EVALUATION OF PRESS-FIT CONNECTOR FOR SPACE-FLIGHT APPLICATIONS, FEEDBACK AND DESIGN IMPROVEMENTS

TÜV NORD GROUP

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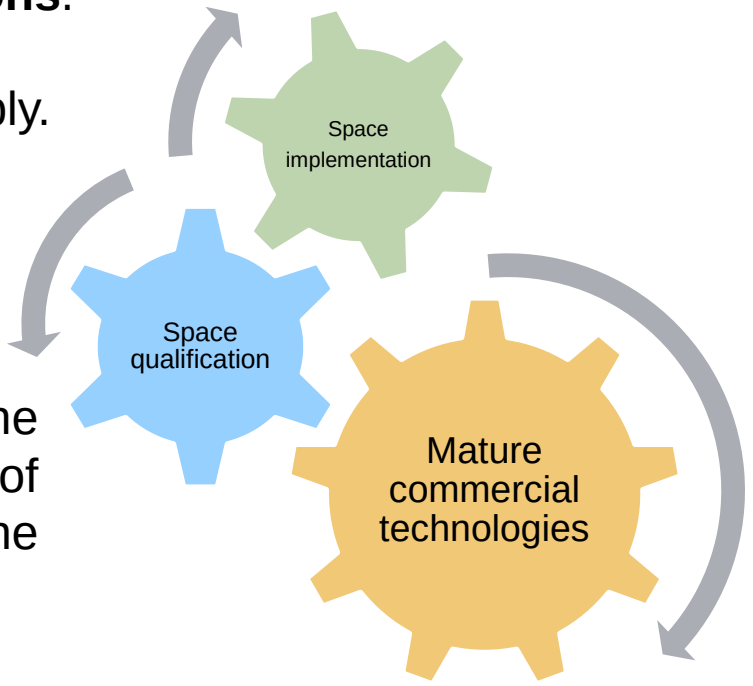
INTRODUCTION

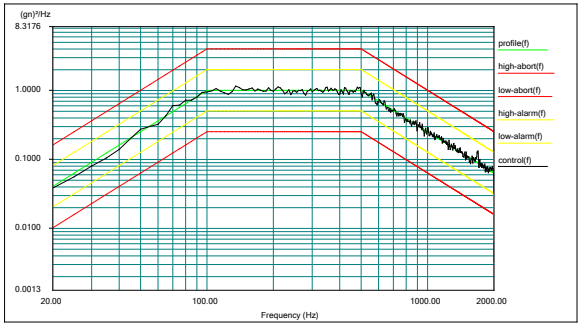
- Trends show an increasing demand for the **incorporation of new fabrication concepts and components** into the space industry. This requires for **fast and reliable evaluation processes** adapted to the specific system design and the characteristics.

- Press-fit technology is already consolidated in different industrial sectors and currently **is emerging for space applications**.
  - Solder-less alternative for PCB assembly.
  - Cost and time effective.

- This communication reports on the qualification process to asses the reliability of selected press-fit connector for the implementation in space applications.

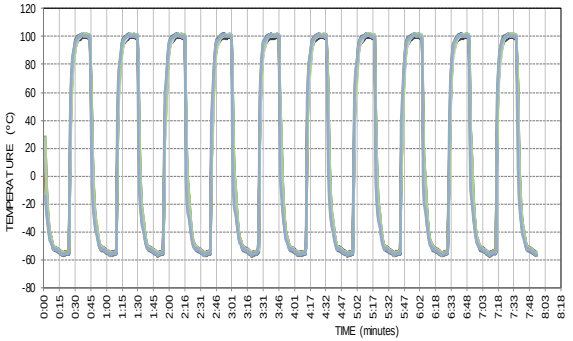


Thorough and accurate tests are conducted to determine the suitability for space applications

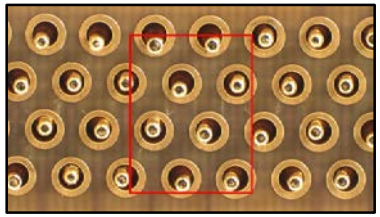


Environmental test

Vibration
and temperature cycling



Control visual inspections



Standard and high density connectors comply with the space regulation

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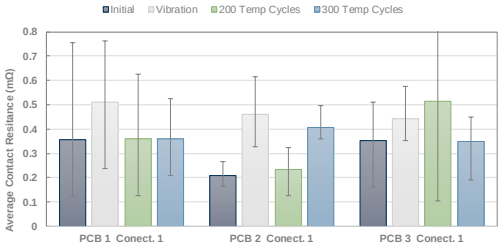
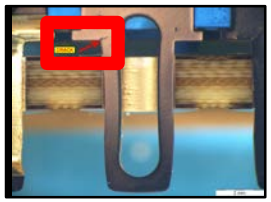
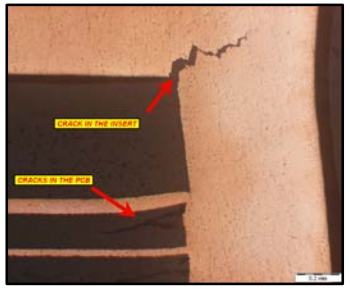
Control electrical measurements



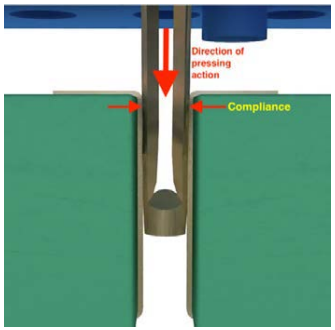
Microsectioning

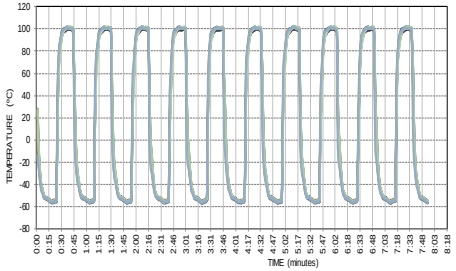
Microinspection

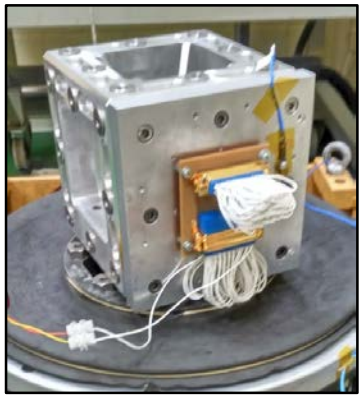




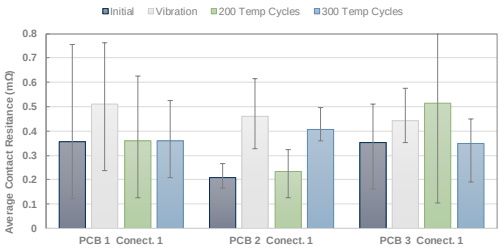
OUTLINE

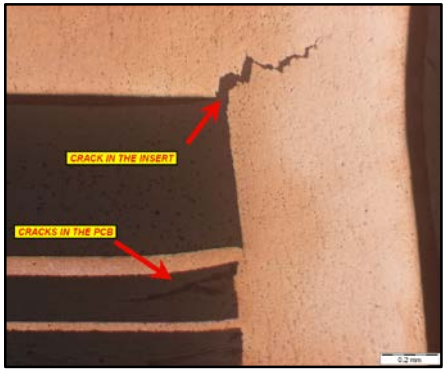






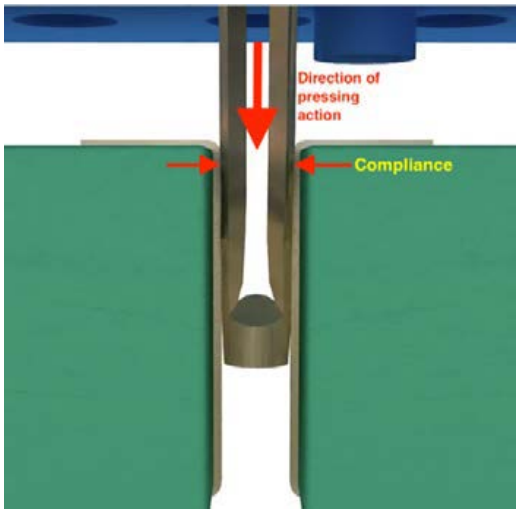
1. Compliant-Press-Fit concept
2. Test vehicles and test flow
3. Vibration test
4. Temperature cycling
5. Visual inspection and electrical verification control test
6. Micro section inspection
7. 2nd Generation
8. Summary



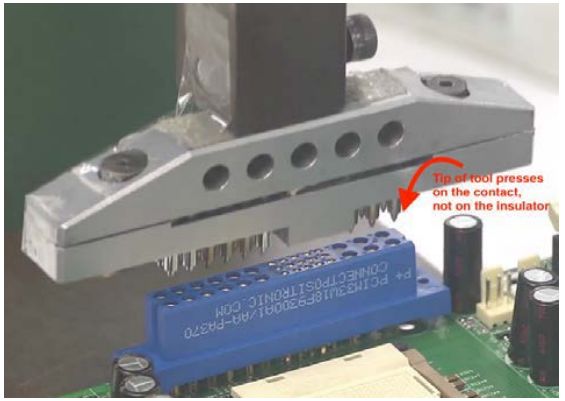


COMPLIANT-PRESS-FIT CONCEPT

- Deformable tail is inserted into a plate through hole (PTH).
- PTH slightly narrower than the insertion pin.
- Eye-of-the-needle design: The tail is adapted to the PTH at the same time that the spring-force ensures permanent low-resistivity electrical contact.



- Semiautomatic mounting tool to regulate the insertion force.



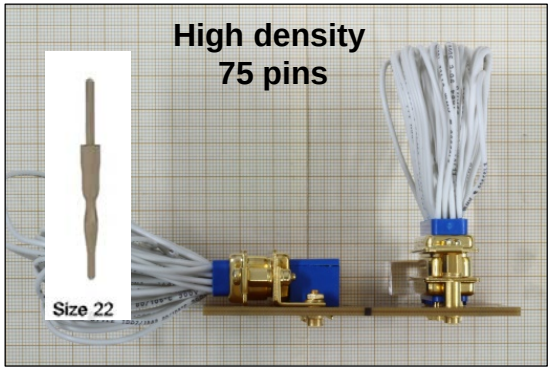
TEST VEHICLES

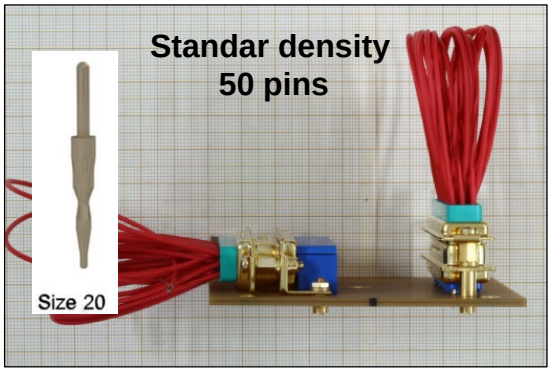
3 types of **press fit** connectors conceived for **different applications**:

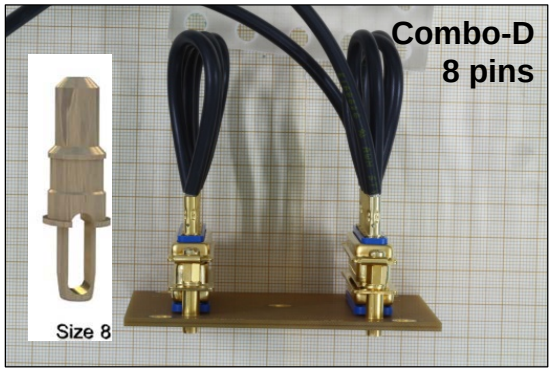
- ✓ Signal communication.
- ✓ Low power supply.
- ✓ High power supply.

General PCB characteristics

- 4 Cu layers of 2.4 mm of thickness
- Electroless Nickel Immersion Gold (ENIG)
- PTHs gold coating of 5 µm of thickness

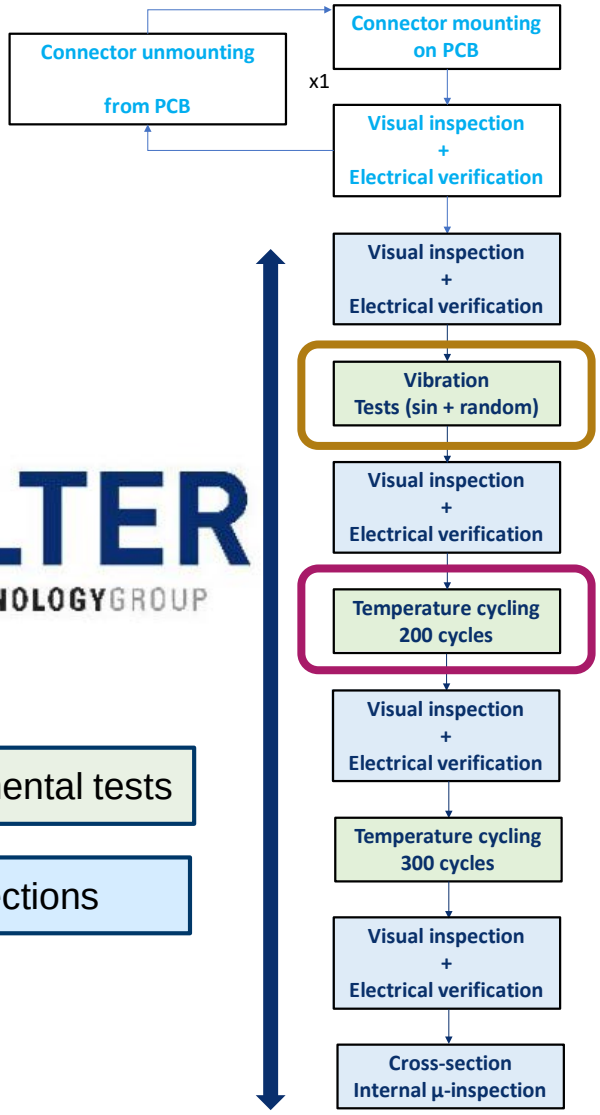






Denomination	Pin size	Number of pins	Intended aplication	Quantuty
High density	22	75	Singal comunication	3 PCBs with 2 connectors
Standard density	20	50	Low power supply	3 PCBs with 2 connectors
Combo-D	8	5	High power supply	3 PCBs with 2 connectors

TEST FLOW

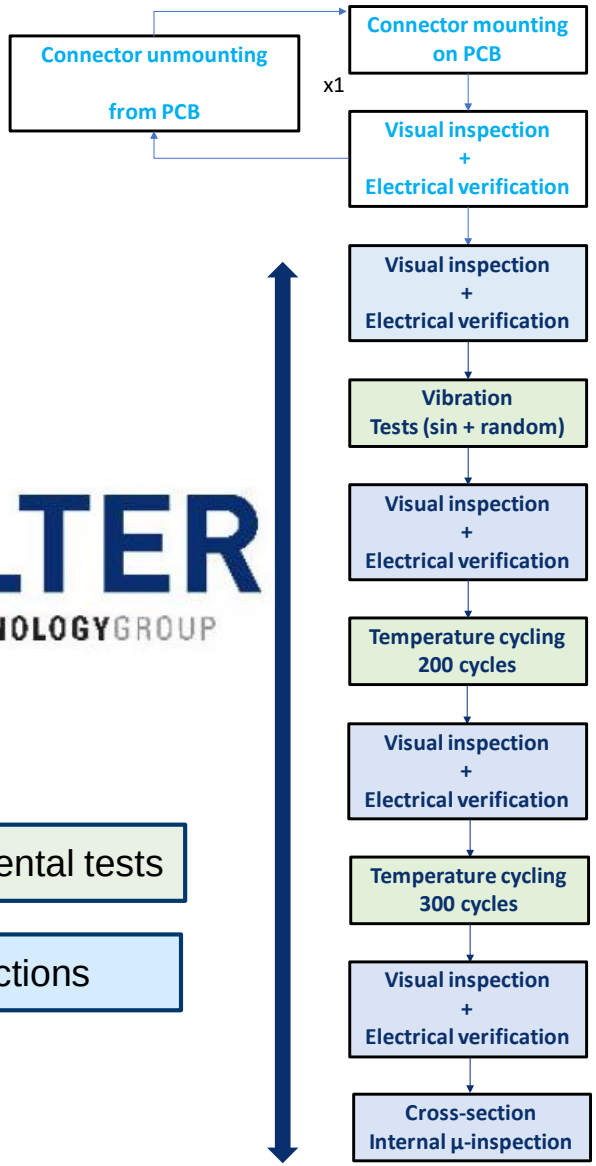


Environmental tests

Inspections

Qualification program adapted from ECSS-Q-ST-70-38C for surface mounting technology but **including harder requirements**

Test / inspection	Specification
Visual inspection	ESCC 20500
Electrical characterization	DENG-008-1 Rev. B § 7 (customer procedure)
Vibration	ECSS Q ST 70 08C § 13 (sine + random) **Additional provision µ-cuts ≥ 1 µs are not allowed**
Temperature Cycling	DENG-008-1 Rev. B Par. 14 -55 ºC to +100 ºC **abrupt thermal shock**
Cross-section µ-inspection	DENG-008-1 Rev. B



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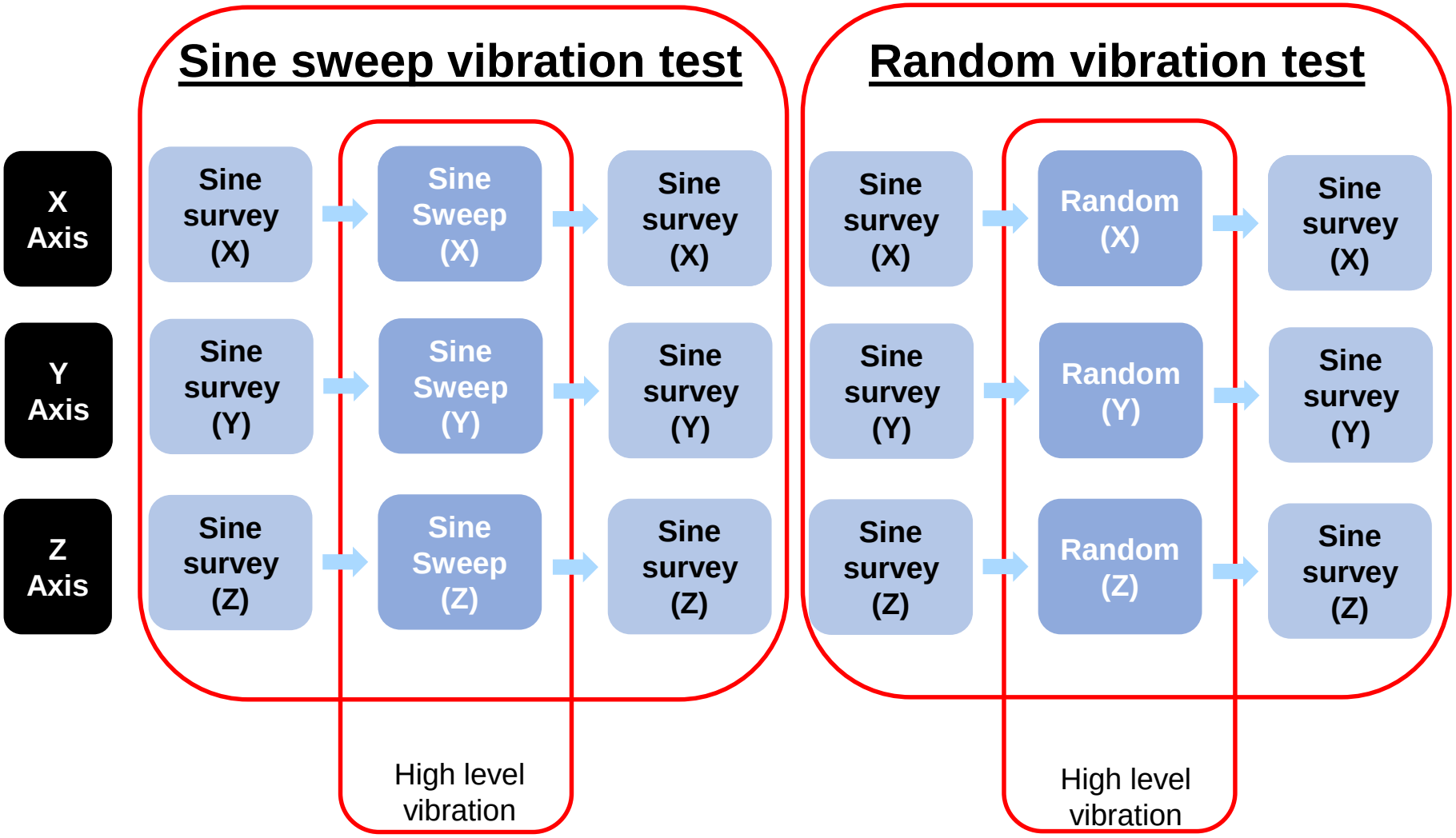
Environmental tests

Inspections

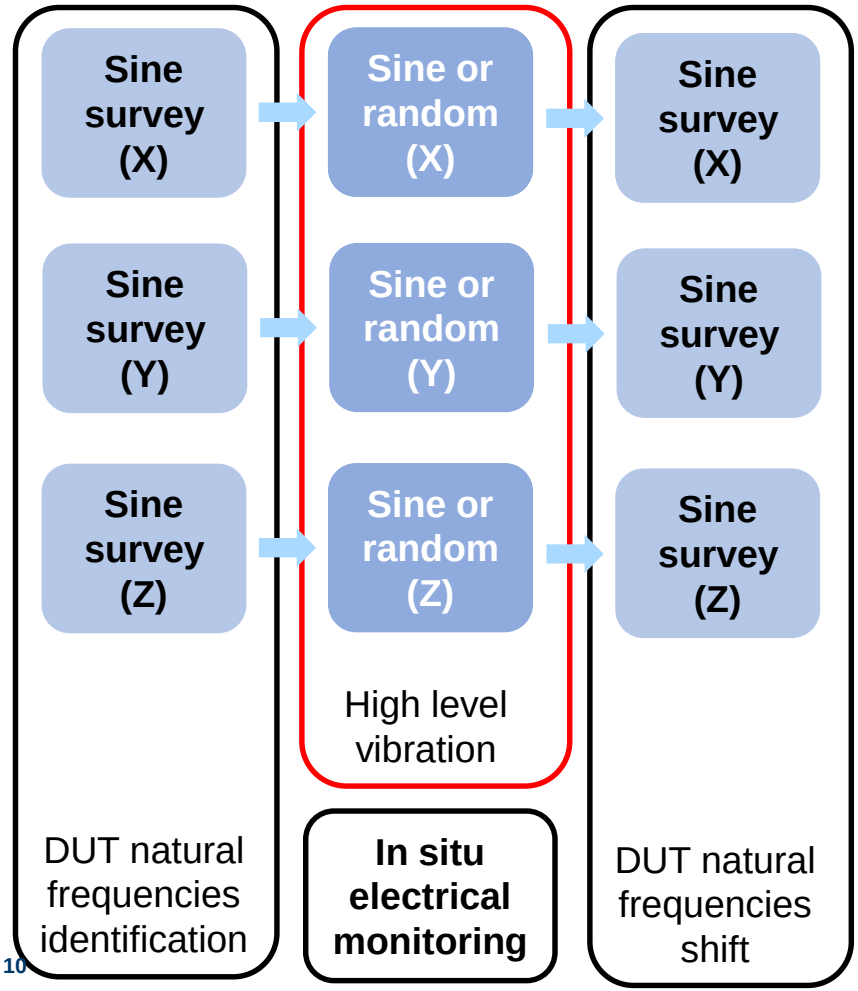
Vibration

VIBRATION TEST: TEST SEQUENCE



VIBRATION TEST: INSPECTED PARAMETERS

Sine sweep and random vibration tests



Inspected parameters

Electrical

Electrical discontinuities (in-situ)

Resistance drift (ex-situ)

Mechanical

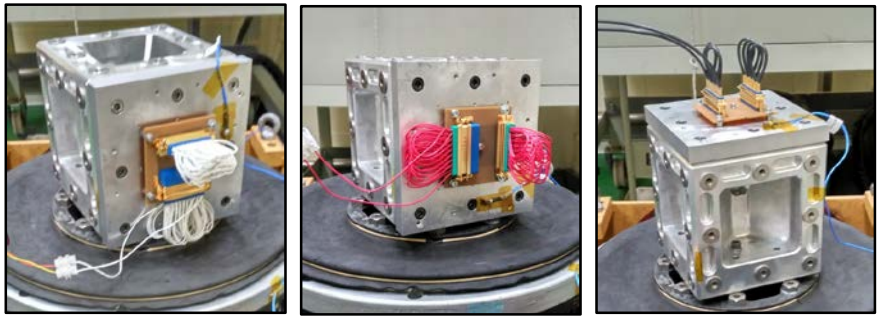
Natural frequencies (in-situ)

Visible damages (ex-situ)

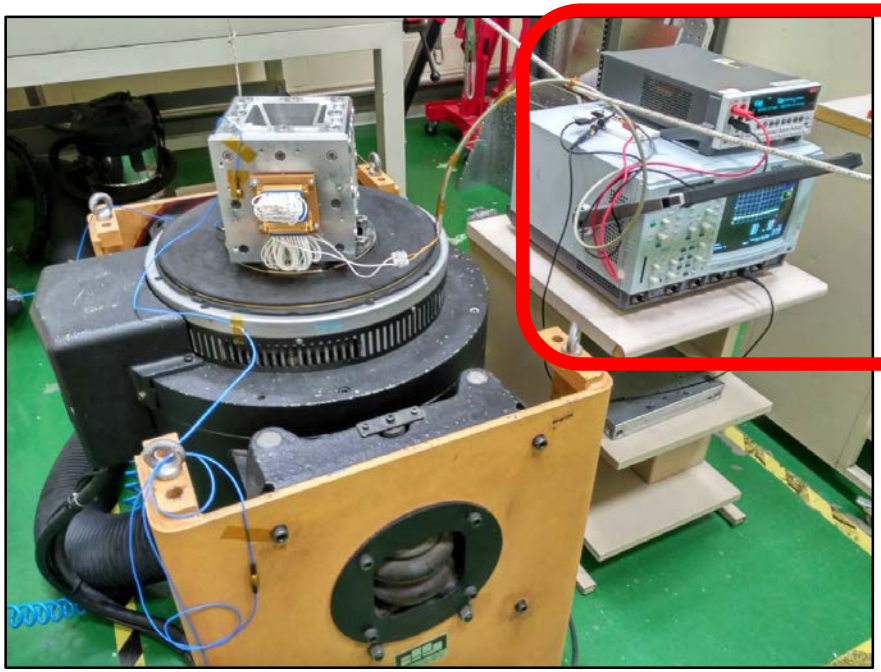
In-situ inspection

VIBRATION TEST: SET-UP

X-axis vibration | **Y-axis vibration** | **Z-axis vibration**

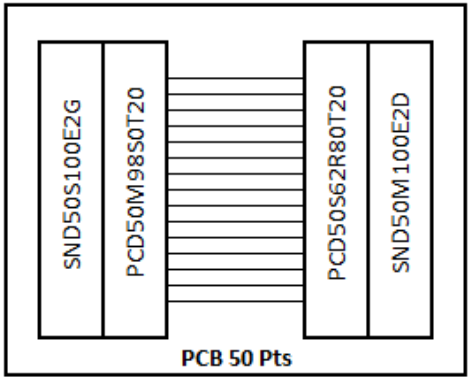


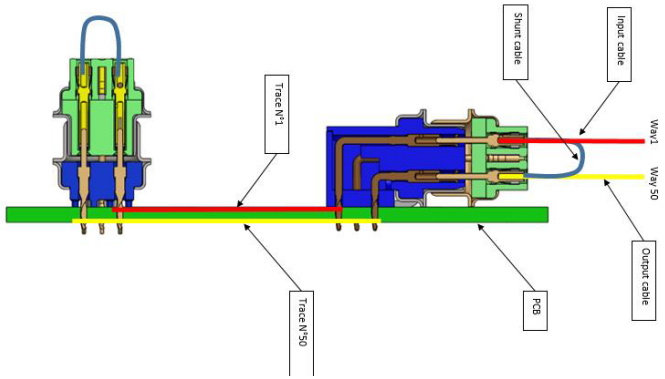
Vibration



Electrical monitoring

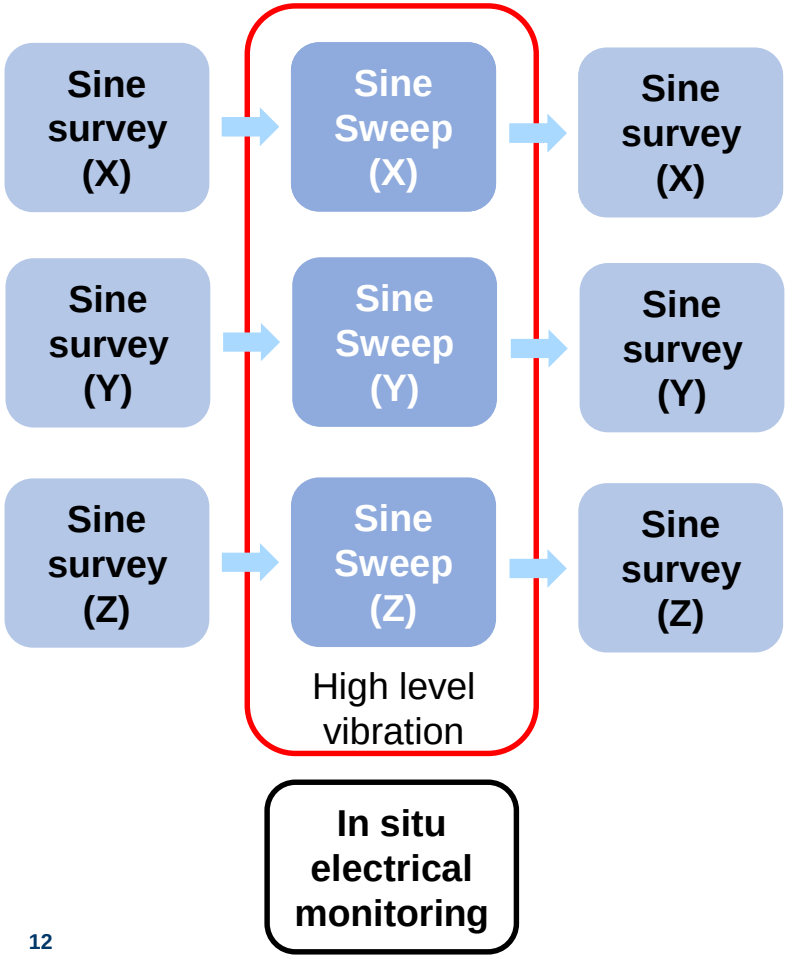
Daysi chain electrical monitoring



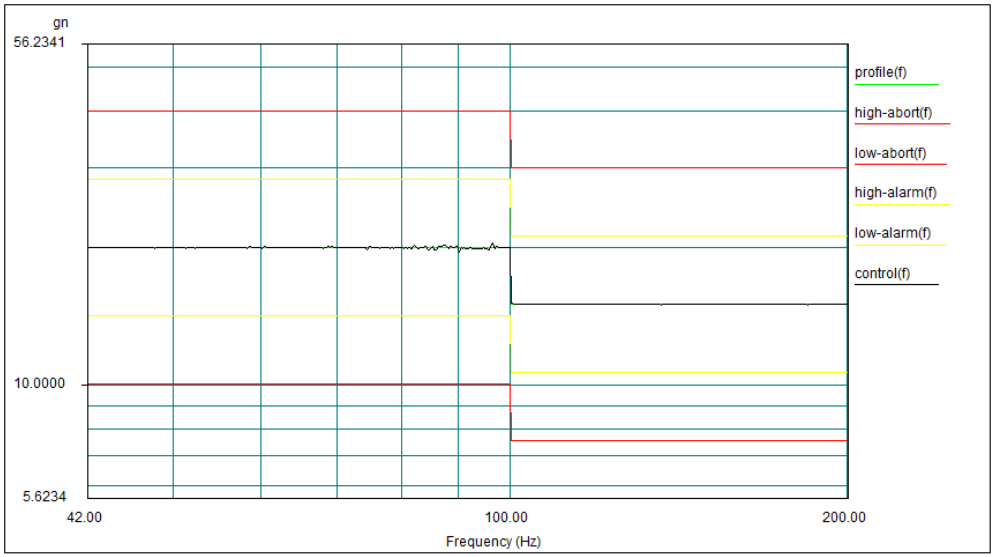


VIBRATION TEST: SINE SWEEP

No discontinuities longer than **1 µs** were observed

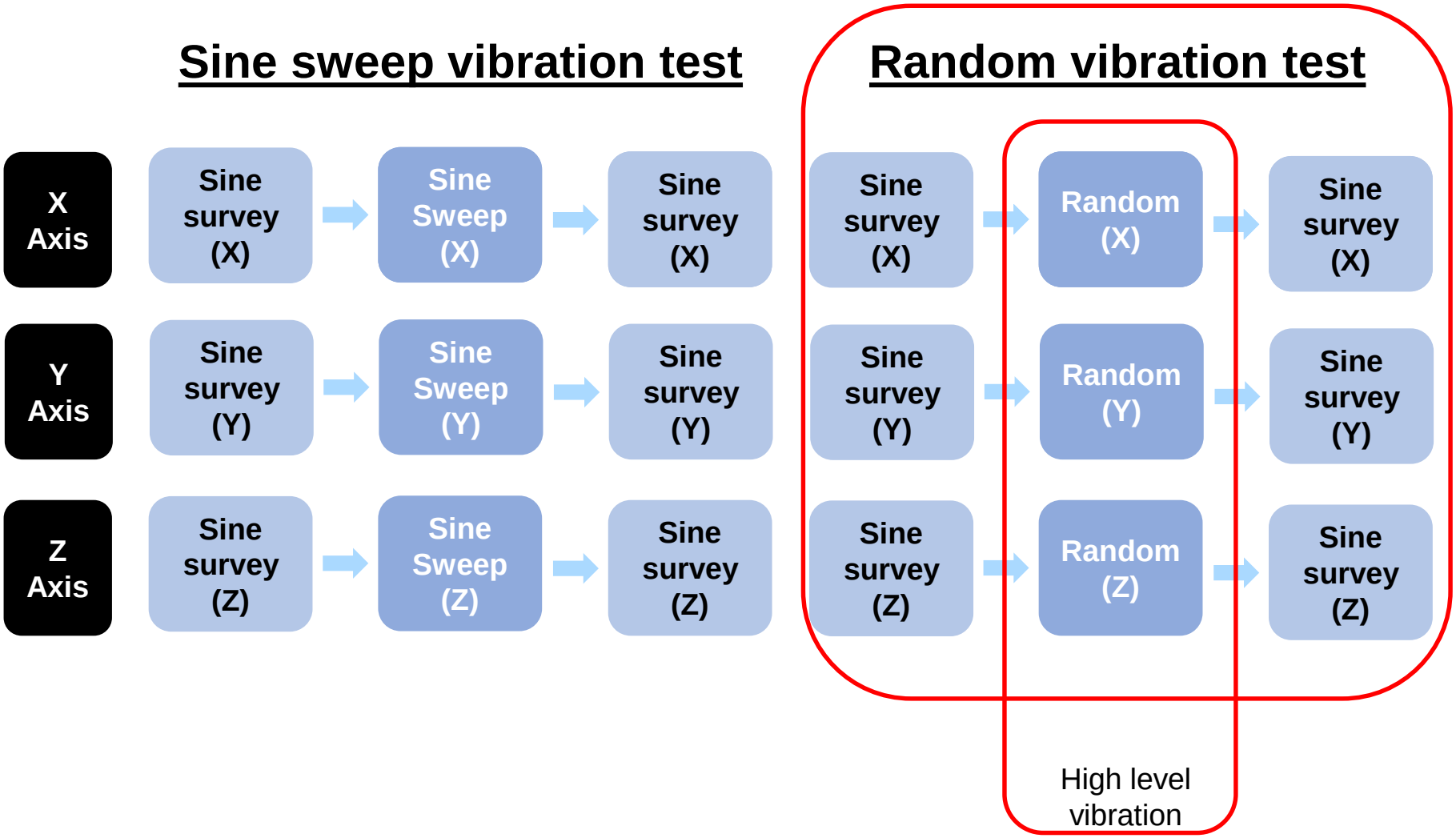


Vibration level follows the required profile neither resonances nor other deviations were observed



Sine Sweep conditions		
Range	Amplitude (0 to peak)	Sweep rate
25 to 100 Hz	20 g	1 oct/min
100 to 200 Hz	15 g	1 oct/min

VIBRATION TEST: RANDOM



VIBRATION TEST: RANDOM

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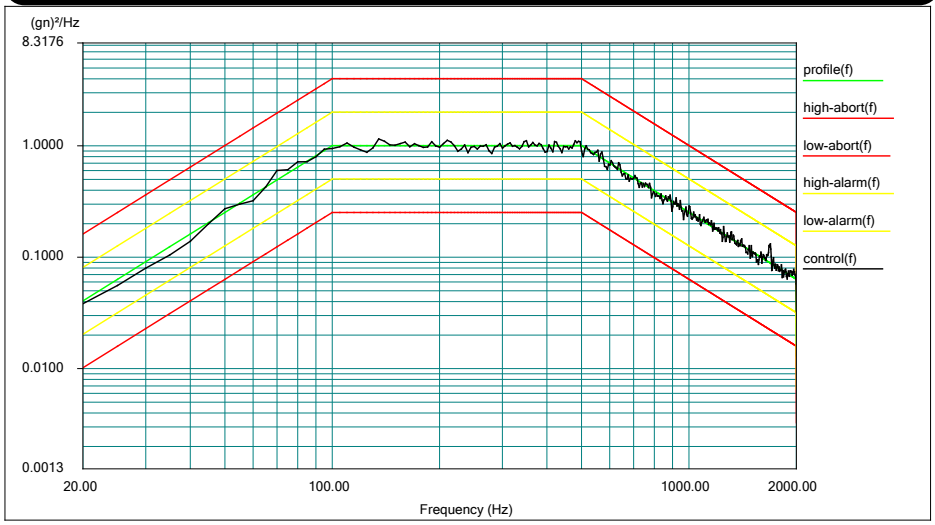
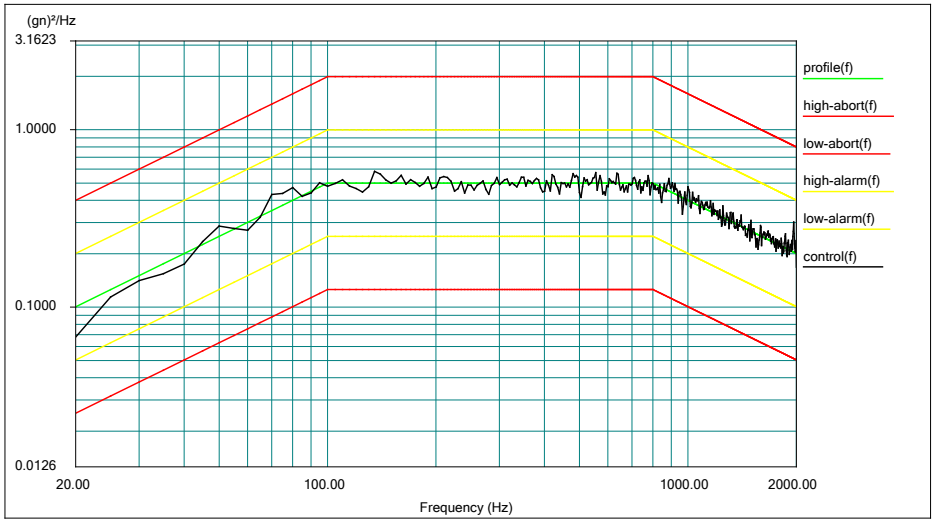




Vibration level confined within the required range.
Neither resonances nor other deviations were observed

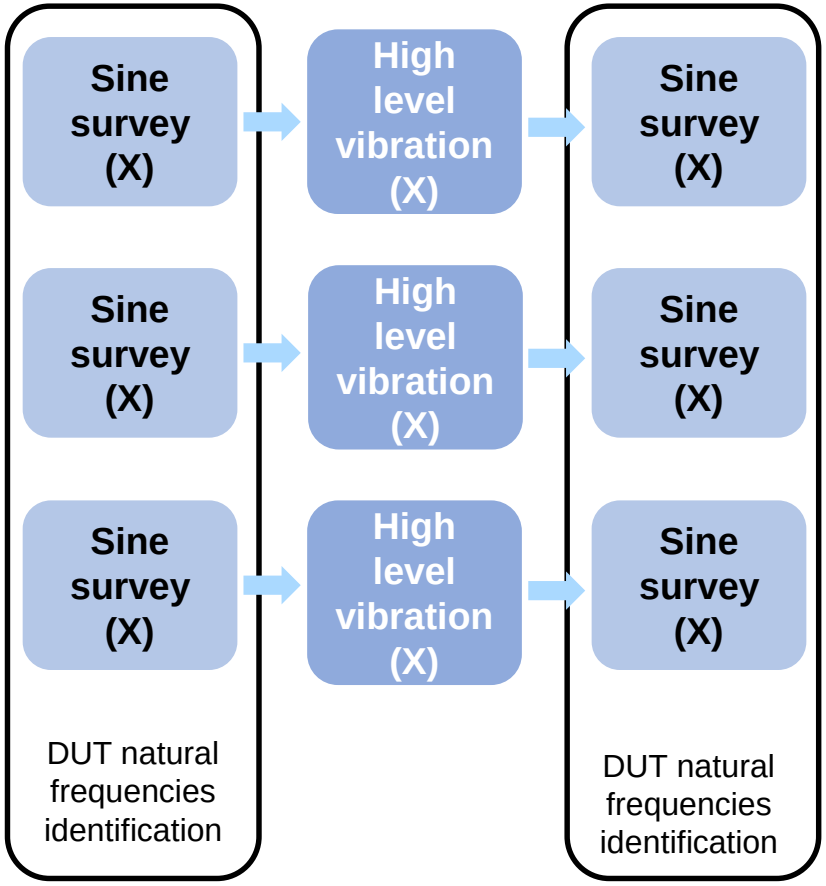
Perpendicular to PCB	
Range (Hz)	PSD level
20 to 100	+6 dB/oct (ramp)
100 to 500	1 g^2/Hz (plateau)
500 to 2000	-6 dB/oct (ramp)
Global RMS 28.5	

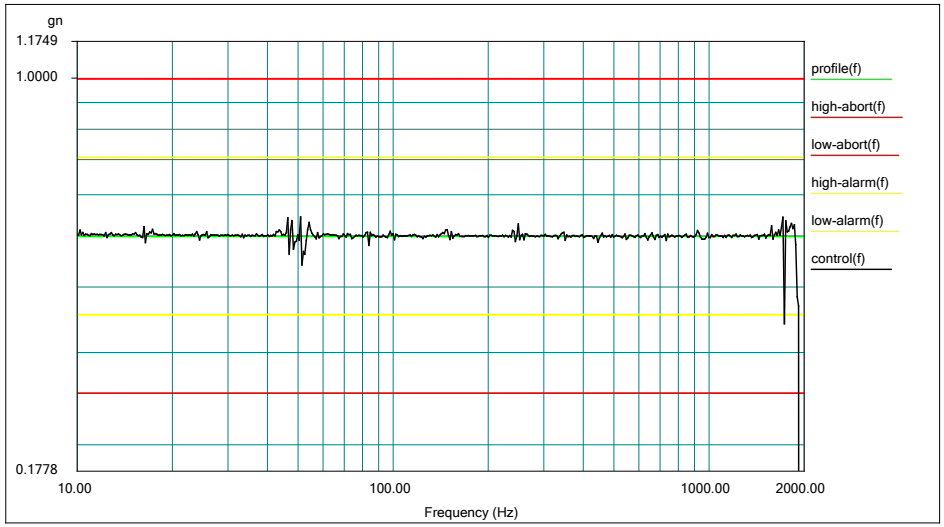
Parallel to PCB	
Range (Hz)	PSD level
20 to 100	+3 dB/oct (ramp)
100 to 800	0.5 g^2/Hz (plateu)
800 to 2000	-3 dB/oct (ramp)
Global RMS 27.1	

VIBRATION TEST: NATURAL FREQUENCIES

Sine survey

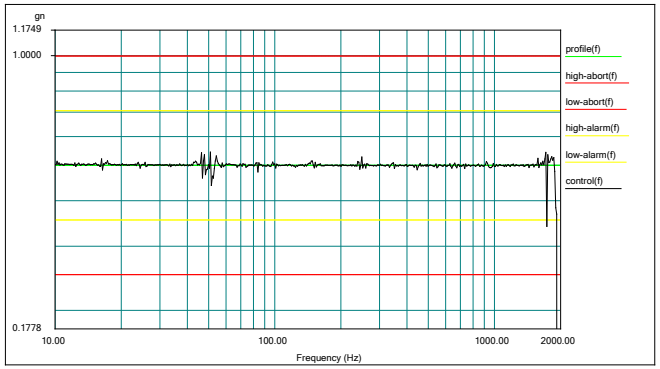
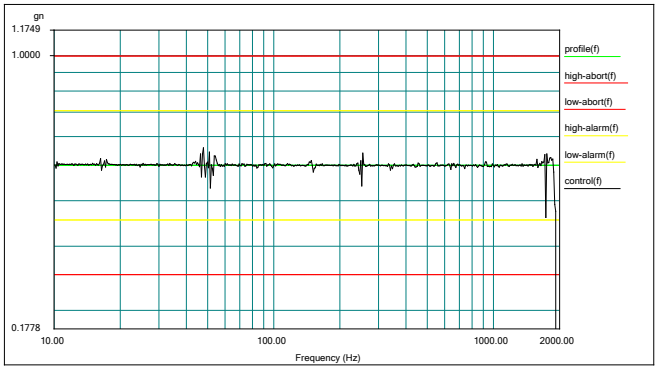
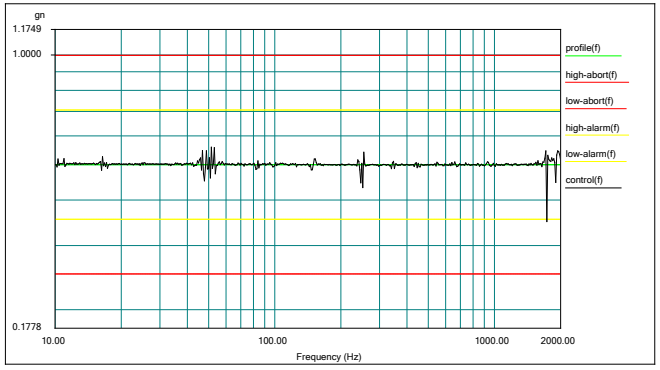
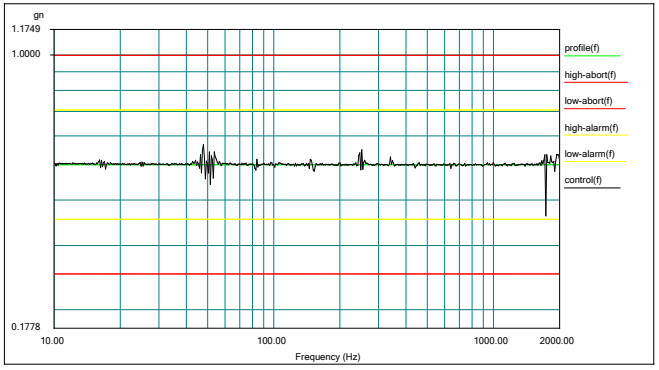
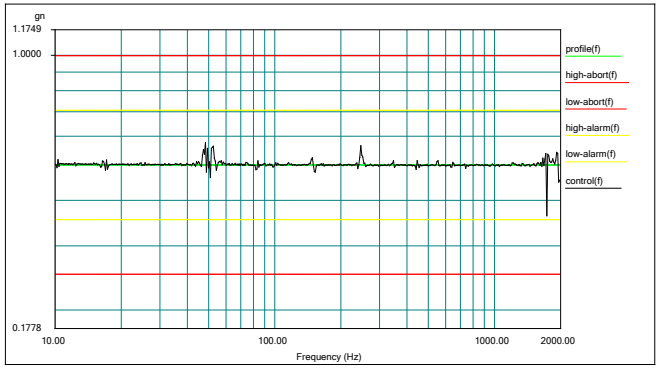
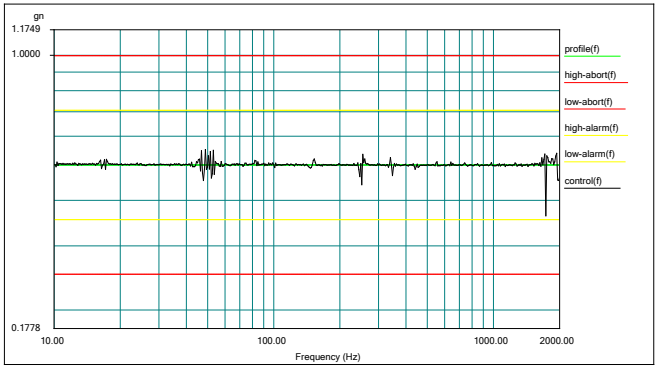
Natural frequencies analysis





Test conditions	
Amplitude	0.5 g (0 to peak)
Frequency	10 to 2000 Hz
Sweep rate	2 oct/min
Direction	X, Y & Z

VIBRATION TEST: NATURAL FREQUENCIES

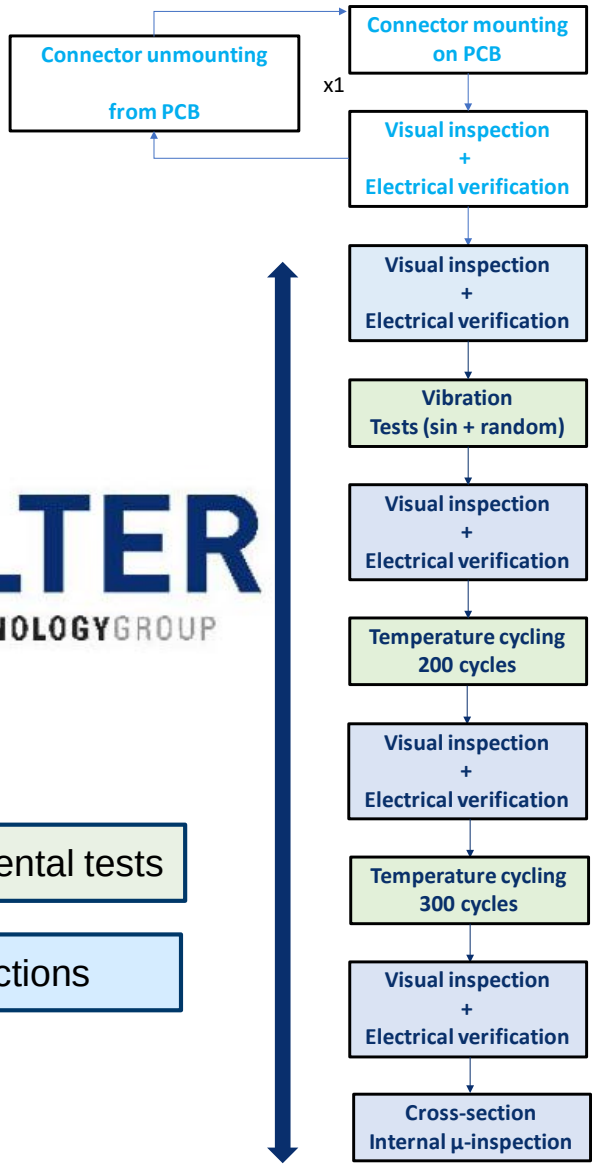
	Initial	After high level vibration
X- Axis		
Y- Axis		
Z- Axis		

After high level vibration

(sine sweep and random)

The DUT preserves its mechanical impedance.

No changes on the DUT **natural frequencies** are observed



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Environmental tests

Inspections

Temperature cycling

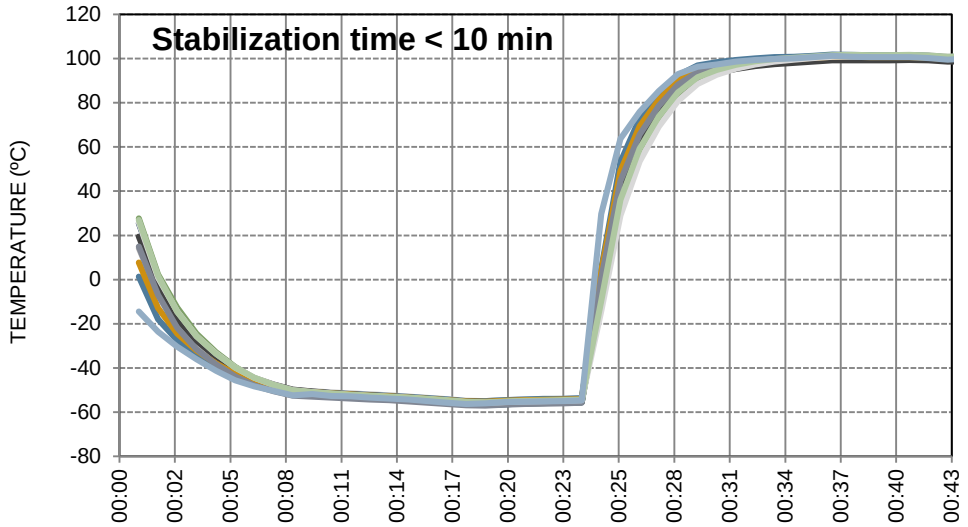
TEMPERATURE CYCLING: SET-UP AND CONDITIONS

High temperature	100 ºC
Low temperature	- 55 ºC
Soak time	15 min

ESA speciation for soldered connections imposes temperature ramps < 10 ºC/min

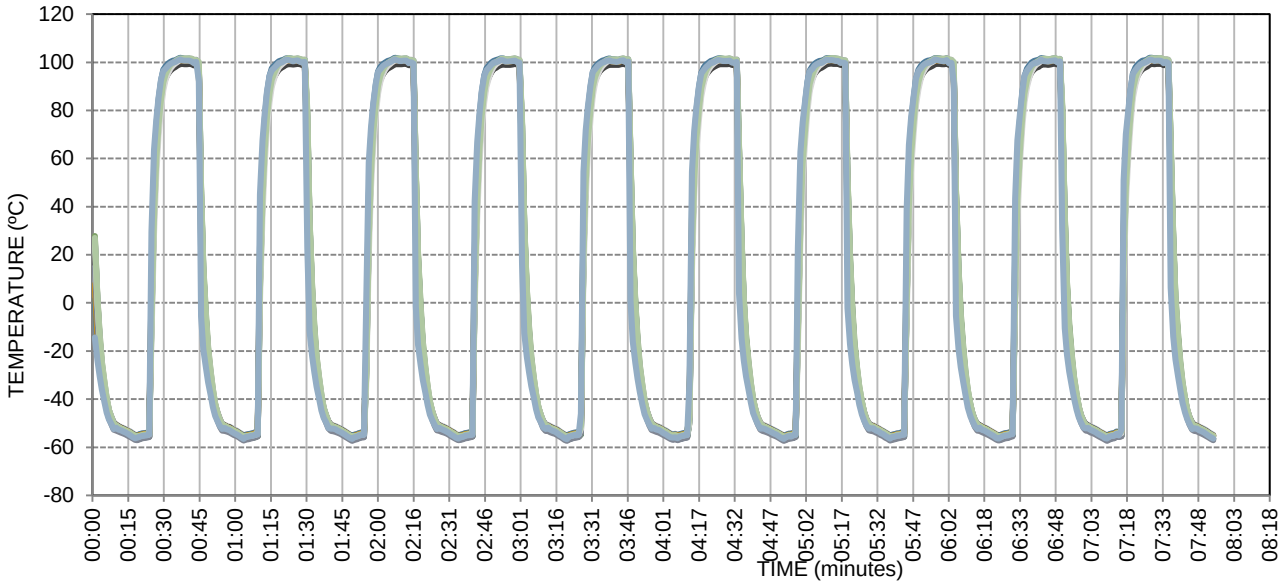
According to the customer specifications **harder conditions** were applied.

Thermal shock between two air baths.



TEMPERATURE CYCLING: SET-UP AND CONDITIONS

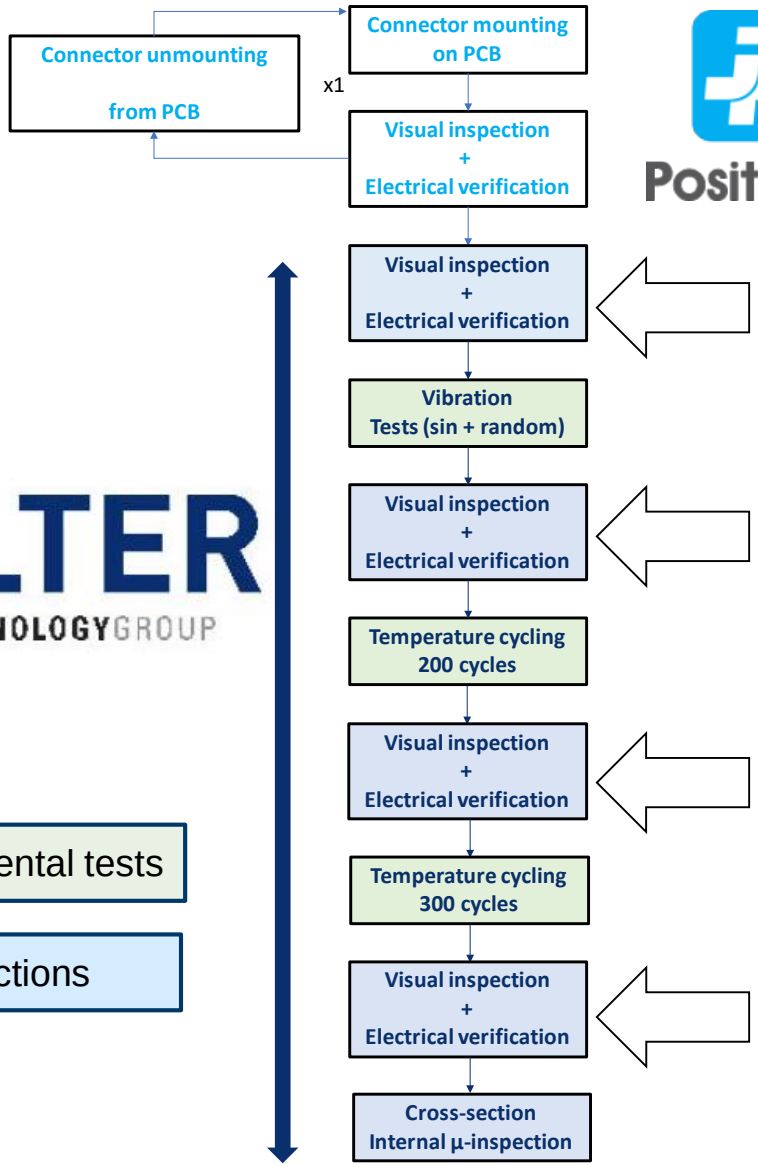
To ensure the test reliability the temperature is continually monitored with **ISO17025**-calibrated thermocouples attached to the DUT surface.



Temperature register of 10 representative cycles

PCB	ComboD S/N 0	ComboD S/N 1	ComboD S/N 2	Standard S/N 0	Standard S/N 1	Standard S/N 2	High S/N 0	High S/N 1	High S/N 2
Min	-57.0	-56.6	-56.7	-57.0	-57.0	-56.8	-57.0	-57.0	-57.0
Max	101.2	102.4	100.6	102.1	101.9	103.0	102.7	102.3	102.8

Max and min temperatures are within the tolerances stated by MIL-STD-202 TM107



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Environmental tests

Inspections

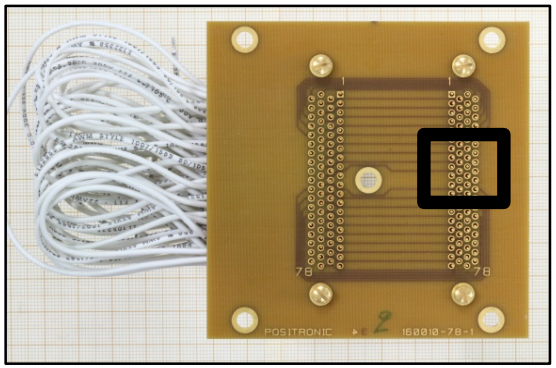
Visual inspection

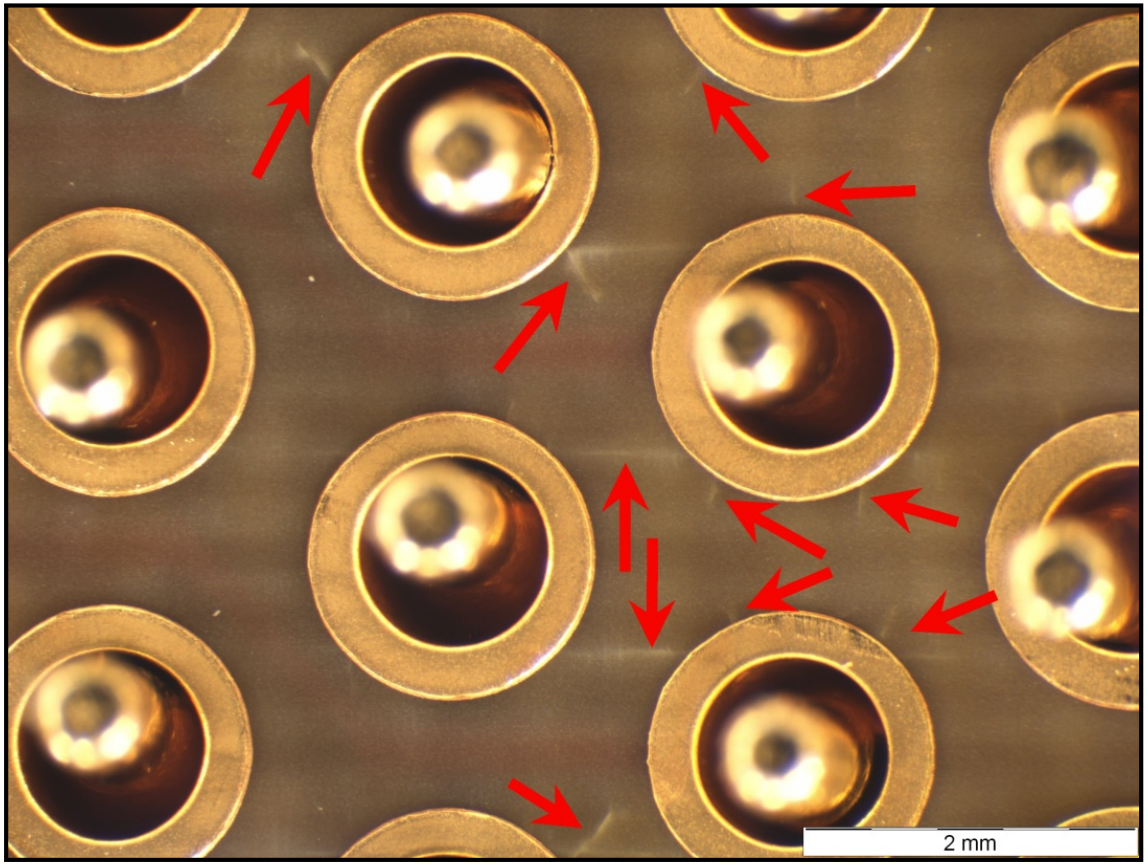
VISUAL INSPECTION

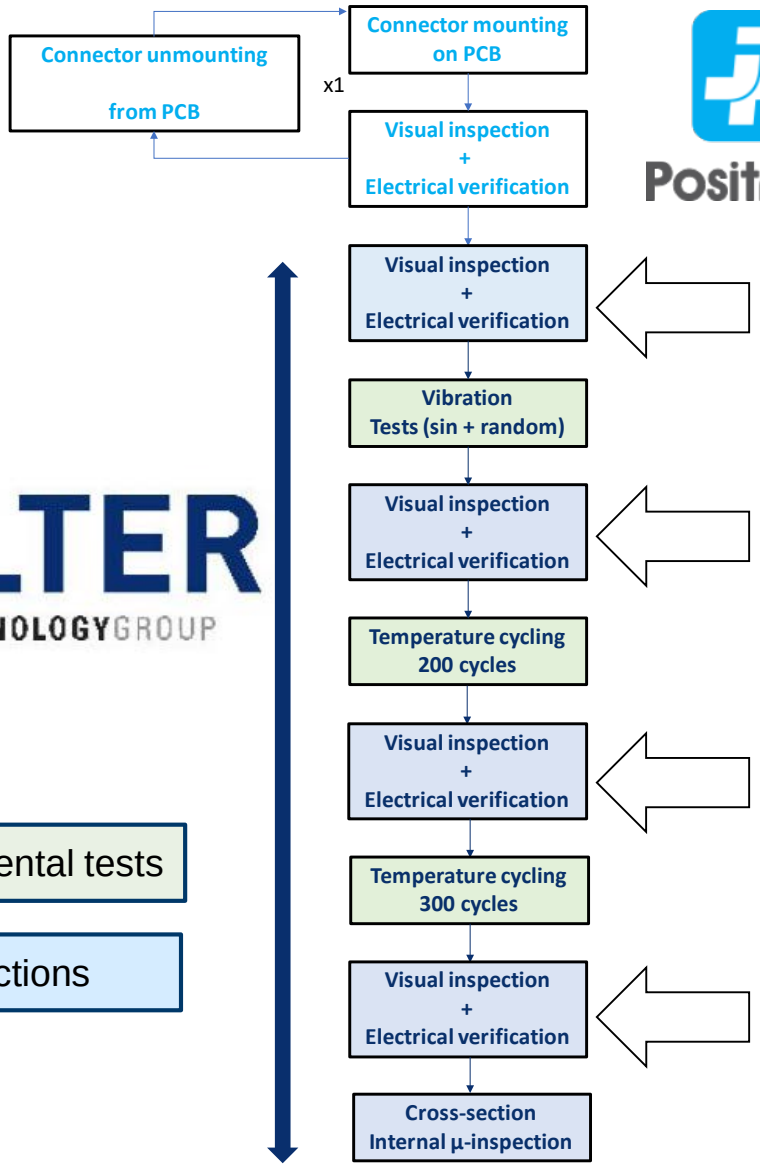
For most of inspected connectors and PCB no noticeable deviations were observed

In one case small marks were observed near the PTH after mounting and unmounting test.

<u>No evolution was observed after each environmental test</u>







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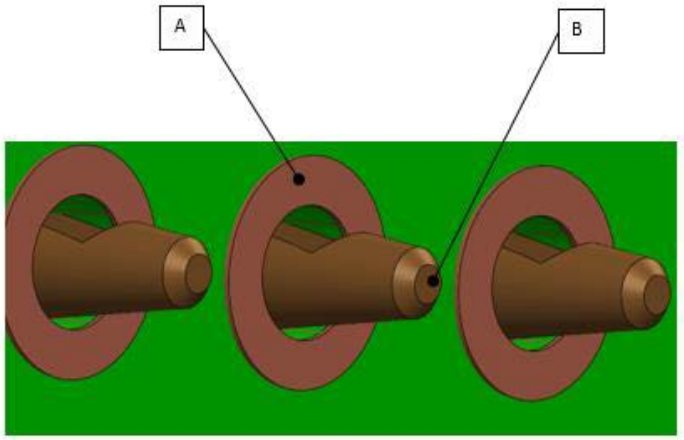
Environmental tests

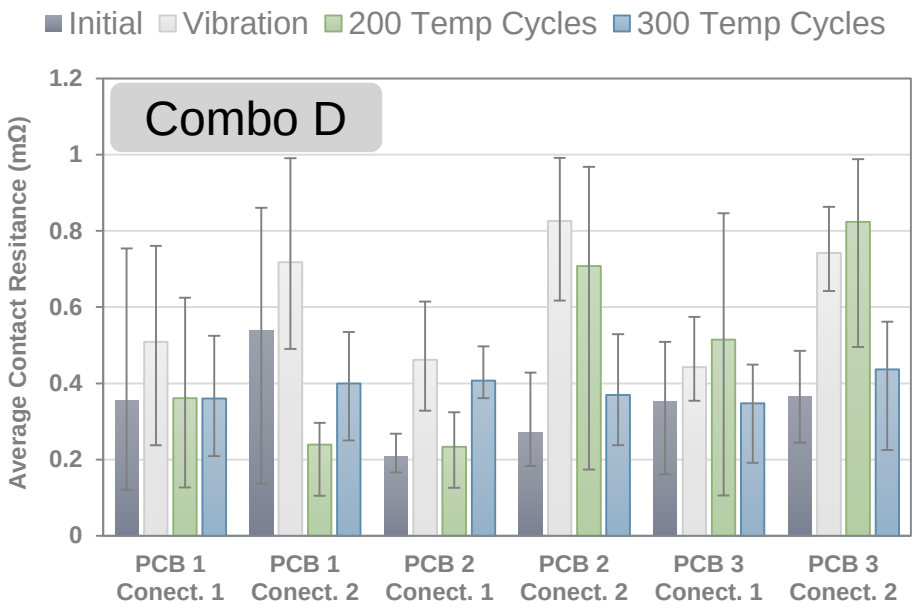
Inspections

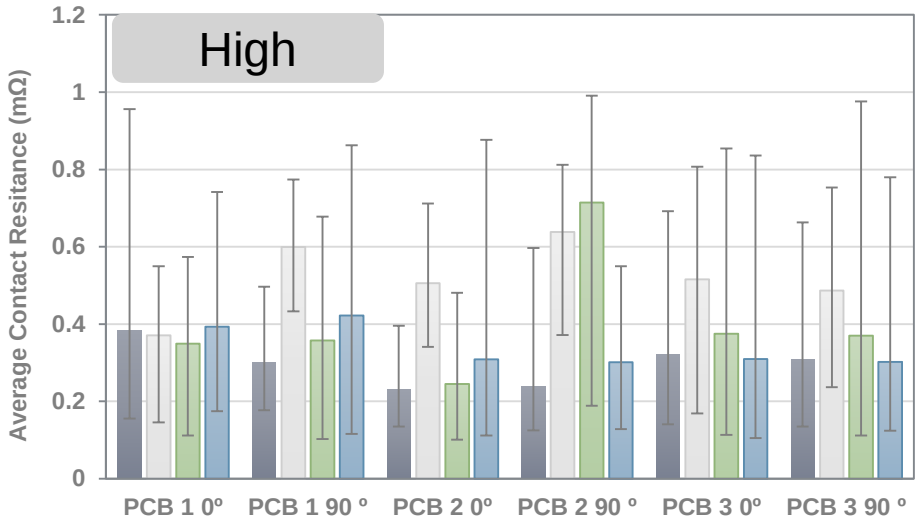
Electrical verification

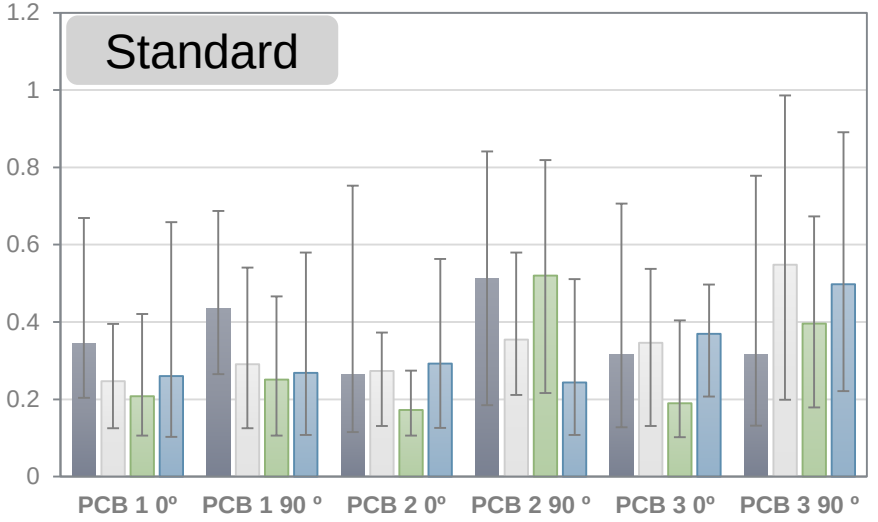
VISUAL INSPECTION

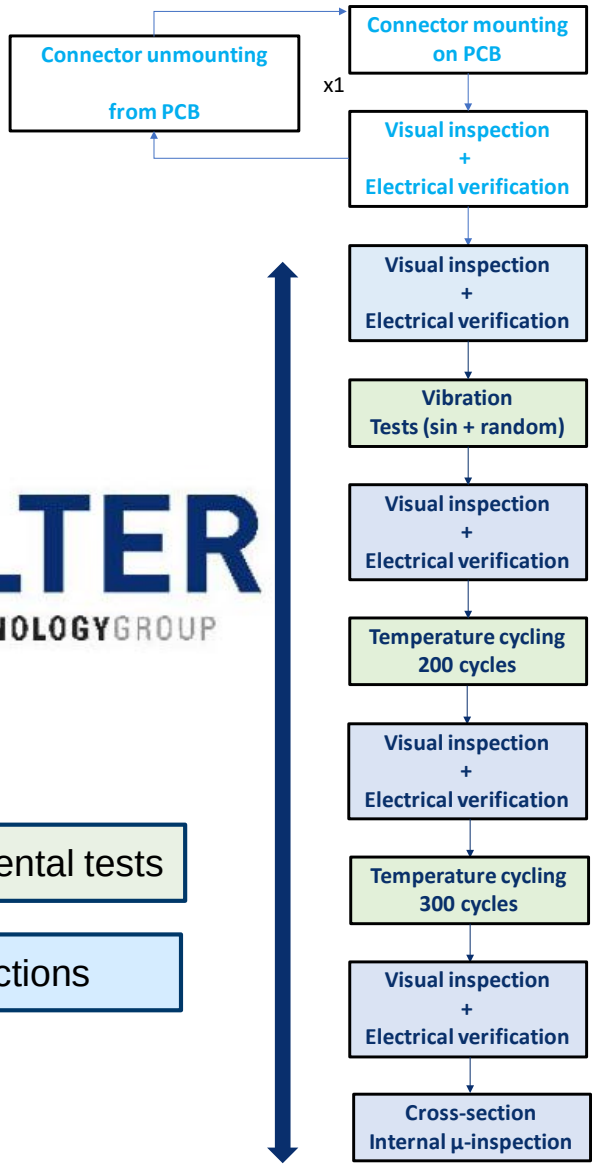
In all the cases **R < 1 mΩ no variations** of statistical significance were observed











Positronic

ALTER TECHNOLOGY

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Environmental tests

Inspections

Microsectioning

MICROSECTIONING & MICROINSPECTION

Accurate wire cutting

Cold Mounting
suitable for sensitive parts

Multi-step delicate
gridding & polishing

µ-sectioning

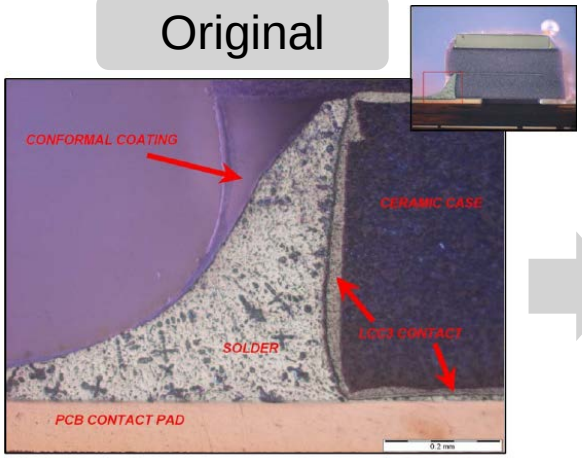
- Selected parts are separated from PCB & cut using a precision diamond wire saw.
- Each sample placed in a mounting mold & embedded into epoxy resin (low exothermic).
- Luminescent marker added to the resin to analyse defects using its fluorescence.
- Automatic Grinding/polishing machine.
- Normal and/or fluorescent micro-inspection

Visual & fluorescent µ-inspection

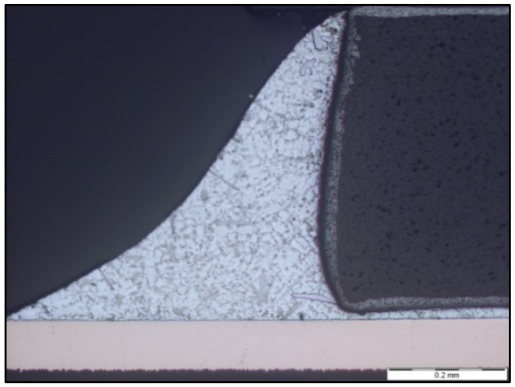
Gridding and Polishing optimization by DOE methodology.

Results presented at the ***Electronic Materials and Processes for Space***
9th Workshop, YVERDON-LES-BAINS

Original



Optimization



- ✓ **Control the removal rate** depending on Pressure, Time & Rotational Speed.
- ✓ **Damages reduction** produced by the grinding process.

Certifications

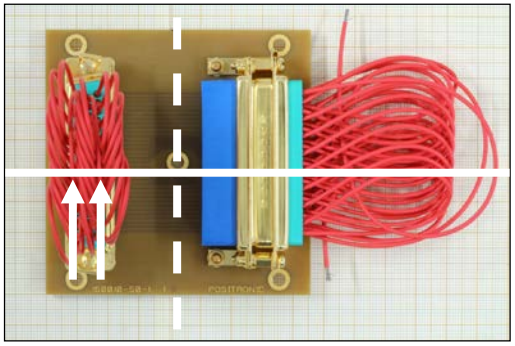
Certified inspectors:	Inspection of crimping connections (ECSS-Q-ST-70-26) Inspection of solder joints for SM & mixed technology (ECSS-Q-ST-70-38).
To be announced:	ESA Recommended company for PCB assembly verifications (ECSS-Q-ST-70-38).
In progress:	ISO17025 certification to conduct PCB verification programmes (ECSS-Q-ST-70-38)

MICROSECTIONING & MICROINSPECTION

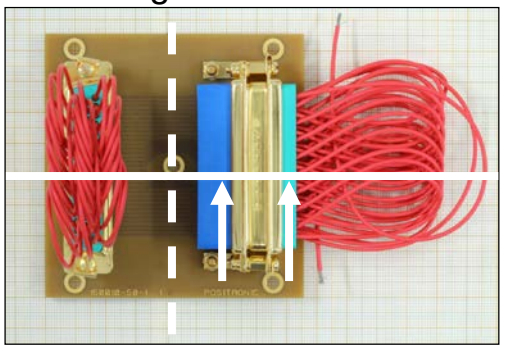
Through and an detailed inspection in different inspection planes

Standard and high density connectors

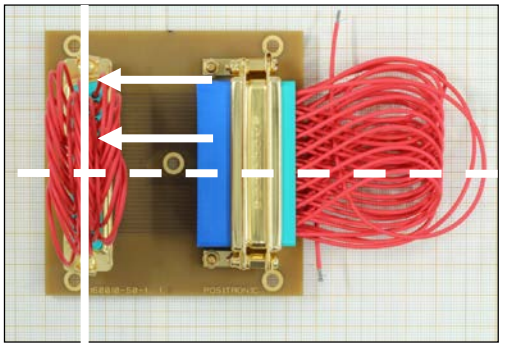
Transversal cut vertical connector



Transversal cut right connector

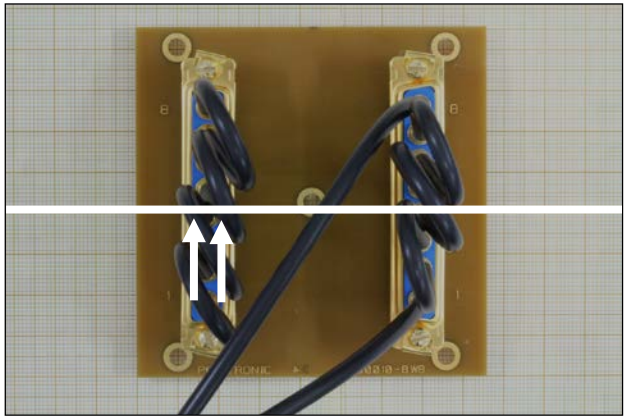


Longitudinal cut vertical connector

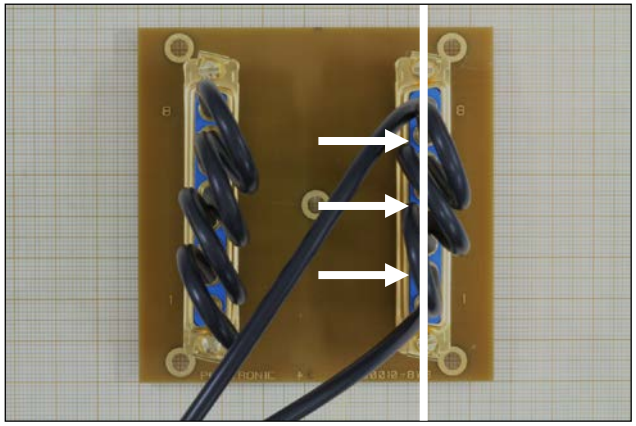


Combo-D connectors

Transversal cut vertical connector

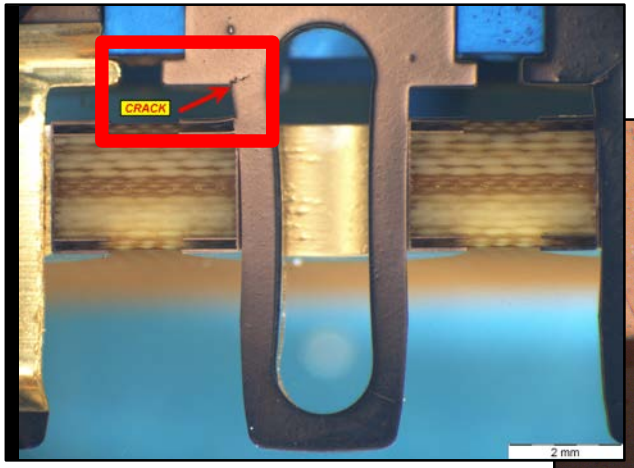


Longitudinal cut vertical connector



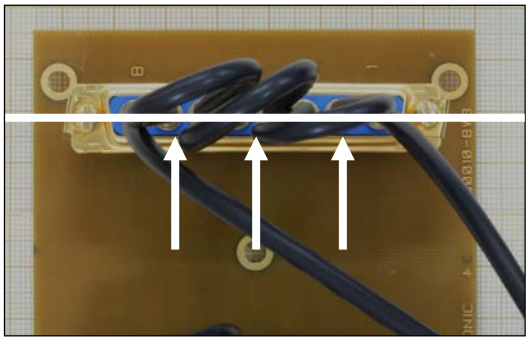
MICROSECTIONING & MICROINSPECTION

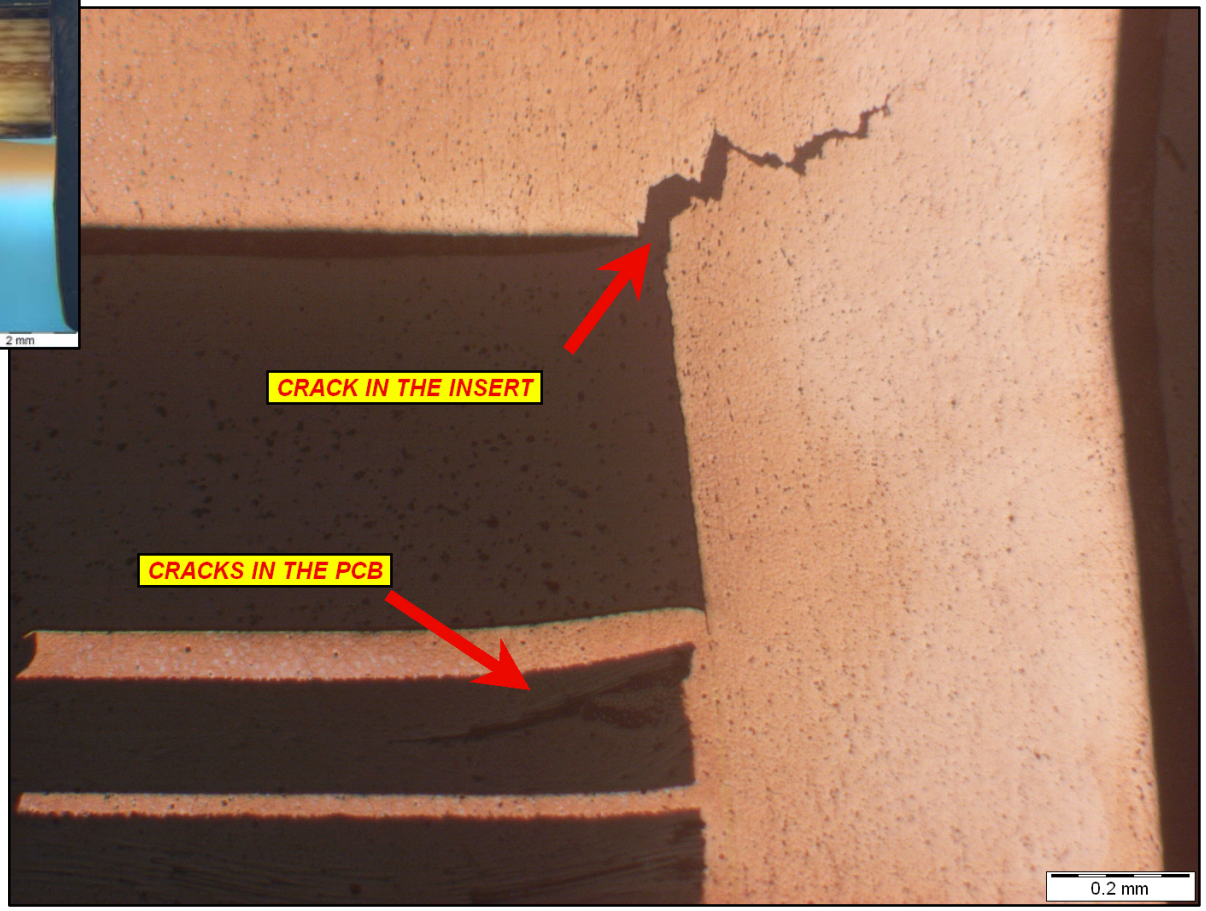
Combo-D connectors



Cracks:
- Base of the pin insert
- PCB resin

No other anomalies are observed

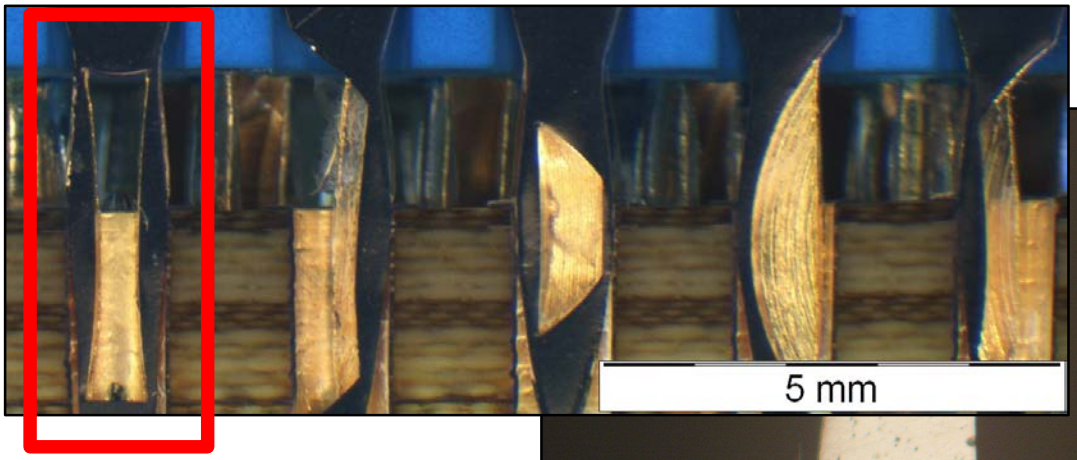


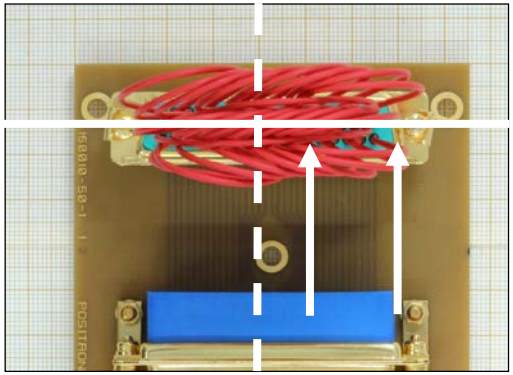


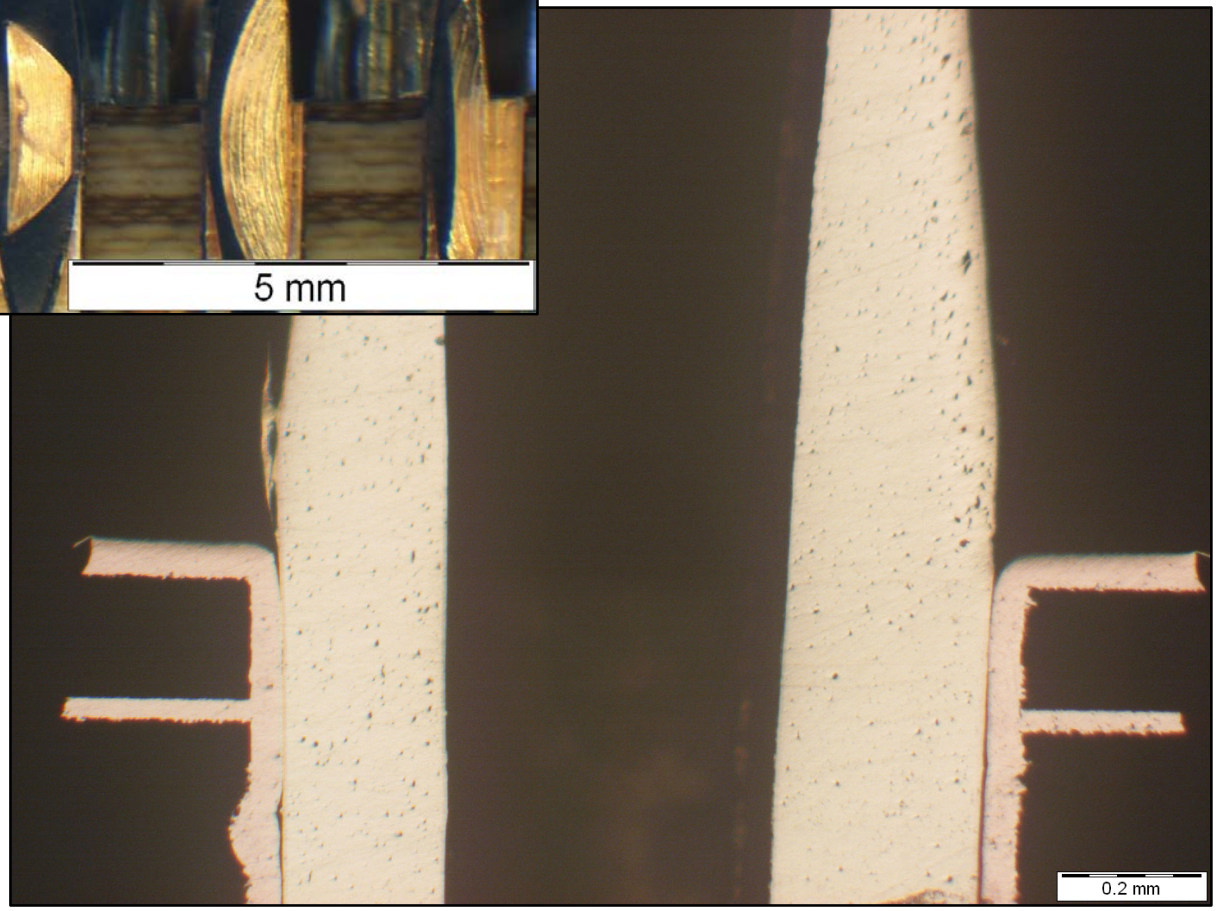
MICROSECTIONING & MICROINSPECTION

Standard and high density connectors

No anomalies observed







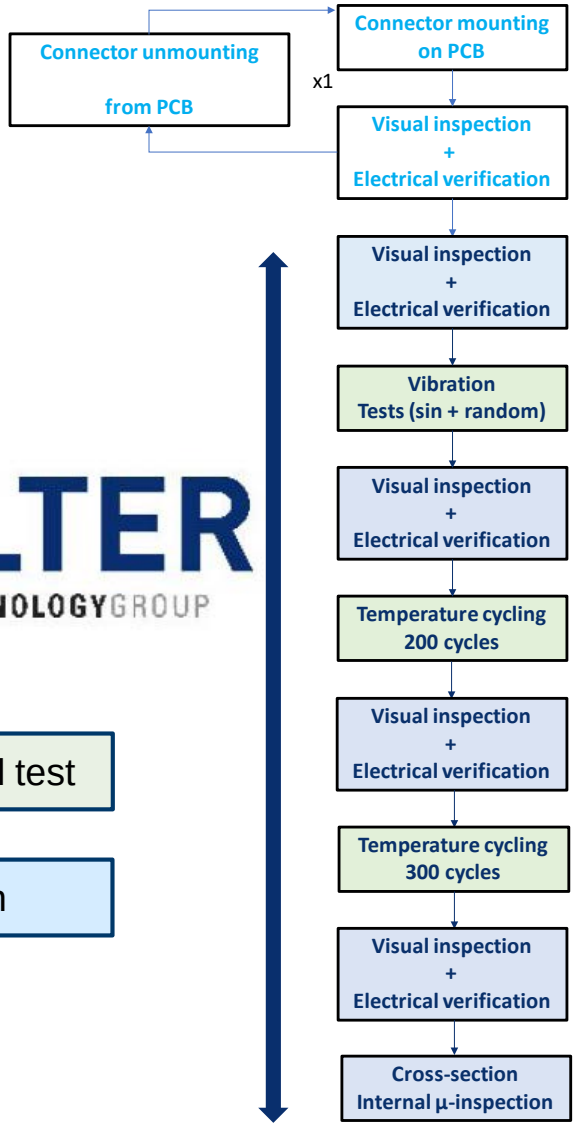
1ST GENERATION SUMMARY

Standard and high density connectors successfully pass all the tests

	Environmental	Visual + Electrical	µ-inspection
Standard and high density 	✓	✓	✓
Combo-D 	✓	✓	✗

Detailed µ-inspection enables Positronic to identify the trouble and develop new design to overcome the observed issues

2ND GENERATION SUMMARY



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In some cases initial external visual inspection revealed anomalies (crazing) at the PCB.

ALTER TECHNOLOGY GROUP

Environmental test

Inspection

Environmental test
All the inspected specimens successfully pass the environmental tests and the electrical verifications.

Microsection inspection
Dissimilar results. Further developments in progress.

SUMMARY.

- Different types of **press-fit connectors** conceived for different applications has been assesses for their implementational in **space environments**.

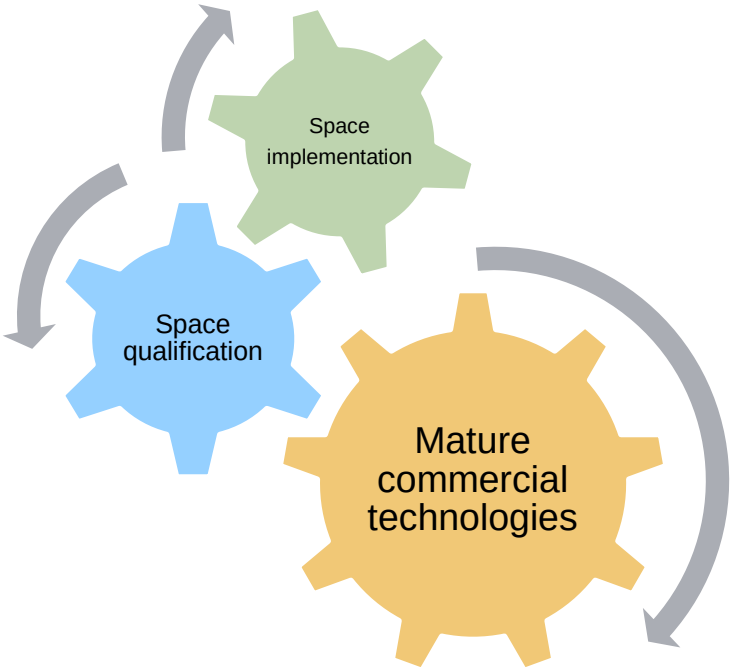
- The verification program included:

  - **Hard environmental** (vibration and temperature cycling) tests.
  - Control **electrical and visual inspections**.
  - Detailed **microsection** inspections.

- **Standard and high density** connectors **successfully passed** all the tests and inspections , demonstrating high reliability and assembly consistency.

- **Combo-D** presented **internal cracks** as revealed by µ-inspection.

- **New Combo-D** are under developed indenting to overcome such shortcoming.



THANK YOU FOR YOUR KIND ATTENTION!

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Positronic

https://www.altertechnology-group.com/en/home/

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