Group standard

VW 80332

Issue 2019-01

Class. No.: 8ME20

Descriptors: contact, high voltage, high-voltage contact

Motor Vehicle High-Voltage Contacts

Preface

This Volkswagen standard (VW) combines the requirements from VW 80302 and VW 80304.

Previous issues

VW 80332: 2017-09

Changes

The following changes have been made to VW 80332: 2017-09:

– Section 14 "Applicable documents" adapted.

1 Scope

This standard describes the technical and functional requirements and tests for high-voltage (HV) contacts that are used in HV electrical systems of passenger cars.

2 Abbreviations

AC	Alternating current
CPA	Connector position assurance
DC	Direct current
DUT	Device under test
EDX	Energy dispersive X-ray spectroscopy
EMC	Electromagnetic compatibility
EUT	Equipment under test
FEM	Finite element method
HF	High-frequency

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HV	High voltage
HVIL	HV interlock
LineScan	Method for surface analysis
NWA	Network analyzer
RFT	Remote field testing
R_{insul}	Insulation resistance
SE	Severity
SMD	Surface-mount device

3 Definitions

Live part

All conductors and conductive parts to which voltage is applied under normal use.

Operating voltage

The maximum root mean square (RMS) voltage in a circuit, as specified by the manufacturer, that can be measured with any insulation, with the circuit open or under normal operating conditions.

Direct contact

People or animals (pets or farm animals) coming into contact with live parts.

Electrical ground

A set of conductive parts that are electrically (galvanically) connected to one another, as well as all other conductive parts that are electrically (galvanically) connected to this set of parts and that use their potential as a reference. The HV circuit does not use this potential as a reference, with the exception of the shielding and equipotential bonding.

HV electrical system

The infrastructure for supplying and distributing electrical power to the HV system, but without components for consuming, storing, and generating electrical power and without controllers.

Indirect contact

People or animals (pets and farm animals) coming into contact with electrical equipment that may be energized in the event of a fault.

Creepage distance

As per DIN EN 60664-1, the shortest distance along the surface of an insulator between two conductive parts.

Conductive part

A conductive part is a part that is able to conduct current, even if it is not necessarily live under normal operating conditions.

Clearance

As per DIN EN 60664-1, the shortest distance in air between two conductive parts.

Voltage class B

The HV system must be classified as per the defined voltage ranges of voltage class B (see ISO 6469-3): 60 V DC < V ≤ 1 500 V DC

For AC voltages of voltage class B, the following voltage range is defined:
30 V AC (rms) < V ≤ 1 000 V AC (rms)

The AC voltage specification is relevant to HV system circuits that use AC or three-phase current components, such as the electric drive system.

Bare conductive part

A bare conductive part is a part that can be easily touched and that, although not live during normal use, may conduct voltage in the event of a fault (insulation fault). This term is specified in relation to a specific circuit, e.g., a vehicle body can be a live part of the auxiliary circuit, but a bare conductive part of the drive circuit.

4 Test number structure

As per VW 75174.

Supplementary to VW 75174:

PG 49A	Imperviousness to dust
PG 49B	Water tightness after exposure to dust
PG 50	EMC testing
PG 51	Protection against contact

5 Loads

As per VW 75174.

Deviating from VW 75174:

B 18.3	Severity 5
B 19.1	Temperature: -40 °C/140 °C 15 min each
B 19.2	Temperature: -40 °C/140 °C 3 h each
B 19.3	Temperature: 140 °C
B 20.1	Temperature: 140 °C
B 21.1	Temperature: 140 °C
B 23.1	Immersion with pressure difference
B 23.2	Cable movement during immersion with pressure difference
B 23.3	Thermal shock test
B 6.1	Drop test (with new housings, see batch size) as per DIN EN 60068-2-31 free fall as per method 1. Test setup: Housing fully equipped with maximum cable cross-sectional area; cable length: 500 mm; drop height: 1 m.

Requirement: There must not be any discernible broken parts or any damage that will have a negative impact on suitability of use.

Supplementary to VW 75174:

B 11.2 Installation/removal of threaded fasteners

6 Properties testing

As per VW 75174.

Deviating from VW 75174:

E 0.3 In addition, the insulation resistance between all contacts, including HVIL, and the housing shielding must be measured. The following must be measured:

1. Every HV potential to each other
2. Every HV potential to shielding
3. Every HV potential to HVIL
4. Shielding to HVIL

Measurements 2 and 3 can be performed together for galvanically connected HVIL and shielded contacts.

Requirement for measurements 1 – 3: R_{insul} > 200 MΩ at V = 1 000 V DC, t = 60 s

Requirement for measurement 4: R_{insul} > 100 MΩ at V = 500 V DC, t = 60 s

E 5.2 Testing is permissible with housings for shielding contacts

Supplementary to VW 75174:

E 0.2.3 Volume resistance of the shielding

E 0.4 Dielectric strength

E 1.3 Graphical verification (CAD) of clearance and creepage distance

E 3.1 Testing of materials for housings and single-wire seals

E 11.2 Holding force for protection against contact

E 13.2 Load contact/plug connection derating (DIN EN 60512-5-2)

E 13.3 Shielding derating (DIN EN 60512-5-2)

E 51.1 Protection against contact (ISO 20653)

7 General rules

As per VW 75174.

This standard is an extension to VW 75174. For HV contacts, only cables released in the Volkswagen Group may be used.

If modifications to individual test sections become necessary in individual cases, these must be agreed upon separately between the appropriate department and the relevant manufacturer. All tests in this standard are described as tests for plug connections and must also be applied to tests for threaded connections.

8 Determining the volume resistance (E 0.2, E 14.0, and E 16.0)

As per VW 75174.

Deviating from VW 75174:

- Measuring the volume resistance as per DIN EN 60512-2-2 with a maximum test current as per table 2.
- The contact resistance of the contacts must not exceed the maximum values specified in table 2.
- The contact resistances of the HVIL contacts must be determined and adhered to as per VW 75174.
- For all measurements, the exact position of the measuring points must be indicated for the resistance measurements. The documentation must be substantiated with pictures and can be implemented in the form of a CAD cross section.

9 "Crimp" definition

As per VW 75174.

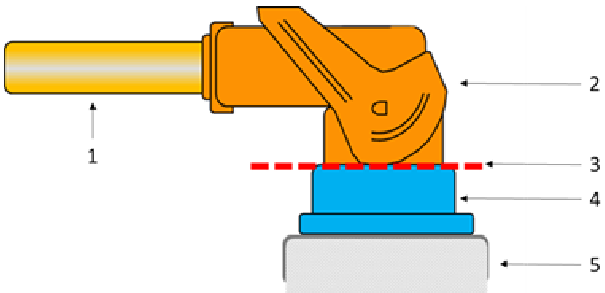
10 "Interface drawing specification" definition

The HV contact system consists of the HV unit connection, the specification for the interface (implementation regulation), and the wiring harness-side HV contact (see figure 1).

The HV unit connection is the device-side connection. This connection can be realized in the form of a sub-component or also as a molded-on/shaped component part.

The specification for the interface describes completely all functionally pertinent electrical, mechanical, and geometrical properties and requirements of the interface between the wiring harness-side HV contacts and a HV unit connection.

The HV contacts are part of the electrical HV wiring harness.



Legend

1	HV cable
2	Wiring harness-side HV contacts
3	Implementation regulation/interface
4	HV unit connection
5	HV component

Figure 1 – Interface layout

11 General requirements

11.1 Full functional capability

It must be verified that the reliability requirements have been met. To do this, service life tests must have been performed before production ramp-up and the results (failures per mileage) must be evaluated statistically, e.g., by means of Weibull analysis as per VDA Volume 3 Part 2.

11.2 Clearance and creepage distance

Design as per DIN EN 60664-1

- Upper HV circuit limit voltage: 1 000 VDC
- Elevation: 4 000 m above sea level
- Rated surge voltage: 2,5 kV
- Pollution degree: 2

The following features must be indicated in the plug connection drawing:

- Insulation group as per DIN EN 60664-1
- Clearance in mm
- Creepage distance in mm

The values must be indicated both in the plugged state and also the unplugged state matching the associated interface drawing.

11.3 Operational safety

The requirements of HV safety as per VW 80303 must be adhered to and implemented.

11.4 Contact system

Electrical connections must be designed in such a way that they make it impossible for the connection to be opened by accident.

Connectors must have reverse polarity protection. It must not be possible to mix them up.

11.5 High-voltage safety

The requirements of HV safety as per VW 80303 must be adhered to and implemented.

There must be protection against direct and indirect contact of live parts.

11.6 HVIL

- The question as to whether HVIL contacts must be provided must be agreed upon on a case-by-case basis.
- If an HVIL is required in a plug connection, it must be implemented with separate contacts.
- An HVIL bridge can be integrated into HV plug connections. In this case, it must be ensured that the HVIL circuit will be reliably disconnected whenever the plug connection is disconnected.
- For HV plugging systems with integrated HVIL system, the HVIL contacts must have a lagging design in the plugging process (at least 1.0 mm for all tolerance zone positions).

11.7 Part markings on HV plug connections

HV connectors must have an orange color similar to RAL 2003.

If this cannot be implemented, the HV connector must be provided with a separate HV marking.

11.8 Geometric requirements

The requirements for the pertinent interface result from the specifications of both interface counter-parts.

Coordination between the two interface partners is mandatory and must be defined with an inter-face drawing (implementation regulation).

The HV connectors must be designed in such a way that the individual phases/cables cannot be mixed up.

11.9 Thermal requirements

The HV plugging system must be designed for ambient temperatures between -40 °C and 140 °C.

11.10 Cable cross section and current-carrying capacity

The cable cross section and contact size to be used must be appropriate for the expected current spectrum.

The HV contacts are subdivided into 5 classes.

The HV contact system must be designed for the current-carrying capacity values in table 1.

The following conditions apply to the values:

- 80% value for connectors as per DIN EN 60512-5-2
- Contact in open air
- Maximum temperature at contact point: 180 °C

Table 1 – Current-carrying capacity values

Class	Cross section	Current-carrying capacity at specific ambient temperatures			
		65 °C	85 °C	125 °C	140 °C
1	2,5 mm^2	29 A	25 A	16 A	10 A
	4 mm^2	34 A	30 A	19 A	12 A
2	4 mm^2	50 A	45 A	35 A	30 A
	6 mm^2	70 A	60 A	50 A	40 A
3	10 mm^2	100 A	90 A	65 A	56 A
	16 mm^2	120 A	115 A	85 A	75 A
4 plugged-in contacts	16 mm^2	125 A	120 A	90 A	80 A
	25 mm^2	170 A	150 A	115 A	100 A
	35 mm^2	210 A	195 A	145 A	130 A
	50 mm^2	265 A	245 A	190 A	170 A

Class	Cross section	Current-carrying capacity at specific ambient temperatures			
		65 °C	85 °C	125 °C	140 °C
4 screwed contacts	16 mm^2	145 A	135 A	105 A	90 A
	25 mm^2	195 A	170 A	130 A	115 A
	35 mm^2	240 A	220 A	170 A	150 A
	50 mm^2	300 A	275 A	215 A	190 A
5 plugged-in contacts	70 mm^2	335 A	310 A	240 A	205 A
	95 mm^2	405 A	370 A	285 A	250 A
5 screwed contacts	70 mm^2	380 A	350 A	275 A	235 A
	95 mm^2	460 A	420 A	325 A	285 A

11.11 Contact resistance values

The following contact resistance values in table 2 must not be exceeded:

Table 2 – Contact resistance values

Wire cross section in mm^2	Crimp resistance		Contact resistance (total resistance including crimped connection)		Maximum test current in A
	Unused condition in mΩ	After aging in mΩ	Unused condition in mΩ	After aging in mΩ	
2,5	0,17	0,35	1,17	2,34	1
4	0,11	0,22	0,72	1,44	1
6	0,09	0,18	0,68	1,36	1
10	0,07	0,14	0,17	0,34	5
16	0,05	0,10	0,15	0,30	5
25	0,035	0,07	0,14	0,28	5
35	0,029	0,059	0,13	0,26	10
50	0,025	0,05	0,13	0,26	10
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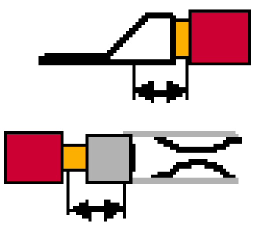
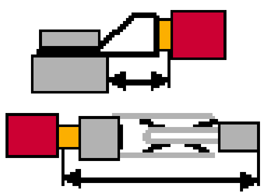
95	0,016	0,032	0,11	0,22	20
					

11.12 Insulation resistance

The insulation resistance must be measured as per DIN EN 60512-3-1. In the unused condition, the insulation resistance must be greater than 200 MΩ. At the end of the service life, the values as per VW 80303 must be adhered to for the whole HV wiring harness.

11.13 CPA

A CPA mechanism must be provided as an option. A CPA mechanism is not relevant for threaded connections

11.14 Tightness

It must be possible to plug in the HV plugging system at least 50 times without any negative effect on its tightness. The design of the sealing elements must be robust enough that plugging and unplugging the connectors in a dirty vehicle environment, e.g., when in a workshop, has no adverse effect on the tightness.

11.14.1 Plugged-in condition

When plugged in, regardless of the point of use (pollution degree 2), the HV plugging system must fulfill the following degrees of protection as per ISO 20653: IP6K9K, IPX7.

This applies to the entire connector, including the cables.

11.14.2 Sealing element and sealing surface design

The sealing element must be integrated exclusively on the wiring harness side. Sufficiently constant sealing compression across the entire sealing surface is absolutely required. Radial seal systems must be used. It must be ensured that all sealing surfaces and sealing elements are protected against mechanical damage.

There must not be any parting lines in the sealing area.

If the sealing element needs to be designed as a molded part, it must be positioned exactly and placed in a manner that will prevent it from rotating.

The sealing system must be designed in such a way that it will provide the required tightness at all tolerance zone positions for its entire service life.

11.14.3 Seal on cable side

The connector must have single-wire seals on the cable side.

The sealing elements must ensure that all cables being used will meet the required tightness specifications.

To prevent the sealing elements on the cable side from being directly exposed to splash water and water from steam-jet cleaners, a splash shield cap receptacle must be incorporated into the contact housing.

A longitudinal water seal based on a grommet between the cable and the contact housing is not permissible as a sole sealing solution.

11.15 Assembly capability

Due to system responsibility reasons, the contact manufacturer must define processing tools, including inserts (wear parts), and a processing specification and must provide these to the cable manufacturer. The DUTs for release testing must be finished on original tools as per the processing specifications.

Verification of cable manufacture feasibility under production conditions must be confirmed by an independent cable manufacturer.

The contact part manufacturer has system responsibility for the contact part.

The cable manufacturer is responsible for the crimping process in production.

It must be possible to remove or release unused contact parts and an unused secondary latching mechanism, if planned, and then re-engage them at least 3 times without any functional impairment.

Only the cable manufacturer may disassemble the contact part.

11.16 Geometric design of the shielding metal faces

For HV plugging systems made of plastic, the shielding must be realized with metal faces.

Nothing must interfere with joining the two metal faces (socket housing and unit), and joining the faces must not damage them or any other parts.

The metal face thickness must be selected in such a way that no mechanical damage will occur when the system is being plugged in.

The forces produced on the metal faces during the plugging and unplugging processes must not lead to any negative effects on the connector during its service life.

The metal face's thickness and the coverage provided by the metal face must ensure that all pertinent EMC requirements and HV safety requirements are met.

The sheet metal, surface, and springiness characteristics must be designed for at least 50 plugging cycles.

11.17 Selection of materials

Materials must be used that meet the pertinent functional requirements under the vehicle-specific usage conditions throughout the vehicle's entire service life.

Plastics from the appropriate insulation group must be used, so that the clearance and creepage distance as per DIN EN 60664-1 are adhered to.

Materials already released by the purchaser must be used. A release must be obtained from the appropriate department for any other materials.

11.18 Installability

Installation in the plant/ at the appropriate department's facilities must be verified. All installation-relevant measures must be supported by means of the connector construction so that they are reliable and safe during production.

11.19 Housing latching mechanism

Friction-locking housing latching mechanisms are not permissible.

11.20 Rubbing through the contact surface

An intact contact surface must still have, in the worst area of an active contact zone, at least 20% of the surface coating and a current-carrying capacity as per table 1.

If the surface coating falls below this value, the number of active contact zones that are needed for maintaining the required resistance value after aging as per table 2 must not fall below the required number of contact zones. The required number must be verified by FEM analysis (FEA).

Possible measurement methods are EDX, LineScan, and RFT.

Just measuring the contact resistance as sole verification is not permissible.

11.21 Housing locking mechanism

The locking mechanism must be symmetrical and have its engaging parts on two opposite sides.

The locking mechanism must be designed in such a way that it is possible to feel when it locks into place. Joining and locking must occur at the same time as a result of the respective mechanisms' design.

The active locking elements must be placed on the wiring harness side.

It must not be possible to unlock the mechanism unintentionally. It must not be possible to separate the two housing parts unless the locking mechanism has been released first.

11.22 Contact latching mechanism

The contacts must engage in a clearly perceptible/recognizable manner. It must be possible to insert the contact parts by hand.

11.23 Contact securing

Connectors must be designed in such a way that the contact parts are secured in the following manner:

– With a primary locking device when the contact is inserted into the contact cavity.
– Also with an independently acting, secondary locking device on the housing.
– Both active and passive secondary latching mechanisms are permissible.
– In its insertion position, the secondary latching mechanism (slider, flap, etc.) must be positioned in such a way that it cannot hinder the contact while it is being inserted. It is also permissible to insert the latching slider into the contact housing subsequently.
– The secondary latching mechanism's activation force must not exceed 40 N. It must be impossible to open or close the secondary latching mechanism by accident (transportation, handling, etc.).
– It must be impossible to open the secondary latching mechanism by accident. The secondary latching mechanism's engagement element must be able to withstand a force of at least 60 N. If the force it can withstand is less, this must be discussed with the appropriate department.
– The engagement elements must be stress-free in their final engagement position.
– The secondary latching mechanism's locking position must be visually recognizable.

The secondary latching mechanism must be designed in such a way that the contact housing can only be inserted if the mechanism is in its final engagement position.

12 Test sequence

Test sequence as per figure 2.

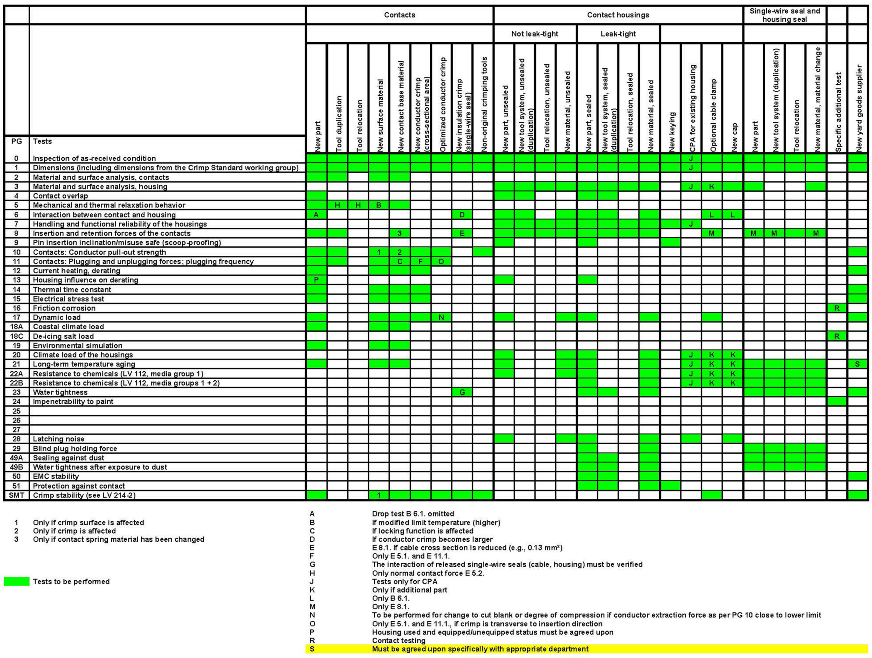


Figure 2 – Test sequence

Test sequence

13 Test groups

13.1 PG 0 – Inspection of as-received condition

As per VW 75174.

Supplementary to VW 75174 as per section 13.1.1, section 13.1.2, and section 13.1.3.

13.1.1 E 0.2.3

Volume resistance of the shielding R1 + R2 after PG 50 table 6; measuring method as per E 0.2.

The exact position of the measuring points must be documented.

Requirement

The measured values must correspond to the manufacturer’s specifications. The limits for R1 and R2 as per table 6 must be adhered to and the measurement values (initial value, standard deviation of the respective DUTs) must be documented accordingly in the test report.

13.1.2 E 0.3 Insulation resistance

In addition, the insulation resistance between all contacts, including HVIL, and the housing shielding must be measured.

The following must be measured:

1. Every HV potential to each other
2. Every HV potential to shielding
3. Every HV potential to HVIL
4. Shielding to HVIL

Measurements 2 and 3 can be performed together for galvanically connected HVIL and shielded contacts.

Requirement for measurements 1 – 3: R_{insul} > 200 MΩ at V = 1 000 V DC, t = 60 s

Requirement for measurement 4: R_{insul} > 100 MΩ at V = 500 V DC, t = 60 s

13.1.3 E 0.4

Dielectric strength for verifying the clearance (one-time test) as per VW 80303 test voltage 2 150 VDC for 60 s and leakage current < 10 mA.

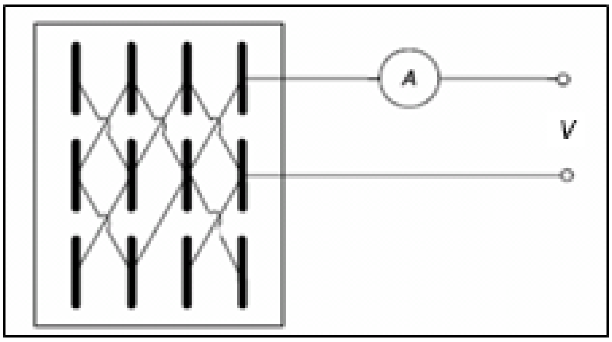


Figure 3 – Test setup

Housing insulation

Connect all circuits to each other (see figure 3) and wrap the outside of the DUT in conductive film.

Apply the test voltage between the film and the circuits for 1 min. Document the results.

Conductor insulation

Test each conductor individually by using the shield as the other reference point.

Apply the test voltage between the conductors, including HVIL, and the shield for 1 min. Document the results.

Requirement

During the test, no dielectric breakdown or flash-overs must occur between the individual chambers or between the chambers and the DUT's exterior.

13.2 PG 1 – Dimensions

As per VW 75174.

Supplementary to VW 75174:

E 1.3 Graphical verification (CAD) of clearance and creepage distance

13.3 PG 2 – Material and surface analysis, contacts

As per VW 75174.

13.4 PG 3 – Material and surface analysis, housing and single-wire seal

As per VW 75174.

Supplementary to VW 75174:

E 3.1 Testing of materials for housings and single-wire seals

Verification of the materials:

Creepage current classification (CTI values) in the paints being used or with the respective paint batch.

13.5 PG 4 – Contact overlap

As per VW 75174.

Requirement

The load, shielding, and HVIL contacts must be verified by means of computation using an arithmetic and statistical tolerance stack-up analysis for all contacts. The selection of the computation method must be agreed upon with the appropriate department.

13.6 PG 5 – Mechanical and thermal relaxation behavior

Load contacts as per VW 75174.

The following applies to HV threaded connections:

The threaded connection for the housing and cable lug must have an appropriate design for the component and must be checked during the release tests for the component, since the actual material combinations will only be available at that point.

13.7 PG 6 – Interaction between contact and housing

As per VW 75174.

Supplementary to VW 75174, after B 6.1, the insulation resistance must be determined as per E 0.3.

13.8 PG 7 – Handling and functional reliability of the housings

As per VW 75174.

Deviating from VW 75174, the housing holding force for round contacts with a diameter ≥ 8 mm is at least 350 N.

13.8.1 HV safety

The tensile force must be increased up to 2 times the housing holding force. If the connector disconnects from the interface during this increasing tensile force, it must not be possible to touch any live parts as per the requirement "IPXXB" as per ISO 20653. The tensile force must be introduced via the cable in the cable branch-off direction. For multi-pole housings with individual cables, the force must be introduced via an individual cable.

13.8.2 Keying

In addition to mechanical keying, the housing parts must have a clearly recognizable color marking as per table 3.

Table 3 – Color marking

Keying	Color	Similar to RAL
A	Black	9005
B	Natural/white	9010
C	Blue	5012
D	Violet	4004
E	Green	6017
F	Brown	8011
Z	Aqua blue	5021

13.8.3 Plugging force or actuation force for all classes

As per VW 75174.

If necessary, appropriate aids such as slides or levers must be provided on the connector.

13.9 PG 8 – Plugging and retention forces of the contact parts in the housing

As per VW 75174 if removal is planned.

Requirements on holding forces

The required holding forces must be generated by the primary locking device and the secondary locking device acting independently from each other. Starting from class 4, the contact pin retention force must be at least 450 N. The test must be performed as a pull-out test in the direction opposite the plugging direction and opposite the component placing direction of the contacts. If necessary, push-out tests must be performed in both directions.

13.10 PG 9 – Pin insertion inclination/misuse safe (scoop-proofing)

As per VW 75174.

Supplementary to VW 75174, shielding metal faces such as contacts must be examined and tested.

13.11 PG 10 Contacts: Conductor pull-out strength

As per VW 75174.

Supplementary to VW 75174, the following conductor pull-out strengths for copper cables must be adhered to:

35,0 mm^2 2 300 N

50,0 mm^2 2 800 N

70,0 mm²	3 400 N
95,0 mm²	4 200 N
120,0 mm²	4 800 N

The conductor pull-out strengths for aluminum cables must be agreed upon with the appropriate department.

For the shielding braid, the following pull-out strengths apply depending on the diameter of the HV cable released in the Volkswagen Group:

≤ 5 mm	≥ 50 N
> 5 mm ≤ 8 mm	≥ 150 N
> 8 mm ≤ 13 mm	≥ 300 N
> 13 mm	≥ 450 N

13.12 PG 11 – Contacts: Plugging and unplugging forces; plugging frequency

As per VW 75174.

Supplementary to VW 75174, all contacts of the contact housing (load, shielding, and HVIL contacts) must be tested. At least 50 plugging cycles are required.

E 11.2 Holding force protection against contact: A suitable device must be used to try to pull the protection-against-contact element.

Requirement

It must be verified that the protection-against-contact element can handle 2x the unplugging force, but a t least 50 N, of the contact pair against the plugging direction and, if there are installed elements, against the installation direction of the protection-against-contact cap.

13.13 PG 12 – Current heating, derating

As per VW 75174, the following applies for HV connectors:

For the screwed-in electrical connections, the following tightening torques (±10%) apply for steel bolts (property class 8.8 or higher) as a recommendation:

M6	8 Nm
M8	15 Nm
M10	25 Nm

The torque that is used and the threaded connection partner in the connection must be included in the test report.

Supplementary to VW 75174, only the contact part temperature is decisive for the derating. Cutting off the curve due to the conductor temperature must not be shown in the plot. The maximum conductor temperature 10 mm after the conductor connection area on the surface of the inner conductor insulation must be measured and indicated in the test report.

After each E 0.1, measure and document the contact resistances as per E 0.2 as well.

13.14 PG 13 – Housing influence on the derating

As per VW 75174.

Supplementary to VW 75174 as per section 13.14.1 and section 13.14.2.

13.14.1 E 13.2

Load contact/plug connection derating as per DIN EN 60512-5-2.

Plot the derating curves with a variable shielding current as well. The shielding current must be increased from 0 A in 10 A increments until either the maximum load contact temperature or the permissible temperature of the connector is reached.

13.14.2 E 13.3

Shielding derating as per DIN EN 60512-5-2.

Derating for the shielding contact must be created. The load contact does not carry a current here; the temperature at the contact point of the load conductor must be shown in the diagram.

13.15 PG 14 – Thermal time constant (current vs. temperature at n-times the nominal current)

As per VW 75174.

Supplementary to VW 75174, in addition to the heating time constant, the cooling curve must also be plotted.

13.16 PG 15 Electrical stress test

As per VW 75174.

Deviating from VW 75174, the testing is performed without the housing.

Supplementary to VW 75174, the crimping and volume resistance must be indicated individually for the test E 0.2.

The following applies to HV threaded connections:

B 15.1	Insert and disconnect the DUTs 2 times.

Supplementary to VW 75174, the resistance values as per table 2 must not be exceeded. The individual measurements for crimping and volume resistance must be performed before and after the loading.

13.17 PG 16 – Friction corrosion

As per VW 75174, as agreed with the appropriate department.

13.18 PG 17 – Dynamic loading

As per VW 75174.

Deviating from VW 75174:

– Vibration profile as per severity 3
– Temperature profile as per severity 4

The test setup must be tuned so that vibrations are not increased by the device connection.

The maximum cross section of the plugging system must be tested.

Both the HVIL and also the shielding contact must be tested as contacts.

The cables must be fastened using cable ties and harnessing tape (temperature resistant up to 140 °C, wrapped in 3 layers beneath the cable tie).

The cable must be fastened as per figure 4 in table 4. The position of the second fastening point can be chosen to suit test setup. The test setup and the tightening force of the cable fastening must be documented.

Table 4 – Cable support under mechanical loading

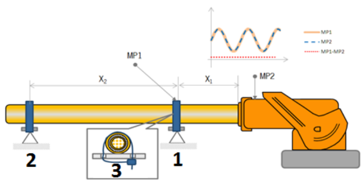
<table>
<tr><th rowspan="2">Example</th><th rowspan="2">Fastener</th><th rowspan="2">Class</th><th colspan="2">Fastening point 1</th><th>Fastening point 2</th></tr>
<tr><th>×1 for severity 2</th><th>×1 greater than severity 2</th><th>×2 all severities</th></tr>
<tr><td rowspan="2">

Figure 4 – Cable support under mechanical loading
1. Fastening point 1
2. Fastening point 2
3. Cable tie</td><td rowspan="2">Cable tie, temperature-resistant up to 140 °C, width 4,6 mm. Wrapped in 3 layers beneath the cable tie. Tensile force must not negatively affect the insulation resistance</td><td>1 – 3</td><td>To be indicated by the manufacturer</td><td>200 mm</td><td>250 mm</td></tr>
<tr><td>4 – 5</td><td>200 mm</td><td>100 mm</td><td>250 mm</td></tr>
</table>

Rubbing through of the effective contact surface is not permissible. Corresponding verification must be provided.

The resistance values in table 2 must not be exceeded.

Supplementary to VW 75174 after E 0.2:

E 0.2.3 Shielding contact resistance

13.19 PG 18A – Coastal climate load

Omitted

13.20 PG 18C – De-icing salt load

As per VW 75174.

Deviating from VW 75174, the following applies: Only in the plugged-in state

B 18.3 Severity 5 (DIN EN IEC 60068-2-52)

Salt mixture (Nordic country salt): 3% salt solution, of which 95% is NaCl, 2,5 % is $MgCl_2$, and 2,5 % is $CaCl_2$

Supplementary to VW 75174:

E 0.2.3 Shielding contact resistance

As per E 0.2:

B 23.1 Immersion with pressure difference

E 0.3 Insulation resistance

E 0.1 Visual inspection

The resistance values in table 2 must not be exceeded.

For metal housings, the base material must not be corroded.

It must be possible to disconnect the connector without a tool after the test (exception: Threaded connection or bolted housing). Appropriate verification must be presented in the test report.

13.21 PG 19 – Environmental simulation

As per VW 75174.

Deviating from VW 75174

- Housing sealed
- Not applicable B 19.4

Supplementary to VW 75174 after E 0.2:

E 0.2.3	Shielding contact resistance The contact surface required for proper operation must not be worn all the way through to the base material or barrier layer. Corresponding verification must be provided.
B 19.5	In addition, insulation resistance continuously as per E 0.3 Measurement frequency: 10 measurement values per minute During the loading, the insulation resistance value may fall below the specified value by up to 50 MΩ.

13.22 PG 20 – Climate load of the housing

As per VW 75174.

13.23 PG 21 – Long-term temperature aging

As per VW 75174.

Deviating from VW 75174:

Group 2	10 fully equipped housings. Drop test B 6.1 with only 5 DUTs from group 2, remaining DUTs from group for E 8.2

Supplementary to VW 75174 after E 0.2:

E 0.2.3	Shielding contact resistance

13.24 PG 22A – Resistance to chemicals

Omitted

13.25 Resistance to chemicals, extended test

As per VW 75174.

Deviating from VW 75174:

- All media from media list, table E.1
- Battery electrolyte test from media list omitted

13.26 PG 23 – Water tightness

As per VW 75174.

Supplementary to VW 75174:

Group 3 — 5 fully equipped contact housings for analyzing tightness after multiple plugging cycles

After B 19.1 only for group 3:

B 11.1 — Plugging cycle test

Deviating from VW 75174; all tests must be performed with at least 0,5 m cable length:

B 23.1 — Cable ends closed

B 23.2 — Cable ends closed

B 23.3 — The dwell time in air must be selected so that the connector is completely heated through.

To ensure this, a reference DUT is equipped with a temperature sensor in the interior, immersed once in ice water, and then heated in air (heating cabinet) until a temperature of 120 °C ±5% has settled in the interior of the connector.

A constant supply of heat and sufficient capacity of the heating cabinet must be ensured. The time until the DUT is completely heated through must be indicated in the test report.

The water temperature may increase by a maximum of 3 K during the loading.

The cable ends must be closed as per table 5:

Table 5 – Cable closure

Number of shielded individual cables	Cable ends
= 1	Open
≥ 2	One cable open, others closed
Multiple-core, shielded and sheathed cable	Open

When plugged in, regardless of the point of use (pollution degree 2), the HV plugging system must fulfill the following degrees of protection as per ISO 20653: IP6K9K and IPX7.

This applies to the entire connector, including the cables.

During the loading, the insulation resistance value may fall below the specified value by up to 50 MΩ.

13.27 PG 24 – Impenetrability to paint

Omitted

13.28 PG 28 – Latching noise

As per VW 75174.

13.29 PG 29 – Blind plug holding force

As per VW 75174, if the parts are intended for the project.

13.30 PG 49A – Imperviousness to dust

This test simulates the dust load of the component during vehicle operation.

Batch size: 6 housings
Contact parts: Fully equipped housing
Contact housings: Sealed, all cross sections, keying, and colors discretionary

Cable ends closed.

Test type:

B 49	Imperviousness to dust as per ISO 20653 Test duration: 20 cycles of 20 min each
E 0.1	Visual inspection The required degree of protection as per ISO 20653 must be achieved.

13.31 PG 49B – Water tightness after dust load

This test simulates the water tightness after the dust load.

Batch size: 6 housings

Cable ends closed.

Test type:

B 49	Imperviousness to dust as per ISO 20653
B 49.1	After the end of the test of B 49, all connectors are unplugged completely once and replugged without cleaning. The plugging and unplugging processes must be performed in different spatial axis for each DUT, in order to simulate all possible as-installed positions.
B 23.1	Immersion with pressure difference. Cable ends closed.
E 0.3	Insulation resistance
E 0.1	– Visual inspection – It must be possible to open and close the connector without damage after the testing. There must be no leaks after the loading.

13.32 PG 50 – EMC testing (high-frequency properties of an HV connector)

13.32.1 Average wave impedance

Determining the average wave impedance of the DUT with capacitance and transit time must be performed as per DIN EN 50289-1-11.

13.32.2 Surface transfer impedance

Based on VG 95214-11, the test must be conducted within a frequency range of 100 kHz to 500 MHz. The difference between a reference cable (bulk) and a finished cable must be measured. The total length of the DUT is 1 000 ±100 mm from the terminal resistance Z_3 to the receiver connection (see figure 5).

13.32.3 Measurement setup and coupling cable

VG 95214-11 describes the test setup.

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 shield resistance of the EUT without the measuring contact systems.

The asymptotic wave impedance value that results at high frequencies as per section 13.32.1 must be used as the terminal resistance for the DUT. The terminal resistances Z_0 and Z_3 must be suitable for HF in the entire frequency range.

Carbon film and wire-wound resistors must not be used. A reflection measurement on the network analyzer (NWA) can be carried out on the resistors in order to check their frequency stability. The resistors must be inserted into an N connector for this purpose. The reflection factor can be improved by connecting several SMD resistors in parallel.

The entire measurement setup must be operated in isolation (no grounding surfaces). The NWA provides the reference ground. It must be ensured that there are no metallic objects in the vicinity of the setup (minimum clearance: 20 cm).

The coupling characteristics must not change during the measurement. For this purpose, the power supply cable in particular must be secured in such a way that there is continuous contact between the power supply cable and the DUT. The power supply cable's reflection factor must be up to 30 MHz < -20 dB and up to 110 MHz < -10 dB.

The measurement must be performed at the receiver and sender with a system impedance of 50 Ω. Any impedance mismatch must not be corrected. In particular, this means that impedance matching circuits, as well as the NWA's port Z conversion function, must not be used. (This is to prevent the measured result from depending on the quality of the impedance matching circuit setup or from conversion algorithms by different NWA manufacturers.)

13.32.4 Requirements

The following requirements apply for applications with DC cables up to maximum 6 m and AC cables up to 1 m. For longer HV cable lengths, the appropriate limits must be agreed upon with the EMC department. All values must be adhered to throughout the service life (see table 6 and table 7).

Table 6

Initial condition			Requirements
DC resistance of the cable shielding braid			< 3 mΩ/m
DC contact resistance of the contacts	Cable shield – connector shield	R_1	< 3 mΩ
	Connector shield – header shield	R_2	< 4 mΩ
	Header shield – unit	R_3	< 3 mΩ
Transfer impedance of yard goods at 2 MHz			< 5 mΩ/m
Transfer impedance of yard goods at 30 MHz			< 90 mΩ/m
Delta transfer impedance, terminated on one end, at 2 MHz			< 10 mΩ
Delta transfer impedance, terminated on one end, at 30 MHz			< 50 mΩ

Table 7

After aging			Requirements
DC contact resistance of the contacts after aging	Cable shield – connector shield	R_1	< 3 mΩ a)
	Connector shield – header shield	R_2	< 4 mΩ a)
	Header shield – unit	R_3	< 3 mΩ a)

a) Significant differences between the initial condition and after service life testing (> factor of 2) must be indicated in regard to the underlying physical mechanism.

13.32.5 Measurement

Batch size: 3 housings

Contact parts: All occurring variants, conductor cross-sectional areas, and surfaces

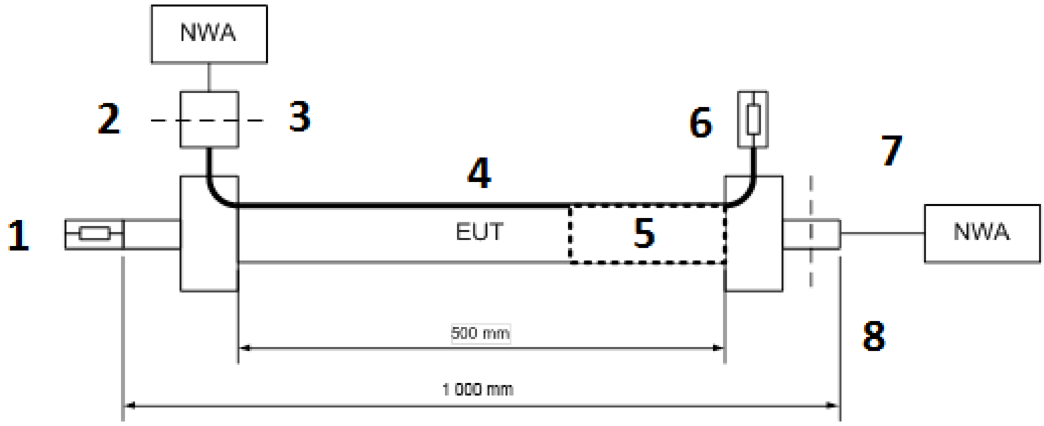
Contact housings: All occurring variants, any keying, and any color

The measurement must be performed with the "far-end" configuration.

The difference between a reference cable and a cable terminated on one end must be measured. The cable terminated on one end consists of the reference cable and the high-voltage contact system being evaluated. As the reference cable, an HV cable released in the Volkswagen Group must be used. The chosen cable's cross-sectional area must match the connector's permissible cross-sectional area.

For a multi-core cable, the cores must be connected in parallel if an overall shielding is used. In the case of contact systems with multiple shielded individual cables that use a common contact carrier, the EMC department must be consulted to determine whether the individual cables need to be measured separately or whether a combined measurement with all the shields needs to be performed.

The measurement must be performed at 3 positions within the DUT's perimeter. For this purpose, the DUT must be turned 120° relative to the power supply cable. It must be ensured that the power supply cable is carefully secured and impedance-matched for every measurement.



Legend

1	Average wave impedance Z_3
2	Calibration-level transmitter
3	Supply connection
4	Supply wire
5	Contact system (l_{CS}: Length of the contact system)
6	Resistance Z_0 (50 Ω)
7	Calibration-level receiver
8	Receiver connection

Figure 5 – Parallel wire method setup

"OSL" (open-short load) and "Thru" must be used as the calibration methods.

The measurements must be performed from 100 kHz to 500 MHz.

13.32.6 Evaluation

The surface transfer impedance Z_T must be calculated for the evaluation. The conversion of the measured transfer attenuation A_T into the surface transfer impedance Z_T is based on formula 2 from section 6.2.3 in VG 95214-11 and is simplified by the assumption from formula (1):

$$Z_R = Z_T = Z_0 = 50\ \Omega \qquad (1)$$

Legend

Z_R	Input impedance of the measurement receiver in Ω
Z_T	Output impedance of the measurement transmitter in Ω
Z_0	Supply wire terminal resistance (50 Ω)

for formula (2):

Length-weighted transfer impedance of bulk reference cable

$$Z_T = \frac{(Z_3 + 50\ \Omega)}{l} \cdot 10^{-\frac{A_T}{20}} \qquad (2)$$

Legend

Z_T	Surface transfer impedance in mΩ/m
Z_3	DUT's terminal resistance (the DUT's average wave impedance)
l	DUT's coupling length (as per figure 5: l = 0,5 m)
A_T	Measured level on network analyzer/voltage ratio, in dB, between measuring receiver and measuring sender.

Compared with VG 95214-11, the length reference in formula (2) is omitted.

Transfer impedance of finished DUT

$$Z_{T(terminated)} = (Z_3 + 50\ \Omega) \cdot 10^{-\frac{A_T}{20}} \tag{3}$$

The transfer impedance delta (requirement from table 6) is computed as per formula (4):

-

$$Z_{T(Delta)} = Z_{T(terminated)} - (l - l_{CS}) \cdot Z_T \tag{4}$$

Legend

l_{CS}	Length of the contact system

The determination of the DUT's average wave impedance must be documented in the test report.

In the test report, the measurement results from all angles must be documented for each DUT. This includes the recording and plotting of the reflection factor for the power supply cable, the transfer impedance of the cable that is finished on one side and the unfinished cable, and the computation of the delta transfer impedance.

13.33 PG 51 – Protection against contact

The purpose of this test is to verify the protection against contact.

Batch size:	1 housing
Contact parts:	All variants, largest conductor cross section, and any surface
Contact housings:	All occurring variants, any keying, and any color

Test type:

E 51.1	Protection against contact (ISO 20653)

Requirements:

- A completely assembled HV connector system must fulfill the degree of protection "IPXXD" as per ISO 20653.
- An HV connector system that is not completely assembled must fulfill the degree of protection "IPXXB" as per ISO 20653.
- The access probe must not come into contact with hazardous (live) parts.
- The lamp must not turn on in the signal circuit method.

The access probe (for an example, see figure 6, see DIN EN 60529) is pressed against each opening of the housing with a force of 10 N ±10%. If it penetrates partially or completely, it is moved into every possible position. However, the locating surface must not go completely through the opening under any circumstances.

Possible mechanical parts must be moved slowly during the test.

When performing tests on low-voltage operating equipment, a low-voltage power source (not lower than 40 V and not higher than 50 V) must be connected in series with a suitable lamp between the probe and the hazardous parts inside the housing (signal circuit method).

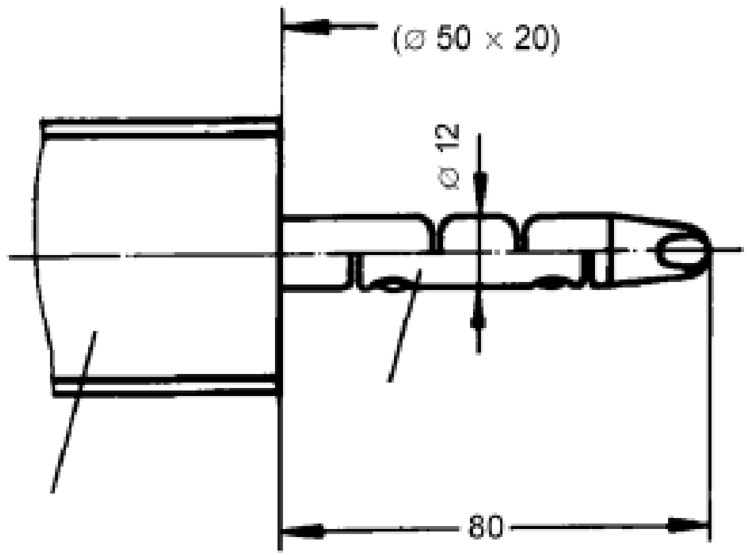


Figure 6 – German Commission for Electrical, Electronic & Information Technologies of DIN and VDE (DKE) test finger as per DIN EN 60529.

14 Applicable documents

The following documents cited are necessary to the application of this document:

Some of the cited documents are translations from the German original. The translations of German terms in such documents may differ from those used in this standard, resulting in terminological inconsistency.

Standards whose titles are given in German may be available only in German. Editions in other languages may be available from the institution issuing the standard.

VW 75174	Motor Vehicle Connectors; Tests
VW 80303	Electrical Characteristics and Electrical Safety of High-Voltage Components in Road Vehicles; Requirements and Tests
DIN EN 50289-1-11	Communication Cables – Specifications for Test Methods – Part 1-11: Electrical Test Methods – Characteristic Impedance, Input Impedance, Return Loss; German version EN 50289-1-11:2016
DIN EN 60068-2-31	Environmental Testing – Part 2-31: Tests – Test Ec: Rough Handling Shocks, Primarily for Equipment-Type Specimens (IEC 60068-2-31:2008)

DIN EN 60512-2-2	Connectors for electronic equipment - Tests and measurements - Part 2-2: Electrical continuity and contact resistance tests - Test 2b: Contact resistance - Specified test current method
DIN EN 60512-3-1	Connectors for electronic equipment - Tests and measurements - Part 3-1: Insulation tests; Test 3a: Insulation resistance
DIN EN 60512-5-2	Connectors for electronic equipment - Tests and measurements - Part 5-2: Current-carrying capacity tests; Test 5b: Current-temperature derating
DIN EN 60529	Degrees of Protection Provided by Enclosures (IP Code) (IEC 60529:1989 + A1:1999 + A2:2013); German version EN 60529:1991 + A1:2000 + A2:2013
DIN EN 60664-1	Insulation Coordination for Equipment Within Low-Voltage Systems – Part 1: Principles, Requirements, and Tests
DIN EN IEC 60068-2-52	Environmental Testing – Part 2-52: Tests – Test Kb: Salt Mist, Cyclic (Sodium Chloride Solution) (IEC 60068-2-52:2017); German version EN IEC 60068-2-52:2018
ISO 20653	Road vehicles - Degrees of protection (IP code) - Protection of electrical equipment against foreign objects, water and access
ISO 6469-3	Electrically propelled road vehicles - Safety specifications - Part 3: Electrical safety
VDA Volume 3 Part 2	Quality Management in the Automotive Industry – Part 2: Reliability Assurance for Automobile Manufacturers and Suppliers – Reliability Methods and Aids
VG 95214-11	Test of components - Part 11: Measuring methods for transfer impedance and screening attenuation, transfer impedance of screened components (line-injection method, KS 11 B)