Experience with cumulative He leak detection (CHLD)

Adaption of MIL-STD-883/J requirements

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V. Bergaplass, Kongsberg Norspace AS, ESCCON 2016

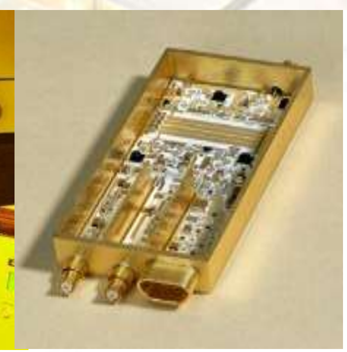
Scope

- Kongsberg Norspace company introduction
- Seal test standard
  - MIL-STD-883, issue j
- CHLD principle
- CHLD experience

History & background

- 1984: Start of space activity
- 1986: Separate company: AME Space AS
- 1988: MBO
- 1989 - 2003: Subsidiary of Alcatel (now Thales Alenia Space):
  - Alcatel Space Norway (ASN)
- 2003: ASN closed down, Norspace AS created
- 2004: MBO (Take-over of assets, certain contracts, obligations and facility from ASN)
- 2011: Acquired by Kongsberg Defence Systems, change name to Kongsberg Norspace






Kongsberg - Norspace

- 30 years experience as world class global supplier of analogue and microwave electronic equipment and components for satellites and launchers
- On-board 170 satellites in orbit
  - Analogue Signal (IF) Processing / Frequency Converters
  - Frequency Generation
  - Search & Rescue Transponders
  - Telemetry, Tracking and Command
- Building blocks; SAW filters and modules, signal amplifiers, filter banks, frequency converters, switch matrices, frequency synthesizers, VCOs

Main Products and Applications

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- Analogue signal processing electronics for satellite payloads
- Frequency generation and distribution
- Telemetry, Tracking and Command units
- Building blocks & modules:
  - SAW filters, amplifiers, converter modules, VCOs, switches etc.

Express AM.
C-L and L-C Converters.
48 units delivered

Terrestar.
IF-S and S-IF converters.
16 units delivered.
648 converter channels

TT&C products
C, Ku and Ka band
43 units delivered, 10 in progress

Galileosat FGUU
IF-L band
30 units delivered / in progress
132 converter channels

SAW filters
Amplifier Hybrids
Converter Hybrids

Search & Rescue Transponder
30 units delivered / in progress

SAW Filters and SAW Modules

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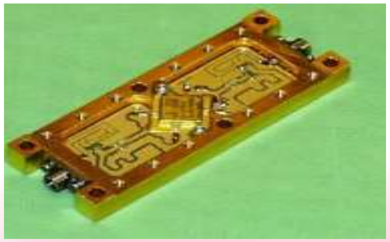

Solidaridad
NSTAR
Globalstar
ACeS
ICO
Thuraya
MT-Sat 1, 1R & 2
Anik F2
Inmarsat 4
Hotbirds
XM Radio
Worldstar
Syracuse 1,2,3
AMC 15/16
Skynet 5
Galileo
TerreStar
ICO Global
MUOS
Alphasat
Express AM4,5,6,7,8
MSG & MTG

- Applications
  - Baseband converters for digital onboard processing
  - IF (or RF) analog processors
  - UHF/L-band transponders
  - TTC Receivers
  - Frequency sources
- Functions
  - Channel Filters
  - Antialiasing / Mirror reject
  - Notch Filters
  - Resonator Filters

european space agency
agence spatiale européenne

Certificate of Technology Flow Qualification No. 313A

This is to certify that Kongsberg Norspace AS, Horten, Norway has been qualified by ESA for the supply of SAW Filters, Hermetically Sealed, Surface Mount, Frequency Range 10 MHz to 4 GHz based on process flows NORSF-C1 and A1 for use in ESA space programmes, according to the ESCC Qualified Manufacturers List, Basic specification 25400, Generic Specification 3502 and associated Detail Specification 3502/002.

This certificate is valid until January 2016.

Head of the Product Assurance and Safety Department

Date 11 March 2014

- Performances
  - Center Frequency 20 MHz - 3 GHz
  - Bandwidth: 0.1-300 MHz
  - Pass band ripple
    - amplitude: 0.3-1.0 dBpp
    - phase: 2-6 degpp
  - Insertion loss: 3-30 dB
  - Shape factor down to 1.15
  - Stopband rejection: 40-60 dB
- Heritage
  - 14.000 SAW devices supplied
  - 9.000 in orbit in ~140 satellites
  - >750 million hours (>85.000 years) accumulated operating life
- ESA Qualified
  - According to ESCC QML

Signal amplifiers

- Hermetically sealed surface mount packages; solder pins or plugs
- As specified or adapted to specific customer needs
- Frequency range up to Ku-band

Product Reference	Freq. Range [GHz]	Gain [dB]	NF [dB]	IP3 [dBm]	Voltage [V]	Current [mA]
STH-2130	0.001 – 0.25	14	5.0	27	5	40
STH-2135	0.001 – 0.25	14	5.0	20	5	20
STH-2140	1.0 - 3.0	13.5	3.5	23	5	42
STH-2145	1.0 - 3.0	13.5	2.5	18	5	22
STH-2150	0.02 – 1.0	13	4.5	25	5	42
STH-2155	0.02 - 1.0	13	2.0	20	5	20
STH-2170	1.0 - 3.0	24	3.5	25	5	60
STH-2175	1.0 – 2.0	24	3.0	23	5	48

Seal test method 1014

- MIL-STD-883, issue J, Method 1014 (June 2013)

Internal Free Volume of package (cm^3)	L Failure Criteria atm-cm^3/sec (air) Hybrid Classes B and H, and Monolithic Classes B, S, Q and V	L Failure Criteria atm-cm^3/sec (air) Hybrid Classes S and K only
≤ 0.05	$5 X 10^{-8}$	$1 X 10^{-9}$
>0.05 - ≤ 0.4	$1 X 10^{-7}$	$5 X 10^{-9}$
> 0.4	$1 X 10^{-6}$	$1 X 10^{-8}$

New requirement for classes S and K: up to 2 orders of magnitude stricter.

Pending ESA and DLA (Defense Logistics Agency) extension on implementation

Seal test method, motivation

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NASA Electronic Parts NEPP and Packaging Program

Atmospheric Exchange

NASA

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 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.

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

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

isoVac Engineering Inc. EST. 1969

K. Laird, P. McManus: NASA NEPP 2014 workshop (http://nepp.nasa.gov/workshops/etw2014/)

Seal test method, options

- MIL-STD-883, issue J, Method 1014 (June 2013)

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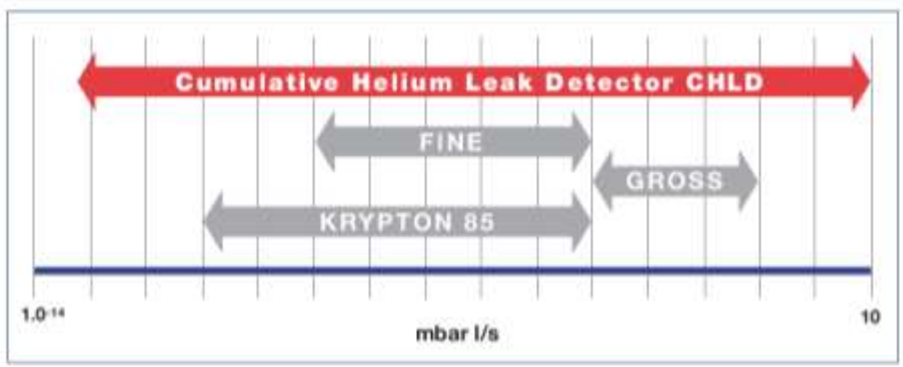
3 methods are considered capable with respect to sensitivity:

- Optical Leak Test (OLT)
- Cumulative Helium Leak detection (CHLD)
- Radioisotope Kr-85



Graph: Dynamic leak detection range of CHLD technology vs. other methods

From Inficon CHLD sell-sheet

CHLD, operating procedure

Procedure:

1. He bombing of parts “as usual” with He leak methods.
2. Preforming gross and fine leak combined (~2 minutes)

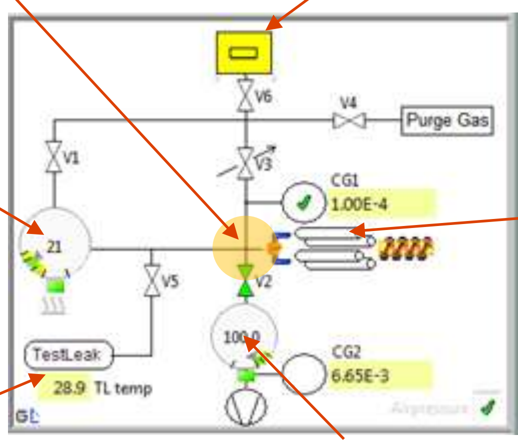
CHLD, principle

- Instrumentation:
  - Test chamber
  - cryo pump controlled at 20K
  - Mass analyzer

“Measuring spot”

Test chamber

Temperature controlled cryo pump



Mass analyzer

Calibrated leak reference

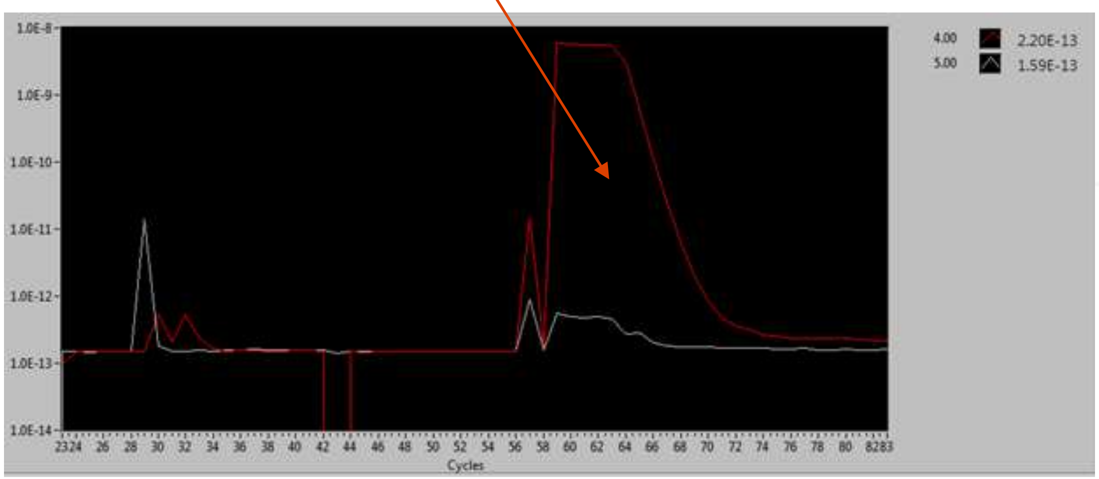
Turbo pump

CHLD, principle

Gross leak:

- Measure He content of all air in test chamber

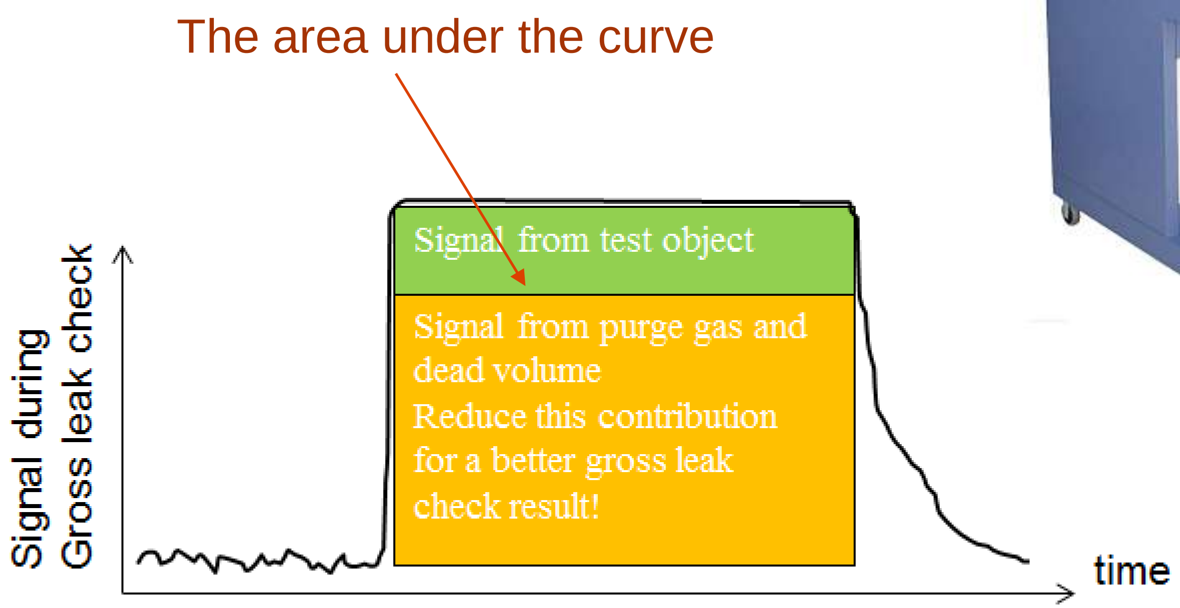
The area under the curve



CHLD, principle

Gross leak:

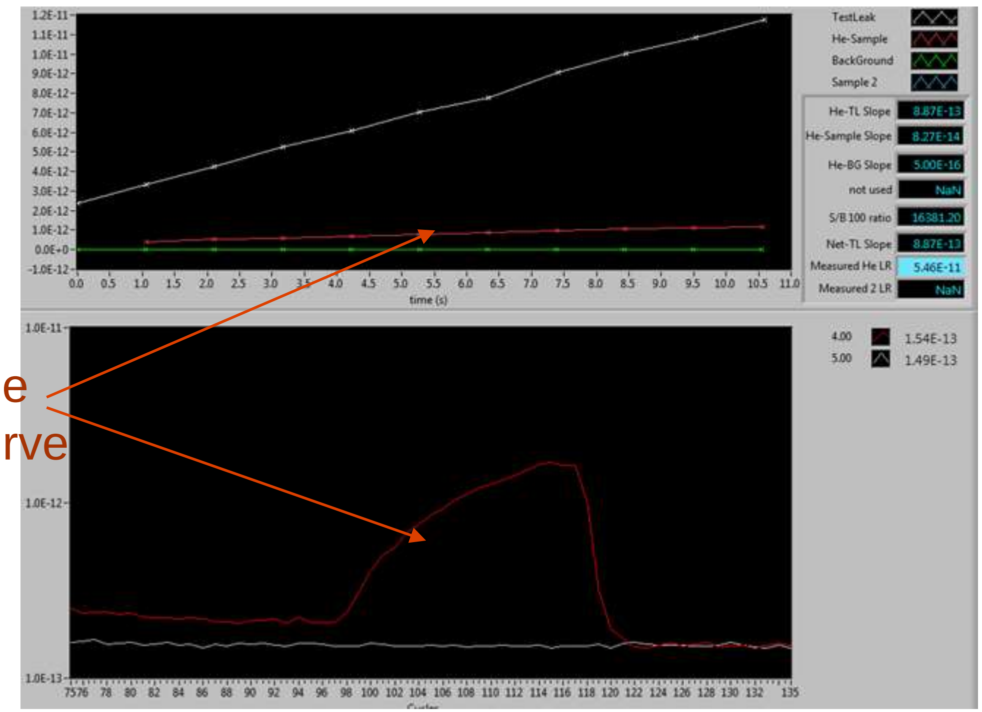
– Measure He content of all air in test chamber



CHLD, principle

Fine leak:

- Cumulative measuring the amount of He, integration for a periode of time



The slope of the curve

CHLD, experience

- Easy to implement as fine leak instrument.
- Gross leak test is not theoretically well-established, but we find it to be robust.
- The overlap between gross and fine leak is several orders of magnitude.

- Some challenges to reach new, stricter fine leak limits
  - More sensitive to He-trapping in both samples and instrumentation
    - Some process corrections needed (He-bombing and dwell)
  - Package manufacturers have no tools to guarantee hermeticity according to new requirements
    - Unsealed package test (condition A4) corresponds to old requirement
    - We experience bad yield, especially with glass feed through involved.

- Benefits:
  - No need for Flurorocarbon fluids for gross leak
    - No clogging of leak paths
    - We experience a way better correlation between leak results and RGA results
  - Sensitivity:
    - easily an order of 2 better than traditional He-leak equipment
    - By optimization: another order of magnitude

Thank you!

Any questions?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