BS ISO 20076:2019

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

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee AUE/16, Data Communication (Road Vehicles).

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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.

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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 mm^2 to 120mm^2.

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 8092-5[1)], *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.

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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]

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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.

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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.

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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.

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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.

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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.

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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

[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.

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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[j]
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.

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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

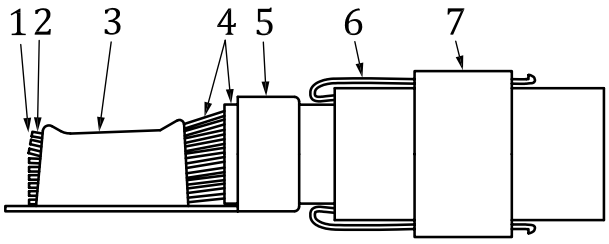
Carry out a visual examination of all connectors and contacts with the naked eye, at normal strength of vision and colour perception, at the most favourable viewing distance, and with suitable illumination. In the event something is questionable, use appropriate diagnostic equipment to evaluate.

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.

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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

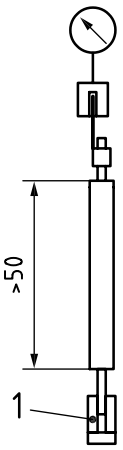
4.4.1 Purpose

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

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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) mm2	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.

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