Class. No.: 69606

Descriptors: crimp connection, electrical connection, crimp, contact, connector, solderless connection

Crimp Connections

Solderless Electrical Connections

Previous issues

VW 60330: 1993-01

Changes

The following changes have been made as compared to Volkswagen standard VW 60330: 1993-01:

– Standard completely revised

Contents

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1 Scope

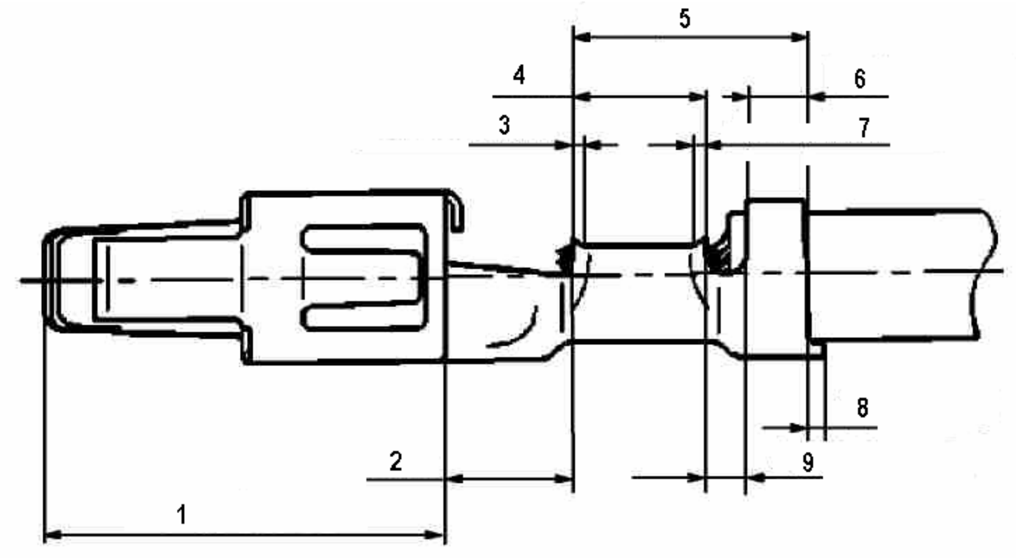
This standard specifies the definitions, requirements, and test criteria for evaluating solderless electrical crimp connections that are produced using crimp barrels and multi-stranded, fine stranded, and ultra-fine stranded conductors made of flexible copper. The specifications in this standard apply only to single wire crimps.

This standard also specifies the requirements for producing, testing, and evaluating crimp connections. In individual cases, the standard part drawings of the contacts and cable lugs provide detailed crimp specifications. In addition to this, the contact manufacturers supply processing specifications containing additional information that must be also be taken into consideration. Specifications in the respective standard part drawing take precedence.

2 Definitions

The terms and definitions in this standard are specified in DIN IEC 60050-581.

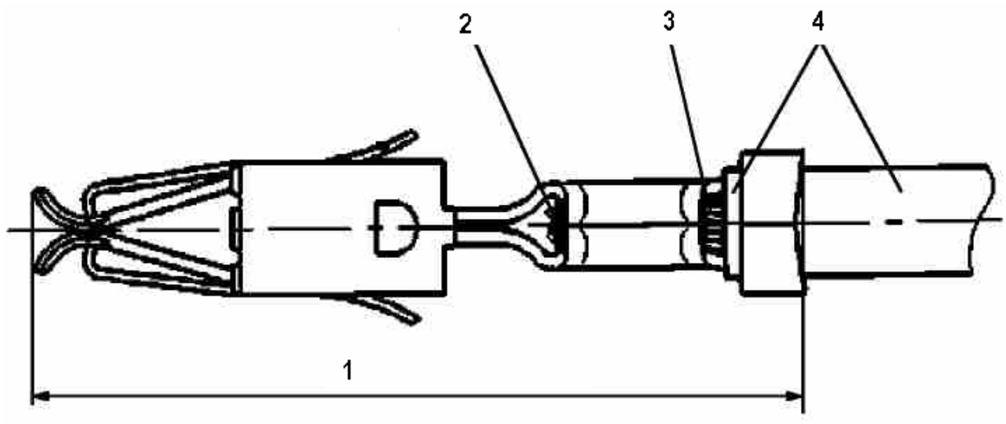
Refer to Figures 1 and 2 for identification.



Legend

1	Contact area	4	Conductor crimp	7	Rear runout
2	Connection A	5	Crimp connection	8	Separation bridge
3	Front runout	6	Insulation crimp	9	Connection B

Figure 1



Legend

1 Contact element

2 Conductor end

3 Conductor

4 Insulation

Figure 2

2.1 Crimp connection

2.1.1 Open crimp barrel

Open crimp barrels are conductor crimps, insulation crimps, or single-conductor sealing crimps with a U-shaped, V-shaped, or preshaped opening. Open crimp barrels are customary in punched contact elements. The crimping operation simultaneously closes the open crimp barrel while separating the contact element from the transport strip.

2.1.2 Closed crimp barrel

Conductor crimps, insulation crimps, or single-conductor sealing crimps with closed contour have closed crimp barrels. They are customary in tubular cable lugs. Closed crimp barrels are usually conductor crimps. Single-conductor sealing crimps or insulation crimps in the form of closed crimp barrels require significant effort and, thus, are seldom implemented.

2.1.3 Conductor crimp

Connection between the contact element and the stranded conductor. The conductor crimp must ensure the permanent electrical connection between the contact element and the stranded conductor.

2.1.4 Insulation crimp

Connection between the contact element and the cable at the outer diameter of the insulation. The insulation crimp is designed to absorb mechanical loads and vibrations to prevent them from affecting the conductor crimp.
For the designs of the insulation crimp, refer to Section 3.3.6.

2.1.5 Single-conductor sealing crimp

Connection between the contact element and the single-conductor sealing crimp by means of compression deformation. The single-conductor sealing crimp must ensure the permanent seat of the single-conductor sealing on the contact element.
For the designs of the single-conductor sealing crimp, see Sections 3.3.7.2.1 and 3.3.7.2.

2.1.6 Connection A

Transition area between the contact box and conductor crimp.

2.1.7 Connection B

Transition area between the conductor and insulation crimp.

3 Requirements

3.1 General requirements

Crimp connections must be implemented according to the drawing specifications in their respective valid version. The contact manufacturer is required to specify the component-specific crimp dimensions (crimp height, crimp width, etc.), which are documented in the standard part drawing. These specified crimp dimensions must be adhered to exactly. The working part sections or crimpers must be assigned properly to the anvil sections according to the wire cross-sections and contact elements to be processed.

3.2 Cable

Only copper cables with bare or surface-treated strands that have been released by Volkswagen must be used; VW 60306 applies.

This crimp standard is strictly not applicable to solid cables, aluminum conductors, or flat ribbon cables. The electrical conductor must not be dip-tinned or soldered.

Cable material whose properties have been adversely affected, e.g., by degassing of the insulation or oxidation of the conductor as a result of aging, must not be used.

After 2 years of storage at the latest, sufficient proof must be provided that the cable material can continue to be used. The cable material must continue to comply with the requirements in VW 60306 and the relevant standard part drawing.

3.2.1 Stripping

Special tools must be used for stripping. The length of insulation to be stripped must be defined by the cable fabricator, taking into consideration the applicable specifications.

No more than x% of the available stranded wires may be cut off, depending on the cable type. The calculated number is always rounded down to an integer value. In addition, no more than 30 individual stranded wires must be cut off for cables with a cross-section of 25 mm² or more.

$x = 5$ for cables $\leq 0{,}5$ mm²

$x = 8$ for cables $\geq 0{,}75$ mm²

Example 1: Number of stranded wires = 7 (cable type A; 0,35 mm^2)
5% of 7 stranded wires = 0,63 stranded wires, after rounding down = 0. No stranded wires must be cut off.

Example 2: Number of stranded wires = 32 (cable type B; 1,0 mm^2)
8% of 32 stranded wires = 2,56 stranded wires, after rounding down = 2 stranded wires. No more than 2 stranded wires must be cut off.

It is not permissible for single stranded wires to stick out; see Figure 3.
In addition, the single stranded wires must not be scored or otherwise damaged when insulation is stripped.

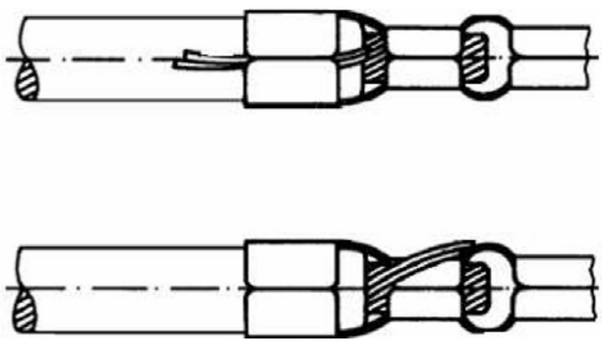


Figure 3 – Single stranded wires sticking out

If the stripped cable is not processed immediately, the stripped ends must be protected from fanning out (e.g., by an insulation barrel).

Fanning out of the strands is not permissible; see Figure 4.

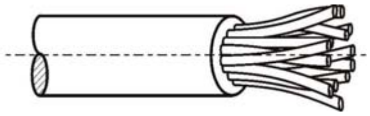


Figure 4 – Fanned out stranded conductors

Failure to cut through the insulation cleanly, damage to the insulation, or the presence of insulation residues on the stripped portion of the conductor is not permitted; see Figure 5.

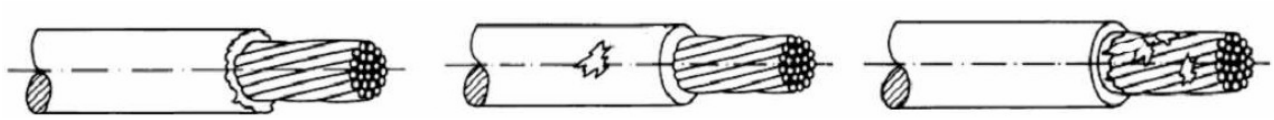


Figure 5 – Faulty insulation

Strands must not be overtwisted, in order to prevent severing or damaging of the strands during the crimping operation; see Figure 6.

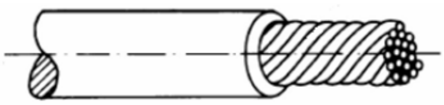


Figure 6 – Overtwisted cable end

3.2.2 Conductor end

The conductor end terminates at a point not before the conductor crimp but no more than 1 mm beyond it. The plug-in, latching, or bolting function of the contact element must not be impaired by the projecting end of the conductor.

For cable lugs, the conductor end also must not extend into the bolt-on surface.

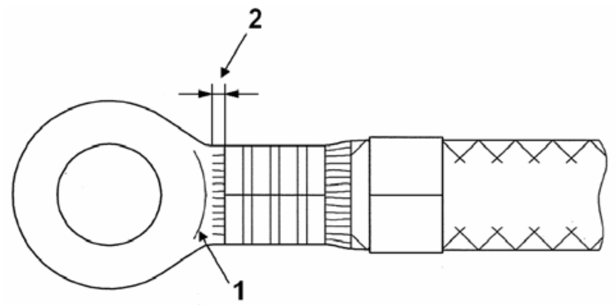


Figure 7 – Maximum projection of cable end

Legend

1 Extended outer diameter

2 Conductor projection

For plug contacts intended for use with collective seals, single stranded wires are not allowed to project significantly. For these plug contacts, the maximum permissible conductor projection is 0,4 mm.

The insulation end must be visible in the window between the wire crimp barrel and insulation crimp barrel. There must not be any cable insulation caught in the conductor crimp.

3.3 Requirements for the crimped contact element

3.3.1 Contact elements

The contact elements used must conform to the requirements and specifications of the standard part drawing. There must not be any mechanical damage or twisting/bending of the transport strip or contact elements.

Contact material whose properties have been adversely affected, e.g., by oxidation or other reactions with the environment as a result of aging, improper storage, or excessive storage periods, must not be used.

After 2 years of storage at the latest, sufficient proof must be provided that the contact material can continue to be used. The contact material must continue to comply with the requirements in VW 75174 and the relevant standard part drawing.

3.3.2 Damage

The contact area (see Figure 1) and the stop spring must not be damaged or deformed after the crimping operation. Deformations of the contact area of the contact element as a result of crimping are not permitted.

3.3.3 Bending and twisting

If the standard part drawing does not contain any specifications, the following requirements apply:
Lateral bending of the longitudinal axis in the crimp area must not exceed 3° toward either side; see Figure 8.

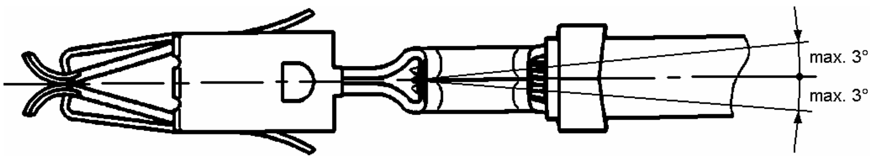


Figure 8 – Lateral bending

Bending of the longitudinal axis in the crimp area must not exceed 5° up or downward. Twisting of the crimp area towards the contact body must not exceed 5°;see Figure 9.

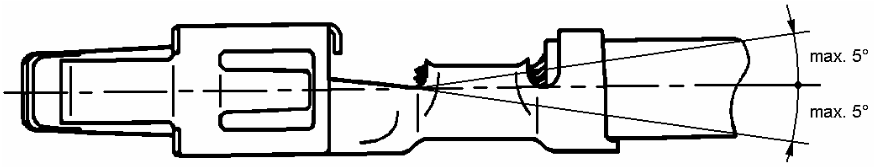


Figure 9 – Bending of the longitudinal axis of the contact element

3.3.4 Dimensions of conductor crimp (see Figure 10)

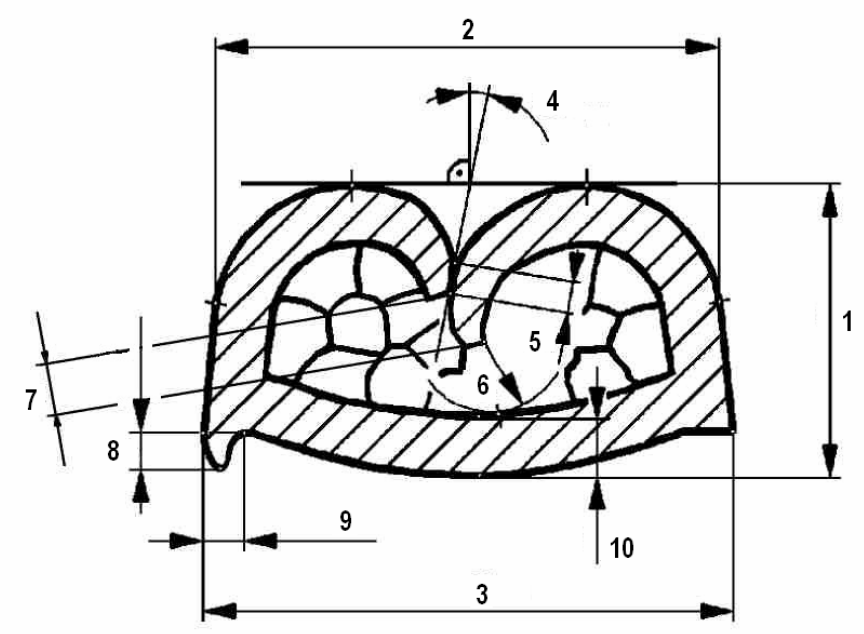


Figure 10 – Dimensions of conductor crimp

Legend

1	Ch	Crimp height
2	Cw	Crimp width
3	Cwm	Measurable crimp width
4	Sa	Supporting angle
5	Hs	Supporting height
6	Fc	Face end clearance
7	CFE	Distance between crimp face ends
8	Bh	Burr height
9	Bw	Burr width
10	Sb	Base thickness

The thickness of the contact material (S) in the crimp area must be taken from the standard part drawing. Limits are specified for the indicated crimp dimensions. Any deviating values specified in standard part drawings are binding.

The specified crimp dimensions must be adhered to without exception and documented by the cable set manufacturer.

3.3.4.1 Crimp height

Not tool-dependent, i.e., adjustable dimension of the crimp connection. The crimp height is specified by the contact element manufacturer and is documented on the standard part drawing of the relevant contact element.

If crimp height tolerances are not specified on the standard part drawing of the contact element, the following general tolerances apply to the crimp height:

Crimp height range [mm]	Tolerance [mm]
0,22 to 0,5	$\pm$ 0,03
0,5 to 2,5	$\pm$ 0,05
$>$ 2,5	$\pm$ 0,1

For information on measuring the crimp height, see Section 4.5.1.2

3.3.4.2 Crimp width

Tool-dependent, i.e., non-adjustable dimension of the crimp connection. The crimp width is specified by the contact element manufacturer and is documented along with the corresponding tolerance on the standard part drawing of the relevant contact element.

3.3.4.3 Measurable crimp width

Width of the crimp at the crimp base that can be determined in a nondestructive manner, e.g., with a micrometer. It is specified by the manufacturer of the contact element.

3.3.4.4 Supporting angle

The supporting angle must not deviate more than 30° from the vertical.

Sa $\leq$ 30°

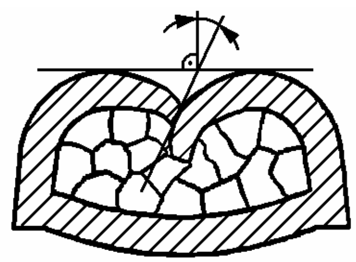


Figure 11 – Supporting angle

3.3.4.5 Supporting height

The crimp barrel must be closed along its entire length between the runouts. The rolled-in crimp faces touch and support each other. As a minimum requirement, the supporting height of the crimp face ends must be equal to the contact material thickness; see Figure 12.

Hs ≥ 1,0 × S

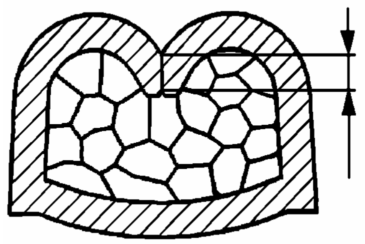


Figure 12 – Supporting height

3.3.4.6 Face end clearance

Uneven rolling-in of the two crimp faces is permissible, provided that the requirements for the supporting length, supporting angle, and distance between crimp face ends are adhered to. None of the crimp face ends must abut the inner wall of the crimp barrel; see Figure 13.

Fc ≥ 0,5 × S

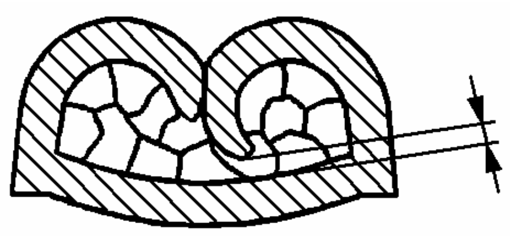


Figure 13 – Symmetry and roll-in depth

3.3.4.7 Distance between crimp face ends

Distance between the opposite, rolled-in crimp face ends.

CFE ≤ 0,5 × S

3.3.4.8 Burr height

The height of the burr is affected by the degree of wear of the crimping tool and the feed settings; see Figure 14.

Bh ≤ 1 × S

3.3.4.9 Burr width

Bw ≤ 0,5 × S

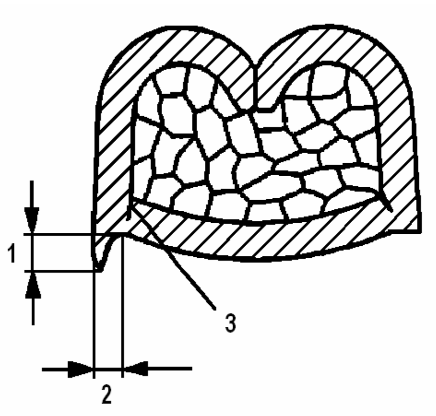


Figure 14 – Burr on crimp base

Legend

1	Burr height
2	Burr width
3	Crack

3.3.4.10 Base thickness

Sb ≥ 0,75 × S

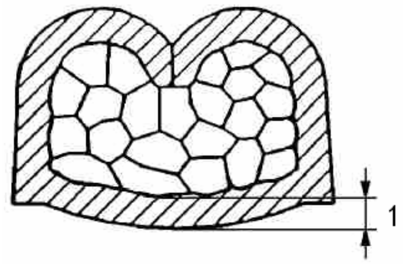


Figure 15 – Base thickness

Legend

1	Base thickness

3.3.4.11 Degree of compression

The manufacturer of the contact elements ensures that a good degree of compression is achieved when the specified crimp dimensions are complied with. A good degree of compression is characterized by a completely filled crimp barrel, in which the strands in the wire crimp area are completely compressed in a honeycomb structure. Individual cavities due to asymmetrical rolling in of the crimp faces, uneven distribution of the strands, or an unfavorable tolerance circumstance involving the crimp height, conductor cross-section, and material thickness are not permitted.

3.3.5 Shape of conductor crimp

3.3.5.1 Crimp length

The conductor crimp must be closed along the entire length between the front and rear runouts (see Figure 16). The rolled-in faces support each other.

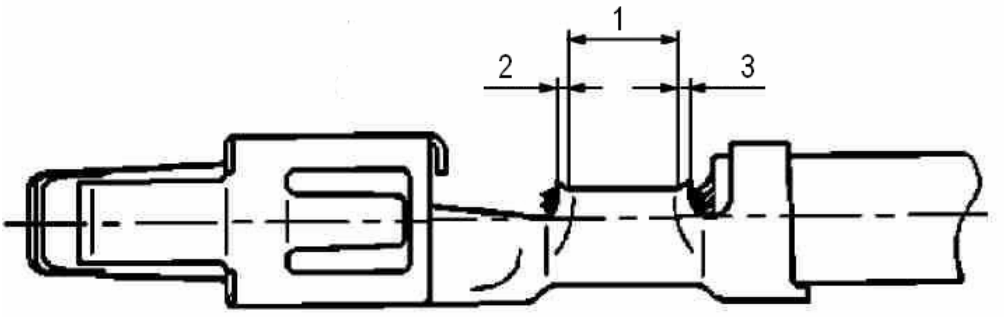


Figure 16 – Crimp length and runout

Legend

1 Crimp length

2 Front runout

3 Rear runout

3.3.5.2 Cracks

Cracks are not permitted; see Figure 17.

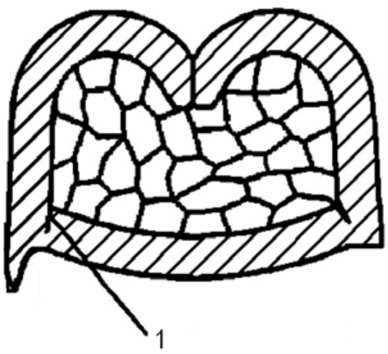


Figure 17 – Formation of cracks in the crimp base

Legend

1 Cracking

3.3.5.3 Runout

A bell-shaped runout (bell mouth) is required at the rear edge of the conductor crimp (for cable, see Figure 16). This runout must prevent notching or cutting off of the single stranded wire.

No runout is prescribed at the front edge of the conductor crimp (towards the contact). A runout toward the front of the same or less size as the rear runout is permissible.

3.3.6 Insulation crimp

The insulation crimp of the contact element must be configured in conformance with the standard part drawing for a thin- or thick-walled insulated cable according to VW 60306.

3.3.6.1 Position deviations of the insulation crimp faces

The crimp faces may tip within a range of 5° to the front and 3° to the rear; see Figure 18.

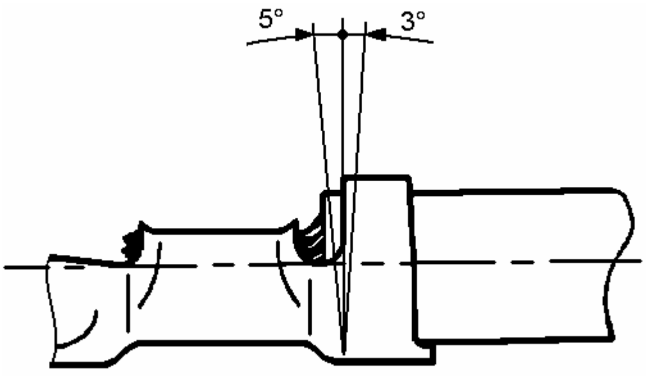


Figure 18 – Position deviations of the insulation crimp faces

3.3.6.2 Insulation crimp Type A (F-crimp)

See Figures 19 and 20.

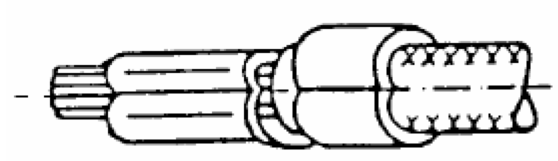


Figure 19 – Type A (F-crimp)

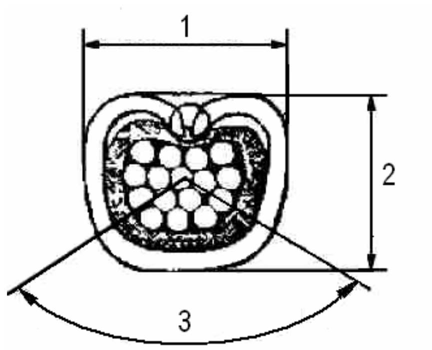


Figure 20 – Dimensions of insulation crimp, type A

Legend

1 Crimp width

2 Crimp height

3 Wrap angle

Compliance with the crimp width and crimp height dimensions specified in the standard part drawing is mandatory.

At least 1/3 of the cable circumference (120°) must be encompassed by the insulation crimp.

The crimp claw must enter into the insulation. The insulation may be punctured by the crimp claw, but this must not cause any damage to the strands.

The bending test according to DIN EN 60352-2 (movement of the conductor over 3 cycles) must be fulfilled.

3.3.6.3 Insulation crimp, type B (wrap crimp)

See Figures 21 and 22.

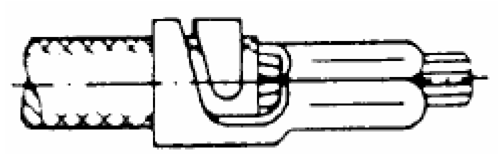


Figure 21 – Type B (wrap crimp)

At the maximum cable diameter, the crimp faces must overlap for a distance that is greater than or equal to their material thickness.

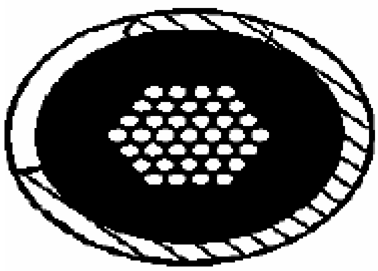


Figure 22 – Section of insulation crimp, type B

3.3.6.4 Insulation crimp, type C (overlap crimp)

See Figures 23 and 24.

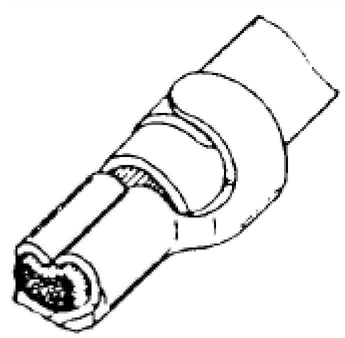


Figure 23 – Insulation crimp, type C

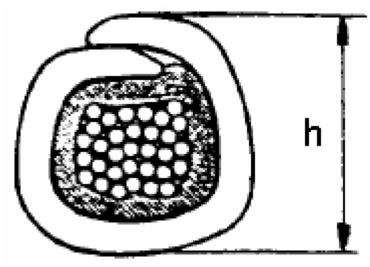


Figure 24 – Section of insulation crimp, type C

At least 2/3 of the cable circumference must be encompassed by the insulation crimp. The encircled insulation must be closed (overlap). The insulation can be punctured by a crimp claw, but this must not cause any damage to the strands.

The bending test according to DIN EN 60352-2 (movement of the conductor over 3 cycles) must be fulfilled.

3.3.7 Single-conductor sealing crimp

The crimp faces must be rolled in to the extent that the single-conductor sealing is maintained reliably when the contact is fitted into the connector housing.

3.3.7.1 Position of the single-conductor sealing

The insulation crimp flaps must abut the single-conductor sealing over the entire length. The single-conductor sealing must not be constricted excessively, damaged, or punctured by the crimp faces.

Position of the single-conductor sealing conforms to the drawing specification; see Figure 25.

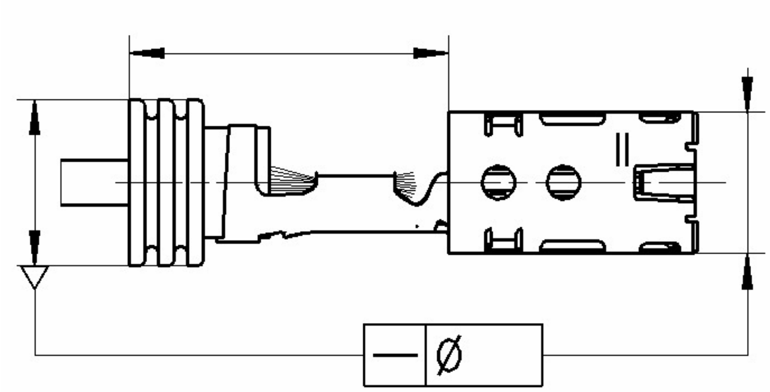


Figure 25 – Position of single cable in the crimp pattern of the standard part drawing

3.3.7.2 Symmetrical O-shaped single-conductor crimp (O-crimp)

The insulation crimp flaps wrap around the single-conductor sealing by a maximum of 360°, i.e., overlapping of the crimp claws is not permitted; see Figure 26.

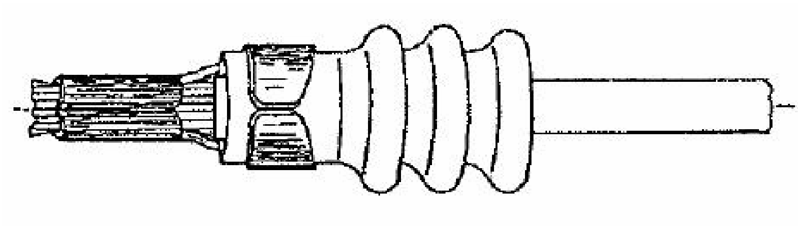


Figure 26 – Symmetrical O-shaped single-conductor crimp

3.3.7.2.1 Asymmetrical O-shaped single-conductor crimp (wrap crimp)

The insulation crimp flaps wrap around the single-conductor sealing by at least 360°; see Figure 27.

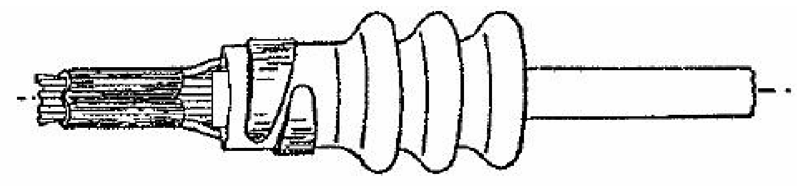


Figure 27 – Asymmetrical single-conductor crimp

3.4 Further requirements

3.4.1 Separation bridge

The separation bridge is still visible to some extent and can have a length up to the equivalent of one contact plate thickness, but not to exceed 0,5 mm.

The permissible burr on the cut edge as a function of contact plate thickness t is as follows:

Plate thickness [mm]	Burr [mm]
$t \leq 0{,}4$	Max. 0,05
$0{,}4 < t \leq 0{,}8$	Max. 0,1
$t > 0{,}8$	Max. 0,15

Separation bridge and burr must not impair the fitting ability into the housing and the plug-in function of the contact.

For plug contacts intended for use with collective seals, the length of the separation bridge must not exceed 0,3 mm. The separation bridge must not stick out; a separation burr is only permissible on the side facing the cable insulation. Separation bridge and separation burr must not damage the collective seal or single-conductor sealing.

The requirements also apply to removal and refitting of the contact element during subsequent rework.

3.5 Special crimp types

3.5.1 Double-wire crimps

In preparation.

3.5.2 Closed crimp barrels

In preparation.

4 Producing the crimp connection

Non-destructive measurement of the crimp connection quality is only possible to a limited extent. Consequently, the required quality of the crimp connection and, thus, its functional capability can only be achieved in the presence of

- Proper tools and working parts
- Proper machines
- Preventive maintenance of the indicated machines, tools, and working parts
- Expert operation
- Effective and reliably applied process assurance based on crimp force monitoring

4.1 Tools

Because the contact part manufacturer is responsible for the system, the use of original crimping tools and inserts (working parts) is prescribed. The respective standard part drawings of the contact part manufacturer, which are made available to the fabricator via the Volkswagen systems, are the basis for this.

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

The fabricator is responsible for the entire crimping process.

Justified deviations from these specifications require approval by the engineering departments of the Design Engineering and Quality Assurance departments of the vehicle manufacturer.

4.2 Crimping devices

Crimping devices, which include both automatic cable fabrication equipment and table presses (semi-automatic equipment), must be equipped with a device for continuous automatic monitoring of crimp quality.

Crimping devices must be equipped in such a way that faulty parts can be sorted out reliably.

4.3 Crimp force monitoring

Crimp force monitoring involves a load/displacement measurement during the working stroke of the crimping tool: The load/displacement curve of an OK crimp varies within a desired characteristic curve. This desired curve is determined by a teach-in process after every:

- Change in the tool setting
- Change of tool clamping/tool
- Change of contact roll
- Change of the reeled cable or cable container

With this process, the crimp force monitoring can ensure at best an adequate repeatability.
To ensure the quality of the crimp connections produced, the teach-in crimp must be evaluated based on a microsection (Section 4.6.2) and the crimp dimensions that can be measured as a result (see Section 3.3.4).

4.4 Quality assurance

For each sampling of a cable set, the quality of the crimp connection must be proven and documented for each contact, contact supplier, and crimp cross-section used.

The proof is based on the microsection, crimp height, crimp width (measurable, Cbw), and pull-out strength. A total of 5 measuring results must be documented for each dimension; a dimensional specification "from...to" is not permitted. The measured values are documented with the part no. (contact), name of contact manufacturer, and the desired dimension. This applies to the overall power supply system as well as to cables that are used on or in electrical components and to spare parts.

The plant Quality Assurance departments use random samples to check the specifications.

4.5 Nondestructive testing

4.5.1 Crimp dimensions

4.5.1.1 Crimp width

The crimp width is a primary tool-dependent dimension; Section 4.1 applies. Suitable measuring means must be used.

4.5.1.2 Crimp height

The crimp height is a primary dimension that can be affected during the crimping process and that is crucial for the crimp resistance values and the stability of these values.
The crimp height is measured in the center of the wire crimp using a special micrometer (crimp height micrometer); see Figure 28.

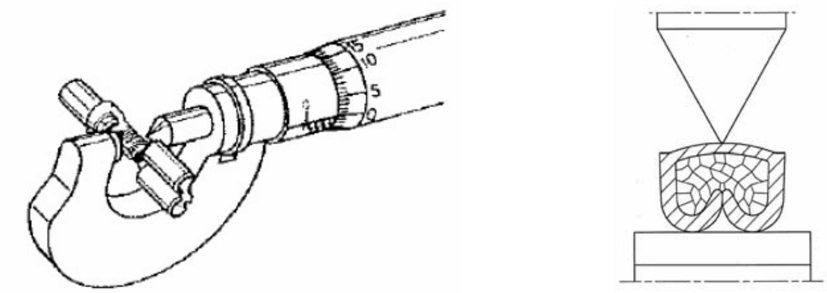


Figure 28 – Measuring the crimp height using a special micrometer

4.6 Destructive testing

4.6.1 Conductor extraction force

The conductor extraction force from the conductor crimp is measured according to VW 75174 as an accompanying manufacturing check and without insulation support; see Table 1.
The following minimum values for conductor extraction force are required for low-pressure contacts: 该处说的就是拉力测试的时候应当是在绝缘不压接的情况下进行，采用下表中括号外的标准

Table 1

Cable cross-section	Contact size				
	0,63	1,2 /1,5	2,8	4,8	9,5
0,09 mm^2			-	-	-
0,14 mm^2			-	-	-
0,22 mm^2			-	-	-
0,35 mm^2	50 N [75 N]				-
0,5 mm^2	60 N [85 N]				-
0,75 mm^2	85 N [105 N]				-
1,0 mm^2	-	108 N [125 N]		140 N [162 N]	-
1,5 mm^2	-	(150 N) [180 N]	150 N [180 N]		-
2,5 mm^2	-	-	200 N [235 N]		
4,0 mm^2	-	-	-	310 N [325 N]	
6,0 mm^2	-	-	-	(450 N)	450 N
10,0 mm^2	-	-	-	-	500 N

该处说的就是，在生产过程中，由于打开绝缘压接翼比较麻烦，替代的方法是绝缘压接翼不打开，但要用上表中括号内的值，我认为，这种方法既然是作为替代方法出现的，那么，绝缘压接羽翼打开情况下测试拉力才是优选的

NOTE: If for production reasons, the conductor extraction force is measured with an insulation crimp, the values in the square brackets apply. For receptacles and cable lugs, the values according to VW 75173-1 apply.

4.6.2 Microsection

The microsection is located in the center of the conductor crimp, perpendicular to the longitudinal axis. The microsection plane must not be located within any of the transverse stamping areas in the wire crimp.
Attention must be paid that the machining direction is opposite the direction of the crimp opening so that no forces occur during grinding that could open the crimp.

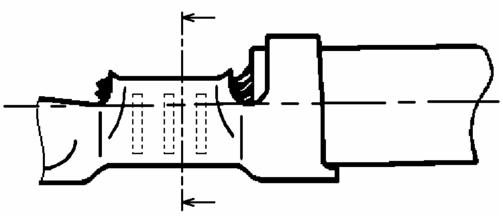


Figure 29 – Microsection plane

4.6.2.1 Metallographic sample preparation for technical engineering approval (BMG)

In order to evaluate the crimp quality achieved with the crimping tool, microsections taken crosswise through the conductor crimp must be prepared.

For tests that are not conducted during production, the part must preferably be cast in synthetic resin to prevent changes to the crimp when the microsection is prepared.

To facilitate the evaluation, the surface of the crimp must be polished and etched following separation.

The evaluation criteria are as described in Sections 4.6.2.2 and 4.5.1.

4.6.2.2 Preparation of microsections for tests conducted during production

For standard production monitoring, the embedding of samples in synthetic resin is not required when producing microsections. Microsections are produced using suitable devices and taking into consideration the relevant manufacturer specifications.

Unless otherwise specified, the teach-in curve for the crimp force monitoring must be verified each time with at least one microsection. The teach-in curve for the crimp force monitoring must be generated on each change of the crimp die, contact roll, and cable container and after any other interruption in the manufacturing process.

The microsection must be represented with appropriate magnification and evaluated according to the following criteria.

The following specifications must be checked and documented:

- Contact part no.
- Contact supplier
- Part number and manufacturer of the reeled cable
- The microsections or sample parts must be measured directly based on the crimp width and crimp height.
- The values of the supporting angle and height, face end clearance, burr height and width, base thickness, and compression must be measured, if they cannot be reliably evaluated in the microsection.

The microsections must be evaluated according to the subsections of Section 4.5.1 Crimp dimensions.

Crimp height, measuring

Crimp width, measuring

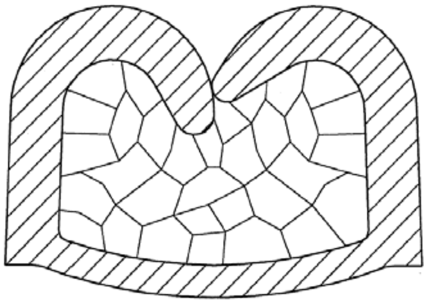
With respect to the supporting angle, supporting height, face end clearance, distance between crimp face ends, burr height, burr width, base thickness, and compression, the dimensions must be measured if it is not absolutely certain that the specified values are fulfilled.

4.6.3 Testing of insulation crimp

The insulation crimp is evaluated by testing according to DIN IEC 60512-8. The acceptance criterion is that the insulation must still be encompassed after the test is performed.

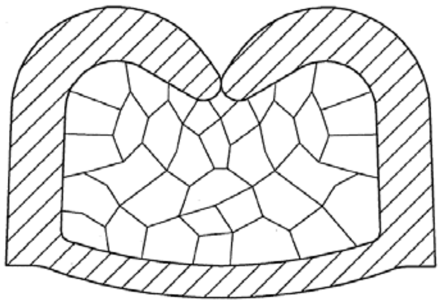
4.6.4 Examples of not OK microsections

A few examples of not OK crimp connections are shown here; see Figures 30 to 35.



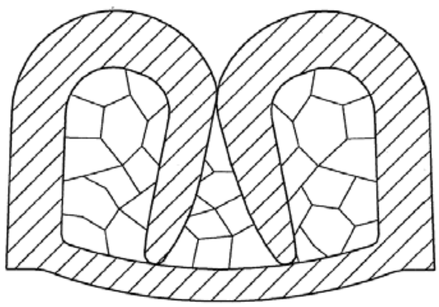
Crimp tip is supported on the face

Figure 30



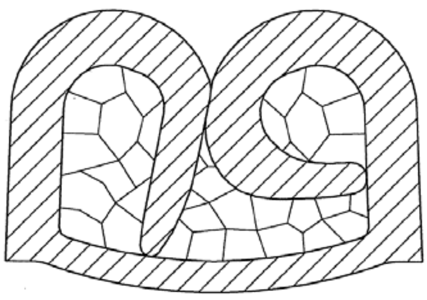
Insufficient supporting height

Figure 31



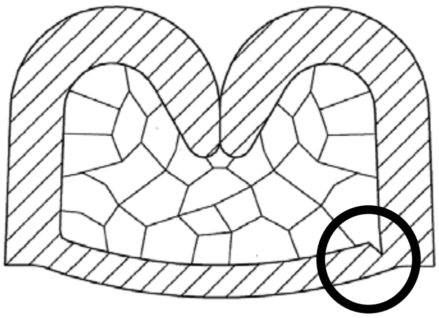
Crimp claws too long

Figure 32



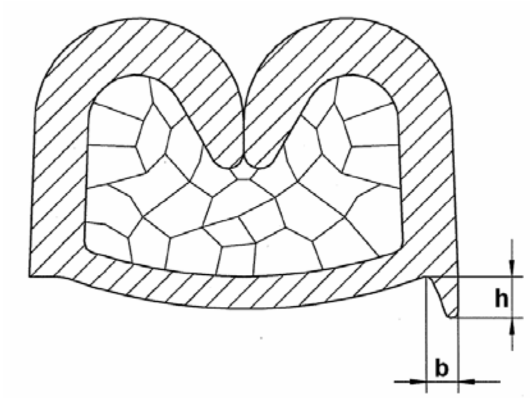
Crimp claws too long

Figure 33



Crimp torn

Figure 34



Impermissible burr formation

Figure 35

5 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.

VW 60306	Electric Wiring in Motor Vehicles; Single-Wire, Unshielded
VW 75173-1	Blade Terminal Connections, Requirements; Test
VW 75174	Motor Vehicle Push On Connectors; Test Guidelines
DIN IEC 60050-581	International Electrotechnical Vocabulary – Part 581: Electromechanical Components for Electronic Equipment
DIN EN 13602	Copper and Copper Alloys – Drawn, Round Copper Wire for the Manufacture of Electrical Conductors
DIN EN 60352-2	Solderless Connections – Part 2: Crimped Connections – General Requirements, Test Methods and Practical Guidance
DIN IEC 60512-8	Electromechanical Components for Electronic Equipment; Basic Testing Procedures and Measuring Methods; Part 8: Connector Tests (Mechanical) and Mechanical Tests on Contacts and Terminations