Wiring Harness Inspection & Repair

Self-Study Program
Course Number 871003

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Always check Technical Bulletins and the Volkswagen Worldwide Repair Information System for information that may supersede any information included in this booklet.

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The self-study program is not a Workshop Manual!

Precise instructions for testing, adjustment and repair of various electrical and electronic systems can be found in the appropriate Service Information. Specific tools and procedures for proper wiring harness repair using the VAS 1978 Wiring Harness Repair Kit can be found in the *Instruction Manual* provided with that kit.

Introduction

Wiring harnesses in Volkswagen vehicles have undergone a tremendous evolution over the past 30 years. Changing customer expectations, regulatory requirements, and advances in technology have resulted in broad proliferation of electrical and electronic components. Wiring harnesses have become much more complex. The number of terminals alone has increased from just over 200 in a typical 1966 model, to over 1,400 terminals in the latest models.

Cost has increased just as dramatically, from about 8% to more than 26% of the total manufacturing cost of the vehicle, making the wiring harness the single most expensive assembly in our cars. If that fact is difficult to accept, consider that it takes about 1-1/4 hours of direct labor to assemble an engine, but well over 5 hours are required to construct the wiring harness!

The difficulty associated with repairing the wiring harness has, unfortunately, kept pace. Smaller wires and terminals, carrying extremely low-level signals, with increasingly limited access, and more complicated, interlinked electronic control modules and sensors have all contributed to the “confusion factor.”

While we have continuously improved wiring harness design, layout and assembly processes, about half of all warranty repairs address electrical malfunctions, and roughly half of *those*, and one third of all tow-ins, are caused by problems associated with the wiring harness.

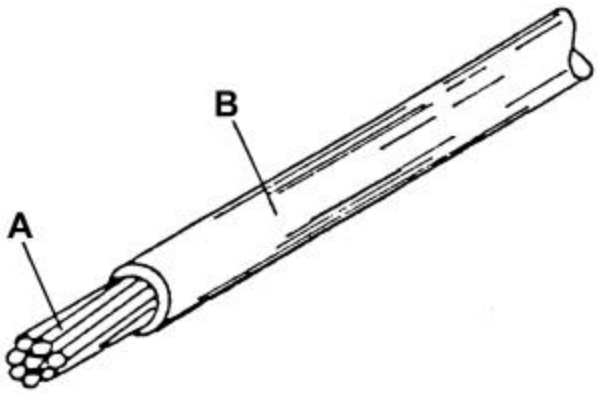
With that in mind, it is easy to see that the wiring harness can no longer be considered a simple, bound collection of wires and connectors. Every length of wire, every connection, every attachment, every twist and turn, is carefully engineered to suit the application and its environment. When repairs are necessary, they will be successful *only* when the quality of the repair and the components *completely* restores the wiring harness to its original integrity.

To assure quality repairs, Volkswagen has developed a simplified harness repair concept, and developed the **VAS 1978 Wiring Harness Repair Kit**. This kit provides everything that may be needed for proper, high-quality harness repairs. Within the framework of the new repair concept, any authorized repair can be carried out using the tools and hardware supplied in the kit. The harness must *never* be repaired by any other means.

The purpose of this Self-Study Program is to provide essential background technical information about all aspects of the wiring harnesses used in Volkswagen vehicles. It describes why they are designed and built the way they are. It goes on to describe the repair fundamentals that, if respected, will maintain those high standards.

This information is intended to assist you in completing critical wiring harness repairs properly, in evaluating the quality of those repairs, and in preventing recurrent problems by getting it ***fixed right the first time****!*

Wiring Harness Design



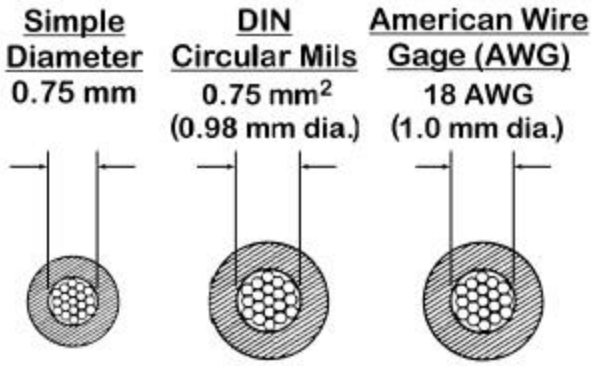
Wire and Cable

An automotive wiring harness employs wires and cables. Each is made up of at least seven conductor strands (A), and covered with an insulating material (B).

Within Volkswagen, wire and cable are classified in three general categories, and then specified according to size, type of insulation, and color.

Wires

Wires are stranded conductors ranging in size from 0.35 mm^2 to 6.0 mm^2, or approximately 22 to 9 gage (AWG), that make up most of a vehicle's wiring harness. Smaller sizes save cost and weight. The larger sizes accommodate higher current loads with less resistance. Wire larger than 6 mm^2 or 9 gage (AWG) is generally considered "cable."



Wire size

Wire size (cross-sectional area) is the primary factor that will determine the current-carrying capacity of a conductor. Standard sizes differ slightly, depending on which measuring standard is used.

Volkswagen uses wire and cable that is manufactured according to the German industrial or "DIN" standards. Wire size is defined by cross-sectional area, and is measured in *circular mils* (mm^2). As in the example shown, "0.75 mm" refers to the area (0.75 mm^2), not the diameter.

Sizes of wire and cable originating in North America are described according to the American Wire Gage (AWG) standard. The standard wire sizes in both systems are roughly equivalent.

In practical terms, this discussion is significant only because there are slight differences between AWG sizes and the "equivalent" DIN sizes. When carrying out wiring harness repairs, it may be necessary to check and confirm that two wires sizes are indeed equivalent.

The table at the right lists standard DIN wire sizes, their approximate AWG equivalents, and the actual size (cross-sectional area) of AWG-sized wires.

Cables

Cables are large-gage stranded wiring with high current-carrying capacity. Such cables are used to connect the battery to the starter, the generator and the fuse/relay panel, and for other similar high-current-load applications.

Special-case wire and cable

Some wire characteristics are modified for improved performance, or to meet specific environmental requirements such as resistance to extreme heat or cold, improved abrasion resistance, greater flexibility, etc.

Ignition secondary or "high-tension" cables — such as spark plug wires — fall into just such a special category. Their design and construction is determined by the unique requirements of the ignition system — carrying very high voltage, operating reliably in harsh under-hood conditions, and suppressing radio interference, to name just a few.

Wire sizes

DIN (mm^2)	**AWG**	**AWG actual size**
0.35	22	(0.32 mm^2)
0.50	20	(0.51 mm^2)
0.75	18	(0.79 mm^2)
1.0	17	(1.0 mm^2)
1.5	16	(1.3 mm^2)
2.0	14	(2.1 mm^2)
2.5	13	(2.6 mm^2)
4.0	11	(4.2 mm^2)
6.0	9	(6.6 mm^2)

Cable sizes

DIN (mm^2)	**AWG**	**AWG actual size**
10.0	7	(10.3 mm^2)
12.0	6	(13.3 mm^2)
16.0	5	(16.9 mm^2)

Insulation

Insulation is non-conductive material that covers the conductors of a wire or cable to guard against unwanted electrical contact — short circuits. The type of insulation used in a particular application is part of the wire or cable specification.

"Standard Duty" or "Thick Wall"
Wiring with this type of insulation was commonly used until the mid-1980s. It has a relatively thick layer of insulation, usually made from polyvinyl chloride (PVC). It may still be found on cables or wiring within some components.

"Thin Wall"
Thin wall refers to the reduced insulation thickness. Wiring of this type was introduced in Volkswagen vehicles to save weight, and space, and to reduce the amount of PVC material used.

"Special Duty"
Some wire and cable is designed and selected for a specific use, and equipped with insulation meeting the demands of that "special duty." Double-insulated wire, high-heat resistant wire and cable, and shielded wire are some examples.

Color codes

Wire color codes are used on wiring diagrams to help identify different circuits. The code identifies the wire's base color, and often a tracer color.

Base color
The "base" color is the dominant wire color that covers at least 60% of the circumference of the insulation.

Tracer color
The second or tracer color is the color of the contrasting identification stripe used on some wires to help identify the circuit.

Identifying wire colors
Wire colors may be identified on wiring diagrams by color codes using German abbreviations for the color names. For example, "ro/ws" indicates a red wire with a white tracer. Look for the color code chart on the diagram you are using.

The table below lists the German color abbreviations, the German color names, and their English equivalents*.

Color codes

Abbr.	Color (German)	Color (English)
ws	weiss	white
ge	gelb	yellow
ws/gn	weiss/grün	white/green
ro	rot	red
li	lila	purple -or- violet
bl	blau	blue
gn	grün	green
gr	grau	gray
br	braun	brown
sw	schwarz	black

* Other colors such as Orange, Pink and the natural insulation color may also be used, but they are not officially released into the system.

Connectors

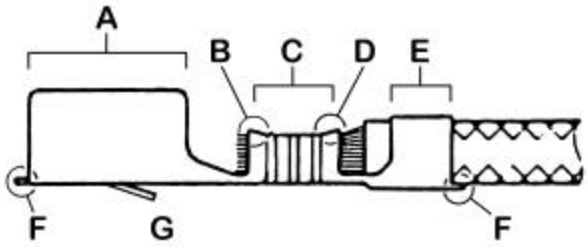
Connectors are used to make separable (non-permanent) connections between the wiring harness and an electrical or electronic device, or between two wiring harnesses. Each connector half consists of one or more terminals and a housing.

Terminals

Terminals are the electrical contacts in a connector, or at the mating connection to an electrical or electronic device. The only function of a terminal is to conduct electricity as efficiently as possible.

The terminal design, material, surface protection and method of attachment or "termination" (see page 10) all depend on the cost, reliability and durability requirements of the application.

The main features of a typical terminal in a Volkswagen wiring harness are:



A – Contact

B – Exit radius

C – Core crimp

D – Entry radius

E – Insulation crimp

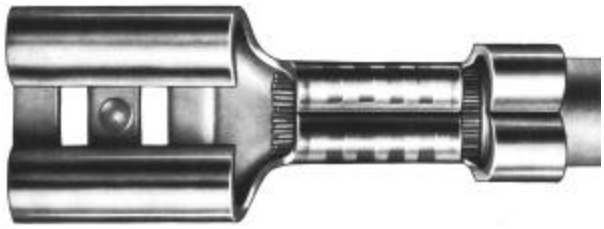
F – Runner
The stub that remains after machine crimping of production terminals supplied on a reel.

G – Primary lock
Ensures that the terminal locks into the housing; usually a lock tab on one or more sides; its purpose is to simplify harness fabrication.

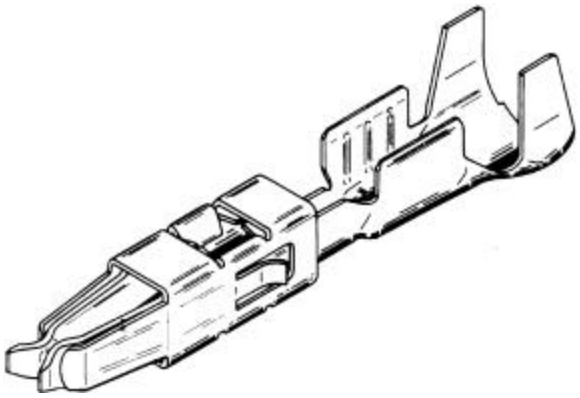
Types of terminals

The terminals used in wiring harnesses for Volkswagen vehicles are classified under four general headings.

Blade and receptacle terminals
Terminal widths from 0.63 mm to 9.5 mm are in general use. Two distinct types are predominantly used in harnesses for Volkswagen vehicles:

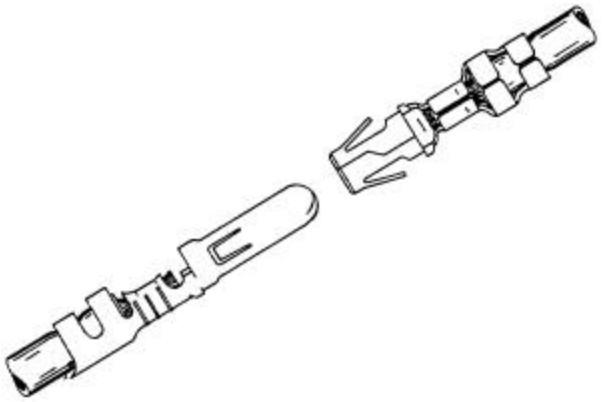


Older generation “Faston” terminals get their name from the original name used by the supplier (AMP) for this product line. The name became common usage, and is still used within Volkswagen to refer to this type of terminal, even though other manufacturers have introduced some slightly different designs. “Faston” terminals in 2.8 mm and 6.3 mm widths are still frequently encountered.

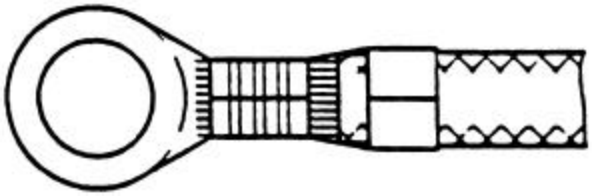


The newer generation “Power-Timer” terminal uses a two-part receptacle. A contact support spring helps to maintain pressure on the contacts, so that the metal terminal does not “take a set,” relax its tension, and loosen over time. Here again, AMP’s product name is commonly used to refer to this type of terminal, even though there are other manufacturers with similar designs.

Pin and socket terminals
Round pin terminals of two standard diameters (1.6 mm and 3.5 mm) are used in Volkswagen vehicles.



Ring terminals
Ring terminals include versions with or without internal teeth at the through-hole. Some have special shapes to keep the terminal in a certain position — at the battery positive (B+) terminal on the starter, for example.

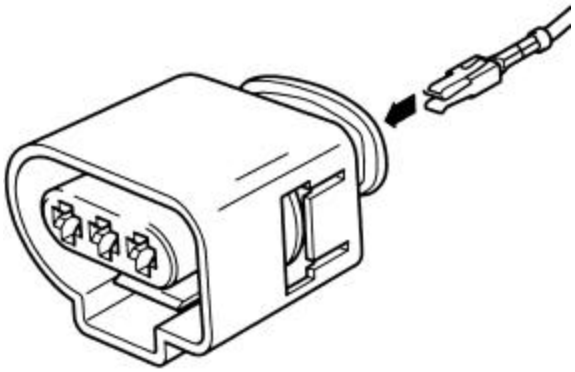


Special purpose terminals
These include splice connectors and other types of terminals used at crimped splice junctions in the wiring harness.

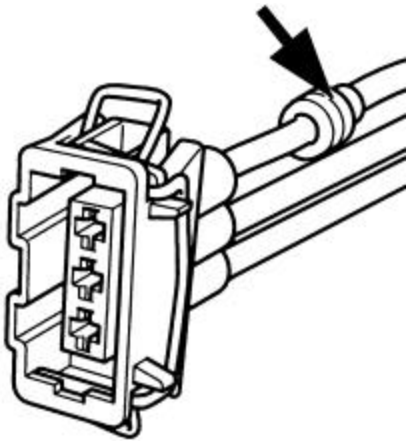
The barrel-type crimp connector found in the VAS 1978 Wiring Harness Repair Kit is an example. Others include the bridge terminals in voltage distribution ("TV") connectors, and the bus bar in the fuse block on the battery.

Housings

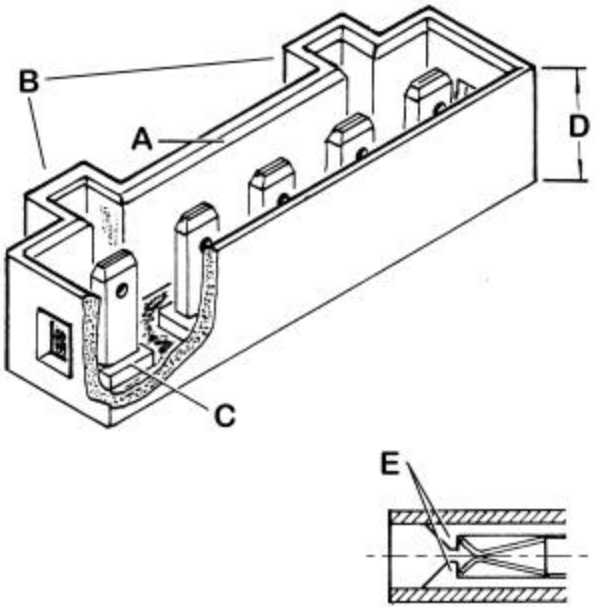
A connector housing insulates the terminal(s) and serves the mechanical function of safeguarding and maintaining the connection. The housing shape, the type of engagement, and the materials used depend on functional requirements, and on the operating environment.



Seals
Where terminals and connectors may be subjected to a harsh environment, the connector housings are equipped with seals to protect the internal connections from contamination and corrosion. They may be in the form of a gasket that fits between two mating connector housings, or single-wire seals (arrow) that seal the openings at the back of the housing, or both. For more information on single-wire seals, refer to pages 13 and 26.



Wiring Harness Design



The main features of a typical connector housing are:

A – Beveled edge
Helps in aligning and mating the two halves of the housing; the edge also acts as a sealing surface when a gasket is used

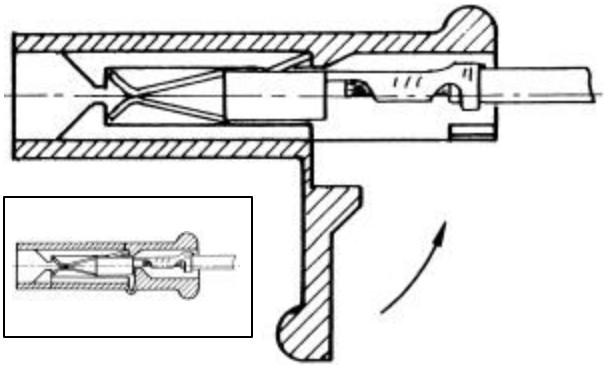
B – Polarization features
Design of the housing ensures that the connection is only possible when the two halves, and therefore the mating terminals, are in correct alignment with respect to each other; in other words, it can only be connected one way

C – Terminal socket
For pin- or blade-type terminals, the socket supports and guides the terminal; it also serves to increase the insulated distance between terminals

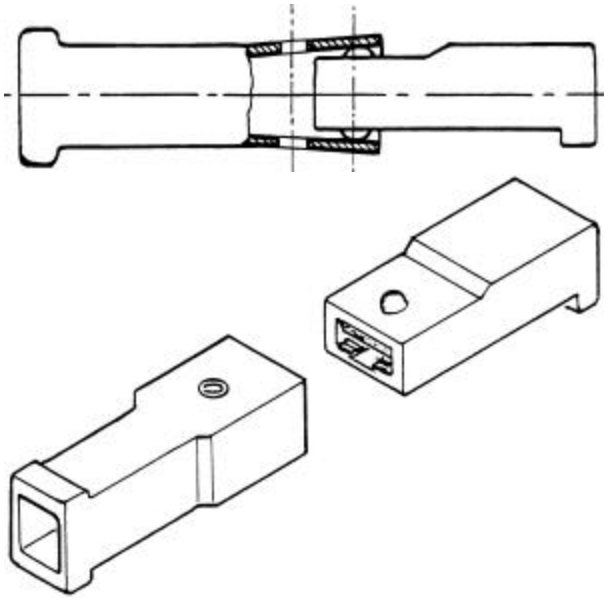
D – Housing length
The housing must be long enough to shield the terminals when disconnected, and prevent them from making contact with anything other than the intended terminals in the mating connector half

E – Insertion guides
An aid to proper alignment in the "female" side of a pin and socket terminal connector; they guide the blade or pin into proper position while making the connection

F – Secondary lock
A mechanical interlock that keeps terminal(s) in place; normally a separate piece or a molded hinge that fits into position after the terminals have been inserted (inset); the main functions of the secondary lock are to simplify assembly, and to ensure that a terminal is not pushed out while joining two connector housings.

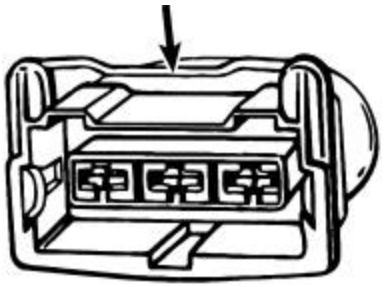


G – Housing detent
A mechanical retaining feature with mating parts built into the each half of the connector housing, such as a ball and dimple (as shown); the mating housings can be separated, without damage, simply by pulling; more force is required to connect or disconnect this type than is required for a connector with a separate locking feature



Housing lock
This is a mechanical interlock that keeps the two halves of the housing securely connected. Unless it has been released, the two halves cannot be disconnected without mechanical damage. By design, the lock can be opened without special tools, although a screwdriver or pliers may be required.

The most common types of housing lock currently used in Volkswagen harnesses are versions of the so-called “K-Jetronic” connector that feature a latching spring (arrow). Depressing the spring with a thumb opens the latching segments, so that the mating connector housings can be freely disconnected.



Termination Methods

Termination describes the attachment of some kind of terminal to the end-point of a wire or cable, on the wiring harness or in an electrical device. Termination also refers to the formation of splices or other junctions within a wiring harness.

Terminations are either permanent or non-permanent. Permanent terminations are **crimped**, **welded** or **soldered**.

Insulation displacement, **discrete force** (clamping), or **wire wrapping** are examples of non-permanent methods.

As we discuss termination types, we will see that some are acceptable, and some are not. Proper termination method is critical. To ensure quality production and long-term reliability, Volkswagen has created rigorous production standards that are reviewed and enforced with regular performance audits.

Crimping

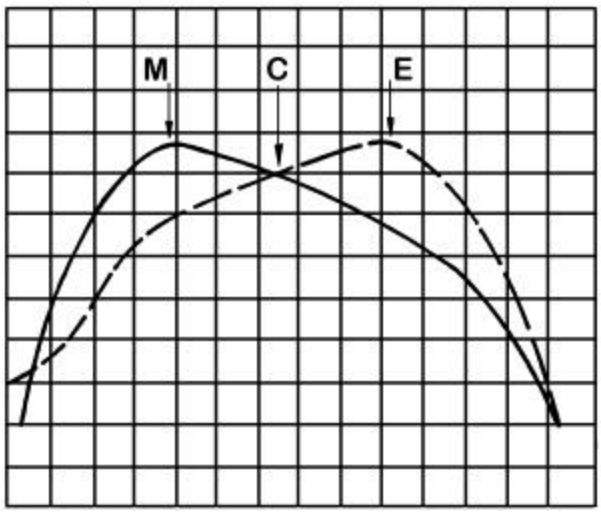
Crimping means using force to compress and mechanically deform or "crimp" the terminal around the uninsulated strands of the wire or cable. Compressing the terminal and wire accomplishes two important results:

1. Forces contaminants out of the crimp area, achieving more direct contact and better conductivity

2. Causes terminal and wire strands to "flow," filling the space between strands, significantly increasing contact area, and conductivity

The ideal amount of compression or crimping force — and therefore the degree of deformation — is a balance of mechanical strength and electrical conductivity. *Too little* crimping force means greater resistance (reduced conductivity) and less strength — the wire may pull out. *Too much* crimping force means there is greater potential for wire fatigue, and breakage.

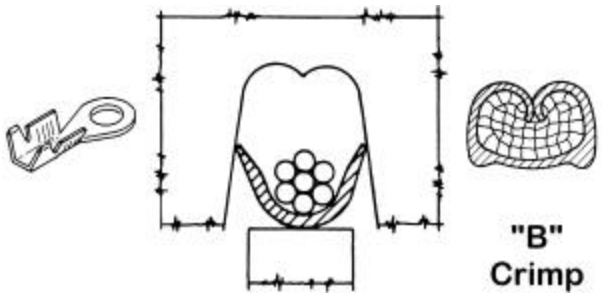
As shown by the graph below, the amount of crimping force that produces the **ideal deformation "C"** lies between the **peak mechanical strength "M"** and the **peak electrical conductivity "E."** This ideal result is achieved when the crimped terminal and the wire inside are compressed by approximately 20%, for both open- and closed-barrel terminals.



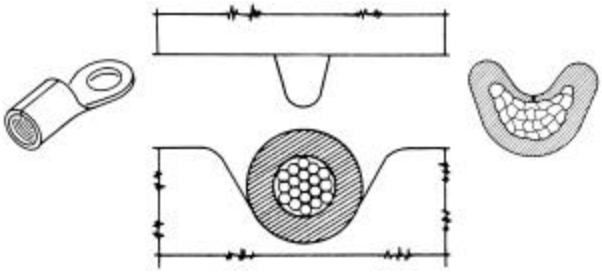
Crimping compression force ➔

We can see that, for crimping to work effectively, the wire and terminal must be matched in size. This ensures that both the terminal and wire will be compressed during crimping, resulting in a good, reliable crimped connection.

Open-barrel terminals
An open-barrel terminal has crimping "wings" that are folded over to compress the wire during crimping. When folded in sequence, they form an overlapping crimp. When folded simultaneously, they form a "B" crimp, as shown.



Closed-barrel terminals
Closed-barrel terminals have a round of oval shaped crimp area. Crimping deforms the barrel using, for example, a nest and indent die, as shown.



Repair practices
We can see that the quality of crimped terminations in wiring harnesses is critical! It is important to always use the proper tools and components.

Inspection of several features can be used to assess the quality of a crimped termination. Refer to *Crimped Terminals — Visual Checks*, page 24.



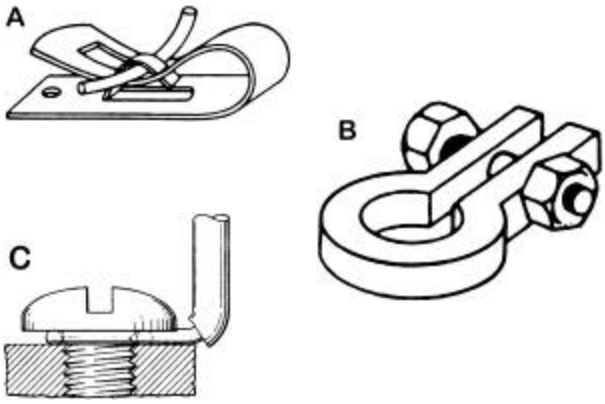
Repair wires and connectors must both be of the correct, matched size.

Welding

Welding fuses the uninsulated strands of wire or cable. The flow of material and expulsion or burning off of contaminants improves contact and conductivity much like crimping. Like proper crimping, a welded termination reduces the size of the conductor strands by about 20%

Improper welding causes faults ranging from welds that pull apart, to those that break due to heat embrittlement.

Wiring Harness Design



Discrete force (clamping)

Clamping involves mechanically joining an uninsulated wire or cable to a terminal, or to another uninsulated wire or cable, using a clamp or clamping feature. Examples are spring clip terminals (A), battery terminal clamps (B), and threaded fasteners (C).

Splices

A splice is a junction of common circuits within the wiring harness, used to reduce weight and cost by eliminating redundant wire or cable leads.

Example
The five Ground (–) circuits for the headlight, parking light, side marker light, turn signal and fog light on the right side are all routed to a splice near the right front corner of the car. From that splice, a single, larger diameter wire runs the 8 feet to a chassis ground connection, thus saving 32 feet of wire.



Splices may be welded or crimped – never soldered!

Light bulb sockets

Bulb sockets are “connector” housings that make electrical contact with, and physically hold, a light bulb. They are considered part of the wiring harness.



Wire wrapping

Lacquered or coated wire is wrapped tightly around a binding post terminal. The edges of the post cut into the wire to make the connection. This method may be used inside some devices, but not in Volkswagen wiring harnesses.

Seals

Multi-wire seal
This type is essentially a flat piece of rubber or other elastomer with holes for the size and number of wires. A ribbed outer edge fits a recess in the connector.

Single-wire seal
These are generally made of silicone, allowing them to remain flexible at both temperature extremes. The seal slips onto the wire before it is terminated. In production, the terminal's insulation crimp wings secure the seal collar.

When making harness repairs using the VAS 1978 kit, new single-wire seals are installed, but *not* crimped to the terminal.

Visual inspection can help determine the condition of a seal, and whether or not it has been damaged. Refer to *Seals — Visual Checks*, page 26.



For wiring harness repair, new single-wire seals are installed differently. Refer to the VAS 1978 Instruction Manual for details.

Gasket
A gasket is generally a flat rubber or elastomer washer, fit between the two parts of a connector, seated or retained by features of the mating part.

A clean, undamaged edge is required to maintain an effective seal. It is important during repairs to examine the connector carefully for any sign of damage to the sealing edge that contacts the gasket.



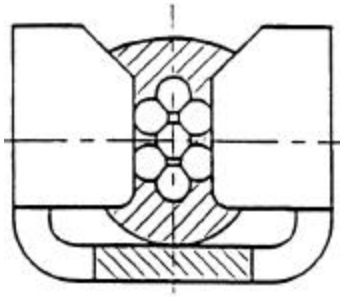
When connector halves are disconnected, their seals or gaskets may get dislodged and be lost. Watch for any seals or gaskets that get separated from connectors.

Radial seal
A seal is secured inside one connector half by a retainer. It is compressed by the mating connector, which makes the seal. Always make sure that the seal and retainer are in place for reassembly.





Soldering *must not* be used to repair wiring harnesses in Volkswagen vehicles.





Most insulation displacement terminals *must not* be used for wiring harness service and repair in Volkswagen vehicles.

Only the tools, materials and repair procedures that have been specifically approved under stringent Volkswagen guidelines may be used.

Termination "Don'ts"

Soldering

Soldering adds conductive material that flows into position between conductors to make electrical contact and hold them together. It is most often used for attaching terminals to conductors inside an electrical or electronic device.

While soldering is not inherently faulty, soldered terminations tend to be reliable and economical *only* when prepared in a controlled manufacturing environment, and *only* when the attached components are not subject to flexing or vibration. Thus, soldering is *not* recommended for wiring harness repair.

Insulation displacement terminals

Using this type of termination, a terminal with lancing or shearing features (like 3M's Scotchlok® for example) pierces the insulation to contact the core conductor strands, *in the process* of terminating the wire or assembling the terminal in a housing. Stripping the insulation from the wire is unnecessary.

Several shortcomings of this method can affect the quality of the repair. The most common is corrosion, either because the termination is not adequately sealed, or because of the inherent potential for corrosion between dissimilar materials.

Insulation displacement terminals are released under stringent guidelines for special wiring harness applications. Only the tools, materials and procedures specified for service or repair of these insulation displacement terminals may be used in Volkswagen vehicles.

Wiring Harness Fabrication

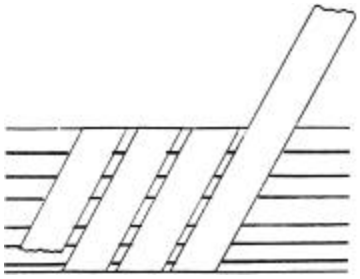
Terminated lengths of wire and cable are bundled together into a wiring harness to facilitate efficient routing in a vehicle, and to provide protection. The materials and components used to fabricate the wiring harness are specifically selected to help prevent mechanical, thermal or chemical damage. Many of these key components are described below.

Tape wrap

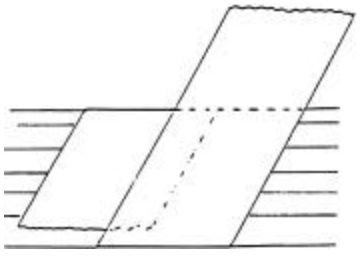
Several types of wrapping tape are used to secure wires and cables in the desired form. The type of tape (PVC, nylon reinforced, cloth, coated cloth, metallic, etc.) and the type of wrap are specified in an Engineering Part Drawing.

As part of a repair, the harness should be re-wrapped from the connector end, to help ensure even wire lengths. Try to restore the original wrap configuration, using the same type of tape material, if possible. For repairs using yellow tape from the VAS 1978 kit, it should be used to wrap the harness in the same style as the original. See the descriptions below.

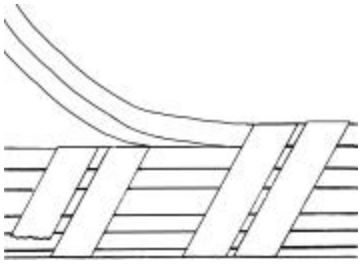
Open spiral wrapping
Open spiral wrapping leaves space between the wraps. This allows for greater flexibility of the wiring harness.



Overlapped wrapping
In this case, the wraps overlap by about 1/3rd. This results in a very rigid wiring harness, with less flexibility. This method is used to ensure that the harness is routed in a specific manner.

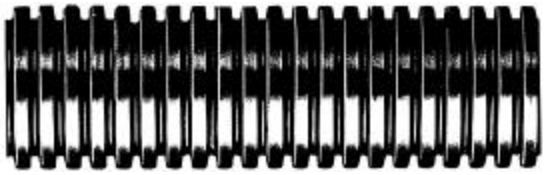


Spot taping
This technique is used during fabrication of the wiring harness to hold dimensions, specifically for branches and breakouts. Spot tapes may also be also applied to keep wiring from tangling.



Tubing

Tubing (also called sheathing or a wire "loom") protects wires branching off from the main harness to other devices, and protects the harness from abrasion and other hazards. Like other parts of the harness, an Engineering Part Drawing specifies the materials, dimensions and locations. Typical versions are:



Convoluted tube
Also called convoluted conduit, this is a semi-rigid ribbed construction used for mechanical protection and for its appearance. Both continuous-tube and slit-tube versions are used.



Thermal sheath
A thermal sheath is reinforced tubing made of reflective, high-temperature resistant materials. It may be flexible to semi-rigid in design.



Woven armor sheath
This is sheathing woven of synthetics or metal for mechanical protection. It may be flexible to rigid, depending on design.



Carefully remove tubing for repairs, so that it might be re-used. If this is not possible, always re-install the same type of tubing, in the same manner as the original.

Shrink tube
Shrink tube or "heat-shrink" tubing is sheathing that will shrink to form a tight seal around the component when heat is applied. Shrink tubing is not reusable.

Fasteners

A wide range of anchors, clips, cable ties and other special-purpose hold-downs are used to route and retain the wiring harness in a vehicle, and to fasten it to the bodywork or to major components.

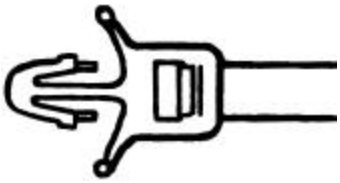


During repairs, always replace or re-install all fasteners and retainers to match the original harness configuration.

Socket anchor
The socket base fits onto a welded stud on the body, or some other retainer that is cast or molded into a component.

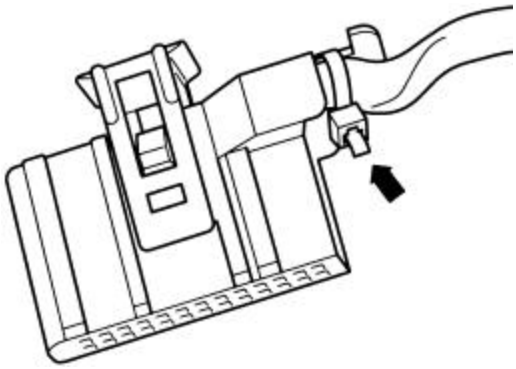


Splay anchor / Tree anchor
These anchors flex and expand to retain themselves after being pushed through a hole in the bodywork or a component.



Clips
Clips hold the wiring harness to some feature of the bodywork, or a component. Most clips must be opened deliberately to release the harness.

Cable ties / Tie-wraps
Cable ties are used in production, as shown here, for example. They must always be replaced, but must *never* be over-tightened, as this can easily damage the harness. *Never* use cable ties to secure the harness to flexible parts like coolant hoses.





Fasteners are for mounting and routing only. Do not add any extra ones. Avoid pinching, stretching or other distortion of the harness, and check for any previous damage.



As for any other fasteners used to attach the harness, always make sure that the fixed-point fasteners have been re-attached in the same locations following repairs.

Fixed-point fasteners or "fix-points"

These fasteners are attached to the wiring harness. The location of such fasteners is specified in an Engineering Part Drawing. Fix-points are an aid to assembly, helping the worker on the assembly line to route the harness correctly and avoid strain or tension, hanging loops, or routing too close to potential hazards. It may be necessary to detach them for increased access during harness repairs.

Conduit

Also called a wire or cable channel, a conduit is a formed enclosure specifically designed to hold, route or protect the wiring harness in a defined area of the motor vehicle.



Grommets may be easily damaged. Care must be taken when removing and installing them, both on the wiring harness and in the vehicle, to ensure that they are not damaged, and that they are re-installed correctly.

Grommets

Grommets are made of rubber or synthetics and are intended to seal the passage of a harness through a hole in the bodywork, and to prevent the harness from chafing at the edges of the hole. Some grommets are molded in place and are, therefore, not reusable.

Mounting brackets

Brackets and other wiring harness mountings may be either separate components or features of the bodywork, or features of other components. They retain the wiring harness in a specific position, route the harness in a specific direction, or hold the harness away from a specific component or area. The harness may be attached to a bracket either temporarily or permanently.

Wiring Repairs

Fundamentals of wiring harness repair



All repairs must be carried out using *only* the VAS 1978 Wiring Harness Repair Kit!

Looking back, we know that the modern wiring harness is a very complex assembly of specialized components. Every inch of the wiring harness has been the subject of detailed design consideration throughout the many stages of vehicle development. Considering this, it is clear that quality repairs require a lot more than finding the damage and splicing in some new wire.

Each and every component of the original wiring harness plays an important role. Some parts enhance electrical reliability; some are there for physical protection.

1. *All* parts of the harness must be completely "rebuilt" and restored to *original* condition.

Either way, when the harness has been damaged, those requirements still exist after a repair. **Rule #1**: *all* parts of the harness must be completely "rebuilt" and restored to *original* condition.

Harness routing and attachment is equally important. Repairs must take into account and duplicate every detail of the way the harness was mounted and protected. Do not improvise. Do not leave anything out.

2. The repaired harness must *always* be mounted and routed exactly as it was before repair — no changes.

This rule applies in reverse as well. Do not add fasteners where none were used before. If there is a part of the harness that seems unsecured, it is for a reason. Perhaps some degree of flexibility is required to prevent damage.

Rule #2: the repaired harness must *always* be mounted and routed exactly as it was before repair — without changes.

3. *Every* repair adds some resistance. When carrying out repairs, make as few repairs as possible, using only the proper tools and components.

Any addition of terminals, connectors, splices, etc. — in short, any repair — runs the risk of degrading the harness. Every new feature adds *some* resistance. No matter how skillfully done, it can never match the conductivity of an unbroken conductor. **Rule #3**: make as few repairs as possible, using only the proper tools and components.

4. Repairs must be carried out using *only* the tools, wires, terminals and other components supplied in the VAS 1978 Wiring Harness Repair Kit.

Harnesses are produced to exacting standards, so harness repair is no place to cut corners on repair methods, or use old parts scavenged from the dark recesses of the tool box! The focus of the new repair concept is restoring the harness to its original condition, using exactly the right tools and exactly the right components.

5. When a top-quality repair cannot be achieved, for whatever reason, the wiring harness must be replaced.

The well-known “Murphy’s Law” states that anything that possibly *can* go wrong, *will* go wrong. Sometimes a quality repair is just not possible – the harness is too badly damaged, or it cannot be fully restored to original condition, or good connections cannot be made, even though all repair instructions have been followed.

Rule #5: when a top-quality repair cannot be achieved, for whatever reason, the wiring harness must be replaced.

CAUTION!

BEFORE working on the electrical system:

- **Determine the correct code for the anti-theft radio.**
- **Stop the engine, and be sure the ignition is switched OFF. Failure to do so may damage the Engine Control Module (ECM).**
- **Disconnect the battery Ground (GND) strap.**

When connecting and disconnecting electrical test equipment (e.g. LED voltage tester, multimeter, etc.):

- **Switch the ignition OFF.**
- **Use the correct adapters from the VW 1594 connector test kit.**

When wiring harness repairs are complete:

- **Always determine what problem has caused the harness damage (i.e. sharp-edged body features, faulty electrical components, corrosion, etc.) and eliminate the cause.**
- **Carry out a functional test after each repair.**
- **Check Diagnostic Trouble Code (DTC) memory, correct indicated malfunctions as necessary, and erase DTC memory.**
- **Check and re-establish control module "Basic Settings" as necessary.**

Basic repair methodology

To repair a wiring harness, the first step (after locating the damaged area) should be to assess the extent of the damage:

- How extensive is the damage? Does it extend through the bulkhead or special grommets that cannot be repaired?
- What other components may have been affected by the damage to the circuit? Have the plastic connector housings been damaged? Are the electronic components damaged?
- Can the harness be repaired to a level that matches factory quality? Will the repair last? Will it be weatherproof?

Only after answering these questions, is it possible to determine whether the harness can be repaired and "rebuilt" to the original quality, or whether it must be replaced.

In either case, determine the cause of the damage, and take action as necessary to ensure that the repair or the replacement harness will not be damaged again.

The following pages list several key points to keep in mind while using the VAS 1978 kit to make harness repairs. For more detailed questions about special cases, or the latest information about critical repairs involving safety systems, refer to the Technician Helpline.

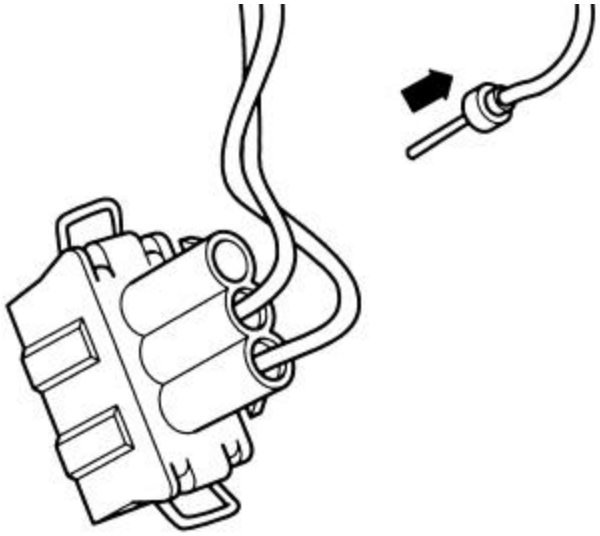
Wiring Repairs



All repairs must be carried out using *only* the VAS 1978 Wiring Harness Repair Kit!



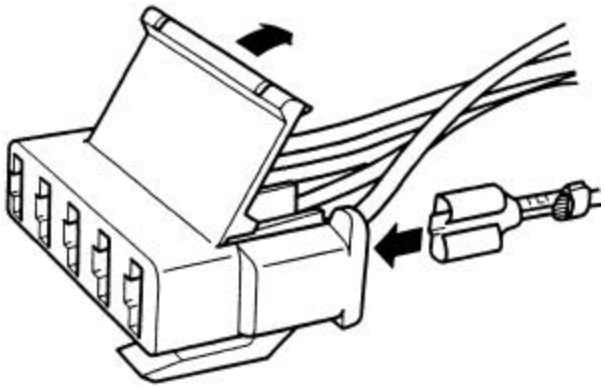
Repair wires and connectors must both be of the correct, matched size.

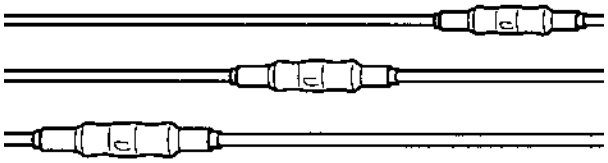


***Points to remember*:**

- *When making wiring harness repairs, use only the tools and components from the VAS 1978 Wiring Harness Repair Kit.*
- *Replace any harness that cannot be repaired and restored to its original configuration using the VAS 1978 kit.*
- *When making repairs by splicing a new length of wire, choose a replacement wire that is the same size as the original, or greater.*
- *Choose from among the color-coded connector terminals and other kit components to match them to the proper wire size.*
- *If it is necessary to join an original wire and a replacement wire using a butt-joint crimp connector, the wires and the crimp connector must be matched in size to ensure a reliable crimp.*
- *Check for special surface treatment on connector terminals. If, for example, the original terminal was gold-plated, a gold-plated replacement must be used.*
- *If heat-resistant wire was used in the original harness (typically with a softer, matte-finish insulation), the equivalent wire must also be used for the repair.*
- *Always replace single-wire seals, where applicable, using color-coded seals that match the wire size. Refer to the VAS 1978 Instruction Manual.*

- *Secondary locking features are critical components that help maintain positive terminal contact. Always fully insert the terminal in the housing before engaging the lock.*
- *Always inspect all features of the connectors and terminal housings for damage before reassembly.*
- *Always wrap the repaired area with the yellow tape provided in the kit — both to replace the original harness wrap, and to identify the repaired area.*
- *Do not locate a wire repair where the harness will flex, such as at a doorjamb or trunk hinge. Replace damaged sections with new wire, and locate the new connections where they won't flex.*
- *When repairing more than one wire, stagger the crimped connections. Do not position them directly side by side.*
- *When cutting a replacement wire to fit, be certain there is sufficient length to ensure that the repaired section is not in tension after being reinstalled.*
- *Shielded cable should not be repaired.*
- *Never use soldered connections to attach terminals, make any kind of termination, or otherwise repair the wiring harness.*





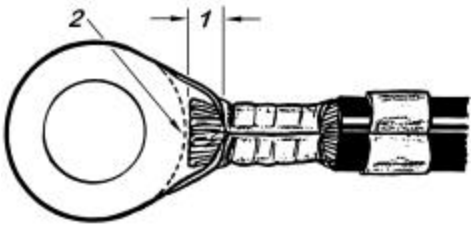


Soldering *must not* be used to repair wiring harnesses in Volkswagen vehicles.

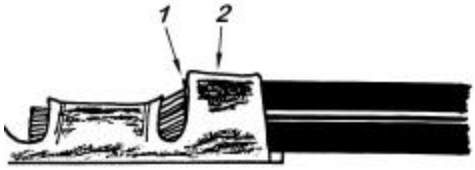
Additional information

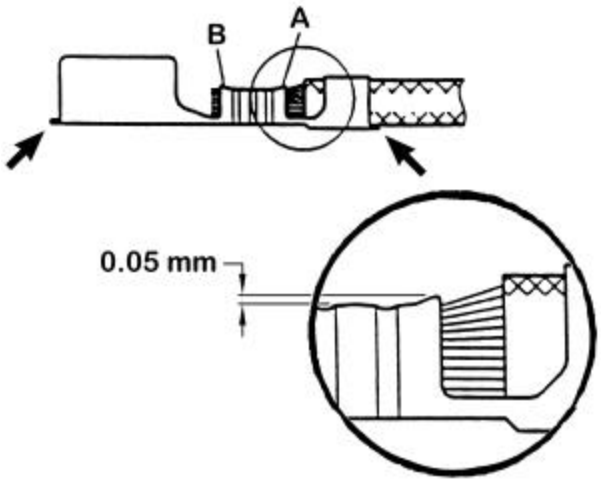
The instruction manual that accompanies the VAS 1978 kit is an excellent guide for how to use the kit and its contents. It also has detailed instructions on disassembly of many types of connectors commonly used on Volkswagen vehicles.

Crimped Terminals – Visual Checks









Crimped Terminals – Visual Checks

Terminals must not be bent, cracked, or otherwise deformed. Check the overall shape. Inspect the locking tabs and, if necessary, re-bend them. If a terminal cannot be restored to original condition, it must be replaced. The key features and basic checks described below will help ensure quality repair.

Wire length in the crimped terminal

1 – The ends of the core strands must be visible beyond the core crimp.

2 – The ends of the core strands must not extend into the area where they will interfere with a fastener.

Insulation in the crimped terminal

1 – Insulation must not be drawn into the core crimp, or it might insulate the conductor strands. Stripped insulation must be at least even with the insulation crimp wing.

2 – The insulation crimp wing must grip the insulation securely to provide strain relief. If not, wire fatigue may cause the termination to fail.

Crimp accuracy

If crimping tools become worn, they may be deformed such that crimping cuts the wire strands, or causes other damage.

Check to see that the runners (arrows) are visible, and have not been eliminated by the crimping operation (also see p. 5).

Check for a slight radius (flaring) at the entry (A) and exit (B) of the core crimp.

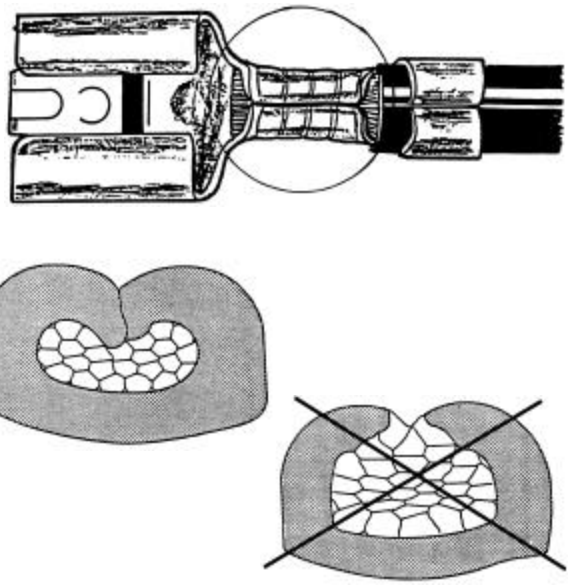
Inset

The 0.05 mm shown is the minimum dimension for the radius flaring, as specified by the VW Terminal Audit.

Fully closed crimp
The terminal crimp wings support each other in a correct “B” crimp, so evenness and symmetry in the crimp is important.

Left: the terminal crimp wings should be folded evenly and uniformly, indicating a good cross-section match, achieved with properly adjusted crimp-tools

Right: there must be no gap between the crimp wings



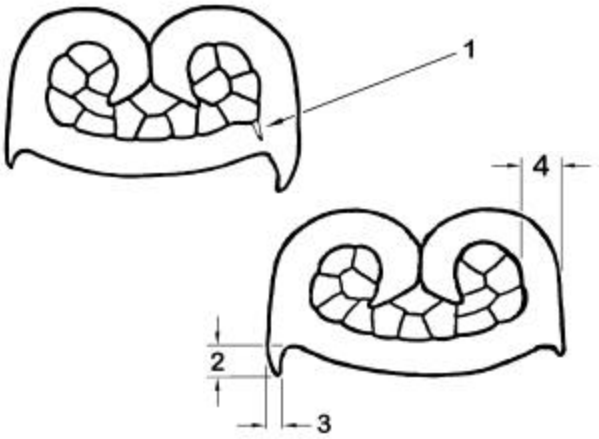
Over-crimping
Burrs at the bottom of the core crimp area are created by excessive crimping pressure, which in turn generates too much compression force acting to deform the metal. This “over-crimping” creates sharp edges and weak spots in the terminal walls.

1 – Cracks

2 – Burr length

3 – Burr width

4 – Terminal material thickness



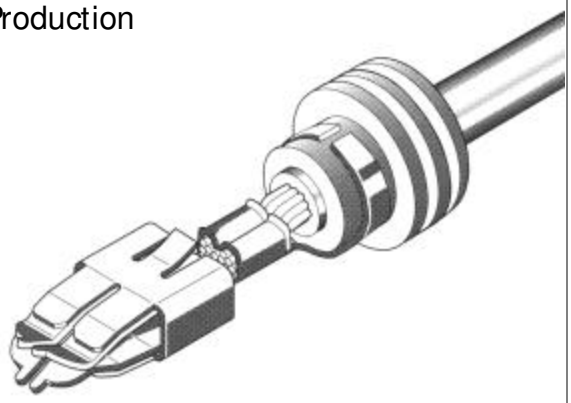
General guidelines
When burrs have been created by the crimping process, neither the length of the burr (2) nor the width of the burr (3) may be greater than one-half of the terminal’s material thickness (4), as specified by the VW Terminal Audit.

Terminals that have been subjected to excessive crimping compression force invariably show cracks (1) that lead to reduced strength and possible failure.

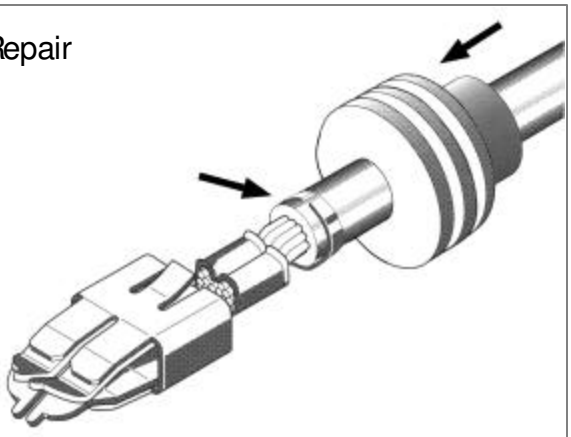


Always inspect wire and connector seals to be sure they are in place, clean and undamaged, and that the mating connector housing is intact, undamaged, and able to seal properly.

Production



Repair





For wiring harness repair, new single-wire seals are installed differently. Refer to the VAS 1978 Instruction Manual for details.

Seals — Visual Checks

Most of the information in this section pertains to single-wire seals, but a few general guidelines apply to any kind of wire or connector seal.

As for any seal, the sealing surfaces and the seal itself must be clean and free of damage. For flat gaskets or radial seals, this also means inspecting the sealing parts of the connector housing to ensure that they are intact and undamaged.

Single-wire Seals

Single-wire seals are used with certain types of connectors. In production, the seal is installed with the wire, and held in place by a larger set of crimp wings that are part of the terminal, as shown. The pages that follow show various ways of inspecting these factory-installed seals for damage.

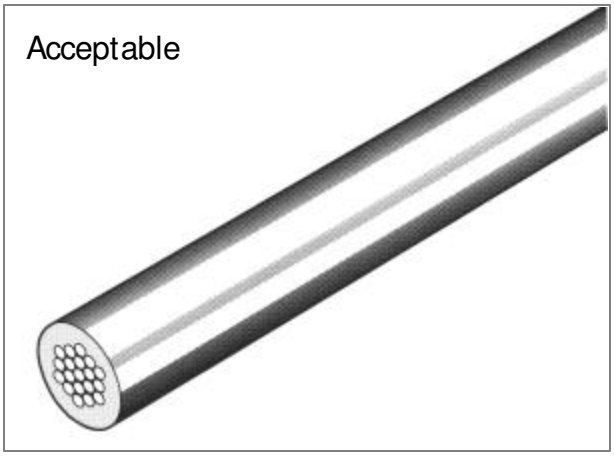
When making repairs to a harness using the VAS 1978 kit, the pre-crimped repair wires have smaller crimp wings used to secure the wire's insulation (left arrow). There is no provision on the terminal for attaching the single-wire seal.

Instead, the new seal is installed over the wire (right arrow) — in the *opposite* orientation, with the *larger* part facing the terminal — *before* attaching the repair wire to the harness.

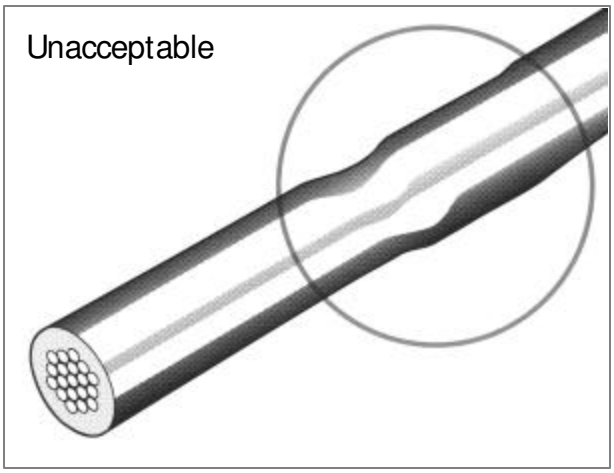
Once the terminal is re-installed in the connector housing, the new seal is pressed into place using special tools supplied in the kit. More complete installation instructions, with details on pressing in a new seal, are included in the VAS 1978 Instruction Manual.

Wire and insulation condition

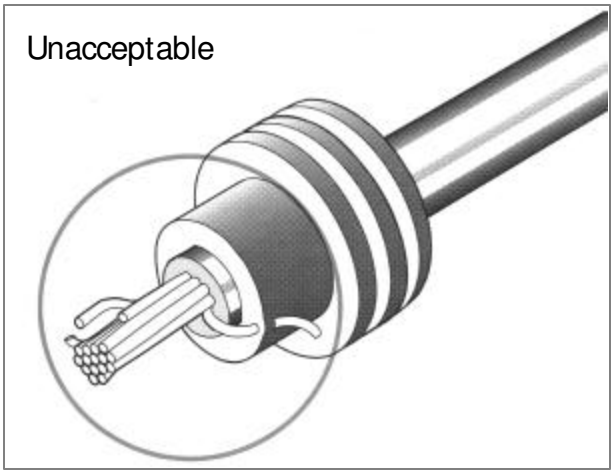
The end of the wire, which is crimped to a terminal and carries the seal, must be free of damage and distortion. Check for unevenness in the outer insulation that may prevent a proper seal.



Inspect especially where a cable tie or other fastener has been used to secure the harness. If it has been installed too tightly, and the insulation has been damaged, it may be necessary to make the repair in a different place, where there is undamaged wire.



Seals – Visual Checks

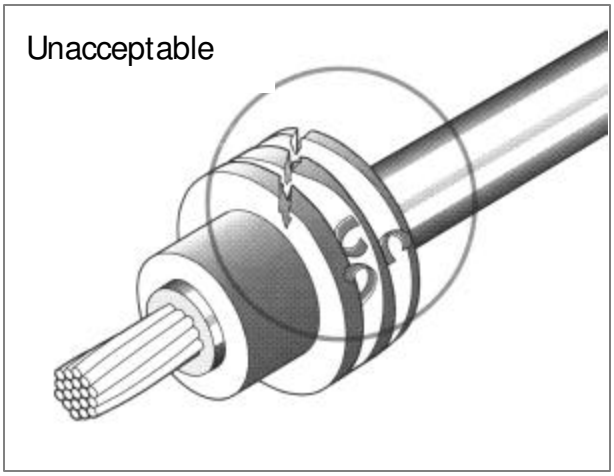


Seal installation (production)

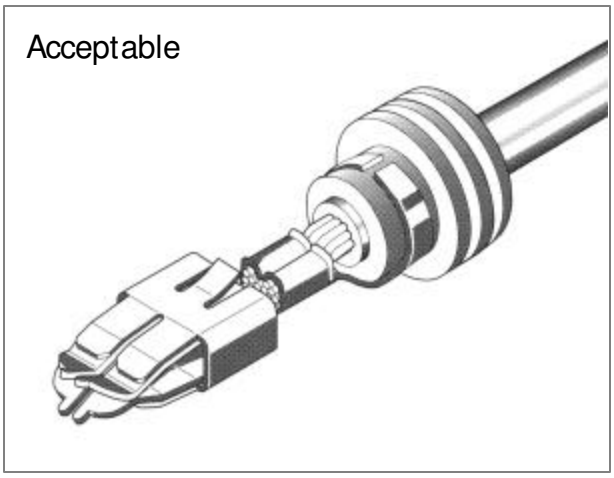
When inspecting the condition of a seal that was installed in production:

a) Check to be sure that the wire strands have not been folded back and trapped under the seal.

b) Make sure that no wire strands are poking through the seal.



c) Check the outer edges or sealing surfaces of the seal to make sure that the seal itself is not damaged.



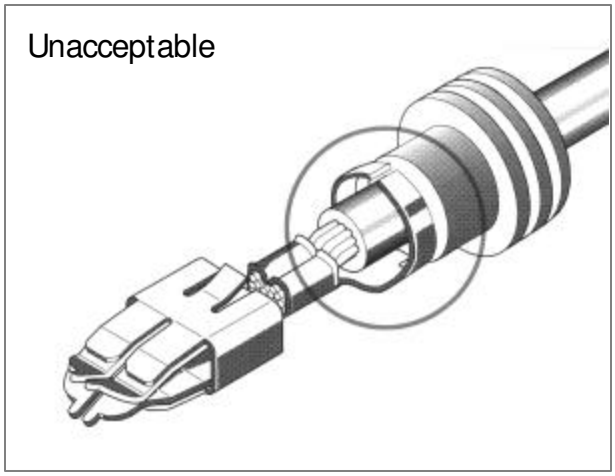
Seal attachment to terminal (production)

When inspecting the condition of a seal that was installed in production and attached to the terminal by crimp wings:

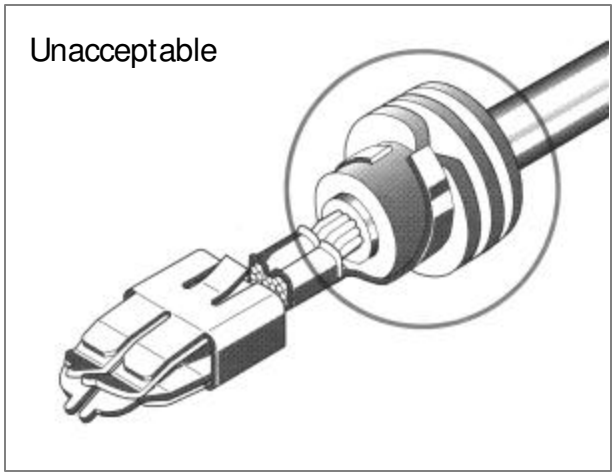
a) Make sure that the seal is properly secured.

b) Make sure that the seal itself is not damaged.

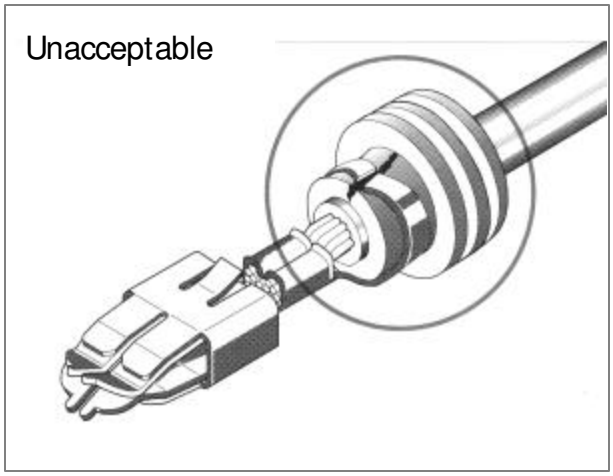
c) Check to see that the seal is not too far from the end of the wire, and thus not adequately secured by the terminal crimp wings.



d) Check the crimp wings to be sure that the seal is well attached and secure, but not damaged in the sealing area itself.



e) Also, check to be sure the crimp wings have not been over-crimped to the point of damaging the seal.





Do NOT **apply Stabilant 22A to oxygen sensor terminals, or other very small terminals (0.64 to 1.5 mm).**

For questions about specific applications, refer to VESIS repair procedures, Technical Bulletins, or the Volkswagen Technician Helpline.

Stabilant 22A

The problem

Poor or intermittent electrical contact between terminals of a component and a harness connector can cause problems that result in customer complaints, and may lead to unnecessary repairs.

The main cause of these problems is what is known as “fretting” corrosion. Metals expand and contract with changes in temperature, and metal terminals do the same. On a very small scale, temperature changes can cause the mating terminals to “fret” back and forth against each other.

The fretting is actually a good thing, up to a point. It helps scrape away the oxide molecules created by natural atmospheric corrosion. Over time, however, a terminal can “ride up” on the accumulated oxide material, and actually break the circuit. What makes troubleshooting so difficult is that the very act of disconnecting and connecting terminals “cleans” them, and temporarily resolves the problem!

A solution

Stabilant 22A is a compound that is used to enhance contact, and to help avoid the problems described above. It does not, by its chemical make-up alone, increase conductivity or improve electrical contact. The chemical compound itself is, in fact, non-conductive in most circumstances!

In a thin layer, under pressure between mating electrical terminals, the compound becomes conductive. While it is not an *electrical* insulator, it seals and protects the connection, and helps delay oxidation and the onset of fretting corrosion.

Regardless of the scientific details, the real “bottom line” is that Stabilant 22A, when used properly, enhances contact.

Stabilant 22A should be used whenever a harness connector has been disconnected or when component has been replaced.



Do NOT **apply Stabilant 22A to oxygen sensor terminals, or other very small terminals (0.64 to 1.5 mm).**

For questions about specific applications, refer to VESIS repair procedures, Technical Bulletins, or the Volkswagen Technician Helpline.

Be sure to clean the terminals thoroughly, then apply Stabilant 22A to contacts in both the male and female connectors. Use a toothpick or equivalent to overcome surface tension and work small amounts past the openings of a multi-pin connector. Avoid “gobbing.” Allow Stabilant 22A to dry before reconnecting.



Stabilant 22A is good for *one use only*. It must be re-applied each time terminals are disconnected.



Use only Stabilant 22A. Other materials may not be compatible.



Use Stabilant 22A sparingly. A very thin coat is useful. Too much is harmful.

Points to Remember ...

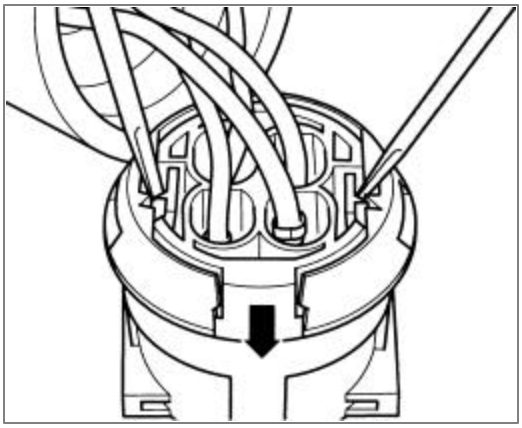
When diagnosing the cause of a customer complaint, always inspect and clean the electrical connectors before replacing a component.

Wiring Harness Repair Kit VAS 1978

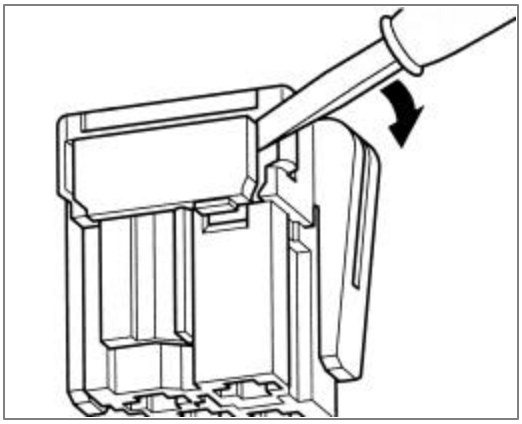


Wiring Harness Repair Kit VAS 1978

The VAS 1978 kit has been designed specifically to meet the needs of the latest Volkswagen wiring diagram repair concept. It is equipped with the tools, equipment and spare components needed to make the necessary repairs in the manner endorsed by Volkswagen. Replacement tools and supplies of the terminals and other repair components are available separately.



The kit includes detailed instructions for disconnecting, unlocking, disassembling and repairing most of the different types of multi-point connector currently in use in Volkswagen vehicles. The illustrations shown here are examples.



Points to Remember ...

When diagnosing the cause of a customer complaint, always inspect, clean and test the electrical connectors before replacing a component.

Summary

We can summarize the key things we have learned in this course as follows:

1. The wiring harness is a complicated and expensive part of the vehicle. About half of all electrical system warranty claims involve repair or replacement of the wiring harness.

The wiring harness is complicated, and proper repairs are critical …

2. Each part of the harness is designed, engineered and built to meet specific needs. This includes its routing and attachments. A proper repair ensures that all elements of the harness are fully restored to original configuration.

All parts of the harness must be restored to original condition …

3. Because proper repair of the wiring harness is critical, all repairs should be made using only the tools and components found in the VAS 1978 Wiring Harness Repair Kit, and in accordance with the *Instruction Manual* supplied with the kit.

Use only the VAS 1978 Wiring Harness Repair Kit …

4. If the wiring harness cannot be fully restored to its original configuration and function using the contents of the VAS 1978 kit, then an adequate and acceptable repair is not possible and the harness must be replaced.

If it can't be done with VAS 1978, it cannot be done right — and the harness must be replaced!

5. Unauthorized means of repair such as soldering, and non-OEM wires and components, must *never* be used to repair a Volkswagen wiring harness.

No welding, no soldering, no hardware store connectors …

6. There are *no* exceptions!

No exceptions!

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Product illustrations and component information from several Volkswagen suppliers have been used as aids in preparing this course material. Those suppliers are:

AMP	AMP
GH	Grote & Hartmann
PE	Delphi/Packard Electric Systems
Schlemmer	Josef Schlemmer GmbH
Schunk	Schunk Untraschalltechnik GmbH
Siemens	Siemens Bordnetze GmbH & Co. KG
Stapla	Stapla Ultraschall Technik GmbH

Many diverse DIN, ISO and Volkswagen standards, recommended practices and test specifications were also used (specifically, VW 603 30 and VW Wire Harness Audit Procedures).

External publications and sources considered in the preparation of this information are:

Committee of Sheet Steel Producers, *Cracking Down on Corrosion – Cooperative Efforts toward Vehicle Durability* (AISI SO 731-1078-20M-SR), Washington, D.C.: American Iron and Steel Institute

Denny, Hugh W., *Grounding for the Control of EMI*, 1st edition, Don White Consultants, Inc., 1983

Electronic Connector Study Group, Inc., *Connectors and Interconnection Handbook*, Volumes 1-5, 4th printing, Fort Washington, PA: Electronic Connector Study Group, Inc., 1985

Society of Automotive Engineers, Inc., SAE Handbooks, Warrendale, PA: SAE, Inc.