
**Road vehicles — Test methods and
performance requirements for voltage
class B connectors**

*Véhicules routiers — Méthodes d'essai et exigences de performance
pour connecteurs haute tension*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

High voltage connectors differ from low voltage connectors in several ways due to their higher operating voltage and need for shielding. These differences lead to unique failure modes and a need for unique validation tests. This document is a test specification that is unique to high voltage connectors on road vehicles. Some of the unique items that are tested in this document are:

- higher limits on dielectric withstanding voltage,
- more exhaustive testing for airtightness,
- evaluation of EMC compatibility, and
- evaluation of unique components such as shielding and metal housings (also for electrical shielding).

Note that safety features in a connector design to prevent electric shock (such as high voltage interlock) are specific to the connector and the vehicle electrical architecture and therefore must be assessed separately.

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Road vehicles — Test methods and performance requirements for voltage class B connectors

WARNING — The use of this document can involve hazardous materials, operations and equipment. It does not purport to address all of the safety or environmental problems associated with its use.

1 Scope

This document defines terms and specifies test methods for general performance requirements of voltage class B connectors with single-pole and multi-pole connections used with electrical wiring harnesses of road vehicles.

This document applies to connectors for voltage class B electric circuits of electric propulsion systems and conductively connected auxiliary electric systems of electrically propelled road vehicles.

This document applies to voltage class B connectors designed to be disconnected after mounting in the vehicle for repair and maintenance only. It does not apply to vehicle inlets of charging systems.

This document applies to cable conductor sizes ranging from 1,5 mm² to 120mm².

This document is not applicable to internal connections of electronic devices.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8092-2:2005, *Road vehicles — Connections for on-board electrical wiring harnesses — Part 2: Definitions, test methods and general performance requirements*

ISO 8092-5¹⁾, *Road vehicles — Connections for on-board electrical wiring harnesses — Part 5: Automotive parts — Test methods and general performance requirements for wiring harness connector operation*

ISO 19453-3:2018, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles — Part 3: Mechanical loads*

ISO 19453-4:2018, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles — Part 4: Climatic loads*

ISO 19453-5, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment for drive system of electric propulsion vehicles — Part 5: Chemical loads*

ISO 20653, *Road vehicles — Degrees of protection (IP code) — Protection of electrical equipment against foreign objects, water and access*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

1) Under preparation. Stage at the time of publication: ISO/DIS 8092-5:2019.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

**3.1
cable attachment**

any permanent junction of cable to terminal

Note 1 to entry: Crimp and weld are typical methods.

**3.2
connector**

assembly of terminal, housing and related parts that terminate cable and shielding for the purpose of providing connection and disconnection to a suitable mating connector

**3.3
connector coding**

visual or mechanical feature to provide differentiation, preventing mating of *connectors* (3.2) not intended to be mated

**3.4
connector position assurance
CPA**

device that prevents accidental release of the *connector* (3.2) lock and serves as an indicator of full connector mating

**3.5
female terminal**

terminal, including means for *cable attachment* (3.1), designed for electrical engagement on its inner surface, and to accept entry of a *male terminal* (3.6), thus forming an electrical connection

**3.6
male terminal**

terminal, including means for *cable attachment* (3.1), designed for electrical engagement on its outer surface and to enter a *female terminal* (3.5), thus forming an electrical connection

**3.7
shield**

conductive material intended to reduce the penetration and/or radiation of a varying electromagnetic field

Note 1 to entry: Metallic sheaths, foils, braids, armour, and earthed concentric conductors may also serve as shields.

**3.8
terminal position assurance
TPA**

feature installed or seated after the terminals are inserted into their housing to assure that the terminals are properly positioned, which reinforces the primary terminal locking mechanism or provides a separate redundant terminal lock

**3.9
voltage class A**

classification of an electric component or circuit with a maximum working voltage of ≤ 30 V AC (rms) or ≤ 60 V DC, respectively

[SOURCE: ISO 6469-4:2015, 3.17]

3.10**voltage class B**

classification of an electric component or circuit with a maximum working voltage between 30 V AC (rms) and 1 000 V AC (rms) or between 60 V DC and 1 500 V DC

[SOURCE: ISO 6469-4:2015, 3.18]

4 Test and requirements**4.1 General****4.1.1 Preconditioning for environmental and mechanical durability**

All test samples shall be preconditioned at standard ambient temperature (23 ± 3) °C and 45 % to 75 % relative humidity for 24 h before the start of any test sequence.

4.1.2 Test conditions

All tests shall be carried out at a standard ambient temperature (23 ± 3) °C and 45 % to 75 % relative humidity unless otherwise stated in the test procedure. This is referenced as room temperature (RT).

Cable in compliance with applicable part of ISO 19642 is encouraged. The cable or cables used shall be noted in the test report.

Cable attachment shall be performed in accordance with the terminal manufacturer's specifications, or as agreed between customer and supplier.

When length of cable is not specified, it is 500 mm. When tolerance of length of cable is not specified, it is ± 10 mm.

Typical sample preparation for environmental tests is shown in [Annex B](#).

Care shall be taken so that test samples do not influence each other (e.g. in a heat chamber).

Each connector shall have the full complement of terminals fitted unless otherwise specified.

Connectors shall be tested in mated conditions unless stated otherwise. In the case of a connector connecting directly to a device, a mating dummy may be used to carry out tests. This dummy shall represent the intended device's interface and electrical properties.

Measurements shall be taken on all terminals regardless number of poles per connector unless otherwise specified in the test methods.

Lubrication or other means of attaining better test results shall not be added to the test surface, unless representative of production intent. Production-related remains of lubricants on the terminals are permitted.

Unless otherwise specified, all forces shall be applied at a constant speed of (50 ± 10) mm/min.

Unless otherwise specified, when a temperature of T_{\max} is specified in a test, use the applicable "highest value" temperature per [Table 1](#). When a temperature of T_{\min} is specified in a test, use the applicable "lowest value" temperature per [Table 1](#).

Table 1 — Environmental and test temperatures

Class ^a	Environmental temperature range	
	°C	
	Lowest value Use for T_{\min} of chamber	Highest value Use for T_{\max} of chamber
1 (D)	-40	70
2 (G)		85
3 (J)		100
4 (O)		125
5 (S)		155

^a Class designations align with ISO 8092-2:2005, Table 3 equivalents as “Class” 1 through 5.
 () Value aligns to ISO 19453-4:2018, Table 1.

Cross-sectional area of cable mentioned in this document refers to cables with a copper conductor. When the conductor of a cable is a material other than copper, the cross-sectional area of cable shall be specified by agreement between customer and supplier.

The terminals and connectors used in the test shall be fully assembled unless otherwise specified. The cross-sectional area of cable conductor is defined in [Tables 2, 3, 4](#) and [5](#).

4.1.3 Test sequences and sample quantities

[Tables 2, 3, 4](#) and [5](#) list the test sequences. The test groups in the tables apply to sealed and unsealed connectors as noted. New samples are used for each test group. The test sequence for each test group is performed in accordance with the sequence number defined in the table’s rows for each sequence. For each test group, perform the complete test sequence for the group on each sample.

Table 2 — Mechanical test sequences groups A through G

Test group identification		A	B	C	D	E	F	G
u=apply test if samples are unsealed		u	u	u	u	u	u	u
s=apply test if samples are sealed		s	s	s	s	s	s	s
Minimum test quantity of terminals/connectors		10	10 ^k	10 ^k	10	10	10	10
Sample cable length (mm)		-	>50	>50	-	-	-	-
Sample cable size	Maximum	-	See "l"	See "l"	-	-	-	-
	Minimum	-	See "l"	See "l"	-	-	-	-
4.2 Visual examination		1, 3	1, 3	1, 3	1, 3	1, 3	1,3	1,4
4.3 Connection and disconnection		2 ^g						
4.4 Tensile strength between terminal and cable			2					
4.5 Tensile strength for shield connections				2				
4.6 Locking device strength					2			
4.7 Unintentional lever release force						2		
4.8 Lock button release force							2	
4.9 Locking force of CPA								2
4.10 Disengage force of CPA								3
4.11 Locking force of TPA								
4.12 Extraction force of TPA								
4.13 Connector coding and polarization effectiveness								
4.14 Terminal insertion force								
4.15 Terminal insertion force with incorrect orientation								
4.16 Terminal extraction force								
4.17 Connector engagement sound								
^g Perform force measurement for first mate and first unmate with part held in force tester. Remaining mate and unmate cycles can be either hand mated or using the mechanized force test machine. ^k Sample is made from terminal and cable only. ^l Test quantity is per terminal/cable combination; each combination shall be validated with a 10-piece sample, minimum. - Cells containing "-" to be defined between supplier and customer. Selection typically does not matter to test result.								

Table 3 — Mechanical test sequences groups H through N

Test group identification		H	I	J	K	L	M	N
u=apply test if samples are unsealed		u	u	u	u	u	u	u
s=apply test if samples are sealed		s	s	s	s	s	s	s
Minimum test quantity of terminals/connectors		10	10 ^f	10 ^f	10	20 ^f	10 ^f	10
Sample cable length (mm)		-	-	-	-	-	-	-
Sample cable size	Maximum	-	-	-	-	10	10	-
	Minimum	-	-	-	-	10	-	-
4.2 Visual examination		1,3	1, 3	1, 4	1, 3	1, 4	1, 3	1,3
4.3 Connection and disconnection								
4.4 Tensile strength between terminal and cable								
4.5 Tensile strength for shield connections								
4.6 Locking device strength								
4.7 Unintentional lever release force								
4.8 Lock button release force								
4.9 Locking force of CPA		2						
4.10 Disengage force of CPA								
4.11 Locking force of TPA			2	2				
4.12 Extraction force of TPA				3				
4.13 Connector coding and polarization effectiveness					2			
4.14 Terminal insertion force						2		
4.15 Terminal insertion force with incorrect orientation							2	
4.16 Terminal extraction force						3		
4.17 Connector engagement sound								2
^f Use unmated wire harness connector; the mating (header) connector is not used in the test. - Cells containing "-" to be defined between supplier and customer. Selection typically does not matter to test result.								

Table 4 — Environmental test sequence groups O through V

Test group identification	O	P	Q	R	S	T	U	V
u=apply test if samples are unsealed	u	u	u			u		u
s=apply test if samples are sealed	s ^q	s ^q	s ^q	s ^q	s ^q	s ^q	s ^q	
Minimum test quantity of connectors	5	3 ⁱ	3	3	5	3 ⁱ	5	3
Sample cable length (mm)	1 250	500	min 1 000	max 1 000	-	500	min 150	min 150
Sample cable size	Maximum	all	all					
	Minimum	all		all	all	all	all	all
4.2 Visual examination	1, 11	1, 10	1, 7	1, 9	1, 8	1, 8	1, 11, 16	1, 13
4.3 Connection and disconnection		2	2	2		2	14	
4.7 Unintentional lever release force							13 ^c	
4.8 Lock button release force							13 ^c	
4.10 Disengage force of CPA							12	
4.18 Connection resistance		3, 6, 8				3, 6	2, 6, 10, 15	2, 6, 10
4.19 Temperature rise		(4), 9				4, 7		
4.20 Insulation resistance	2, 7				2, 6		3, 7	3, 7, 11
4.21 Withstanding voltage	3, 8				3, 7		4, 8	4, 8, 12
4.22 Electromagnetic shielding			(3),6					
4.23 Water tightness (internal- 4.23.2.1) ^a	4 ^b , 9 ^b			3 ^b , 7 ^b				
4.23 Water tightness (external- 4.23.2.2) ^a	5 ^b , 10 ^b			4 ^b , 8 ^b				
4.24 Mechanical shock		5 ^d	4 ^d	5 ^d				
4.25 Drop	6							
4.26 Vibration with thermal cycling		7 ^d	5 ^d	6 ^d				
4.28 Thermal aging					4			

^a Aside from test sequence, test to failure can be performed using additional samples ($n=5$) for test 4.23 until the upper limit pressure is reached.

^b Sealed connectors only: apply either internal, external, or both by agreement between customer and supplier.

^c Perform either 4.7 or 4.8 as applicable.

^d It is allowed to apply each shock/vibration direction directly before the vibration test for this direction. Take intermediate resistance measurements between testing for each axis.

ⁱ Samples require thermocouples to measure or monitor temperature rise.

ⁿ Perform insulation resistance during condensation phase.

^q Seal cable on far end.

() It is possible to omit this step by agreement between customer and supplier.

- Cells containing "-" to be defined between supplier and customer. Selection typically does not matter.

Table 4 (continued)

Test group identification	O	P	Q	R	S	T	U	V
4.29 Thermal shock						5		
4.30 Temperature/humidity							5 ⁿ	5 ⁿ
4.33 High pressure water jet					5			
4.34 Dust resistance							9	9
<p>^a Aside from test sequence, test to failure can be performed using additional samples ($n=5$) for test 4.23 until the upper limit pressure is reached.</p> <p>^b Sealed connectors only: apply either internal, external, or both by agreement between customer and supplier.</p> <p>^c Perform either 4.7 or 4.8 as applicable.</p> <p>^d It is allowed to apply each shock/vibration direction directly before the vibration test for this direction. Take intermediate resistance measurements between testing for each axis.</p> <p>ⁱ Samples require thermocouples to measure or monitor temperature rise.</p> <p>ⁿ Perform insulation resistance during condensation phase.</p> <p>^q Seal cable on far end.</p> <p>() It is possible to omit this step by agreement between customer and supplier.</p> <p>- Cells containing "-" to be defined between supplier and customer. Selection typically does not matter.</p>								

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Table 5 — Environmental and electrical test sequence groups W through AD

Test group identification		W	X	Y	Z	AA	AB	AC	AD
u=apply test if samples are unsealed				u	u	u	u	u	u
s=apply test if samples are sealed		s ^q	s ^q	s	s ^q	s ^q	s	s ^q	s
Minimum test quantity of connectors		3	3	5 ⁱ	5	-	5 ⁱ	5	5 ⁱ
Sample cable length (mm)		min 1 000	min 1 000	min 150	max 1 000	max 1 000	500	max 1 000	500
Sample cable size	Maximum						all	all	See "p"
	Minimum	all	all	all	all	all			
4.2 Visual examination		1, 5, 7	1, 7, 9	1, 8, 10	1, 9	1, 12, 19	1, 7	1, 9	1
4.3 Connection and disconnection				2	2	2, 13	2	2	2
4.6 Locking device strength			8		8			8	
4.16 Terminal extraction force		6 ^m		9			6		
4.18 Connection resistance (voltage drop)				3, 6	3, 6 ^h	18	3, 5		
4.19 Temperature rise				(4), 7					3 ⁱ
4.20 Insulation resistance			2, 5			3, 8, 14			
4.21 Withstanding voltage			3, 6			4, 9, 15			
4.22 Electromagnetic shielding		(2), 4							
4.23 Water tightness (internal- 4.23.2.1) ^a					4 ^{b,h} , 7 ^{b,h}	5 ^b , 10 ^b , 16 ^b		3 ^b , 6 ^b	
4.23 Water tightness (external- 4.23.2.2) ^a						6 ^b , 11 ^b , 17 ^b		4 ^b , 7 ^b	
4.27 Current cycling							4 ^e	5	
4.28 Thermal aging				5	5 ^h				
4.32 Salt spray		3	4						
4.35 Oil/liquid resistance						7			

^a Aside from test sequence, test to failure can be performed using additional samples (n=5) for test 4.23 until the upper limit pressure is reached.

^b Sealed connectors only: apply either internal, external, or both by agreement between customer and supplier.

^e Monitor temperature rise during step.

^h Use the test configuration that stresses cable most representative of application (see Figures 10, 11).

ⁱ Samples require thermocouples to measure or monitor temperature rise.

^j This test is to estimate initial current in test part.

^m Perform test only if terminal locking structure is external to seal.

^p Test all cable sizes that are applicable.

^q Seal cable on far end.

() = It is possible to omit this step by agreement between customer and supplier.

- Cells containing "-" to be defined between supplier and customer. Selection typically does not matter.

4.2 Visual examination

4.2.1 Purpose

This test is used to document the physical appearance of test samples. A comparison can then be made with other test samples.

4.2.2 Test

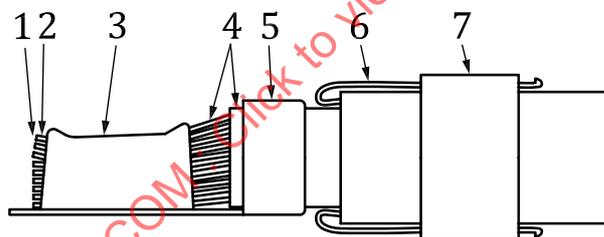
Carry out a visual examination of all connectors and contacts with the naked eye, at normal strength of vision and colour perception, at the most favourable viewing distance, and with suitable illumination. In the event something is questionable, use appropriate diagnostic equipment to evaluate.

NOTE When something is questionable and additional review is performed, inspect for plating wear and assess the percentage of the original surface coating still present using an agreed-on method.

4.2.3 Requirements

Identification, appearance, workmanship and the finish of each item shall be as specified. There shall be no wear through, crack, corrosion, rough surface, damage, deformation or discoloration, which may cause a functional problem on the connector's performance. Where applicable, there shall be no ingress of a solution or substance.

For crimped cable attachments, both insulation and the conductor shall be visible between the conductor crimp and the insulation support on the male and female terminals, as shown in [Figure 1](#). Conductors shall protrude from the conductor crimp but shall not interfere with the mating part. In case of damaged cable strands, the functional performance shall be confirmed. For other types of cable attachment, no visible damage is allowed. Customer and supplier to agree on criteria for plating wear.



Key

- 1 conductor end
- 2 wire strands
- 3 conductor connection
- 4 conductor and insulation
- 5 insulation support
- 6 shield braid
- 7 shield connection

Figure 1 — High voltage terminal with shield connection

4.3 Connection and disconnection

4.3.1 Purpose

This test preconditions the connector for further tests by being subjected to multiple connections and disconnections. It is also used to measure mate and unmate forces for ergonomic assessment.

4.3.2 Test

Perform connection and disconnection as specified by the connector manufacturer at a constant speed in accordance with 4.1.2. Subject the connector to an agreed-on number of cycles as needed for intended application (minimum is 10).

If measurements are called for in the test table, measure the force to mate at the first connection and first disconnection and apply the criteria in 4.3.3. If a measurement is not specified in the test table, hand mating and unmating is allowed instead of mating by machine, and the criteria in 4.3.3 do not apply.

4.3.3 Requirements

The test samples shall have a first connection mate force and first disconnection unmate force as shown in Table 6. If both hand-mate and lever-mate actions are needed, both shall be tested and meet the requirement.

Table 6 — Mate and unmate force limits

Class	Maximum mate force N	Maximum unmate force N
All	75	75

4.4 Tensile strength between terminal and cable

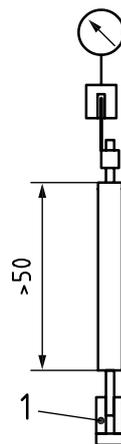
4.4.1 Purpose

Testing tensile strength for connections is used to determine capability for mechanical robustness.

4.4.2 Test

Fix the terminal on the tension tester per Figure 2 by pulling the cable with constant speed per 4.1.2. Pull not closer than 50 mm from the cable attachment area. When applicable, the insulation support shall be disabled (uncrimped) prior to performance of this test. Measure the maximum load until the cable breaks or the terminal is extracted from the cable.

Dimensions in millimetres



Key

- 1 conductor fixation

Figure 2 — Tensile strength set-up for terminal and cable

4.4.3 Requirements

The tensile strength between terminal and cable shall be higher than the value specified in [Table 7](#). Criteria for non-ISO cables may be calculated by interpolation method.

Table 7 — Minimum tensile strength of cable conductor to terminal attachment

Cable conductor size (per ISO 19642) mm ²	Tensile strength N	Cable conductor size (per ISO 19642) mm ²	Tensile strength N
<1,5	By agreement of customer and supplier	16	1 500
1,5	150	20	1 800
2	175	25	2 000
2,5	200	30	2 200
3	250	35	2 300
4	310	40	2 500
5	355	50	2 800
6	450	60	3 100
8	475	70	3 400
10	500	95	4 200
12	830	120	5 000

4.5 Tensile strength for shield connections

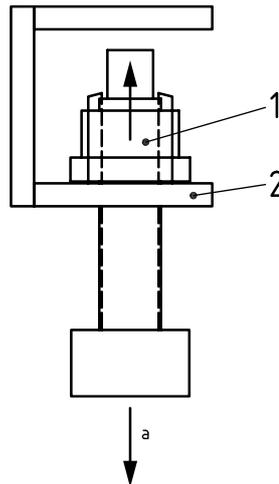
4.5.1 Purpose

Testing tensile strength between a shield and its shield connection is used to determine ability of the overall assembly to withstand mechanical forces.

4.5.2 Test

Install the sample on the fixture as shown in [Figure 3](#) and pull it in the axial direction with a constant speed in accordance with [4.1.2](#). Hold the shield connection and pull along the cable axis.

Measure the force applied when the cable pulls out of the shield connection. Record the peak force reached when separating the shield from the cable. This test shall be conducted for all cable sizes to be used.

**Key**

- 1 shield connection
- 2 fixture
- a Pull direction.

Figure 3 — Set-up for tensile strength of shield connection**4.5.3 Requirements**

The force required to move the shield connection from the assembly shall be more than the strength specified in [Table 8](#). Table value may not be applicable for very large or very small braid constructions. Agreements between customer and supplier may be used in these situations.

Table 8 — Minimum tensile strength for shield connections

Class	Tensile strength of shield connection N
All	≥150

4.6 Locking device strength**4.6.1 Purpose**

This test determines the retention force of a connector assembly. Retention forces are important in determining serviceability of the design and ensuring the connection will stay mated for the service life of the vehicle.

4.6.2 Test

Using a completely mated connector, but with the CPA disengaged, fix one side of the connector on the tensile tester and pull the other side of the connector with a constant speed per [4.1.2](#) in a straight direction. Measure the load when the locking structure is extracted or destroyed. The connector shall be completely fixed on the tension tester during the test and any side of the connector shall not be distorted during the test. Report the force when the locking device breaks.

4.6.3 Requirements

The force when the locking device breaks shall be 100 N minimum.

4.7 Unintentional lever release force

4.7.1 Purpose

This test determines the lever release force, which is used to assure that the lever cannot move unintentionally from its locked position.

4.7.2 Test

Ensure that the connector is completely locked, but with CPA disengaged. Apply a force in the intended direction for the lever to operate in the release direction until the lever releases from the locked position. Measure the force applied at the moment when the mechanical lever comes out from locked position. Remove and inspect the sample. Mate and unmate to determine if the lock mechanism functions properly. Reassemble connector in the fully-locked position. Reattach to the force testing fixture. Apply force (same force direction as before) until the lock releases. Measure the force applied at the moment when the mechanical lever comes out from locked position.

4.7.3 Requirements

The following requirements are applicable:

- a) Force applied when the mechanical lever comes out from its locked position shall exceed 100 N.
- b) After the initial release, the connector lock shall still function properly and inspection shall show no damage to the connector system.
- c) The lever release force, when applied the 2nd time shall be a minimum of 100 N.

4.8 Lock button release force

4.8.1 Purpose

This test determines the force to release the connector lock button to assess its ergonomic capability.

4.8.2 Test

Using a force tester, depress the connector lock release button starting from its free state. Push to the point where the connector lock is released and the lock mechanism is no longer locking the connector parts together (note that this is a measurement requiring a precise location where the lock just clears past the locking device so applying a constant speed is not appropriate). This test applies to push buttons on a connector. It is applicable to manually operated button-style releases on hand-plug and some lever designs. It is not applicable to bolt designs.

4.8.3 Requirements

Force to deflect the release button, so the lock mechanism is disengaged, shall be between 6 N and 50 N.

4.9 Locking force of CPA

4.9.1 Purpose

This test is used to determine if a secondary connector lock is sufficiently retained in its shipping position and will remain in its intended position (not intentionally activated). It also is used to assess its ergonomic capability to be easily actuated.

4.9.2 Test

This test shall be conducted for connectors equipped with a connector position assurance (CPA) device. Note that this test is performed with the connectors mated in one test sequence and in another with the connectors unmated. Refer to [Tables 2](#) and [3](#) for the applicable configuration. Measure the load as the CPA is moved from the shipping position to fully-seated position by pushing at a speed not exceeding 60 mm/min.

4.9.3 Requirements

The following requirements are applicable:

- a) Locking force of CPA with connector mated correctly shall be 5 N to 30 N.
- b) The force to seat CPA with connector in unmated condition shall meet or exceed the greater of 80 N or 1,5 times the maximum measured connector mating force from test group 'A'.

4.10 Disengage force of CPA

4.10.1 Purpose

This test determines the disengage force associated with a CPA to assess its ergonomic capability and to assure the CPA does not unlock in service.

4.10.2 Test

This test is conducted on connectors equipped with a connector position assurance (CPA) device. With the connector mated and the CPA fully engaged, measure the load to release CPA by applying a force at a speed not exceeding 60 mm/min. Apply the force in the direction to disengage the CPA. Record the force. Continue the motion to fully remove the CPA and record the force.

4.10.3 Requirements

The following requirements are applicable:

- a) Release force of CPA shall be between 5 N and 30 N.
- b) The force to fully remove the CPA from a connector shall be a minimum 80 N.

4.11 Locking force of TPA

4.11.1 Purpose

This test determines the mating force associated with moving the TPA to its assembled position to assess its ability to resist unintentional activation and ability to detect when a terminal is incorrectly positioned. The intention of requiring a maximum locking force is to avoid having connectors without a correctly seated TPA assembled in serial production.

4.11.2 Test

This test is conducted on connectors equipped with a terminal position assurance (TPA) device. Move TPA to its final position and measure the load for the TPA. Push the TPA in accordance with [4.1.2](#) with the exception that testing speed shall not exceed 60 mm/min. Perform this test for the following two conditions:

- a) test group "J" – terminal correctly placed (connector with terminals correctly placed in all positions);

- b) test group "I" – terminal incorrectly placed (connector with terminals correctly placed in all positions except one location where terminal is partially inserted and not locked in position).

4.11.3 Requirements

The following requirements are applicable:

- a) Force to move TPA to its final position with terminals in their correct position shall be between 15 N and 30 N.
- b) Force to move TPA to its final position with incorrectly positioned terminal shall be 50 N minimum.

4.12 Extraction force of TPA

4.12.1 Purpose

This test determines the removal force associated with the TPA to assess its ability to resist unintentional unlocking.

4.12.2 Test

With the connector fully equipped with terminals and TPA engaged, measure the load at the point where the TPA is disengaged by applying constant speed in the direction to disengage the TPA at a testing speed not to exceed 60 mm/min. For connectors with a prepositioned TPA, measure force to fully remove TPA from connector.

- a) Force to make the TPA disengaged, and
- b) Force to fully remove TPA from connector, if fitted with a prepositioned TPA.

4.12.3 Requirements

The following requirements are applicable:

- a) The disengage force of the TPA shall be 10 N to 50 N.
- b) The removal force of the prepositioned TPA from a connector shall be 50 N minimum.

4.13 Connector coding and polarization effectiveness

4.13.1 Purpose

This test ensures that connectors of differing coding and polarizations do not mate.

4.13.2 Test

Using a tensile test machine, apply force, in applicable direction based on the design, for all possible incorrect combinations. Apply force as specified below:

- a) Hand-plug designs: apply the larger of 150 N or 3 times the first mating force measured in [4.3.2](#).
- b) Lever designs: apply 150 N, with force applied directly to connector body.
- c) Bolted designs: apply 150 N, with force applied directly to connector body.

4.13.3 Requirements

The following requirements are applicable:

- a) It shall not be possible to mate connectors partly or fully using any incompatible coding or polarization.
- b) If connector has a bolt, the bolt threads shall not start to engage on a connector with incompatible coding or polarization.
- c) If connector has a lever, lever shall not start to engage for any connector with incompatible coding or polarization.

4.14 Terminal insertion force

4.14.1 Purpose

This test is required in order to measure the insertion force of a terminal into its connector cavity to assess its ergonomic capability and ensure cable buckling will not happen during terminal insertion.

4.14.2 Test

Insert terminal into connector housing at constant speed per [4.1.2](#). Measure the insertion force. Use of a tool for insertion in lab test is permitted but must be noted. When the structure requires a waterproofing seal or shielding, perform the test with the waterproofing seal and shielding components present and assembled.

4.14.3 Requirements

Insertion force of terminal into housing shall meet the applicable criterion below.

30 N (max.) - For cable conductor cross-section size $\leq 6 \text{ mm}^2$

75 N (max.) - For cable conductor cross-section size of $> 6 \text{ mm}^2$

4.15 Terminal insertion force with incorrect orientation

4.15.1 Purpose

This test is conducted to ensure that the design of the cavity and terminal polarization features will prevent insertion of the terminal in incorrect orientation.

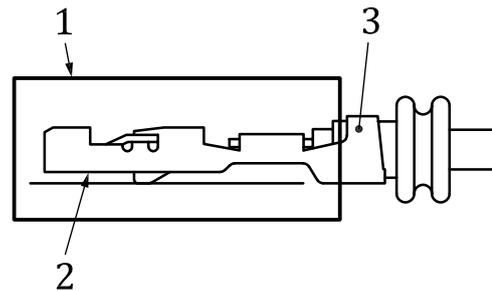
4.15.2 Test

This procedure is not required for multi-directional (round) or other designs where the terminal is meant to plug and lock in any (360°) orientation.

Fix the cable with the terminal in incorrect orientations specified by agreement of customer and supplier. Apply a force to insert the terminal into the housing until 1,5 times the measured maximum insertion force per [4.14](#) or 30 N (whichever is greater) is achieved.

4.15.3 Requirements

Terminal shall not fit or lock into a connector cavity beyond the insulation support with force applied. Refer to [Figure 4](#) for additional visual criteria.



Key

- 1 housing
- 2 misplugged terminal
- 3 insulation support or seal shall be visible

Figure 4 — Illustration of terminal with incorrect orientation

4.16 Terminal extraction force

4.16.1 Purpose

Extraction testing is required to ensure that the terminal is retained in its housing with sufficient strength to withstand the rigors of the wiring harness and vehicle assembly processes.

4.16.2 Test

The test shall be conducted with the maximum thickness cable which may be assembled and the terminal shall be completely assembled on the housing (TPA closed). The terminal shall have all locking devices effective. Fix the cable and housing on the tension tester completely and measure the maximum load at the moment the terminal is released from the housing by pulling and/or pushing the terminal to the direction opposite to the terminal insertion into housing direction, with constant speed and conditions per [4.1.2](#). Record the extraction force.

4.16.3 Requirements

Minimum extraction force of terminal from connector shall meet force listed in [Table 9](#).

Table 9 — Minimum extraction force of terminal from connector

Cable conductor size mm ²	Extraction force N
≤8	≥120
> 8 and ≤ 12	≥180
>12	≥450

4.17 Connector engagement sound

4.17.1 Purpose

This test determines the intensity of the sound made when a connector is fully mated. This test measures the level of sound generated when two connectors are mated.

This test is applicable only for connectors intended to produce a sound upon connection as audible feedback of complete mating.

4.17.2 Test

The application of this test shall be agreed between customer and supplier.

The test shall be performed according to ISO 8092-5:2014 4.3.

4.17.3 Requirements

The following requirements are applicable:

- a) Peak sound pressure (L_p) at >5 kHz frequency shall be 60 dB min.
- b) Overall value (L_{0A}) shall be 70 dB min.

4.18 Connection resistance (voltage drop)

4.18.1 Purpose

This test determines the voltage drop associated with the electrical resistance of the conductor crimps and contact interface regions at specific current conditions. This voltage drop is then used to calculate the total connection resistance

4.18.2 Test

Perform the test according to ISO 8092-2:2005 with the testing current (in Amps) equal to 1 A/mm² in the core cable. This applies for all cable sizes.

4.18.3 Requirements

The voltage drop shall be less than the values specified in [Table 10](#). Cable sizes that are not specified in the table may be calculated using interpolation.

Table 10 — Permitted connection resistance according to conductor cross-sectional area

Cable area mm ²	Initial Resistance mV/A	Final Resistance mV/A
1,5	1,49	2,97
2	1,24	2,47
2,5	1,07	2,14
3	0,95	1,90
4	0,79	1,58
5	0,69	1,37
6	0,61	1,22
8	0,51	1,02
10	0,44	0,88
12	0,39	0,78
16	0,33	0,65
20	0,28	0,57
25	0,25	0,49
30	0,22	0,44
35	0,20	0,40
40	0,18	0,36
50	0,16	0,32
60	0,14	0,28
70	0,13	0,26
95	0,11	0,21
120	0,09	0,18

4.19 Temperature rise

4.19.1 Purpose

This test is to ensure the temperature rise of the terminal in the connector is under a certain limit before and after the connector durability evaluation. This test shall be conducted for all applicable cable sizes to be used in test group AD.

4.19.2 Test

The sample consists of the fully assembled connector with cable as specified per applicable test sequence in [Table 4](#) or [5](#). This test shall be conducted for all cable sizes to be used in test group AD. Ensure the sample is cooled by natural cooling. Place a thermocouple as close as possible to the hottest spot on the terminal, as determined by testing. The test is conducted with the connector on which terminals are completely assembled. Apply current and measure the temperature of the terminals and ambient temperature after thermal equilibrium has been established and record. Subtract the ambient temperature from the temperature measured and calculate the temperature rise of hottest spot in connector. Number of poles energized are determined by agreement between customer and supplier. Allowable temperature rise, ΔT (°C), is defined as following formula:

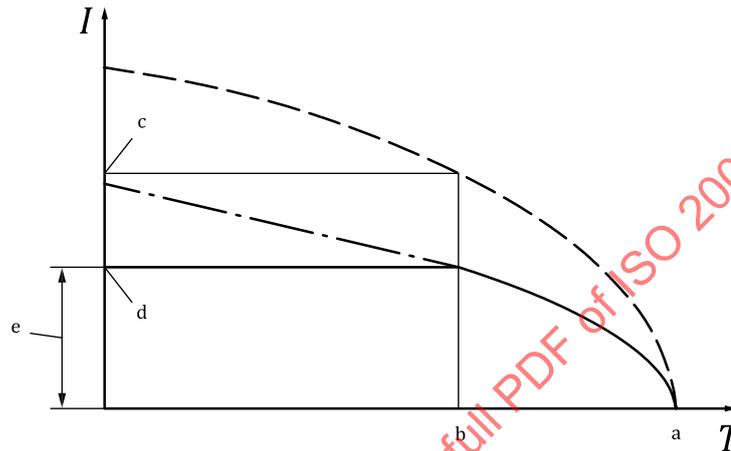
$$\Delta T = T_p - T_{\max}$$

where

T_p (°C) is the permissible temperature by limit of the materials according to agreement between customer and supplier, and

T_{max} (°C) is the ambient temperature as defined in [Table 1](#).

The relation between the current, temperature rise, and ambient temperature is represented by a curve as shown in [Figure 5](#). T_p which is plotted on the horizontal axis, represents the material temperature limit where no current is allowed. If T_p and T_{max} are determined, it is possible to energize a current for ΔT . It is defined as I_n (initial current). Corrected curve is defined by the current value, the ratio of which to current value of base curve is 0,8 times.



Key

T temperature [°C]

I current [A]

a T_p , permissible temperature by limit of the materials.

b T_{max} , highest value temperature as defined in [Table 1](#).

c I_n , Initial current, defined as the current which the terminal temperature becomes T_p at T_{max} .

d Initial current at T_{max} times 0,8.

e Permissible operating range.

----- base curve

..... corrected curve

_____ defined current limit curve

Figure 5 — Current limit and permissible temperature rise

4.19.3 Requirements

Permissible operating conditions of connector ΔT (°C) shall be equal to or less than $T_p - T_{max}$ when I_n of 0,8 times is applied.

4.20 Insulation resistance

4.20.1 Purpose

This test verifies that the electrical resistance between any two cavities in a connector system will be sufficient to prevent detrimental electrical conductivity (current leakage) between the circuits passing through that connector. This test is typically done after other environmental stress tests to ensure that any contaminants that may have entered the connector during testing are not sufficient to create an unintended electrical path.

4.20.2 Test

Measure the insulation resistance by applying a test voltage of 1 000 V DC to the connector for 60 s using measurement points between the following terminals. See Figure 6 for a graphical representation.

- a) Between every two adjacent voltage class B terminals.
- b) Between every class B terminal and shield shell (applicable to individual shield type connector).
- c) Between every class B terminal and metal housing (applicable to group shield type connectors).
- d) Between every class B terminal and a metal foil electrode wrapped around the housing (applicable to plastic housings).
- e) Between shield shell and a metal foil electrode wrapped around the housing (applicable to plastic housings).
- f) Between voltage class B terminals and voltage class A terminals (applies to designs with mixed voltage classes A and B).

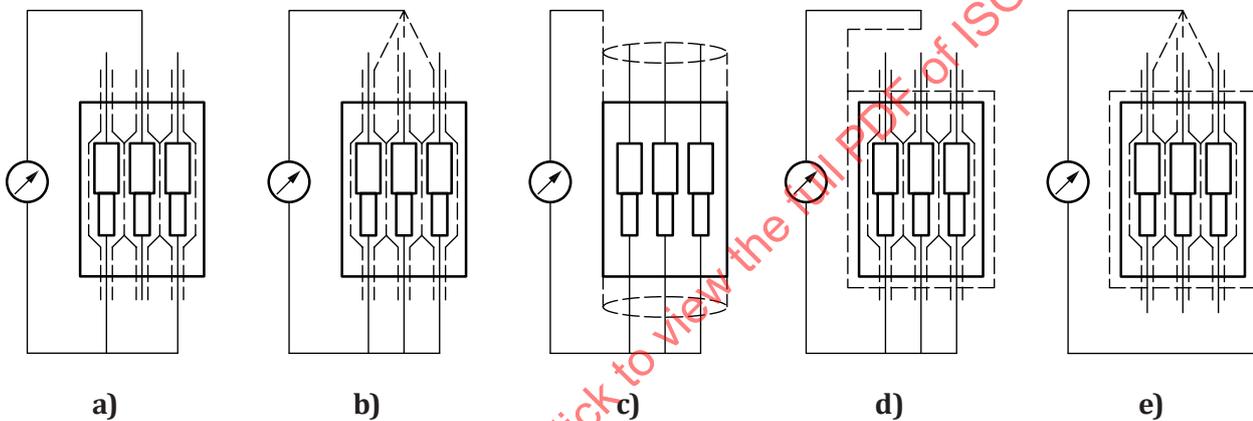


Figure 6 — Measurement points for insulation resistance and withstanding tests

For connectors with voltage class B₄₇₀ or lower, a different applied voltage may be agreed between customer and supplier. (Refer to ISO/PAS 19295 for voltage classes of connector.)

Insulation resistance between two adjacent voltage class A terminals and between voltage class A terminals and housing (or shield) shall be tested per ISO 8092-2:2005, 4.12 at 500V.

4.20.3 Requirements

The insulation resistance of the connector shall be at least 100 MΩ. (Exception: insulation resistance between voltage class A terminals shall be in accordance with ISO 8092-2:2005, 4.12.)

4.21 Withstanding voltage

4.21.1 Purpose

The dielectric voltage withstanding test is an integral part of the product safety evaluation of connectors and provides manufacturers with information regarding the quality and appropriateness of the chosen insulation system. The test involves placing an extra-high voltage across the insulation barrier of the device.

4.21.2 Test

Determine AC test voltage using the formula $2 \times U + 1\,000$ (V) (50 Hz/60 Hz), where U is the upper voltage limit of the connector design intent specified in the test request. Multiply this voltage by the applicable altitude correction factor per ISO 19453-4:2018, Table C.1. (Code to be determined between customer and supplier. Code A with a correction factor of 1,48, representing 5 000 m above sea level, shall be used unless otherwise specified.)

Dwell at specified voltage for at least 60 s at the following probe locations (see [Figure 6](#) for illustrations).

- a) Between voltage class B terminals. The test voltage shall be applied with a different test sample to every two adjacent voltage class B terminals.
- b) Between voltage class B terminals and shield shell (applies to designs with individually-shielded terminals and a metal shell).
- c) Between voltage class B terminals and shield shell (applies to designs with collectively-shielded terminals and a metal shell).
- d) Between voltage class B terminals and an electrode wrapped around the housing (applies to designs with individually-shielded terminals and a plastic shell).
- e) Between shield shell and an electrode wrapped around the housing (applies to designs with collectively-shielded terminals and a plastic shell).
- f) Between voltage class B terminals and voltage class A terminals (applies to designs with mixed voltage classes A and B). Probe location "f" is not illustrated in [Figure 6](#) since designs will vary.

Withstand voltage between two adjacent voltage class A terminals and between voltage class A terminals and housing (or shield) shall be tested per ISO 8092-2.

4.21.3 Requirements

There shall be no dielectric breakdown or flash-over.

4.22 Electromagnetic shielding performance

4.22.1 Purpose

This test provides a measurement of the effectiveness of the shielding around the housing.

4.22.2 Test

Perform the test for electromagnetic shielding performance by agreement between customer and supplier. Four test methods are listed in [A.1](#), [A.2](#), [A.3](#), and [A.4](#).

4.22.3 Requirements

The requirements for electromagnetic shielding performance are established by agreement between the customer and supplier.

4.23 Water tightness

4.23.1 Purpose

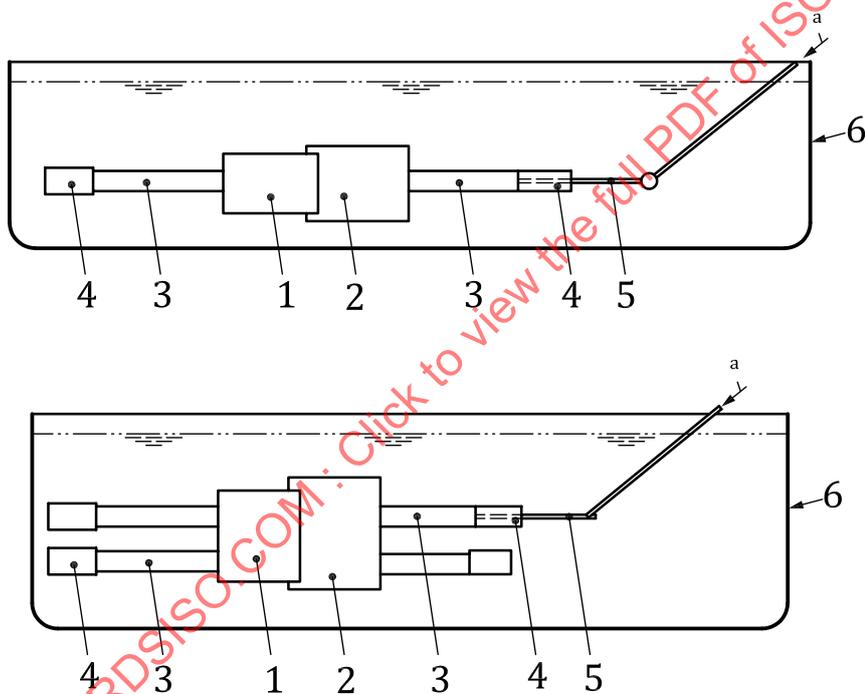
This test determines the sealing capability of connectors by creating a pressure differential between the inside and outside of the sealed area. It includes a simulation of the effect of cable position at an unfavourable angle relative to the connector and the seal.

4.23.2 Test

Use minimum applicable cable size for the selected seal in order to apply the most likely condition for leaking. Apply the internal or external test as called for in [Tables 4](#) and [5](#).

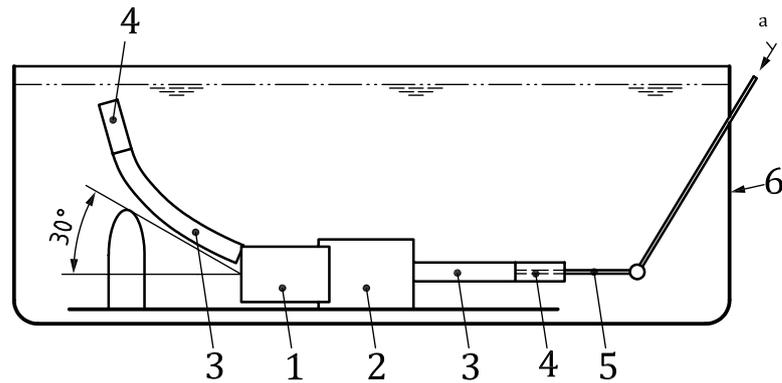
4.23.2.1 Internal pressure application test

Put the test sample in a water tank at $(23 \pm 5) \text{ }^\circ\text{C}$. Fix as shown in [Figure 7](#) unless the sequence table ([Table 4](#) or [5](#)) calls for cable stress per footnote h. If footnote h is called-for, fix sample to deflect cable 30° angle as shown in [Figure 8](#) or [9](#) (selection of the applicable cable deflection method is determined between customer and supplier and is based on which method can create a realistic 30° angle between the connector and cable for the specific connector design and cable size/type used). Apply 10 kPa compressed air from a tube that passes through the connector housing and maintain that state for 30 sec. Observe whether there are bubbles and identify the pressure when bubbles are first seen. Increase pressure by 10 kPa every 30 s until the pressure reaches 50 kPa and hold that pressure for 30 s. If bubbles are seen, record the pressure when bubbles were first seen. If pressure above 50 kPa is desired for research or analysis, make a new test group for this evaluation. Perform this additional test only per agreement of customer and supplier.



- Key**
- 1 connector
 - 2 connector/unit
 - 3 cable
 - 4 seal
 - 5 air inlet
 - 6 water bath
 - a Air.

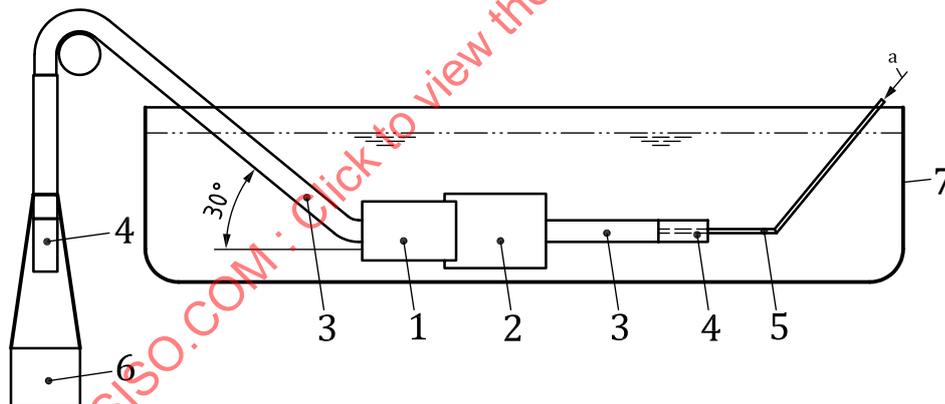
Figure 7 — Test configuration with no cable strain: single pole (above) and multi-pole (below)



Key

- 1 connector
- 2 connector/unit
- 3 cable
- 4 seal
- 5 air inlet
- 6 water bath
- a Air.

Figure 8 — Test configuration using obstacle for cable deflection



Key

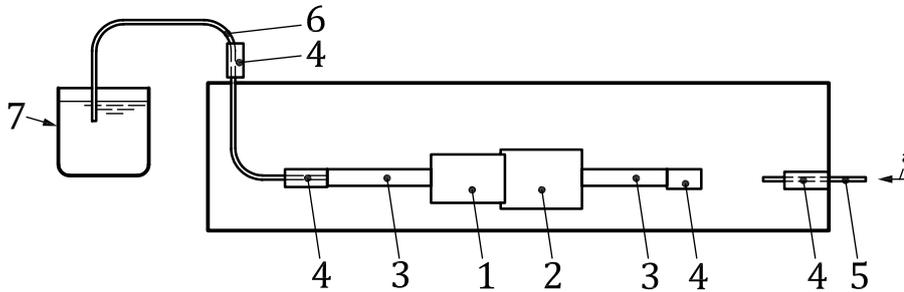
- 1 connector
- 2 connector/unit
- 3 cable
- 4 seal
- 5 air inlet
- 6 weight (10 N)
- 7 water bath
- a Air.

Figure 9 — Test configuration using pulley for cable deflection

4.23.2.2 External pressure application test

Place the test pieces in a pressure chamber per [Figure 10](#). Apply 10 kPa compressed air from a configuration per [Figure 10](#). Maintain that state for 30 s. Observe whether there are bubbles and

identify the pressure when bubbles are first seen. Increase pressure by 10 kPa every 30 s until the pressure reaches 50 kPa and hold that pressure for 30 s. If bubbles are seen, record the pressure when bubbles were first seen. If the pressure which is above 50 kPa is desired for research or analysis, make a new test group for this evaluation. Perform this additional test only per agreement of customer and supplier.



Key

- 1 connector
- 2 connector/ device header
- 3 cable
- 4 seal
- 5 air inlet
- 6 tube
- 7 beaker
- a Air.

Figure 10 — External pressure test set-up

4.23.3 Requirements

No bubbles shall be observed at the 50 kPa pressure level. If testing above 50 kPa for research reasons, record pressure when bubbles are first seen.

4.24 Mechanical shock

4.24.1 Purpose

This test evaluates a connector system to mechanical shock, simulating exposure to extreme component (or vehicle) conditions such as sudden impacts from potholes, road hazards, unpaved surfaces, speed bumps, hard braking, flat tire etc. Shock can cause wear of the terminal interfaces, intermittent electrical contact and failure of mechanical components of the connector system.

4.24.2 Test

Perform the test in accordance with ISO 19453-3:2018, 4.2.1 (Test for devices on rigid points on the body and the frame). Test the connector in all six spatial directions with 10 shocks per spatial direction. Include instrumentation for detection of interruptions greater than 7 Ω for longer than 1 μs with a current of 100 mA.

Use the following test parameters:

- pulse shape: half-sinusoidal;
- acceleration: 500 m/s²;
- duration: 6 ms;

— number of shocks: 10 per test direction.

4.24.3 Requirements

The following requirements are applicable:

- All test samples shall fulfil subsequent requirements in the test group.
- No interruptions greater than 7Ω shall last longer than $1 \mu\text{s}$.

4.25 Drop

4.25.1 Purpose

This test evaluates connector robustness when dropped on a hard surface, as may be encountered during wire harness and vehicle assembly processes.

4.25.2 Test

Assemble an unmated connector to match its production application. The length of the cable(s) and the test arrangement are given in [Figure 11](#). Attach the cable(s) to a fixed point and allow a free swinging of the test sample (a simple attachment on a hook is sufficient). Hold the test sample horizontally and let it swing down to hit a steel plate of dimensions $(300 \times 500 \times 25)$ mm (thickness). For each unit of testing, perform one drop in each of the four connector orientations, also shown in the figure.

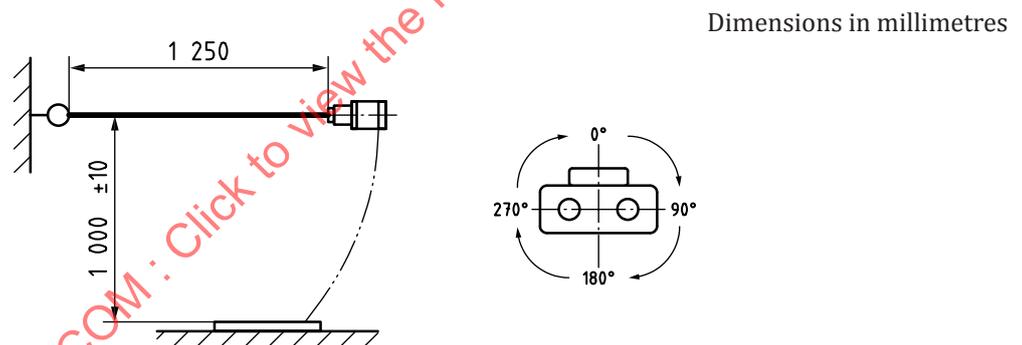


Figure 11 — Drop test arrangement and four orientations to test

4.25.3 Requirements

All test samples shall fulfil subsequent requirements in the test group. TPA shall still be in fully-assembled position after drop test. Obvious breakage or damage is permitted after this test by agreement between customer and supplier.

4.26 Vibration with thermal cycling

4.26.1 Purpose

This test evaluates the ability of the connector to sustain mechanical loads. The test exposes a connector system to vibration, simulating accelerated exposure to actual vehicle conditions. Vibration can cause wear of the terminal interfaces, intermittent electrical contact and failure of mechanical components of the connector system due to fatigue.

4.26.2 Test

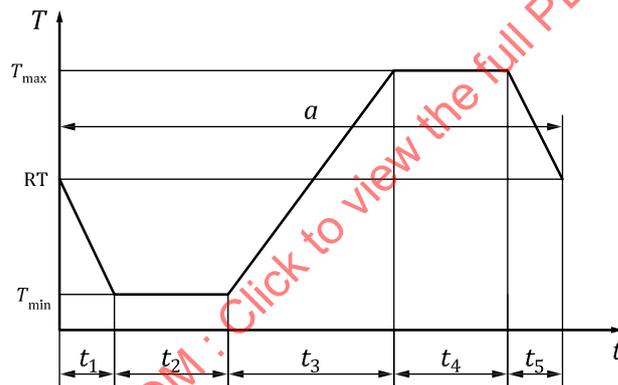
Perform the test in thermal cycling as shown in [Figure 12](#) and [Table 11](#) in accordance with ISO 19453-3:2018, 4.1. According to mounting location, the relevant vibration profile is referenced in [Table 12](#). Thermal cycle shall be performed at least 1 cycle during the vibration test. The supplier and the customer shall agree on a complete profile of thermal cycle. When the connector is installed in a specific axis of the component (e.g. electric motor), it is allowed to apply each vibration profile to all three primary axes according to the agreement between customer and supplier.

If test requestor chooses to use the maximum profile out of all three axes in ISO 19453-3 for all three axes and passes, no additional testing is needed for any other orientation.

Test samples shall be fixed in a straight cable direction as shown in [Figure 13](#). When a connector is not able to be installed as [Figure 13](#) or is wanted to be tested in actual mounting condition, set-up condition can be decided by agreement between customer and supplier. Include instrumentation for detection of interruptions greater than 7 Ω for longer than 1 μs, with a current of 100 mA. Micro interruptions shall also be measured in shield connection.

Cable length shall be (100 ± 5) mm to the retention point as shown in [Figure 13](#). Samples shall be mounted on same vibration plane.

The vibration control point is set on retention point on the fixture with using average control in accordance with ISO 19453-3:2018, A.3.



Key

- t time (h)
- T temperature (°C)
- T_{min} lowest value of environmental temperature range as defined in [Table 1](#)
- T_{max} highest value of environmental temperature range as defined in [Table 1](#)
- RT room temperature
- a one cycle
- $t_1 \sim t_5$ time parameters (as defined in [Table 11](#))

Figure 12 — Temperature profile for vibration with thermal cycling

Table 11 — Temperature versus time for the vibration test

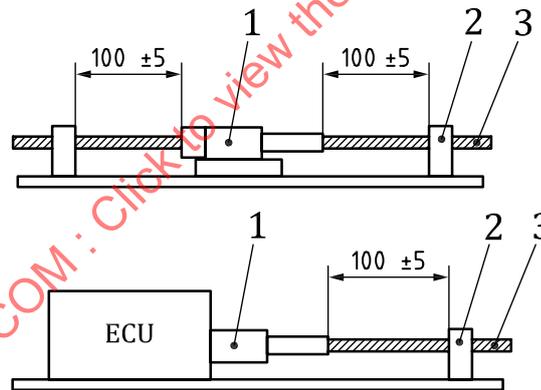
Parameter	Duration h	Temperature °C
t_1	as agreed	from RT to T_{\min}
t_2	>1	stabilized time at T_{\min}
t_3	as agreed	from T_{\min} to T_{\max}
t_4	>1	stabilized time at T_{\max}
t_5	as agreed	from T_{\max} to RT

NOTE T_{\min} and T_{\max} are defined in [Table 1](#).

Table 12 — Reference of vibration profile and test duration

Mounting location		Reference clause in ISO 19453-3:2018
On/in powertrain	Combustion engine, gearbox	4.1.2.1
	Electric motor for electric vehicle	4.1.2.3
On body/frame	All	4.1.2.2

Dimensions in millimetres

**Key**

- 1 connector
- 2 fixture
- 3 cable

Figure 13 — Vibration test set up**4.26.3 Requirements**

The following requirements are applicable:

- 1) All test samples shall fulfil subsequent requirements in the test group.
- 2) No interruptions greater than 7 Ω shall last longer than 1 μ s.

4.27 Current cycling at environmental temperature

4.27.1 Purpose

This test simulates the deterioration of terminals by self-heating with current over expected life of the vehicle.

4.27.2 Test

Perform the test with mated connectors using the full complement of terminals fitted. Place the test sample in a thermally controlled test chamber at the highest value of environmental temperature range as defined in [Table 1](#). Apply 500 test cycles, each with 45 min current on, 15 min current off, using the current determined in key d) of [Figure 5](#). Take care to protect the test samples from drafts and artificial cooling.

NOTE Cable size can be changed by agreement between customer and supplier to reflect actual use case.

4.27.3 Requirements

All test samples shall fulfil the requirements of [4.19.3](#) while being tested. All test samples shall fulfil subsequent requirements in the test group.

4.28 Thermal aging

4.28.1 Purpose

This test subjects the connector assembly to temperature cycles that simulate a lifetime of exposure. This is intended to produce accelerated stress relaxation and oxidation to systems affected by elevated temperatures.

4.28.2 Test

Refer to ISO 8092-2:2005, 4.18. Test for 1 000 h. Determine maximum temperature from [Table 1](#).

4.28.3 Requirements

All test samples shall fulfil subsequent requirements in the test group.

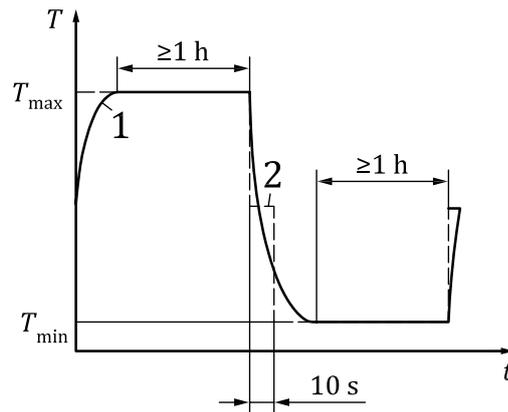
4.29 Thermal shock

4.29.1 Purpose

This test simulates actual operating conditions using temperature variations as an aging mechanism for evaluation of a connector system's electrical durability.

4.29.2 Test

Subject the mated samples to 100 thermal shock cycles as defined in [Figure 14](#). Test duration of T_{\max} and T_{\min} shall be 1 h minimum not including the time to reach thermal equilibrium (measured by thermocouple). Transition time of ambient temperature shall be within 10 s.

**Key**

t time (h)

T temperature (°C)

T_{\max} highest value of environmental temperature range as defined in [Table 1](#)

T_{\min} lowest value of environmental temperature range as defined in [Table 1](#) (-40 °C)

1 terminal temperature (solid line)

2 ambient temperature (dashed line)

Figure 14 — Thermal shock temperature profile

4.29.3 Requirements

All test samples shall fulfil subsequent requirements in the test group.

4.30 Temperature/humidity cycle

4.30.1 Purpose

This test simulates actual operating conditions using temperature and humidity variations as aging mechanisms for evaluation of a connector system's electrical durability. High humidity and temperature can promote galvanic and electrolytic corrosion of the terminals which may cause electrical and mechanical degradation. Temperature cycling promotes relative movement.

4.30.2 Test

Carry out the temperature/humidity cycling test using mated connectors with a housing possessing the full complement of terminals. If requested by the customer, carry out this test with connections on a device.

Subject the test samples (mated connectors), in a suitable test chamber, per ISO 19453-4:2018, 5.5 (Humid heat, cyclic test). Perform insulation resistance, [4.20](#), either a) and b) [or a) and c)] during the time of highest condensation as determined in lab. (See ISO 19453-4:2018, Figure 10).

4.30.3 Requirements

All test samples shall fulfil subsequent requirements in the test group.

4.31 Condensation

4.31.1 Purpose

This test simulates condensation by rapid change of temperature and humidity, e.g. the condensation occurring while the connector from cold ambience to warm ambience. The possible failure mode is electrical malfunction(s) caused by moisture. This failure mode applies to unsealed connectors only.

4.31.2 Test

Condition mated test samples per ISO 19453-4:2018, 5.7. Confirm that the connector temperature reaches the specified temperature during soak at low temperature phase. If the connector needs to move to the other chamber, it shall be carried out within 30 s.

Perform insulation resistance in accordance per 4.20 either a) and b) [or a) and c)] during the last 30 min of the high temperature and high humidity phases. (See ISO 19453-4:2018, Figures 12 and 13) Wind speed is preferred to be $(1 \pm 0,5)$ m/s only during condensation.

4.31.3 Requirements

The following requirements are applicable:

- a) Insulation resistance at high temperature and high humidity phase shall meet the requirements of 4.20.
- b) Subsequent tests shall be fulfilled.

4.32 Salt spray

4.32.1 Purpose

This procedure evaluates the ability of connectors with exposed electrical shields or metal components to survive exposure to water mixed with road salt.

4.32.2 Test

This procedure only applies to connection systems intended to be exposed to splash where the shield or metal is exposed. Perform 60 cycles of test sequence shown in Figure 15 in accordance with ISO 19453-4:2018, 5.4.3 (Salt spray combined cycle test). Samples are to be placed as shown in Figure 16. When the connector is not able to be placed per Figure 15 or is desired to be tested in actual mounting position, set-up condition can be decided by agreement between customer and supplier.

When connector is freely placed or is not anticipated to be installed in a certain position and posture, set-up condition can be decided by agreement between customer and supplier.

When the mounting location of the connector is limited, the number of test cycles can be changed in accordance with ISO 19453-4:2018, 5.4.3, Table 5 and Figure 8

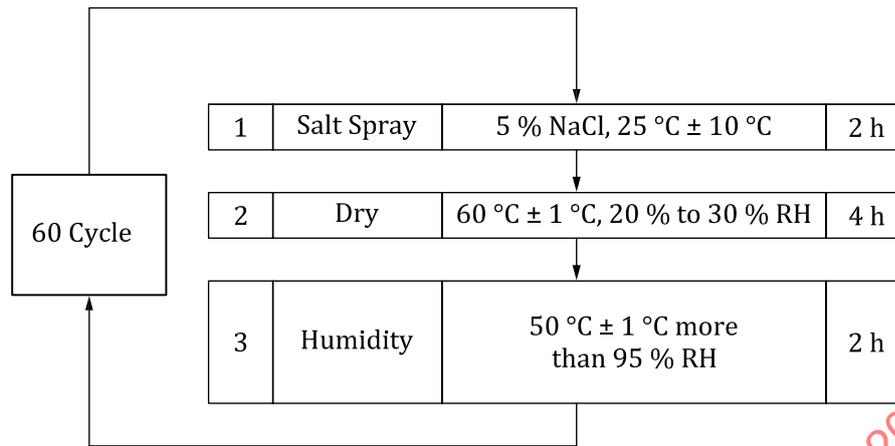
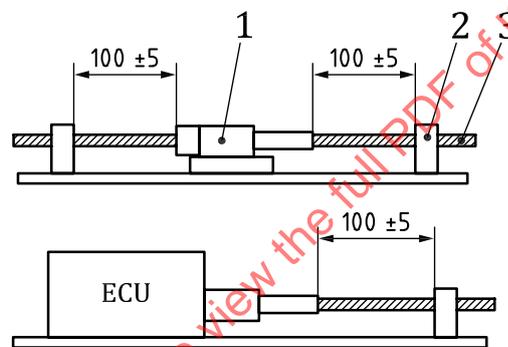


Figure 15 — Salt spray cycle



Dimensions in millimetres

Key

- 1 connector
- 2 fixture
- 3 cable

Figure 16 — Salt spray test set-up

4.32.3 Requirements

All test samples shall fulfil subsequent requirements in the test group.

4.33 High-pressure/steam-jet cleaning**4.33.1 Purpose**

This test evaluates the sealing capability of a sealed connector system when subjected to a heated water jet as might be found in a car wash.

4.33.2 Test

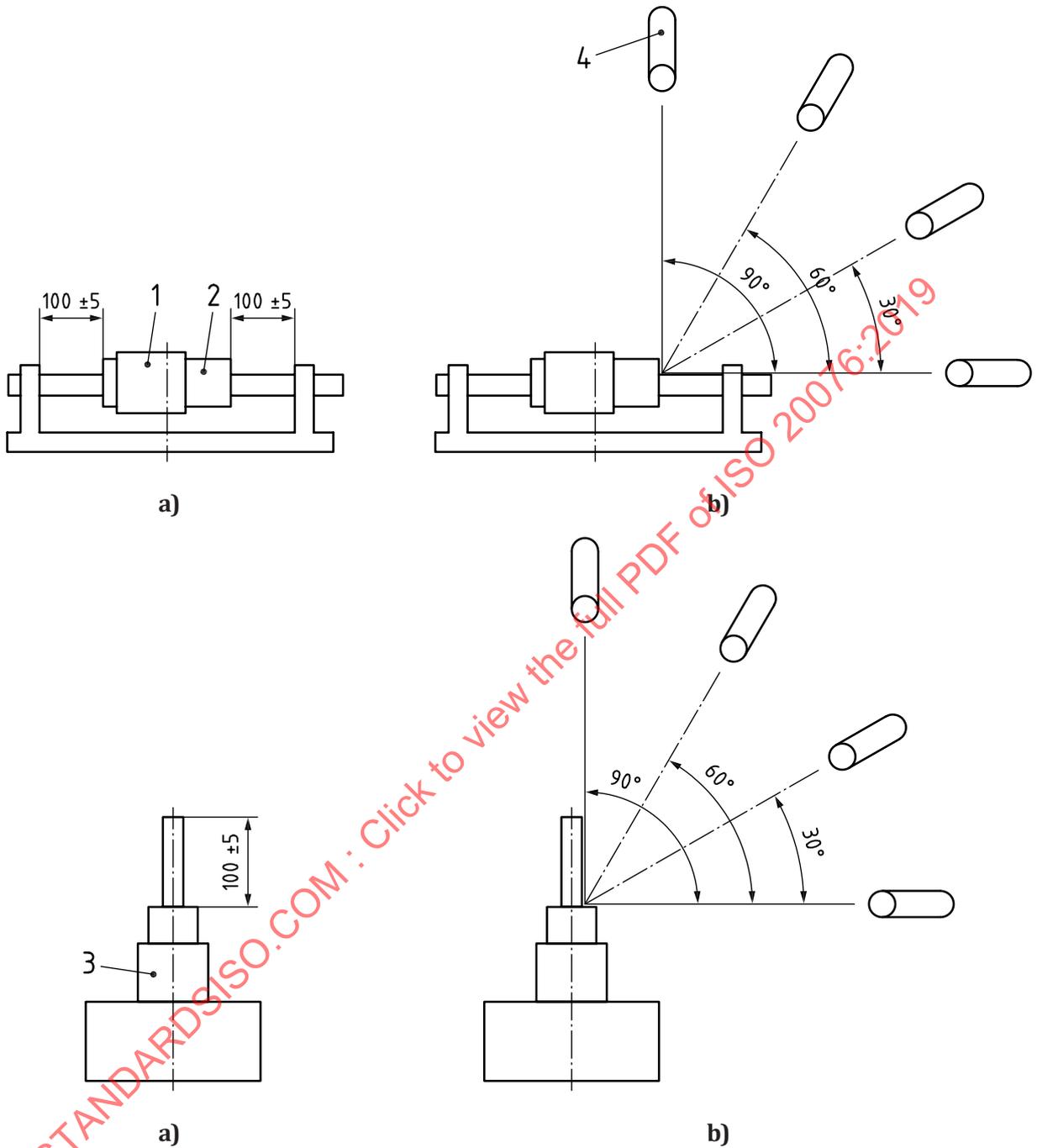
Test to IPX9K designation per ISO 20653. Use the test set-up per [Figure 17](#) and apply the following test parameters:

ISO 20076:2019(E)

- Sample rotation: 360°
- Water temperature: $(80 \pm 5) \text{ }^{\circ}\text{C}$
- Water pressure: 8 MPa to 10 MPa

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Dimensions in millimetres



Key

- 1 male connector
- 2 female connector
- 3 connector
- 4 nozzle
- a) test set up
- b) aiming position

NOTE When connector is blocked by other parts in the vehicle condition, the aiming position and the angle can be adjusted by agreement between customer and supplier.

Figure 17 — Water spray set-up

4.33.3 Requirements

Test sample(s) shall meet criteria for IPX9K according to ISO 20653. No water ingress visible.

4.34 Dust resistance

4.34.1 Purpose

This test evaluates the ability of the connector to perform in dusty conditions at an accelerated rate.

4.34.2 Test

Perform test per ISO 8092-2:2005, 4.21.

4.34.3 Requirements

All test samples shall fulfil subsequent requirements in the test group. And after disconnection, no visible damage is permitted.

4.35 Oil and liquid resistance

4.35.1 Purpose

This test evaluates the sealing capability and material compatibility of a connector system when exposed to various fluids commonly found in and around road vehicles.

4.35.2 Test

Test according to ISO 19453-5. Customer and supplier choose the oil, liquid, and application method depending on the connector's application.

4.35.3 Requirements

All test samples shall fulfil subsequent requirements in the test group.

Annex A (informative)

EMC test methods

A.1 Method 1 — Line injection — Parallel cable test procedure

A.1.1 General

This subclause describes the evaluation of the electromagnetic shielding performance of the connector by the line injection or parallel cable method. The determination of the average impedance of the reference high voltage (HV) cable including capacity and transit time shall be performed. The transfer impedance measurement should be performed with the line-injection method according to IEC 62153-4-6 for a frequency range from 100 kHz to 500 MHz.

A.1.2 Test sample

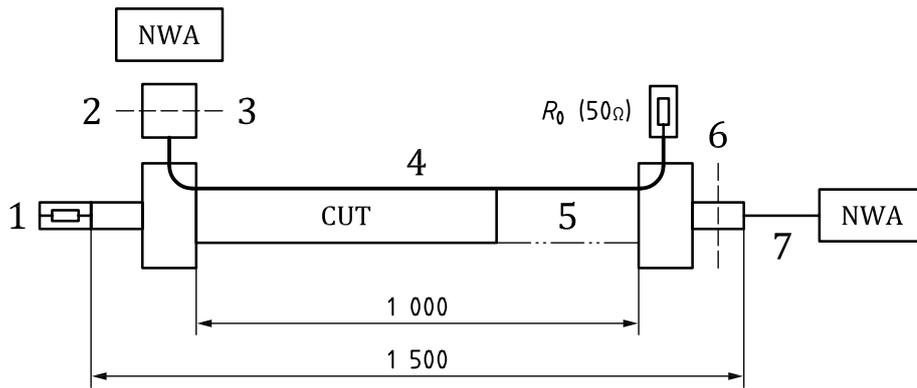
The test should be performed with connector assembly with all defined components included to reach the expected shielding performance.

A.1.3 Test set-up

The measurement shall be performed with the far end configuration. Measure the difference between a reference HV cable and a cable terminated on one end. The one end cable assembly is built of the reference HV cable and the HV-connector system to test. At multi pole cables with summary shield the single strands shall be parallel connected. The measurement shall be performed at 3 or 4 positions. The device under test (DUT) shall be rotated therefore with 120° or 90° relative to the supply cable. The DC resistance between the measuring contact systems, on both sides of the DUT, that connect the equipment under test (EUT) and the measuring adapters must not be more than 10 % greater than the measured static shield resistance of the EUT without the measuring contact systems. As the terminal resistance for the specimen, use the asymptotic wave impedance value that results at high frequencies as per determinate average impedance. Terminal resistances R_0 and R_3 shall be suitable for high frequencies throughout the entire frequency range.

Remark: Carbon film and wire-wound resistors shall not be used. A reflection measurement on the vector network analyzer (VNA) can be carried out on the resistors in order to check their frequency stability. Insert the resistors into an N connector for this purpose. The inductance of the resistors can be reduced by connecting several surface mounted device (SMD) resistors in parallel. The entire measuring set-up shall be insulated (do not use a ground plane). The VNA provides the reference ground. Ensure that there are no metallic objects in the vicinity of the set-up (minimum clearance: 20 cm). The coupling characteristics shall not change during the measurement. For this purpose, the supply cable in particular shall be secured in such a way that there is a continuous and stable contact between the supply cable and the test specimen isolation.

The supply cable's reflection factor shall be up to 30 MHz < 20 dB and up to 110 MHz < 10 dB. Perform the measurement at the receiver and sender with a system impedance of 50 Ω . Any impedance mismatch should not be corrected. In particular, this means that impedance matching circuits, as well as the VNA's port Z conversion function, should not be used. (This is to prevent the measured result from depending on the quality of the impedance matching circuit set-up or from conversion algorithms by different VNA manufacturers.) See Figure A.1 for a parallel cable method set-up.



Key

- 1 R_3 (average wave impedance)
- 2 sender calibration point
- 3 supply connection
- 4 supply wire
- 5 contact system
- 6 receiver calibration point
- 7 receiver connection

Figure A.1 — Line injection — Parallel cable method set-up

The calibration shall be performed with OSL (Open Short Load) and Thru method. The measurements shall be performed from 100 kHz to 500 MHz

A.1.4 Requirements

For evaluation of transfer impedance, Z_T shall be determined. The calculation of the measured coupling attenuation A_T to transfer impedance Z_T is determined per the following formula:

$$Z_T = (R_3 + R_0) \times 10^{\frac{A_T}{20}}$$

where

- Z_T is the surface transfer impedance in Ω/m ;
- R_0 is the supply cable terminal resistance (50 Ω);
- R_3 is the DUT terminal resistance (DUT average wave impedance); and
- A_T is the measured level on a vector network analyser (VNA), in dB, between measuring receiver and measuring sender.

Document the values used in the formula. For each DUT, show all the measurements for the angles in a single diagram in the test report. For all measurements, show the information related to determining the supply cable. Since only the transfer impedance of the contact system is of interest the contribution of the connecting cable shall be subtracted from the overall result of the transfer impedance. The influence of the cable shall be subtracted of the measurement result. This shall be done by an initial and a final measurement of an identical cable from the same material batch before and after aging of the cable. The aging shall be performed according to the relevant test group.

A.2 Method 2 — Alternate line injection test procedure

A.2.1 General

This method determines the effectiveness of the HV connector's electromagnetic interference (EMI) shielding using a modification of the line injection method to measure the surface transfer impedance.

A.2.2 Overview

A noise source (injection line) is placed next to a shielded (HV) connector assembly, and the noise penetrating the shield is measured with a vector network analyzer (VNA). The measurement of the HV connector under test (CUT) transfer impedance is performed at 4 positions equally about the HV connector, with the noise source positioned at both the far end and the near end, relative to the measuring point. The measurements are performed from 10 kHz to 200 MHz, or as required by the test plan. If requested in the test plan, a reference HV cable of the same length used with the CUT may also be measured for comparison. The following procedure uses VG 95214-11 and IEC 62153-4-6 as reference documents for the test configuration. Due to the method of Z_t calculation utilizing complex S-parameter data, this method has greatly reduced sensitivity to the values of termination impedance on the injection and HV lines. Therefore, standard 50 Ω terminations are used for simplicity, but other values (e.g. short circuit or matched to the HV line impedance) may be specified in the test plan.

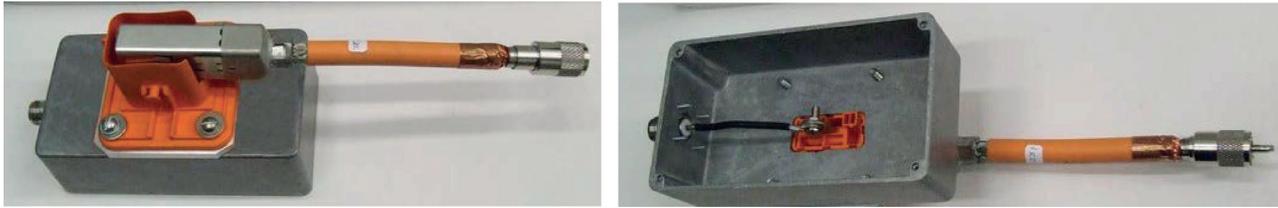
A.2.3 Termination of HV cable

Terminate the HV cable with a radio frequency (RF) connector to allow connection to a shielded coaxial bulkhead feed through and load. The preferred load is coaxial RF 50 Ω termination. This test is also capable of using the alternative method of short circuit in place of the 50 Ω termination(s). Unless otherwise stated in the test plan, the cable length(s) shall be only as long as needed to allow for proper termination of the HV cable. Cable manufacturer recommended bend radius should be observed so as not to damage shielded cables. Keeping cables short will reduce the influence of the cable on the connector shielding data.

A.2.4 Construction of shielded adapter boxes

If an adapter box is needed to simulate the connector assembly mounting to a bulkhead or panel, use a small sealed metal box (e.g., Compac Development Corp.TM, Bud Industries Inc.TM, or Hammond Mfg. Co. Inc.TM aluminum box²⁾). See Figure A.2 for examples of cable and header adapter box construction. The box size should be as small as possible for the CUT. Keep the interconnect wires short. All connector mating surfaces must be cleaned of tarnish and oxidation to minimize interface resistances in the shield path.

2) These are examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.



Single HV connector



Individual HV cables

Figure A.2 — Examples of cable and header adapter box construction

A.2.5 Test setup

A VNA with system impedance of 50 Ω shall be used for all measurements. Examples of test set-ups for various HV connector types are illustrated in [Figures A.3](#) through [A.8](#). The entire measuring set-up does not use a ground plane. Ensure that there are no metallic objects in the vicinity of the set-up (minimum clearance: 50 mm). The coupling characteristics shall not change during the measurement; therefore, the injection line shall be secured in such a way that there is a continuous and stable contact between the injection line and the test specimen insulation. If uninsulated, the injection line shall be kept from direct contact with any shield path metal surfaces, i.e. adapter box, connector shields, brass plate or support brackets. The VNA test system cables should be of double shielded or solid shield construction.

A.2.6 Calibration

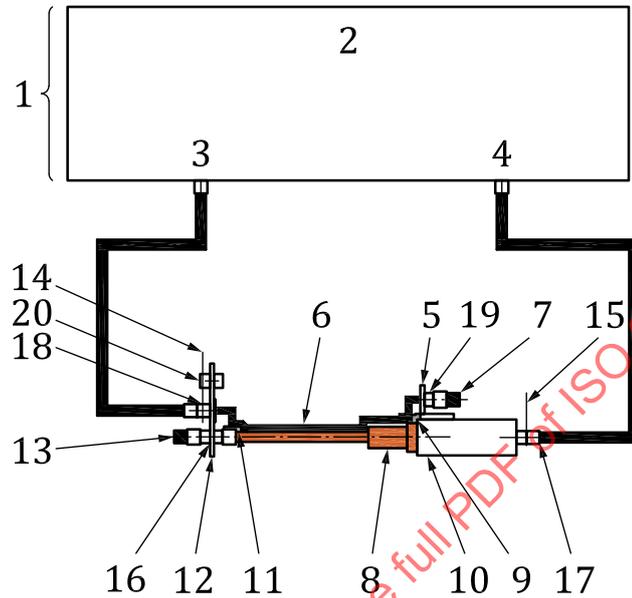
After the VNA is set-up to the desired settings (i.e. span 10 kHz to 200 MHz, IFBW 100 Hz, 10 dBm source power, minimum number of points 1601), a full 2-port calibration shall be performed using OSL (Open Short Load) and Thru method. The OSL calibration is performed at the points defined as “calibration plane” in [Figures A.3](#) through [A.8](#). Following setup, a null check should be performed by connecting port 1 cable to port E with a 50 Ω load as illustrated in [Figure A.9](#). The results of the null check should be 20 dB below the HV CUT in the frequency range of 10 kHz to 20 MHz. If the null test result exceeds the CUT minus 20 dB result due to measurement system cable leakage, the leakage may be reduced by addition of ferrite beads to the measurement cables. If it is due to the VNA noise floor, the bandwidth may be reduced.

A.2.7 Measurement

Unless a short circuit termination is specified in the test plan, the supply cable’s return loss (S_{11}) shall be less than -20 dB up to 30 MHz and less than -10 dB from 30 to 110 MHz when connected to the injection line (port C or D). Any impedance mismatch should be corrected by adjusting the injection line relative to the HV CUT. The mismatch shall not be corrected by means such as; impedance matching circuits, VNA port Z conversion function, other mathematical manipulation within the VNA. The injection line shall be secured in place using electrical tape, cable ties or other non-metallic fasteners. Unless otherwise specified in the test plan, the HV-connector system measurement shall be performed at 4 positions equally spaced about the HV connector with the injection line source connected in both the near end and far end configurations as defined in [Table A.1](#) and illustrated in [Figures A.3](#) through [A.8](#).

Table A.1 — Near end and far end injection line source connections

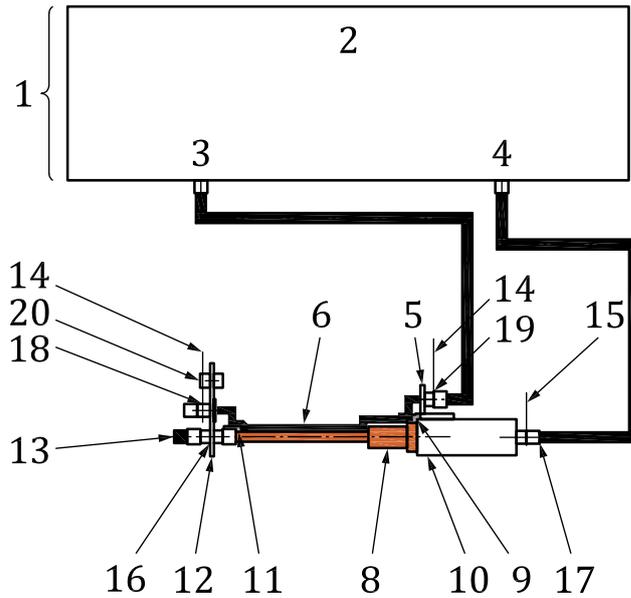
Method	VNA port 1 injection line source connected to port:	Injection line load connected to port:
Far end	C	D
Near end	D	C



Key

- 1 signal source connected at **far end**
- 2 vector network analyzer
- 3 port 1 measuring S_{11}
- 4 port 2 measuring S_{21} and S_{22}
- 5 aluminium bracket with N panel mount screwed to box
- 6 copper braid injection line
- 7 injection line load
- 8 shielded HV bulkhead assembly with short shielded lead
- 9 insulation between injection line and metal box
- 10 sealed aluminium box adapts shielded bulkhead connector to N panel mount
- 11 insulation between injection line and UHF connector
- 12 brass plate with: port E: $N_f - N_f$ bulkhead feed through
port C: N_f panel mount
port A: $UHF_f - N_f$ bulkhead feed through
- 13 HV cable load
- 14 port 1 calibration plane
- 15 port 2 calibration plane
- 16 port A
- 17 port B
- 18 port C
- 19 port D
- 20 port E

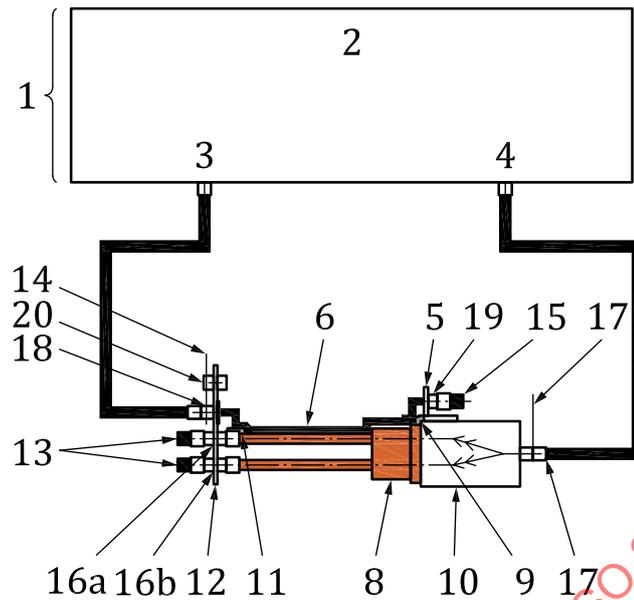
Figure A.3 — Setup for single HV connector — Far end measurement



Key

- 1 signal source connected at **near end**
- 2 vector network analyzer
- 3 port 1 measuring S_{11}
- 4 port 2 measuring S_{21} and S_{22}
- 5 aluminium bracket with N panel mount screwed to box
- 6 copper braid injection line
- 7 shielded HV bulkhead assembly with short shielded lead
- 8 insulation between injection line and metal box
- 9 sealed aluminium box adapts shielded bulkhead connector to N panel mount
- 10 insulation between injection line and UHF connector
- 11 brass plate with:
 - port E: $N_f - N_f$ bulkhead feed through
 - port C: N_f panel mount
 - port A: $UHF_f - N_f$ bulkhead feed through
- 12 HV cable load
- 13 port 1 calibration plane
- 14 port 2 calibration plane
- 15 port A
- 16 port B
- 17 port C
- 18 port D
- 19 port E

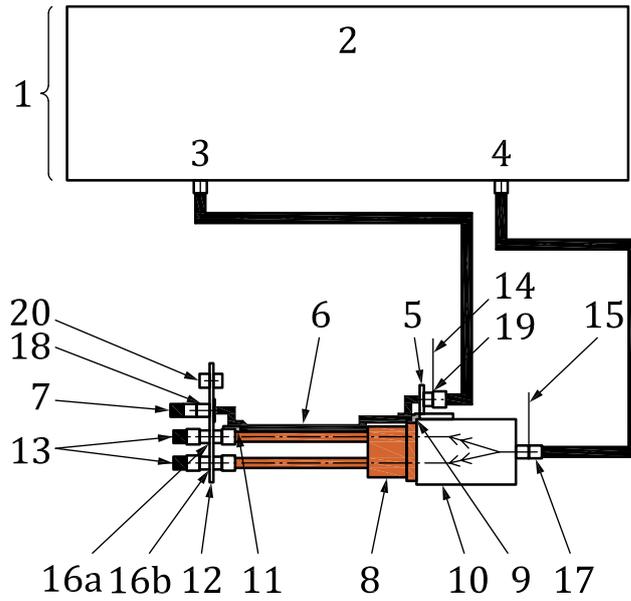
Figure A.4 — Setup for single HV connector — Near end measurement



Key

- 1 signal source connected at **far end**
- 2 vector network analyzer
- 3 port 1 measuring S_{11}
- 4 port 2 measuring S_{21} and S_{22}
- 5 aluminium bracket with N panel mount screwed to box
- 6 copper braid injection line
- 8 shielded HV bulkhead assembly with 2 short shielded leads
- 9 insulation between injection line and metal box
- 10 sealed aluminium box adapts shielded bulkhead connector to N panel mount
- 11 insulation between injection line and UHF connector
- 12 brass plate with: port E: $N_f - N_f$ bulkhead feed through
port C: N_f panel mount
port A1 and A2: $UHF_f - N_f$ bulkhead feed through
- 13 HV cable load
- 14 port 1 calibration plane
- 15 port 2 calibration plane
- 16a port A1
- 16b port A2
- 17 port B
- 18 port C
- 19 port D
- 20 port E

Figure A.5 — Setup for individual shielded HV cable connectors — Far end measurement (figure illustrates 2 HV cables)



Key

- 1 signal source connected at **near end**
- 2 vector network analyzer
- 3 port 1 measuring S_{11}
- 4 port 2 measuring S_{21} and S_{22}
- 5 aluminium bracket with N panel mount screwed to box
- 6 copper braid injection line
- 7 injection line load
- 8 shielded HV bulkhead assembly with 2 short shielded leads
- 9 insulation between injection line and metal box
- 10 sealed aluminium box adapts shielded bulkhead connector to N panel mount
- 11 insulation between injection line and UHF connector
- 12 brass plate with: port E: $N_f - N_f$ bulkhead feed through
port C: N_f panel mount
port A1 and A2: $UHF_f - N_f$ bulkhead feed through
- 13 HV cable load
- 14 port 1 calibration plane
- 15 port 2 calibration plane
- 16a port A1
- 16b port A2
- 17 port B
- 18 port C
- 19 port D
- 20 port E

Figure A.6 — Setup for individual shielded HV cable connectors — Near end measurement (figure illustrates 2 HV cables)