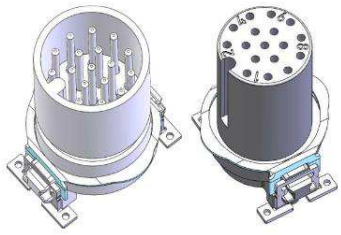
M8/ M12 - M17 CIRCULAR CONNECTOR, A, B, D - CODE SMD – STYLE

1 SCOPE

1.1 Content

This specification covers the performance, tests and quality requirements of the **SMD - version** of an **M8/ M12 Socket, A- code** for use in Industrial Ethernet applications. The qualification testing has been carried out representatively with the 17 pin version. Tests can be applied to connectors with deviating number of contacts and design of test devices.



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.*

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
  based on: Rep. No. **H3AP0001** / *SGS Germany GmbH – Munich* and Test Report No.: 1042
  501-19336 Qualification Test Report - TEC
- 114-94781 M8 / M12 PCB Connector Vertical, Code A, B, D, X
- 107-_____ Packaging is specified on the individual drawings
- 408-_____ Instruction Sheet (replaced by application spec.)

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 60512-6-3: 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 60512-11-1: 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 60512-16-5: 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 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 60068-2-27: 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
IEC 60512-9-1: 2010-03	Connectors for electronic equipment – Tests and measurements – Part 9-1: Endurance tests – Test 9a: Mechanical operation
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 61076-2-101: 2008	Connectors for electronic equipment – Product requirements – Part 2-101: Circular connectors – Detail specification for M12 connectors with screw-locking
IEC 60 512-5-2 Test 5b	Current-temperature derating curve: Test 5b
IPC/ JEDEC J-STD-020D	Moisture/Reflow Sensitivity Classification for No-hermetic Solid State Surface Mount Devices.

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 Material / Product

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.

The following connectors independently by the number of contact positions are to be examined:

1) Test Group	No. of Pins	Number of Connector Pairs			Part Number	Total
		Contact Resistance	Insulation Resistance Voltage Proof	Contact Disturbance		
P	17	9	9	3	**Female**: e.g. 484071-E	21
AP	17	3	3	3		9
BP	17	3	3		**Male:** e.g. 454645-E	6
CP	17	3	3			6

1) Test groups description acc. to IEC 61076-2-101
Deviation of quantities of test device to be agree between laboratory and product engineer.
The pre-investigation acc. to test group P is implemented within test sequencies as Step 1-5.

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

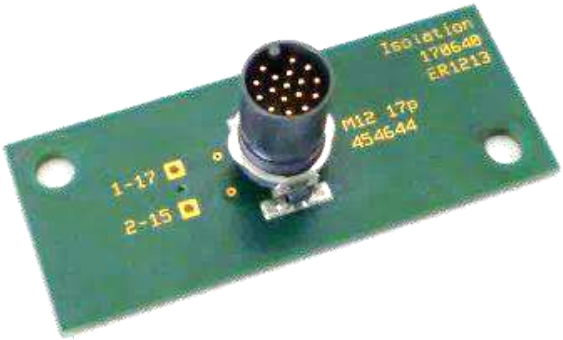


Fig.1: M12 Header, 17 Pins, Male-version
Representing all variants

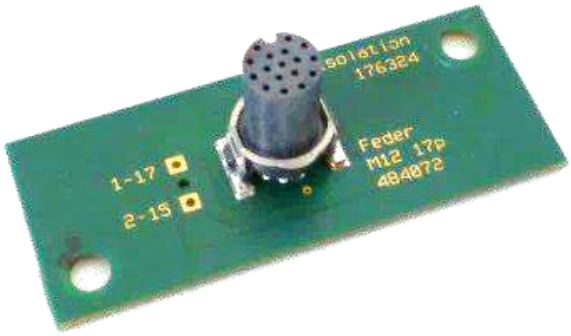


Fig.2: M12 Header, 17 Pins, Female-version
Representing all variants

3.3 **Ratings** - M12 Connector Couple, A-code

Operation Voltage	250 Vdc	contacts: 2 - 4
	60 Vdc	contacts: 5
	30 Vdc	contacts: 6 – 17
Rated Current	4.0 A	contacts 2 - 5
	2.0 A	contacts 6 - 8
	1.5 A	contacts 9 – 17
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 Moisture Sensitive Level 1 (MSL) applicable	
Ingress Protection (mated)	IP 67	
Mating Cycles	100 (specified for Au-plated contacts)	
Vibration	5 g	
Shock	50 g	
Reflow solderability	see: Reflow-profile / appendix	

3.4 Approvals and Certifications

The products have the following Agency Approvals Certifications:

Europe	CE (Conformité Européenne)
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.

3.6 Qualification Test Requirements and Procedures

3.6.1 Initial Pre-Investigation

EUT = Equipment Under Test

1. General Inspection		
Test	**Requirement**	**Comment**
Visual and dimensional examination	Meets specified dimensions and appearance	IEC 60512-1-1, Test 1a; Visual examination, performed with naked eyes

2. 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
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
Insulation resistance	500 Vdc / 60s min. 100 MOhm	IEC 60512-3-1, Test 3a, Insulation Resistance, Method: B
Voltage proof	500 Vac eff. / 60s No breakdown or flashover	IEC 60512-4-1, Test 4a Voltage proof, Method: B

3.6.2 Mechanical /Environmental Test

3. Mechanical Tests		
Test	**Requirement**	**Comment**
Gauge Retention Force	> 0,20 N alternative 20g	**Valid for all: IEC 60512-16-5; 16e; Method A; Female contacts only;** **Pin diameter: 1.00** ±0.03 Expending gauge diameter: 1.03 Drawing force gauge diameter: 0.97 3 contacts/test specimen
	> 0,20 N alternative 20g	**Pin diameter: 0.80** ±0.03 Expending gauge diameter: 0.83 Drawing force gauge diameter: 0.77 3 contacts/test specimen
	> 0,15 N alternative 15g	**Pin diameter: 0.60** ±0.03 Expending gauge diameter: 0.63 Drawing force gauge diameter: 0.57 3 contacts/test specimen
	> 0,20 N alternative 20g	**Pin diameter: 0.76** ±0.03 Expending gauge diameter: 0.79 Drawing force gauge diameter: 0.73 3 contacts/test specimen
Mechanical Vibration (Sinusoidal)	No contact disturbance $> 1\ \mu s$	IEC 60068-2-6, Test Fc; 0,35mm or 50m/s²; 10 – 60 - 500Hz; 1 oct/min; 5 sweeps per 3 axes >50% supply voltage
Mechanical Shock	No contact disturbance $> 1\ \mu s$	IEC 60068-2-27; Test Ea Half sine shock acceleration $490\ m/s^{-2}$ (50g) Duration of impact: $11\ ms$ Number of pulses per direction: 3 =18 shocks over all
Insertion/ Withdrawal Force **5 cycles**	Insertion force: 30 N max. Withdrawal force: 30 N max.	IEC 60512-13-2; Test 13b Rate: 5 mm/min max. speed = $10\ mm.s^{-1}$ Cycles: 5
Polarization and keying Method	Polarization: correctly aligned and mated	Keying (180° rotated): Force: 35 N No mated
Mechanical Operation		IEC 60512-9-1, Test 9a Mating speed: 10 mm/s Interval (unmated): 30 s Cycles: 50 (not for Sn/ Ag-plating)

4. Environmental Tests		
Test	**Requirement**	**Comment**
Temperature Shock		IEC 60512-11-4 / Test 11d Ta = -25 °C/ Tb = +80 °C t = 30 min, 5 cycles Transition Time : <10s
Dry heat 85		IEC 60512-11-1; Test 11i +85 °C / 16 h
Dry heat 125		IEC 60512-11-9; Test 11i t = +125 °C ; T = 1000 h
Damp heat, 1 cycle		IEC 60512-11-3 / Test 11c; 25/40 °C, 95 % r.H; 1 cycle; 24 h/cycle
Damp heat, 5 cycles		IEC 60512-11-3 / Test 11c; 25/40 °C, 95 % r.H; 5 cycles; 24 h/cycle
Coldness		IEC 60512-11-10 / Test 11j; -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

3.7 Qualification and Requalification Tests Sequence

Test Description	AP	BP	CP	ZP1	ZP2	ZP3
Visual and dimensional examination	**1**,10, 13,18,27	**1**,9,16	**1**	1, 6	1, 6	1, 6
Polarizing and keying method	**2**, 28	**2**	**2**			
Contact resistance (10 mOhm max.)	**3**	**3**	**3**	2	2	2
Contact resistance (15 mOhm to initial)	9,12,15, 23	8,11,13	7,13			
Insulation Resistance	**4**, 16,24	**4**,14	**4**, 8, 14	3	3	3
Voltage Proof	**5**, 17,25	**5**, 15	**5**, 9,15	4	4	4
Insertion and Withdrawal Forces 5x	6, 26	17				
Gauge Retention Force 1x	7	6,18				
Vibration (sinusoidal)	8					
Mechanical Shock	11					
Temperature Shock	14		6			
Dry Heat (85 °C)	19					
Dry Heat (125 °C)			12			
Damp Heat, 1x cyclic	20					
Coldness	21					
Damp heat, 5x cyclic	22					
Mechanical operation (50 cycles)		7,12	1)10+11			
Flowing Mixed Gas		10				
Reflow Solderability				5		
Reflow Solder Heat Resistance					5	
Derating						5

Last sequence number yellow marked
1) Mating cycle sequencies are to be performed continuously

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 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 ZP1/ ZP2	Reliability with (several time) reflow-soldering
Group ZP3	Reliability for Current Carrying Capacity

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 3.6. 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 OTHERS

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

acc. to IEC 61076-2-101 → Test Group P

Shown diagrams can deviate from the laboratory results depending on the test device resp. tested connectors.

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 10 contacts was measured using the millivolt level method.

Fig. 3 Test Group P: Setup contact resistance measurement millivolt level method

6.1.3. Insulation Resistance

The insulation resistance measurement was performed with method B.

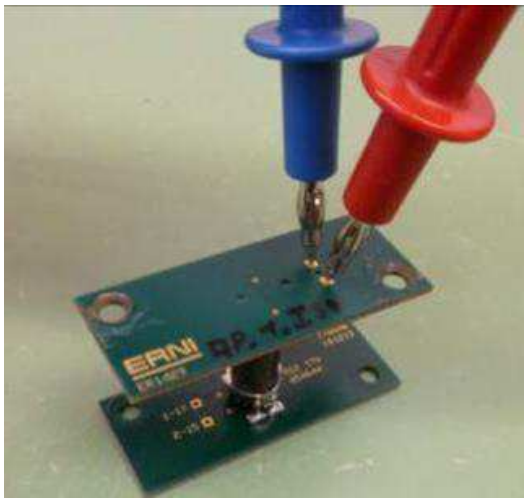


Fig. 4 Test Group P: Setup insulation resistance measurement

6.1.4. Voltage Proof

The insulation resistance measurement to be performed with method B.

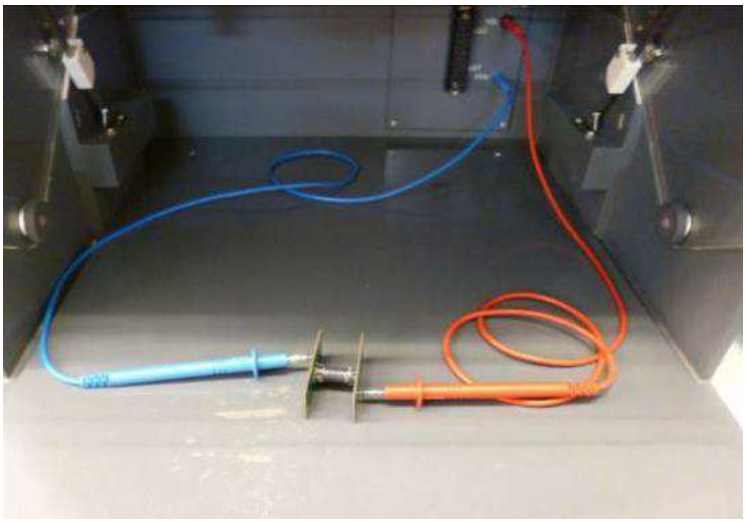


Fig. 5 Test Group P:
Setup voltage proof

6.2. Test Performance

acc. to IEC 61076-2-101 → Test Group AP

Pre-Tests to Test Group AP were performed upfront as described below Pos. 6.1

6.2.1. Insertion and Withdrawal Forces

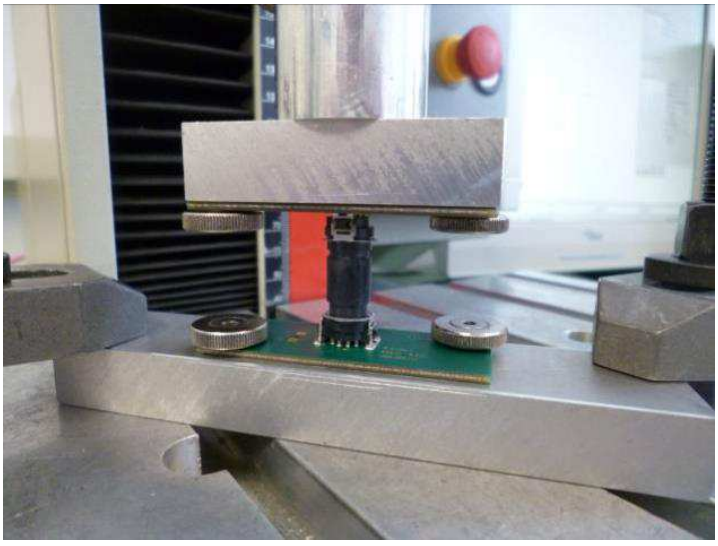


Fig. 6 Test Group AP: Test setup for insertion and withdrawal forces

6.2.2. Gauge Retention Force

Before the first gauge retention force test the maximum size gauge specified was inserted and withdrawn three times.

Fig. 7 Test Group AP:
Test setup for gauge retention force

6.2.3. Polarizing and Keying Method

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

Fig. 8 Test Group AP: Test setup for polarizing and keying method

6.2.4. Vibration (sinusoidal)

The EUT was screwed to an Aluminum mounting plate with a thickness of 30 mm. The mounting plate was fixed over a rigid Aluminum cube to the shaker. The test was performed in 3 mutually perpendicular axes During vibration (sinusoidal) the connectors were monitored for contact disturbance.

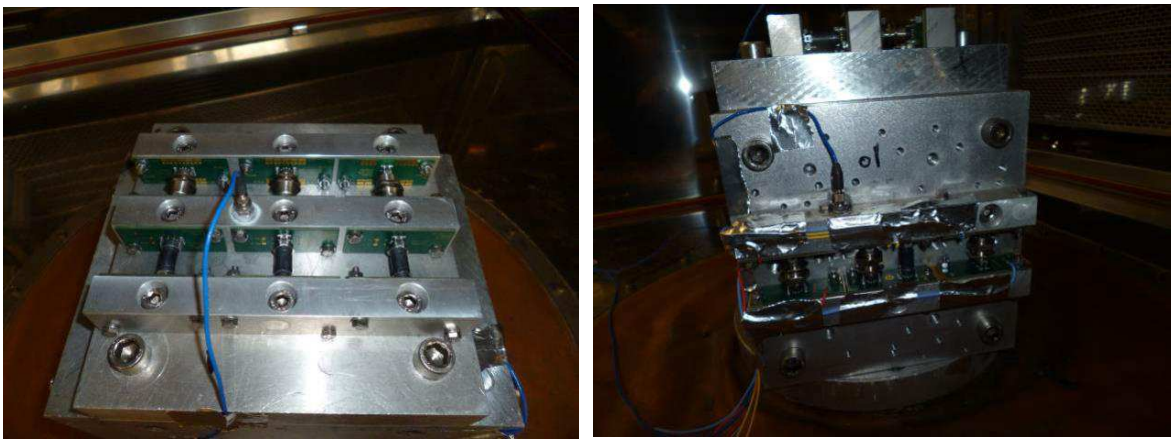


Fig. 9 Test Group AP:
EUTs mounted on shaker for Vibration (sinusoidal) 1st Run

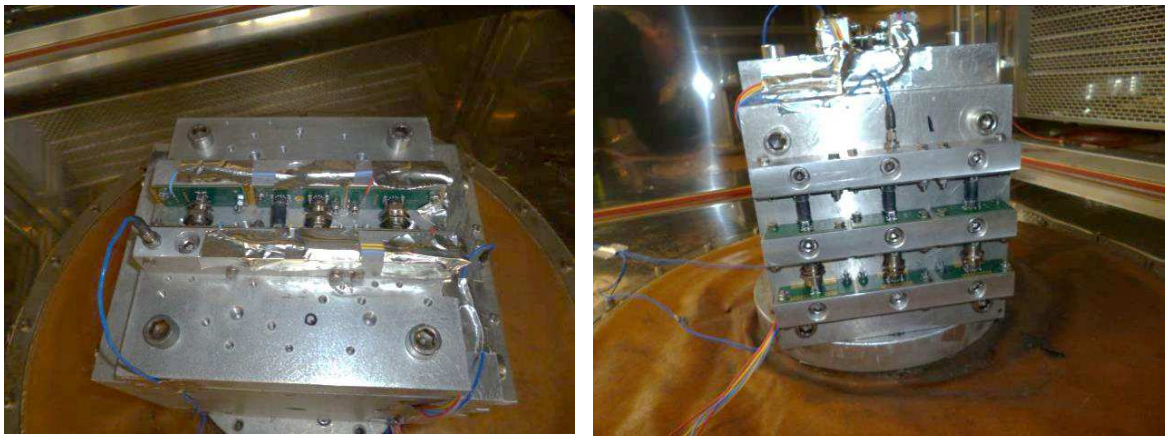
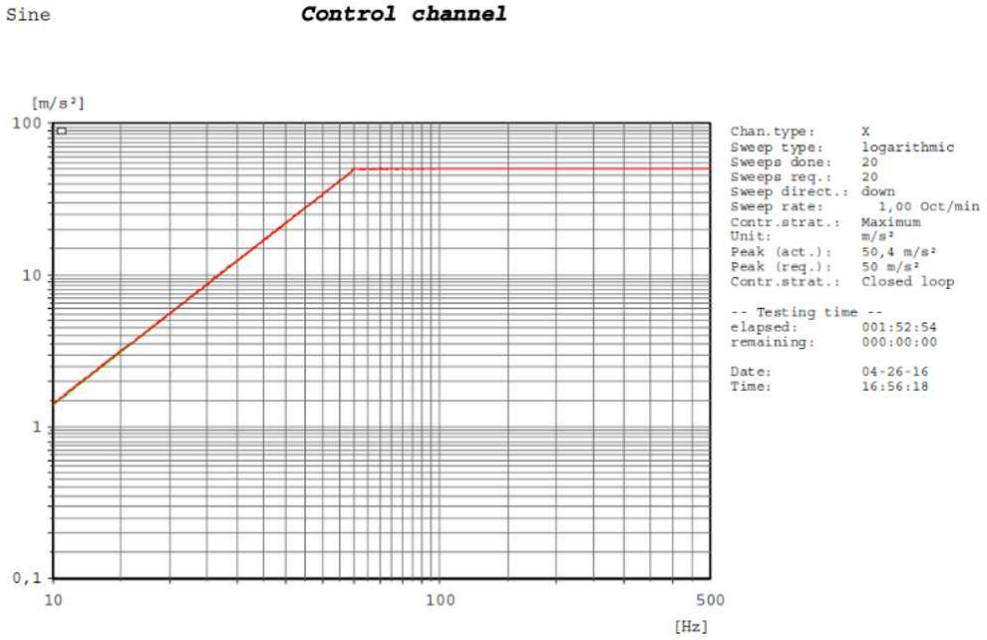


Fig. 10 Test Group AP: EUTs mounted on shaker for Vibration (sinus) 2nd Run

Fig. 11 Test Group AP: EUTs mounted on shaker for Vibration (sinus) 3rd Run



6.2.5.

Fig. 12 Test Group AP:
Acceleration vibration (sinus)

6.2.6. Mechanical Shock

The EUT was screwed to an Aluminum mounting plate with a thickness of 30 mm. The mounting plate was fixed over a rigid Aluminum cube to the shaker. The test was performed in 3 mutually perpendicular axes.

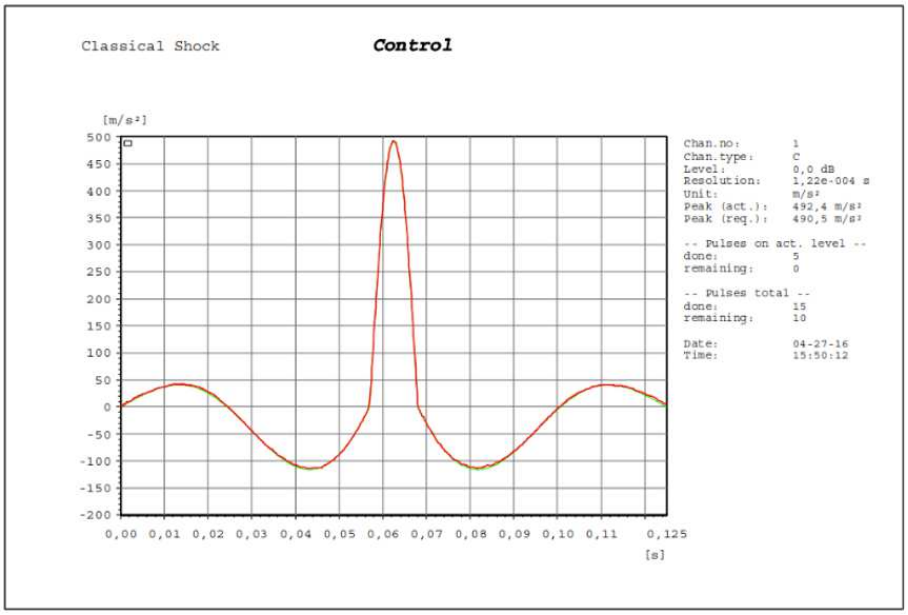


Fig. 13 Shock response direction up

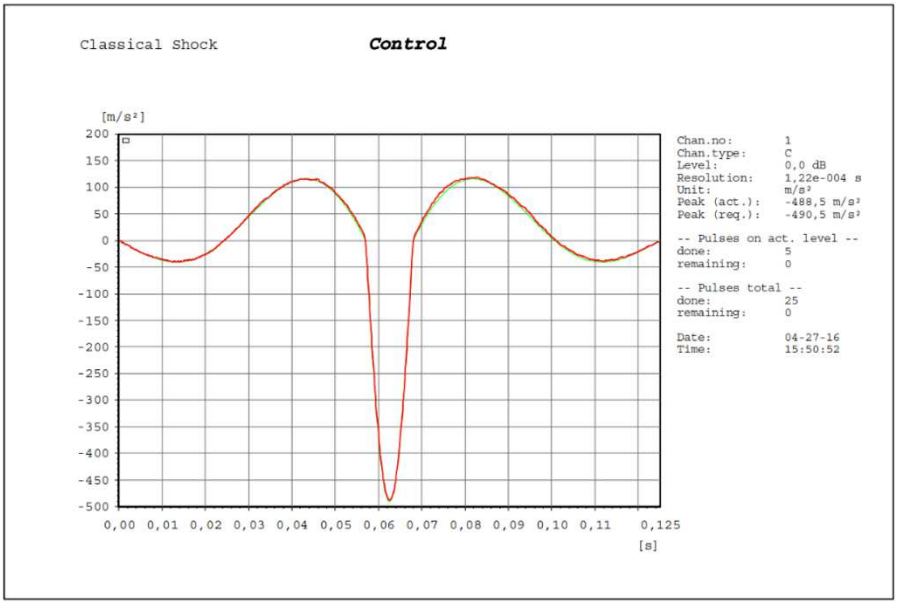
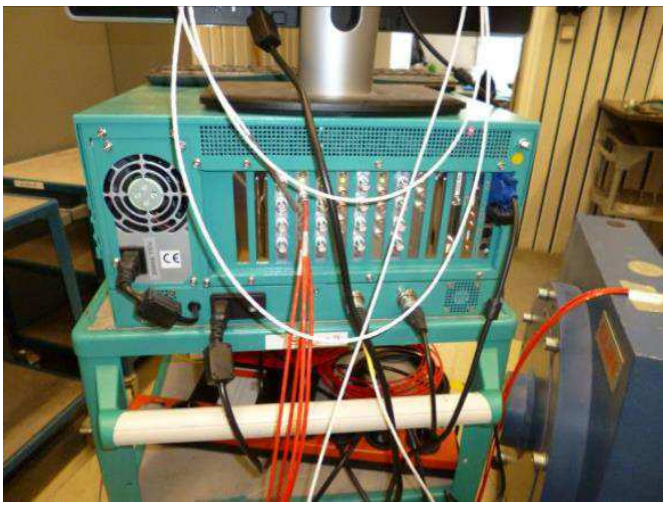


Fig. 14 Shock response direction down

6.2.7. Contact Disturbance Monitoring

During vibration (sinusoidal) and shock tests the connectors were monitored for contact disturbance wired with a 100Ω resistance and loaded with 10V DC. The voltage drop on the EUT was monitored with a data logger with 40



MS/s. The trigger level was adjusted to a voltage of 5V.
Fig. 15 Test Group AP: Setup contact disturbance monitoring

6.2.8. Change of Temperature

Fig. 16 EUTs in the climatic chamber for rapid change of temperature

6.2.9. Dry Heat / Climatic Sequence

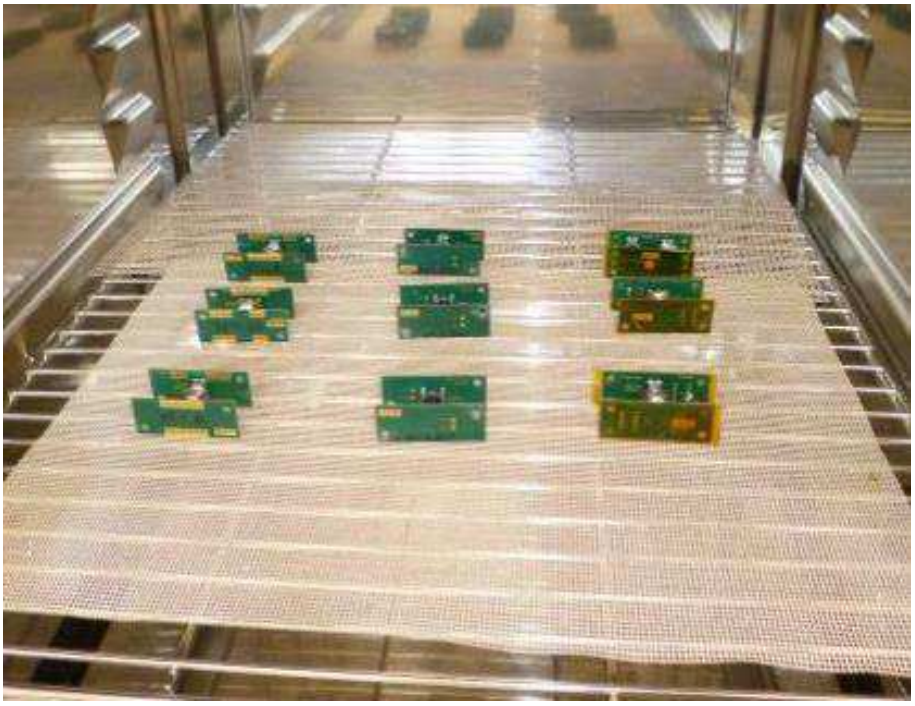


Fig. 17 Test Group AP: EUTs in the climatic chamber for Climatic Sequence

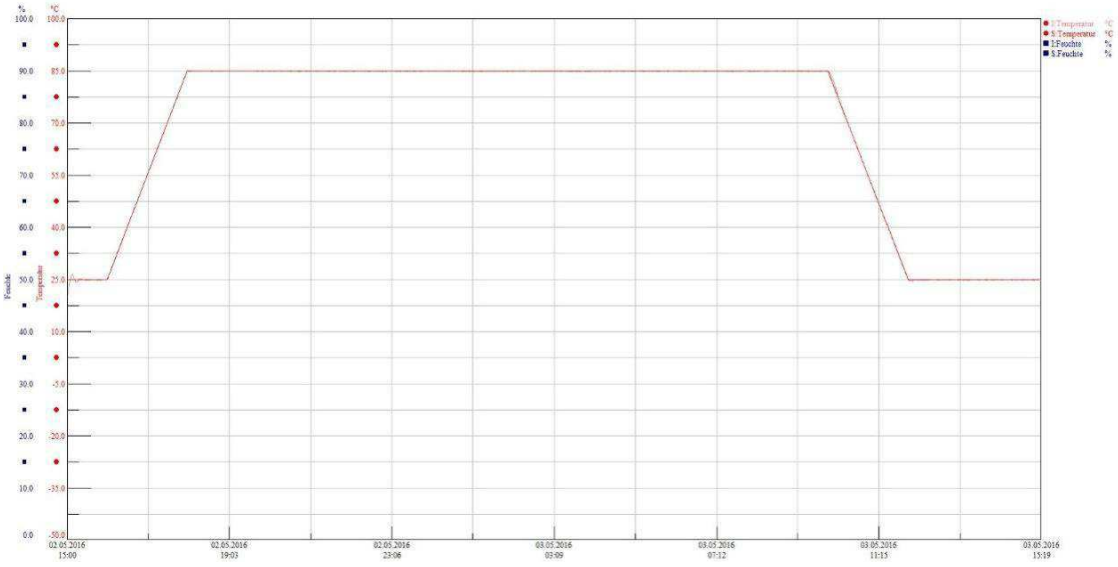


Fig. 18 Test Group AP: Temperature recording from dry heat

6.2.10. Coldness

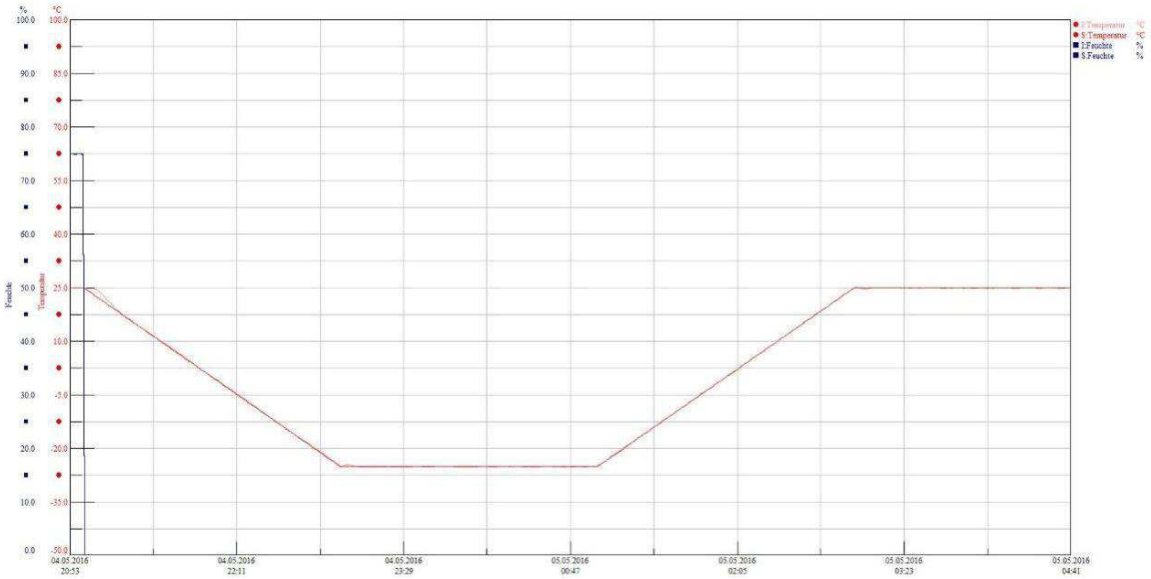


Fig. 19 Test Group AP: Temperature changing to / from coldness

6.2.11. Damp Heat, Cyclic

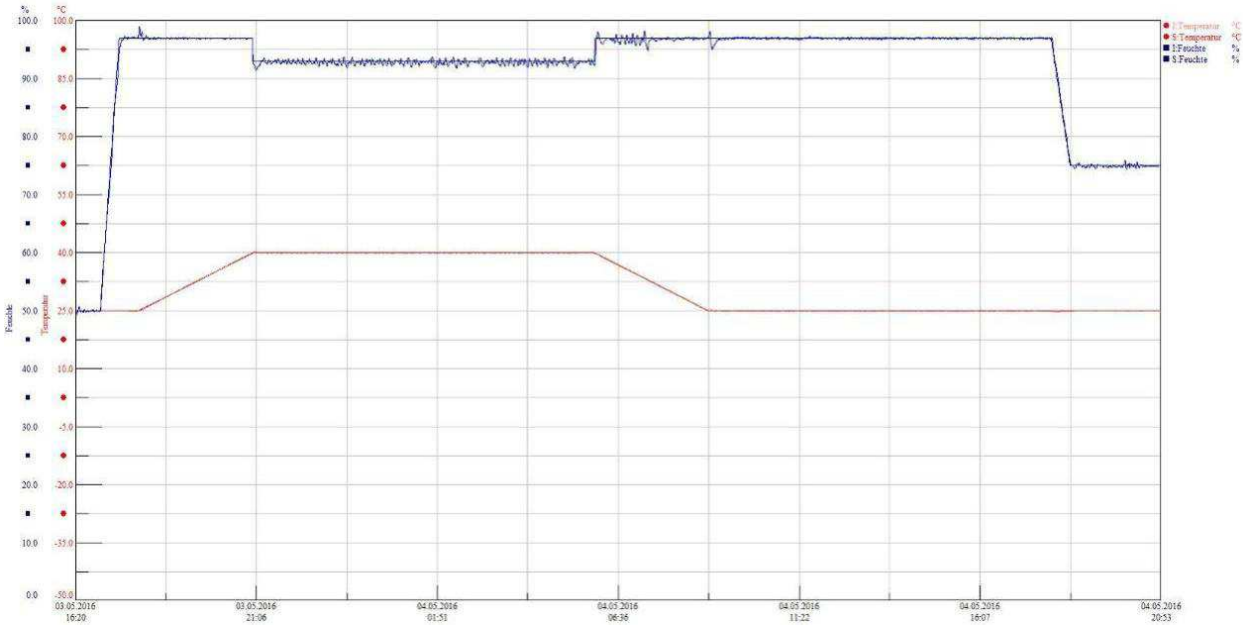


Fig. 20 Test Group AP: Temperature and humidity during damp heat; cycle 1

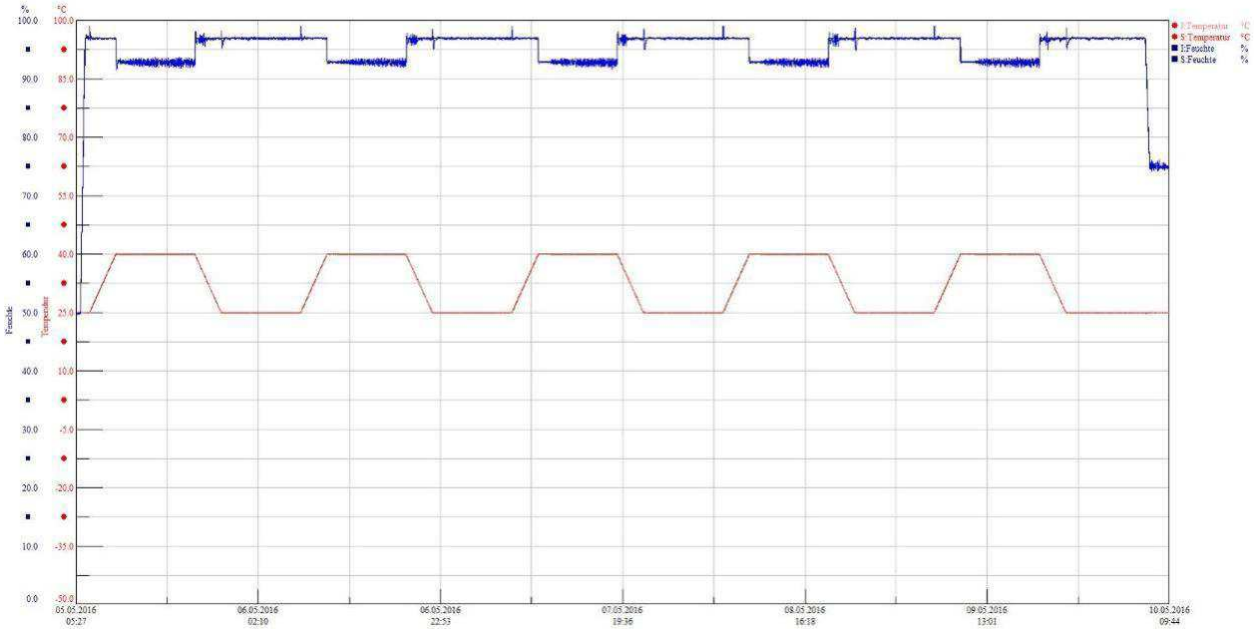


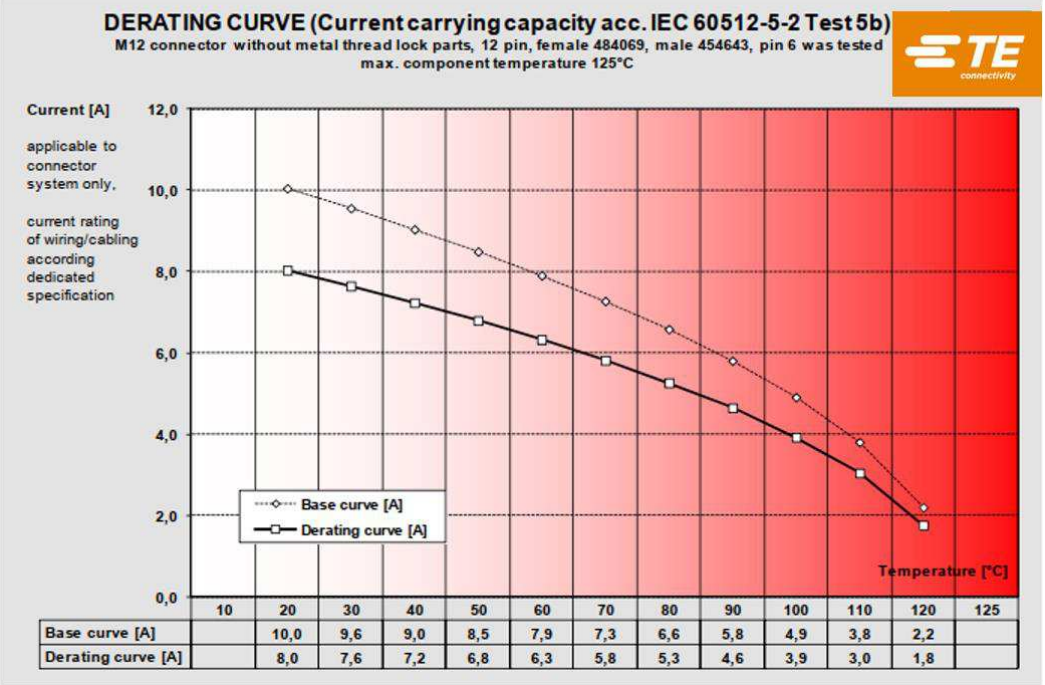
Fig. 21 Test Group AP: Temperature and humidity recording from damp heat cyclic / cycles 2 till 6

6.3.1 Derating Test – ZP3

IEC 60 512 test 5b

Other connectors with different number of pins will lead to deviations in the result.

Derating curve of the 12 pin variant



	10	20	30	40	50	60	70	80	90	100	110	120	125
Base curve [A]		10,0	9,6	9,0	8,5	7,9	7,3	6,6	5,8	4,9	3,8	2,2	
Derating curve [A]		8,0	7,6	7,2	6,8	6,3	5,8	5,3	4,6	3,9	3,0	1,8	

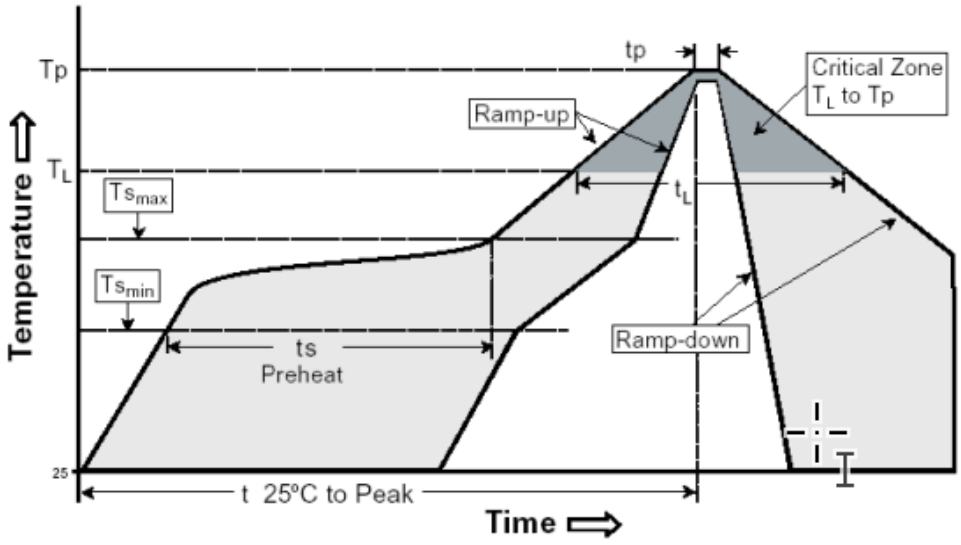
6.4.1 Reflow Solderability - ZP2

IEC 60 068-2-58 Ed.3
3x Soldered for more reliability

Solder paste: SnAgCu / melting point: 217°C

Reflow profile to verify solder ability

Profile Feature	Pb-Free Assembly
Average Ramp-Up Rate (Ts_{max} to Tp)	3°C/ second max.
Preheat – Temperature Min (T_{smin}) – Temperature Max (T_{smax}) – Time (ts_{min} to ts_{max})	 150 ± 5°C 180 ± 5°C 60-120 seconds
Time maintained above: – Temperature (T_L) – Time (t_L)	 225°C 20 ± 5seconds
Peak/Classification Temperature (Tp)	235°C (+0/-5°C)
Time within 5 °C of actual Peak Temperature (tp)	10 seconds
Ramp-Down Rate	6 °C/second max.



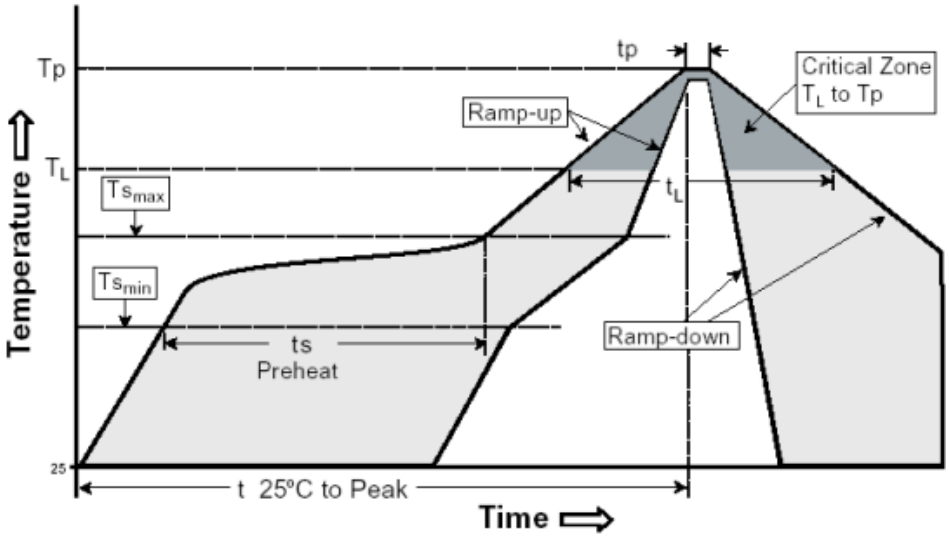
6.4.2 Reflow Resistance to Soldering Heat - ZP3

IPC/ JEDEC J-STD-020D
1x Soldered

Number of cycles:3

Reflow profile to verify resistance to soldering heat

Profile Feature	Pb-Free Assembly
Average Ramp-Up Rate (Ts_{max} to Tp)	3°C/ second max.
Preheat – Temperature Min (Ts_{min}) – Temperature Max (Ts_{max}) – Time (ts_{min} to ts_{max})	 150°C 200°C 60-150 seconds
Time maintained above: – Temperature (T_L) – Time (t_L)	 217°C 60-150 seconds
Peak/Classification Temperature (Tp)	260°C (+0/-5°C)
Time within 5 °C of actual Peak Temperature (tp)	20-40 seconds
Ramp-Down Rate	6°C/second max.
Time 25 °C to Peak Temperature	8 minutes max



Revision Record

Revision	Remarks	Name	Date
A	Specification initiated	MSZ	09.09.2022
B	Chap.1: “Content” extended; Chap. 2.1: 107-/ 408- changed; Page 3 bot.: 2 spec´s added; Chap. 3.2 Tab. Value 6->3 changed, Note 1 modified; Fig. description extended Chap. 3.3: “MSL 1” added; “6-12” → “6-17”, “9-12”→ “9-17” Chap. 3.6.2.: Gauge Retention Force: extended; Description “Mechanical Operation”: comment extended; Chap. 3.7 foot note 1 modified, Description test group ZPx added; Chap. 6.4.1/6.4.2 added; Pos. 3.4: not required UL-filed removed	MSZ	08.05.2024