zvei electrifying ideas

Validation of Low Voltage Automotive Connectors

Technical Guideline – TLF 0214

Electro and Digital Industry Association

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Preface

This technical guideline represents a non-binding technical description of test procedures for automotive connectors up to 60 V DC. Representatives of the connector manufacturers in the ZVEI prepared the actual version. The aim is to enable a non-binding comparability of test procedures and the transferability of results.

Equivalent or different test procedures are not to be excluded, as they serve the purpose of rapid further development in consideration of the increasing requirements in the development of vehicles.

In addition to the association's publication, it is intended that this ZVEI technical guideline (TLF) should be used for international standardization in the relevant standardization organization.

The ZVEI-TLF corresponds to the respective processing status at the time of the creation of the guideline.

It is intended as a non-binding guide for manufacturers and does not claim to be complete.

Tests can be individually adapted according to the state of the art in measurement and manufacturing technology.

This document is an English translation of the German version. In case of questions of understanding which could be causal in the English translation, it is recommended to contact one of the involved contact manufacturers. In case of doubt, the German version applies.

1 Decision-Making Process

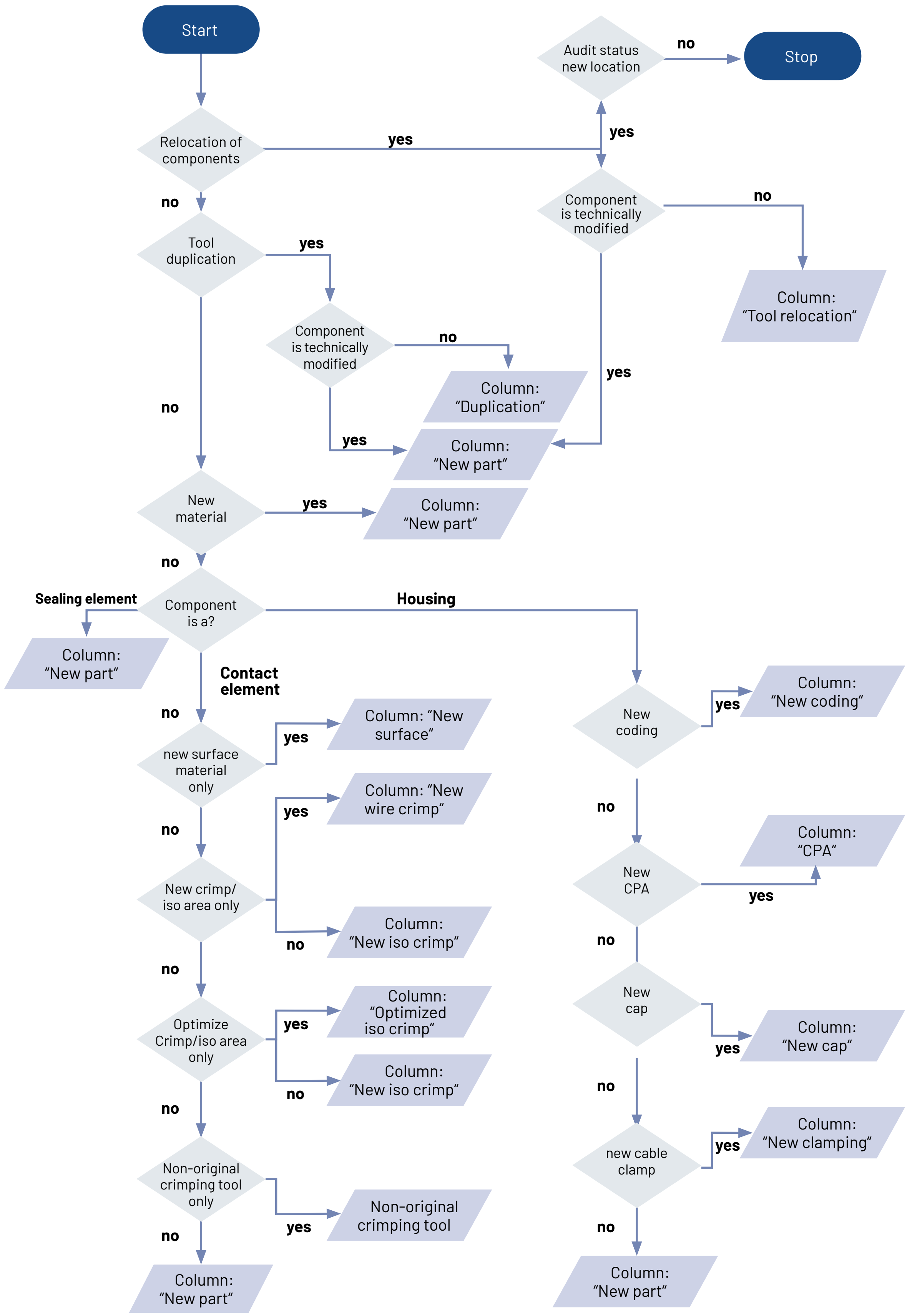


Figure 1: ZVEI

2 Test Matrix Contacts

PG	Validation Tests acc. to TLF 0214	Contacts: New Contacts	Tool Duplication	Tool Transfer	New Surface /Coating	New Surface / Coating Supplier (Galvanic)	New Base Material (Changed Specification)	New Base Material Supplier	New Conductor Crimp (Cross Section)	Optimized Conductor Crimp (Layout)	New ISO (SWS) Crimp	Applicator, other than original (Validation by Supplier)	Special Add-On Validation Test
0	Visual Inspection	■	■	■	■	■	■	■	■	■	■	■	
1	Dimensions	■	■				■		■	■	■		
2	Material- and Surface Analysis, Contacts	■	■		■	■	■	■					
3	Material- and Surface Analysis, Connectors and Sealing Elements												
4	Contact Overlap	■											
5	Mechanical and Thermal Relaxation Behavior (4)												■
6	Interaction Between Contact and Connector Housing	A							D	D	D		
7	Connector Handling and Functional Integrity												
8	Insertion and retention forces of the contacts in the contact housing	■	■				3		■		■		
9	Skewed insertion (Kojiri-Safety)												
10	Contacts: Conductor Pull-Out Strength	■	■		1	1	2	2	■	■		■	
11	Contacts: Insertion and Extraction Forces, Mating Cycles	■	S		■	S	■		S	O, S			
12	Temperature Rise, Derating	■			■		■		■				
13	Influence of the housing on the Derating												P
14	Short Term Overload	Z					Z		Z				
15	Electrical Stress Test	■			■		■		D				
16	Fretting Corrosion												R
17	Dynamic Load	■			■		■		D				
18A	Coastal Climate Stress Test	■			■		■						
18C	Road Salt Stress Test												■
19	Environmental Simulation	■			■		■						
20	Climate Stress Test, Connectors												
21	Long Term Temperature Storage – Connectors												
22A	Chemical Resistance												
22B	Chemical Resistance, Advanced Test												
23	Watertightness	G									G		
28	Audible Click												
29	Blind Plug Holding Force												
31	Measurement of Contact (Pin / Tab) Extraction Force on Header / Connector												
60	Headroom Integrity of Crimp Contacts	■	Y		1		■		■	■		■	
70	Crimp Test – SMBT (Slow Motion Bending Test)	■			1		■		■	■	■	■	

Source: ZVEI

3 Test Matrix Connectors

		Connector housings														
		Unsealed					Sealed									
PG	Validation Tests acc. to TLF 0214	New Tool Unsealed	Tool Duplication Unsealed	Tool Transfer Unsealed	New Material Unsealed	New Material Supplier	New Tool Sealed	NTool Duplication Sealed	Tool Transfer Sealed	New Material Sealed	New Material Supplier	New Coding	Additional CPA of existing Connector Housing	Optional Wire Clamping	New Cover	Special Add-On Validation Test
0	Visual Inspection	■	■	■	■	■	■	■	■	■	■	■	J	■	■	
1	Dimensions	■	■		■	■	■	■		■	■	■	J	■	■	
2	Material- and Surface Analysis, Contacts															
3	Material- and Surface Analysis, Connectors and Sealing Elements	■	■		■	■	■	■		■	■		J	K	■	
4	Contact Overlap	■					■									
5	Mechanical and Thermal Relaxation Behavior (4)															
6	Interaction Between Contact and Connector Housing	■	■		■		■	■		■				L	L	
7	Connector Handling and Functional Integrity	■	■		■	V	■	■		■	V	■	J			
8	Insertion and retention forces of the contacts in the contact housing	■	■		■	U	■	■		■	U	■		M		
9	Skewed insertion (Kojiri-Safety)	■					■					■				
10	Contacts: Conductor Pull-Out Strength															
11	Contacts: Insertion and Extraction Forces, Mating Cycles															
12	Temperature Rise, Derating															
13	Influence of the housing on the Derating	■			T		■			T						
14	Short Term Overload															
15	Electrical Stress Test															
16	Fretting Corrosion															
17	Dynamic Load	■			■		■			■				■		
18A	Coastal Climate Stress Test															
18C	Road Salt Stress Test															
19	Environmental Simulation															
20	Climate Stress Test, Connectors	■			■		■			■			J	K	K	
21	Long Term Temperature Storage – Connectors	■			■		■			■			J	K	K	
22A	Chemical Resistance	■			■		■			■			J	K	K	
22B	Chemical Resistance, Advanced Test						■			■			J	K	K	
23	Watertightness						■	■		■						
28	Audible Click	■			■		■			■						
29	Blind Plug Holding Force						■	■		■						
31	Measurement of Contact (Pin / Tab) Extraction Force on Header / Connect															
60	Headroom Integrity of Crimp Contacts															
70	Crimp Test – SMBT (Slow Motion Bending Test)															

Source: ZVEI

4 Test Matrix Sealing / Sealing Elements

PG	Validation Tests acc. to TLF 0214	SWS, Family- and Connector housing Seal Elements: New Tool Part	Tool Duplication	Tool Transfer	New Material Supplier	Special Add-On Validation Test
0	Visual Inspection	■	■	■	■	
1	Dimensions	■	■	■	■	
2	Material- and Surface Analysis, Contacts					
3	Material- and Surface Analysis, Connectors and Sealing Elements	■	■	■	■	
4	Contact Overlap					
5	Mechanical and Thermal Relaxation Behavior (4)					
6	Interaction Between Contact and Connector Housing					
7	Connector Handling and Functional Integrity	W	W		W	
8	Insertion and retention forces of the contacts in the contact housing	M	M		M	
9	Skewed insertion (Kojiri-Safety)					
10	Contacts: Conductor Pull-Out Strength					
11	Contacts: Insertion and Extraction Forces, Mating Cycles					
12	Temperature Rise, Derating					
13	Influence of the housing on the Derating					
14	Short Term Overload					
15	Electrical Stress Test					
16	Fretting Corrosion					
17	Dynamic Load					
18A	Coastal Climate Stress Test					
18C	Road Salt Stress Test					
19	Environmental Simulation					
20	Climate Stress Test, Connectors					
21	Long Term Temperature Storage – Connectors	■	■		■	
22A	Chemical Resistance	■			■	
22B	Chemical Resistance, Advanced Test	■			■	
23	Watertightness	■	■	■	■	
28	Audible Click					
29	Blind Plug Holding Force	■	■	■	■	
31	Measurement of Contact (Pin / Tab) Extraction Force on Header / Connector					
60	Headroom Integrity of Crimp Contacts					
70	Crimp Test – SMBT (Slow Motion Bending Test)					

Source: ZVEI

5 Test Matrix Header

PG	Validation Tests acc. to TLF 0214	Header: New Tool Part	Header: Tool Duplication	Header: Tool Transfer	Header: New Material Supplier	Header: Special Add-On Validation Test
0	Visual Inspection					
1	Dimensions					
2	Material- and Surface Analysis, Contacts					
3	Material- and Surface Analysis, Connectors and Sealing Elements					
4	Contact Overlap					
5	Mechanical and Thermal Relaxation Behavior (4)					
6	Interaction Between Contact and Connector Housing	L	L		L	
7	Connector Handling and Functional Integrity	W	W		W	
8	Insertion and retention forces of the contacts in the contact housing					
9	Skewed insertion (Kojiri-Safety)					
10	Contacts: Conductor Pull-Out Strength					
11	Contacts: Insertion and Extraction Forces, Mating Cycles					
12	Temperature Rise, Derating					
13	Influence of the housing on the Derating					
14	Short Term Overload					
15	Electrical Stress Test					
16	Fretting Corrosion					
17	Dynamic Load					
18A	Coastal Climate Stress Test					
18C	Road Salt Stress Test					
19	Environmental Simulation					
20	Climate Stress Test, Connectors					
21	Long Term Temperature Storage – Connectors					
22A	Chemical Resistance					
22B	Chemical Resistance, Advanced Test	X			X	
23	Watertightness	X			X	
28	Audible Click					
29	Blind Plug Holding Force					
31	Measurement of Contact (Pin / Tab) Extraction Force on Header / Connector					
60	Headroom Integrity of Crimp Contacts					
70	Crimp Test – SMBT (Slow Motion Bending Test)					

Source: ZVEI

6 Legend – Test Matrix and General Rules

Legend Test Matrix

1. Applicable only, if crimp surface is involved.
2. Applicable only, if crimp is involved.
3. Applicable only, if locking lance material was changed
4. Only, if a spring element in the contact area is available

A "Drop test" (B 6.1) not applicable.
C Applicable only, if locking mechanism function is involved.
D Applicable only, if wire crimp is increased.
E Contacts insertion force (E 8.1) if wire cross section is reduced (e.g. 0.13 mm^2).
G Sealing integrity of released SWS (wire, connector) has to be proven.
J Test of CPA only.
K Applicable only, if additional component.
L "Drop test" only (B 6.1).
M "Contact insertion force" only (E.8.1).
O "Contact gap size" only (E 5.1) and "Insertion- and extraction force" (E 11.1) if crimp is across the mating direction.
P Connector and assembly situation has to be agreed.
S Onlyfirst insertion and extraction force.
T Applicable only, if the new material is rated to a different temperature class.
U Applicable only, if the contact seating is affected.
V Applicable only, if relevant areas are affected.
W Only, "insertion force" (E 7.4) / Applicable only, if housing seal element is affected.
X Sealed applications only.
Y Applicable only, if stamping process changed (i. e. double out stamping tools).
Z Applicable only, if contact / wire cross section were the wires can withstand the applied current

General Rules

Unless otherwise specified in the individual TGs, following test parameters to be used:
Speed: 50 mm/min ± 5 %.
Measuring frequency during continuous monitoring: min. 1 value per 5 minutes.
Ambient temperature: 23 ± 5 °C

Default tolerances of nominal values:

Temperature: ± 3 °C
Relative humidity: ± 5 % r. F.
Voltage: ± 5 %
Current: ± 5 %
Resistance: ± 5 %
Length: ± 5 %
Time: ± 5 %
Force: ± 5 %
Frequency: ± 5 %
Pressure: ± 5 %

Input values of the TGs can be transfered to or from TG 0 are transferred.
All tests within a test group must carried out in the specified order. Deviations must be released separately.
In all tests it must be ensured that the test samples are according the valid drawing documents and meet product specifications.

Unless otherwise stated, all tests are to be carried out with parts from series production. Sorting, lubricating, cleaning or other modifications are not permitted.

Terminal sizes from 0.60 mm to 0.64 mm are consolidated as 0.63 mm.

7 Classification

Temperature Classes (Ambient temperature corresponds with climate chamber during the entire test)

Without self-heating of the contact system thru current temperature rise.

T1 -40 °C / +85 °C
Chassis, passenger compartment, battery electric vehicles

T2 -40 °C / +105 °C
Chassis, passenger compartment with increased temperature exposure, e.g. sun

T3 -40 °C / +125 °C
Protected areas engine compartment, e. g. splash/fire wall, transmission

T4 -40 °C / +150 °C
Engine applications, direct engine mounted or with high heat radiation (e.g. exhaust)

T5 -40 °C / +175 °C
Engine applications, direct engine mounted nearby the exhaust system or exposed thru heat accumulation

T6 -40 °C / +200 °C
Special/severe applications

TP specific temperature. Product-related selection based on information of the product specification and / or component drawing

Sealing Classes, Water Tightness

D1 IPX0
Unsealed systems passenger compartment, or in boxes.

D2 IPX4K
Sealed systems with normal exposure without cover or packaged on chassis.

D3 IPX8
Sealed systems temporarily below water level, e.g. located on vehicle underbody.

D4 IPX9K
Connector systems exposed by high pressure steam jet cleaning.

Weight Classes (Weight limit refer to unloaded connector housings)

G1 No drop test
Components with high dead weight of (> 100 g) or multi-part components like boxes

G2 Drop test on concrete floor
Components with dead weight of (15 g ≤ m ≤ 100 g)

G3 Drop test with drum
Components with low dead weight of (< 15 g)

Vibration Classes (Combustion Engine)

V1 Noise and Shock
Chassis unsealed, passenger compartment

V2 Noise and Shock
Chassis sealed, engine compartment, wheel mounted

V3 Sinusoidal / Noise
Aggregate engine mounted, transmission mounted

V4 Sinusoidal / Noise
Direct engine mounted, sensor engine mounted

V5 Sinusoidal
Direct engine mounted, increase requirements

V6 Sinusoidal
Direct engine mounted, special applications

8 Evaluation Contact Surfaces after Test*

Carrying out this evaluation requires a stable resistance behavior in the case of electrically monitored test samples. As a final examination, it is recommended to evaluate all test samples in the test group using a light microscope (after opening the contacts and cleaning them in an ultrasonic bath, for example) and to further analyze the visually worst test samples using the methods described. The assessment must be carried out separately according to the surface plating and can only be used for standard surfaces according to the AV tab standard (SnI, SnII, Au, AgI, AgII). For other contact finishes, a state-of-the-art evaluation criterion must be specified.

Depending on the surface plating and type of exposure the following analysis methods may be used in following order: Light microscopy (also in combination with microsections in the contact areas), X-ray fluorescence analysis (XRF) to determine the layer thickness, scanning electron microscopy (SEM) in conjunction with EDX and, in individual cases, FIB (Focussed Ion Beam) cuts in the contact zone can be used.

The measurement of the layer thickness using X-ray fluorescence analysis (XRF) is possible both in the incoming inspection (PG 2) and after loading, but the size of the measuring spot (collimator) should be adapted to the effective contact point size.

Criteria for Sn-surfaces:

For SnII (hot dip tin plating), no appearance of base material (normally Cu) is permitted; smearing or thinning of the layer down to the intermetallic phases (Cu_xSn_y) is permitted. A light microscopic examination is sufficient if the damage is clear; the remaining layer thickness in the contact point can also be additionally evaluated by means of XRF.

For the detection of fretting corrosion (formation of tin oxide, recognizable by the dark color of the contact point) after e.g., vibration exposure, the analysis of the oxygen content in the contact point in comparison to an unexposed area using EDX is recommended. It should be noted that the beginning of fretting corrosion is not a criterion for failing this test (end-of-life test).

For SnI (galvanic tin-plating with a nickel underlayer), the assessment is analogous to SnII, with the difference that wear through to the nickel intermediate layer is assessed as not having been passed. The formation of nickel oxide after e.g., vibration exposure can be detected by using EDX.

Criteria for Au-surfaces:

Gold surfaces must be intact after exposure, this can clearly be checked by means of light microscope on the basis of the characteristic color. The layer thickness can also be measured using XRF to assess the extent of wear. In the event of a dispute, an analysis using EDX at low acceleration voltage is recommended to determine the layer morphology at the contact point.

Criteria for Ag-surfaces:

The following applies to AgII and AgI:
Due to the ductility of silver, both microscopic and macroscopic loading lead to smearing of the silver layer, in some cases associated with a decrease in layer thickness compared to the initial state. However, as a rule, finely dispersed silver crystallites remain in the contact point and ensure stable electrical contact after loading. Under the light microscope, this effect shows up as a black coloration of the contact point, which is not a failure criterion for silver. Evaluation by means of EDX is recommended, especially after vibration loading or, if suitable reference tests are available, evaluation by means of XRF.
Based on a known contact spot size, the analysis of the silver content in this area shall be analysed using EDX with a suitable acceleration voltage. A verified silver content of at least 20 percent by weight is to be assessed as passed. The silver layer does not have to be intact or homogenous.
After macroscopic mechanical stress, for example in PG 11, it is possible to measure the silver thickness using XRF in relation of the initial state. The remaining silver thickness should be in the range of 20 percent of the initial thickness in order to evaluate the examination as passed.

* as a property test in PG 2 and especially after stresses in PG 11, PG 15, PG 17 and PG 19.

9 PG 0 Visual Inspection

Purpose:
Required inspection of all contacts and connector housings in new conditions, without previous loads.

Requirement:
Determination of deviations from the actual state.

Test \ Test item	Connector housing	Contact	New Application (Aggregate / Inline)	New Wire Cross Section	SWS Mat seal
E 0.1 Visual inspection	X	X	X	X	X
E 0.2.1 Contact resistance		X	X		
E 0.2.2 Crimp resistance		X		X	
E 0.3 Insulation resistance*)	X			X	

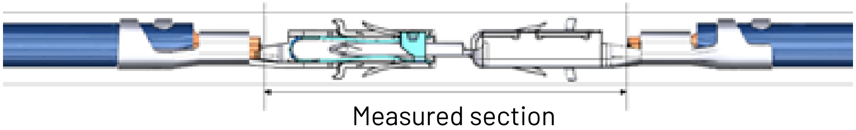
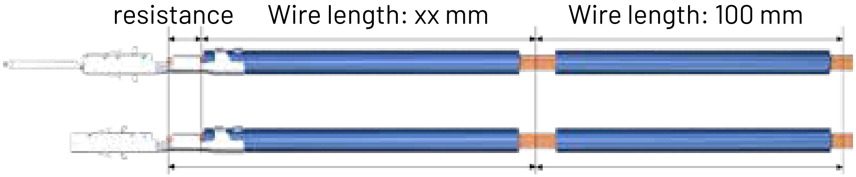
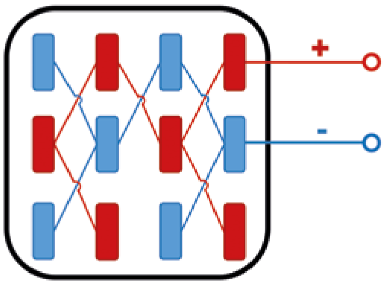
*) The measurement E 0.3 insulation resistance to be carried out only if the required air and creepage distances have not been verified by CAD. (Source: ZVEI)

Contacts:
All existing variants.

Connector housings:
All existing variants.

SWS / Mat seal:
All existing variants.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
	The basic mechanical functions of the test samples must be checked as part of the visual inspection.
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
	Contacts: 10 test samples per variant **Wire cross section:** All variants

E 0.2.1	Contact resistance
	Exemplary illustration:  Figure PG 0-1 (Source: Kostal Kontakt Systeme)
E 0.2.2	Crimp resistance
	 $R_{\text{Calculated resistance}} = R_{\text{Measured section 2}} - R_{\text{Measured section 1}} \cdot \frac{xx}{100}$ Figure PG 0-2 (Source: Kostal Kontakt Systeme)
E 0.3	Insulation resistance DIN EN 60512-3-1
	Contact parts: arbitrary **Housing:** 1 housing Insulation resistance between all neighboring contacts.  Figure PG 0-3 (Source: Kostal Kontakt Systeme)

Requirement:

Connection resistance:

The measured values must correspond to the manufacturer's specification.
The limit values of the connection resistance (E 0.2) must be meet (see Appendix A).
Measured values according to E 0.2.1 and E 0.2.2 must be documented.
The measured values and standard deviation of the respective test items must be documented.

Insulation resistance:

R_{isol} > 100 MΩ bei U = 500 V DC
The value of the insulation resistance to be read out after a stable state has been reached.

However, if a stable state cannot be reached, the value of the insulation resistance to be read out 60 s – 5 s after the measuring voltage has been applied.

10 PG 1 Dimensions

This test is only to be carried out if the dimensions are not in other reports, e.g. measurement report. A separate cross-reference in the functional report / test report is not required.

Purpose:
Dimensional control of all contacts, connector housings and sealing elements:

Number of Test Samples:
All parts of a production step must be considered (multiple outputs / multiple cavities).

Contacts:
All existing variants.

Connector housings:
For each variant exemplary 1 test sample per cavity has to be checked.

Sealing elements:
Single Wire Seals, Blind Plugs und Connector Housing Sealings (all relevant variants).

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
	The visual inspection must be carried out with an appropriate magnification for the purpose of use (contacts maximum 50 times, connectors and seals maximum 10 times).
E 1.1	Dimensions connector housings / Sealing elements DIN EN 60512-1-2
	Measurement of the article according to customer drawing.

Requirement:
All measured values to be compliant with the release drawing

No functionally significant cracks, burrs, voids or other damages must be visible.
Deviations to be documented with photos.

11 PG 2 Material- and Surface Analysis, Contacts

Purpose:
Aquisition of all material parameters of all metallic parts.

Number of Test Samples:
5 samples

Test item:
All occurring material and surface variants.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 2.1	Materials Testing Contacts
	The materials testing must be verified for all parts of the contact (contact area and connection area). All materials must be documented in the product specification of the supplier. • Material verification of the base material: Data sheets as alternative verification must be enclosed with the test report. • Material verification of the contact finish: – Surface protocols may be enclosed alternatively. – Measurement of the layer thickness in the contact area and connection area. – Measurement of the surface roughness (if defined in e.g. drawings) and proof that the surface was not damaged by the production process.
E 2.2	Markings on the visible surface
	The markings on the contact must be identifiable after processing. (e.g. crimping).

Requirement:
Confirmation that all materials are according to the specification.

Functional relevant damages of the surface at the contact area and the crimp area are not permitted.

The markings on the contact must be identifiable after a processing operation (e.g. crimping).

Clear legibility of all information provided in the drawing.

12 PG 3 Material- and Surface Analysis, Housings and Sealing Elements

Purpose:
Visual inspection all plastic- and elastomer parts.

Number of Test Samples:
1 sample per cavity.

Test item:
All occurring material and surface variants.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:
The markings on the housing parts (described in the customer drawing or product specification) must be identifiable.

Flashs, tool misalignments and parting lines must not impair handling and function.

13 PG 4 Contact Overlap

Purpose:
Special test (Standard is Worst Case CAD Study).
Proof of the minimum required contact overlap under worst-case conditions, also based on theoretical studies.

Number of Test Samples:
1 connector housing
Fully loaded with contacts up to 5-way, from 6-way and above with 5 contacts.

Contacts:
Customer released contacts only, if contacts are not subject of the test.

Connector housings:
Customer released connector housings only, if connector housings are not subject of the test.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 4.1	Contact Overlap
	Proof by microsection or 2D / 3D CT under worst-case conditions. The contact overlap and the required clearance (as per the manufacturer's specifications) from the pin tip to the contact bottom must be verified by numerical simulation under all worst conditions of the contacts and contact housings and their locks (including, e.g., pulling on the wire until all locks are at the stop). The contact pin and the contact socket may only touch at their contact points. Definition of contact overlap (Figure PG 4-1).

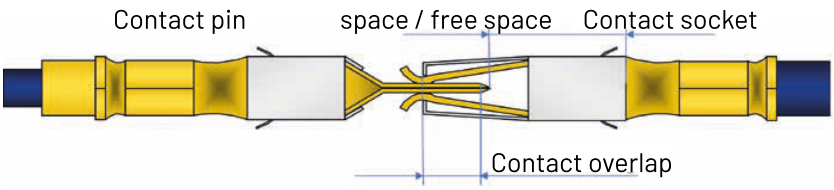


Figure PG 4-1: Contact overlap of a pin/socket pair (Source: TE Connectivity Germany)

Contact overlap is the length of the contact pin at full cross section that enters the socket contact. Contact overlap is measured from the contact point of the socket contact to the end of the chamfer at the full cross section (deviationg from DIN EN 60512-1-3).
The distance between the pin tip and the contact bottom is called the clearance. This clearance is mandatory for the floating support of the contact in the connector cavity and must still be present taking into consideration all tolerances of the pin/socket pair.

Requirement:
Contact overlap:
> 1.00 mm (for all contact points or according to product specification)
Clearance:
> 0 mm
Tolerance stack-up with all involved dimensions is required.

14 PG 5 Mechanical and Thermal Relaxation Behavior

Purpose:

- Functional evaluation of the upper temperature limit T_{Limit} of the contact system and of the contact normal force specified by the supplier.
- Additional test does not belong to the standard validation program.

Number of Test Samples:

4 test batches of 10 contacts divided into 2 groups of 5 contacts each per removal time.

Contacts:

All relevant materials and design variants.
Counterparts acc. to product specification.

Connector housings:

Without

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 5.1	Contact opening dimension measurement at initial state (optical measurement) – all test batches / groups
B 5.1	Group 1 (5 contacts) of each test lot is prior to further stress 5x plugged and unplugged
	Group 2 (5 contacts) of each test lot is stored or measured in new condition
E 5.1	Measure the contact opening dimension of the test samples (optical measurement) (Group 1 only)
E 5.2	Contact normal force (Group 1 and 2) (unless otherwise agreed, sum related)
	Determination of contact normal force – on test lot 1. The measurement procedure must be documented. Indirect measurement is allowed. All test samples of group 2 to 4 are plugged in. Until the measurement of the contact opening dimension and the contact normal force, the test lots must not be separated any more.
B 5.2	Dry heat storage, plugged in, acc. to DIN EN 60068-2-2, (Group 1 and 2)
	Test B **Duration:** 1,000 h Limit temperature T_{Limit} (I = 0A from derating curve) acc. to product specification. Test lots 2 to 4 are placed in storage and taken out at the respective times (1 hour, 100 hours and 1,000 hours). The contact opening dimension and the contact normal force are measured.

E 0.1	Visual inspection (Group 1 and 2) DIN EN 60512-1-1
E 5.1	Contact opening dimension (optical measurement) – test lots 2 to 4 (Group 1 and 2)
E 5.2	Contact normal force (Group 1 and 2)
	Determination of the contact normal force on all test lots. The measurement procedure must be documented. Indirect measurement is allowed.

15 PG 6 Interaction Between Contact and Connector Housing

Purpose:
Verifying the function of the connector housing contact chamber and the contact interlocks.

Number of Test Samples:
3 unpopulated housings and the corresponding contacts for E 6.2 and E 6.3.
6 Connector housings for B 6.1:
- 3 fully populated connector housings, secondary locking device in final position.
- 3 fully populated connector housings, secondary locking device in pre-lock position.

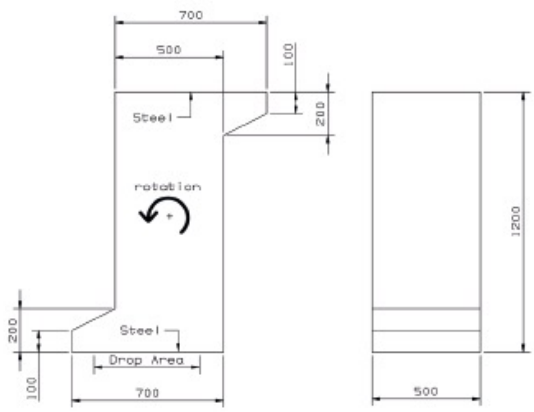
Three times 3 unpopulated connector housings for E 6.4.

Contacts:
Arbitrary

Wire cross sections:
Minimum / Maximum approved wire cross section

Connector housings:
All occurring variants, coding and color.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 6.1	Tumbling of the contacts in the connector housing contact chamber (theoretical verification according to manufacturer's specification)
E 6.2	Function of the primary locking device / latching clearance (with new housings, see lot size).
E 6.3	Function of secondary locking device / latching clearance (with new housings, see lot size)
B 6.1	Drop test (acc. to weight class with new connector housings, see lot size)
	Weight class G3: Test with fully populated connector housing to verify the connector housing and locking mechanism integrity in rotating drum (see DIN EN 60068-2-31, see figure PG 6-1). Cut off all wires at the end of the connector housing. • Test at RT • All test samples are tested sequentially • Drop height: 1 m • Rotation speed: must be set so that the test specimen hits the drop area. • Number of drop tests: 10 Thickness of the steel plate in the drop area: ≥ 5 mm

	 Figure PG 6-1: Drop test in drum (Source: Aptiv Services Deutschland) Weight class G2: one-time free fall per spatial axis from a height of 1.0 m onto uncoated concrete floor at room temperature.
E 6.4	Actuating force for secondary locking device (in each case with new housings, see batch size) analogous to table PG 6-1.
E 0.1	isual inspection acc. to DIN EN 60512-1-1

Requirement:

Test point accuracy:

Based on the connector housing contact chamber drawings and the pin drawings, it must be verified that the pin and the contact can be fitted together without the possibility of damage. The verification must be provided graphically or mathematically for the worst case.

Latching clearance :

The primary locking device must latch with an audible click. The correct funktion must be checked by pulling back the contact on the cable (≤ 10 N). If all contact parts are correctly positioned in their connector housing contact chambers, the secondary lock must be able to close with the specified actuating force.

Drop test:

The secondary locking device in pre-engaged position (simulation of transport of unequipped contact housings) must not close during the drop test.

The secondary locking device in final position (simulation of transport of equipped contact housings) must not open during the drop test.

There must be no functional damage occur (documentation only).

Actuation Forces Secondary Locking

Actuation	Condition	Limits
Opening	–––	10 N ≤ F_0 ≤ 50 N
Closing	For film hinge, hinge length < 15 mm	F_S ≤ 50 N
Closing	For film hinge, hinge length ≥ 15 mm Every locking area to be tested separately.	F_S ≤ 75 N
Closing	Slider only	F_S ≤ 50 N
Closing n.o.k.	contact, not in end-position.	$F_{S\,n.i.O.}$ ≥ F_S + 50 N, blade width ≥ 0.63 mm
		$F_{S\,n.i.O.}$ ≥ F_S + 25 N, Blade width < 0.63 mm

Table PG 6-1: Requirements Actuation Forces (Source: ZVEI)

16 PG 7 Connector Handling and Functional Integrity

Purpose:
Contact housing testing, verification of the retention forces and actuation forces.

Number of Test Samples:
- Min. 10 fully populated and 10 unpopulated connector housings.
- New components can be used for each of the following properties tests within this TG.

Connector housings:
Random. For E 7.1 only: All existing variants.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 7.1	Distinctiveness of unpopulated connector housings (coding / polarization) acc. to DIN EN 60512-13-5
	Contact size < 0.63 mm: 1. test performed with unpopulated connector housings: If Connection cannot be mated, test 7.1 is completed. 2. connection can be mated (also with damages): Perform test with fully populated connector housing and check if electrical connection occurs during mating. Apply 2-times F_{Steck} (but min. 50 N): No electrical signal or functional damage shall occur. **Contact size ≥ 0.63 mm:** Apply 3-times F_{Steck} (but min 80 N): No electrical signal or functional damage shall occur.
E 7.2	Retention force of the connector housing latch / connector housing locking (unpopulated connector housings) DIN EN 60512-15-6
	Applicable to contact housings for inline connections and device-mounted connections. **Sample preparation:** 10 complete connector couplings without contacts. If the connector housings are equipped with a CPA, the tests must be performed both with open and closed CPA. The test samples must be fastened in the tensile testing machine with suitable fixations so that the housings are not damaged or deformed. The force must be applied opposite to the plugging direction of the contact housings. The maximum force on the first displacement millimeter or according to product specification (contact opening dimension PG4) is defined as the retention force (see figure PG 7-1).

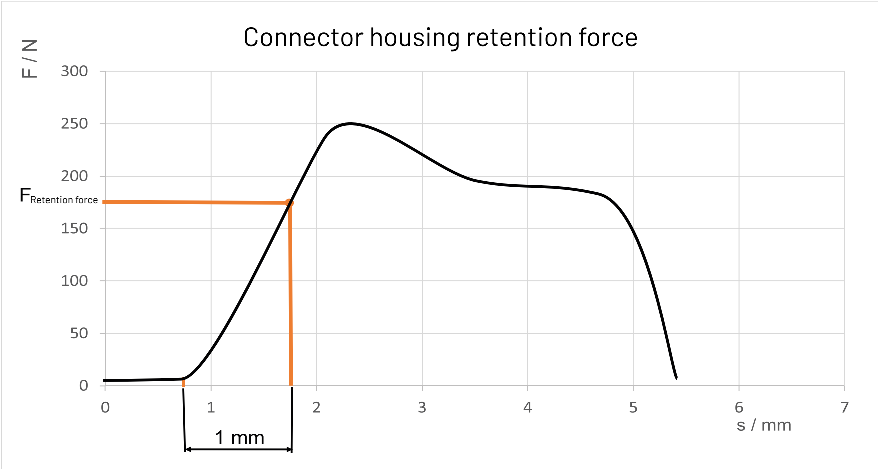


Figure PG 7-1: Force-path diagram of the holding force (path to determine the force according to the above definition)(Source: Aptiv Services Deutschland)

E 7.3	CPA functional check (unpopulated contact housings)
E 7.4	Insertion force or actuation force for mechanically assisted connectors (fully populated connector housings)
	The insertion force in the plugging direction or the actuation force of the mechanically assisting device must be measured. The insertion force (also at mechanically assisting devices) must always be measured in the operating direction. The test samples must be fastened in the tensile testing machine with suitable fixations so that the housings are not damaged or deformed.
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:

No functional damages are permitted on the entire connector housing including all belonging parts (CPA, Lock, Lever, Slide, Hinge, etc.).

- Actuated terminal locking mechanism shall not open during the test.
- For hybrid Connectors the value applies for the total number of contacts and the largest contact size.
- CPA- and connector housing retention force to fulfill the requirements acc. to table PG 7-1 and table PG 7-2.
- All properties must correspond to the product specification or the drawing note.

Actuation Forces Connector Housings / CPA

Actuation	Condition	Limit
Coding efficiency	Fully populated connector housings, no electrical signal	see E 7.1
Polarization efficiency	Fully populated connector housings, no electrical signal	see E 7.1
Insertion force / actuation force	Fully populated connector housings	$F_S \leq 75$ N
CPA opening	Connector housings in end position	5 N ≤ F ≤ 30 N
CPA closing	Connector housings in end position	5 N ≤ F ≤ 30 N
CPA blocking force	Connector housings not in end position*)	$F_{Block.}$ > 1.5 times F_S (populated connector housing)
		But ≥ 60 N, with tab width ≥ 0.63 mm
		But ≥ 50 N, with tab width < 0.63 mm
*) Alternatively: CPA must be able to move Connector housings into end position.		

Table PG 7-1: Requirement Actuation Force Connector housing / CPA (Source: ZVEI)

Form -Fitting Connector Housing retention Forces			
Contact Size / mm	Number of Pins		
	1- to 2-pos	3- to 6-pos	> 6-pos
< 0.63	> 30 N	> 40 N	> 40 N
≥ 0.63 to 1.2	> 60 N	> 80 N	> 80 N
> 1.2 to 2.8	> 80 N	> 100 N	> 100 N
> 2.8 to 6.3	> 100 N	> 100 N	> 100 N
> 6.3	> 150 N	> 150 N	> 150 N

Friction-Locking Connector Housing Retention Forces:
values have to be agreed case-by-case with the specialized department or taken from the product specification.
Table PG 7-2: Form-Fitting Connector Housing Retention Forces (Source: ZVEI)

17 PG 8 Insertion and retention forces of the contacts in the contact housing

Purpose:

Verification of the wire manufacturability and of the contact locks.

Number of Test Samples:

Contact Release:

3-times 10 contacts – biggest wire size (independent of number of positions of the used connector housing and number of mold cavities or TPAs).
If Wire cross section ≤ 0.35 mm^2 is available, the smallest wire size must also tested (E 8.1 only).
The use of a steel connector cavity instead of housing is permitted.

Number of Test Samples:

Connector Housing Release:

For E 8.1:

1 connector housing per mold cavity fully populated, min. 10 contacts per test.

For E 8.2.1 + E 8.2.2 each:

1 connector housings per mold cavity fully populated, min. 10 contacts per test.
If the number of contacts exceeds 50 pcs. per test (sum of number of positions (connector) and mold cavities) the following procedure is acceptable:
1 connector housing of 1 mold cavity fully populated. For all additional mold cavities populate min. 1 contact cavity. Reasonable selection of min. 50 contacts.

For E 8.2.3:

Min. 10 contacts. Select mold- or connector cavities, were the lowest forces at E 8.2.1. have been measured.

Contacts:

Random

Connector housings:

All existing variants (mold cavities).

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 8.1	Determination Contact Insertion forces
E 8.2	Contact retention Forces in Connector Housing
E 8.2.1	Contact retention Forces in Connector Housing, Primary Locking Device Only

E 8.2.2	Contact retention Forces in Connector Housing, Secondary Locking Device Only
E 0.1	Visual inspection DIN EN 60512-1-1
B 8.1	Disassemble Contacts 3-times with Original Extraction Tools
E 8.2.3	Contact retention Forces in Connector Housing, Primary Locking Device Only
	Min. 10 contacts. Select mold- or connector cavities, were the lowest forces from E 8.2.1. have been measured.
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:

Measure and document contact insertion force.
Contact retention force values must correspond acc. to table PG 8-1.

Test Distance Primary Locking Device:
$s \leq 1$ mm for required retention forces (if contact overlap is < 1 mm, use worst-case value of PG 4).

F_{prim} = Primary Locking retention Force
F_{sek} = Secondary Locking retention Force

Tab Width / mm	F_{prim} (Locking Lance)	F_{prim} (Clean Body)	F_{sek}
< 0.63	> 25 N	> 20 N	> 25 N
≥ 0.63 to 1.5	> 55 N	> 40 N	> 55 N
> 1.5 to 2.8	> 80 N	> 60 N	> 80 N
> 2.8 to 6.3	> 120 N	> 80 N	> 120 N
> 6.3 to 8.0	> 180 N	> 110 N	> 180 N
< 8.0	> 200 N	> 150 N	> 200 N

Table PG 8-1: Values valid for new parts. After 3-times disassembly only documentation of measured values. (Source: ZVEI)

18 PG 9 Skewed insertion (Kojiri-Safety)

Verification using terminal housings that a skewed insertion cannot damage the terminal.

If possible, the examination to be evaluated using CAD-simulation.

If the CAD evaluation is not possible, the verification to be performed as follows:
Use 1 fully populated connector housing and mating interface / mating connector.

Terminals:
All existing variants, if they influence the skewed insertion.

Connector housings:
All existing variants, if they influence the skewed insertion.

Procedure:	
E 9.1	Determining the terminal opening dimension (optical measurement), pin tip position, and pin geometry.
E 9.2	Max. possible pin insertion angle. One insertion cycle each at the maximum possible pin insertion angle in the y- and z-directions (x is the insertion direction).
E 9.1	Determining the terminal opening dimension (optical measurement).
E 0.1	Visual inspection DIN EN 60512-1-1
E 9.3	Determining connector housing Kojiri-Safety The examination to be evaluated using CAD

Requirement Skewed Insertion:
While inserting with maximum possible skewing angle a widening of the contact zone or bending of the terminals pins is only allowed, under all specified tolerance limits, if the terminal supplier specification is still met.

To be determined for all connector / terminal combinations of any supplier.

If an examination cannot be conducted in CAD, E 9.1 must be performed. The pin tip position and the terminal opening dimension must change only within the specified tolerance values.

Requirement Kojiri-proofing:
Scoop proofing is required, verification to be performed by CAD.

During installation/removal, it may only be possible to touch signal- and current-carrying components (terminals) with their corresponding signal- and current-carrying mating piece (and its guide cup). The design must preclude a touch of terminal with terminal housing parts.

19 PG 10 Contacts: Conductor Pull-Out Strength

Purpose:
Measurement of the mechanical strength of conductor and crimp contact.

Contacts:
All materials and surfaces that exists for the conductor crimp area.

Wire:
According to TLF 0112-1 or TLF 0112-4

Number of Test Samples:
At least 11 test samples of any specified conductor cross section at upper and lower crimp height.
Use 3 test samples only, for conductor cross section > 50 mm^2.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 10.1	Measure crimp height of crimped contacts
E 10.2	Conductor pull-out strength
	Test Procedure: Deactivate the ISO-Crimp (open ISO-crimp or usage of a longer deisolated wire). Test samples to be fixed with a suitable device. The test is carried out by introducing the test force in the direction of the wire. The force-displacement curve is to be recorded at a constant speed v = (25 to 50) mm / min. maximum value to be documented.
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:
For all test samples the single values of crimp height and width to be documented. All values must be in accordance with the release drawing or product specification. For the upper and lower crimp height, one crimp cross section each to be documented.

Wire cross section / mm²	Min conductor pull-out strength / N
0.08	30*
0.13 – 0.22	50*
0.35	50
0.50	60
0.75	85
1.00	108
1.50	140
2.50	200
4.00	310
6.00	450
10,00	500
16.00	1,500
25.00	1,900
35.00	2,300
50.00	3,400
70.00	4,200
95.00	4,800
120.00	5,500
* Valid for reinforced wire types	
Values must for intermediate cross-sections are to be interpolated. Test three samples for cross-sections > 50 mm² only.	

Table PG 10-1: Conductor pull-out strength (Source: ZVEI)

20 PG 11 Contacts: Insertion and Extraction Forces, Mating Cycles

Purpose:
Evaluating the contact surfaces after mating cycles and measurement of the occurring insertion and extraction forces.

Number of Test Samples:
Min. 10 contacts.

Contacts:
All existing base materials, contact finishes and variants which are in relation to the contact area (e. g. different contact normal forces, gap sizes, etc.).

Counter Parts for the test samples:
For Testing of socket contacts a pin or tab contact (exemplary) must be used.
For Testing of pin or tab contacts a socket contact (exemplary) must be used.
All counter parts must have a serial release of the customer.
For comparability ot the test results it is recommended to refer on the same part number of the respective counter parts.

Contacts:
An auxiliary device to hold the contacts or a connector housing can be used.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 5.1	Contact gap size
E 0.2.1	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 11.1	Insertion and extraction force, without additional lubricants
	Continous measurement during B 11.1 (force / displacement diagram). All max. readings must be recorded and documented in a table.
B 11.1	Number of mating cycles (unless otherwise specified in product specification)
	Contact finish: Sn: 20 mating cycles Ag: 50 mating cycles Au: 100 mating cycles
E 5.1	Contact gap size
	Remark: The test sample with lowest insertion force and the test sample with biggest spread (from initial insertion to x-insertion) from B 11.1 is also tested.

E 0.2.1	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 5.2	Contact normal force
	Analogous to PG 5 indirect measurement is possible.
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:

The insertion and extraction forces must correspond to the product specification.
Contact normal force and gap size must be documented.
The contact resistance after test must not exceed the intial value multiplied by factor 1.5.

Contact finish:

Evaluation of the contact surfaces as defined in chapter 8 (evaluation of contact surfaces after tests).

21 PG 12 Temperature Rise, Derating

Purpose:
Determination of current carrying capacity of contacts.

Number of Test Samples:
3 contact pairs (pin and socket).

Contacts:
All contact finishes are documented.

Remark:
It is permissible to measure one contact finish and derive the values of the other contact finishes from it. If the new limit temperature is higher than the one tested here, it must be verified acc. to PG 15.

Wire cross section:
All existing variants (identical crimp variant pin and socket contact, ECU interface must be agreed with the customer).

Wire length:
DIN EN 60512-5-2

Insulation:
Must withstand limit temperature.

Connector housings:
None

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 12.1	Current overtemperature DIN EN 60512-5-1
	Choosing of min. 3 current levels which are 50 % above the current carrying capability of the used wire. Contact temperature: To be measured with suitable temperature sensors on each contact.
E 12.2	Derating DIN EN 60512-5-2
	Continous measurement during B 11.1 (force / displacement diagram). All max. readings must be recorded and documented in a table.

E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:

All resistance values must be acc. to chapter A or to the supplier specification.

Wire length of the test samples are documented.

Picture of the test samples with temperature sensors, alternatively, the test can be performed using thermography camera.

The rated current is defined as current at 80 °C für contacts up to $T_{limit} \leq 130$ °C.

Contacts with $T_{limit} > 130$ °C the rated current has to be read at T_{limit} minus 50 K.

The following must be marked in the derating diagram:
The statement "in free air" must be included.

Acc. to DIN EN 60512-5-2 the reduction factor 0.8 (80 %) must be applied.

22 PG 13 Influence of the housing on the Derating

Purpose:
Determining the maximum influence of the housing on the derating by supplying current to all neighboring contacts at the same time. For similar contacts only, hybrid housings must be tested acc. to a separate test plan.

Number of Test Samples:
3 fully populated connector housings with same size (no hybrid housings).

Contacts:
All contact finishes are documented.

Remark:
It is permissible to measure one contact finish and derive the values of the other contact finishes from it.

Wire cross section:
All existing variants (identical crimp variant pin and socket contact).

Wire length:
Acc. to DIN EN 60512-5-2

Connector housings:
Sealed / unsealed connector housings.
For sealed contact housings, all sealing elements must be present. The number of ways must be agreed between the supplier and the customer.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 13.1	Current overtemperature with connector housing acc. to DIN EN 60512-5-1
	The contact for which the maximum temperature influence (e.g., due to adjacent connector cavities) is to be expected, is measured. Loading with incrementally increasing current and measurement of the current overtemperature. Contact temperature: To be measured with suitable temperature sensors on each contact.
E 13.2	Derating in the connector housing

E 0.2	Connection resistance acc. to DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 0.1	Visual inspection acc. to DIN EN 60512-1-1

Requirement:

All resistance values must be acc. to chapter A or to the supplier specification.

Wire length of the test samples are documented.

Documentation of the contact arrangement in the connector housing (view on mating side).

Picture of the test samples with temperature sensors.

The following must be marked in the derating diagram:
Derating with connector housing (with name of the connector housing).

Acc. to DIN EN 60512-5-2 the reduction factor 0.8 (80 %) must be applied.

23 PG 14 Short Term Overload (t > 100 ms, Current Overtemperature at n-times Rated Current)

Purpose:
Evaluating the temporary exceedance of the maximum current-carrying capacity (peaks).

Number of Test Samples:
3 contact pairs pin and socket (Note: PG 12 test samples can be used).

Contacts:
All existing base materials and contact finishes.

Wire cross section:
All existing variants (identical crimp variant pin and socket contact).

Wire length:
Acc. to DIN EN 60512-5-2

Insulation:
Must withstand limit temperature.

Connector housings:
None

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 14.1	Thermal time constant Use rated current from PG12
	Descritpion of the test cycle: Loading of a contact with 1/2/3/4/5 times the rated current and simultaneous recording of the temperature curve versus time. The load is carried out until thermal equilibrium is reached or until the maximum permissible limit temperature limit from PG 15 T_{limit} is reached, whichever occurs first. Contact temperature: To be measured with suitable temperature sensors on each contact.
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:
All resistance values must be acc. to chapter A or to the supplier specification.

Wire length of the test samples are documented.

Picture of the test samples with temperature sensors, alternatively, the test can be performed using thermography camera.

Contact finishes must be examined for failures/damages. Melting or wear through in the contact area are not permitted.

Diagram Current versus time with cooling curve must be documented (an extrapolation for times smaller than the one determined in the test is not admissible).

24 PG 15 Electrical Stress Test

Purpose:

Functional evaluation of the upper limit temperature (T_{limit}) of the contact system specified by the manufacturer with current supply during temperature change and humid heat.

Number of Test Samples:

Min. 10 contact pairs (pin and socket).

Contacts:

All relevant base materials and design variants. Counter part acc. to product specification.

Wire cross section:

Max. wire cross section (or by agreement).

Wire length:

DIN EN 60512-5-2

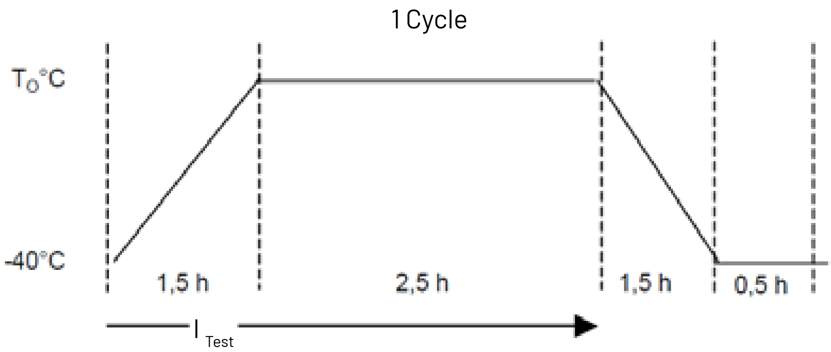
Connector housings:

Case by case: free contact or unsealed connector housing (must withstand T_{limit}, contacts in the connector housing should not influence each other thermally).

Wire:

Must withstand T_{limit}.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 15.1	Test samples are 3-times inserted and 2x extracted
E 12.1	Derating DIN EN 60512-5-2
	Measure all (10) test samples, prodecure analogous PG 12. Determine the 3 test samples with the highest temperature values and derive Derating curve out of these data (document current curves of all (10) single measurements).
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)

E 15.0	Connection resistance continuously during B 15.2 at test current
	Measurement frequency: Min. 1 measured value per 5 mins. The test current and the voltage drop are continuously recorded and documented as resistance value. (adjust the voltage limitation appropriately). Continous monitoring of the measured contact temperatures.
B 15.2	Temperature cycle durability test / current cycle durability test: 60 cycles
	Determination of the upper climatic chamber temperature (T_0) prior start of the test: T_0 is determined once at the start of the test such that after thermal equilibrium is established, the contact temperature corresponds to the limit temperature. (In the case of DC measurement, the deviation of the temperature sensor must be considered). **Descritpion of the test cycle:** Temperature profile of the climate chamber: -40 °C / T_0  Figure PG 15-1(Source:: TE Connectivity Germany) Test current I_{test}: Is taken from the derating diagram of PG 12, at (T_{limit} minus 50 K) for T_{limit} > 130 °C, otherwise current at 80 °C. If the product specification shows a lower rated current, this value must be used for the test. Contact temperature: The contact temperature is measured with suitable temperature sensors on each test sample and adjusted by changing T_0 so that all contacts in the area of must the hottest measurable spot reach at least the limit temperature T_{limit}. It must be ensured that the hottest spot of all samples at least reaches the limit temperature T_{limit}.
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
B 15.3	Damp heat, cyclic DIN EN 60068-2-30Db
	Number of cycles: 21 (1 day = 1 cycle) **Relative humidity:** 95 % **Temperature:** TLH = 25 °C, TUH = 55 °C T_{LH} = lower cycle temperature humidity (9 h) T_{UH} = upper cycle temperature humidity (9 h) (each 3 h temperature change)
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)

E 15.0	Continous connection resistance during B 15.2 at test current
	Measurement frequency: min. 1 maesured value per 5 mins
B 15.2	Temperature cycle durability test / current cycle durability test. 60 cycles
E 12.2	Derating DIN EN 60512-5-2
	Measure all (10) test samples, procedure analogous PG 12. Derive base curve for all 10 samples (document current curves of all (10) single measurements).
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 0.1	Visual inspection DIN EN 60512-1-1

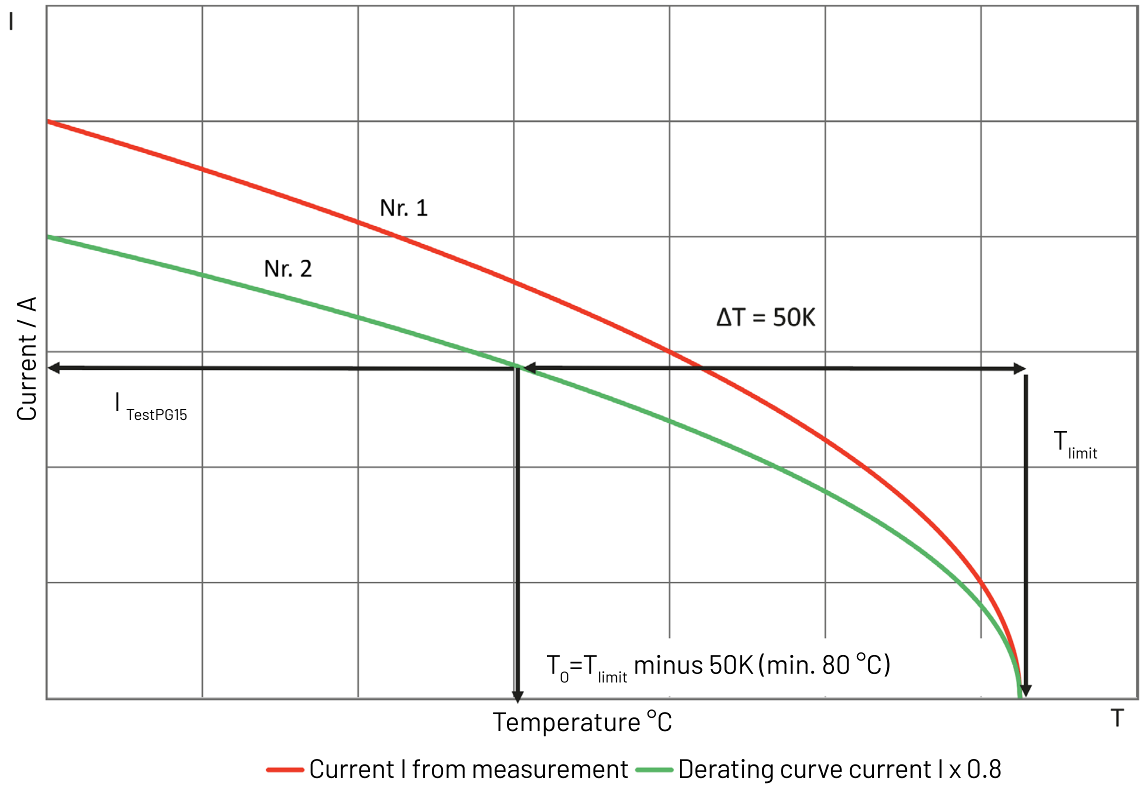
Requirement:

All resistance values must be acc. to chapter A or to the supplier specification.

Contact surfaces are to be examined for failures/damages. Melting in the contact zone is not permitted.

The determined base curves (no. 1)(without reduction factor 0.8) must be above the derating curve (no. 2) from this test group for all samples. If a lower value is given for the nominal current in the product specification than determined in this test group, this value is used as the evaluation criterion.

Example for determining the test current for PG 15 (mean value of the 3 hottest samples) for T_{limit} > 130 °C



Criteria to pass PG 15 (Example for T_{limit} = 150 °C)

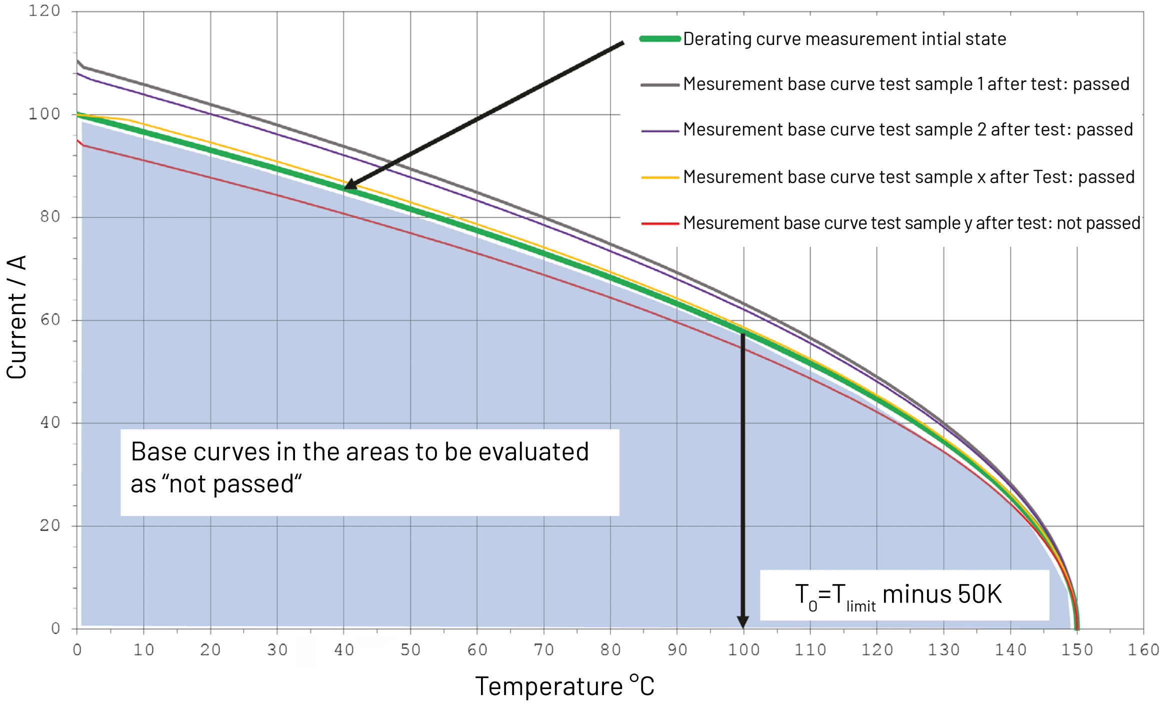


Figure PG 15-2, above no. 1 and below no. 2 (Source: TE Connectivity Germany)

25 PG 16 Fretting Corrosion

Purpose:

- Abrasion resistance of the surface finish (destructive test)
- "Fingerprint" / snapshot of the contact surface
- Specif additional test. Not part of a standard validation.

Number of Test Samples:

3 contacts

Contacts:

- All specified base material and surface (coating) combinations.
- All specified lubricants.
- All specified passivations.

Connector housings:

None

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 16.0	Connection resistance, continuous monitoring during B 16.1, reading and saving: Measurement frequency: ≥ 4 Hz
E 16.1	Frictional load
	Friction displacment: 50 µm **Cycle time:** 1 Hz **Number of cycles:** 100,000 or till a resistance of 300 mΩ is reached **Electrical load:** max. 100 mV, 10 mA

Requirement:

Document all measurement values until the specified number of of cycles or a connection resistance of 300 mΩ is reached.

Documentation:

Diagram: Draw the evaluation of the connection resistance over the number of cycles,
Document the number of cycles until the connection resistance of 300 mΩ is reached, or the final resistance if the number of specified cycles is reached.

26 PG 17 Dynamic Load

Purpose:
Vehicles are exposed to vibrations and shocks in daily use. Vibration and shocks can lead to contact wear, intermittent electrical contact and mechanical component failure.

In this test, a connector system is exposed to increased sinusoidal, random and shock profiles, which simulates a similar stress that actually occur in the vehicle over its service lifetime.

The following information is based on vehicles with combustion engines in various application areas. Separate profiles still have to be developed for vehicles with e-machines.

Requirement:
Wires that comply with TLF 0112 must be used. The wire insulation must withstand the temperatures occurring during the test. Different wire types can be considered depending on the specification. The resonance behavior of the test fixture must be checked before the test. Deviations of 6 dB in the frequency range to be tested are permissible if an influence on the result is not expected. The verification can be carried out by suitable calculation tools (FEM) and / or by resonance tests on a vibration system. The test sample must be considered in both test methods.

Number of Test Samples:
Terminal Validation
Terminals:
Min. 10 terminals, max. wire cross section, unless otherwise specified.
Test samples of different tool cavities (i.e. double-out) will not be considered explicitly.

Connector housings:
Sealed / unsealed, depending on application area.

Connector Housing Validation
Connector housing:
Min. 3 connector housings with min. 10 terminals.
Up to 5-pole – fully populated, from 6-pole – min. 5 terminals, from 10-pole min. 50 % of the cavities populated.
Test samples from different tool cavities (mold cavities) will not be considered explicitly.

Wire cross section:
To be determined on a case-by-case basis, preferably all wire cross sections that occur are divided among the test samples.

Information:
The connection resistance (E 0.2) is measured before and after each spatial axis (vibration), as well as before and after each direction during shock load in the fixed and firmly wired condition at room temperature (test samples must be temperature through) before the test samples are changed to another axis.

If contacts are connected in series for testing, measurement of the series resistance is also permissible. However, the total resistance may exceed the required evaluation criteria, defined by table (connection resistance in the table) allowed for a contact. If this criterion is not met, an individual resistance measurement by each single contact must be used.

A temperature change is overlaid on the vibration load for the duration of the vibration exposure. The temperature specification Tmax (but not more than 150 °C) refers to the upper temperature of the selected temperature class. The temperature profiles are designed in such a way that RT is reached at the end of the vibration load.

X – axis: mating direction
Y – axis: 90 °C to mating direction (horizontal longitudinal)
Z – axis: 90 °C to mating direction (horizontal transversal)

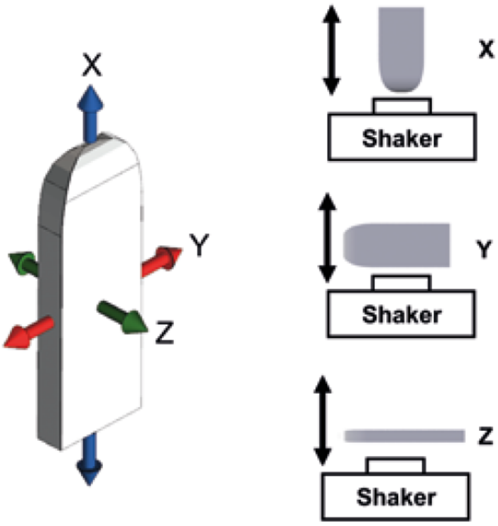
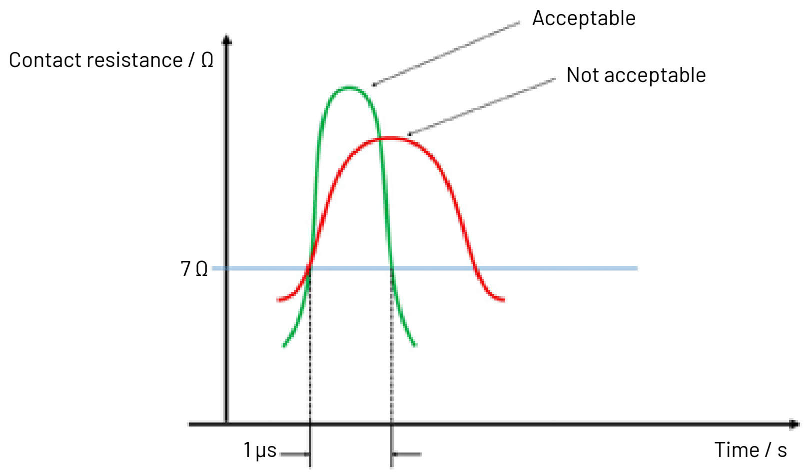


Figure PG 17-1 (Source: Kostal Kontakt Systeme)

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
	Depending on the size to be measured, it may be necessary to carry out the alternatively permitted measurement of the connection resistance using the measurement method with the defined current.
E 17.0	Measurement connection resistance under load
	The test current must be set in such a way that stable measured values are obtained. As a rule, the test current is to be used in accordance with the definition of the crimp validation (PG 70). Measurement frequency to be applied with 1/min.

E 17.1	During the test, both the load profiles V1 – V6 and the shock load are monitored for electric circuit interruptions. An electric circuit interruption occurs, if the resistance value exceeds 7 Ω for more than 1 µs.
	Remark: Other limit values may apply to other requirements (e.g. data transmission). These must be specified and requested separately by the customer. **Remark:** The number of measuring channels for short-term interruption / trend recording must be divided in a reasonable ratio.  Figure PG 17-2 (Source: Kostal Kontakt Systeme)
B 17.0	The severity levels of the vibration loads (V1 – V6) are described and defined in the "classification" section.

26.1 Test Procedure

Setup axis 1	
E 0.1	Visual inspection DIN EN 60512-1-1
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
	• Single contact resistance • Serial contact resistance (if contacts connected in series)
E 17.0	Measurement connection resistance under load
E 17.1	Measurement of short-term interruption under load
B 17.0	Vibration test acc. to severity class (V1 – V6) – axis 1
	Sinusoidal / Noise (if required) Mechanical Shock (if required)
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
	• Single contact resistance (if serial contact resistance criteria is not passed) • Serial contact resistance (if contacts connected in series)

Setup axis 2	
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
	• Single contact resistance (if serial contact resistance criteria is not passed) • Serial contact resistance (if contacts connected in series)
E 17.0	Measurement connection resistance under load
E 17.1	Measurement of short-term interruption under load
B 17.0	Vibration test acc. to severity class (V1 – V6) – axis 2
	Sinusoidal / Noise (if required) Mechanical Shock (if required)
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
	• Single contact resistance (if serial contact resistance criteria is not passed) • Serial contact resistance (if contacts connected in series)

Setup axis 3	
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
	• Single contact resistance (if serial contact resistance criteria is not passed) • Serial contact resistance (if contacts connected in series)
E 17.0	Measurement connection resistance under load
E 17.1	Measurement of short-term interruption under load
B 17.0	Vibration test acc. to severity class (V1 – V6) – axis 3
	Sinusoidal / Noise (if required) Mechanical Shock (if required)
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
	• Single contact resistance (if serial contact resistance criteria is not passed) • Serial contact resistance (if contacts connected in series)
E 0.1	Visual inspection DIN EN 60512-1-1
	Analysis

26.2 Fixation on Shaker

The control sensors are to be placed in such a way that the test samples are not exposed to inadmissibly high or too low loads.

The test setup shall be designed to prevent excessive vibration load from the aggregate connection unless it is the subject of the test.

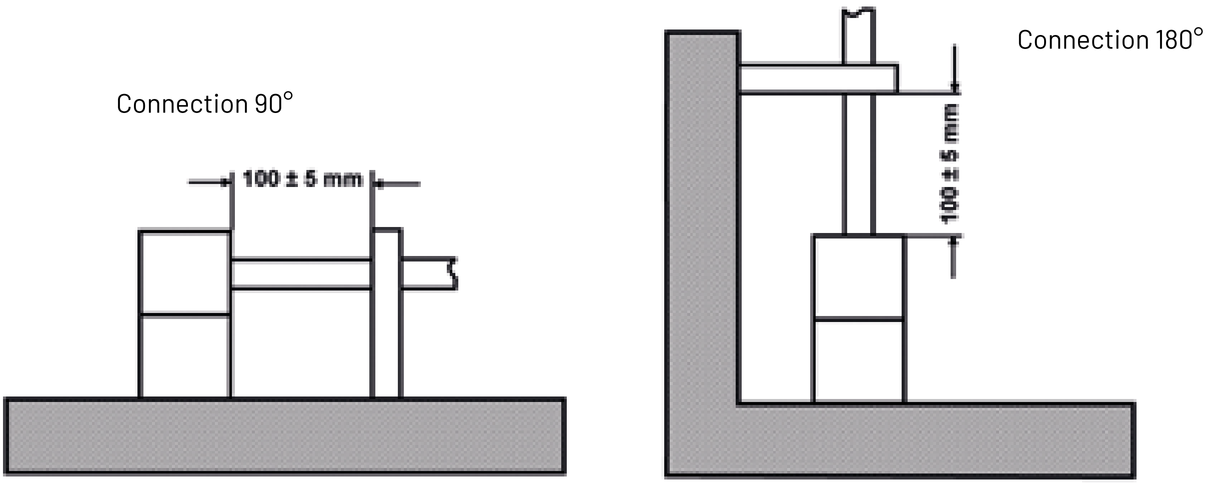
Deviating from the standard, it may be necessary to fix the acceleration sensors for the control signal on the aggregate connection. However, it must be ensured here that the sensor does not affect the result.
In the case of "Inline" connector systems, the original fasteners (e.g. ad on element) must be recreated or used.

When fixing the wire, make sure that no tensile or compressive forces act on the connector system.

Unless otherwise specified, the wire fixings also vibrate in phase.

If alternative fastening methods (e.g. wire ducts, corrugated tubes, clamps) are to be used for the wires, these must be made available and the test to be ordered separately.

Examples of how to mount the test samples to the shaker.



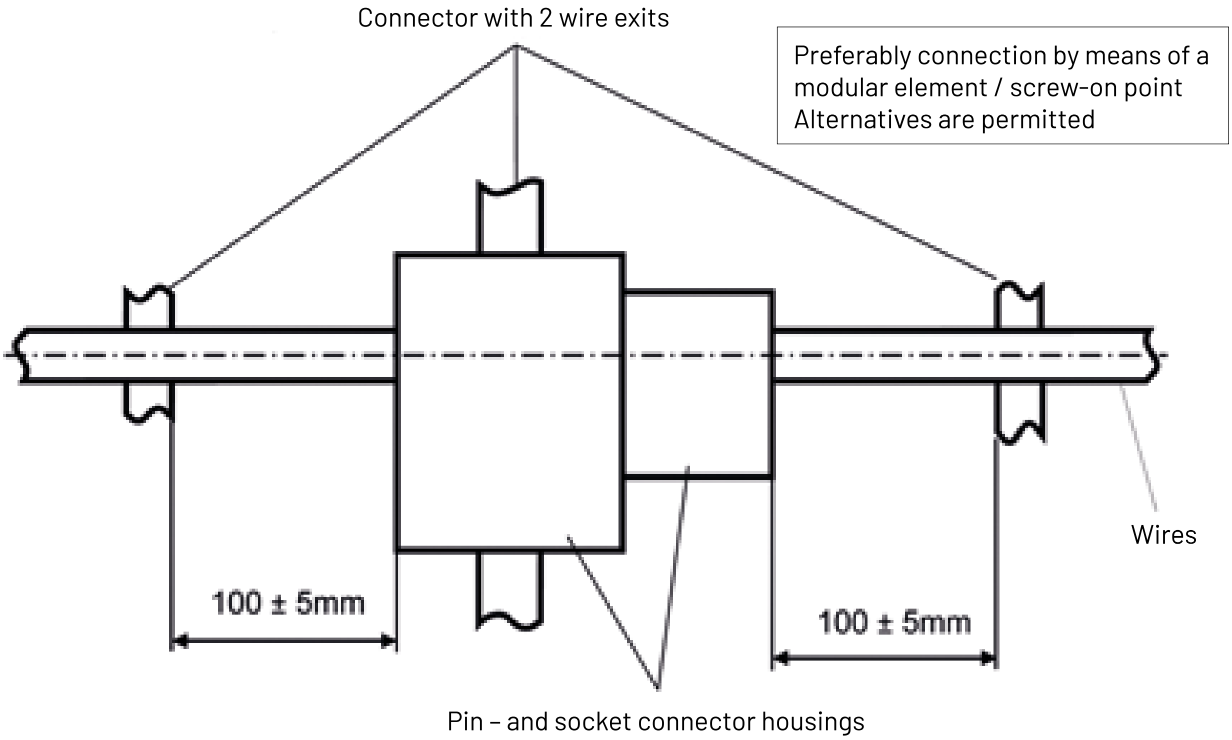


Figure PG 17-3 und Figure PG 17-4 (Source: Kostal Kontakt Systeme)

In case of particularly critical or strongly deviating installation conditions, separate agreements must be made between the manufacturer and the user.

26.3 Vibration Classes

Vibration class V1

Body unsealed, Passenger compartment.
Profile: Random with overlaid temperature change.

Temperature profile DIN EN 60068-2-14

Duration / min	Temperature / °C
0	20
60	-40
150	-40
300	T_{max*}
420	T_{max*}
480	20

* max. 150 °C
No. of cycles: 1 per axis

Random DIN EN 60068-2-64

Frequency / Hz	Power Density Spectrum / $(m/s^2)^2/Hz$
10	10
55	3.250
180	0.125
300	0.125
360	0.070
1,000	0.070
RMS value of acceleration: 19.7 m/s^2	

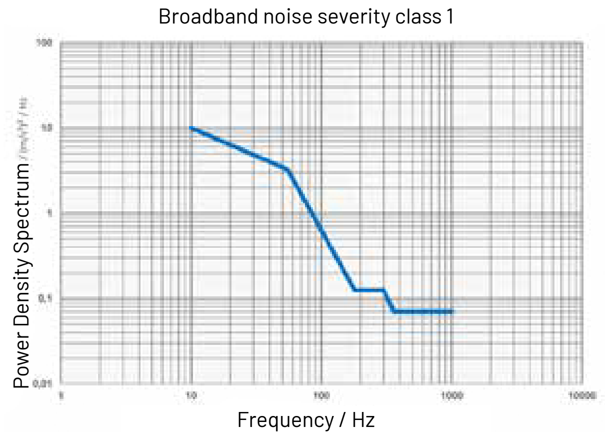


Figure PG 17-5 (Source: Kostal Kontakt Systeme)

Test duration: 8 h per axis
Clipping: 2.5

Mechanical Shock DIN EN 60068-2-27

Acceleration / m/s^2	Pulse duration / ms
300	6

Shock type: half sine
No. of shocks: 6,000
Direction: 6 (➜ 1,000 shocks per axis)

Vibration class V2

Body sealed, engine compartment, wheel arches.
Profile: Random with overlaid temperature change.

Temperature profile DIN EN 60068-2-14

Duration / min	Temperature / °C
0	20
60	-40
110	-40
260	T_{max*}
340	T_{max*}
400	20

* max. 150 °C
No. of cycles: 3 per axis

Random DIN EN 60068-2-64

Frequency / Hz	Power Density Spectrum / (m/s^2)^2/Hz
10	20
55	6.50
180	0.25
300	0.25
360	0.14
1,000	0.14
RMS value of acceleration: 27.8 m/s^2	

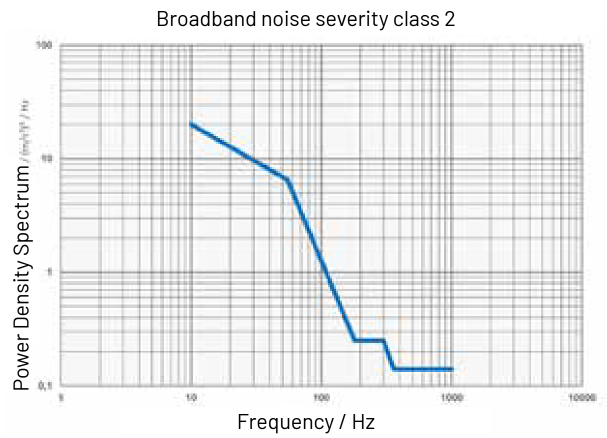


Figure PG 17-6 (Source: Kostal Kontakt Systeme)

Duration: 20 hours per axis
Clipping: 2.5

Mechanical Shock DIN EN 60068-2-27

Acceleration / m/s^2	Pulse duration / ms
300	6

Shock type: half sine
No. of shocks: 6,000
Direction: 6 (➔ 1,000 shocks per directions)

Vibration class V3

Aggregate connection, which is mounted close to the engine, gearbox mounted, profile Sine / Random with overlaid temperature change. Sine and Random may be overlaid (SoR).

Temperature profile DIN EN 60068-2-14

Duration / min	Temperature / °C
0	20
60	-40
90	-40
240	T_{max*}
380	T_{max*}
440	20

* max. 150 °C

No. of cycles: 3 per axis

Random DIN EN 60068-2-64

Frequency / Hz	Power Density Spectrum / $(m/s^2)^2/Hz$
10	10
100	10
300	0.51
500	5
2,000	5
RMS value of acceleration: 96.6 m/s^2	

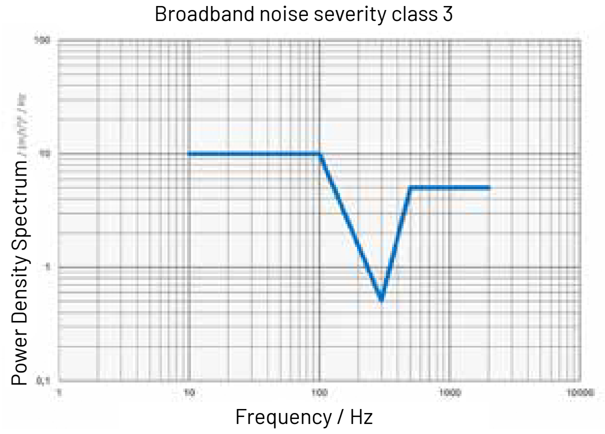


Figure PG 17-7 (Source: Kostal Kontakt Systeme)

Duration: 22 hrs per axis

Clipping: 2.5

Sine DIN EN 60068-2-6

Frequency / Hz	Acceleration / m/s^2
100	100
150	150
440	150

Duration: 22 hrs per axis

Dwell time: 1 octave/minute

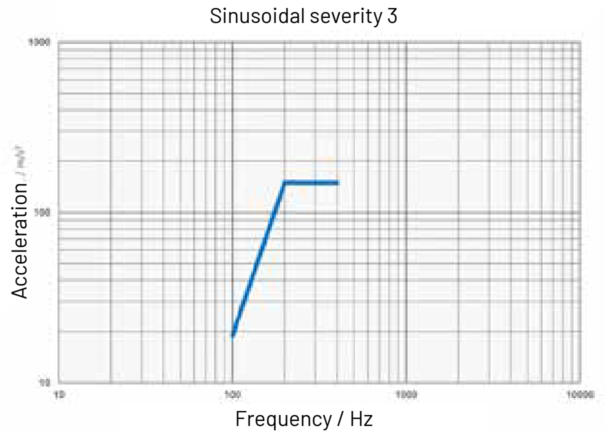


Figure PG 17-8 (Source: Kostal Kontakt Systeme)

Vibration class V4

Engine mounted parts, sensors direct mounted on engine. Profile Sine / Random with overlaid temperature change. Sine and Random may be overlaid (SoR).

Temperature profile DIN EN 60068-2-14

Duration / min	Temperature / °C
0	20
60	-40
90	-40
240	T_{max*}
380	T_{max*}
440	20

* max. 150 °C

No. of cycles: 3 per axis

Random DIN EN 60068-2-64

Frequency / Hz	Power Density Spectrum / $(m/s^2)^2/Hz$
10	10
100	10
300	0.51
500	20
2,000	20
RMS value of acceleration: 181 m/s^2	

Duration: 22 hrs per axis
Clipping: 2.5

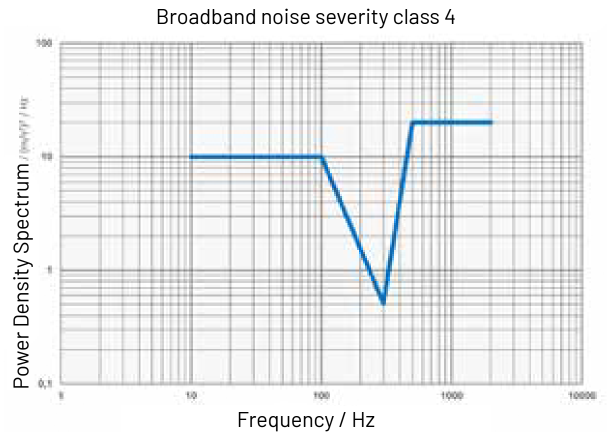


Figure PG 17-9 (Source: Kostal Kontakt Systeme)

Sine DIN EN 60068-2-6

Frequency / Hz	Acceleration / m/s^2
100	100
150	150
200	200
240	200
255	150
440	150

Duration: 22 hrs per axis
Dwell time: 1 octave/minute

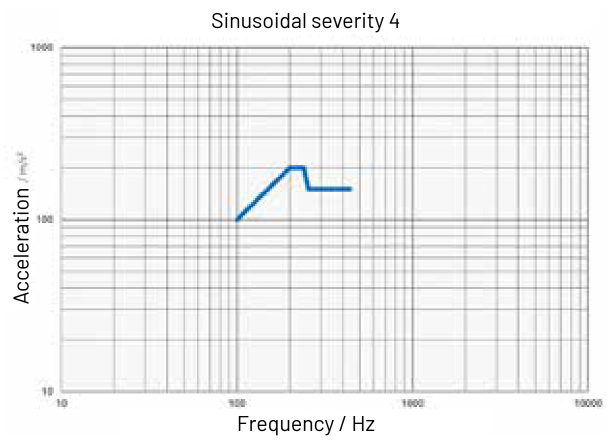


Figure PG 17-10 (Source: Kostal Kontakt Systeme)

Vibration class V5

Engine mounted parts, increased requirements
Profile Sine with overlaid temperature change.

Temperature profile DIN EN 60068-2-14

Duration / min	Temperature / °C
0	20
60	-40
150	-40
300	T_{max*}
440	T_{max*}
500	20

* max. 150 °C
No. of cycles: 12 per axis

Sine DIN EN 60068-2-6

Frequency / Hz	Acceleration / m/s²
100	100
200	300
400	300
900	600
2,000	600

Duration: 100 hrs per axis
Dwell time: 1 octave/minute

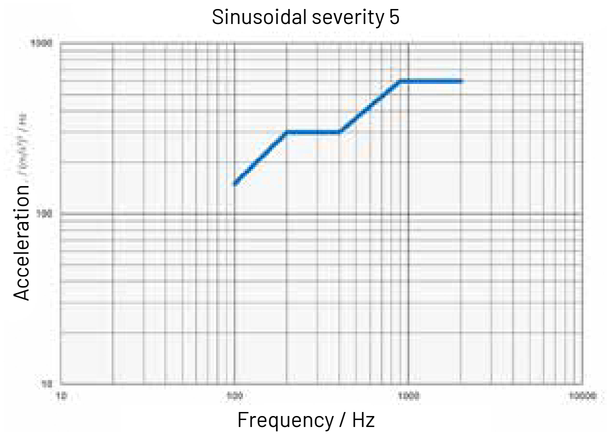


Figure PG 17-11 (Source: Kostal Kontakt Systeme)

Vibration class V6

Engine mounted parts, special applications
Profile Sine with overlaid temperature change.

Temperature profile DIN EN 60068-2-14

Duration / min	Temperature / °C
0	20
60	-40
150	-40
300	T_{max*}
440	T_{max*}
500	20

* max. 150 °C
No. of cycles: 12 per axis

Sine DIN EN 60068-2-6

Frequency / Hz	Acceleration / m/s²
100	100
200	500
400	500
900	800
2,000	800

Duration: 100 hrs per axis
Dwell time: 1 octave/minute

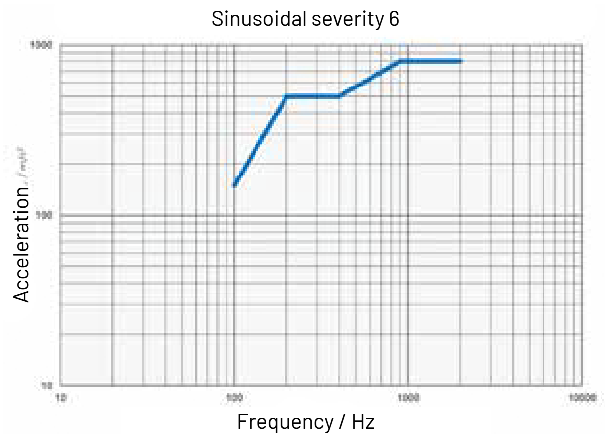


Figure PG 17-12 (Source: Kostal Kontakt Systeme)

Procedure:	
B 17.1	Resonance frequency of the contact system
	This test is intended to determine the resonance frequencies of the test samples in the 3 test axis X, Y and Z. The test takes place at room temperature. The recording of the resonance frequency of the connector housing parts including contacts and wires under sinusoidal vibration is to be provided. Acceleration sensors of smallest dimensions have to be attached to the connector housings which are not firmly screwed to the vibrating table. Alternatively, the non-contact measurement e.g. permissible by means of a laser scanning. Evidence must be provided on a test sample.

Sine DIN EN 60068-2-6

Frequency / Hz	Acceleration / m/s^2
5	10
2,000	10

Duration: 1 per axis
Dwell time: 1 octave/minute

Requirement:

The maximum values of the resistances from Appendix A for the preliminary, intermediate and final measurements at RT after the axes must not be exceeded.

Vibration test:

- There must be no functionally relevant damage.
- The handling (mating and unmating) must be given after the test.
- Evaluation of the contact surfaces as defined in this document (see Chapter 8: Evaluation of contact surfaces after tests).
- During the test, both the load profiles V1 – V6 and the shock load are monitored for electric circuit interruptions.
- An electric circuit interruption occurs, if the resistance value exceeds 7 Ω for more than 1 µs.

Resonance frequency of the contact system:

- The vibration responses of the connector housing must also be recorded and documented as a diagram together with the excitation profile in the test report.

27 PG 18A Coastal Climate Stress Test

Purpose:
Test for metal parts (test for sea transport or use near the coast).

Number of Test Samples:
10 contacts in connector housings.

Contacts:
Alle relevant base materials and surfaces (coatings).

Connector housings:
Unsealed or sealed w/o sealing elements, mated.

Wire cross section:
Random (preferably small wire cross sections)

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
B 18.1	Test samples will be inserted 2-times and extracted 1-time
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
B 18.2	Salt spray, cyclic DIN EN 60068-2-52, severity class 3
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 0.1	Visual inspection DIN EN 60512-1-1 Particularly the wire crimp area and the contact zone

Requirement:
The maximum values of table A must not be exceeded. Photographic documentation in removed condition.

28 PG 18C Road Salt Stress Test

Purpose:
Special additional test which does not belong to the standard validation.
Test for unsealed applications outside the dry area (use of "nordic country salt").

Number of Test Samples:
10 contact pairs populated in the connector housings.

Contacts:
All relevant base materials and surfaces (coatings).

Connector housings:
Unsealed or sealed w/o sealing elements, mated.

Wire cross section:
Random (preferably small wire cross sections)

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
B 18.1	Test samples will be mated 2-times and unmated 1-time
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
B 18.2	Salt spray, cyclic acc. to DIN EN 60068-2-52 Severity class 3
	Salt mixture (Nordic country salt): 3 % solution, with 95 % NaCl, 2.5 % $MgCl_2$ and 2.5 % $CaCl_2$.
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
E 0.1	Visual inspection DIN EN 60512-1-1 Especially the wire crimp area and the contact zone

Requirement:
The maximum values of table A must not be exceeded. Photographic documentation in disassembled condition.

29 PG 19 Environmental Simulation

Purpose:
Evaluation of different environmental loads on the contact system

Number of Test Samples:
3 groups with min. 10 contacts per group.

Contacts:
All relevant base materials and surfaces (coatings).

Wire:
The insulation must withstand the test temperature.

Wire cross section:
Case by case.

Connector housings:
Unsealed at wire exit, must be determined case by case.

	Group 1	Group 2	Group 3
No. of test samples	10	10	10
No. of matings prior test	1x	1x	Half the required mating cycles acc. to PG 11
During test	unmated	mated	mated
Resistance measurement method	DIN EN 60512-2-1	DIN EN 60512-2-1	DIN EN 60512-2-1

Table PG 19-1: Description of the 3 groups (Source: ZVEI)

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2)
B 19.0	insertion and extraction of groups acc. table PG 19-1
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2) (group 2 and 3 only)

E 19.0	Continuous monitoring of connection resistance during B 19.1 at 100 mA test current (group 2 and 3 only)
	Measurement frequency: 1 measured value every 5 minutes
B 19.1	Temperature schock (all groups) DIN EN 60068-2-14
	Test Na **Duration:** 144 cycles **Temperature:** -40 °C / T_{max} each 15 minutes **Duration for change:** max. 10 seconds
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2) (group 2 and 3 only)
E 19.0	Continuous monitoring of connection resistance during B 19.2 at 100 mA test current (group 2 and 3 only)
	Measurement frequency: 1 measured value every 5 minutes
B 19.2	Temperature change (all groups) DIN EN 60068-2-14
	Test Nb **Duration:** 20 cycles **Temperature:** -40 °C / T_{max} per 3 h **Temperaturechange:** max. 2 h
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2) (group 2 and 3 only)
E 19.0	Continuous monitoring of connection resistance during B 19.3 at 100 mA test current (group 2 and 3 only)
	Measurement frequency: 1 measured value every 5 minutes
B 19.3	Dry heat aging (all groups) DIN EN 60068-2-2
	Test B **Duration:** 120 hrs **Temperature:** T_{max}
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2) (group 2 and 3 only)
E 0.1	Visual inspection DIN EN 60512-1-1
B 19.4	Industrial climate (multi-component climate) (all groups) DIN EN 60512-11-7 (method 4)
	0.2 ppm SO_2, 0.01 ppm H_2S, 0.2 ppm NO_2, 0.01 ppm Cl_2 / 25 °C / 75 % r. h. / 21 d) **Volumetric flow rate:** 1 m^3/h
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2) (group 2 and 3 only)

E 19.0	Continuous monitoring of connection resistance during B 19.5 at 100 mA test current (group 2 and 3 only)
	Measurement frequency: 10 measured values per minute
B 19.5	Damp heat, cyclic (all groups) DIN EN 60068-2-30
	Variant 2 **Relative humidity:** 95 % constant **Duration:** 10 cycles – 24 hrs each cycle **Temperatures:** T_U = 25 °C, T_0 = 55 °C T_U = lower cycle temperature T_0 = upper cycle temperature
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2) (group 2 and 3 only)
E 0.1	Visual inspection DIN EN 60512-1-1
E 19.0	Continuous monitoring of connection resistance during B 19.6 at 100 mA test current (group 2 and 3 only)
	Measurement frequency: 10 measure values per minute
B 19.5	Dynamic load, DIN EN 60068-2-64 Broadband noise (group 2 and 3 only)

Frequency / Hz	Power Density Spectrum / $(m/s^2)^2/Hz$
10	5
55	1.6250
180	0.0625
300	0.0625
360	0.0350
1,000	0.0350
Effectice value of Acceleration: 13.9 m/s^2	

Resonance evaluation of the clamping fixture acc. to PG 17
Duration: 6 hours per axis
Clipping: 2.5

Table PG 19-2: Broadband noise (Source: ZVEI)

E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2) (group 2 and 3 only)
B 19.7	One-time mating (group 1)
E 19.0	Continuous monitoring of connection resistance during B 19.8 at 100 mA test current (group 2 and 3 only)
	Measurement frequency: 10 measure values per minute
B 19.8	Mech. Shocks (single shocks) (only group 2 und 3) DIN EN 60068-2-27
	Acceleration: a = 30 g **Individual shock duration:** t = 6 ms, halve wave, sine **No. of shocks:** 50 per spatial axis
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2) (group 2 and 3 only)
B 19.9	One-time mating and unmating (all groups)
E 0.2	Connection resistance DIN EN 60512-2-1 / DIN EN 60512-2-2 (> 10 mm^2) (all groups)
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:

The connection resistance must not exceed the maximum values specified in table A at any test.
Evaluation of the contact surfaces as defined in this document.

30 PG 20 Climate Load Test – Connectors

Purpose:
Test of pin housing / basic requirement.

Number of Test Samples:
5 *connector housings*: up to 5-way fully populated, from 6-way with 5 contacts, from 50-way at least 50 percent of the cavities are poulated.

Contacts:
Any contact.

Connector housings:
Any connector.

Wire:
Insulation must withstand test temperature.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 0.3	Insulation resistance DIN EN 60512-3-1
B 20.1	Dry heat storage DIN EN 60068-2-2
	Test B **Duration:** 120 hours **Temperature:** T_{max}
B 20.2	Damp heat, constant DIN EN 60068-2-78
	Duration: 10 days **Temperature:** 40 °C **Relative humidity:** 95 %
E 0.3	Insulation resistance DIN EN 60512-3-1
	The insulation resistance must be measured at the earliest 30 min and at the latest 60 min after conclusion of test B 20.2.
E 0.1	Visual inspection (plugged connection) DIN EN 60512-1-1
B 20.3	Low temperature storage DIN EN 60068-2-1
	Duration: 48 hours **Temperature:** -40 °C

B 20.4	Disconnect and connect at -20 °C
	It must be ensured that the test samples are fully tempered.
E 0.1	Visual inspection (plugged connection) DIN EN 60512-1-1
B 20.5	Dry heat storage DIN EN 60068-2-2
	Test B **Duration:** 48 hours **Temperature:** 80 °C
B 20.6	Disconnect and connect at 80 °C
	It must be ensured that the test samples are fully tempered.
B 20.6	5x disconnect and connect at RT
	It must be ensured that the test samples are fully tempered.
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:

No functional deviations after test are permitted.

It must be possible to disconnect and connect the test sample at -20 °C / RT / +80 °C.

Existing film hinges and latching elements must not break or tear during actuation.

Insulation resistance acc to damp heat (B 20.2): ≥ 50 MΩ.

31 PG 21 Long Term Temperature Storage – Connectors

Purpose:
Test of long-term stability of the connector housings.

Number of Test Samples:
5 connector housings per group.

Connector housings:
Group 1: Unsealed connector housings
Group 2: Sealed connector housings
Group 3: Sealing elements with separate locking function

Contacts:
Up to 5-pos fully populated with contacts.
6 – 10-pos with 5 contacts.
Above 10-pos with 50 % with contacts.

Remark:
Each cavity must be populated once within one test batch.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
	All test samples
B 21.1	Dry heat long term ageing (all test samples) DIN EN 60068-2-2
	Test B **Duration:** 1,000 hours **Temperature:** T_{max} Subsequent ageing min. 48 h at RT.
B 21.2	Functional check with all groups
	Connect and disconnect all test samples 5 times.
E 0.1	Visual inspection DIN EN 60512-1-1
E 8.2	Contact extraction force all contacts og group 1 and 2
	The limit value from PG 8 is the value for the secondary locking, even if the primary and secondary locking are closed.
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:
After completion of the test, there must be no detectable functional impairments on the housings. Cracking or delamination that affect the function are not permissible.
- Contact extraction force: The limit value from PG 8 is the value for the secondary locking, even if the primary and secondary locking are closed.

32 PG 22A Chemical Resistance

Purpose:
Special test of the chemical resistance of the connector housings only if a new (not formerly released) material is used. Significantly new design features are checked initially only. References to manufacturer certificates are permitted.

Number of Test Samples:
2 fully populatede connector housings per test medium.

Contacts:
Any version.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
E 22.1	Evaluate 3 basic dimensions
	Basic dimensions must be defined and determined before the test.
B 22.1 A	Restistance to chemicals (basic requirements)
	Procedure: Test samples must be exposed with the media (chemicals and method acc. to PG 22A-1) and 48 hours stored at required storage temperatures. Test samples must be thoroughly cleaned with water and dried after test.
E 22.1	Evaluate 3 basic dimensions
	Basic dimensions must be defined and determined before the test.
E 0.1	Visual inspection DIN EN 60512-1-1
B 20.7	5x disconnect and connect at RT
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:
- No functionally significant structural changes permitted.
- Any deviations from the original state must be documented.
- Dimensions to be documented before and after the test.

Pour over: Min. 100 ml
Rub in: weat cotton cloth
Spray: ca. 1 second per relevant area

Nr.	PG	Chemical	Description	Applying			Storage temp. / °C
				Pour over	Rub in	Spray	48 h
1	22A	Cold cleaner / Cockpit cleaner	commercially available			X	50
2	22A	Penetrant	commercially available			X	50
3	22A	Wash water antifreeze, undiluted	commercially available	X			50
4	22A	Isopropanol	commercially available	X			RT
5	22A	Grease	commercially available		X		50

Table PG 22A-1: List of media (Source ZVEI)

33 PG 22B Chemical Resistance, Advanced Test

Purpose:
Special test of the chemical resistance of the connector housings only if a new (not formerly released) material is used. Significantly new design features are checked initially only. References to manufacturer certificates are permitted. Application specific functional test to be committed with the user.

PG 22A and PG 22B to be tested for sealed requirements.

Number of Test Samples:
2 fully populated sealed connector housings and mating connectors per test media.

Contacts:
Any version.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
B 22.1 B	Resistance to cehmicals (sealed version)
	Procedure: Test samples must be exposed with the media (chemicals and method acc. to PG 22A-1) and 48 hours stored at required storage temperatures. Test samples will not be cleaned acc. to PG 22A.
E 0.1	Visual inspection DIN EN 60512-1-1
B 20.7	5x disconnect and connect at RT
E 0.1	Visual inspection DIN EN 60512-1-1

Requirement:
- No functional changes permitted (see PG 22A).
- Any deviations from the original state must be documented.

Pour over: Min. 100 ml
Rub in: weat cotton cloth
Spray: ca. 1 second per relevant area

Nr.	PG	Chemical	Description	Applying			Storage temp. / °C
				Pour over	Rub in	Spray	48 h
1	22B	Brake fluid	DOT 4 / DOT 5	X			50
2	22B	FAM test fuel (gasoline/super)	commercially available	X			RT
3	22B	Diesel	DIN EN 590	X			RT
4	22B	Diesel additive AdBlue	DIN EN 70070	X			RT
5	22B	Engine oil 5W-30	fully synthetic	X			50
6	22B	Power steering oil	according to requirement	X			50
7	22B	Automatic transmission oil	fully synthetic	X			50
8	22B	Radiator antifreeze	resistant down to -40 °C	X			50
9	22B	Deicing salt solution	Mixture PG 18C	X			50

Table PG 22B-1: List of media (Source: ZVEI)

34 PG 23 Watertightness

Purpose:
Test of sealed connector housings, cavity plugs and single wire seals.
Group 1: Connector housings with cavity plugs.
Group 2: Connector housings with single wire seals (SWS etc.).

Number of Test Samples:
Group 1: 2 connector housings
Group 2: 5 fully populatede connector housings

Contacts:
Any

Connector housings:
All sealed versions.

Wire cross section:
Per sealing element smallest and largest permissible wire cross section.

Wire:
The insulation must withstand all thermal and mechanical requirements acc. to PG 23.
The ends of all stranded wires are sealed pressure tight.

For sealing systems without SWS, the contacts must be removed and re-inserted once before the test.

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
B 19.3	Dry heat storage (all groups, connected) DIN EN 60068-2-2
	Test B **Duration:** 120 hours **Temperature:** T_{max}
B 19.1	Temperature schock (all groups, connected) DIN EN 60068-2-14
	Test Na **Duration:** 144 cycles **Temperature:** -40 °C / T_{max} 15 minutes each **Cycle time:** max. 10 seconds
E 0.1	Visual inspection (all groups) DIN EN 60512-1-1
	Connected condition.

B 23.1	Immersion with pressure difference (all groups) DIN EN 60512-14-5, DIN EN 60068-2-13
	Can be performed in combination with B 23.2. Both groups are pressurized via a contact chamber with a hose or a suitable connection; pressurization via a wire is not permitted. The remaining connector cavities are closed/ sealed with cavity plugs or sealed wire ends. In the following, pressure differences to the environment (normal pressure) are set inside the connector housing. The specified holding times apply from the persistence of the required pressure values (a-d). **Medium:** Low-surface tension, 5 % NaCl-solution a Normal pressure b -10 kPa, hold time 5 minutes c -50 kPa, hold time 5 minutes d Normal pressure **Pressure change:** 10 kPa/min
B 23.1	Wire movement during immersion with pressure difference (vacuum): for group 2 only:
	Can be performed in combination with B 23.1. For contact housings with cover, the test must be performed without the cover. For contact housings that cannot be installed without covers (e.g., for insertion and extraction aids), this test section is omitted. **Definition of wire movement:** • No fixed clamping of the wires (no tension on wires). • *Free, moving wire length:* 100 mm • *Movement profile:* – Deflection of the wire bundle by 100 mm (final position) at a distance of 100 mm from the SWS, – hold for 10 seconds, – Deflection to the opposite final position, – Hold for 10 seconds. • This movement profile is performed once for each pressure stage during the test run. • Direction of movement: vertically to the branch-off direction, in both spatial axes.
E 0.1	Visual inspection (all groups) DIN EN 60512-1-1
	Connected condition.
B 23.3	Thermal shock test (all groups)
	Medium: low-tension, 5 %-NaCl-solution (ice-water) **Air temperaturs:** T_{max} acc. to temperature class / **Duration:** each 30 minutes **Water temperature:** 0 °C / **Duration:** each 5 minutes **Number of cycles:** 5
E 0.1	Visual inspection (all groups) DIN EN 60512-1-1
	Connected condition.

B 23.4	Degree of protection (acc. to sealing class, all groups) ISO 20653
	Severity class: IPX0 No test required. **Severity class:** IPX4K (spray device) *Duration:* 10 minutes (5 minutes per side, additional 5 minutes in 90° turned psotion) *Distance from nozzle to test sample:* ≤ 200 mm *Spray device movement:* ± 180° to 20° *Velocity:* 1 sec./60° *Nozzle:* Ø 0.8 mm *Flow rate:* 0.6 l/min, ± 5 % *Pressure:* ~ 400 kPa **Severity class:** IPX8 (submerge) Unless otherwise specified, the parameters of IPX7 to be used. *Duration:* 30 minutes *Dew depth:* 1.0 m (min. 0.15 m water line above the test sample) *Temperature:* max. 5 K temperature difference between water and test sample **Severity class:** IPX9K (high pressure jet spray) Test w/o cover. W/o cover prevent wedge effect of the jet sprayer. *Duration per position:* 30 socinds *Position:* 0°, 30°, 60°, 90° *Distance nozzle-test sample:* (100 – 150) mm *Pressure:* (8,000 – 10,000) kPa *Flow rate:* (14 – 16) l/min *Bench velocity:* (5 + 1) revs/min *Temperature:* (80 + 5) °C
E 0.3	Insulation resistance (Group 2 only) DIN EN 60512-3-1
E 0.1	Visual inspection (all groups) DIN EN 60512-1-1 Disconnect all connector housings

Requirement:

No media entrance permitted, i.e. water detection paste must be used.

Insulation resistance must be > 100 MΩ.

The function of the locking or releasing elements must remain fully intact.

35 PG 28 Audible Click

Purpose:
All locking mechanism to be actuated during vehicle assembly must provide an audible click.

Number of Test Samples:
1 fully populated connector housing per mold cavity / each test sample with separate counter part.

Connector housings:
All existing variants, not applicable for connector housings with mating aid (lever, slide, etc.).

<table>
<tr><th colspan="2">Procedure:</th></tr>
<tr><td>E 0.1</td><td>Visual inspection DIN EN 60512-1-1</td></tr>
<tr><td></td><td></td></tr>
<tr><td>E 28.1</td><td>Audible click</td></tr>
<tr><td></td><td>

Distance to the measuring microfon: (600 ± 50) mm
Actuation of the locking mechanism: by hand, with the smallest possible touch area.
Avoiding of distorting reflections from surfaces (table) or near walls (see figure PG 28-1).

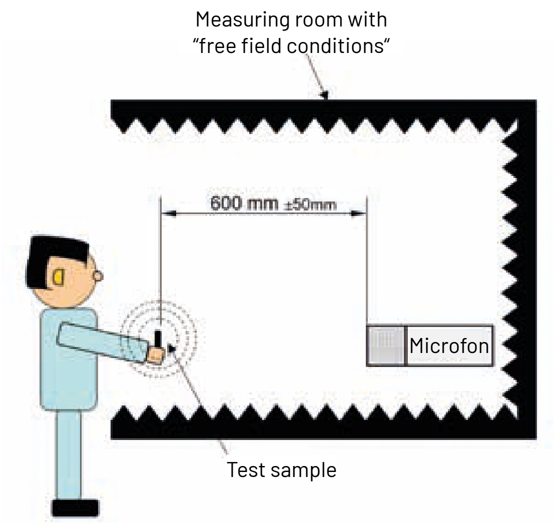


Figure PG 28-1 (Source: TE Connectivity Germany)

</td></tr>
<tr><td>E 0.1</td><td>Visual inspection DIN EN 60512-1-1</td></tr>
</table>

Requirement:
- The measured dB(A) values must be documented.
- For this purpose, the signal-to-noise ratio between the audible click and the ambient noise must be at least 7 dB(A).
- The audible click must be at least $L_{Apeak} \geq 70$ dB(A).
- L_{Apeak}: peak level of the sound level with frequency weighting A.

36 PG 29 Blind Plug Holding Force

Purpose:
Validating the blind plug holding force in relation to the internal pressure of the sealed contact system during the mating process.

Remark:
If it is ensured that the possible pressure inside oft the housing is maximum 50 KPa this test group can be replaced by a pressure test acc. to PG 23-1.

Number of Test Samples:
3 fully populated sealed connector housings, however minimum 10 blind plugs.

Contacts:
No

Procedure:	
E 29.1	Theoretical determination of the internal pressure p_0
	Determination of the air volumes inside of the connector housing in the closed state and in the state where the housing seal touches the mating piece for the first time. With the two volumes, the maximum possible internal pressure p_0 can be calculated.
E 0.1	Visual inspection DIN EN 60512-1-1
B 20.1	Dry heat storage DIN EN 60068-2-2
	Test B **Duration:** 2 hours **Temperature:** 60 °C

<table>
<tr><td>E 29.2</td><td>Determination of the blind plug extraction force</td></tr>
<tr><td></td><td>
• The pressure difference between the closed and locked housing and the exterior environment must be continuously increased (5/min) until the pressure level reached p_0.
• Hold pressure for at least 30 seconds.
• Continously increase of the pressure (50 kPa/min) till a maximum pressure of 1.5-times p_0 is reached or the blind plug slips out (= p_{max}).

This may be achieved by increasing the internal pressure or by decreasing the external pressure.

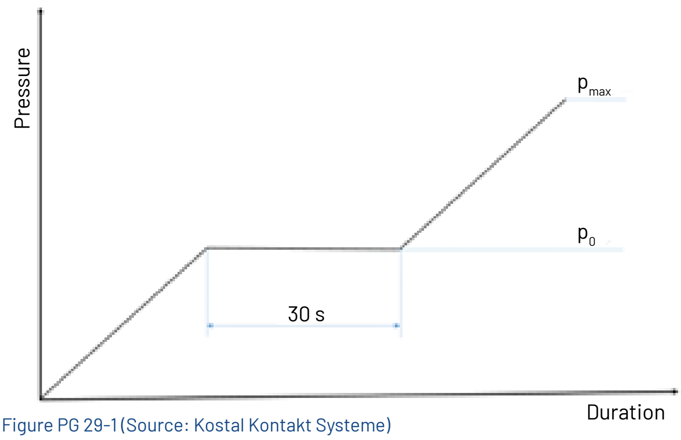


Figure PG 29-1 (Source: Kostal Kontakt Systeme)
</td></tr>
<tr><td>E 0.1</td><td>Visual inspection DIN EN 60512-1-1</td></tr>
</table>

Requirement:

$p_{max} \geq 1* p_0$
Max. pressure must be documented.

37 PG 31 Measurement of Contact (Pin / Tab) Extraction Force on Header / Connector

Purpose:
Verifying the contact plug holding forces required for the mating process in device-mounted connector receptacles/interfaces/molded-on connector re-ceptacles to ensure sufficient contact overlap.

Number of Test Samples:
Per mold cavity min. 3 pin- or tab-header (fully equipped).

Contacts:
All

Procedure:	
E 0.1	Visual inspection DIN EN 60512-1-1
B 31.1	Dry heat storage DIN EN 60068-2-2 (simulation solder process)
	Duration: 2 hours **Temperature:** 85 °C Cool down test samples at room temperature
E 31.1	Extraction force pin / tab
	The pins/tabs of the test samples are pushed out of the shrouded pin-header and a load-displacement curve is recorded. The distance between two tested pins/blades must be large enough to preclude mutual interference during the measurement. The number of test samples (tab- / pin-header) must be adjusted so that 3 measured values are determined for each mold cavity and every populated header cavity. Suitable support must be provided for the shrouded pin header near the point of force application. **Test velocity:** 10 mm/min Starting force (preliminary force) $F_{(V)} = 5$ N **Zero-point distance:** $s\,(_{0mm}): = s\,(F_{(V)})$

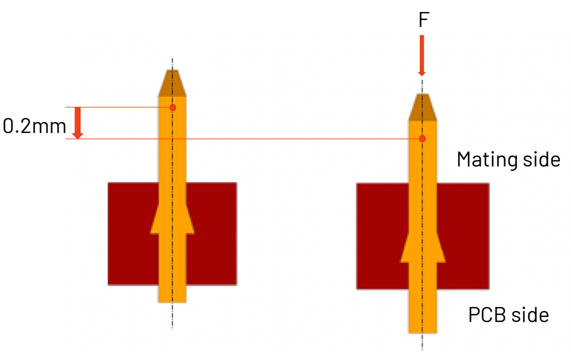


Figure PG 31-1: Schematic representation of the relative displacement of the contact to its connector housing by 0.2 mm (Source: Aptiv Services Deutschland)

Requirement:

Visual inspection (unused condition): no damages in the contact area.
The required extraction forces F (min) must be achieved within the range of 0 mm to 0.2 mm in relation to the pin.
The holding forces $F_{(min)}$ required in the pin / tab definition must be achieved within 0 mm to 0.2 mm relative displacement in relation to the pin-header reference (see Figure PG 31-1).
The maximum value $F_{(0.2)}$ must be documented (see Figure PG 31-2).

The documentation in the test report may be in graphic form or in table form.

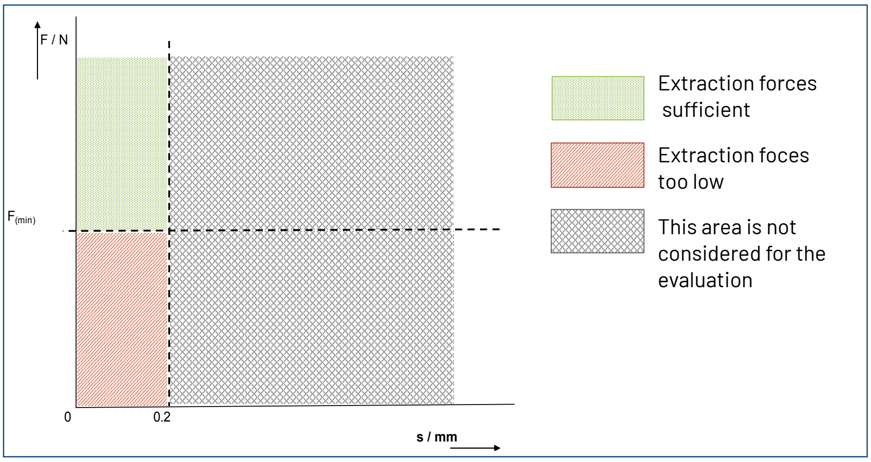


Figure PG 31-2: Load-displacement curve with the target corridor for the extraction force (Source: Aptiv Services Deutschland)

Spezification of the size-dependent, minimum holding forces:

Plug

contact size (mm)	minimum holding (N)
0.5	15
0.63	25
1.2	30
1.5	40
2.8	60
4.8	60
5.2	60
5.8	60
6.3	60
8.0	80
9.5	80
12.0	80
14.5	80

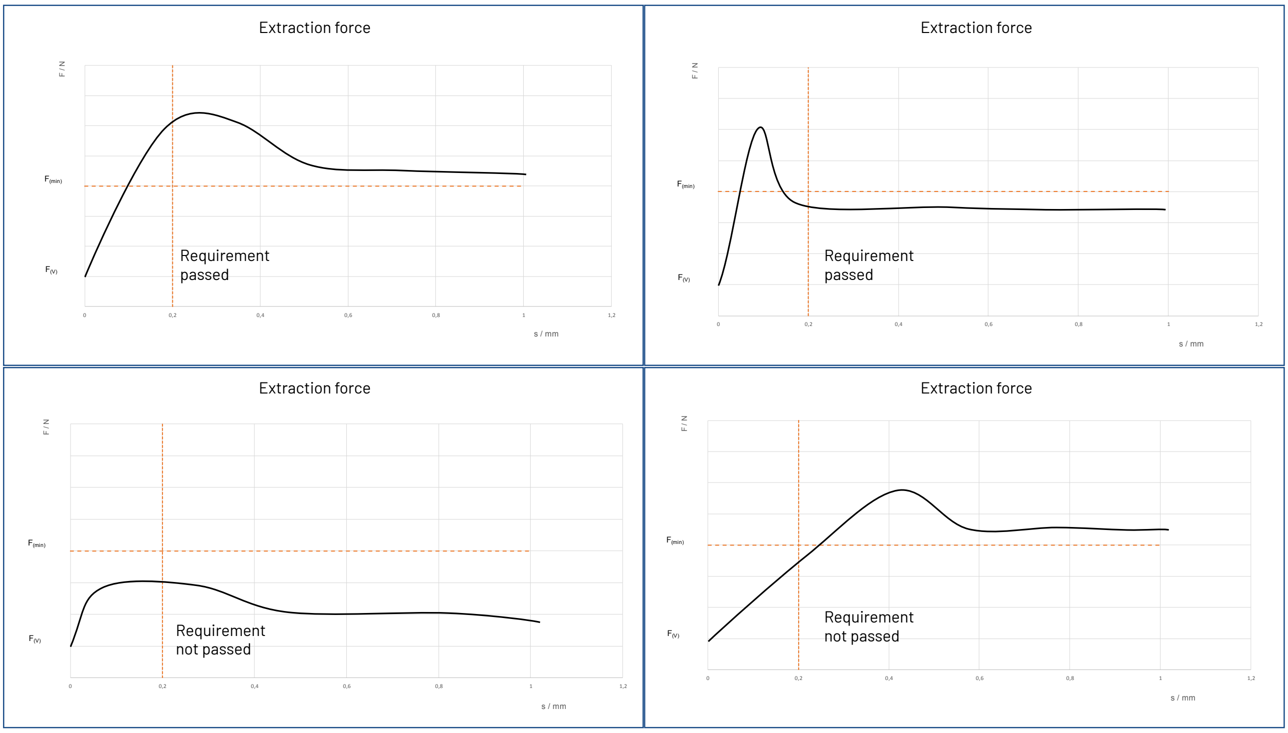


Figure PG 31-3: Exeamplary extraction force characteristics (Source: Aptiv Services Deutschland)

38 PG 60 Headroom Integrity of Crimp Contacts

Purpose:
Processability and reliability of process monitoring for solderless, electrical crimp connections.

Scope:
This test group applies to crimp contacts (on reel) from 0.13 mm^2 up to and 6 mm^2 wire cross section and to the wires according to TLF 0112-1 or TLF0112-4.

Contact manufacturers and wiring harness manufacturers can use the test group equally.

Crimp force monitoring test method:
The crimp force monitoring is a force (or signal) via distance (or time) measurement during the working stroke of the applicator.

Test:

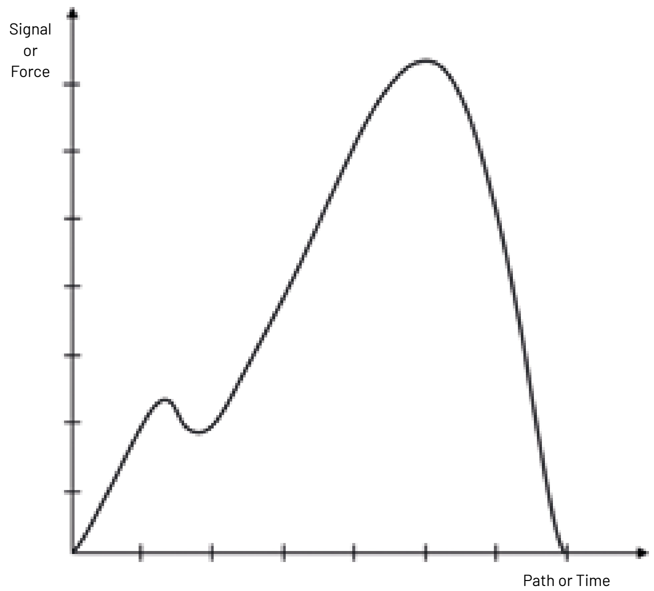


Figure PG 60-1: Crimp force curve (Source: Schleuniger)

Cutting machine:
It is foreseen to use cutting machine types, representing the series status of a wire assembly for this test.

Applicator:
Original crimping tools or crimping tools approved by the contact manufacturer must be used for this test.

Crimp force-monitoring equipment:
The test is to be carried out with the machine's type-specific monitoring system and preferably using the associated standard monitoring parameter set.

Primarily, new contacts and wire material should be used.

Only single crimped contacts are checked. Within a contact family, only those contacts must be checked, that differ in terms of the stamping tools used, the materials in the crimping area or the layout geometry.

For succeeding stamping tools the processability test must only be proven again if the succeeding stamping method is changed (e.g. double out).

For the evaluation of the monitoring criteria, the smallest allowed wire cross section of the respective contact system must be used.

Reliability of error detection:
The reliability of error detection is mainly influenced by the contact design and its processing parameters, the wire, the processing machine, the crimping tool, as well as the proper execution of the test.

Sufficient error detection:
The test on the application is carried out according to the test procedure. If the limit values are not exceeded, sufficient error detection is demonstrated.

Requirement:

The application to be tested must meet the individual limits for pseudo error rate, missing wire material and crimping on insulation. The processability with regard to the process capability limits must be demonstrated.

Test sample description for test sequence as shown in Figure 60-2:
The test sample must be produced in accordance with the contact manufacturer's processing specification, e.g., setting up the nominal crimp height, using a released crimping tool, using the specified wire and the wire cross section to be tested.

Test sequence:

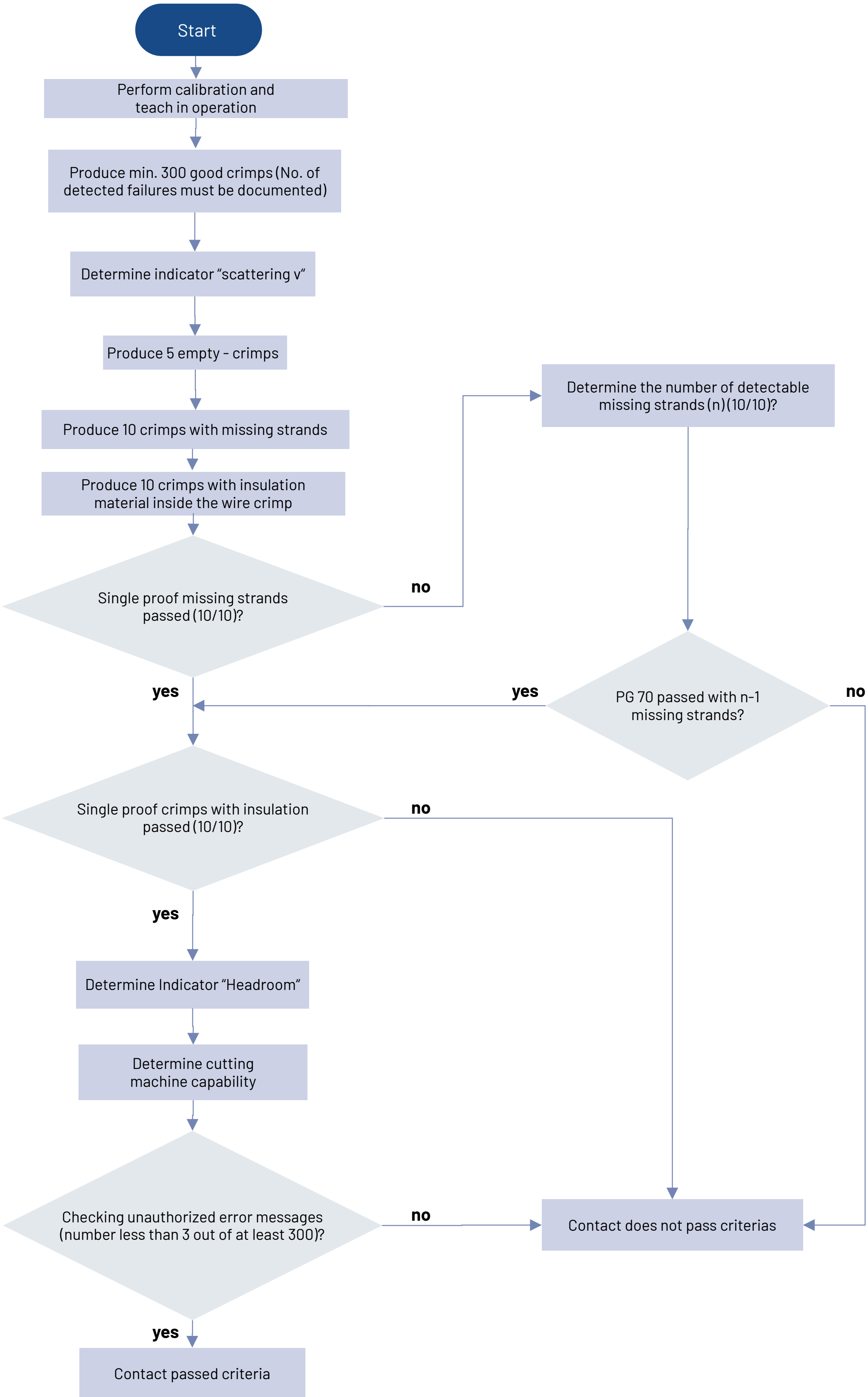


Figure PG 60-2 (Source: Schleuniger)

Error detection:

The error detection is divided into the areas of missing individual wire material and crimped insulation material.

Detection of missing strands:

The individual verification for "missing strands" must meet the following criterion:

During the crimping process, the error caused by the required number of missing individual strands (generally stated in percent) must be 100 percent detected by crimp force monitoring (CFM).

Calculation example:

For wire structure: with number of individual strands = 19 (wire structure TYP-A, 0.75 mm^2).
Requirement: Detection of 10 percent missing single wires => 10 percent of 19 single wires = 1.90 single wires.
To carry out the test, the value needs to be rounded up to the nearest whole number (here to 2 individual strands).

Detection of 30 percent crimped insulation:

The individual verification for "crimped insulation" must meet the following criterion:
During the crimping process, the error caused by the required percentage value for crimped insulation in the wire crimp area must be 100 percent detected by crimp force monitoring (CFM).

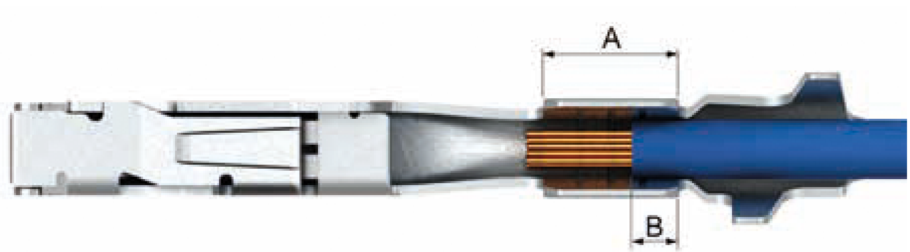


Figure PG 60-3: Insulation end-position for error „crimped insulation" (Source: Kostal Kontakt Systeme)

Legend

A: Wire crimp length (corresponds to 100 percent)
B: Insulation end protrudes with 30 percent of the wire crimp length (A) into the wire crimp

Cutting machine capability and reliability of error detection:

Machine capability is given if less than 3 stops occur when performing at least 300 good crimps.
The reliability of the error detection is determined and documented by at least 300 good crimps and their evaluation.

Pseudo scrap rate:

Crimps rated as not okay by the crimp force monitoring need to be examined individually. However, if these crimp samples do not deviate from the contact manufacturer's product specification (= good crimping), these are pseudo errors. The pseudo error rate must be less than 1 percent of the good crimps.

Headroom determination:

The headroom is an indicator for the ability to monitor a crimp connection. It is used to assess whether potential failures like "missing strands" and "insulation in the crimp" can be detected during the crimp operation. With a calculated headroom value greater than 35 percent, the expected monitoring capability is usually achieved.

Extended test scope in case of non-achievement of the criterion “missing individual strands“:

If the required number of individual strands is not 100 percent detected as an error in the individual proof, the number of strands that are reliably detected as an error must be determined in further individual detection tests (10/10).

Subsequently, test samples with a number of n-1 missing individual strands are created. These test samples are manufactured with nominal crimp height and then subject to an additional test „PG 70“.

Calculation example:
Wire structure: number of individual strands = 19 (wire structure TYP-A, 0.75 mm^2).
Requirement: Detection of 10 percent missing single strands ➡ 10 percent of 19 single wires = 1.90 single wires. To carry out the test, the value is only rounded up to the nearest whole number (here to 2 individual strands). In case the detection of missing single strands is not securely detected, continue with ➡ n = 3 single wires and perform individual proof again. If errors are reliably detected with n = 3 (10/10). ➡ Create test samples for PG 70 with n-1 = 2 missing individual strands.

Glossary and formulas:

Headroom:
The headroom is the distance between the average peak value of a good crimp and the average peak value of an empty crimp in percentage.

The headroom is used to estimate whether potential errors like “missing strands“ and “insulation in the crimp“ are detected during the crimp operation.

Headroom = $\left(1 - \frac{\bar{x}_1}{\bar{x}}\right) \cdot 100\%$

$\bar{x}_1$ = arithmetic mean value of the peaks of an empty crimp

$\bar{x}$ = arithmetic mean value of the peaks of a good crimp

Relative scattering:

Relative scattering is an indicator of process stability. With a calculated relative scattering of less than or equal to 1.2 percent, the expected monitoring capability is usually achieved. It is calculated from the standard deviation of the measured values relative to the average peak value of the good crimps.

Standard deviation: $\sigma = \sqrt{\frac{\Sigma\,(x-\bar{x})^2}{(n-1)}}$
(equal to the function “STABW.S“ in MS Excel)

Relative scattering in percent: $v = \frac{\sigma}{\bar{x}} \cdot 100\%$
with:
x = respective single values (good crimps)
$\bar{x}$ = arithmetic mean of the peaks of a good crimp
σ = Standard deviation
n = number of measured values
v = relative scattering

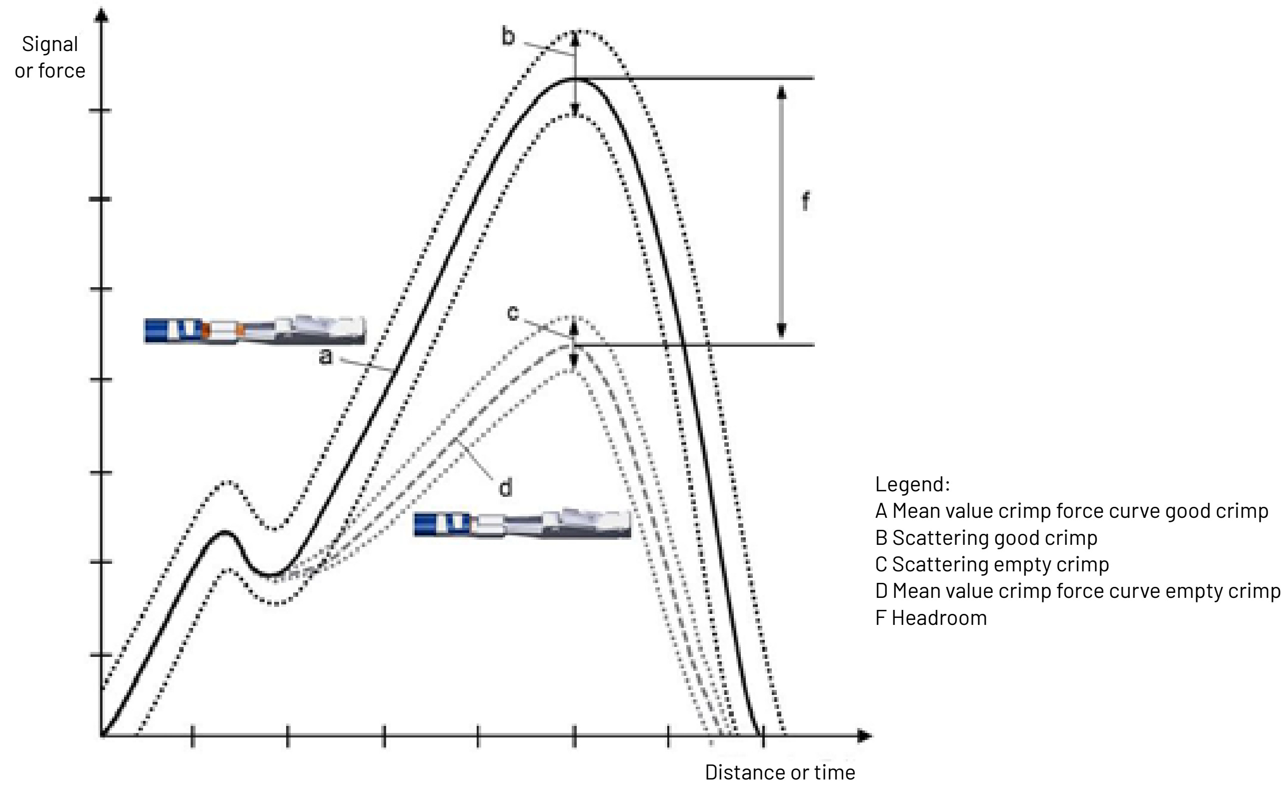


Figure PG 60-4: Crimp force course of good- and empty crimps as well as definition "Headroom" (Source: Kostal Kontakt Systeme)

39 PG 70 Crimp Test – SMBT (Slow Motion Bending Test)

Purpose:
The test described here serves as a standardized method for validating a crimp connection (= connection from a contact to an electrical wire): The test primarily applies to the connection of a contact with open crimp barrel in the shape of an F-crimp (= B-crimp) and a single-core copper stranded wire (e.g., according to ISO 6722) with a nominal size of the wire cross section from 0.13 mm^2 to 50 mm^2. Larger cross-sections must be agreed separately regarding test setup and implementation.

Test item:
Number of Test Samples 10 pcs. + 1 reference sample:
- All wire cross sections of the respective contact acc. to the application specification.
- Test samples are produced with minimal compression (the test target can also be verified with test samples with larger crimp heights that deviate from the specifications).

The following transfers of test results to other contact part numbers are permitted:

Requirement:
The crimp barrels are equal in the wire crimp according to the drawing regarding geometry (in particular material thickness and wire crimp length) and base material and for processing the same crimp parameters and wire cross section are used.

Permitted transferabilities: (in specified direction only)
- Crimp barrel with galvanic coating (Sn / Ag) and Ni-underlayer to other coating combinations (especially hot dipped tin and galvanic (Sn / Ag) w/o Ni-underlayer).
- Crimp barrel w/o insulation crimp to crimp barrel for single-wire-seal to crimp barrel with Insulation crimp.
- The difference in the nominal strength of the base material of the crimp barrel is no more than 15 percent.

Alignment of the test samples:
The direction of the wire movement is to be laid parallel to the greatest extent of the crimp connection (based on a section perpendicular to the wire axis). For F- or B-crimp as shown in Figure PG 70-1, means in the direction of the crimp width.

Fixation of the test samples:
The contacts are inserted in an associated connector housing and they can move within the cavity play. Contacts with a sealing element (e.g. single wire seal) are inserted and tested with the associated seal and associated connector housing.
The connector housing is firmly clamped taking care on the alignment of the test samples. Alternatively, instead of connector housings, contact-holding combs can be used, which simulate the chamber contour.

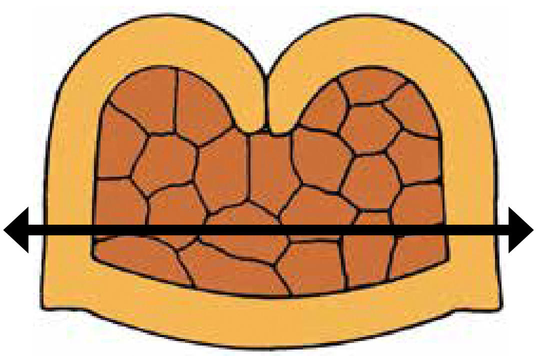


Figure PG 70-1: Direction of wire movement (Source: TE Connectivity Germany)

Test Procedure:

Test sequence includes:

- Pre-aging by temperature shock (see chapter 39.1).
- Then movement with superimposed temperature change (see chapter 39.2).

Resistance measurements are made via the attached measuring lines.

39.1 Pre-aging by temperature shock

The pre-aging takes place on the fully assembled test samples (i.e. contacts inserted in the connector housing, all measuring lines attached, movement slide is threaded, etc.).
The resistance values are recorded continuously including the resistance measurement for 30 minutes at room temperature (RT) before and after the temperature shocks.

Parameter:

Upper temperature: T_U = 125 °C
Lower temperature: T_L = -40 °C
Cycle time: < 10 seconds
Holding time: $t_0 = t_U$ = 0.5 h (30min)
No. of cycles: 100
Duration: 100 hours
After completing the last cycle, bring the chamber temperature to RT and hold it for 30 minutes.

There should be a maximum of 72 hours between the end of "pre-aging" and the beginning of the "movement phase".

39.2 Movement phase with superimposed temperature change

The movement phase takes place on the fixture used in the pre-aging process, if necessary with an additional moving system, in a temperature chamber.
The resistance values (sampling rate 0.1 to 1 Hz) are recorded continuously including the resistance measurement for 30 minutes at room temperature before and after the movement phase.

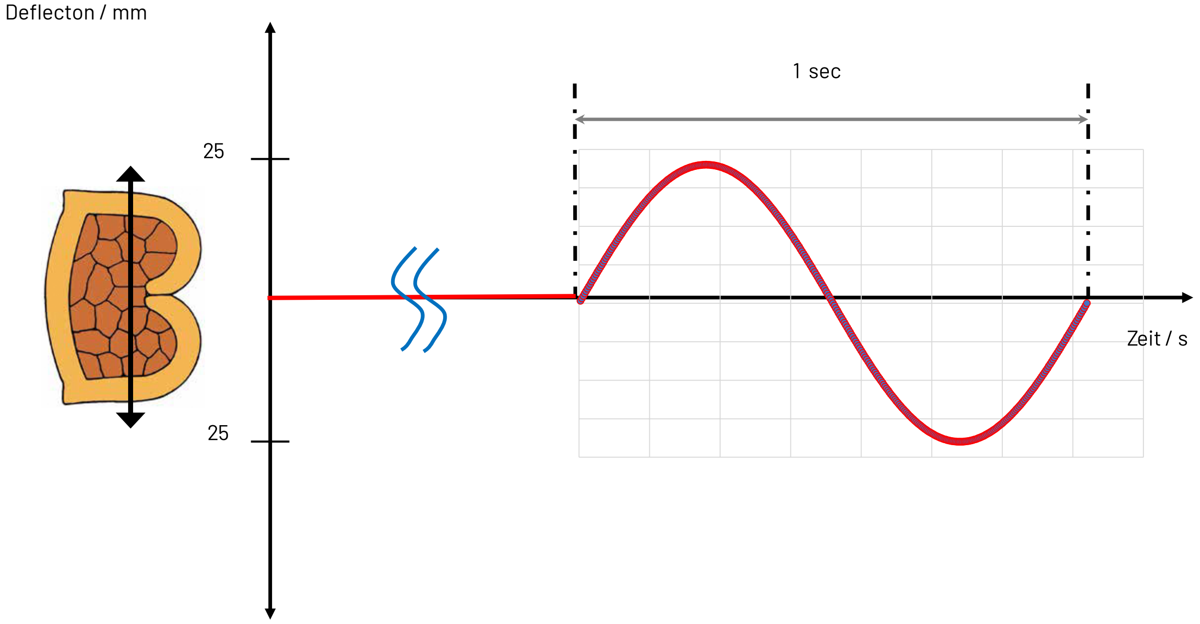


Figure PG 70-2: Temperature change (TC) (Source: TE Connectivity Germany)

The temperature change (TC) according to Figure PG 70-3 is superimposed in the movement phase.

Parameter:

Amplitude (effective): w = ± (25 ± 2) mm
Form: sinusoidal
Duration: 1 second / every 15 minutes
Rest phase: in middle position of the wire
No. of cycles: n = 720 / Total duration: 180 hours
Temperature change (TC):
T_L = RT / t_L = 1 hour
T_U = 80 °C / t_U = 3.5 hours
Gradient 1,33 K/min (➔ 45 minuts cycle time) ➔ 1 TC takes 6 hours
No. of TC-cycles: 30 / Total duration: 180 hours

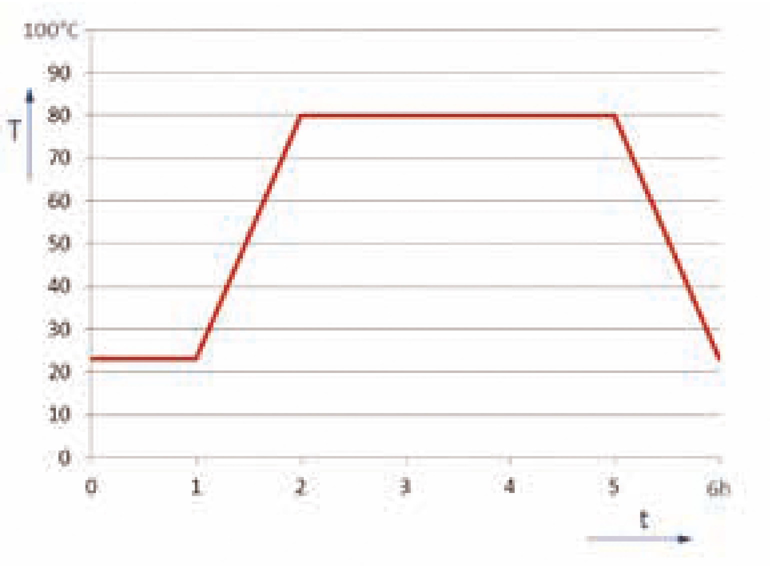


Figure PG 70-3: Movement cycle (Source: TE Connectivity Germany)

Comparison, evaluation and acceptance limits:
The comparison and evaluation parameters are to be determined from the measured resistance values of the test samples. For this, only the resistance measurements at RT in the rest phases between the movements are to be used. The arithmetic mean of the measured values at the reference temperature (23 °C ± 1 °C) is to be used for the evaluation. All 10 test items must meet the evaluation criteria in order to pass the test for a crimp combination.

39.3 Definition of the comparison and evaluation parameters

The comparison and evaluation values are to be calculated as the difference between defined resistance values. The defined values to be used for the respective comparison or evaluation parameter are specified in Table PG 70-1. The determination of the defined values is described below.

The assessment for passing the test is based on the assessment parameters and their limit values. The comparison values are only used for comparison with tests of other crimp combinations and not for evaluation.

There are 5 variables to be considered (each related to resistance measurement at RT):

ΔR1	comparison parameter (no rating)	Difference of start values of resistance	For all 10 test samples	Intitial condition
ΔR2	Evaluation parameter	Resistance change End value – start value	Per test sample	For the entire test run
ΔR2v	comparison parameter (no rating)	Resistance change After pre-aging – start value	Per test sample	For pre-aging phase
ΔR3	Evaluation parameter	Resistance change Highest value – start value	Per test sample	For the entire test run
ΔR4	Evaluation parameter (case by case)	Resistance change Highest value – lowest value	Per test sample	During the 2nd half of the movement phase

Table PG 70-1: Comparison and evaluation parameters (Source: ZVEI)

Definition of start value, end value, after pre-aging, maximum value and lowest value:

- ΔR1 is determined for all test items. It is the maximum difference between the initial values of the resistance of the test objects when they are new (largest value minus smallest value over all test objects from the 30-minute resistance measurement before pre-aging).
- ΔR2 is determined for each test item. It is the difference of its resistance value between the end of the movement phase (end of test) and before pre-aging (new condition), in each case at RT.
- ΔR2v is determined for each test item. It is the difference of its resistance value between the end of the pre-aging and before the pre-aging (new condition), in each case at RT.
- Δ R3 is determined for each test item. It is the difference between its highest measured resistance during the movement phase and its resistance value before pre-aging (new condition), in each case at RT.
- ΔR4 is determined on a case-by-case basis for each test item. It is the difference between the highest resistance and the lowest resistance in the 2nd half of the movement phase.

In figures PG 70-4 to PG 70-6 the evaluation criteria are shown schematically (simplified to only 4 temperature cycles each and (in figure PG 70-4) 4 test samples).

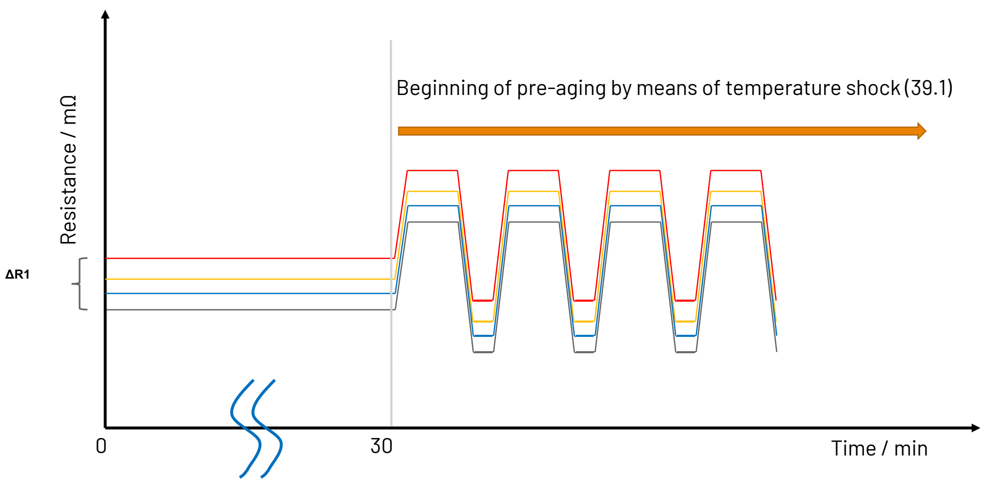


Figure PG 70-4: ΔR1 (schematic) (Source: TE Connectivity Germany)

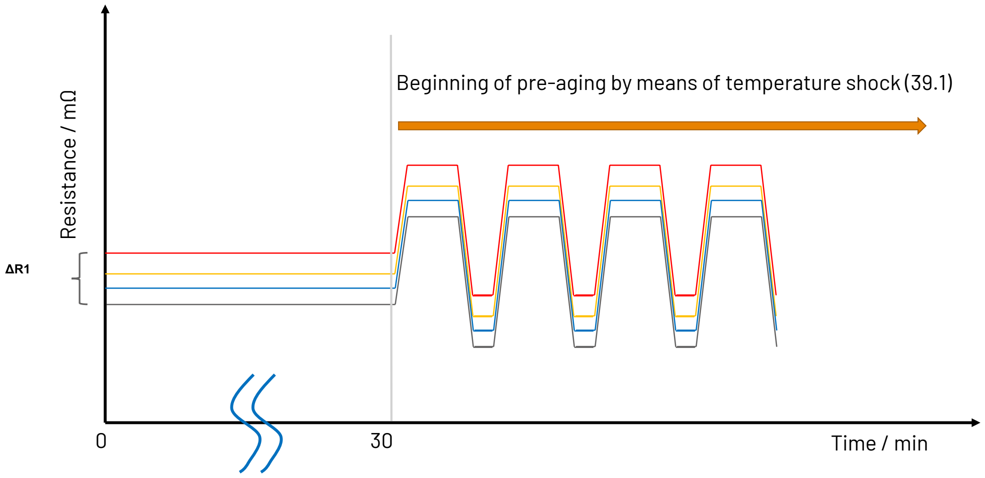


Figure PG 70-4: ΔR1 (schematic) (Source: TE Connectivity Germany)

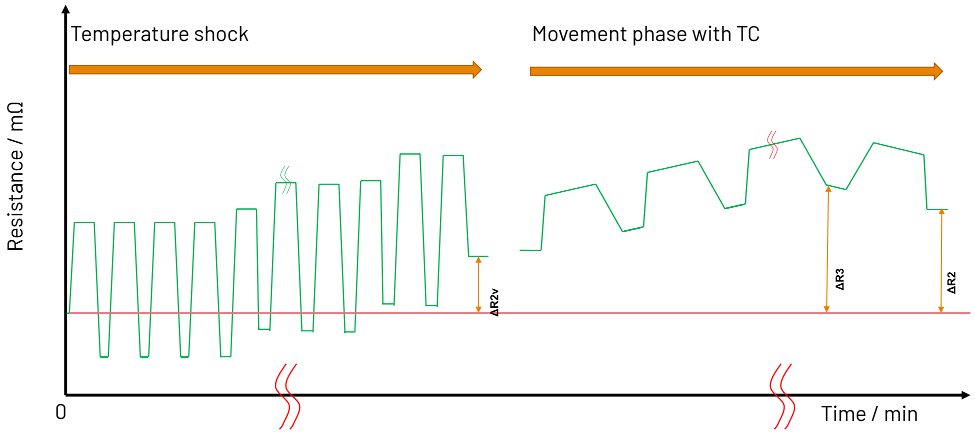


Figure PG 70-5: ΔR2, ΔR2v and ΔR3 (schematic) – Maximum value in the middle of the movement phase (schematic) (Source: TE Connectivity Germany)

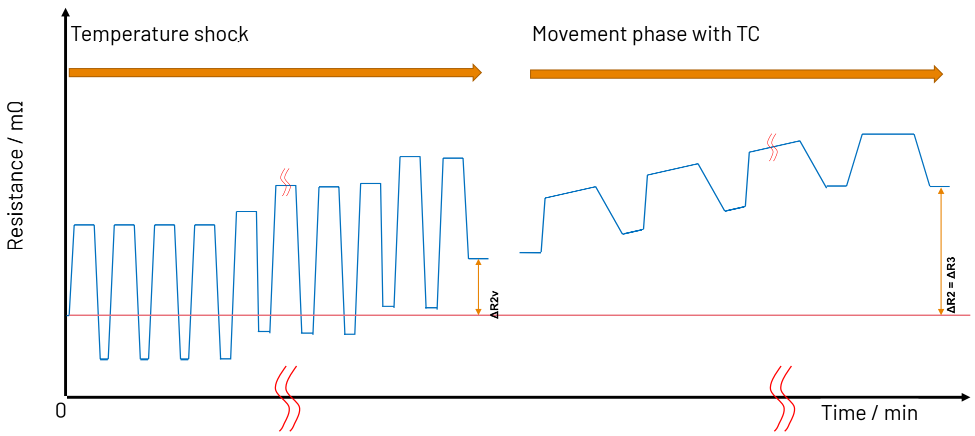


Figure PG 70-6: ΔR2, ΔR2v und ΔR3 (schematic) – Maximum value at the end of the movement phase (schematic) (Source: TE Connectivity Germany)

39.4 Evaluation of the resistance curve (stability criterion)

For the trend of the resistance value during the movement phase, a distinction must be made between behavior that increases towards the end and behavior that is stable towards the end.

In order to include the stability of the resistance profile in the acceptance assessment, the stability criterion ΔR4 is provided and applied if ΔR2 or ΔR3 in each case do not exceed twice their limit value.

The determination of ΔR4 takes place from the resistance measurements at room temperature, starting with the 16th temperature cycle, which is superimposed in the movement phase, up to the end of the 30th temperature cycle and must not exceed 50 percent of the limit values for ΔR2 or ΔR3 at any point in time.

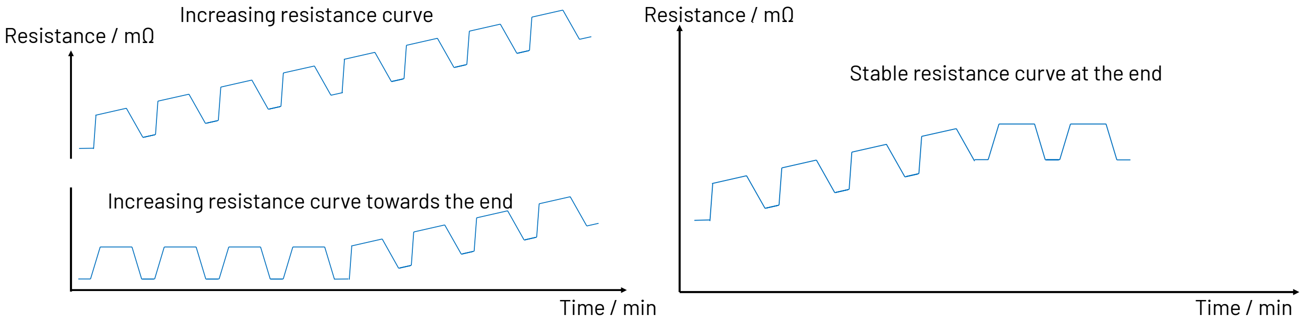


Figure PG 70-7: Examples: increasing towards the end / stable towards the end (Source: TE Connectivity Germany)

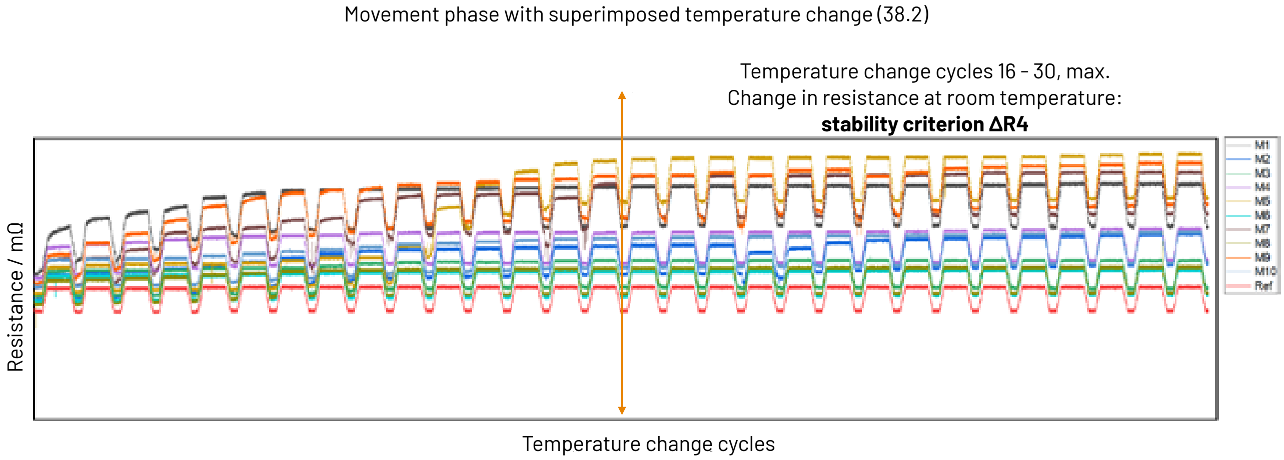


Figure PG 70-8: Stability criterion ΔR4 (Source: TE Connectivity Germany)

39.5 Comparison and limit values

Wire cross section / mm^2	Rcrimp – for Information / mΩ	Limit values for ΔR2 & ΔR3 Comparison values for ΔR2v / mΩ	Max. Measuring-current / A
0.13 – 0.17	6.2	4.6	0.1
0.22 – 0.35	3.4	2.9	0.1
0.5	2.3	1.9	0.1
0.75	1.7	1.4	0.1
1	1.3	1,2	1
1.5	0.9	0.9	1
2.5	0.61	0.59	1
4	0.41	0.42	1
6	0.29	0.31	5
10	0.19	0.21	5
16	0.12	0.14	5
25	0.084	0.10	5
35	0.063	0.076	10
50	0.047	0.057	10
70*	0.035	0.043	10
95* and larger	0.027	0.032	20
* to be checked separately with the client			

Table PG 70-2: Comparison values and limit values for ΔR (i) and measuring currents (Source: ZVEI)

Considering the stability criterion ΔR4, the following possible cases arise for the evaluation of a slow-motion-bending-test:

ΔR2 and ΔR3	ΔR4	Test result
≤ limit value	-	Passed
> limit value	≤ 1/2 ΔR3 limit value	Passed
≤ 2x limit value	> 1/2 ΔR3 limit value	Not passed
> 2x limit value	-	Not passed

Table PG 70-3: Evaluation with inclusion of the stability criterion ΔR4 (Source: ZVEI)

Appendix A: Maximum Resistance Values

- The specified resistances are valid for a conductivity of the base material > 20 % IACS. For lower conductivities, the correction factor according to DIN EN 60352-2 must be used.
- Wire acc. to TLF 0112 (wire test specification, low voltage wires).
- Valid for all surfaces (Coatings) (e. g. Au, Ag, Sn).
- Resistance measurement acc. to DIN EN 60512-2-1.
- Both values consist of: connection resistance plus 2 times crimp connection resistance, measured acc. to DIN EN 60512-2-1.

The same limit values must be used for aggregate connections.

Max. limit values of the connection resistance in mΩ at room temperature.

Wire cross section / mm² / Contact dimension / mm	≤ 0.13	0.22	0.35	0.5	0.75	1.0	1.5	2.5	4	6	10	16	> 16
≤ 0.63	30	30	15	15	15	-	-	-	-	-	-	-	-
1.2	20	20	15	15	15	15	10	-	-	-	-	-	-
1.5	-	15	15	15	15	15	10	10	-	-	-	-	-
2.8	-	15	15	15	15	15	10	10	5	-	-	-	-
4.8 – 6.3	-	10	10	8	8	8	5	5	3	3	2	-	-
8	-	-	-	-	-	-	-	3	3	3	2	2	-
≥ 9.5	-	-	-	-	-	-	-	-	3	2	2	1	1

Table Appendix A-1: Maximum Resistance Values (Source: ZVEI)

For not listed wire cross sections the min. values of the next smaller wire cross section must be used.

Appendix B: Abbreviation Overview

Abbreviation	Meaning
AES	atomic emission spectrometry
AgI	silver-plated surface with anti-tarnish (for limit temperature < 150 °C 0.1 – 0.5 µm Ag)
AgII	silver-plated surface with anti-tarnisch (for limit temperature ≧ 150 °C 3 – 6 µm Ag over 1 – 3 µm Ni)
AK POK	working group process optimization wiring harness
CT	computer tomography
EDX	energy dispersive X-ray spectroscopy
SWS	Single Wire Seal
F	force
F_{Block}	CPA blocking force
FIB	Focussed Ion Beam
$F_{(max\ 0,2)}$	determined maximum force on a distance of 0.2mm
$F_{(min)}$	min required extraction force
F_0	opening Force
F_{prim}	primary locking mechanism disengage force
F_S	Closing force
F_{sec}	Secondary locking mechanism retention force
F_{Steck}	Mating force
$F_{(V)}$	Intial force (Preforce)
I	Electrical current
I_{test}	Measuring current
$I_{test\ PG\ 15}$	test current to be used during the PG 15
L_{Apeak}	Peak level of the sound level with frequency weighting A
n	Number of readings
p_0	Maximum internal pressure occurring
p_{max}	Maximum pressure
REM	Raster Electron Mikroscope
RFA / XRF	X-ray flouresence analysis
R_{Isol}	Insulation resistance
RT	Room temperature

ΔR1	Difference in the initial values of resistance
ΔR2	Change in resistance end value – start value
ΔR2v	Change in resistance aging – start value
ΔR3	Change in resistance highest value – start value
ΔR4	Change in resistance highest value – lowest value
σ	Standard deviation
s	Distance
$S_{(0\ mm)}$	Zero point distance
SnI	Galvanic tin with Ni-underlayer
SnII	Hot dipped tin
SoR	Sine on Random
T_{limit}	Limit temperature
$T_{limit\ connector}$	Limit temperature connector
T_{max}	Max. temperature acc. to temperature class
T_0	upper test temperature
T_{0F}	upper cycle temperature humidity
t_0	Upper holding time
TOF-SIMS	Secondary ion mass spectrometry
T_U	Lower temperature
T_{UF}	Lower temperature humidity
T_{Umg}	Ambient temperature
t_U	Lower holding time
ΔT	Temperature difference
U	Voltage
ⱱ	relative scattering
v	Velocity
w	Motion amplitude
x	Respective single values (good-cimps)
$\bar{x}$	arithmetic mean of the peak values of the good crimps
XPS	X-ray photoelectron spectroscopy

Appendix C: Standards Overview / Supporting Documents

Norm/Standard	Edition	Title	Alternativ/ Equivalent	Edition
DIN EN 60068-2-1	2008/01	Environmental Testing Part 2-1: Tests Test A: Cold	EN 60068-2-1 IEC 60068-2-1 VDE 0468-2-1	2007 2007/03 2008/01
DIN EN 60068-2-2	2008/05	Environmental Testing Part 2-2: Tests Test B: Dry Heat	EN 60068-2-2 IEC 60068-2-2 VDE 0468-2-2	2007 2007/07 2008/05
DIN EN 60068-2-6	2008/10	Environmental Testing Part 2-6: Tests Test Fc: Vibration (Sinusoidal)	EN 60068-2-6 IEC 60068-2-6 VDE 0468-2-6	2008 2007/12 2008/10
DIN EN 60068-2-13	2000/02	Environmental Testing Part 2: Tests Test M: Low Air Pressure	EN 60068-2-13 IEC 60068-2-13	1999 1983/01
DIN EN 60068-2-14	2010/04	Environmental Testing Part 2-14: Tests Test N: Change of Temperatur	EN 60068-2-14 IEC 60068-2-14 VDE 0468-2-14	2009 2009/01 2010/04
DIN EN 60068-2-27	2010/02	Environmental Testing Part 2-27: Tests Test Ea and Guidance: Shock	EN 60068-2-27 IEC 60068-2-27 VDE 0468-2-27	2009 2008/02 2010/02
DIN EN 60068-2-30	2006/06	Environmental Testing Part 2-30: Tests Test DB: Damp Heat, Cyclic (12 H + 12 H Cyclic)	EN 60068-2-30 IEC 60068-2-30	2005 2005/08
DIN EN 60068-2-31	2009/04	Environmental Testing Part 2-31: Tests Test EC: Rough Handling Shocks, Primarily for Equipment-Type Specimens	EN 60068-2-31 IEC 60068-2-31 VDE 0468-2-31	2008
DIN EN 60068-2-52	1996/10	Environmental testing Part 5: Guide to Drafting of Test Methids; Terms and Definitions	IEC 60068-2-52	2017/11
DIN EN 60068-2-64	2009/04	Environmental Testing Part 2-64: Tests Test Fh: Vibration, broadband random and guidance	EN 60068-2-64 IEC 60068-2-64 VDE 0468-2-64	2019 2008/04 2009/04
DIN EN 60068-2-78	2002/09	Environmental Testing Part 2-78: Tests Test Cab: Damp Heat, Steady State	EN 60068-2-78 IEC 60068-2-78 VDE 0468-2-78	2013 2012/10 2013/01

DIN EN 60512-1-1	2003/01	Connectors for Electronic Equipment – Tests and Measurements – Part 1-1: General Examination Test 1A: Visual Examination	EN 60512-1-1 IEC 60512-1-1	2002 2002/02

DIN EN 60512-1-2	2003	Connectors for Electronic Equipment – Tests and Measurements – Part 1-2: General Examination Test 1B: Examination of Dimension and Mass	EN 60512-1-2 IEC 60512-1-2	2002 2002/02
DIN EN 60512-2-1	2003/01	Connectors for Electronic Equipment – Tests and Measurements – Part-1: Electrical Continuity and Contact Resistance Tests Test 2A: Contact Resistance - Millivolt Level Method	EN 60512-2-1 IEC 60512-2-1	2002 2002/02
DIN EN 60512-2-2	2004/01	Connectors for Electronic Equipment – Tests and Measurements – Part 2-2: Electrical Continuity and Contact Resis-tance Tests Tests Test 2B: Contact Resistance - Specified Test Current Method	EN 60512-2-2 IEC 60512-2-2	2003 2003/05
DIN EN 60512-3-1	2003/01	Connectors for Electronic Equipment – Tests and Measurements Part 3-1: Insulation Tests Test 3A: Insulation Resistance	EN 60512-3-1 IEC 60512-3-1	2002 2002/02
DIN EN 60512-5-1	2003/01	Connectors for Electronic Equipment – Tests and Measurements– Part 5-1: Current-Carrying Capacity Tests Test 5A: Temperature Rise	EN 60512-5-1 IEC 60512-5-1	2002 2002/02
DIN EN 60512-5-2	2003/01	Connectors for Electronic Equipment – Tests and Measurements – Part 5-2: Current-Carrying Capacity Tests Test 5B: Current-Temperature Deration	EN 60512-5-2 IEC 60512-5-2	2002
DIN EN 60512-11-7	2004/06	Connectors for Electronic Equipment – Tests and Measurements – Part 11-7: Climatic Tests Test 11G: Flowing Mixed Gas Corrosion Test	EN 60512-11-7 IEC 60512-11-7	2003 2003/05
DIN EN 60512-13-5	2006/11 2008/11 Cor	Connectors for Electronic Equipment – Tests and Measurements – Part 13-5: Mechanical Ooperation Tests Test 13E: Polarizing and Keying Method	EN 60512-13-5 IEC 60512-13-5	
DIN EN 60512-14-5	2006/11	Connectors for Electronic Equipment – Tests and Measurements – Part 14-5: Sealing Tests Test 14E: Immersion at Low Air Pressure	EN 60512-14-5 IEC 60512-14-5	2006 2006/03
DIN EN 60512-15-6	2009-03	Connectors for Electronic Equipment - Tests and Measurements – Part 15-6: Connector Tests (Mechanical) Test 15F: Eeffectivenes of Connector Coupling Devices	EN 60512-15-6 IEC 60512-15-6	2008 2008/05

ISO 20653	2013/02	Road Vehicles — Degrees of Protection (IP code) Protection of Electrical Equipment Against Foreign Objects, Water and Access		

TLF 0112-1	2019/01	Elektrische Leitungen für Kraftfahrzeuge Teil 1: Kupferleitung, einadrig, ungeschirmt, ZVEI.		

TLF 0112-4		Elektrische Leitungen für Kraftfahrzeuge Leitungen aus Kupferlegierung, einadrig, ungeschirmt, ZVEI.		

Formblatt: AK POK		Arbeitskreis POK Dokumentation Überwachungsfähigkeit Contact, Verarbeitungsfreigabe und Automatenfähigkeit (Red. Formblatt ist bekannt als „Verarbeitungsfreigabe und Automatenfähigkeit des Arbeitskreis POK“)		

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