M12 HEADER RIGHT ANGLED
A, B, D - CODE

1 SCOPE

1.1 Content

This specification covers the performance, tests and quality requirements of the **SMD - version** of an M12 **Socket, A, B, D-Code** for use in Industrial Ethernet applications. The qualification testing has been carried out representatively with the 5 pin header variants.

1.2 Qualification

When tests are performed on the subject product line, procedures specified in the validation test requirements table (Pos. 3.7) shall be used. All inspections shall be performed using the applicable inspection plans and product drawings.

All test groups follow strictly the requirements defined with *IEC 61076-2-101 / ~104 .*

2 APPLICABLE DOCUMENTS

The following documents and forms constitute a part of this specification to the extent specified herein. Unless otherwise indicated, the latest edition of the document applies. In the event of conflict between the requirements of this specification and the product drawings, the product drawings shall take precedence. In the event of conflict between the requirements of this specification and the reference documents, this specification shall take precedence.

2.1 TE Documents

- 501-19314 Qualification Test Report Base: Tr1118e / F0K90001 ETL-RQ3440
- 114-94781 M8 / M12 PCB Connector Right Angled Version, Code A, B, D
- 114-94782 M8 / M12 Circular Header – R/A Sub- Specification
- 114-94795 M12 Header R/A - Integration Sub- Specification
- 114-94796 M12 Header R/A - PCB Layout 5 Pos. Sub- Specification
- 114-94797 M12 Header R/A - PCB Layout 8 Pos. Sub- Specification
- 107-18177 M8/ M12 Circular Connector (Vertical and Right Angle)

2.2 Overview of the applied Standards

IEC 60512-1-1: 2002-02	Connectors for electronic equipment – Tests and measurements – Part 1-1: General examination – Test 1a: Visual examination
IEC 60512-2-1: 2002-02	Connectors for electronic equipment – Tests and measurements – Part 2-1: Electrical continuity and contact resistance tests – Test 2a: Contact resistance – Millivolt level method
IEC 60512-2-5: 2003-05	Connectors for electronic equipment – Tests and measurements – Part 2-2: Electrical continuity and contact resistance tests – Test 2e: Contact disturbance
IEC 60512-3-1: 2002-02	Connectors for electronic equipment – Tests and measurements – Part 3-1: Insulation tests – Test 3a: Insulation resistance
IEC 60512-4-1: 2003-05	Connectors for electronic equipment – Tests and measurements – Part 4-1: Voltage stress tests – Test 4a: Voltage proof
IEC 60512-5-2: 2002-02	Connectors for electronic equipment – Tests and measurements Part 5-2: Current-carrying capacity tests; Test 5b – Current temperature derating
IEC 60512-6-3: 2002-02	Connectors for electronic equipment – Tests and measurements – Part 6-3: Dynamic stress tests – Test 6c: Shock
IEC 60512-6-4: 2002-02	Connectors for electronic equipment – Tests and measurements – Part 6-4: Dynamic stress tests – Test 6d: Vibration (sinusoidal)
IEC 60512-7-1: 2010-03	Connectors for electronic equipment – Tests and measurements- Part 7-1: Impact tests (free connectors) – Test 7a: Free fall (repeated)
IEC 60512-9-1: 2010-03	Connectors for electronic equipment – Tests and measurements; Part 9-1: Endurance tests – Test 9a: Mechanical operation
IEC 60512-11-1: 1995-11	Electromechanical components for electronic equipment – Basic testing procedures and measuring methods Part 11: Climatic tests – Section 1: Test 11a – Climatic Sequence
IEC 60512-11-4: 2002-02	Connectors for electronic equipment – Tests and measurements – Part 11-4: Climatic tests – Test 11d: Rapid change of temperature
IEC 60512-11-7: 2003-05	Connectors for electronic equipment – Tests and measurements – Part 11-7: Climatic tests – Test 11g: Flowing mixed gas corrosion test
IEC 60512-11-9: 2002-02	Connectors for electronic equipment – Tests and measurements – Part 11-9: Climatic tests – Test 11i: Dry Heat
IEC 60512-11-10: 2002-02	Connectors for electronic equipment – Tests and measurements- Part 11-10: Climatic tests – Test 11j: Cold

IEC 60512-11-12: 2002-02	Connectors for electronic equipment – Tests and measurements- Part 11-12: Climatic tests – Test 11m: Damp heat, cyclic
IEC 60512-13-2: 2006-02	Connectors for electronic equipment – Tests and measurements- Part 13-2: Mechanical operation tests – Test 13b: Insertion and withdrawal forces
IEC 60512-13-5: 2006-02	Connectors for electronic equipment – Tests and measurements – Part 13-5: Mechanical operation tests – Test 13e: Polarizing and keying method
IEC 60512-14-7: 1997-10	Electromechanical components for electronic equipment – Basic testing procedures and measuring methods – Part 14: Sealing tests – Section 7: Test 14g: Impacting water
IEC 60512-16-5: 2008-07	Connectors for electronic equipment – Tests and measurements – Part 16-5: Mechanical tests on contacts and terminations – Test 16e: Gauge retention force (resilient contacts)
IEC 60529: 2001-02	Degrees of protection provided by enclosures (IP Code)
IEC 61076-2-101: 2010	Connectors for electronic equipment – Product requirements – Part 2-101: Circular connectors – Detail specification for M12 connectors with screw-locking; Detail specification for M12 connectors with screw-locking IEC-Corr.:2010 to IEC 61076-2-101:2008
IEC 60068-2-1: 2007-03	Environmental testing – Part 2-1: Tests – Tests A: Cold
IEC 60068-2-2: 2007-07	Environmental testing – Part 2-2: Tests – Tests B: Dry heat
IEC 60068-2-6: 2007-12	Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)
IEC 60068-2-14: 2009-01	Environmental testing – Part 2-14: Tests – Test N: Change of temperature
IEC 60068-2-18: 2000-10	Environmental testing - Part 2-18: Tests – Test R and guidance: Water
IEC 60068-2-27: 2008-02	Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock
IEC 60068-2-30: 2005-08	Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 + 12-hour cycle)
IEC 60068-2-60: 1995-12	Environmental testing – Part 2: Tests – Test Ke: Flowing mixed gas corrosion test
IEC 60068-2-61: 1991-06	Environmental testing Part 2: Test Methods, Test Z/ABDM: Climatic Sequence

Just the listed standards above were considered for the qualification tests.

3 REQUIREMENTS

3.1 Design and Construction

Product shall be of the design, construction, materials and physical dimensions specified on the applicable product drawings.

3.2 Equipment under Test (= EUT)

All samples were mounted on specially designed PCBs to allow for easy test conduction of contact resistance, insulation resistance / voltage proof and contact disturbance. A total of 21 sample pairs were tested as part of the project. Information about the product's material is given in TE Connectivity's product drawings.

Altogether 15 pairs of samples were tested during the project.

Tab 2 Overview of samples and PCB types used for each test group

1) Test Group	No. of Pins HSG´s	Number of Connector Pairs		Part Number	Total Pin's HSG´s
		Contact Resistance	Contact Disturbance		
P	5	9	3	225254 M12 90° Male shielded 5 pin 225361 Locking screw M12 90° 225275 M12 90° Female shielded 5 pin 225362 Locking Nut M12 90° 225360 O-Ring (for male+female) 7,2x0,8 835284 O- Ring 7x1 (between male+female) 834899 O- Ring 14x1	12
AP	5	3	3		6
BP	5	3			3
CP	5	3			3
IP	6 HSG's				6 HSG´s
Derating	5		3		3

1) Test groups description acc. to IEC 61076-2-101 / ~104

All assemblies are equipped with housings made from LCP.
The contacts are Au-plated with Ni-underlayer as specified on drawings.
SMD was tested on performance level: 301

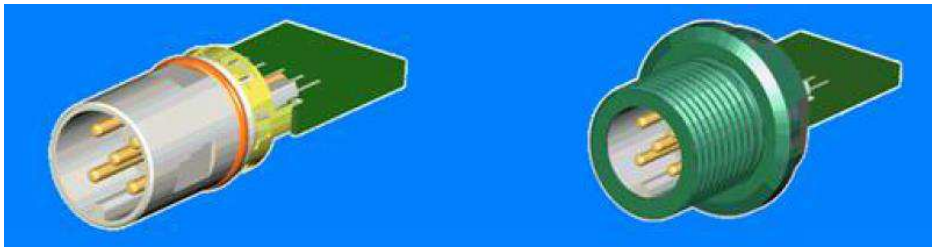


Fig.1: M12 90° Header male, shielded, 5 Pins (supplied by customer)

Fig.2: M12 90° Header, female, shielded, 5 Pins (supplied by customer)

Fig. 3: M12 90° Male shielded 5pin

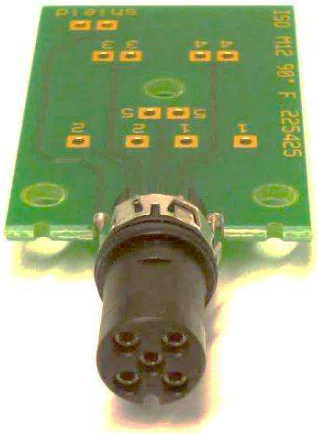


Fig. 4: M12 90° Female shielded 5pin

Fig. 5 Schematic mounting male and female with O-ring and locking

3.3 **Ratings** – M12 Connector Couple, A, B, D - code

Operation Voltage	60 Vdc	contacts: 4, 5, 8
Rated Current	4.0 A	contacts 4 , 5
Details see: Derating-graph	2.0 A	contacts 8
Insulation Resistance	10^8 Ohm min.	
Operating Temperature	-25 °C up to +85 °C	
Storage Temperature	-50 °C up to +100 °C / max. 6 months for solderable products	
Ingress Protection (mated)	IP 67 mated and under locked condition	
Mating Cycles	100 (specified for Au-plated contacts)	
Vibration	5 g	
Shock	50 g	
Reflow solderability	see: Reflow-profile / appendix	

The connector is suitable for potting after assembly due to optional O-ring. Male and female can be used with housings, which provide integrated M12 threads.

3.4 Approvals and Certifications

The products have the following Agency Approvals Certifications:

United States and Canada	UL (Underwriters Laboratories) as Recognized Component E84703

3.5 Performance and Test Description

Unless otherwise specified in the following tables, all tests shall be performed at ambient environmental conditions per IEC 60512.Qualification Test Requirements and Procedures

3.5.1 Measurement Equipment

All test equipment must be operated by trained, qualified personnel and adapted to the required measurements. The equipment must have been previously calibrated and tested for unrestricted usability by qualified personnel. Written approval must be available.

That includes additonal created devices like adaptors to fit with the prepared test devices (=EUT).

3.5.2 Initial Pre-Investigation Test Group P
valid for Test Groups

EUT = Equipment Under Test

P2 "Polarizing and Keying Test" can be performed within test group AP.

A. General Inspection		
Test	**Requirement**	**Comment**
Visual examination	Meets specified dimensions and appearance	IEC 60512-1-1, Test 1a; Visual examination, performed with naked eyes IEC 61076-2-101; Test No P1

1) Only Visual Inspection to be performed.

B. Electrical Tests		
Test	**Requirement**	**Comment**
Contact resistance Δ10	Millivolt level method, all contacts max. 10 mOhm	IEC 60512-2-1, Test 2a; 20mV max./ 100mA max. Millivolt level method, all contacts IEC 61076-2-101; Test No P3
Contact resistance Δ15	Millivolt level method, all contacts max. change 15 mΩ to initial	IEC 60512-2-1, Test 2a; 20mV max./ 100mA max. Millivolt level method, all contacts IEC 61076-2-101; Test No P3
Insulation resistance	500 Vdc / 60s min. 100 MOhm	IEC 60512-3-1, Test 3a, Insulation Resistance, Method: A Similar to: IEC 61076-2-104, Test No P4
[1)] Voltage proof	500 Vac eff. / 60s No breakdown or flashover	IEC 60512-4-1, Test 4a Insulation Resistance, Method: B IEC 61076-2-101; Test No P5

2) The High Voltage can be reduced from 1kV to 500V, so far a proper layout on the PCB cannot withstand that requirement.

3.5.3 Mechanical /Environmental Test

C. Mechanical Tests		
Test	**Requirement**	**Comment**
Mechanical Vibration (Sinusoidal)	[1)] No contact disturbance, breakdown or flash-over $> 1\ \mu s$	IEC 60068-2-6, Test Fc; 0,35mm or 50m/s²; 10 – 60 - 500Hz; 1 oct/min; 5 sweeps/ 3 axes; IEC 61076-2-101; Test AP3 Cont. Disturbance acc. to IEC 60512-2-5, 2e: U=10V, Imax= 100mA

C. Mechanical Tests		
Test	**Requirement**	**Comment**
Mechanical Shock	[1)] No contact disturbance $> 1\ \mu s$	IEC 60068-2-27; Test Ea Half sine shock; accel.: $490\ m/s^{-2}$ (50g) Duration of impact: $11\ ms$ Number of pulses/ dir.: 3 (=18 shocks) IEC 61076-2-101, Test AP4 Cont. Disturbance acc. to IEC 60512-2-5, 2e: U=10V, Imax= 100mA
Insertion/ Withdrawal Force	Insertion force: 10 N max. Withdrawal force: 15 N max. No lubricant required	IEC 60512-13-2; Test 13b Rate: 5 mm/min max. speed = $10\ mm.s^{-1}$ Cycles: 5 No lubricant required
Polarization and keying Method	Polarization: correctly aligned and mated	IEC 60512-13-5, Test 13e Keying (180° rotated): Force: 35 N ; No mated same as: IEC 61076-2-101; Test P2 (5.3.4)
Gauge retention force	insertion forces =< 10N withdrawal forces =< 15N	IEC 60512-16-5; Test 16e; Method A Pin diameter: 1.00 ±0.03mm Expanding gauge diameter: 1.03mm Drawing force gauge diameter: 0.97mm min. length of gauge: 10mm IEC61076-2-101; pos. 3.4
Mechanical Operation		IEC 60512-9-1, Test 9a Mating speed: 10 mm/s Interval (unmated): 30 s Cycles: 50 Required cycles by IEC 61076-2-101, Test BP2
Free Fall (repeated)		IEC 60512-7-1 Test 7a Fall height: 1m Number of Revolution: 3

D. Environmental Tests		
Test	**Requirement**	**Comment**
Temperature Shock		IEC 60068-2-14 / Test Na T_a = -25 °C/ T_b = +85 °C t = 30 min, 5 cycles Transition Time : <10s
Dry heat 85		IEC 60068-2-2 / Test Bb +85 °C / 16 h
Dry heat 125		IEC 60068-2-2 / Test Bb +125 °C / 1000h

D. Environmental Tests		
Test	**Requirement**	**Comment**
Damp heat, 1 cycle		IEC 60068-2-30 / Test Db 25/ +40°C, 95 % r.H; 1 cycle; 24 h/cycle
Damp heat, 5 cycles		IEC 60068-2-30 / Test Db 25/ +40°C, 95 % r.H; 5 cycle; 24 h/cycle
Coldness		IEC 60068-2-1 / Test Ab -25 °C / 2h
Flowing mixed gas		IEC 60512-11-7; Test 11g IEC 60068-2-60; Test Ke; Method 4 H_2S: 10ppb , NO_2: 200ppb CL_2: 10ppb , SO_2: 200ppb Temperature: 25°C; rel. humidity: 75%; duration: 4d
Reflow Solderability		acc. to: IEC 60068-2-58 Ed. 3 see: appendix for details
Reflow Solder Heat Resistance		acc. to: PC/ JEDEC J-STD-020C see: appendix for details
Derating		IEC 60 512-5-2 Test 5b see: appendix for details
IP-Code second number IPX5	No penetration of water	IEC 60529, Method IPX5 Water jet: 12,5l/min ±5% Nozzle diameter: 6,3mm Distance: 2,5 – 3m Duration: 3min
IP-Code second number IPX7	No penetration of water	IEC 60529, Method IPX5 Water level: 0,15m above top 1m above bottom; Duration: 30min
IP-Code first number IP6X	No penetration of powder	IEC 60529 Method IP6X Test fluid: Talcum powder Nominal diameter: 50 - 75µm Amount: 2kg/m³ of chamber Under-pressure (EUT): ≤20mbar Duration: 40 – 60 : 2h extraction rate: <40: till 80 volumes, at last 8h (Case Volumes / h)

3.7 Qualification and Requalification Tests Sequence

[1] Test Description	AP	BP	CP	ZP1
Visual and dimensional examination	**1**, 9,12,17,23,26,33	**1**,8,15	**1**, 15	**1**, 6
Contact resistance (10 mOhm max.)	**2**	**2**	**2**, 12	**2**
Contact resistance (15 mOhm to initial)	8, 11, 14, 22, 29	7,10,12	6,	
Insulation Resistance	**3**, 15, 30	**3**, 13	**3**, 7,	**3**
Voltage Proof	**4**, 16, 24,31	**4**, 14	4, 8, 13	**4**
Insertion and Withdrawal	5, 25, 32	16		
Gauge Retention Force	6	5, 17		
Vibration (sinusoidal)	7			
[2] Mechanical Shock	10			
[2] Temperature Shock	13		5	
Dry Heat (85 °C)	18			
Dry Heat (125 °C)			11	
Damp Heat, 1x cyclic	19			
Damp heat, 5x cyclic	21			
Coldness	20			
Mechanical operation (50		6,11	9+10	
Flowing Mixed Gas		9		
Reflow Solderability				
Reflow Solder Heat Resistance				
IP-Code (2nd No.)	27			
IP-Code (1st No.)	28			
Polarization/ Keying	34			
Free-Fall (3x)			14	
Derating				5

1) Last sequence number yellow marked
2) Contact Disturbance to be monitored

Classification of test groups:

Group P	IEC 61076-2-101 specifies an initial testing for test group: AP, BP, CP as mentioned below. That has been considered as defined with *chapter 3.7 "Qualification and Requalification Tests Sequence"* as testing in advance. "Group P" was integrated into the "Test Sequence" with pos. 3.7 chapter.
Group AP	Reliability with focus on mechanical, climatic performance.
Group BP:	Reliability with focus on mechanical, industrial atmosphere (MFG) performance.
Group CP:	Reliability with focus on mechanical, higher dry heat performance.
Group Derating:	Current Carrying Capacity of Connector System
Group IP:	Reliability with focus on dust and water tightness (IP = Protection Class Test)

4 QUALITY ASSURANCE PROVISIONS

4.1 Qualification Testing

A Sample selection

The samples shall be prepared in accordance with product drawings and application specification. They shall be selected randomly from current production, in accordance with Appendix A.

B Test sequence

Qualification inspection shall be verified by testing samples as specified in paragraph 3.6.

4.2 Requalification Testing

If changes affecting significantly form, fit or function are made to the product or to the manufacturing process, product assurance shall coordinate requalification testing, consisting of all or part of the original testing sequence as determined by development/product, quality, and reliability engineering.

4.3 Acceptance

Acceptance is based on verification that the product meets the requirements of paragraph 3.5. Failures attributed to equipment, test setup, or operator deficiencies shall not disqualify the product. When product failure occurs, corrective actions shall be taken and samples resubmitted for qualification.
Testing to confirm corrective action is required before resubmission.

4.4 Quality Conformance Inspection

The applicable TE quality inspection plan will specify the sampling acceptable quality level to be used. Dimensional and functional requirements shall be in accordance with the applicable product drawing and this specification.

5 DISCLAIMER

The product described herein has not been fully tested to ensure conformance to the requirements outlined above.
TE makes no representation or warranty, expressed or implied, that the product or design will comply with these requirements. Further, TE may change these requirements based on the results of additional testing and evaluation. Contact TE Engineering for further details.

6.1. Test Performance

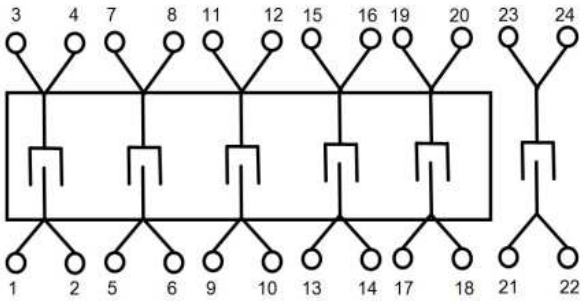
Number of test samples specified differently per test group.

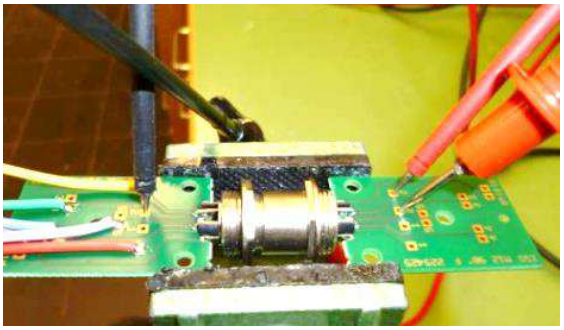
6.1.1. Visual Inspection

The visual inspection was performed with naked eye.
Requirement: Meets specified dimensions and appearance, no damage of connectors.

6.1.2. Contact Resistance

Contact resistance of 5 contacts must be measured using the millivolt level method and 4-point-measurement.





	Contact Resistance (millivolt level method)	
	measurement points	
Contact	positiv	negativ
1	1-2	3-4
2	5-6	7-8
3	9-10	11-12
4	13-14	15-16
5	17-18	19-20
shield	21-22	23-24

Fig. 6:
Setup for contact resistance measurement in millivolt level method and Overview measurement points

6.1.3. Polarizing and Keying Method

A force of 35 N applied and hold for 60 sec.

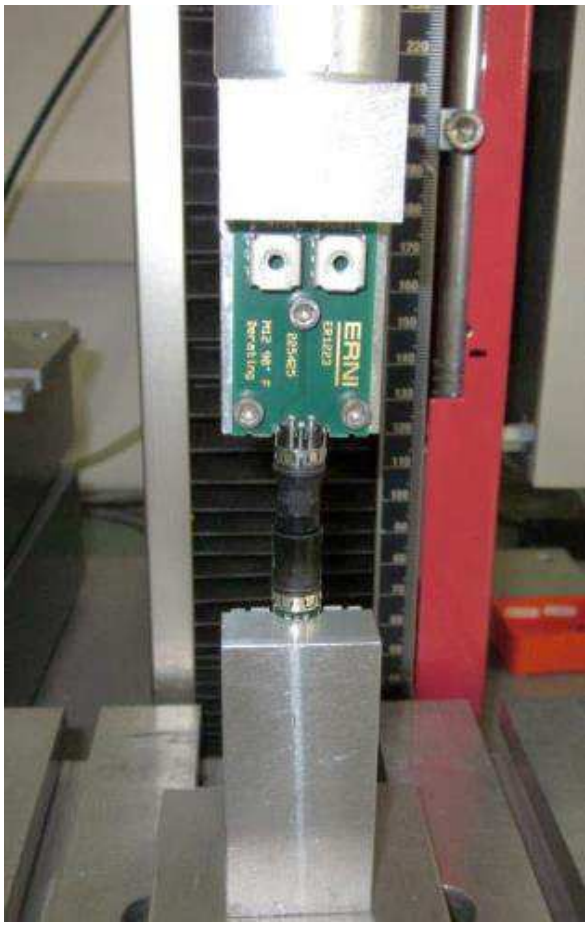


Fig. 7: Setup polarizing and keying method

6.1.4. Insulation Resistance

The insulation resistance measurement must be performed with method A. Each termination being tested and all others connected together and to the housing

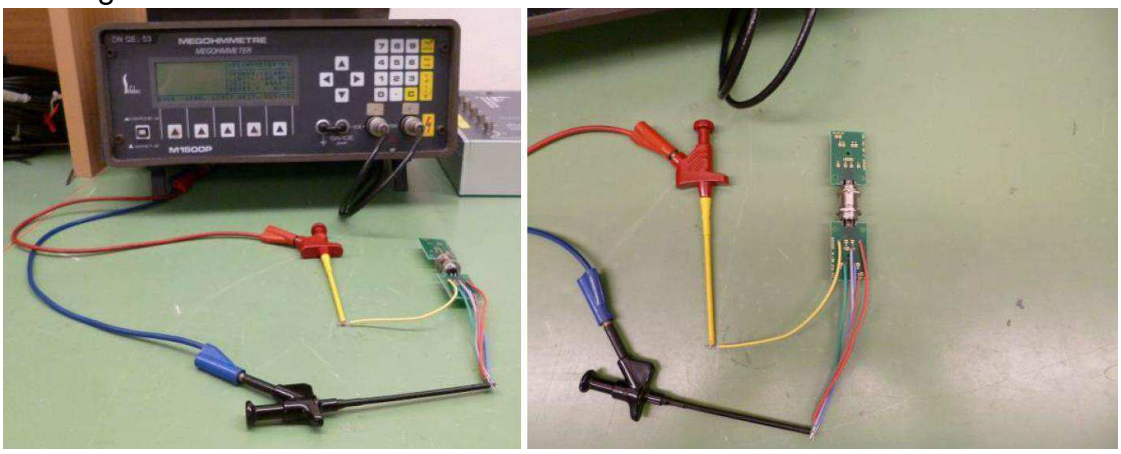
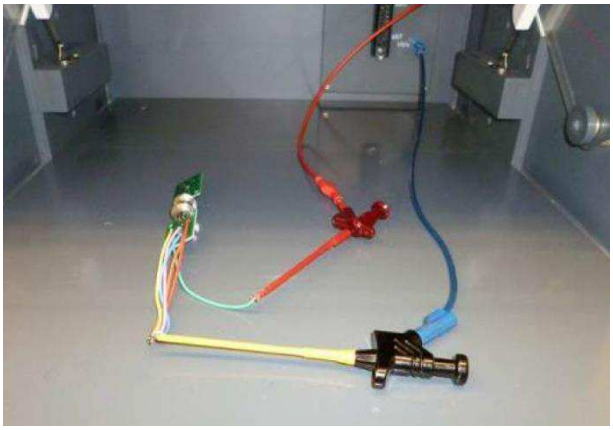


Fig. 8: Test Group P / Setup insulation resistance measurement

6.1.5. Voltage Proof

The insulation resistance measurement to be performed with method A.

Fig. 9:
Setup Voltage Proof



6.1.6. Insertion and Withdrawal Forces

The first insertion and withdrawal force test must be performed with five cycles. For the successive insertion and withdrawal force test only one cycle must be performed.

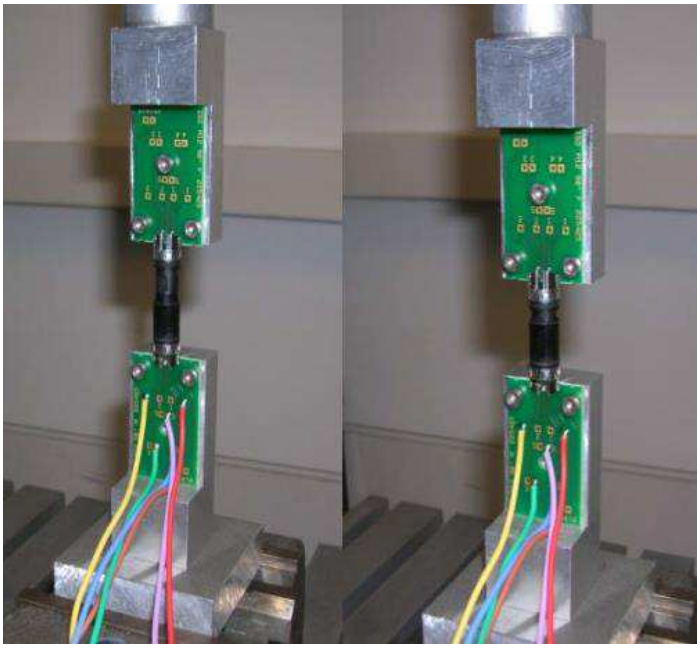


Fig. 9:
Test setup for insertion and withdrawal forces in
left: upper position and
right: lower position

6.1.7. Gauge Retention Force

Three female contacts (1, 3 and 5) will be tested. Before the first gauge retention force test the maximum size gauge specified must be inserted and withdrawn three times.

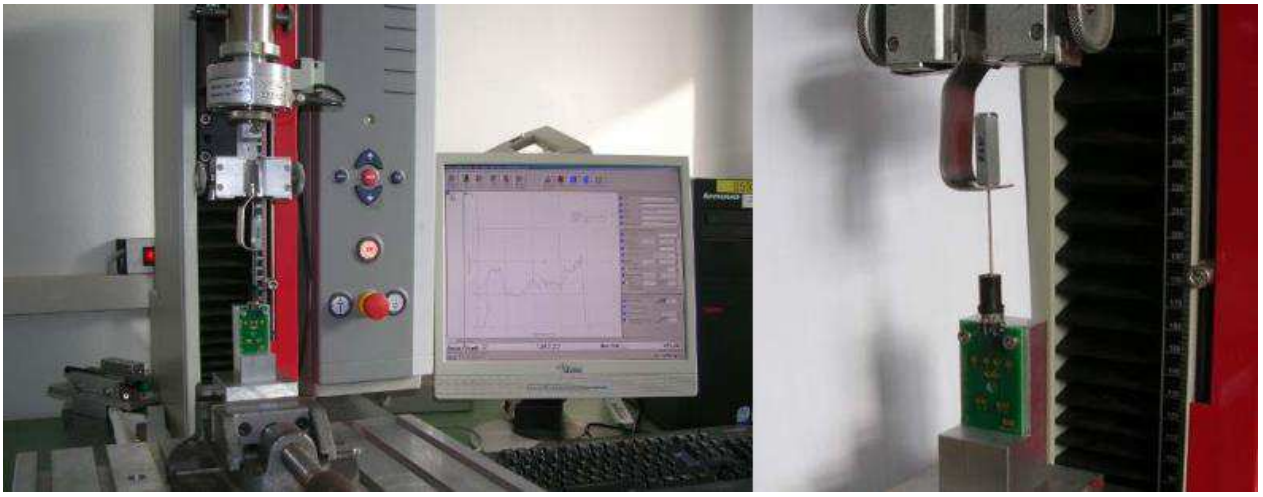


Fig. 10: Test setup for gauge retention force

6.1.8. Mechanical operation

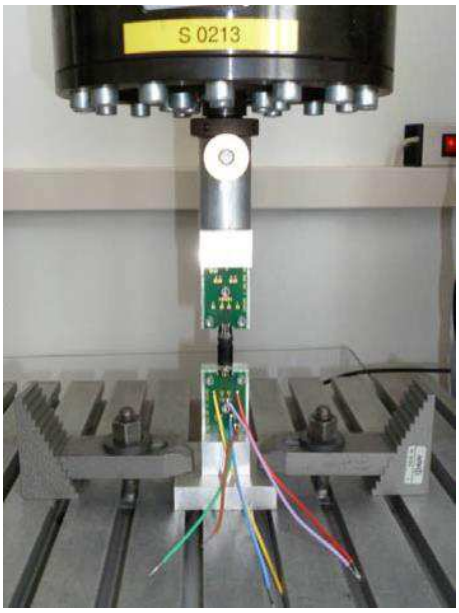


Fig. 11: Test setup for Mechanical operation

6.1.9. Vibration (sinusoidal)

The EUT will be screwed to an aluminum mounting plate with a 30mm thickness. The mounting plate will be fixed over a rigid aluminum cube to the shaker. The test will be performed in 3 mutually perpendicular axes. During Vibration (sinusoidal) the connectors must be monitored for contact disturbance.

Fig. 12:
EUTs mounted on shaker for Vibration (sinusoidal) here for the z-axis.

Fig. 13:
EUTs mounted on shaker for Vibration (sinusoidal) here for the x-axis.

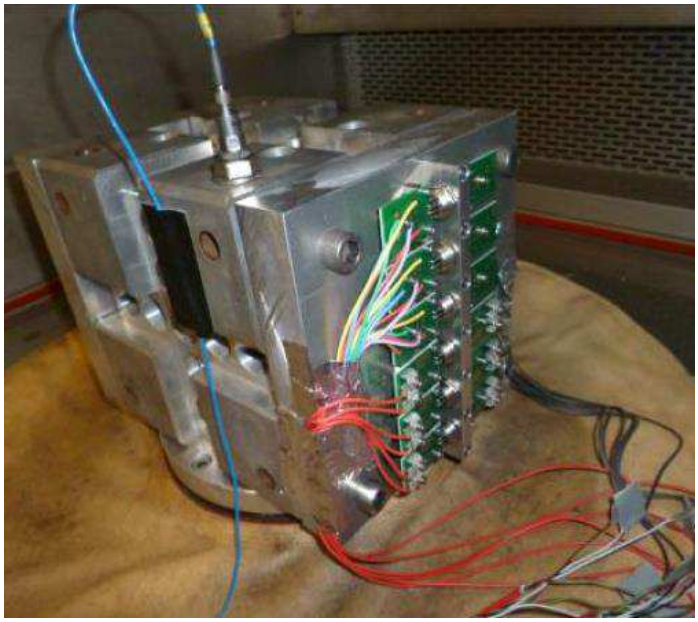


Fig. 14:
EUTs mounted on shaker for Vibration (sinusoidal) here for the y-axis.

6.1.10. Mechanical Shock

The EUT will be screwed to an aluminum mounting plate with 30mm thickness.
The mounting plate must be fixed over a rigid aluminum cube to the shaker.
The test will be performed in 3 mutually perpendicular axes.
During shock tests the connectors were monitored for contact disturbance.

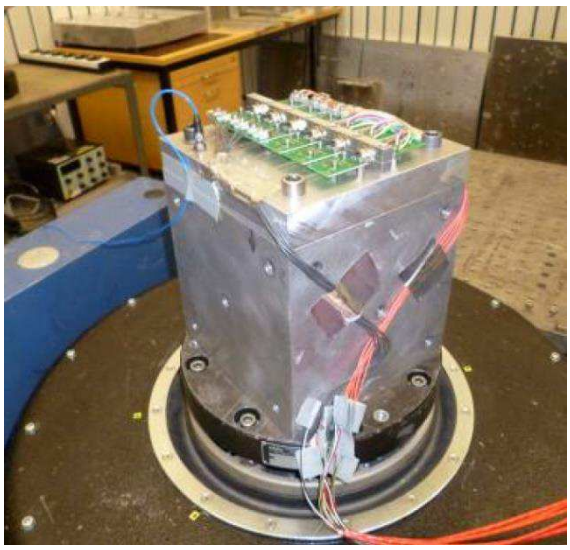


Fig. 16: EUTs mounted on shaker for shock test here for z-axis

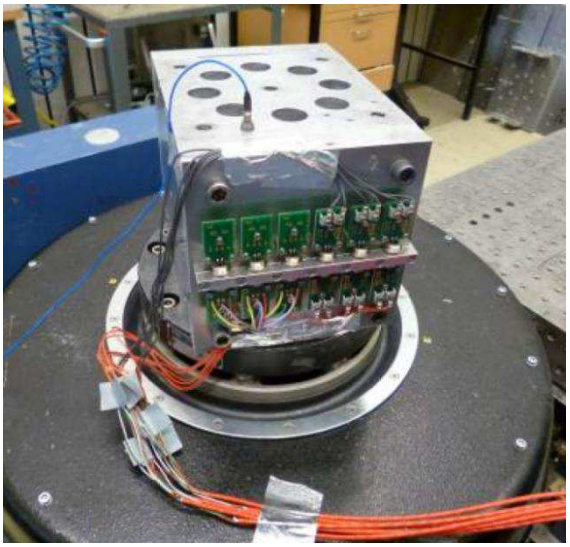


Fig. 17: EUTs mounted on shaker for shock test here for x-axis

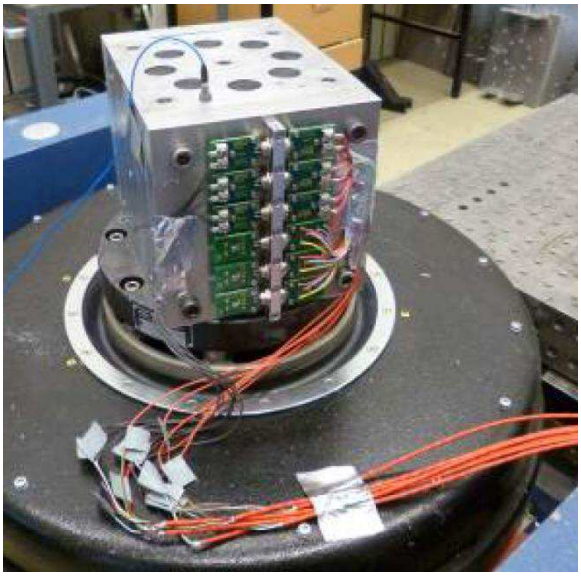


Fig. 18: EUTs mounted on shaker for shock test here for y-axis

6.1.11. Contact Disturbance Monitoring (performed with Shock and Vibration)

During vibration (sinusoidal) and shock tests the connectors must be monitored for contact disturbance wired with a 100Ω resistance and loaded with 10Vdc. The voltage drop on the EUT will be monitored with a data logger with 40 MS/s. The trigger level must be adjusted to a voltage of 5V.

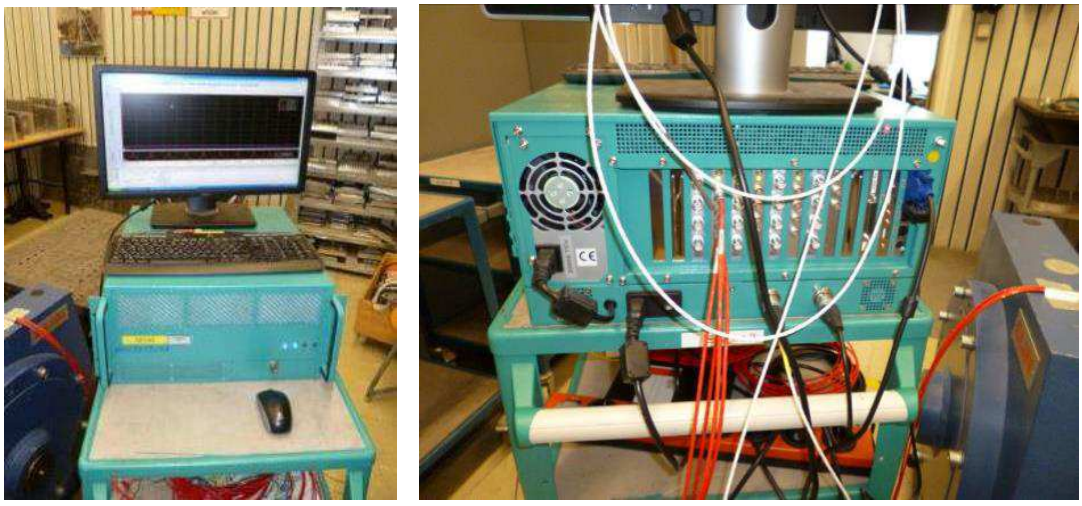


Fig. 21: Test Group AP: Setup contact disturbance monitoring

6.1.12. Flowing mixed gas corrosion test, method 4

Fig. 22: Test Group BP: Samples in mixed flowing gas chamber

6.1.13. Change of Temperature

Fig. 23: EUTs in the climatic chamber for rapid change of temperature.

6.1.14. Dry Heat

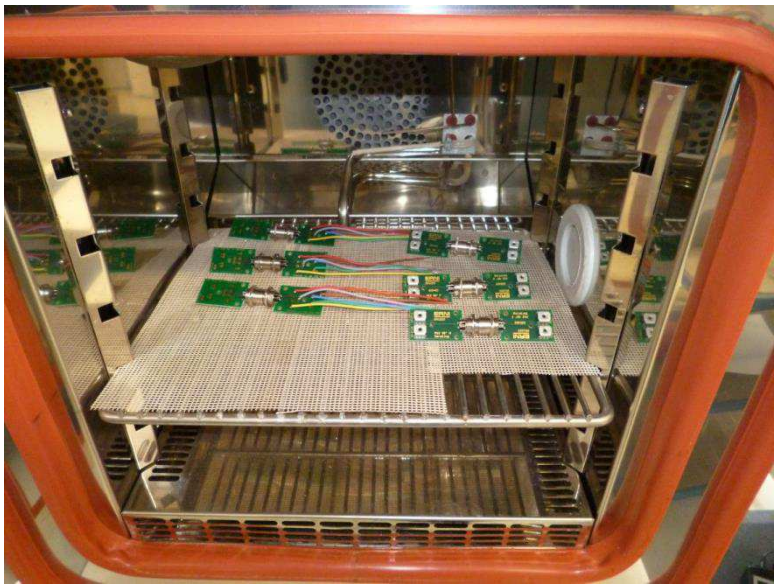


Fig. 25: EUTs in the climatic chamber for dry heat**.**
Temperature must be recorded for +85°C resp. +125°C showing the value of the dry heat.

6.1.15. Cold

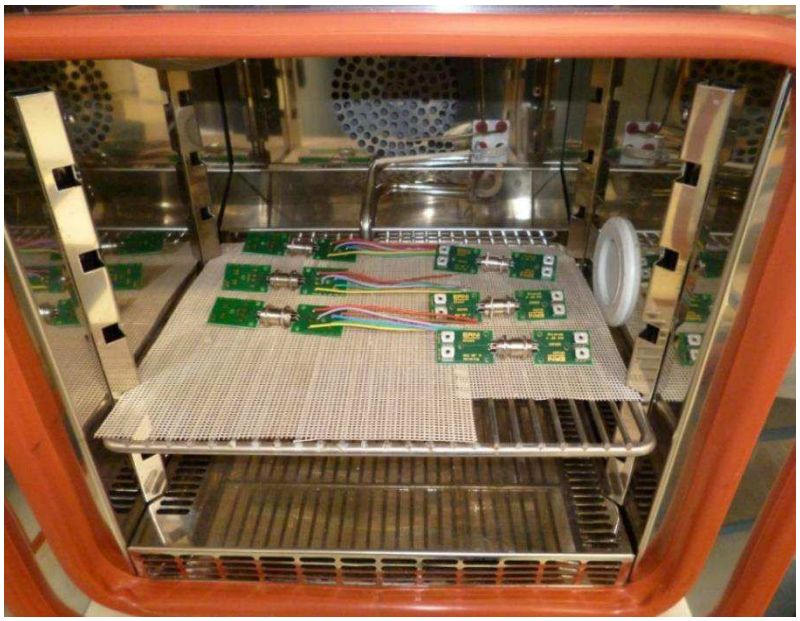


Fig. 27: EUTs in the climatic chamber for cold.
Temperature must be recorded showing the value of cold

6.1.16. **Damp Heat, Cyclic**

After test dry heat one cycle (cycle 1) must be performed.
After test cold five cycles (cycle 2 till 6) must be performed.

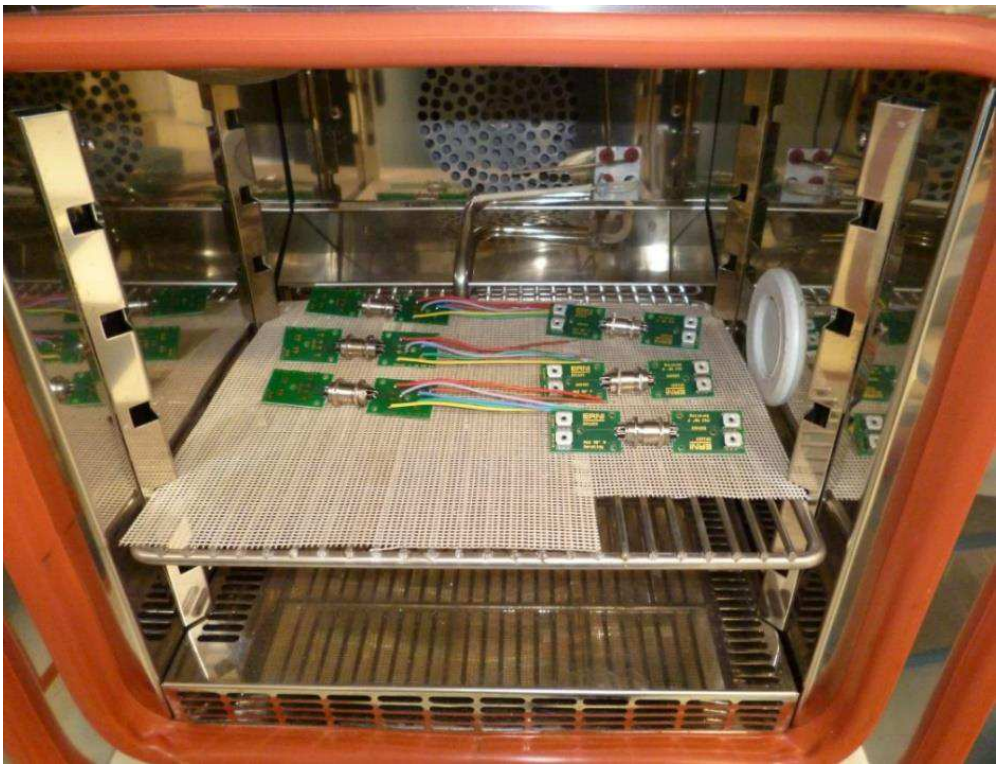


Fig. 29: EUTs in the climatic chamber for Damp heat, cyclic 1. Temperature + humidity recorded showing the value of damp heat cyclic/ cycles 2 till 6

6.1.17. Water Tightness (IP-Code 1st number)

According to the customer specification the EUT must be mounted in a case for the test. On the case the under-pressure of ≤20mbar (under normal atmospheric) will be applied.

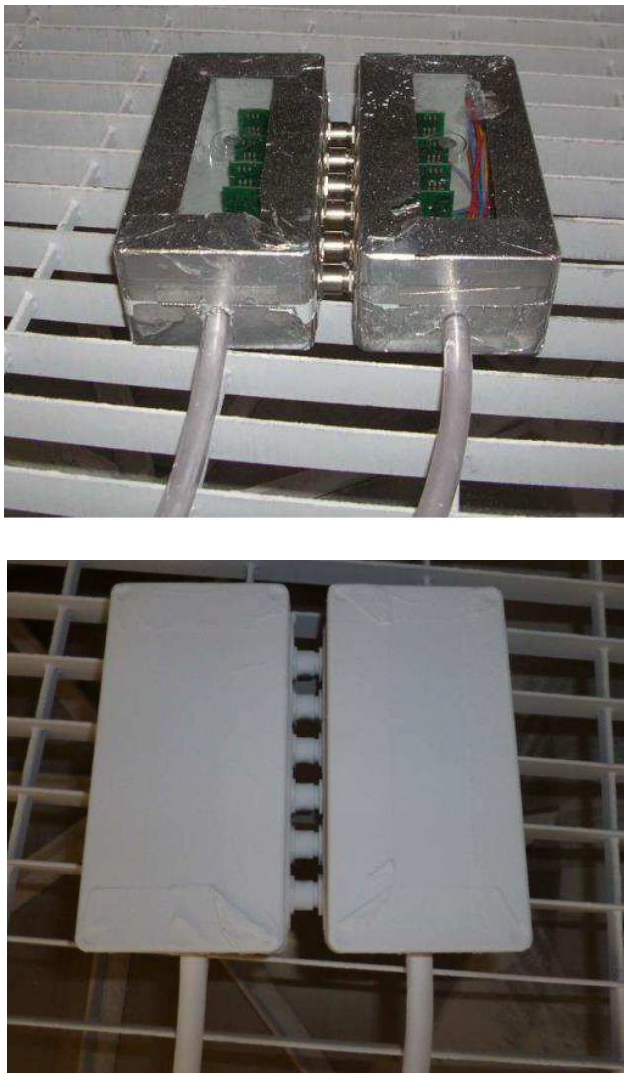


Fig. 34: Test Group AP: EUTs in chamber for IP6X test

6.1.18. Dust Tightness (IP-Code 2nd number)

According to the customer specification the EUTs must be mounted in a case for the tests.

Fig. 32: Test Group AP: EUTs in IPX5 test

Fig. 33: EUTs in IPX7 test

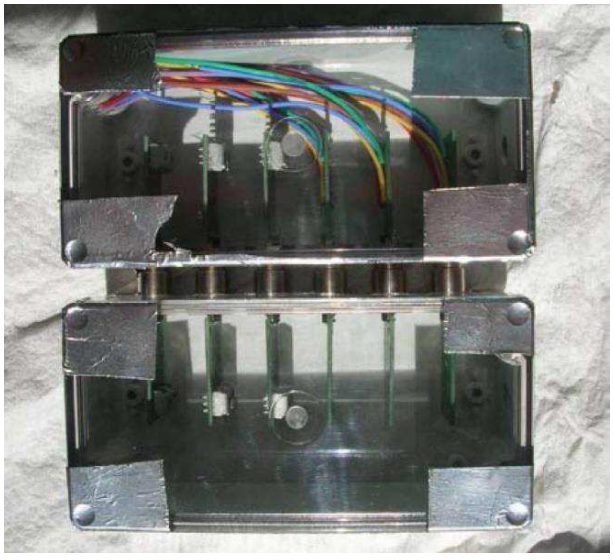


Fig. 34: Open case prepared with indicator paste for showing water intrusion with IP X5 and IPX7 test procedure.

6.1.19. Current Temperature Derating

All samples must be mounted on a properly designed PCBs to allow easy test conduction of current temperature derating.
Between the EUTs a 1.5mm² cable will be used as jumper according to the IEC 60512-5-2. Only pin 5 of EUTs were measured with a thermo-couple.
The temperature of a measuring point (the expected hottest position) on the contact spring and the temperature in the immediate vicinity of the component must be measured here with different current values.
The difference between the two temperatures is the self-heating or rise created by the current flow.

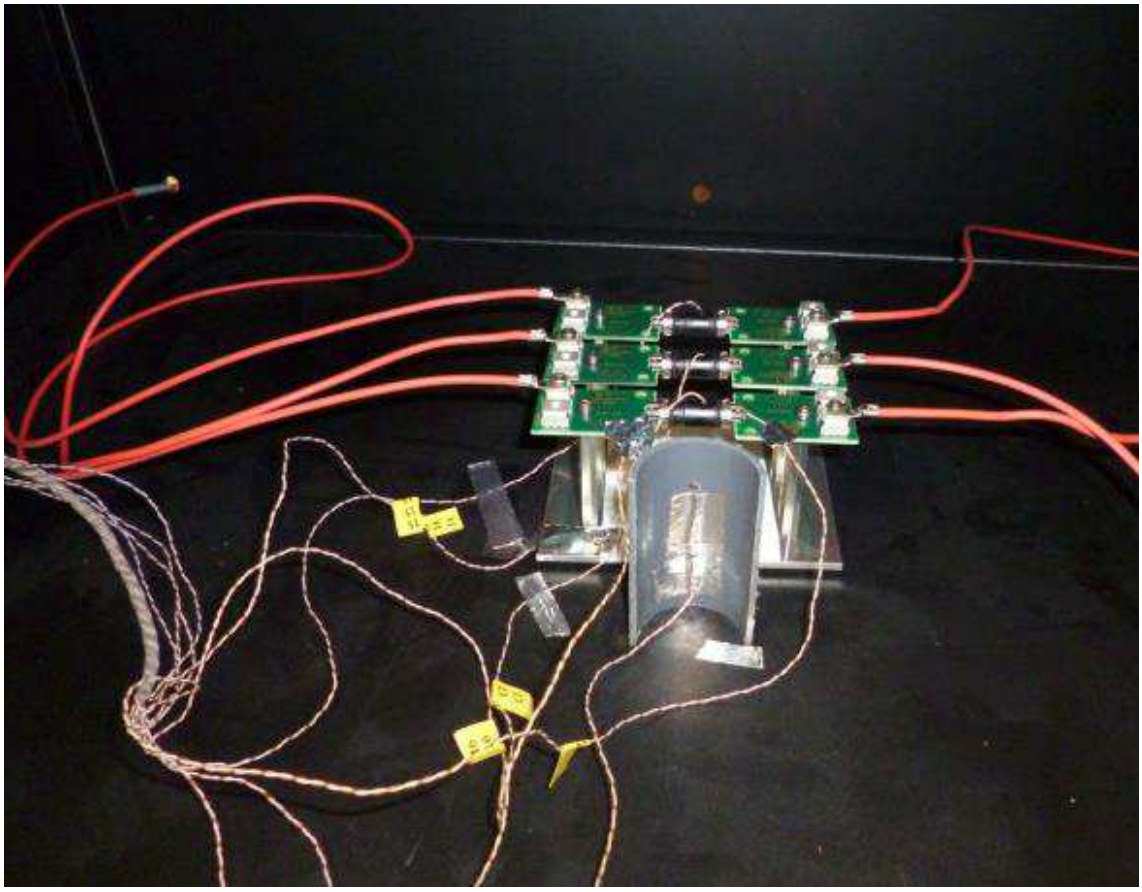


Fig. 36: Setup Current Temperature Derating

Revision Record

Revision	Remarks	Name	Date
A	Specification initiated	MSZ	27.02.2023