VOLKSWAGEN AG	**Low-Voltage Cables in Motor Vehicles** Single-Wire, Unshielded, Requirements and Tests	**VW 603 06**
Konzernnorm		

Descriptors: Cables, Low-Voltage Cables, LV 112

Changes

The following changes have been made as compared to the September 1990 issue:

– Adaptation to Team Paper LV 112

Previous issues: First issue: 09/90

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Fachverantwortung/*Responsibility*		Normung/*Standards*)		
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Preface

The content of this standard has been adapted from Team Paper LV 112, which was agreed upon by representatives of the companies AUDI AG, BMW AG, DaimlerChrysler AG, Porsche AG and Volkswagen AG.

Deviations from the agreed-upon version of LV 112 are indicated in VW 603 06 with *italic type*.

The companies listed above agree on mutual recognition of test reports from cable manufacturers as long as the tests are performed by an independent testing institute that is accredited according to DIN EN ISO/IEC 17025. The above-named companies reserve the right to require additional testing. The mutual acceptance of the test reports does not mean automatic release.

1 Scope and Aim

This in-house standard defines requirements and tests for single-wire, unshielded low-voltage cables with thin-walled *or thick-walled* insulation for a nominal-voltage range of ≤ 60 V.

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

Cables made according to this standard are subject to mandatory technical engineering approval.

Thin-walled and thick-walled cable types are distinguished only by the dimensions listed in Appendix A, Tables A.1, A.2 and A.3.

2 General Supply Requirements

***Standard parts drawings take precedence over this standard**.*
Approval of first supply and changes per VW 011 55.
First samples must be delivered accompanied by a test certificate containing all data regarding the quality requirements listed below. In addition, the test certificate must contain the company's trade name, the manufacturing period of the cables and the company's recipe number for the insulation material.
Deviations regarding the completeness of the data are only permissible in exceptional cases and only with the agreement of the relevant materials testing department.
Long-term tests are a deciding factor for the production sample release test.
Standard production shipments must include the manufacturing date. The manufacturing date must be visible on the cable tags. Different rules may be negotiated between the suppliers and the materials testing laboratories or responsible engineering departments.
Environmental standard VW 911 00 must be observed.
Emissions behavior per VW 501 80 and per usage guideline No. 3211 issued by Audi laboratory in Ingolstadt, Germany

3 Dimensions, Conductor Setup, Examples of Designation

Dimensions *(see Figure 1:)* and conductor setups can be found in Appendix A1 [Symmetrical conductor setup (Type A)) and Appendix A2 (Asymmetrical conductor setup (Type B)]. In general, the cable must be designed so that it can be processed properly and welded using commercial devices.

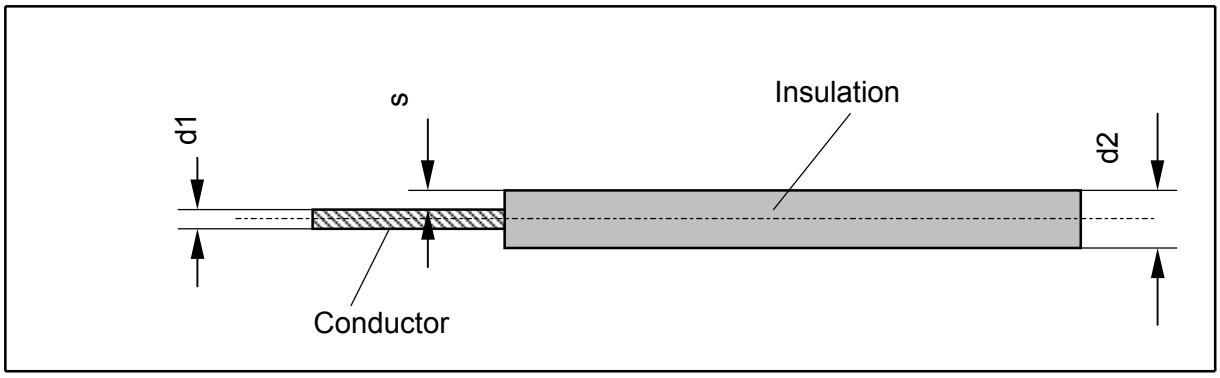


Figure 1:

Designation of an unshielded low-voltage cable (FL) with thin-walled insulation (R), *insulation material heat-resistant PVC (YW), nominal conductor cross section 1.5 mm² (1.5), conductor setup Type A (A), bright individual wires, two-color coding, 1st color = basic color black (bk), 2nd color = code color white (wh)*

Cable VW 603 06 FLRYW *) 1.5 A black (bk) white (wh)

In the case of tin-coated conductors, (sn) should be added after the nominal conductor cross section:

Cable VW 603 06 FLRYW *) 1.5 (sn) A black (bk) white (wh)

4 Drawing Entry

See standard part drawing

5 Materials

5.1 Requirements for the Conductor

The surface must be clean and free of lubricants and corrosion.

5.1.1 Bright Conductors

Softened, bright copper wires made of E-Cu58 F21 per DIN 40 500-4.

5.1.2 Tin-Coated Conductors

Softened, tin-coated copper wires made of E-Cu58 F21-V per DIN 40 500-5.

***)** Insulation material symbol per DIN 76 722

5.2 Insulation

The insulation material must correspond to the requirements of VDA 231-106.
The minimum and maximum service life temperatures (T_U and T_O) for a stress duration of 3,000 h can be found in Table 1: according to the temperature classes *or in the standard part drawing*.

Table 1: Temperature classes

Class	Service live temperature (3,000 h)	Short-term - temperature (240 h)	Temperature for thermal overload (6 h)
	T_U ° C to T_O ° C	(T_O + 25)° C	(T_O +50)° C
A	-40 to 85	110 ± 2	135 ± 3
B	-40 to 100 ***)**	125 ± 3	150 ± 3
C	-40 to 125	150 ± 3	175 ± 3
D	-40 to 150	175 ± 3	200 ± 3
E	-40 to 175	200 ± 3	225 ± 3
F	-40 to 200	225 ± 4	250 ± 4
G	-40 to 225	250 ± 4	275 ± 4
H	-40 to 250	275 ± 4	300 ± 4
***)** Except for PVC up to 105° C			

6 Identification

6.1 Manufacturer's Identification

For cross sections ≥ 0.5 mm², the manufacturer's identification must be either printed or stamped on.
For cross sections < 0.5 mm², the identification method may be negotiated between the supplier and the development department.

6.2 Color Coding

6.2.1 First Code Color in the Form of Lengthwise Colored Stripes

per DIN 72 551-7

6.2.2 Second Code Color in the Form of Colored Circles

per DIN 72 551-7

6.2.3 Meaning and Sequence of Code Colors

The code colors allow many wiring cables in a cable bundle to be distinguished with certainty. The code colors and their sequence can be selected freely in an individual wiring cable, i.e., the two code colors in a three-color wiring cable are interchangeable and therefore equivalent.

7 General Test Conditions

7.1 Test Climate

If no other test climate is defined, testing will be carried out in the *DIN 50 014-23/50-2 standard climate*.

7.2 Specimens

The cables must be inspected in as-received condition. Unless a different specimen count is indicated, 3 specimens must be tested. Except for tests that are directly connected to the manufacturing process for process assurance, the specimens must be aged for at least 16 h beforehand in the *DIN 50 014-23/50-2 standard climate*.

7.3 Rounding of Numerical Values

The calculated numerical values should be rounded to the number of digits with which the desired values are listed, according to DIN 1333.

8 Tests

The tests described are based on DIN ISO 6722-1 and -2.
In case of differences between the standard and the drawing, the standard part drawing is binding.

8.1 Cable Setup Test

The *parameters* indicated in Appendices A1 to A.3 for the cable setup must be tested for. The mean value of the measurements as well as the minimum and maximum values should be indicated in the test report.

8.1.1 Insulation Test Wall Thickness Sp (Thin-Walled Cables)

Nominal conductor cross section 0.22 mm^2 and 0.35 mm^2: *Sp = 0.22 mm*
Nominal conductor cross section 0.5 mm^2: *Sp = 0.26 mm*
Conductor cross section 0.75 mm^2: *Sp = minimum wall thickness + 0.02 mm*

If the insulation test wall thickness is too small in two cases, a cable batch may be rejected by the finisher of the wire assembly.

8.1.2 Insulation Test Wall Thickness Sp (Thick-Walled Cables)

See A.3

8.2 Physical and Chemical Properties of the Insulation

The measured values for each cable specimen obtained from the tests described below should be included as an appendix to the test report and serve as a unique identification of the cable.

8.2.1 Density

Test per ISO 1183-3

8.2.2 Determining the Extractable Portion

Test per DIN EN ISO 6427

8.2.3 Determining the Viscosity Number

Test per DIN EN ISO 1628-2 in as-received condition and after 3,000 h

8.2.4 Temperature at 5% Weight Loss

Test per VDA 675-135 (heating rate 10° C/min)

8.2.5 Determining the Infrared Spectrum

Test per VDA 675-140 in as-received condition and after 3,000 h

8.2.6 Determining the Tensile Strength and Elongation at Tear

Test per DIN EN 60 811-4-2

8.2.7 Lead-Free Verification

As agreed between the supplier and development department.
Test, see Section 10

8.2.8 Ignition Residue

Test per DIN 53 568-2 / in accordance with sample

8.2.9 Microhardness

Test per VDA 675-101 / in accordance with sample

8.3 Mechanical Properties in As-Received Condition

8.3.1 Insulation Stripability and Secure Fit of Conductor

Requirements

At least 20 mm of the insulation must be removable cleanly and with no difficulty using standard commercial equipment.

The forces required to strip the remainder of the insulation (50 ± 1) mm must be within the limits indicated in Table 2:.

Table 2: Secure Fit of Conductor

Nominal conductor cross section		**mm²**	**0.22**	**0.35**	**0.5**	**0.75**	**1.0**	**1.5**	**2.5**	**4.0**	**6.0**
Force	min.	N	3	5	5	5	5	10	10	10	10
Force	max.	N	20	30	30	40	40	50	60	70	70

Test

Specimen length: (150 ± 5) mm

Strip the insulation from the specimen up to a length of (50 ± 1) mm and pull the stripped end of the conductor through a sheet with a hole of (conductor diameter + 0.1 mm). The remaining insulation is then pulled off at a strip rate of 100 mm/min. The test must be performed on a minimum of five specimens.

8.3.2 Insulation Abrasion Resistance

Requirements

Resistance to abrasion by scraping is defined by the number of complete cycles that are required until the scraping blade has rubbed through the insulation and the electrical contact has shut off the machine. The required minimum number of cycles is listed in Table 3: and must be met by every specimen.

Test

Setup and implementation per DIN ISO 6722-1 (Abrasion Resistance section) at a test temperature of (23 ± 1)° C, 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 by 50 %. It must be ensured that the needle is lifted up at the reversal point.

Table 3: Number of cycles

Nominal conductor cross section	**mm²**	**0.22**	**0.35**	**0.5**	**0.75**	**1.0**	**1.5**	**2.5**	**4.0**	**6.0**
Contact force	N	7.00 ± 0.05								
Cycles	min.	*200*	200	300	350	500	1,500	1,500	1,500	1,500

8.3.3 Abrasion Resistance of Wire Against Wire

Requirements

Resistance to abrasion by wires rubbing against one another is defined by the number of complete cycles that are required until the wire insulation has been rubbed through and the electrical contact of the conductors has shut off the machine. The required minimum number of cycles is indicated in Table 4:.

Test

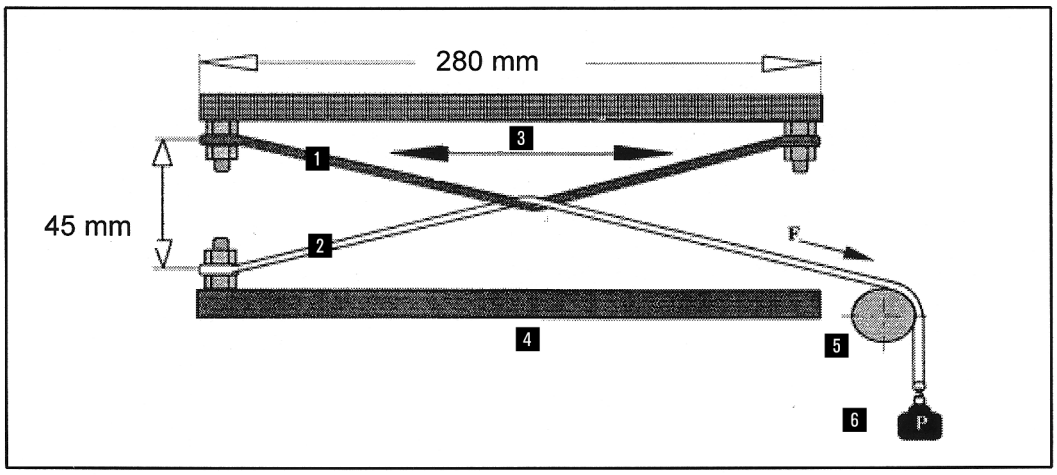
Test regulation, see Figure 2:.

The friction point of the cable must be near the center of cable 1 (± 10 %). The diameter of the axle must be greater than 14 times the cable diameter. Two cables of the same material and cross section should be used as specimens.

The test is performed based on DIN EN 3745-511. The moving part of the device is moved back and forth in the x axis with a frequency of 10 Hz and (6.35 + 0.25) mm peak to peak.

Table 4: Number of cycles

Nominal conductor cross section	**mm²**	**0.22**	**0.35**	**0.5**	**0.75**	**1.0**	**1.5**	**2.5**	**4.0**	**6.0**
Contact force	N	1.0	1.0	1.25	1.25	1.25	1.25	1.5	1.5	2.0
Cycles	min.	150								



1 Fixed cable
2 Moving cable
3 Movable table
4 Fixed base
5 Axle
6 Weight

Figure 2: Abrasion resistance test setup

8.3.4 Sliding Behavior of the Cables

Test according to the specifications in Table 5:

Table 5: Sliding behavior test specifications

Nominal conductor cross section	**mm²**	**0.22**	**0.35**	**0.5**	**0.75**	**1.0**	**1.5**	**2.5**	**4.0**	**6.0**
Tension weight	kg	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0
Test roller diameter	mm	20	20	30	40	40	50	60	80	80
Tensile force max.	N	*according to the sample*								

The test device (see Figure 3:) consists of a variable-width roller that is fixed in place, a turning roller and a tensile test machine.

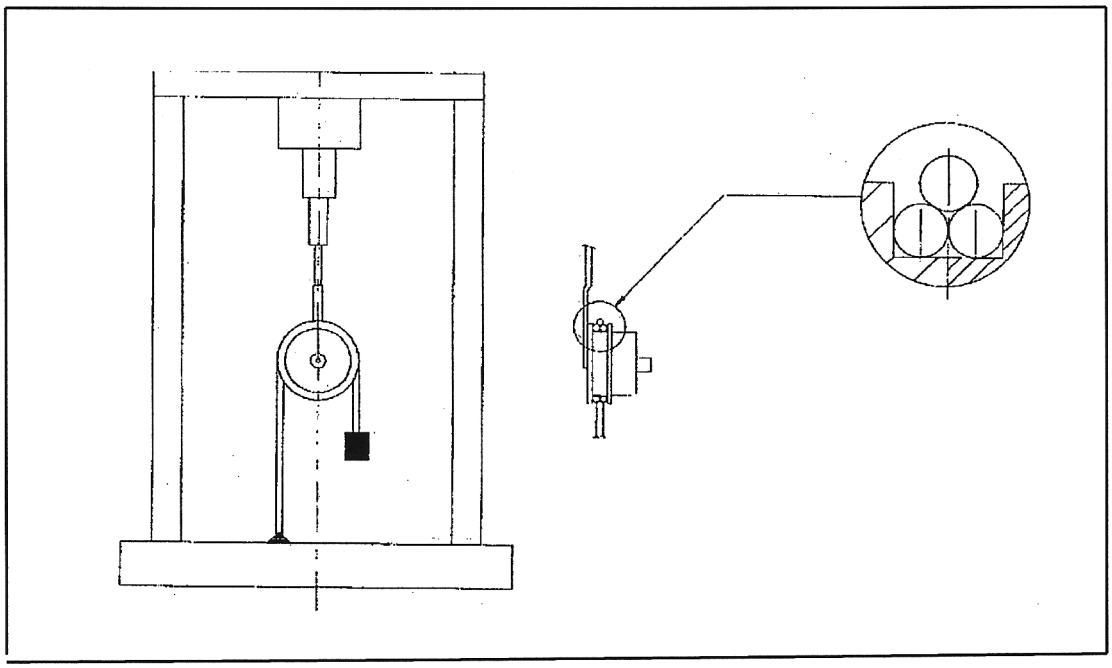


Figure 3:

Wind the cable to be tested two turns around a test roller with a diameter according to Table 5:. This winding is pressed together and held by two flanges on the sides. Place a piece of cable of suitable length, loaded with a tension weight per Table 5:, in the gusset of the wound cable, guide it over a rotating roller and affix it to the jaws of a tensile test machine.

Now pull the cable over the test roller at a pull-off speed of 250 mm/min and determine the tensile force. The measurement is made twice on the same specimen and then more times with a cable specimen taken from another point for a total of 6 measured values.

8.3.5 Bending Force of the Cables

Requirements

The bending force must be within the range of values in Table 6:.

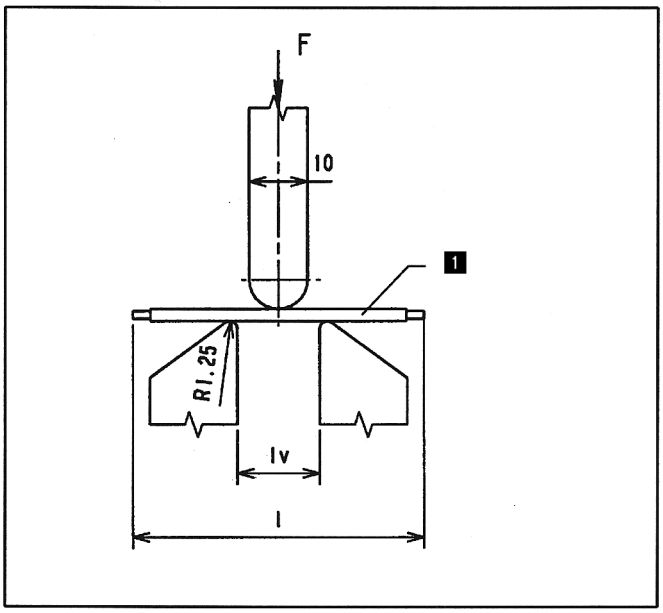
Test

The test device consists of two metal legs, a test mandrel and a tensile test machine and is illustrated schematically in Figure 4:.

Straighten out the cable specimens (number and length per Table 6:) and store them in this way for at least 12 h. Then place the cables next to one another on the metal legs, which are space at a distance of l_V per Table 6:. Mark the upper side of this specimen with a felt-tip pen on the left and the right perpendicular to the lengthwise axis of the cable.

In a tensile test machine, press the test mandrel onto the cables with 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 and test them again. The mean value of the two measurements is the bending force.



1 Cable specimen

Figure 4: Bending force test device

Table 6: Specifications for the bending force test

Nominal conductor cross section	**mm²**	**0.22**	**0.35**	**0.5**	**0.75**	**1.0**	**1.5**	**2.5**	**4.0**	**6.0**
Specimen length l	mm	50					70			
Number of specimens		5					3			
Distance l_V	mm	20					30			
Bending force max.	N	*according to the sample*					*according to the sample*			

8.3.6 Insulation Notch Strength

Requirements

The notching force must correspond to the values in Table 7:.

Table 7: Notching force

Nominal conductor cross section	**mm²**	**0.22**	**0.35**	**0.5**	**0.75**	**1.0**	**1.5**	**2.5**	**4.0**	**6.0**
Notching force min.	N	*according to the sample*								

Test

The test device (see Figure 5:) consists of a tensile test machine or a force-sensing device, a notching tool (cutter) and a circuit with a low voltage. A round spring wire per DIN 2076, dimensional accuracy C with a diameter of 0.45 mm made of X12CrNi177 per DIN 17 224, should be used for the notching tool.

Affix the specimen in the tensile test machine according to Figure 5:. Press the steel wire with a constant speed of 10 mm/min through the insulation until an electrical contact between the steel wire and the conductor of the specimen is made and the machine is shut off. The axes of the specimen and the cutter should be at right angles to one another. Record the force displayed when contact is made. After each reading, move the specimen 10 mm farther and turn it a total of 4 times 90° about its lengthwise axis. The mean value of the 4 measurements is the notching force.

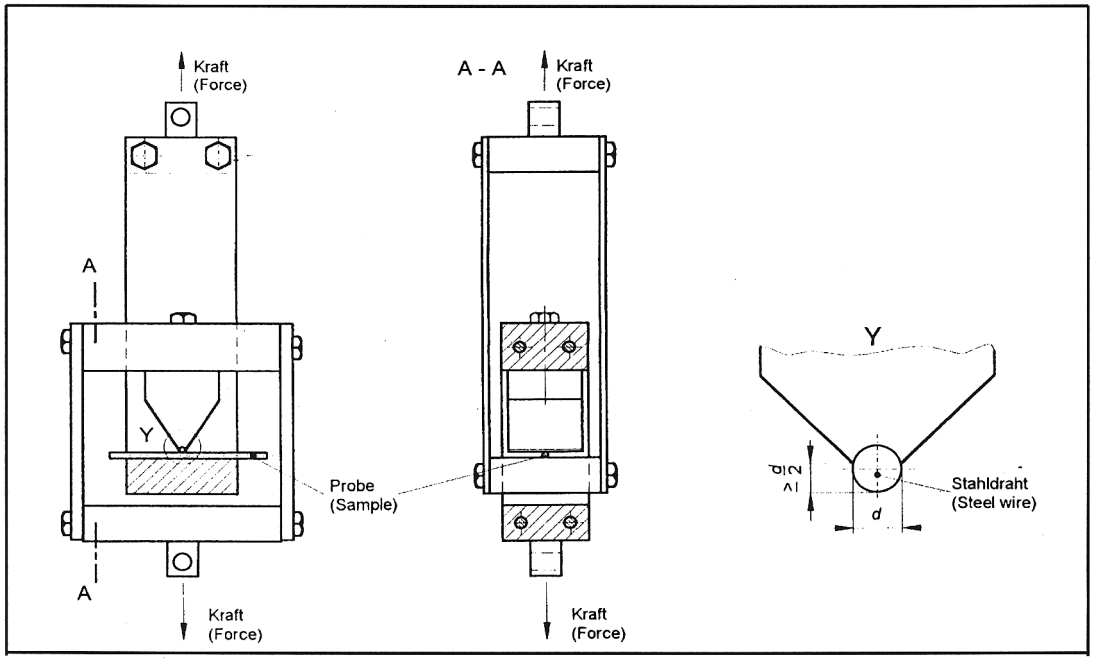


Figure 5: Notch Strength test device

8.4 Non-Flammability

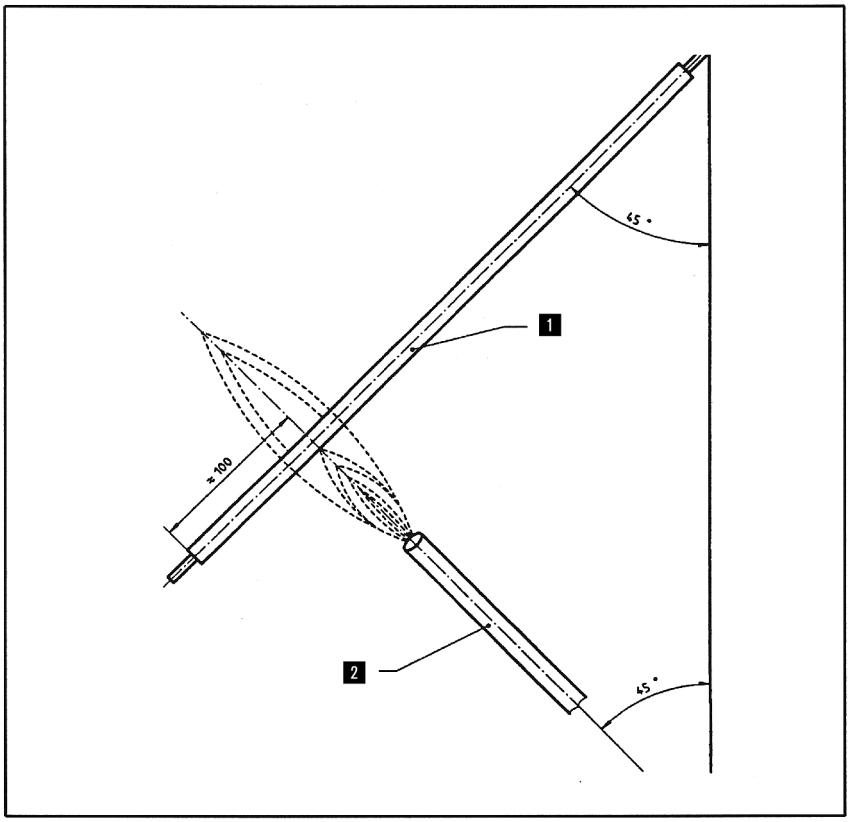
Requirements

The flame of the burning insulation must go out within 30 s after removing the burner flame. At least 50 mm of the insulation must remain unburned on the top end.

Test

Specimen length: (500 ± 5) mm
The test is performed according to DIN ISO 6722-1 (Non-flammability section). The test requires a Bunsen burner with a burner pipe of approximately 9 mm inside diameter and an approximately 100 mm high flame. The length of the blue core within the flame must be approximately 50 mm and its temperature (950 ± 50)° C.

Hang the specimen in a draft-free environment and expose its tip to the inner core of the test flame as shown in Figure 6:. Apply the flame for no more than 30 s, or until the conductor becomes visible.



1 Test sample 2 Bunsen burner

Figure 6: Non-flammability test setup

8.5 Electrical Properties in As-Received Condition

8.5.1 Insulation Defects in the Entire Shipment

Requirements and Tests

Per DIN ISO 6722-1 and -2 (section on Testing for Insulation Defects)

8.5.2 Specific Volume Resistance

Requirements

The specific volume resistance must be at least 10^{10} Ω cm.

Test

The test is performed according to DIN ISO 6722-1 (section on Insulation Resistance).

8.5.3 30-Minute Voltage Protection

Requirements

No electric breakdown must occur.

Test

The test is performed according to DIN ISO 6722-1 (section on Voltage Protection), *except the test voltage is 3 kV_{rms} for cable cross sections ≤ 0.35 mm² and 5 kV for cable cross sections ≥ 0.5 mm².*

8.5.4 1-Minute Voltage Protection *(Only after Aging)*

This test is to be used to evaluate only those trials that contain a reference to it.
The **Requirements and Testing** are the same as under Section 8.5.3 for the test setup (30-Minute Voltage Protection), except a test voltage of 1 kV_{rms} is applied for 1 min.

8.6 Mechanical and Electrical Properties after Mechanical, Thermal and/or Chemical Stress

8.6.1 Heat-Shrinking of the Insulation

Requirements and Tests

Per DIN ISO 6722-1 and -2 (section on Heat-Shrinking of the Insulation).

Deviating from this, the test temperature for cables of class D and up is the thermal overload temperature per Table 1:.

8.6.2 Compressive Strength Under Heat

Requirements and Tests

Per DIN ISO 6722-1 and -2 (section on Compressive Strength Under Heat).

Deviating from this, the test temperature for PVC conductors of class is A is 80° C and 105° C.

8.6.3 Thermal Stability in Wound State

Requirements

No electric breakdown must occur.

Test

Wind a cable specimen of sufficient length around a mandrel with a diameter per Table 8: in 6 windings that are spaced very closely to one another and tie it in place.

Age the samples prepared in this way for 1 h in a natural convection oven per DIN 50 011-12 at the thermal overload temperature per Table 1:. After cooling to room temperature, perform the test described under Section 8.5.4 (1-Minute Voltage Protection).

Table 8: Mandrel diameter

Nominal conductor cross section	**mm²**	**0.22**	**0.35**	**0.5**	**0.75**	**1.0**	**1.5**	**2.5**	**4.0**	**6.0**
Mandrel diameter	mm	5			9				13	

8.6.4 Thermal Overload

Requirements and Tests

Per DIN ISO 6722-1 and -2 (Section on Overload and Winding Testing at Room Temperature).

8.6.5 Short-Term Aging (240 h)

Requirements and Tests

Per DIN ISO 6722-1 and -2 (Short-Term Aging 240 h and Winding Testing -25°C).

8.6.6 Long-Term Aging (3,000 h)

Requirements and Tests

Per DIN ISO 6722-1 and -2 (Long-Term Aging 3,000 h and Winding Test at Room Temperature).

8.6.7 Low-Temperature Winding Test (-40° C)

Requirements and Tests

Per DIN ISO 6722-1 and -2 (Section on Low-Temperature Winding Test -40°C).

8.6.8 Low-Temperature Impact Test

Requirements and Tests

Per DIN ISO 6722-1 and -2 (Impact Testing), except for the following parameters:
- *Perform test on all cross sections except 0.22 mm² cables*
- *Temperature: - 40° C*
- On 0.35 mm² cables, use a hammer mass of 100 g

8.6.9 Resistance of Cable Marking to Wiping

Requirements

The marking must still be easily legible after the test.

Test

The test applies only to cables whose markings are printed on.

Spray the surface of 300 mm long specimens with DIN 51 604-B FAM test fluid, engine oil HD 10W50 per DIN 53 521 and DOT-4 brake fluid, one after another, and age with adhering test media for 48 h in a natural convection oven per DIN 50 011-12 at a temperature of (50 ± 2)° C.

Then place each of the specimens between two felt sheets that are aligned with one another, felt hardness DIN 61 200-F4, dimensions (20 x 20 x 3) mm, which are attached to two fixed plates of a test device similar to DIN VDE 0472-606. Pull the specimens through the two felt sheets twice at a speed of approximately 100 mm/s over a length of approximately 200 mm so that the markings to be tested are turned as directly as possible toward one plate. The contact pressure of the two plates should be (10 ± 1) N.

The felt sheets should be replaced prior to each test.

8.6.10 Dynamic Flexural Strength

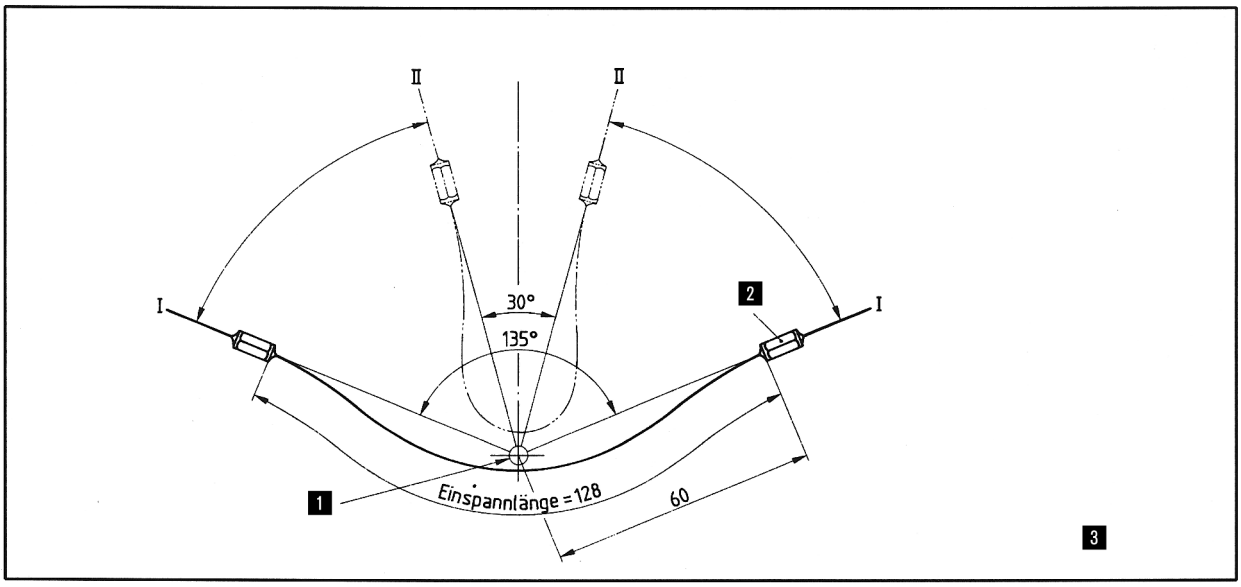
Requirements

While applying the test voltage, no dielectric breakdown must occur on the specimen and the conductor of the stripped specimen must show no damage (e.g., individual wire breakage) on visual inspection.

Test

Age specimens of (200 ± 25) mm length in a natural convection oven per DIN 50 011-12 at the service life temperature per DIN 50011-12 for 48 h. Next, clamp the aged specimens in the test device per Figure 7: and store at T_U for at least 4 h. Perform 300 bending cycles (cycle time approximately 3 s at nearly constant jaw speed) in the cold chamber. Then let the sample warm up to room temperature.

Then perform the test per Section 8.5.4 (1-Minute Voltage Protection test), followed by a visual inspection.



1 Point of rotation 2 Jaws 3 Cycle time 3 seconds for I - II - I

Figure 7: Flexural Strength Test Device

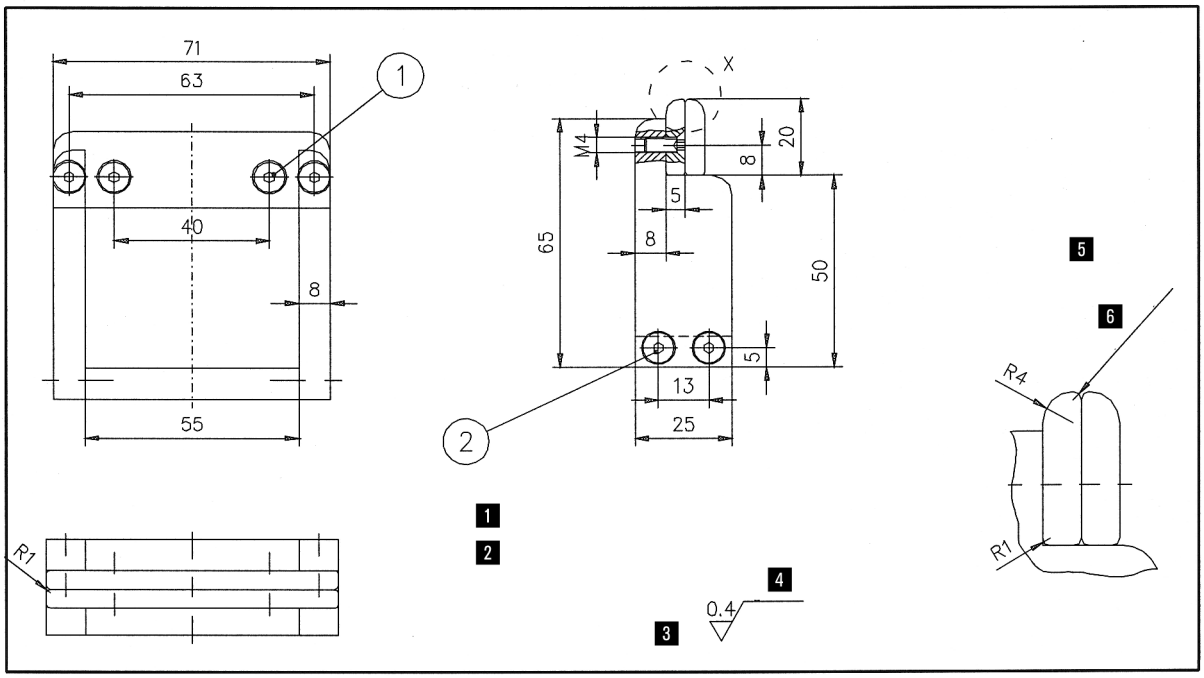
8.6.11 Kink Test

Requirement

No electric breakdown must occur.

Test

Test device, see Figure 8:. Assign bending radius r and spacer ring to the nominal conductor cross section to be tested according to Table 9:.
Strip 20 mm of insulation from the ends of the at least 200 mm long cable specimens. Clamp the specimen vertically between the jaws of the test device until the spacer rings meet the stop. Then subject the cable to 20 bending cycles. One cycle corresponds to bending the cable 180° to one side until the cable lies flat on the device, bending it 360° to the other side of the test device and returning it 180° to its original position. It must be ensured that as little pulling stress is applied to the cable as possible.
After unclamping the cable specimen, test it as described under Section 8.5.4 (1-Minute Voltage Protection).



1 All non-dimensioned radii R5 2 All edges broken!!
3 All surfaces 4 Milled 5 Detail X 6 r (see Table)

2	4	Hexagon socket screws	M4x16	Leicher	8.8: A2	7991
1	4	Hexagon socket screws	M4x16	Leicher	8.8: A 2	7991
Item	Qty.	Designation	Drawing No.	Company	Material / DIN	Raw finished mass

Figure 8: Kink test device

Table 9: Spacer rings

Nominal conductor cross section	**mm²**	**0.22**	**0.35**	**0.5**	**0.75**	**1.0**	**1.5**	**2.5**	**4.0**	**6.0**
Bending radius r	mm	1.0				1.5			3.0	
Spacer ring thickness	mm	1.0	1.1	1.3	1.6	1.8	2.1	2.6	3.3	3.9
Spacer ring tolerance	mm	-0.1								

8.6.12 Electrical Properties with Water Immersion

Requirements

The resulting fault current must be no greater than 10^{-6} A.
No electric breakdown must occur.

Test

Wind a specimen of sufficient length in the center in 10 turns around a mandrel with a diameter according to Table 10:. Tie the cable and remove the mandrel.

Connect the first specimen to the plus pole of a 48 V DC power supply unit and store for 40 days in a salt solution (1 % NaCl) at a temperature of (80 ± 2)° C in which 2 m of the specimen are immersed. *Measure the resulting fault current to the ground (bright Cu electrodes in water bath).*

Test the second specimen in the same way, except with reversed polarity.
Immediately after water immersion, test all specimens is as described under Section 8.5.4 (1-Minute Voltage Protection).

Table 10: Mandrel diameter

Nominal conductor cross section	**mm²**	**0.22**	**0.35**	**0.5**	**0.75**	**1.0**	**1.5**	**2.5**	**4.0**	**6.0**
Mandrel diameter	mm	6				10		15	20	

8.6.13 Moist Heat, Constant

Requirements

No electric breakdown must occur.

Test

Strip the insulation from the ends of a (3 000 ± 50) mm long cable specimen. Lay the cable in rings with a radius ≥ 25 mm, affix to the base plate and age for 30 days at a temperature of 80° C and a relative humidity of (85 ± 3) %. Allow the specimen to cool to room temperature and then test as described under Section 8.5.4 (1-Minute Voltage Protection).

8.6.14 Ozone Resistance

Requirements
No electric breakdown must occur.

Test
Wind cable specimens of sufficient length 4 to 6 times around a mandrel with a diameter of 3 x the outside diameter of the cable and affix. The test is performed based on DIN 53 509-1, Method A.
The specimens are aged (70 + 2) h at room temperature and then 48 h at 40° C, with a relative humidity of (55 ± 10) % and an ozone concentration of (50 ± 5) pphm (1 pphm = part per hundred million = 1 part ozone to 10^8 parts air by volume). After cooling to room temperature, unwind the specimens from the mandrel and test as described under Section 8.5.4 (1-Minute Voltage Protection).

8.7 Mycological Test

Requirements

There must be no mold or mildew growth. The insulation must have no cracks, fractures or other damage. *The necessity of this test depends on the insulation material and should be determined by the appropriate development departments.*

Test

The test is performed in accordance with DIN EN ISO/IEC 17025 (optionally on cables as well as test plates) or cables of the largest cross section of the specific compound. The specimens should be tested for 28 days according to Version 1. In addition to those required in DIN IEC 60 068-2-10, the following organisms should be used:

- Aspergillus Amsterlodami
- Paecilomyces Varioti
- Chaetomium Globosum

Check the specimens every 24 h for mold growth. The test can be terminated when mold growth is determined.

8.8 Compatibility with Other Cable Loom Components

8.8.1 Resistance to Agents

For a list of agents, see Table A.5. Test duration at least 1,000 h.

Requirements

The insulation must have no cracks, fractures or other damage that is relevant to its function. There must be no electric breakdown in subsequent voltage testing.
For agents in Group 1, resistance of more than 1,000 h is required.
For agents in Group 2, a minimum resistance of 240 h is required.
If the resistance is less than 1,000 h, the appropriate protection from those agents in Group 2 must be provided in the affected cable loom area (e.g., corrugated pipe, protective hose) where the cable is in use.

Test

Twist two cables of the same material with a cross section of 0.35 mm² together (twist length approx. 2 cm) and cut off 40 cm long specimens. Prepare the following test groups:

Test Group 1:

Bend the specimens in the center into a U shape so that the specimen fits into an open test glass with a diameter of approx. 25 mm. Wrap the specimens with 50 % overlap with a type 1 adhesive tape of the adhesive tapes listed in Table A.4. It must be ensured that the service life temperature of the adhesive tape is at least as great as that of the cable.

Test Group 2:

Like test Group 1, except using a type 2 adhesive tape per in Table A.4

Test Group 3:

Specimens are not wrapped.

Dip at least 4 specimens of each test group into the specific agent at room temperature for 2 minutes (cable ends must not come in contact with the agent) and then let drip dry for 2 min (10 min for fuels). For each type of agent (for each column in Table A.5), use one agent from the indicated selection of agents.

Then place 1 specimen with the cable end up into 1 test glass and age the test glasses in an oven at T_O for 1,000 h. After 240 h, 480 h, 720 h and 1,000 h, remove one of the specimens and immerse the remaining specimens in the agent again, let them drip dry and age them again.
Untwist the specimen just removed and subject it to a visual inspection. Next, wind the cable around a mandrel with a diameter of 2 mm, repeat the visual inspection and perform a voltage test per Section 8.5.4 (1-Minute Voltage Protection). Any visual changes to the cable or adhesive tape must be noted in the test report.
If the adhesive tape cannot be removed from the cable without causing obvious damage, further steps should be agreed upon with the responsible development department.

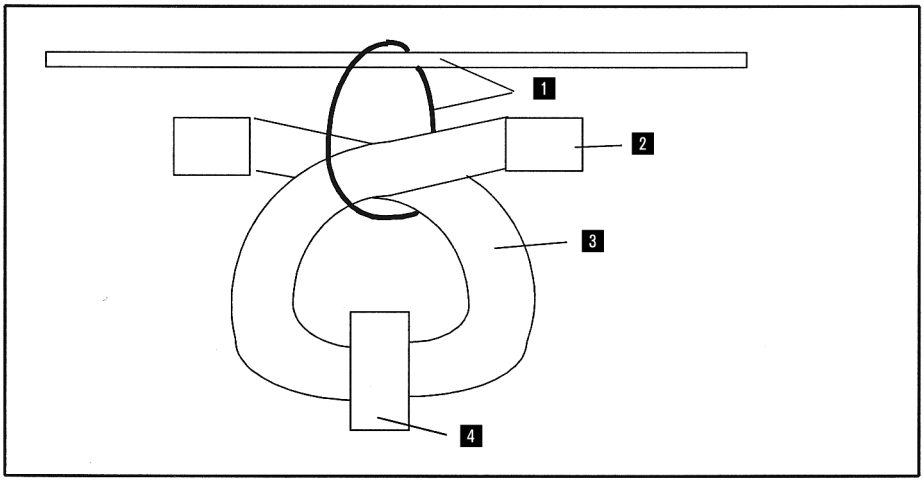
8.8.2 Base Cable Loom Compatibility

Requirements
The insulation must have no cracks, fractures or other damage that is relevant to its function. There must be no electric breakdown in subsequent voltage testing.

Test
The cable manufacturer, in cooperation with a finisher if desired, must, as the minimum requirement, manufacture the base cable sets as described below with all component types in Table 12: (parts list).

Each sample set consists of no less than 6 cables of (300 to 400) mm length with cross sections of 0.35 mm² and 2.5 mm², which are affixed on both sides with contact parts from Table 12:, and affixed with other contact parts from Table 12:, and another cable loom component listed in Table 12:. 4 sample sets must be made for each cable loom component (3 for heat aging, 1 as a reference)

It must be ensured that the service life temperature of the components is at least as great as that of the cable. The components used must be listed in detail in the test report.
The wire assemblies prepared in this way are aged for 1,500 h in a natural convection oven per DIN 50 011-12 at their T_O so that no contact is made with the oven walls or other metallic objects (see Figure 9:).



1 Suspension 2 Contact parts 3 Cable bundle 4 Cable loom component

Figure 9: Wire assembly

Every 500 h, one set is removed for testing. Conduct a visual inspection of the wire assembly, paying special attention to damage to the insulation in the area of the cable contact, since a voltage test cannot be performed here. Remove the components to the greatest possible extent and remove at least one cable specimen from each of the two cross sections.
Wind the cable specimen around a mandrel with a diameter per Table 11:, inspect it, unwind it and perform a voltage test per Section 8.5.4 (1-Minute Voltage Protection).

Table 11: Mandrel diameter

Nominal conductor cross section	**mm²**	**0.35**	**2.5**
Mandrel diameter	mm	6	15

Table 12: Base cable set parts list

Ser. no.	*Standard part. no. / Production no. / Table no.*	Designation	Supplier	Material	Temperature class	
					100° C	125° C
1	*N 907 327 01* *or* *N 103 358 01*	*Flat contact 4.8 with insulation crimp* *Flat contact 1.5 with insulation crimp*	*Tyco (AMP), GHW, DRN* *Tyco (AMP), GHW, DRN*	*$CuFe_2$, tinned* *$CuFe_2$, tinned*	X	X
2	*1J0 973 047*	Flat contact housing, 47-pole, inc. single core seal	*Tyco (AMP), GHW, DRN*	*- PBT+ASA-GF30 / + -GF10* *- PA6.6T-GF25 (with graphite)* *- PA6.6-GF33* *- PBT-GF50*	X	X
3	*TAB 016 038P*	*Flat contact housing, 8-pole, without single core seal*	*Hirschmann*	*POM*	X	---
4	*7DO 972 913*	*Shrinkdown plastic tube to seal splice, adhesive-coated (RBK-VWS-125-NR1-28 mm)*	*Tyco (Raychem)*	*Modified PE, polyamide-based adhesive*	X	X
5	*N 102 760 01*	*Shrinkdown plastic tube without adhesive (RNF-150-1/2-0)*	*Tyco (Raychem)*	*Fluoropolymer (PE base)*	X	X
6	*N 018 007.5*	*Insulating hose W7*	*Vorneweg*	*PVC per TL 507/1*	X	---
7	*N 908 285 01*	*PUR insulating hose*	*Altenkirchner*	*PUR*	X	X
8	*N 105 148 01*	Netting hose	*Federal Mogul*	*Fiberglass (E glass), MVQ sheathing (silicone) with Al particles, VW 2.8.1-G35*	X	X
9	*N 102 930 01* *with* *N 906 814 01*	*Corrugated hose, slotted, (7.5)* *with* *corrugated-hose holder, (7.5)*	*Soufanou, Schlemmer/ Raymond*	*Modified PP* *PA 66*	X	X

continued

Ser. no.	*Standard part. no. / Production no. / Table no.*	Designation	Supplier	Material	Temperature class	
					100° C	125° C
10	*N 907 621 02 with N 906 688 01*	*Corrugated hose, unslotted, (7.5) with T-piece distributor*	*Schlemmer/ Schlemmer*	*Thermoplastic polyester elastomer (Arnitel), Shore D 55 PA66*	X	X
11	*1J0 957 818 B TAB 004 769 B*	*Cable clips*	*Hellermann*	*PA6.6*	X	X
12	*7 L0 941 913*	*Lengthwise water seal*	*Delphi*	*PUR foam grommet*	X	X
13	*1J0 906 102*	*Grommet*	*ETG*	*EPDM, VW 2.8.1-G45 (Shore A 45)*	X	X
14	*N 105 095 01*	*Coroplast adhesive tape 8550 or Tesa adhesive tape 51608)*	*Coroplast Beiersdorf*	*Non-woven PET, rubber adhesive*	X	---
15	*N 105 598 01*	Coroplast adhesive tape 651 MSX	Coroplast	Plasticized PVC (lead-free), acrylate adhesive	X	X
16	*N 105 601 01*	*Coroplast adhesive tape 8557 XSE*	Coroplast	Non-woven PET, acrylate adhesive	X	X
17 ***)**	Scope and standard part no. in consultation with the development department	Current standard and special cables of insulation materials other than the material of the cable to be tested	Suppliers that have a production sample release from the VW Group for the cable in question	According to the specifications of the development department, e.g., PVC (Pb-free), FEP, ETFE, XPE, PP, PUR, etc. Temperature class 125° C only for insulation materials with resistance thereto.	X	--- / X

The diameter of the cable protection systems (corrugated pipe, shrinkdown and netting hose, etc.) should be according to the sample cable loom.

**) In this case, the base wire assembly should be made of 3 cables of the cable to be tested with 3 cables of the other insulation material, see Section 8.8.2*

9 Supply Specifications

If these supply requirements are not met, the goods will be returned at the supplier's expense.

9.1 Visual Inspection

The insulations must have no nodes, cracking, blistering or foreign inclusions and must be strippable using a standard commercial stripping machine without leaving a residue and without damage to the conductor.

9.2 Test

The cables must be tested after the spark test. The voltage to be applied can be a needle pulse voltage of 3 kV< 0.5 mm^2, 5 kV ≥ 0.5 mm^2 of any frequency. The stay time of the cable in the electrical field should be selected so that each cable section is stressed with at least 18 voltage spikes. When using tubular electrodes, the inside diameter of the electrode must accommodate the cable diameter.

The emphasis in inspection should be placed on production inspection. The test plans and measured value documentation of the production and output inspections must include information on the measuring equipment used, frequency of measurements, desired values and tolerances for all criteria that are important to the function.

9.3 Packaging Units (Only for Delivery to VW-Group Production Units)

The cables must be delivered in undamaged VW AG drums, optionally in coils. The following requirements must be met:

- *The cable must be delivered in one length in the drum/coil, the two ends should be arranged so that they are accessible, do not interfere with processing and cannot be damaged during transport.*
- *The cable must be removable from the drum/coil into a cable-cutting machine at a speed of 420 m/min. in intermittent operation.*

Unless otherwise specified, the packaging units are to be delivered according to Section 9.3.1 and Section 9.3.2.

9.3.1 Delivery in Drums

Table 13: Delivery quantities

FL Cables		*FLR Cables*	
Nominal cross section mm^2	*Delivery quantity *) m*	*Nominal cross section mm^2*	*Delivery quantity *) m*
-	-	0.22	12,000 or as NPS (Niehof package coil) 24,000**)
-	-	0.35	12,000
0.5	9,000	0.5	10,000
1.0	6,000	1.0	8,000
1.5	2,000	1.5	7,000
2.5	3,000	2.5	5,000
4.0	2,500	4.0	2,500
6.0	1,600	6.0	1,500

*) Other delivery quantities in consultation with the processor/recipient
**) Since delivery in drums can lead to entanglements, delivery per NPS (on delivery spools = drums with conical inserts) is favored.

9.3.2 Delivery in Coils

Coil dimensions and delivery quantities per VW 450 01.

9.3.3 Partial Lengths, Ties, Defects

A prescribed length can be made up of partial lengths in exceptional cases; this must be specially noted.

- *Ties used for the partial lengths must not exceed the diameter of the cable and must not crack during processing.*
- *Tie and defect points should be identified by 30 to 100 mm of stripped insulation.*
- *Maximum permissible quantities per drum/coil by nominal cross section:*
- *0.22 / 0.35 / 0.5 / 0.75 mm^2 3 ties/defects*
- *1.0 / 1.5 / 2.5 mm^2 2 ties*
- *$\geq$ 4.0 mm^2 1 tie*

9.3.4 Identification of the Delivery Unit

The coil/drum identification must be applied so that it is always visible, even when packed on pallets.
The compound number must correspond to the compound in the first sample report.
Identification:

- *Standard part number*
- *Compound number*
- *Manufacturer*
- *Date of manufacture*
- *Cable length*
- *Position of ties*

10 Notes on testing: Method for Qualitative Determination of Lead in Polymers

Preparation for analysis:

Approximately 3 to 5 g of the material to be tested is ignited at 500 °C in a muffle furnace.

Analysis:

The ignition residue is poured into a test glass and mixed with approximately twice its volume of concentrated acetic acid. This mixture is briefly boiled. Then it is allowed to precipitate and the fluid on top is poured, still warm, into a beaker. It may still be necessary to filter it. If the specimen contains glass fibers (mineral fibers), it must be filtered since these will interfere with the evaluation.
Next, the solution in the beaker is carefully, slowly boiled down.
The residue is absorbed with as little diluted acetic acid as possible and replaced with a drop of a saturated potassium dichromate solution.

Evaluation:

If the solution remains clear, there is no lead present; if, however, a bright yellow, heavy, crystalline deposit (lead chromate) forms, lead is present. If the result is ambiguous, examine a few drops of the solution with deposit (cloudy solution) under a microscope at 200 to 400 x magnification. Lead chromate forms small, yellow crystal needles that must not be confused with potassium dichromate crystals or residues of the polymer that may be present. To obtain larger lead chromate crystals, the deposit can be allowed to age for several hours. If the test results are uncertain, a quantitative lead verification may be requested by the development department.

11 Referenced Standards

DIN 1333	Numerical Representations
DIN 2076	Round Spring Wire, Dimensions, Weights, Permissible Deviations
DIN 17 224	Round Spring Wire and Spring Band of Stainless Steels
DIN 40 500-4	Copper for Electrical Engineering; Wires of Copper and Copper-Silver Alloys
DIN 40 500-5	Copper for Electrical Engineering; Tin-Coated Wires
DIN 50 011-12	Ovens; Guidelines for the Alloying of Specimens
DIN 50 014	Climates and Their Technical Application, Standard Climates
DIN 51 604-1	FAM Test Fluid for Polymer Materials
DIN 51 604-2	FAM Test Fluid, Containing Methanol, for Polymer Materials; Composition and Requirements
DIN V 51 606	Liquid Fuels; Diesel Fuel from Vegetable Oil Methyl Ester (PME), Minimum Requirements
DIN 53 509-1	Testing of Rubber and Elastomers; Determination of Resistance to Cracking Under the Influence of Ozone
DIN 53 521	Testing of Rubber and Elastomers; Determination of Behavior Against Liquids, Vapors and Gases
DIN 53 568-2	Determination of Ignition Residue after Acid Treatment of the Specimen (Sulfated Ash)
DIN 61 200	Felt; Hardness
DIN 72 551-7	Low-Voltage Lines in Road Vehicles – Part 7: Colors and Color Coding of Wires for Low-Voltage Lines
DIN 76 722	Road Vehicles; Low-Voltage Lines; Symbol Design
DIN EN 590	Automotive Fuels, Diesel, Requirements and Methods of Test
DIN EN 3745-511	Aviation and Space Travel; Optical Fibers and Optical Fiber Cables for Aircraft; Test Methods –Part 511: Abrasion of Cable Against Cable
DIN EN 60 811-4-2	Materials for Insulation, Jacketing and Cable Elements of Electrical and Optical Fiber Cable – General Test Methods – Part 4: Special Test Methods for Polyethylene and Polypropylene Compounds; Main Section 2: Elongation at Tear after Pretreatment; Winding Test after Thermal Aging in Air; Measurement of the Mass Absorption; Long-Term (Service Life) Testing; Method of Testing Acid Aging Under Influence of Copper
DIN ISO 3146	Plastics, Determination of Melting Behavior (Melting Temperature or Melting Range) of Crystalline Polymers
DIN ISO 6722-1	Unshielded Low-Voltage Lines Part 1: Testing
DIN ISO 6722-2	Unshielded Low-Voltage Lines Part 2: Requirements
DIN EN ISO 1628-2	Plastics – Determining the Viscosity of Polymers in Dilute Solution Using Capillary Viscometers – Part 2: Vinyl Chloride Polymers
DIN EN ISO 6427	Plastics; Determining the Extractable Ingredients from Organic Solvents

DIN EN ISO/IEC 17025	General Requirements for the Competence of Testing and Calibration Laboratories
DIN IEC 60 068-2-10	Electrical Engineering; Elementary Environmental Test Methods; Test J and Instructions: Mold Growth
DIN VDE 0472-606	Testing of Cables and Insulated Lines; Resistance to Washing and Absence of Sticking
ISO 1183--3	Plastics – Determining the Density of Non-Foaming Plastics
VDA 231 106	Materials Classification in Automotive Engineering Design and Nomenclature
VDA 675 101	Rubber Components in Motor Vehicles; Test Methods for Identification; Hardness; Microhardness Test (IRHD)
VDA 675 135	Rubber Components in Motor Vehicles; Test Methods for Identification; Thermogravimetry, TGA
VDA 675 140	Rubber Components in Motor Vehicles; Test Methods for Identification, Infrared Spectroscopy Analysis (IR), IR Pyrolysis
TL 507/1	PUR Insulating Hose, Heat-Resistant
TL 766	Brake Fluid
TL 521 46	Central Hydraulic System Fluid
TL 521 57	Heavy Duty Transmission Oil
TL 521 73	Factory-Fill Engine Oil
VW 2.8.1	Rubbers; Material Requirements and Testing
VW 011 55	Vehicle Supply Parts, General
VW 450 01	Coils for Low-Voltage Lines
VW 501 80	Vehicle Interior Components, Emissions Behavior
VW 911 00	Vehicle Environmental Standard, Avoidance of Hazardous Substances

Ingolstadt Laboratory Guideline for Use No. 3211
Requirements for the emission behavior per VW 501 08 for materials and components in the passenger compartment, in the trunk and in the air ducts used in vehicles by AUDI AG.

A.1 Conductor Setup, Symmetrical, Type A (Normative)

Table A.1 Conductor setup, symmetrical, type A (normative)

Nominal conductor cross section	Individual wire		Conductor						Cable					
	Quantity	Ø	Ø d_1	Twist length	Cross section *)		Resistance at 20° C Individual wires, bright		Outside Ø d_2		Wall thickness of insulation s	C_{PK} value (based on s) **)	Concentricity factor K ***)	Weight ≈
[mm²]		[mm]	[mm]	[mm]	[mm²]		[mΩ/m]		[mm]		[mm]		[%]	[g/m]
		max.	max.	max.	max.	min.	max.	min.	max.	Permissible deviation	min.	min.	min.	
0.22	7	0.21	0.70	18	0.219	0.202	84.8	77.9	1.2	-0.1	0.20			3.1
0.35		0.26	0.80	18	0.349	0.329	52.0	47.8	1.3		0.20			4.5
0.5	19	0.19	1.00	30	0.490	0.461	37.1	34.1	1.6	-0.2	0.22	1.33	45	6.6
0.75		0.23	1.20	30	0.735	0.692	24.7	22.7	1.9		0.24			9.0
1.0		0.26	1.35	35	0.982	0.925	18.5	17.0	2.1					11.0
1.5		0.32	1.70	40	1.428	1.345	12.7	11.7	2.4					16.0
2.5		0.41	2.20	50	2.389	2.25	7.6	7.0	3.0	-0.3	0.28			26.0

*) Calculated with a value of the specific electrical conductivity of 58.5 Sm/mm^2, quality control through resistance measurement

**) For cable cross sections of ≥ 0.75 mm^2, a C_{KP} value of ≥ 1.0 will be accepted for the transition period.

***) K [%] = (s_{min}/s_{max})*100, (s_{max} must not be located opposite s_{min}.)
s_{min}: minimum wall thickness; s_{max}: maximum wall thickness

For processed individual wire, a specific electrical conductivity of 58.5 S/mm² must be guaranteed.

A.2 Conductor Setup, Asymmetrical, Type B (Normative)

Table A.2 Conductor setup, asymmetrical, type B (normative)

Nominal conductor cross section [mm²]	Individual wire		Conductor						Cable					
	Quantity	Ø [mm]	Ø d_1 [mm]	Twist length [mm]	Cross section *) [mm²]		Resistance at 20° C Individual wires, bright [mΩ/m]		Outside Ø d_2 [mm]		Wall thickness of insulation s [mm]	C_{PK} value (based on s) **)	Concentricity factor K ***) [%]	Weight ≈ [g/m]
		max.	max.	max.	max.	min.	max.	min.	max.	Permissible deviation	min.	min.	min.	
0.35	12	0.21	0.90	Not specified	0.355	0.329	52.0	47.8	1.4	-0.2	0.20	1.33	45	4.5
0.5	16		1.00		0.498	0.461	37.1	34.1	1.6		0.22			6.6
0.75	24		1.20		0.748	0.692	24.7	22.7	1.9		0.24			9.0
1.0	32		1.35		0.998	0.925	18.5	17.0	2.1					11.0
1.5	30	0.26	1.70		1.455	1.345	12.7	11.7	2.4					16.0
2.5	50		2.20		2.430	2.250	7.6	7.0	3.0	-0.3	0.28			26.0
4.0	56	0.31	2.75		3.930	3.640	4.7	4.32	3.7		0.32			42.0
6.0	84		3.30		5.960	5.520	3.1	2.85	4.3					61.0

*) Calculated with a value of the specific electrical conductivity of 58.5 Sm/mm^2, quality control through resistance measurement

**) For cable cross sections of ≥ 0.75 mm^2, a C_{KP} value of ≥ 1.0 will be accepted for the transition period.

***) K [%] = (s_{min}/s_{max})*100, (s_{max} must not be located opposite s_{min}.)
s_{min}: minimum wall thickness; s_{max}: maximum wall thickness

For processed individual wire, a specific electrical conductivity of 58.5 S/mm² must be guaranteed.

A.3 Conductor Setup, Asymmetrical, Thick-Walled, Type B (Normative)

Table A.3 Conductor setup, asymmetrical, thick-walled, type B (normative)

	Individual wire		Conductor						Cable						
Nominal conductor cross section mm²	Quantity	Ø mm	Ø d1 [mm]	Twist length [mm]	Cross section *) [mm²]		Resistance at 20° C Individual wires, bright [mΩ/m]		Outside Ø [mm]		Wall thickness of insulation S [mm]	Cpk value (based on s) **)	Test wall thickness Sp [mm]	Concentricity factor K***) [%]	Weight ≈ [g/m]
		max.	max.	max.	max.	min.	max.	min.	max.	Permissible deviation	min	min	min	min	
6	84	0.31	3.4	Not specified	5.96	5.52	3.100		5.3	0.6	0.62	1.33	0.64	45	68
10	290	0.21	4.5		9.70	9.20	1.820		6.8	0.6	0.8		0.82		127
16	126	0.41	6.0		15.52	14.72	1.160		8.3	0.6	0.8		0.82		182
25	196	0.41	7.5		24.25	23.00	0.743		10.2	0.7	1.0		1.02		279
35	276	0.41	9.0		33.95	32.20	0.527		11.6	0.6	1.0		1.02		385
50	396	0.41	10.5		48.50	46.00	0.368		13.5	0.6	1.4		1.42		534
70	360	0.51	12.3		67.90	64.00	0.259		15.9	0.8	1.4		1.42		760
95	2850	0.21	14.8		92.15	87.40	0.196		17.7	1	1.34		1.36		911
120	3650	0.21	16.5		116.40	110.40	0.153		19.7	1	1.34		1.36		1146

*) Calculated with a value of the specific electrical conductivity of 58.5 Sm/mm², quality control through resistance measurement

**) A C_{KP} value of ≥ 1 will be accepted for the transition period.

***) K[%] = $(S_{min}/S_{max})*100$, (S_{max} must not be located opposite).
S_{min}: minimum wall thickness; S_{max}: maximum wall thickness

A.4 Survey of Adhesive Tapes (Informative)

Table A.4 Survey of adhesive tapes

Adhesive tape 1 *)	**Part No.**	**Material**	**Adhesive base**
Beiersdorf Tesa 4173 (105° C)	AKL 389 000 / AKL 382 019	Plasticized PVC (lead-free)	Rubber
Coroplast 401 MSW (105° C)	N 103 113 01 / 02 / 03	Plasticized PVC (lead-free)	Acrylate
Certoplast 608 / 609 (105° C)	N 103 113 01 / 02 / 03	Plasticized PVC (lead-free)	Acrylate
Hänsel S 1117 HVT 000 025 (105° C)	N 105 239 01	Compact PVC / PVC foam film	Acrylate
Coroplast 651 MSX (125° C)	N 105 598 01	Plasticized PVC	Acrylate
Adhesive tape 2 *)	**Part No.**	**Material**	**Adhesive base**
Coroplast 8550 / 8560 (105° C)	N 105 095 01 / 02	Non-woven PET	Rubber
Beiersdorf Tesa 51608/51609 (105° C)	N 105 095 01 / 02	Non-woven PET	Rubber
Coroplast 8557 XSE (125° C)	N 105 601 01	Non-woven PET	Acrylate
Beiersdorf Tesa 4606 (130° C)	AKL 373 S19	Velour PET	Acrylate
Coroplast 837 X (150° C)	N 105 492 01	PET woven fabric with smooth surface	Acrylate
***)** Temperature values correspond to service life temperature resistance (3,000 h aging)			

A.5 List of Agents (Informative)

Table A.5

Agent type - Group 1	**Selection of commercial agents / remarks**
Multi-grade engine oil	*SAE 0 W 30, Castrol or ESSO (VW Saturn), (TL 521 73)* *5 W 40 / Fuchs Titan EM 540 (for pump nozzle engines)*
CVT / ECVT transmission oil	*DEA DES 5080 (G50,G51), (TL 521 57)* *G50 SAE 75 W90*
Radiator antifreeze	50% ethylene glycol, 50 % H_2O
Intensive cleaning agent	80 % isopropyl alcohol, 20 % polypropylene glycol
Cold-cleaning agent, undiluted	Auwa engine cleaner L Haku 1025 / 400 Chem. Werke Kluthe
Engine compartment sealant (*/ transmission sealant)*	*AKR 320 KD 604* *(AKR 3211145 / Pfinder)*
Grease	BP Energrease LS-EP2
Fuel	FAM B DIN 51 604-2
Diesel engine	DIN EN 590
Vegetable oil methyl ester (Biodiesel)	DIN V 51 606
Salt solution	5 % NaCl, 95 % H_2O
Agent type - Group 2	**Selection of commercial agents / remarks**
Battery acid	25% H_2SO_4, 75 % H_2O, density 1.28
Brake fluid	Hydraulan 400 NV/1, BASF (DOT 4) *(TL 766)*
Automatic transmission / power steering fluid	Pentosin CHF 11 S (Servo hydraulic oil) *(TL 521 46)*
Penetrating oil	Super Caramba

A.6 Electrical Wiring (Classification) (Informative)

The file memorandum regarding electrical wiring dated 02/20/1979 is made invalid and is replaced by Appendix A6 to Standard VW 603 06.
Until now the standard part numbers for electric wiring have indicated

- the type
- the cable diameter and
- the basic and code colors

with specific numbers.

With the introduction of new models (diesel and larger engines, 5-cylinder), the available digits were exceeded by the number of required cable cross sections.

The system documented in this file memorandum is thus no longer completely meaningful.

For cables within the system, a 6-digit standard part drawing applies (was 5-digit) for each cross section, which has a 0 at the end. The released cables are entered in the table according to their colors.

Example:

Standard part drawing for 1.5²	N	0	1	8	1	3	0
cable	N	0	1	8	1	3	9	6

Type	B
Cross section	1.5²
Basic color	black
Code color	green

Code number for type

The code letters of the previous type versions are dropped. The nomenclature of the electrical cables in vehicles is taken from DIN 76 722. This also applies for the different conductor setup.

Code number for the nominal conductor cross section

0 = 0.5 mm²	5 = 4.0 mm²
1 = 0.75 mm²	6 = 6.0 mm²
2 = 1.0 mm²	7 = 0.14 mm²
3 = 1.5 mm²	8 = 0.22 mm²
4 = 2.5 mm²	9 = 0.35 mm²

Standard part numbers for nominal conductor cross sections larger than 6.0 mm² are assigned unsystematically.

Code Numbers of the Colors (Basic and Code Colors)

0 = white	(wt)	
1 = yellow	(ye)	
2 = white-green		(wtgn) for code color only
3 = red	(rd)	
4 = violet	(vi)	
5 = blue	(bu)	
6 = green	(gn)	
7 = gray	(gr)	
8 = brown	(br)	
9 = black	(bk)	

If the basic and code color have the same code, the cable is one color.
For all cables that cannot be assigned to the system, all cable cross sections must be given a 6-place number. Basic and code colors are controlled with the index. The colors are assigned in the order in which they are called for, e.g.,:

Cable green	N 1
Cable yellow	N 2

If double code colors other than the "white-green cable" are required, the following end numbers should be used. The following listing of color coding is only for documentation and information. It should not be used for new designs.

Colors	Last number of the standard table no.	1st Index	2nd Index
orange	3	3	1
clear	0	0	0
light blue	5	5	0
silver gray	7	7	2
light blue/white	5	0	0
light blue/red	5	3	0
light blue/green	5	6	0
light blue/yellow	5	1	0
light blue/black	5	9	0
brown/light blue	8	5	0
red/light blue	3	5	0
white/black-red	0	9	3
white/blue-violet	0	5	4
white/black-violet	0	9	4
white/green-violet	0	6	4
white/red-green	0	3	6
white/green-gray	0	6	7
white/brown-gray	0	8	7
white/red-yellow	0	3	1
white/blue-gray	0	5	7
white/green-brown	0	6	8
white/black-blue	0	9	5
white/violet-blue	0	4	5
brown/light blue-blue	8	5	5
yellow/red-black	1	3	9
black/red-yellow	9	3	1
black/yellow-red	9	1	3
black/yellow-light blue	9	1	5
black/red/green-white	9	3	2
black/red-white	9	3	0
black/violet-white	9	4	0