Failure Analysis on Radiflo® Rejects

IsoVac Engineering, Inc.
Purpose of this Review

It was requested that IsoVac present data to substantiate the Historical Leak Testing Technology and findings that are associated with Military Standards being reviewed today.

Background:
IsoVac was founded in 1969, and set up a Radiflo and Helium leak test lab for test & failure analysis.
IsoVac has performed thousands of Test Programs for Space & Military Agencies, Military suppliers, and Commercial Organizations as ‘leak testing services’, ‘research studies’, and ‘failure analysis’.

IsoVac test labs have Leak Tested over 15 million devices to the MIL-STDs, as well as special “High-Sensitivity” callouts.
Leak Rate Ranges

Gross Leak Range

Viscous Flow

Molecular Flow

Fine Leak Range

E -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -11 -12
We have been asked if there has ever been any studies that produced data that shows any “Correlation” between Helium mass spec and Krypron85 tests.

The following data shows some of the test programs that provided that data to DSCC and JEDEC to substantiate inclusion of the radioisotope gross and fine leak tests in the MIL-STDs.

It also shows failures found in devices that were previously tested on HMS and F/C.
Some of the correlation studies conducted between Kr85 users & HMS users:

- Motorola “TO-5” R-3726*
- JPL 65 “14/16 lead DIPS R-3829; W/O 14958*
- ASTM “Round Robin” Correlation*
- Northrop Hybrids *
- Litton G&C Hybrids-ICs: R-3820; W/O 14694*
- Litton G&C Hybrids ICs: R-3821; W/O 14702*
- Intel Returns: 12 ea - LCC & E-Proms*
- Litton G&C Hybrids ICs: R-3826; W/O 14845*
- Litton G&C Hybrids-ICs: R-3827; W/O 14845*
Motorola
Radiflo/Helium correlation IV Report R-3726
61,000 - TO-5 Transistors were tested:
1,350 Kr85 leakers were detected.

All leakers were “Punctured” & HMS confirmed:
280ea leaked > 10^-6 [ 92%-header 8%-Weld ]
610 ea (10^-6 to 10^-7) [ 87% header 13% weld ]
460 ea (10^-7 to 10^-8) [ 73% header 27% weld ]

Most of the devices displayed Molecular flow, which would have prevented the detection by bubble test, even though some leak rates were > 10^-6.
Screening of ‘As Received’ Parts

All parts previously leak-tested by manufacturer

- Transistors, diodes, ICs, photo cells, etc
- Lot Failures: 3 large lots
  - 7.7%; 16.9%; 21% (gross*; 10-6*; 10-7*; 10-8)

(*Devices were Radiflo tested and Red Dye confirmed: IV Report R-3829; W/O 14958)
ASTM-Kr85 Round Robin Correlation

ASTM attempted a ‘Round-Robin’ test on HMS at different facilities. Stan Ruthberg of NBS attempted this 3 times with total failure beyond 2 facilities.

- Stan Ruthberg-NBS; & Dr. Byron Martin-IBM, and George Neff-IsoVac, set up a ‘Round Robin’ for 11 Radiflo facilities using 100 parts: (50 Fine Leaks- to 10^-9) (25 Gross leaks > 10^-6) (25 non-leakers).
Parts were taken by NBS to 11 sites with Radiflo equipment.

Parts 1st “Pre-read”, then run for Gross/Fine Quantitative data.

Produced 1,100 data points with less than 1 standard deviation.

Data reported at JEDEC & Physics of Failure Conference.
In the following test programs it is important to note the leak rate ranges of the parts that were detected:

- The devices included ICs and Hybrids
- Some tests were over 15 years ago, others were within the last 5 years.
- Large gross leakers were detected, especially in smaller cavity parts.
- Most of the other parts were >0.4 cm³
- The fine leaks detected were mostly in the \(10^{-7}\) to \(10^{-8}\) range, (below the spec limit).
Northrop Hybrids (He tested returns)  
3 of 4 failed with $10^{-6}$, $10^{-7}$, $10^{-8}$ leaks

Litton: as Received: Pre-tested (He) (F/C)  
176 Hybrids: 5 Failed (10$^{-7}$ to 10$^{-8}$)  
602-ICs Failed 10 (10$^{-6}$ to 10$^{-8}$)

Northrop “Peacekeeper” 4-Hybrids (He/FC)  
Failed 4 with $10^{-6}$ to 8 x 10$^{-8}$ leaks (Glass seals)

Northrop 6 Hybrids (R-3891) All failed with radial cracks in glass (10$^{-7}$ range)

Hughes 135 Static-Rams: Pre-tested (He/FC)  
Failed 15 @10$^{-5}$ to 10$^{-6}$ Glass and lid seals
TRW: 8-Impatt Diodes ~ 0.001cc vol.
Failed 6: ceramic/lid seals and ceramic cracks

Intel Returns: 12 ea - LCC & E-Proms
Failed 9: Leaks $10^{-6}$ to $10^{-10}$

John Hopkins “Microwave Module” Pre-tested 3x
Leaked in $10^{-7}$ range

TRW 50 ea. 300mil S/B Pre-tested (He/FC)
Failed 11ea. “gross through $10^{-8}$ range”

TRW 52ea. IR-Diodes All “Pre-tested” (He/FC)
Failed 24 gross $>10^{-6}$; 2 fine $<10^{-6}$)
Burroughs: 500 18 lead CERDIPS: All Pre-tested
Failed 6.8% gross/fine to $10^{-8}$
Failed 1.6% Radiflo thermal test

RCA 151 ICs Received after He testing
Failed 14 gross leaks > $10^{-6}$
Failed 37 fine leaks $10^{-6}$ to $10^{-8}$

Raytheon 39 ICs (All pre-tested) (He/FC)
Failed 17 gross leaks > $10^{-6}$
Testing devices on circuit boards with Kr85

It is certainly possible to test devices mounted on circuit boards using Kr85.

- The boards are pressurized with Kr85
- The individual devices are then viewed with a Scintillation Crystal detector through a window in a lead plate, with the lead shielding any Kr85 trapped in the PCB
- Thousands of parts have been tested on boards this way.
Intel **Circuit-board** leak testing - IV Report R-3824

2 PCBs: 72 ea ICs + discretes

Radiflo tested and ICs measured through window in lead plate over scintillation crystal.

Nine (9) leakers detected. \((10^{-6} \text{ to } 10^{-8})\)

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**MIT/IsoVac** Radiflo **Circuit-Board** testing:

AF Sponsored MIT Program:

\(10^{-1} \text{ to } 2 \times 10^{-9}\): Detected both gross and fine leakers on boards;

7 leaking devices detected. (MIT published)
Photomicrographs of failed devices

The following are photos of devices that failed Kr85 leak tests and were confirmed using Red-Dye Penetrant.

The first seven pictures are of devices tested over five years ago.

The other 52 pictures are of devices tested within the last four years.

The sources are ‘Generic’ by request.
Impatt Diode Gross leak
HAC Return
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HAC Return
2 x 10-7 leak Northrop, “Failure” 24277
Litton “Cracked IC”  5 x 10^-7
TO package $10^{-5}$ leak “Return”
600 Mil Cerdip E-Prom “Escape”
“Escape” $10^{-7}$ leak
UB “Escape” (Return) (No seam seal)

IsoVac Engineering, Inc.
Red-Dye Gross-leak “Escape”
Hybrid feed-through leak ~ 10^{-6}
Air Force Cartridge “Field Failure”
AF-"Corrosion Failure"

Bridge-wire completely corroded away in a “Non-Hermetic” Impulse Cartridge”
Bio-Medical Non-Hermetic return
Hybrid with ceramic glass feedthroughs

$10^{-10}$ requirement

$10^{-7}$ leak rate
Gross-leak “Escape”
UB Escape Ceramic crack
“Return” Ceramic with Crack
Pin-Glass Seal-Leak $\sim 10^{-6}$
UB “Escape” Gross-Lid-Leak
UB Escape “No Seam Seal”
Northrop “Hybrid Return” $10^{-7}$ range Leak

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 IsoVac Engineering, Inc.
Northrop Hybrid ID & OD Leakage (10^{-7} range)
Northrop Hybrid feed through “Escape” $10^{-7}$ range
“Return” 10-7 Leak

IsoVac Engineering, Inc.
TO-5 “Escape” 10-6 Leak
Ceramic IC Gross Leak “Escape” Cracked Ceramic
10-7 leak, No Plating, No Meniscus
$10^{-13}$ “3+ years in Vacuum/Decay”
Return, Ceramic crack (5 x 10^-7)
5 x 10^{-7} \text{ Return}
~5 x 10^{-6} Hybrid seam seal leak
“Escape” $10^{-3}$ Window Leak
Hybrid 6 x 10^{-7} Leak
$10^{-6}$ Hybrid, “Epoxy Sealed” $<10^{-8}$
“TO-”, Glass “Stress-Cracks” (Return)
AF Glass/Header Leak
Glass-Crack “Escape”
AF Header-Wall-Interface
“Corrosion-Leak”
Hybrid “Thermal-Leak”

Passed 10-10
Thermal leak ~60°C
~ 1 x 10^-6
Hybrid “Escape” Thermal Leaker
TO-3 “Escape” 10^{-7} range Leak

Interior Dye

IsoVac Engineering, Inc.
“Escape” Gross Leak  “Pin-Stretch”
Hybrid Reject “Escape” (On PCB)
Return 10-7 leak

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Crack

IsoVac Engineering, Inc.
TO-3 “Escape” 10^{-7} range leak
Hybrid “Escape” 10^-7 leak
He/FC Escape  $10^{-7}$ range leak

- Radial cracks from pin out into glass
- Pin
- Wire Bond
He F/C escape “Thermal-leak” ($10^{-6}$)
Feed-through 10-7+ leak
Field return 10-7 range leak
UB Escape"
UB seam seal escape
UB seal-leak (gross leak)