was omitted, the results in this study correlate in regards to segregating failed devices and plugging. (Refer to backup slide)
- OLT cannot be used to test ceramic/metal lid UB parts.

Correlation Kr85

- MSFC and IsoVac correlate 100%. All gross leaks and plugged devices were identified ,and fine leak rates were within <1/4 magnitude.
- IsoVac initial testing and ORS IGA correlate 100% proving these devices were all leakers at one time.

Future Work

Helium and Kr85 Desorption Issue

- Research and document the influence of component part material on resultant leak rate data

Instrument Correlation Study

- Receive parts back from RGA, reseal and test with CHLD to determine if parts are still plugged. SEM/EDS analysis and cross sectioning to identify source or areas of plugging.
- Support a second instrument correlation study of MIL-STD-883 devices

Leak Standard Development

- Ensure hermeticity of fabricated devices, machine holes and obtain standardized gross flow rates, and obtain leak rate data
- Conduct patent research and obtain NIST certification

Test Method Optimization

- Provide input to optimize specifications based on the knowledge gained during correlation studies, part testing, and research efforts

NASA Electronic Parts and Packaging (NEPP) Hermeticity Task Overview

Questions?

Correlation Without OLT

Part	System	Order of Testing	Fine a	Fine b	Fine c	Fine d	Fine e	Fine Results	Order of Testing	Gross a	Gross b	Gross c	Gross d	Gross e	Gross Results
Set 1	Kr85	IsoVac (Pass/Fail)						5/5	IsoVac (Pass/Fail)						5/5
(TO-18)	CHLD	CHLD:MSFC	P	P	G	P	G	2/5	CHLD: GSFC	P		P		P	2/5
0.0345 cc		CHLD: GSFC	P	P	P	P	P	0/5	CHLD: MSFC	P		P	P	P	1/5
	K85	IsoVac	P	P	P	P	P	0/5	IsoVac	P	P	P	P	P	0/5
		MSFC	P	P	P	P	P	0/5	MSFC	P	P	P	P	P	0/5
		IsoVac (Red Dye)	P	P	P	P	P	0/5	IsoVac (Red Dye)	N/A	P	N/A	N/A	P	0/2
	RGA	ORS						5/5	ORS						5/5

Part	System	Order of Testing	Fine a	Fine b	Fine c	Fine d	Fine e	Fine Results	Gross a	Gross b	Gross c	Gross d	Gross e	Gross Results
Set 2	Kr85	IsoVac (Pass/Fail)						5/5						5/5
(TO-5)	CHLD	MSFC	2.5E-08	G	G	G	1.6E-08	5/5				1.2E-08	1.2E-08	5/5
0.2244 cc		GSFC	2.5E-08	G	3.4E-08	2.5E-08	1.8E-08	5/5	3.7E-08	3.8E-08		1.5E-08	1.6E-08	5/5
	Kr85	MSFC	P	1.6E-08	P	4.1E-08	P	2/5	1.7E-08	P		P	P	2/5
		IsoVac (Final)	P	2.4E-08	P	3.9E-08	P	2/5	1.7E-08	P		P	P	2/5
	RGA	ORS						5/5						5/5

Part	System	Order of Testing	Fine a	Fine b	Fine c	Fine d	Fine e	Fine Results	Gross a	Gross b	Gross c	Gross d	Gross e	Gross Results
	Kr85	IsoVac (Pass/Fail)						5/5						5/5
	CHLD	MSFC	P	P	P	P	P	0/5						5/5
Set 3		GSFC	P	P	P	P	P	0/5						5/5
(ceramic)	Kr85	IsoVac	P	P	P	P	P	0/5						5/5
0.0026 cc		MSFC	P	P	P	P	P	0/5						5/5
		IsoVac (Red Dye)	P	P	P	P	P	0/5	N/A					
	RGA	ORS						5/5						5/5

Test Specifics: CHLD

							He Bombing			CHLD Set Values				Testing	
Group	Desc.	LDC	Volume (cc)	L (air) (atm-cc/sec)	Item	SN's	Pressure (psig)	Time (hr)	R1 (He) (atm-cc/sec)	Chamber	Insert (mm)	GLT	Method	Dwell (min)	Test Order
Set 1	2N2907A	0937*	0.0345	5.00E-09	Fine	1-5	60	90	8.03E-09	Small	7/11	1.00E-09	20/3/30/30/3	20/24	SN
(T0-18)					Gross	B07, B19, B27, B37, B42	60	90	8.03E-09	Small	7/7	5.00E-10	10/3/10/10/3	40/45	SN
Set 2	2N2219A	1009	0.2244	5.00E-09	Fine	6-10	60	4	5.96E-11	Small	13/7	1.00E-09	10/3/10/10/3	10/14	SN
(T0-5)					Gross	1-5	60	2	2.98E-11	Sm/Med	13/11	1.00E-09	20/3/50/50/5	12/14	SN
Set 3	4 Leaded		0.0026	1.00E-09	Fine	6-10	60	2	1.00E-10	Small	7/7	1.00E-09	10/3/10/10/3	11/6	SN
(ceramic)	Lug				Gross	1-5	60	2	1.00E-10	Small	7/7	1.00E-09	10/3/10/10/3	10/9	SN

Raw Data: CHLD

		Sample #	CHLD					
			GSFC			MSFC		
			atm-cc/sec He	atm-cc/sec Air	Jud	atm-cc/sec He	atm-cc/sec Air	Jud
Set 1 TO-18	Fine	a	3.96E-09	Pass	P	3.25E-09	Pass	P
		b	3.09E-09	Pass	P	2.50E-09	Pass	P
		c	2.62E-09	Pass	P	Gross	Gross	G
		d	2.32E-09	Pass	P	1.82E-09	Pass	P
		e	2.53E-09	Pass	P	Gross	Gross	G
	Gross	a	1.79E-09	Pass	P	2.25E-09	Pass	P
		b	Gross	Gross	G	Gross	Gross	G
		c	1.73E-09	Pass	P	2.12E-09	Pass	P
		d	Gross	Gross	G	2.01E-09	Pass	P
		e	1.46E-09	Pass	P	1.90E-09	Pass	P
TO-5	Fine	a	1.41E-09	2.46E-08	F	1.42E-09	2.47E-08	F
		b	Gross	Gross	G	Gross	Gross	G
		c	2.70E-09	3.40E-08	F	Gross	Gross	G
		d	1.49E-09	2.53E-08	F	Gross	Gross	G
		e	7.78E-10	1.83E-08	F	5.82E-10	1.58E-08	F
	Gross	a	1.59E-09	3.70E-08	F	Gross	Gross	G
		b	1.68E-09	3.80E-08	F	Gross	Gross	G
		c	Gross	Gross	G	Gross	Gross	G
		d	2.81E-10	1.55E-08	F	1.80E-10	1.24E-08	F
		e	3.03E-10	1.61E-08	F	1.73E-10	1.22E-08	F
UB	Fine	a	6.63E-11	Pass	P	5.37E-11	Pass	P
		b	4.12E-11	Pass	P	4.99E-11	Pass	P
		c	5.91E-11	Pass	P	4.38E-11	Pass	P
		d	4.30E-11	Pass	P	4.19E-11	Pass	P
		e	4.36E-11	Pass	P	3.98E-11	Pass	P
	Gross	a	Gross	Gross	G	Gross	Gross	G
		b	Gross	Gross	G	Gross	Gross	G
		c	Gross	Gross	G	Gross	Gross	G
		d	Gross	Gross	G	Gross	Gross	G
		e	Gross	Gross	G	Gross	Gross	G

Test Specifics: OLT

- OLT was performed by NorCom Systems Inc (located in Norristown PA) using NorCom 2020
  - NorCom 2020 resolution: 15nm
  - Pressurization gas: Helium

Parameters	TO-5	TO-18*	UB package
Package Cavity [cc]	0.2244	0.0345	
Test Time	10 hours	5 hours	Could not be tested in OLT
Helium pressure +/- modulation [psi]	57.3psi +/- 2	57.3psi +/- 2	
Fine Leak Limit (L_2) [atm cc/sec He]	1.37e-08	1.37e-08	
Test Sensitivity of NorCom 2020 for this part†	6.0e-9	3.7e-09	
Fine Leak Limit (L) [atm cc/sec air] per MIL-STD-750	5e-09	5e-09	
Number of parts tested	10	10	

(*) TO-18 lid stiffness and package size are right at the edge of NorCom 2020 detection capability

(†) Conversion L= L_2/2.69 results in L values that are tighter than stated in MIL-STD-750

Raw Data: OLT

		Sample #	OLT NorCom		
			atm-cc/sec He	atm-cc/sec Air	Judge
Set 1 TO-18	Fine	a	Gross	Gross	G
		b	3.31E-08	1.23E-08	F
		c	4.97E-08	1.85E-08	F
		d	Pass	Pass	P
		e	Gross	5.00E-06	G
	Gross	a	No Data	No Data	ND
		b	Gross	5.00E-06	G
		c	2.48E-07	9.22E-08	F
		d	3.38E-08	1.26E-08	F
		e	Pass	Pass	P
TO-5	Fine	a	Pass	Pass	P
		b	7.85E-08	2.92E-08	F
		c	Pass	Pass	P
		d	2.24E-08	8.33E-09	F
		e	Pass	Pass	P
	Gross	a	Pass	Pass	P
		b	Pass	Pass	P
		c	Gross	Gross	G
		d	Pass	Pass	P
		e	Pass	Pass	P
UB	Fine	a	No Data	No Data	ND
		b	No Data	No Data	ND
		c	No Data	No Data	ND
		d	No Data	No Data	ND
		e	No Data	No Data	ND
	Gross	a	No Data	No Data	ND
		b	No Data	No Data	ND
		c	No Data	No Data	ND
		d	No Data	No Data	ND
		e	No Data	No Data	ND

Test Specifics: MSFC Kr85

Mark V System Parameters	Leak Test	Bomb Conditions		
		TO-18	T0-5	UB
SA = 230 µCi/atm-cc K = 14,444 CPM/µCi R = 500 CPM	Gross	75 psia @ 0.03 hours		
	Fine	Q_s = 2.9 X 10^{-9} atm-cc/sec Kr P = 75 psia T = 0.57 hrs	Q_s = 5.8 X 10^{-10} atm-cc/sec Kr P = 75 psia T = 2.87 hrs	

Raw Data: Kr85

			Kr 85							
		Sample #	IsoVac			IsoVac Red Dye		MSFC		
			atm-cc/sec Kr	atm-cc/sec Air				atm-cc/sec Kr	atm-cc/sec Air	Judgement
Set 1	Fine	a	PASS	PASS	P	PASS	PASS	PASS	PASS	P
TO-18		b	PASS	PASS	P	PASS	PASS	PASS	PASS	P
		c	PASS	PASS	P	PASS	PASS	PASS	PASS	P
		d	PASS	PASS	P	PASS	PASS	PASS	PASS	P
		e	PASS	PASS	P	PASS	PASS	PASS	PASS	P
	Gross	a	2.00E-08	3.42E-08	F			4.46E-07	7.63E-07	F
		b	Gross	Gross	G			Gross	Gross	G
		c	PASS	PASS	P	PASS	PASS	PASS	PASS	P
		d	1.80E-08	3.08E-08	F			PASS	PASS	P
		e	PASS	PASS	P	PASS	PASS	PASS	PASS	P
TO-5	Fine	a	PASS	PASS	P			PASS	0.00E+00	P
		b	1.40E-08	2.39E-08	F			9.3E-09	1.59E-08	F
		c	2.75E-09	4.70E-09	P			1.2E-09	2.05E-09	P
		d	2.30E-08	3.93E-08	F			2.40E-08	4.10E-08	F
		e	PASS	PASS	P			PASS	PASS	P
	Gross	a	1.00E-08	1.71E-08	F			1.00E-08	1.71E-08	F
		b	PASS	PASS	P			PASS	PASS	P
		c	Gross	Gross	G			Gross	Gross	G
		d	PASS	PASS	P			PASS	PASS	P
		e	PASS	PASS	P			PASS	PASS	P
UB	Fine	a	PASS	PASS	P	PASS	PASS	PASS	PASS	P
		b	PASS	PASS	P	PASS	PASS	PASS	PASS	P
		c	PASS	PASS	P	PASS	PASS	PASS	PASS	P
		d	PASS	PASS	P	PASS	PASS	PASS	PASS	P
		e	PASS	PASS	P	PASS	PASS	PASS	PASS	P
	Gross	a	Gross	Gross	G			Gross	Gross	G
		b	Gross	Gross	G			Gross	Gross	G
		c	Gross	Gross	G			Gross	Gross	G
		d	Gross	Gross	G			Gross	Gross	G
		e	Gross	Gross	G			Gross	Gross	G

What are the leak rate limits?

- **MIL-STD-750E, Test Method 1071.9 "Hermetic Seal"**
  - *Equivalent standard leak rates (atm cc/s air) for volumes:*
    - ❑ $\leq$ 0.002 cc: 5 X 10^{-10}
    - ❑ > 0.002 and $\leq$ 0.05 cc: 1 X 10^{-9}
    - ❑ > 0.02 and $\leq$ 0.5 cc: 5 X 10^{-9}
    - ❑ > 0.5 cc: 1 X 10^{-8}
- **MIL-STD-883H, Test Method 1014.13 "Seal"**
  - *Equivalent standard leak rates (atm cc/s air) for volumes:*
    - ❑ $\leq$ 0.01 cc: 5 X 10^{-8}
    - ❑ > 0.01 and $\leq$ 0.5 cc: 1 X 10^{-7}
    - ❑ > 0.5 cc: 1 X 10^{-6}

OVERVIEW

How do we determine optimum leak rate requirements?

Leak Rates : Vol cc : Time to Exchange 50% atmoshphere

Volume	1.00E-06	5.00E-07	1.00E-07	5.00E-08	1.00E-08	5.00E-09	1.00E-09	5.00E-10
0.002 cc	0.4 *Hrs*	0.8 *Hrs*	3.9 *Hrs*	7.7 *Hrs*	1.6 *Days*	3.2 *Days*	16.0 *Days*	32 *Days*
0.01 cc	1.9 *Hrs*	3.9 *Hrs*	1 *Days*	2 *Days*	8.0 *Days*	16 *Days*	80 *Days*	160.5 *Days*
0.1 cc	19 *Hrs*	2 *Days*	8 *Days*	16 *Days*	80.2 *Days*	160 *Days*	2.2 *Years*	4.4 *Years*
0.4 cc	3 *Days*	6 *Days*	32 *Days*	64 *Days*	321 *Years*	2 *Years*	8.8 *Years*	17.6 *Years*
0.75 cc	6 *Days*	12 *Days*	60 *Days*	120.3 *Days*	2 *Years*	3 *Years*	16 *Years*	33.0 *Years*
1 cc	8 *Days*	16 *Days*	80 *Days*	160.5 *Days*	2 *Years*	4 *Years*	22 *Years*	44 *Years*
3 cc	24 *Days*	48 *Days*	240.7 *Years*	1.3 *Years*	7 *Years*	13 *Years*	66 *Years*	132 *Years*
5 cc	40 *Days*	80 *Days*	1.1 *Years*	2.2 *Years*	11 *Years*	22 *Years*	110 *Years*	220 *Years*
8 cc	64 *Days*	128.4 *Days*	1.8 *Years*	3.5 *Years*	18 *Years*	35 *Years*	176 *Years*	352 *Years*
10 cc	80 *Days*	160.5 *Days*	2.2 *Years*	4.4 *Years*	22 *Years*	44 *Years*	220 *Years*	440 *Years*
12 cc	96 *Days*	192.5 *Days*	2.6 *Years*	5.3 *Years*	26 *Years*	53 *Years*	264 *Years*	528 *Years*
15 cc	120.3 *Days*	240.7 *Days*	3.3 *Years*	6.6 *Years*	33 *Years*	66 *Years*	330 *Years*	659 *Years*

Volume	1.00E-10
0.002 cc	**4.4** ***Years***

Volume	5.00E-11
0.002 cc	**320.9** ***Days***

Volume	1.00E-11
0.01 cc	**2.2** ***Years***

$$P_t = P_0 e^{-(kt)}$$

$$k = \frac{\text{leak rate}}{\text{vol cc}}$$

t = *time (sec)*

This "Exchange Table" shows the number of 'hours,' 'days,' or 'years' required for a device to ingest 50% of the atmoshphere to which it is exposed, based on the volume of the part, (cc), and the leak rate of the part.

These exchange values have been studied and confirmed using Kr85 measured leak rates and IGA evaluation.

Yellow: MIL-STD-883 TM 1014 Leak Rate Limits

Green: MIL-STD-750 TM 1071 Leak Rate Limits

OVERVIEW

How do we determine optimum leak rate requirements?

Leak Rates : Vol cc : Time to Exchange 90% atmoshphere

Volume	1.00E-06	5.00E-07	1.00E-07	5.00E-08	1.00E-08	5.00E-09	1.00E-09	5.00E-10
0.002 cc	1.3 Hrs	2.6 Hrs	12.8 Hrs	1.1 Days	5.3 Days	10.7 Days	53.3 Days	107 Days
0.01 cc	6.4 Hrs	12.8 Hrs	3 Days	5 Days	26.7 Days	53 Days	267 Days	1.5 Years
0.1 cc	3 Days	5 Days	27 Days	53 Days	266.5 Days	1 Years	7.3 Years	14.6 Years
0.4 cc	11 Days	21 Days	107 Days	213 Days	3 Years	6 Years	29.2 Years	58.4 Years
0.75 cc	20 Days	40 Days	200 Days	1.1 Years	5 Years	11 Years	55 Years	109.5 Years
1 cc	27 Days	53 Days	267 Days	1.5 Years	7 Years	15 Years	73 Years	146 Years
3 cc	80 Days	160 Days	2.2 Years	4.4 Years	22 Years	44 Years	219 Years	438 Years
5 cc	133 Days	267 Days	3.7 Years	7.3 Years	37 Years	73 Years	365 Years	730 Years
8 cc	213 Days	1.2 Years	5.8 Years	11.7 Years	58 Years	117 Years	584 Years	1,168 Years
10 cc	267 Days	1.5 Years	7.3 Years	14.6 Years	73 Years	146 Years	730 Years	1,460 Years
12 cc	320 Days	1.8 Years	8.8 Years	17.5 Years	88 Years	175 Years	876 Years	1,752 Years
15 cc	1.1 Years	2.2 Years	10.95 Years	21.9 Years	109.5 Years	219 Years	1,095 Years	2,190 Years

Volume	1.00E-10
0.01 cc	7.3 Years

Volume	5.00E-11
0.002 cc	2.9 Years

Volume	1.00E-11
0.002 cc	14.6 Years

$$P_t = P_0 e^{-(kt)}$$

$$k = \frac{\text{leak rate}}{\text{vol cc}}$$

t = time (sec)

This "Exchange Table" shows the number of 'hours,' 'days,' or 'years' required for a device to ingest 90% of the atmosphere to which it is exposed, based on the volume of the part, (cc), and the leak rate of the part.

These exchange values have been studied and confirmed using Kr85 measured leak rates and IGA evaluation.

(Yellow) MIL-STD-883 TM 1014 Leak Rate Limits

(Green) MIL-STD-750 TM 1071 Leak Rate Limits