VOLKSWAGEN AG

Group Standard

VW 75206-1

2008-10

Class. No.: 69378

Descriptors: cable, radio-frequency cable, antenna cable, coaxial cable

Radio-Frequency Cables in Motor Vehicles

Coaxial Cables

Preface

This standard in the present issue is based on template LV 213-1, which was drawn up by representatives of automobile manufacturers Audi AG, BMW AG, Daimler AG, Porsche AG, and Volkswagen AG.

Deviations from LV 213-1 are shown in italics in this standard. If modifications to individual test sections become necessary in individual cases, these must be agreed upon separately between the responsible engineering department and the relevant manufacturer.

Test reports are accepted as long as the tests were performed by an independent testing institute that is accredited according to DIN EN ISO/IEC 17025. Acceptance of the test reports does not automatically result in a release.

Previous issues

2006-05

Changes

The following changes have been made as compared to Volkswagen standard VW 75206:
2006-05:

– Standard converted to a standard series: This is Part 1. Part 2 addresses non-coaxial radio-frequency cables.
– Standard completely revised

Technical Responsibility	Standards
	I/EZ-11 Heinz J. Winkler
EEB/5 Dr. Liane Wiegel Phone: +49 5361 9 36678	Phone: +49 841 89 30965

Contents Page

Contents Page

1 Scope

Individual coaxial cable for radio-frequency signals in motor vehicles

2 General information

This standard only applies to new designs. Cables already used in standard production do not have to be modified. Subsequent changes in material, dimensions, manufacturing processes, etc. must be reported to the respective design engineering departments; these may require a new release.

The test scope of this standard and special test conditions in individual cases must be defined in cooperation with and approved by the responsible engineering departments.

Parameters, for which no specified limits exist, are labeled as “informative” in Volkswagen standard VW 75206-1 Supplement 1.

Requirements are defined in this standard for existing standard cables.

Radio-frequency cables that are not named in this standard must be tested according to this standard and the values determined must be entered in Supplement 1. Requirements for these cables must be defined in coordination with the customers’ engineering departments.

Note

VW 75206-1 contains no requirements for a tensile test on the cable alone. The tensile test requirements for the cable are to be tested according to VW 75174 (evaluation criteria: pull-out strength, return loss, contact resistance).

3 Description

Description according to VW 75206-1: Manufacturer's number - Koax – 50 - 2,1 - 3,3/T105 - (...)

Where:

Description, see Table 1

Manufacturer’s number	Identification number of the cable assigned by the cable manufacturer
Koax	Cable design
50	Impedance value in Ω
2,1	Dielectric diameter in mm
3,3	Sheath diameter in mm
/T105	Long-term service temperature (3 000 h)
(...)	Placeholder for any suffixes required (e.g. LL for Low Loss)

Cable imprint:

Manufacturer - Manufacturer's number - Koax – 50 - 2,1 - 3,3/T105 - (...)

Table 1 Descriptions, examples

Old description	New description, examples
RTK 31 105 °C	Koax-50-2,1-3,3/T105
RG 58	Koax-50-2,95-4,95/T85
RG 174	Koax-50-1,5-2,8/T85
RG 174	Koax-50-1,5-2,8/T105
RG 178	Koax-50-0,8-1,8/T105
RG 179	Koax-75-1,7-2,7/T105

Cables that do not permit such a cable imprint are marked in consultation with the responsible engineering department.

4 Specimens

If not otherwise specified, three specimens in as-received condition must be tested in each case.

For each test (if not otherwise specified), only specimens that have not been used in previous tests must be used. The preparation of specimens according to 0 is permissible.

If no more than one of the three specimens fails a test, the test will be repeated with ten specimens. In this case, all of the ten specimens must then pass the test, i.e., the test is not passed if one specimen fails in the repeat test.

If more than one specimen fails, a repetition with 10 specimens is not possible; the test is considered not passed.

The cable under test is connected with 50 Ω SMA connectors (as listed, for example, in 0) or 75 Ω N-connectors. If there are no suitable SMA connectors or N connectors available, adapters that do not influence the measurement result to an impermissible degree can be used. This must be documented.

5 Test matrix

The requirements listed in this Section must be determined according to Table 2 (footnotes at the end of the table).

Table 2 Test matrix

Section	Test	Cable	Sheath	Screen/foil	Dielectric	Inner conductor	Radio-frequency and electrical properties according to VW 75206-1, Section:	Release test	Reduced release test	Site test	Change of primary materials	Requalification	Process test
	Short test scope designation							**A1**	**A2**	**B**	**C**	**D**	**E**
8	Cable structure	X						X	X	X	X	X	
8.1	Material					X		X	X	X	X	X	
8.1	Number of wires					X		X	X	X	X		
8.1	Conductor resistance					X		X	X	X	X		X
8.1	Single-wire diameter					X		X	X	X	X		
8.1	Total diameter					X		X	X	X	X		
8.2	Diameter				X			X	X	X	X		X
8.2	Material and physical properties				X			X	X	X	X		
8.3	Foil thickness			X				X	X	X	X		
8.3	Foil overlap			X				X	X	X	X		
8.3	Method of foil application			X				X	X	X	X		
8.4.1	Material of metallization			X				X	X	X	X		
8.4.1	Foil thickness			X				X	X	X	X		
8.4.1	Position of metallization			X				X	X	X	X		
8.4.1	Method of foil application			X				X	X	X	X		
8.4.1	Overlap			X				X	X	X	X		
8.4.2	Structure			X				X	X	X	X		
8.4.2	Material and surface			X				X	X	X	X		
8.4.2	Number of wires			X				X	X	X	X		
8.4.2	Single-wire diameter			X				X	X	X	X		
8.4.2	Optical coverage			X				X	X	X	X		
8.4.2	Diameter			X				X	X	X	X		
8.5	Material		X					X	X	X	X		
8.5	Wall thickness		X					X	X	X	X		
8.5	Outer diameter		X					X	X	X	X	X	X

Section	Test	Cable	Sheath	Screen/foil	Dielectric	Inner conductor	Radio-frequency and electrical properties according to VW 75206-1, Section:	Release test	Reduced release test	Site test	Change of primary materials	Requalification	Process test
8.5	Color		X					X	X	X	X		X
8.5	Imprint		X					X	X	X	X		X
8.6	Temperature class	X						X	X	X	X	X	
9	Radio-frequency properties in as-received condition												
9.1	Insertion loss	X						X	X	X	X	X	X [1)]
9.2	Mean wave impedance												
9.2.1	Capacitance	X						X	X	X	X	X	X[1)]
9.2.2	Running time	X						X	X	X	X	X	
9.2.3	Determination of mean wave impedance	X						X	X	X	X	X	
9.3	Return loss	X						X	X	X	X	X	
9.4	Surface transfer impedance	X						X	X	X	X		
9.5	Screening loss	X						X	X	X	X		
10	Mechanical properties												
10.1	Insulation strippability		X		X			X	X	X	X	X	
10.2	Abrasion resistance	X						X	X	X	X	X	
10.3	Bending force [2)]	X						X			X		
10.4	Flame retardance	X						X	X		X	X	
10.5	Bending test												
10.5.1	Static bending test	X					9.3[3)], 9.4	X			X	X	
10.5.2	Dynamic bending test	X					9.3, 9.4, 9.5, 10.7.3	X	10.7.3				
10.5.3	Torsional endurance test	X					9.1, 9.2, 9.3, 9.4, 9.5, 10.7.3	X					
10.6	Physical and chemical properties												
10.6.1	Density		(X)		(X)			(X)			(X)		
10.6.2	Extractable portions		(X)					(X)			(X)		
10.6.3	Viscosity number/heat-transmission coefficient		(X)					(X)			(X)		

Section	Test	Cable	Sheath	Screen/foil	Dielectric	Inner conductor	Radio-frequency and electrical properties according to VW 75206-1, Section:	Release test	Reduced release test	Site test	Change of primary materials	Requalification	Process test
10.6.4	Temperature at 5% weight loss		X					X			X		
10.6.5	Ignition residue		X					X			X		
10.6.6	Thermal stability		X					X		X	X		
10.6.7	Determination of the infrared spectrum		X		X			X	X	X	X	X	
10.6.8	Tensile strength/elongation at tear		X		X			X	X	X	X	X	
10.6.10	Determination of cross-linking density		(X)		(X)			(X)		(X)	(X)	(X)	
10.6.11	Microhardness		X		X			X		X	X		
10.6	Electrical properties												
10.7.1	Specific volume resistance		X		X			X	X SHEATH				
10.7.2	Dielectric strength		X		X			X	X	X	X		
10.7.3	1-minute dielectric strength (e.g., after aging)		X		X			X					
10.8	Mechanical and electrical properties after mechanical, thermal, or chemical stress												
10.8.1	Shrinkage under heat [4)]	X	X		X			X	X	X		X	X
10.8.2	Compressive strength under heat	X					9.3	X					
10.8.3	Thermal overload[4)]	X					9.1, 9.2, 9.3,10.7.3	X					
10.8.4	Short-term aging (240 h)	X					9.1, 9.2, 9.3, 9.4, 9.5, 10.7.3	X	9.1, 9.2, 9.3, 10.7.3 [6)]	X	X	9.1, 9.2, 9.3	
10.8.5	Long-term aging (3 000 h) [5)]	X					9.1, 9.2, 9.3, 9.4, 9.5, 10.7.3	X	9.1, 9.2, 9.3, 10.7.3 [6)]				
10.8.6	Low-temperature winding test	X					9.1, 9.2, 9.3, 9.5, 10.7.3	X	9.5, 10.7.3	X	X	9.1 9.2 9.3. 10.7.3	

Section	Test	Cable	Sheath	Screen/foil	Dielectric	Inner conductor	Radio-frequency and electrical properties according to VW 75206-1, Section:	Release test	Reduced release test	Site test	Change of primary materials	Requalification	Process test
10.8.7	Low-temperature impact test (-15 °C)	X					10.7.3	X					
10.8.8	Resistance of cable marking to wiping	X						X					
10.8.9	Electrical properties during aging in water	X					9.1, 9.2, 10.7.3	X	9.1, 9.2, 10.7.3 [6)]				
10.8.10	Humid heat, constant	X					9.1, 9.2, 9.3, 9.4, 9.5, 10.7.3	X					
10.8.11	Ozone resistance	X						X					
10.9	Mycological test (like VW 60306-1)	X						X					
10.10	Compatibility tests												
10.10.1	Resistance to agents ISO 6722	X						X					
10.10.2	Resistance to operating fluids and wrapping tapes	X						X					
10.10.3	Resistance to wiring harness components	X						X					

[1)] The test method may deviate from the test described in this standard. Any deviating method must be indicated.

[2)] Only after consultation

[3)] Must be measured during the test

[4)] The test is only to be performed if the overload test temperature is below the specified melting temperature of the dielectric.

[5)] Only for new cables to be qualified

[6)] Only at RT

(X) not possible for all materials

Test scope A1 = release test

Complete testing of cables. Introduction of new cables.

Test scope A2 = reduced release test

Introduction of new cables with released material combinations (same manufacturer) with similar structure as a cable tested with the A1 test scope.

- For static routing
- For highly-stressed cables, testing described in 10.5.2 and 10.5.3 is also required.

A prerequisite for test scopes B to E is a release according to A1.

Test scope B = site test

Identical cable with same compound, different site of same cable manufacturer

Test scope C = change in primary material

If the composition of the compound and the percentage fractions are unchanged and

- with chemically identical primary materials supplied by different sub-contractors or
- with change of compound manufacturing site

The procedure in the case of minor compound modifications must be agreed upon with the engineering departments.

Test scope D:

Regularly at least after every 5 years.

Test scope E:

Recommended process-accompanying test (e.g., batch-related or continuously)

- The supplier bears responsibility for process assurance.

Visual inspection: The sheath must be removed or the cable x-rayed, and the screen and the inner conductor must be checked for damage.

The requalification tests and process tests may be performed by the cable manufacturer.

The process tests are recommended tests, and the supplier is responsible for process reliability.

6 Test climate

If no other test climate is specified, testing will be carried out in the DIN 50014-23/50-2 standard climate.

Prior to testing at T_{min} and T_{max}, the cables must be aged at the test temperature for at least 4 h and at most 6 h. The measurement apparatus is located outside the climatic chamber. Only the connectors that are needed for connecting to the measurement apparatus (outside the chamber) are pre-assembled on the cable under test.

The temperatures specified apply to the release test only.

7 Documentation

The test results are documented in a test report that contains all the information required according to DIN EN ISO/EC 17025 and the test results. In particular, this includes a list and possibly also a description of test equipment and auxiliary test equipment used, as well as the indication of measurement uncertainties (this does not mean that accreditation of the cable manufacturers' laboratories would be required).

The discrete values listed in VW 75206-1 Supplement 1 must be entered into the corresponding table.

In addition, the radio-frequency properties to be determined according to Section 9 must be documented in the form of graphs.

All the test results (including those for specimens that failed) must be documented.

8 Cable structure

8.1 Inner conductor

The following information must be determined and entered into VW 75206-1 Supplement 1:

- Material; type and quality of surface (e.g., for tin-plated Cu, information according to DIN EN 13602: Cu ETP1-A013-A) as specified by the manufacturer
- Number of wires
- DC conductor resistance in Ω/m
- Single-wire diameter in mm
- Total diameter in mm

8.2 Dielectric

The following information must be determined and entered into VW 75206-1 Supplement 1:

- Diameter in mm
- Material and physical properties of material (e.g., "foamed")

8.3 Separating foil, non-metallic

The following information must be determined and entered into VW 75206-1 Supplement 1:

- Material
- Foil thickness in µm
- Overlap in %
- Method of foil application (e.g. lengthwise or as bands)

8.4 Screen

8.4.1 Metallic foil

The following information must be determined and entered into VW 75206-1 Supplement 1:

- Material of metallization (e.g., aluminum-laminated polyester foil)
- Foil thickness in µm and indication of nominal value of metal layer thickness in µm
- Position of metallization (with screen contact or without screen contact)
- Method of foil application (e.g. lengthwise or as bands)
- Overlap in %

8.4.2 Wire screen

The following information must be determined and entered into VW 75206-1 Supplement 1:

- Structure (braid = C or helix = D, metallized foil = B; code letters as in DIN 76722)
- Material and surface of wires (e.g., for tin-plated Cu, information according to DIN EN 13602: Cu ETP1-A013-A) as specified by the manufacturer
- Number of wires
- Single-wire diameter in mm
- Optical coverage in % according to Section 4.4 of DIN EN 50117-1
- Diameter over screen in mm

8.5 Sheath

The following information must be determined and entered into VW 75206-1 Supplement 1:

- Material
- Microhardness measured on sheet material and on cable (see 10.6.11)
- Wall thickness in mm
- Outer diameter in mm
- Color
- Imprint, marking (manufacturer's code, cable type, temperature class). The production date is currently not given on the cable but on the drum. Retraceability must be possible via the assembler's documentation.

8.6 Temperature class

The temperature classes according to VW 60306-1 are used in the marking and must be entered into VW 75206-1 Supplement 1.

9 Radio-frequency properties (RF properties)

The upper cutoff frequency for all measurements on 75 Ω cables is set at 3 GHz for physical reasons.

9.1 Insertion loss

The following values must be determined and entered into Table 1 in VW 75206-1 Supplement 1:

- Insertion loss in dB/100 m in the frequency range from 50 MHz to 6 000 MHz (informative above 5 600 MHz) according to DIN EN 50289-1-8 for 50 Ω cables
- Representation of measurement results versus frequency in the form of a graph

The requirements in Table 3 must be met.

Table 3 Maximum values for insertion loss at room temperature (RT) in dB/100 m

Frequency MHz	Koax-50-1,5-2,8/T85	Koax-50-2,95-4,95/T85	Koax-50-0,8-1,8/T105	Koax- 75-1,7-2,7/T105	Koax-50-2,1-3,3/T105
50	20,9	11,0	35,2	22,4	12,9
100	30,2	16,6	51,8	29,4	17,9
400	66,2	37,4	119	58	36,3
800	99,9	58,6	185	85	53,0
900	107,2	63,4	200	91	56,6
1 000	114,3	68,0	214	97	60,1
1 500	146,9	90,0	282	124	76,0
1 900	170,4	106,4	333	143	87,4
2 000	176,1	110,3	345	148	90,2
2 100	181,6	114,3	358	153	92,9
2 400	197,9	125,9	393	166	100,7
2 500	203,2	129,7	405	171	103,2
3 000	228,8	148,4	463	192	115,5
5 600	347,7	239,0	740	X	172,0

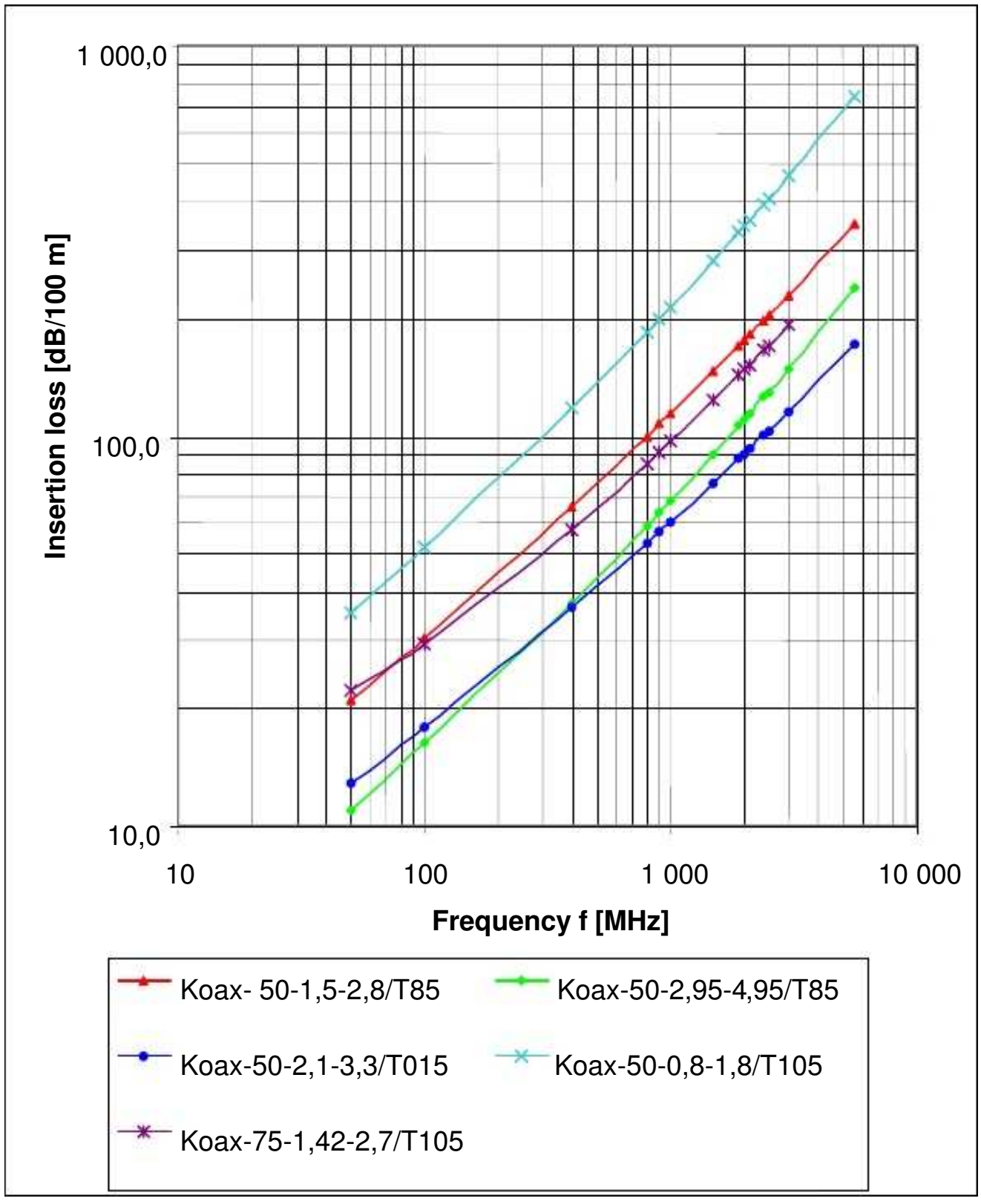

Figure 1 Maximum insertion loss at RT

Other test conditions:

- Test temperature: RT, T_{min}, T_{max} (room temperature, minimum temperature, maximum temperature)
- The length is 10,0 m, of which 8,0 m are in the climatic chamber

Note:

$$Loss[dB/100m] = a + b \cdot f[MHz] + c \cdot \sqrt{f[MHz]} + d / \sqrt{f[MHz]}$$

Formula 1

Maximum values have been established for the insertion loss in [dB/100 m] at room temperature by specifying 4 coefficients (a, b, c, d). These coefficients were determined by curve fitting of actual

measurement series and adjusted by an appropriate safety margin (10%) to make allowance for production tolerances.

Table 3 and Figure 1 have been calculated according to formula 1 and serve as an illustration.

Table 4 shows the coefficients:

Table 4 Parameters for insertion loss at room temperature

	a	b	c	d
Koax-50-1,5-2,8/T85	-3,37	0,0227	2,99	14,3
Koax-50-2,95-4,95/T85	-0,0168	0,0241	1,39	0
Koax-50-0,8-1,8/T105	-2,2	0,0711	4,59	9,49
Koax-75-1,7-2,7/T105	2,44	0,0213	2,29	18,9
Koax-50-2,1-3,3/T105	1,31	0,00976	1,55	1,16

9.2 Mean wave impedance

9.2.1 Capacitance

The following values must be determined and entered into Table 1 in VW 75206-1 Supplement 1:

- Capacitance in pF/m measured at 1 kHz according to DIN EN 50289-1-5

Other test conditions:

- Test temperatures: RT, T_{min}, T_{max}
- Length of cable under test 10,0 m, at least 8,0 m of which is in the climatic chamber, ring diameter 30 cm

Because the temperature (except for PVC) has no appreciable effect on the capacitance and, thus, on the resulting radio-frequency properties (see A.3), the radio-frequency tests described in 9.2.2 to 9.5 can be performed at one temperature, namely, room temperature.

The capacitance test described in 9.2.1 must be performed for cables at RT, T_{min}, and T_{max}.

If the measured capacitance characteristic reveals a temperature dependency of more than $\pm$ 5%, additional actions must be coordinated with the responsible engineering department.

9.2.2 Running time and propagation rate

The following values must be determined and entered into Table 1 in VW 75206-1 Supplement 1:

- Running time in ns/m as a reciprocal value of the propagation rate (phase velocity) in m/s in the frequency range from 10 MHz to 6 GHz according to DIN EN 50289-1-7
- Representation of measurement results versus frequency in the form of a graph

Other test conditions:

- Test temperatures: RT
- Length of cable under test 10,0 m, at least 8,0 m of which is in the climatic chamber

9.2.3 Determination of the mean wave impedance from capacitance and propagation rate

The following values must be determined and entered into Table 1 in VW 75206-1 Supplement 1:

- Mean wave impedance in Ω, calculated from measured capacitance (9.2.1) and measured propagation rate (9.2.2), in the frequency range from 10 MHz to 6 GHz according to DIN EN 50289-1-11
- Representation of the results versus frequency in the form of a graph

The requirements in Table 5 must be met:

Table 5 Requirements for the mean impedance at room temperature

Frequency range [MHz]	Koax-50-1,5-2,8/T85	Koax-50-2,95-4,95/T85	Koax-50-0,8-1,8/T105	Koax-75-1,7-2,7/T105	Koax-50-2,1-3,3/T105
10 - 6 000	50 Ω ± 3 Ω	50 Ω ± 3 Ω	50 Ω ± 3 Ω	75 Ω ± 3 Ω	50 Ω ± 3 Ω

9.3 Return loss

The following values must be determined and entered into Table 1 in VW 75206-1 Supplement 1:

- Return loss in dB in the frequency range from 10 MHz to 6 GHz according to DIN EN 50289-1-11
- Representation of measurement results versus frequency in the form of a graph

The requirements in Table 6 must be met:

Table 6 Provisional minimum values for return loss at room temperature

Frequency range [MHz]	Koax-50-1,5-2,8/T85	Koax-50-2,95-4,95/T85	Koax-50-0,8-1,8/T105	Koax-75-1,7-2,7/T105	Koax-50-2,1-3,3/T105
10 - 1 000	20 dB	20 dB	20 dB	20 dB	20 dB
1 000 – 3 000	20 dB	20 dB	20 dB	20 dB	20 dB
3 000 – 6 000	20 dB	20 dB	20 dB	-	20 dB

Other test conditions:

- Test temperatures: RT
- Length of cable under test 50 m, at least 90% of which is in the climatic chamber

9.4 Surface transfer impedance

In order to determine the EMC properties in the low-frequency range from 10 kHz to 30 MHz, the surface transfer impedance in mΩ/m must be tested using the triaxial measuring procedure according to IEC 62153-4-3/Method B (short/short, rigid tube). This test procedure must be applied both for 50 ohm and for 75 ohm test specimens without additional adaptation (for measuring setup, see Figure 2).

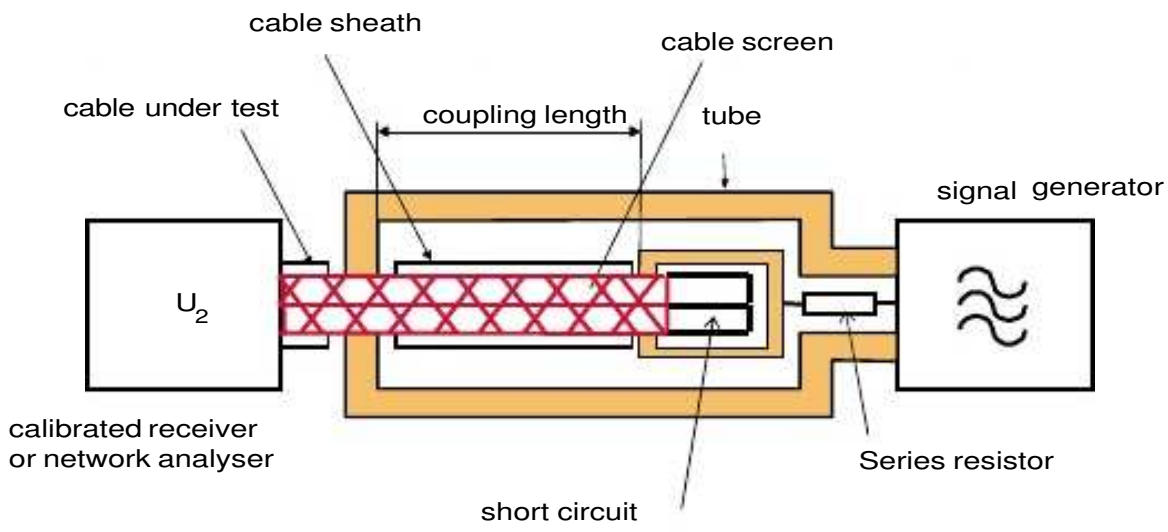

Figure 2 Short/short test procedure and measuring setup

The following values must be determined and entered into Table 1 in VW 75206-1 Supplement 1:

- Surface transfer impedance in mΩ/m for determining the EMC properties in the range from 10 kHz to 30 MHz using the triaxial method according to IEC 62153-4-3/Method B
- Representation of measurement results versus frequency in the form of a graph

The requirements in Table 7 must be met:

Table 7 Maximum values for surface transfer impedance at room temperature

Frequency MHz	Unit	Koax-50-1,5-2,8/T85	Koax-50-2,95-4,95/T85	Koax-50-0,8-1,8/T105	Koax-75-1,7-2,7/T105	Koax-50-2,1-3,3/T105
0,01	mΩ/m	**60**	**20**	**70**	**40**	**30**
0,1	mΩ/m	**60**	**20**	**70**	**40**	**30**
1,0	mΩ/m	**60**	**35**	**100**	**60**	**30**
10,0	mΩ/m	**100**	**100**	**300**	**150**	**30**
30,0	mΩ/m	**200**	**250**	**500**	**300**	**20**

Other test conditions:

- Test temperature: RT
- Length of cable under test = length of measuring tube + 0,5 m

9.5 Screening loss

The following values must be determined and entered into Table 1 in VW 75206-1 Supplement 1:

- Screening loss in dB for determining the EMC properties in the radio-frequency range from 30 MHz to 6 GHz using the triaxial method according to DIN EN 50289-1-6 Section 8
- Representation of measurement results versus frequency in the form of a graph
- Additional specification of “Normalized Screening Attenuation” (NSA) in Table 1 in VW 75206-1 Supplement 1

The requirements in Table 8 must be met.

Table 8 Provisional minimum values for screening loss at room temperature in dB

	Koax-50-1,5-2,8/T85	Koax-50-2,95-4,95/T85	Koax-50-0,8-1,8/T105	Koax-75-1,7-2,7/T105	Koax-50-2,1-3,3/T105
Screening loss value prior to mechanical loading	45	45	38	38	75
NSA prior to mechanical loading	33	33	26	29	68
NSA, loss-corrected, prior to mechanical loading	33	33	20	25	64
Shielding loss value after mechanical load at RT and at T_{min}	40	40	33	33	65

Other test conditions:

- Test temperature: RT
- Nominal length of the measuring tube: 3 m
- Diameter of the measuring tube ≤ 40 mm
- Length of cable under test = length of measuring tube + 0,5 m
- In addition to the specifications in DIN EN 50289-1-6 Section 8, the results must be corrected by the amount of the insertion losses determined in Section 9.1 due to the anticipated losses at radio frequencies (see Table 8).

10 Mechanical properties

10.1 Insulation strippability

Insulation strippability requirements

For cables with strippable insulation, it must be possible to strip at least 20 mm of the insulation cleanly and without difficulty using commercially available tools.

Requirements for secure fit of sheath and dielectric

The forces required to remove (50 ± 1) mm of insulation (sheath and dielectric separately) must conform to the sample.

Test

Number of specimens: At least 5

Specimen length: (150 ± 5) mm

A length of (50 ± 1) mm of insulation is stripped from the specimen, or (20 ± 1) mm if required, and the stripped end of the conductor is pulled through a sheet with a hole measuring (conductor diameter + 0,1 mm).

Removal rate: 100 mm/min

Specimen preparation

Using a sharp blade, cut once around the insulation so that the screen is visible.

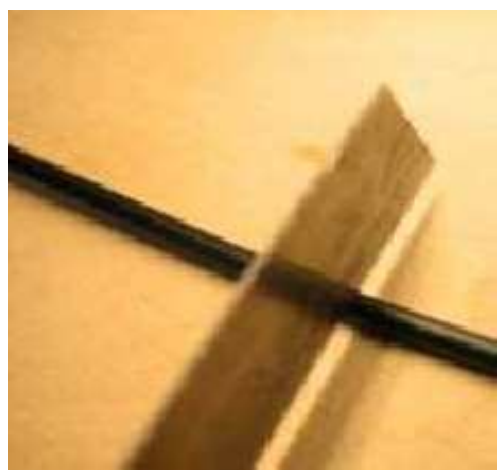

Figure 3 Cut through insulation.

Then use the blade to cut a slit in the longitudinal direction to the end.

Figure 4 Longitudinal cut

Carefully remove the insulation without exerting any mechanical influence on the length to be measured.

Figure 5 Remove the sheath

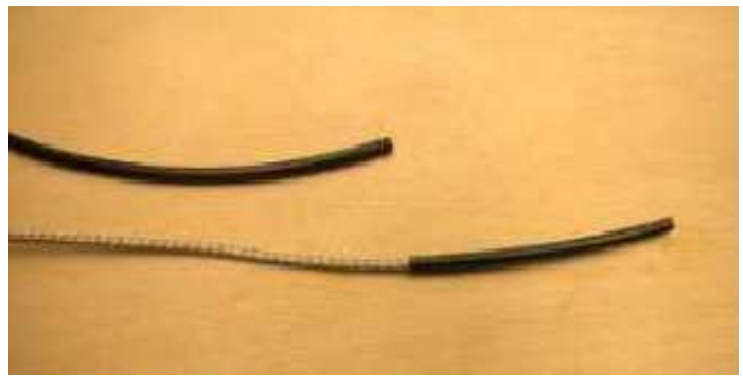

Figure 6 Stripped cable under test

Cut off the 5 cm gage length using a sharp blade. Do not use diagonal cutting pliers for this to avoid compressing the end of the specimen.

Figure 7 End of specimen

Proceed in the same way to test the conductor, with the exception that the screen and the dielectric are also removed.

10.2 Sheath abrasion resistance

Requirements

Resistance to abrasion by scraping is defined by the number of complete cycles that are required until the scraping needle has rubbed through the sheath and the electrical contact with the outer conductor has caused the machine to shut off.

Test

Setup and procedure according to ISO 6722 (Section “Abrasion resistance”)

Contact force 7,00 ± 0,05 N

Needle diameter (0,45 ± 0,01) mm

The test can be stopped as soon as the number of cycles exceeds the minimum number of cycles (see Table 9) by 50%. Attention must be paid that the needle is lifted off at the reversal point.

Alternatively, it can be agreed to perform the sandpaper test according to ISO 6722.

Table 9 Abrasion resistance needle test

	Minimum number of cycles
Koax-50-1,5-2,8/T85	75
Koax-50-2,95-4,95/T85	1500
Koax-50-0,8-1,8/T105	4
Koax-75-1,7-2,7/T105	25
Koax-50-2,1-3,3/T105	29

10.3 Bending force of the cables

The test is only performed if explicitly required.

Requirements

The bending force must be within the values specified in Table 10.

Table 10 Specifications for the bending force test

Specimen length l	mm	70 + (2 x outer diameter of cable)
Number of specimens		≤ 5 mm outer diameter: 3 > 5 mm outer diameter: 1
Distance l_V	mm	30 + (2 x outer diameter of cable)
Bending force max.	N	In conformance with sample

Test

The test device consists of two metal legs, a test mandrel, and a tensile test machine, and is illustrated schematically in Figure 8.

Straighten out the cable specimens (number and length according to Table 10) and age them in this position for at least 12 h. Then place the cables next to one another (in parallel) on the metal legs, which are spaced apart by a distance of l_V according to Table 10. Mark the upper side of these cables under test with a felt-tip pen on the left and the right perpendicular to the longitudinal axis of the cable.

In a tensile test machine, press the test mandrel onto the cables at a test rate of 100 mm/min. Measure the maximum force required to bend the cables.

Then straighten out the cables by hand and place them back on the legs on the side bearing the marking; then measure the maximum force required to bend the cables once again. The mean value of the two measurements is the bending force.

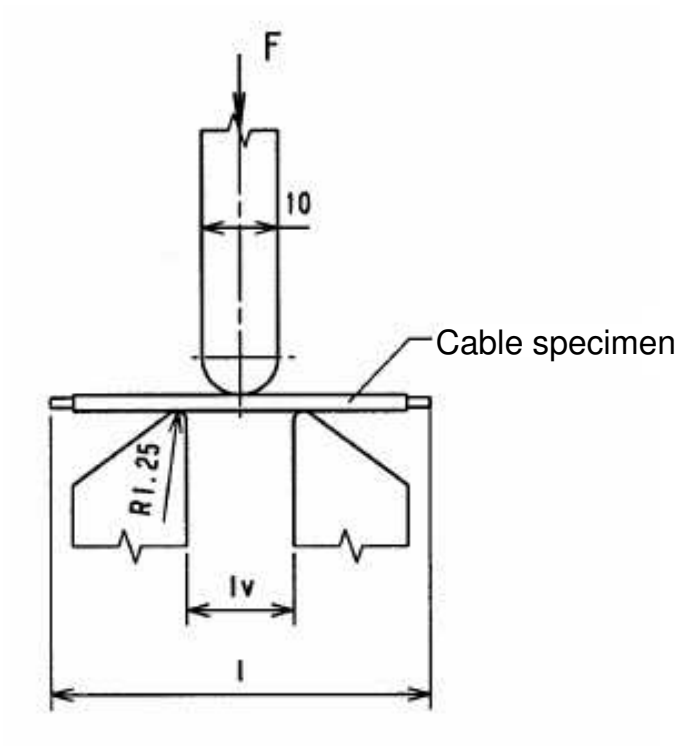

Figure 8 Bending force test device

10.4 Flame retardance

The requirements and the test procedure correspond to ISO 6722 (Section "Resistance to flame propagation"). The flame exposure lasts until the screen is visible, but at most 30 s.

10.5 Bending test

The following applies to the tests described in 10.5.1 – 10.5.3.1.

Specimen preparation

A minimum of 6 specimens for each test.

The bending point is (2 ± 0,5) m away from the connector.

Requirements

Screening loss test:	The specified value must be attained. The bending point must be located in the coupling area.
Visual inspection	No more than 20% of the wires of the screen must be broken, and the foil must not exhibit any cracks

10.5.1 Static bending test

Bend radius in mm (enter bend radius into VW 75206-1 Supplement 1)

Test according to DIN EN 50289-3-9 Section 4.3 Method 1

Mandrel diameter: max. 5 times outer diameter

Number of windings: 5

Number of cycles: 1

Test at RT

10.5.2 Dynamic reverse bending test for standard cables

Test according to VW 75209 Section “Resistance to reverse bending.”

But:

100 cycles at RT

10 cycles at T_{min}

During the tests, there must be constant monitoring for breaks of the inner and outer conductors.

10.5.3 Reverse bending test and torsional endurance test, dynamic, for highly-stressed cables

This test is performed only at the special request of the OEM.

The test example described here is required only for particular installation locations (e.g., liftgate transition). If necessary, the parameters must be individually adapted to the specific application.

Influencing factors are the bend radius, weight load, temperature, and number of bending cycles.

During the tests, there must be constant monitoring for breaks of the inner and outer conductors.

10.5.3.1 Dynamic reverse bending test for highly-stressed cables

180° bend over gages with 50 mm diameter

When the 180° bend has been made, the two connectors are located one above the other. The cable is in a straight line in the 0° position. While bending, one connector is held securely and the other is held under tensile stress with a force of 3 N in the direction of the cable. The weight is attached to the sheath. The radio-frequency properties must not change when the weight is attached. A total of 30 000 bending cycles at 6 bending cycles per minute must be performed.

- 5 000 bends at RT 25 °C minus the temperature cycle times at 3 °C/min
- 600 bends at T_{max}
- 400 bends at T_{min} (at -25 °C in exceptional cases after consultation with the responsible engineering department)

This temperature cycle must be repeated 5 times.

10.5.3.2 Dynamic torsional endurance test for highly-stressed cables

New specimens are used.

Number of specimens and specimen preparation as described in Section 10.5.3.1.

The cable is clamped at two points approx. 80 mm apart. The cable between the clamped points describes a quadrant in free space with R = 50 mm (see Figure 9).

One clamped point is held securely, the other clamped point describes a 180° angle (semicircle) and thus applies torsion to the cable.

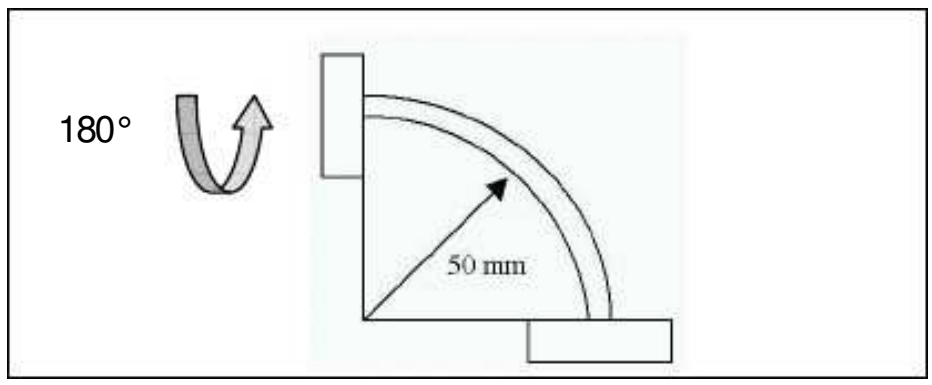

Figure 9 Test setup

10.6 Physical and chemical properties of the insulation

The measured values obtained from the tests described below on each cable specimen must be included as an appendix to the test report and serve to uniquely identify the cable.

10.6.1 Density

Testing according to VW 60306-1

10.6.2 Determination of the extractable portion

Testing according to VW 60306-1

10.6.3 Determination of viscosity

Testing according to VW 60306-1

10.6.4 Thermogravimetric analysis (TGA) temperature at 5% weight loss

Testing according to VW 60306-1

10.6.5 Dynamic differential scanning calorimetry (DSC) ignition residue

Testing according to VW 60306-1

10.6.6 Thermal stability

Testing according to VW 60306-1

10.6.7 Determining the infrared spectrum

Testing according to VW 60306-1

10.6.8 Determining the tensile strength and elongation at tear

Testing according to VW 60306-1

10.6.9 Tear propagation strength

Testing according to VW 60306-1

10.6.10 Determination of cross-linking density

Testing according to VW 60306-1

10.6.11 Microhardness

Testing according to VW 60306-1

10.7 Electrical properties

10.7.1 Specific volume resistance

Requirements

Specific volume resistance of insulation at least 10^9 Ωmm.

Test

Measuring steps according to Section 10.7.2 (dielectric strength)

According to ISO 6722 (but with 1% NaCl solution).

10.7.2 Dielectric strength

The following values must be determined and entered into Table 1 in VW 75206-1 Supplement 1:

The measurement is performed on unassembled test specimens > 2 m long.

Measurement of inner conductor with respect to screen at test voltage ≥ 1 kV for 30 min (1 min for foamed dielectric) based on DIN EN 50289-1-3 (dielectric strength)

Measurement of screen and inner conductor with respect to test fluid at test voltage ≥ 1 kV for 1 min (dielectric strength of sheath, test fluid as in ISO 6722)

Test temperature: RT

10.7.3 Measurement of 1-minute dielectric strength (only after aging)

This test is only performed after tests that contain a corresponding reference.

Requirements and tests

According to Section 10.7.2 (dielectric strength); however, a test voltage of 1 kV_{eff} is applied for 1 minute during the test.

The measurement is performed on unassembled test specimens > 2 m long.

10.8 Mechanical and electrical properties after mechanical, thermal, or chemical stress

10.8.1 Shrinkage under heat

Requirements and tests

According to ISO 6722

Test temperature corresponding to "Thermal overload temperature" according to VW 60306-1

10.8.2 Pressure resistance under heat

Test

According to ISO 6722

Requirements

See test matrix in Table 2 of VW 75206-1

The following applies to the weight calculation:

D: maximum outer diameter of cable according to data sheet

I: nominal sheath wall thickness

Test temperature T_{max} (long-term service temperature)

10.8.3 Thermal overload

Requirements and tests

According to ISO 6722 (thermal overload and winding test at standard climate)

Test temperature according to VW 60306-1

After the test, the color of the cable must still be visible.

10.8.4 Short-term aging (240 h)

Requirements and tests

According to ISO 6722 (short-term aging for 240 h according to VW 60306-1 and winding test of coaxial cables at -25 °C according to Table 11).

Specimen is tightly wound 6 turns by hand onto a mandrel having a diameter according to Table 11.

After the test, the color of the cable must still be visible.

For follow-up tests, see test matrix in Table 2 of VW 75206-1

In addition, IR test described in Section 10.6.7 after short-term aging

Table 11 Cold winding test at -25 °C or -40 °C

Cable description	Mandrel [mm]
Koax-50-2,1-3,3/T105	15
Koax-50-2,95-4,95/T85	25
Koax-50-1,5-2,8/T85	15
Koax-50-0,8-1,8/T105	10
Koax-75-1,7-2,7/T105	15

Note: The mandrel diameters correspond approximately to 5 x D.

10.8.5 Long-term aging (3 000 h)

Requirements and tests

According to ISO 6722 (winding test according to VW 60306-1 at standard climate)

A specimen is tightly wound 6 turns by hand onto a mandrel having a diameter according to Table 12.

Test temperature corresponding to Tmax (long-term service temperature)

After the winding test, perform subsequent tests according to test matrix in Table 2 of VW 75206-1.

After the test, the color of the cable must still be visible.

In addition, IR test described in Section 10.6.7 on cable in as-received condition and after long-term aging

Table 12 Winding test after aging at RT

Cable description (examples)	Mandrel [mm]
Koax-50-2,1-3,3/T105	7
Koax-50-2,95-4,95/T85	10
Koax-50-1,5-2,8/T85	6
Koax-50-0,8-1,8/T105	4
Koax-75-1,7-2,7/T105	6

Note: The mandrel diameters correspond approximately to 2 x D.

10.8.6 Winding test at low temperature (-40 °C)

Requirements and tests

According to ISO 6722 (Section "Winding test at low-temperature (-40 °C), rotating mandrel and weight").

Weights and mandrel diameters according to Table 11

For follow-up test, see test matrix in Table 2 of VW 75206-1

10.8.7 Impact test at low temperature (-15 °C)

Requirements and tests

According to ISO 6722

However, in contrast to this, the radio-frequency cables are tested with a hammer weight of 100 g.

10.8.8 Resistance of cable marking to wiping

This test only applies to cables with printed markings.

Requirements and tests

According to ISO 6722

10.8.9 Electrical properties during aging in water

Requirements

For follow-up tests, see test matrix in Table 2 of VW 75206-1

After the test, the color of the cable must still be visible.

Radio-frequency tests according to test matrix

Assembled cable specimens with a length according to 0 are wound with one cable end (5,0 ± 10%) torsion-free (e.g., by turning the mandrel) on a fluorine polymer mandrel with a diameter of 5 x Dmax ± 5% and tied off (e.g., with PTFE tape).

The mandrel is not removed and (5,5 ± 10%) m of the samples are immersed in a salt solution (1% NaCl) and aged at temperature (85 ± 2) °C.

After 48 h of aging in water, the specimens are aged for (90 to 120) min at RT and then tested in wrapped condition according to the test matrix in Table 2 of VW 75206-1 at RT. Afterwards, they are immediately immersed again. This operation is repeated on the same specimens after a total of 168 h of aging in water and after a total of 1 000 h of aging in water.

If the test cannot be performed within the specified time, the samples must be packed in a suitable manner until tested to secure the moisture (max. 120 h after removal).

Electrical test

The electrical test is performed on unassembled test specimens > 2 m long.

The specimen is wound around the center of a mandrel having a diameter 5 x Dmax ± 5% (at least 3 windings). The cable is tied down (e.g., with PTFE tape) and the mandrel is removed.

The inner conductor and the screen of the coaxial cable are coupled together, connected to the positive terminal of a 48 V DC supply and aged for 1 000 h in a salt solution (1% NaCl) at temperature (85 ± 2) °C in such a way that approximately 2 m of the cable under test is completely submerged.

Electrode surface: (100 ± 10) cm^2

Electrode material: Cu

Calculation of the insulation resistance according to ISO 6722. The following applies to the calculation:

$$\rho_0 = 2{,}725 \frac{L \cdot R}{\lg \frac{D}{d}}$$

ρ_0: calculated insulation resistance value in ohm-millimeters

L: length of cable in salt solution in mm

R: measured resistance in ohm

D: maximum outer diameter of cable according to data sheet in mm

d: outer diameter over the screen corresponding to data sheet in mm

lg: logarithm to base 10

Additionally, the test must be performed with reversed polarity on new cables under test.

10.8.10 Humid heat, constant (hydrolysis test)

Requirements

Following the winding test, the subsequent tests according to the test matrix in Table 2 of VW 75206-1 must be performed.

After the test, the color of the cable must still be visible.

Radio-frequency measurements corresponding to matrix

Place the pre-assembled cable specimens according to 0 in rings with a radius of > 100 mm and secure them using an inert material e.g., PTFE tape. Guide the pre-assembled ends of the cables under test approx. 1 meter out of the climatic chamber and secure them. Ensure that the specimens are not subjected to any pressure load during the aging.

Age the specimens for 3 000 h (1 000 h after consultation) at a temperature of (85 ± 2) °C and a relative humidity of (85 ± 5)%.

No later than 2 h after the hydrolysis test, the specimens are tested according to the test matrix in Table 2 of VW 75206-1.

If the test cannot be performed within the specified time, the samples must be packed in a suitable manner until tested to secure the moisture (max. 120 h after removal).

Electrical test

The electrical test is performed on unassembled test specimens > 2 m long.

Place the cable specimens in rings with a radius > 100 mm, secure them using an inert material, e.g., PTFE tape, and age them for 3 000 h (1 000 h after consultation) at a temperature of (85 ± 2) °C and a relative humidity of (85 ± 5)%.

After removal, age the specimens for 30 min at room temperature, wind them according to Table 12 within another 30 min, and then test the 1-min dielectric strength according to Section 10.7.3.

10.8.11 Ozone resistance

Existing release tests can be used for the sheath material employed.

Requirements and tests

According to VW 60306-1

Dielectric breakdown must not occur.

10.9 Mycological test

Existing release tests can be used for the sheath material employed.

Requirements and tests

According to VW 60306-1

10.10 Compatibility tests

Existing release tests can be used for the sheath material employed.

Test scope

In this Section, tests are described that ensure compatibility of the cables with substances occurring in vehicles and in the vehicle surroundings. These substances may include:

– Operating fluids (group of agents according to VW 60306-1 Supplement 1)
– Wrapping tapes (VW 60306-1 Table A.6)
– Other components of the wiring harness (VW 60306-1 Table A.7).

10.10.1 Resistance to agents according to ISO 6722

To determine swelling and shrinkage, a compatibility test according to ISO 6722, Section "Fluid compatibility" must be performed (all fluids according to VW 60306-1 Supplement 1).

10.10.2 Resistance to operating fluids and wrapping tapes

Requirements and tests

According to VW 60306-1, cross sections > 6,00 mm²

10.10.3 Resistance to wiring harness components

Requirements and tests

According to VW 60306-1, cross sections > 6,00 mm²
Components: see A.1

11 Referenced documents

The following documents cited in this standard are necessary for application. In this Section, terminological inconsistencies may occur as the original titles are used.

DIN 50014	Climates and Their Technical Application; Standard Atmospheres
DIN 76722	Road Vehicles, Low Voltage Cables; Type Abbreviation
DIN EN 13602	Copper and Copper Alloys - Drawn, Round Copper Wire for the Manufacture of Electrical Conductors
DIN EN 50117-1	Coaxial Cables – Part 1: Generic Specification
DIN EN 50289-1	Communication Cables – Specifications for Test Methods – Part 1: Electrical Test Methods
DIN EN 50289-3-9	Communication Cables – Specifications for Test Methods – Part 3–9: Mechanical Test Methods; Bending Tests
DIN EN ISO/IEC 17025	General Requirements for the Competence of Testing and Calibration Laboratories
IEC 62153-4-3	Metallic Communication Cable Test Methods – Part 4-3: Electro Magnetic Compatibility (EMC)
ISO 6722	Road Vehicles – 60 V and 600 V Single-Core Cables – Dimensions, Test Methods and Requirements
VW 60306-1	List of Agents for Cable Testing
VW 60306-1 Supplement 1	
VW 75174	Motor Vehicle Push On Connectors; Test Guidelines
VW 75209	Sheathed Lines for Motor Vehicles
DIN EN 50289-1-3	Communication Cables – Specifications for Test Methods – Part 1-3: Electrical Test Methods; Dielectric Strength
DIN EN 50289-1-6	Communication Cables – Specifications for Test Methods – Part 1-6: Electrical Test Methods; Electromagnetic Performance
DIN EN 50289-1-7	Communication Cables – Specifications for Test Methods – Part 1-7: Electrical Test Methods; Velocity of Propagation
DIN EN 50289-1-11	Communication Cables – Specifications for Test Methods – Part 1-11: Electrical Test Methods; Characteristic Impedance, Input Impedance, Return Loss

A.1 Bill of materials: Component compatibility for cables of temperature class B* 105 °C

Table A1 Bill of materials

			Test temperature										
e.g. PVC	The material is decisive for testing.	5 sample wiring harnesses each	105 °C										
			1	2	3	4	5	6	7	8	9	10	11
Contacts	Koax-B(105)-75-1,7-2,7 (RG179) N 106 176 01 Inner conductor MD445239 >>Rosenberger 59K13D N 106 864 01 Outer conductor MDFA0076 >>Rosenberger 59K17F-102A4	No. 1	1										
	Koax-B(105)-50-2,1-3,3 (RTK031) N 105 895 01 Body + inner contact MDFA0090	No. 2		1									
	Koax-B(105)-50-1,5-2,8 (RG174) N 106 913 01 Housing MDFA0107 >>Rosenberger 59K14B-102A4	No. 3			1								
Seals	Seal, 357 972 742 B, Veritas F17414 Silicone	No. 5			1								
		No. 6											
Connector housing	6Q0 035 576 Housing MD580001 >>Tyco 0-1452728-1 PBT-GF10	No. 7	1										
	6Q0 035 610 Housing >>ROKA K5207406	No. 8		1									
	4L0 035 576 A Housing MD556177 >> Rosenberger 597061-AU0B PA12	No. 9			1								
Components	PVC 9248 acc. to DIN 40621, insulating hose, HC, 2125013	No. 12	1										
	PUR, insulating hose, Sahlberg, 6435641	No. 13		1									
	Silicone coated glass braid, braided sleeving, Relats, VSR 25 NW6	No. 14				1							
	PP modified, Corrugated tube, Fränkische Rohrwerke, Uniwell	No. 15					1						
	PA 66, Cable tie, Hellermann, 111-019 50 PA 66, Corrugated tube, Fränkische Rohrwerke 400008 08	No. 16						1					
	Thermoplastic hot melt, Chamber connector encapsulation, Henkel, Macromelt 6 208 N	No. 17					1						
	Butyl rubber, Longitudinal water sealing, Hellermann, DSG, 460-05029/19-1,5/105AL 30 mm	No. 18							1				
	EDPM Shore A60, grommet, WOKO, 02 5539	No. 19							1				
	PVC, acrylate adhesive, wrapping tape, Certoplast, 608/609 19 mm	No. 20				1							
	Polyolefin, acrylate adhesive, wrapping tape, Coroplast Y 512 19 mm	No. 21						1					

e.g. PVC	The material is decisive for testing.	5 sample wiring harnesses each	Test temperature 105 °C								
			1	2	3	4	5	6	7	8	9	10	11
	PET, acrylate adhesive, wrapping tape, Coroplast 837X 19 mm	No. 22						1					
	Silicone, cables (class E/F)	No. 23a										1	
	ETFE, cables (class D)	No. 23a1									1		
	X-PE, cables (class D)	No. 23b									1		
	PP, cables (class C)	No. 23c								1			
	X-PE, cables (class C)	No. 23d								1			
	PVC, cables (class B 105 °C)	No. 23e											
	TPE-S, cables (class C)	No. 23f								1			

A.2 Specimen matrix (informative)

Table A2 Specimen matrix

		9.1 Insertion loss	9.2 Mean wave impedance	9.3 Return loss	9.4 Surface transfer impedance	9.5 Screening loss	10.7.3 1-minute dielectric strength
	Required length in [m]	10	10	50	≤ 1	4	
	Connector: OE = one end, BE = both ends	BE	BE	OE[1)]	OE	OE	
Load							
	Supply (4 specimens, 1 specimen = reference)	1	1[a]	8	17	24	
10.8.2	Pressure resistance under heat			8[a]			
10.8.4	Short-term aging (240 h)	1[b]	1[c]	9	17[d]	24[e]	X
10.8.5	Long-term aging (3 000 h)	2	2[a]	10	18[b]	25[c]	X
10.8.3	Thermal overload (6 h)	3	3[a]	11			
10.8.6	Winding test at low temperature	4	4[a]	12	19[b]		X
10.8.9	Electrical properties during water aging (48 h, 168 h, 1 000 h)	5	5[a]				X
10.8.10	Humid heat, constant	6	6[a]	13	20	26	X
10.5.1	Static bending test			14	21		