Performance Specification for Ultrasonically Welded Wire/Cable Termination

SAE/USCAR-38
December 2009

ISBN: 978-0-7680-3396-0

SAE International™

SAE/USCAR-38

Issued 2009-12

PERFORMANCE SPECIFICATION FOR ULTRASONICALLY WELDED WIRE/CABLE TERMINATION

SUMMARY OF CONTENTS

QUESTIONS REGARDING THIS DOCUMENT: (248) 273-2470 FAX (248) 273-2494
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX (724) 776-0790

1. SCOPE

IMPORTANT NOTICE: In any intended vehicle application, if the products covered by this specification are, or may be, subjected to conditions beyond those described in this document, they must pass special tests simulating the actual conditions to be encountered before they can be considered acceptable for actual vehicle application. Products certified by their supplier as having passed specific applicable portions of this specification are not to be used in applications where conditions may exceed those for which the product has been satisfactorily tested.

The Authorized Person is the final authority as to what tests are to be performed on his or her parts and for what purpose these tests are required. He or she is also the final authority for resolving any questions related to testing to this specification and to authorizing any deviations to the equipment or procedures contained in this specification. Any such deviation must be documented and included in the final test report.

1. This specification defines basic test methods and requirements for ultrasonically welded cable termination type connections. These procedures are applicable to the ultrasonically welded cable attachment method to buss, terminal, or device connections including welded eyelet or battery terminations.

2. The wiring supplier has the primary responsibility for testing and selection of weld tooling and equipment.

   Specific terminal designs may require specialized ultrasonic weld tooling and equipment. The component supplier is responsible to provide the component processor or wire harness supplier information based on the weld tooling and equipment used in the terminal DV and PV testing process.

   Traceability to the tooling and equipment used to prepare the samples under test must be documented in the test report. Obtaining approval from the customer with appropriate test data showing that the welded termination will function as defined by this specification lies with the wiring harness supplier.

3. New or revised ultrasonically welded terminations shall be tested to the requirements of this specification.

4. Deviations from the requirements of this specification must be approved by the customer engineering department.

5. Procedures included within this specification are intended to cover performance testing and development of welded cable terminations that are part of the electrical connection systems used in road vehicle applications at ambient temperatures of 125°C maximum. The OEM customer must approve use of these test procedures for use at temperatures beyond this limit.

6. Welded terminations using crimped insulation wings for strain relief shall meet the insulation crimped grip requirements of SAE/USCAR 21.

NOTE: This specification was developed with clean, bare, uncoated, stranded automotive copper wire. Welded terminations using compressed, compacted, or solid core construction or other core materials (clad, steel core, etc) need to be reviewed to determine that this specification is applicable to evaluate those terminations. Coating, lubricants, or contamination in the bond area of wires or components can affect the mechanical and electrical performance of ultrasonically welded cable terminations. For the purpose this specification the words: cable and wire shall be used interchangeably

1.1 Ultrasonic Weld Characteristics

1.1.1 Ultrasonically welded termination bond performance is characterized by:

A. Mechanical bond, measured by cable to component adhesive pull. .
B. Electrical connection, measured by cable/wire to component resistance and or voltage drop.

1.1.2 The geometry of a cable to component welded joint is characterized by:

A. Weld bond height (WBH)
B. Weld bond width (WBW)
C. Weld bond length (WBL)
D. Insulation crimp height (ICH)
E. Insulation crimp width (ICW)
F. End of conductor limit
G. End of insulation limit
H. Strand length difference (multiple cable terminations)
J. Strip length
K. Weld position

NOTE: To claim conformance to this specification, the weld characteristics used to ultrasonically terminate a cable to a component must be traceable to a SAE/USCAR 38 test report. The specific cable and component configuration including stranding, actual cable cross sectional area, component base material and thickness as well as the tooling detail the tooling must be detailed in the report.

NOTE: Due to the wide range of possible component configurations and applications for ultrasonic wire terminations, the graphics, illustrations, and figures in this document are intended to show general examples of characteristics and are not intended to represent actual component combinations.

2. REFERENCED DOCUMENTS

- SAE/USCAR-2: Performance Specification for Automotive Electrical Connector Systems
- SAE J1128: Low Voltage Primary Cable
- SAE J1127: Low Voltage Battery Cable
- JISC 3406: Low Tension Primary Cable
- ISO/DIN 6722: Low Tension Primary Cable
- AIAG: Measurement Systems Analysis Reference Manual
- SAE/USCAR-21: Performance Specification for Cable-to-Terminal Electrical Crimps

2.1 Document Hierarchy

1st - Applicable FMVSS requirements and other applicable state and Federal requirements
2nd - Applicable part drawings
3rd - Applicable product design specification(s)
4th - Automotive Industry Action Group (AIAG) Production Part Approval Process (PPAP)
5th - Applicable USCAR/EWCAP performance specifications
6th - Other applicable standards and specifications

2.2 Test Request/Test Work Order

The laboratory test request/order shall provide a description (Wire/cable type, component base material, etc) of test samples, the weld bond dimensions , include tooling and equipment detail (see 1.1.2) identify the type of test to be performed (development, validation, special purpose, etc.) and describe any special tests that are not a part of this specification. Any required revisions to, or deviations from any tests in this specification must include detailed instructions for each change. A copy of the Test request or Test work order shall be attached to the final test report.

2.3 Materials and Processes Specifications

Suppliers are expected to adhere to the appropriate Materials and Process that are referenced in this specification and all associated drawings and reference documents. Unless otherwise specified or required by law, suppliers are expected to use the most recent versions of any applicable drawings, reference documents, and standards.

NOTE: See Appendix D for examples of existing wire/component applications.

3. GENERAL REQUIREMENTS

3.1 Record Retention

The supplier shall maintain a central file for the storage of laboratory reports and calibration records. Such record storage must be in accordance with established ISO and AIAG policies and practices.

3.2 Sample Documentation

All test samples shall be identified in accordance with the requirements of ISO and the AIAG PPAP.

3.3 Sample Size

Minimum sample sizes are given for each test in this specification. A greater number of samples may be required by the test request/order. However, no part or device may be represented as having met this specification unless the minimum sample size has been tested and all samples of the group tested have met the applicable Acceptance Criteria for that test. It is never permissible to test a larger group, then select the minimum sample size from among those that passed and represent that this specification has been met. It is permissible to include additional groups of bond heights (WBH) (at a fixed weld bond width) to insure the minimum and maximum bond heights (+/- 1 bond height tolerance based on the optimal developed weld height) will meet the specified requirements. Any alternative sample size and/or methodology must be approved by the Authorized Person.

3.4 Default Test Tolerances

Default Tolerances, expressed as a percentage of the nominal value unless otherwise indicated:

A. Temperature = ± 3° C
B. Voltage = ± 5%
C. Current = ± 5%
D. Resistance = ± 5%
E. Length = ± 5%
F. Time = ± 5%
G. Force = ± 5%
H. Relative Humidity = ± 5%

3.5 Test Default Conditions

When specific test conditions are not given either in the product design specification, the test request/order or elsewhere in this specification, the following basic conditions shall apply:

A. Room Temperature = 23 ± 5° C
B. Relative Humidity = Work area ambient

3.6 Equipment

Neither the list shown in Table 3.6, nor the list in each test section is all-inclusive. It is meant to highlight specialized equipment or devices with particular accuracy requirements. Many other items of customary laboratory equipment and supplies will also be required.

DESCRIPTION	REQUIREMENTS
DC Power Supply (Regulated)	⇒ 0-20 V …200A **or** ⇒ 0~20V current sized as required.
Micro-ohmmeter	⇒ 0-20 mV maximum open circuit voltage ⇒ 0-100 mA maximum test current ⇒ 0.03 mΩ/mV resolution
Digital Multimeter (DMM)	Capable of measuring the following: ⇒ .001 - 50 Volts DC with an accuracy of 0.5% of full scale ⇒ 0-10 MegOhms with an accuracy of 0.5% of full scale
Current Shunts	100 mA or as required with accuracy of ± 1% of nominal
Millivolt Meter	Capable of measuring 0-100 mV DC an accuracy of 0.5 mV or better
Thermocouples	Type "J" or "T" as required
Force Tester	Capable of an accuracy of ≤1% of measurement
Data Logger	As Required
Vibration table	As Required
Vibration controller	As Required
Thermal shock Chamber	⇒ -40°C to 125°C

Table 3.6 - Equipment

NOTE: Use of equipment with a lesser range is acceptable for specific tests where the required range for that test can be met. The equipment range specified does not preclude use of equipment with a larger range, but the accuracy must remain within the specified tolerance. For example, a DMM with a range of 0-100 volts could be substituted for one specified as 0-50 volts, with the provision that the accuracy could be maintained as 0.25 mV or better.

3.7 Test Order and Set-Up

Diagrams and tables are provided where necessary to clarify the details of the various test requirements. The tests in each section must be performed in the order given unless otherwise specified in the test request/order. Set up details including tolerances for specific tests are provided where necessary.

3.8 Definitions and Glossary of Terms

Terms defined in the definitions or glossary are capitalized (i.e. Room Temperature, Steady State, etc.). A list of definitions is provided in Appendix A. A glossary of terms is provided in Appendix B.

3.9 Measurement Resolution

Unless otherwise specified, meters and gages used in measurements of the test sample(s) shall be capable of measuring with a resolution one decimal place better than the specified value. For example, even though a wire diameter specified as 0.1 mm might actually be the same as one specified as 0.10 mm, calipers capable of 0.01 mm resolution may be used to measure the first wire but a micrometer with 0.001 mm resolution is required to measure the second wire.

3.10 Test Repeatability and Calibration

All equipment used for test sample evaluation shall be calibrated and maintained according to the applicable standards and requirements set forth by ISO and the AIAG publication Measurement Systems Analysis Reference Manual. Copies of this Manual can be obtained from the AIAG by calling (248) 358-3570 or writing to AIAG, Dept. 77839, Post Office Box 77000, Detroit, MI 48277-0839, Attn: Customer Service. Information may also be obtained at the AIAG web site, www.aiag.org . Documentation is to be recorded and retained in accordance with Section 4.1 of this SAE/USCAR specification.

A list of instruments and equipment used, date of the last calibration, and when the next calibration is due shall be included in each final test report.

3.11 Conformance Determination

Test conformance shall be determined by the performance requirements of the test being conducted. All specimens within a sample group must satisfy the performance requirements regardless of age, test cycles, or test temperature, except where a test to failure is specified. It is not acceptable to test a larger sample group then select only those specimens that meet the requirements.

NOTE: Additional sample groups with alternate weld dimensions may be tested to help determine the optimal and min/max dimension of a given cable/component combination. All specimens in the minimum and maximum (two) weld height groups (Optimal +1 tolerance, and –1 tolerance) must meet the requirements but all groups tested need not pass.

4. TEST AND ACCEPTANCE REQUIREMENTS

4.1 General Testing Requirements

The test procedures that follow were written as stand-alone tests and may be used as such. However, they are normally used in a sequential test format and common sense is required to overcome any redundancies in sample preparation or in procedures. For example, if samples have already been prepared for the preceding test in a sequence, it should be obvious that the sample preparation step for that individual test (included so that test can be used as a stand alone test) should be skipped. Should any conflicts or questions arise concerning procedures and/or requirements, contact the Authorized Person. Any test plan approved by the Authorized Person that shows compliance to the minimum performance requirements with test data is acceptable.

4.1.1 Dimensional Characteristics

Part construction shall conform to the dimensions, shape, and detail attributes specified on the latest revision of the applicable part drawing(s).

4.1.2 Material Characteristics

All material used in each test sample shall conform to the material specifications on the latest revision of the applicable part drawing(s).

NOTE: See material condition warning in Appendix C.

1. Any engineering development, prototype, or production part may be submitted for test.

2. The samples submitted for test shall be identified by description, part number, and revision letter where applicable.

3. For validation testing, all parts are to be in their "as furnished for vehicle assembly" condition when testing begins. For example, electrical terminals typically have residual die lubricant on them when finally assembled into a vehicle. This same condition must prevail for test samples.

NOTE: If the samples under test are plated or coated it is not permissible to remove the plating or coating or to clean the samples prior to performing the welding process unless these additional processes are a documented part of the volume production weld process. This test in intended to: evaluate, document, and approve the welded cable termination process for volume production applications.

4. Samples submitted for any test shall be prepared per Appendix C.

4.2 Visual Inspection

4.2.1 Purpose

This test is used to document the physical appearance of test samples and to assist in the evaluation of the effects of environmental conditioning on test samples. A comparison can then be made with other test samples. Examinations shall be conducted under high magnification. Photographs (Micrographs) and/or videos are encouraged as a more complete means of documentation. An appropriately identified untested sample from each test group must be retained for post-test physical comparisons if photographs or video's are not on file.

4.2.2 Sample size

At least two specimens (one minimum and one maximum WBH) for each weld width group under test shall be evaluated.

NOTE: Minimum and maximum WBH is based on the optimal developed weld height and width for that specific wire/component combination, +/- one WBH tolerance.

See Appendix C Weld bond height tolerance table.

NOTE: For purposes of comparison and especially when only subtle appearance changes are anticipated, it is desirable to submit an additional sample to serve as a control.

4.2.3 Equipment

Video/photography (Micrograph) equipment.

4.2.4 Procedure

1. Visually examine the weld bond area on each test specimen prior to testing and/or conditioning, noting in detail any manufacturing or material defects such as wire to weld transition, loose strands, cut strands, long strands that could interfere with component function, short strands that could affect weld function, etc. When specified in the test request/order, take photographs and/or video recordings of representative samples to be tested and keep a properly labeled control sample.

2. After testing and/or conditioning, re-examine each test sample and note in detail any observable changes, such as physical distortions, cracks, etc. Compare the tested and/or conditioned samples to the control samples, the videos, and/or the photographs, recording any differences in the test report. The Authorized Person will need to provide an additional sample for this purpose.

3. If the component supplier's appearance requirements are more strict than those specified below, then the component supplier requirements shall be applied.

4. Return test samples to requestor after all tests are completed and all necessary data have been obtained.

4.2.5 Acceptance Criteria – Refer to Figure 4.2.5.

1. General Appearance

   The welding operation shall not affect mating surfaces or interfere with covers or other device features and functions.

2. End of wire core

    a. The end of the wire strands must extend beyond the end of the weld bond 2mm +/- 1mm. The wire strands must not interfere with the installation of the component, device or terminal being terminated with the weld process. In sealed applications, mat or cable seals must not be damaged by the core, and may require core depressors and strip length control to prevent seal damage from the weld bond or wire strand ends.

NOTE: If the component being welded is supplied with a wire core length identification feature this feature shall be used to determine the appropriate core end position.

    b. Excessive strip length must not allow wire strands to interfere with the component being welded and or allow bare wire between the weld and end of the insulation to create a condition where un-insulated wire could cause a short circuit condition.

    c. Strip length must be sufficient to keep the cable insulation out of the weld area and long enough to allow all wire strand ends to extend past the weld area. See figure 4.2.5 for maximum wire core length past weld bond.

3. End of insulation

    a. If the terminal or component being welded has an insulation grip feature the end of the insulation must be visible in the area between the weld bond and (if applicable) the insulation grip wings.

    b. In no case may un-stripped insulation be in the weld bond profile.

4. Conductor weld bond

    a. All individual strands must be enclosed in the weld. Loose or cut strands are not permitted.

    b. No broken or cut strands are allowed in the transition area between the weld bond and the wire insulation.

    c. The weld bond must be completely in contact with the terminal or component being terminated. No portion of the weld bond length or width can extend outside the surface of the component.

NOTE: The weld bond height and width dimensions of the samples under test must be recorded and included on the test report.

5. Insulation Grip

    a. The purpose of an insulation grip is to add strain relief to the weld bond. This moves the stress riser between welded and un-welded wire strands away from the weld bond area.

    b. The crimped Insulation grip must contact the surface of the insulated cable(s) or wire bundle. (See Paragraph 4.3.5-2)

    c. The crimped Insulation grip dimensions are reference dimensions.

    d. The crimped Insulation grip must not interfere with any subsequent operations.

    e. The crimped Insulation grip must not interfere with the fit or function of the terminal, component, or device being terminated with the welding process.

    f. The crimped insulation grip must not damage the cable seal. (See Paragraph 4.3.5-3)

    g. The crimped insulation grip must not damage damage the wire core. (See paragraph 4.5.5.2)

6. Cable Conductor Appearance prior to welding.

    a. Missing wire strands are not allowed.

    b. Wire strands shall not be nicked or elongated.

    c. Insulation shall not be stuck or imbedded in strands.

    d. Strands shall be clean and free of lubricants and or discoloration.

7. Individual Cable Seal crimp.

NOTE: This specification does not include any requirements for seal sliding force due to the large number of variables. It is understood that individual cable seals be properly seated in their intended component to function.

    a. The crimped seals must be firmly secured by the insulation grip.

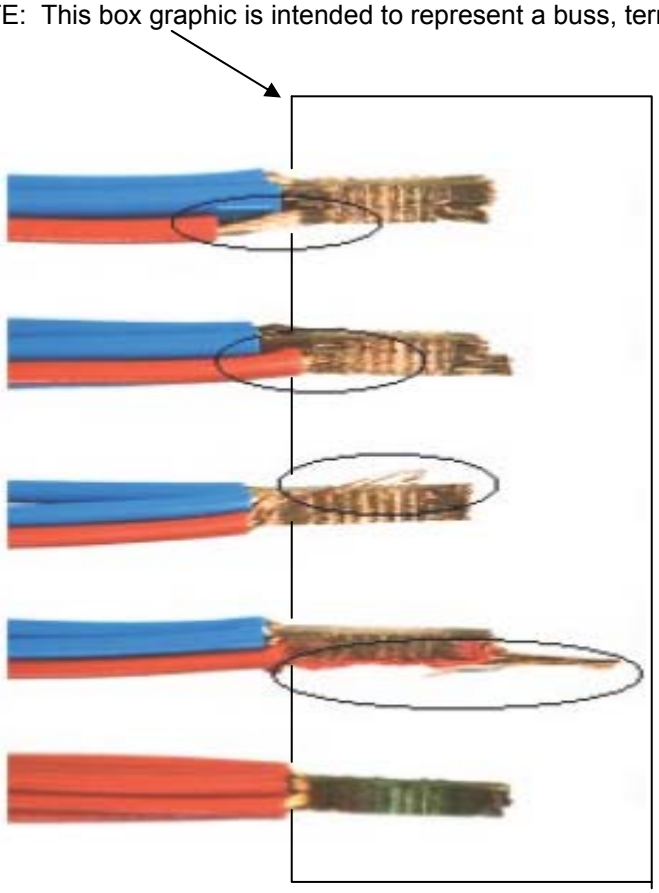
    b. The seal must show no signs of damage.

    c. Seal designs with a neck and or hub must have the end of the seal neck or hub visible in the area between the weld bond and the insulation grip.

    d. The end of the cable insulation must be visible under the seal.

Un-acceptable weld bond characteristics

NOTE: This box graphic is intended to represent a buss, terminal or other welded component.



Wire not fully in weld bond area

Un-even wire position in weld bond area

Loose or un-welded wire strands

Insulation in weld bond area

Scorched, over welded bond

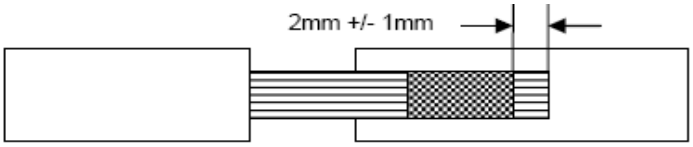
Broken or cut strands are not acceptable in the transition area between the weld bond and un-welded wire strands.

Weld not fully on component

NOTE: Photos courtesy of Stapla Ultrasonics Corporation

Figure 4.2.5.a Unacceptable Weld Bond Appearance

Acceptable weld bond appearance



- All wire strand strands welded
- All wire strands the same length
- Weld bond fully on component
- Strands extend beyond weld 2mm +/- 1mm

Figure 4.2.5.b Acceptable Weld bond Appearance

4.3 Welded termination and insulation grip Cross-Section Analysis

4.3.1 Purpose

Cross-sectional analysis is used as a diagnostic aid in determining why a weld termination fails a portion of this test. Failure to pass the electrical and mechanical requirements of this specification may be caused by insufficient or excessive weld bond compaction and may be identified by visual appearance under high (10 X min.) magnification.

4.3.2 Sample Size

At least two specimens (one minimum and one maximum WBH) for each weld width group under test height shall be evaluated.

NOTE: Minimum and maximum WBH is based on the optimal developed weld height and width for that specific wire/component combination, +/- one WBH tolerance.

See Appendix C Weld bond height tolerance table.

4.3.3 Equipment

Various specialized equipment exists for cross-sectioning samples. The choice of equipment is up to the supplier, but should be capable of sectioning the weld bond with minimal disturbance to the cable stranding or component. Polishing and etching the specimen is necessary to clearly expose the ends of the strands within the bond. It is necessary to use magnification equipment so all individual strand can be seen and photographed.

4.3.4 Procedure

1. Cross-section and photograph each weld bond (and insulation grip where applicable) specimen for analysis.

2. Cross-section analysis shall be performed on all weld bond sample groups at the minimum and maximum production weld heights* for each weld bond width under test. (See Appendix C Weld bond height tolerance table)

3. Cross-sections shall be performed as near to the mid-point of the welded bond area as possible.

4. Compare the specimens to section 4.3.5, Acceptance Criteria and figures 4.3.5.a and b.

*Minimum and maximum WBHs (Based on the optimal developed WBH +/- 1 tolerance) for each nominal selected WBW, are required to meet all weld bond performance requirements. Additional WBHs may be included to determine the optimal WBH +/- 1 tolerance at a single width dimension

4.3.5 Acceptance Criteria

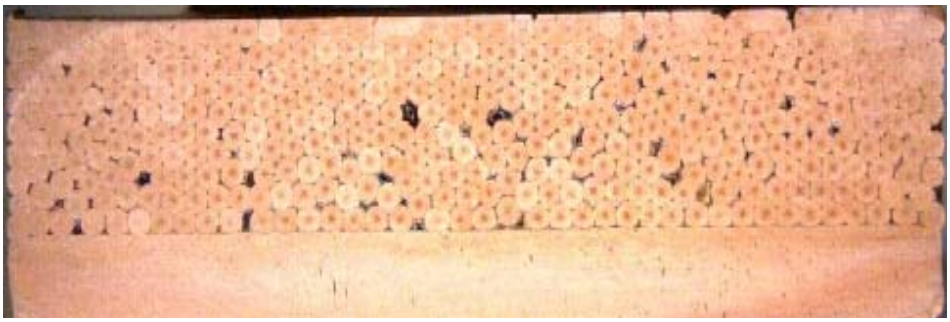
1. Acceptance criteria for the cross-sectioned weld bonds are described as follows:

   a. All strands in the weld bond must be in contact with the weld bond. (See figure 4.3.5.a)
   b. Limited interstitial gaps are acceptable
   c. See Appendix C for additional weld bond judgment information

Unacceptable weld bond cross sectional appearance

Figure 4.3.5.a Example cross sectional view of an un-acceptable weld due to strands not in contact with the weld bond.

Typical acceptable weld bond cross sectional appearance

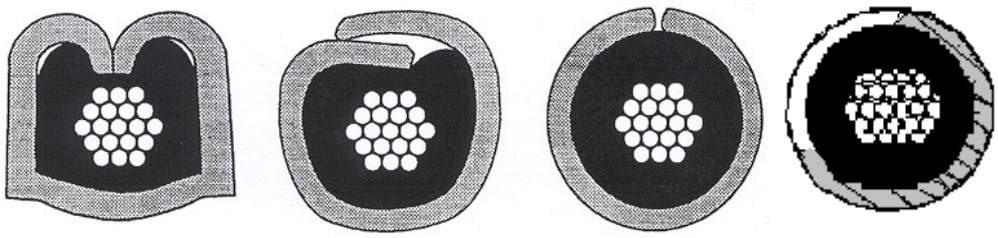


NOTE: Photo courtesy of C&S Technologies and Stapla Ultrasonics Corporation

Figure 4.3.5.b Example of the cross sectional view of an acceptable weld bond

2. Acceptance criteria for the cross-sectioned crimped insulation grips are described as follows:

   - Standard insulation grip attributes considered ideal



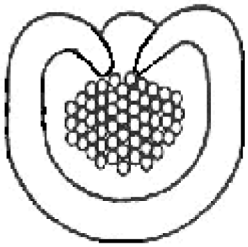
- Symmetric crimp
- No insulation penetration
- Wings (grips) embrace insulation to provide adequate strain relief

NOTE: Insulation grips on welded applications with multiple insulated wires (not shown) should grip the insulated bundle and provide strain relief without damage to the insulation or wire core.

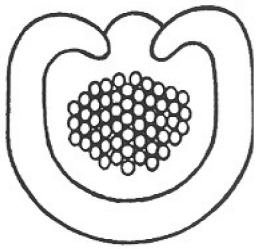
NOTE: Also refer to the terminal manufacturer's recommendations for acceptable/unacceptable insulation grip attributes. Some examples of non-standard insulation grips include "tee-pee", "tear drop", "square", or "tall B".

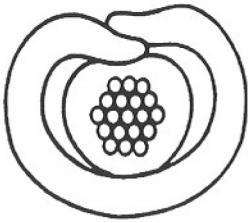
NOTE: Some insulation grips serve as a functional part of the terminal/cavity retention system and must be crimped to meet any functional requirements.

- Crimped insulation grip attributes considered acceptable but not ideal.



Insulation wings contact conductor (no damage to conductor)

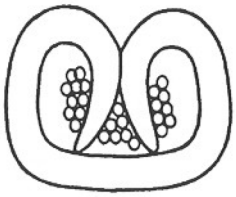




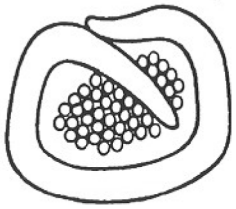
Less than 3-point contact

Insulation extruded outward between open insulation wings

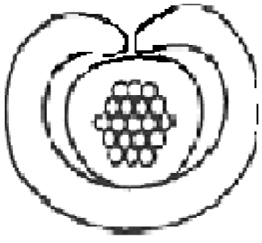
- Crimped insulation grip attributes considered unacceptable



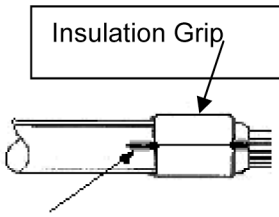
One or both wings penetrate ("crash") to the terminal floor or wall



One or both wings penetrate and damage the conductor*



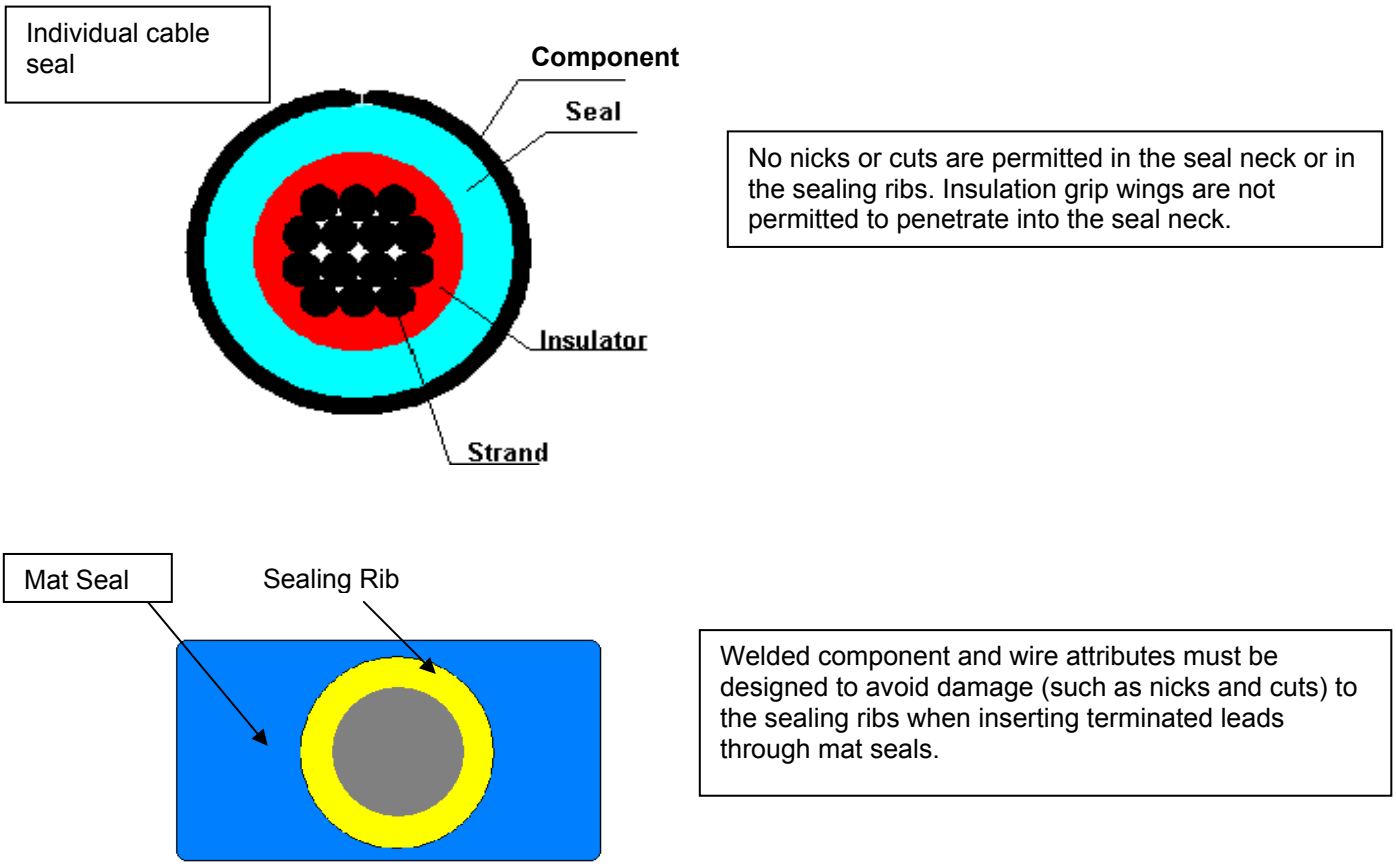
No grip wing contact with insulation



Split insulation is un-acceptable

*Damage is defined as severing strand(s)

3. Cross section views of Cable Seals



4.4 Cable to Component, Weld Bond Mechanical Tensile Peel and Pull Force Test

NOTE: Samples exposed to accelerated environmental conditioning and 4.7.1 or 4.7.2 electrical testing may be used for Mechanical testing at the conclusion of those tests.

4.4.1 Purpose

This procedure details a standard method to measure the component to wire/cable retention capability of weld bonded terminations.

The Peel test is to be used pre test and will determine if the welds under test are suitable to be used for the balance of the testing procedures. This pre test was included so the testing could be halted on any sample groups where the welds were likely to fail other test requirements.

The Pull force test will not be used to determine overall performance of the welded wire to component termination. It will only be used to determine the mechanical limits of the application for handling purposes. Applications may require additional strain relief protection to assure the welded circuit survives the harness handling and vehicle assembly process.

There may be cases where the weld bond tensile is stronger than the component under test. In those instances the tensile failure value of the component shall considered to be the minimum tensile requirement provided the weld bond under test meets the “after aging” electrical requirements.

4.4.2 Equipment

1. Device capable of measuring weld bond dimensions. (Caliper, etc.)

2. De-crimping tool or other suitable means of opening insulation grip wings without damaging the weld bond. (NOTE: it is acceptable to make the samples with the insulation grip not crimped to avoid this step.)

3. Force tester

4. Suitable fixture(s)

NOTE: Fixture design and set up is dependant on the specific component and weld bond configuration. The Authorized Person has the final decision for approving the Peel and Pull test fixture(s) and set up.

4.4.3 Samples

4.4.3.1 Peel Test Samples

At least 4 specimens (2 minimum and 2 maximum WBH) for each weld width group shall be tested.

NOTE: Minimum and maximum WBH is based on the optimal developed weld height and width for that specific wire/component combination, +/- one WBH tolerance.

See Appendix C Weld bond height tolerance table.

4.4.3.2 Pull Test Samples

At least 20 specimens (10 minimum and 10 maximum WBH) for each weld width group shall be tested.

NOTE: Minimum and maximum WBH is based on the optimal developed weld height and width for that specific wire/component combination, +/- one WBH tolerance.

See Appendix C Weld bond height tolerance table.

NOTE: See 4.4.5, step 8 for additional sample requirements

NOTE: Welded samples may be used for electrical testing prior to tensile testing. If samples used for electrical testing are used for tensile testing, expose all tensile samples to the environmental conditioning.

4.4.4 Peel Force Test Procedure

1. If the WUT has an insulation grip, the tensile pull force test shall be performed on leads with insulation grip wings open (not crimped).

2. Peel force test shall be performed on taut leads (i.e., remove slack in cable before performing pull test to prevent incorrect test results due to “jerking”).

3. Measure and record the conductor weld bond height, width, and length. (Refer to Appendix C)

NOTE: Dimensional data shall be obtained, recorded and included in the test report. Measure the weld bond height, weld bond width and weld bond length on the specimens from each sample group under test.

4. If the insulation grip is not already open, open it with a de-crimper or other suitable tool so that the pull force will reflect only the welded conductor connection.

5. Visually inspect the de-crimped area to ensure that none of the conductor strands have been damaged. Do not test any specimens that have damaged conductor strands.

6. All wires in the specimen must be bundled and pulled together.

7. Apply a force 180° to the direction of the welded wire(s) at a rate between 50 and 250 mm/minute (100 mm/min. is recommended). Measure and record peel force required to separate the wire/cable from the component for each specimen under test.

8. The minimum peel force value is based on the cross sectional area of all wire/cable in the weld bond under test.

4.4.4.1 Peel Force Test Acceptance Criteria

The peel test is a pre test is used to determine the suitability for testing the sample groups under test. (See 4.4.1)

The minimum peel force required to separate the wire/cable from the welded component is 20% of the Minimum pull value of wire/cable cross sectional area shown in Table 4.4.6.

4.4.5 Pull Force Test Procedure

1. If the WUT has an insulation grip, the tensile pull force test shall be performed on leads with insulation grip wings open (not crimped).

2. Pull force test shall be performed on taut leads (i.e., remove slack in cable before performing pull test to prevent incorrect test results due to “jerking”).

3. Measure and record the conductor weld bond height, width, and length. (Refer to Appendix C)

NOTE: Dimensional data shall be obtained, recorded and included in the test report. Measure the weld bond height, weld bond width and weld bond length on 5 specimens from each sample group under test.

4. If the insulation grip is not already open, open it with a de-crimper or other suitable tool so that the pull force will reflect only the welded conductor connection.

5. Visually inspect the de-crimped area to ensure that none of the conductor strands have been damaged. Do not test any specimens that have damaged conductor strands.

6. Apply an axial force at a rate between 50 and 250 mm/minute (100 mm/min. is recommended). Pull to 10% above the minimum value for that wire/cable size shown in table 4.4.6. .

7. For double, triple, or multiple welded wire termination setups with conductor sizes within one step, pull the smallest conductor. (e.g. for a .35/.50 double, pull the .35 mm^2 wire)

8. For double, triple, or multiple welded wire termination setups with conductor sizes more than one step apart, one of the smallest and one of the largest gage size cables must be tested. (e.g. for a .5mm^2/1.0mm^2 double, pull both wires individually, for a .5mm^2/1.0mm^2/2.0mm^2 triple, pull the .5mm^2 and the 2.0mm^2 wires, for a .50/.50/2.0 triple, pull one of the .5mm^2 and the 2.0mm^2 wires.) Use a new specimen for each wire pulled.

NOTE: Double the number of specimens if 2 wire sizes are required to be tested from the same wire/terminal configuration.

4.4.5.1 Pull Force Test Acceptance Criteria

The tensile value requirement is minimum value the weld is required to withstand without separation. This test does not require pull to failure. Pull samples to 10% above the listed minimum value. Record the pull value of any failures in the test report. If the terminal or component fails below the value listed for that wire/cable cross sectional area, that value will be considered the minimum value for the weld under test. All specimens in any sample group must meet the minimum requirement for that group to be considered acceptable.

Wire/Cable Cross Sectional Area (mm^2)	**Minimum Pull Force (N)**
≤ 0.22	40[(a)]
≤0.35	50 (Annealed Core)
≤0.5	85
≤0.8	120
≤1.0	150
≤1.5	170
≤2.0	220
≤2.5	250
≤3.0	290
≤4.0	310
≤5.0	340
≤6.0	360
≤8.0	380
≤10.0	390
≤12.0	425
≤14.0	475
≤16.0	500
≤18.0	550
≤20.0	600
≤25.0	675
≤30.0	750
≤35.0	800
≤40.0	850
≤45.0	900
≤50.0	950
>50	1000

[(a)] Or as defined by responsible person.

Table 4.4.6 - Minimum Pull Force Requirements

4.5 Accelerated Environmental Exposure, Thermal Shock Conditioning

(See 4.8 Accelerated Environmental and Vibration Flow Diagram)

4.5.1 Purpose

This environmental conditioning procedure details the requirement for establishing the functional performance of electrical and electronic components when subjected to alternating high and low temperature environments. Rapid transfer between the two environments tests the component's ability to withstand drastic temperature changes.

4.5.2 Samples

At least 10 specimens (5 minimum and 5 maximum WBH) for each weld width group shall be tested.

NOTE: Minimum and maximum WBH is based on the optimal developed weld height and width for that specific wire/component combination, +/- one WBH tolerance. Minimum cable length for samples is 150 mm.

See Appendix C Weld bond height tolerance table.

4.5.3 Equipment

Thermal shock chamber.

4.5.4 Procedure

1. Perform visual examination per paragraph 4.2.
2. Perform dry circuit resistance, per paragraph 4.7.1 or voltage drop per 4.7.2.
3. Set controls to the necessary temperatures, dwell times, and number of cycles.
4. Allow the chambers sufficient time to achieve the programmed temperature.
5. Place the sample group(s) in a transfer basket. If using an automatic T/S chamber insure that the test samples cannot jam the transport mechanism.
6. Start the test program per figure 4.5.4.

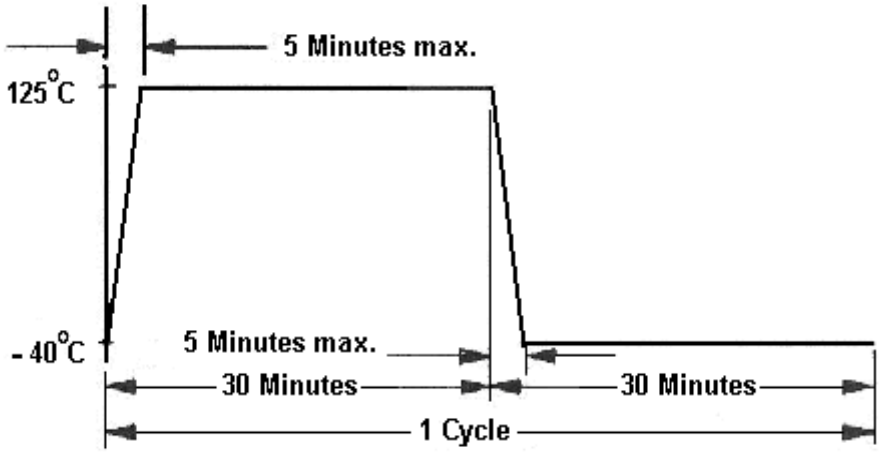


Figure 4.5.4 Thermal Shock Chamber Programming Profile

7. When test program is complete, shut off the thermal shock chamber and remove the sample group(s).
8. Perform visual examination per paragraph 4.2.
9. Include in the report:

- Operating temperatures, dwell times, and number of cycles tested
- Report on evaluation tests, if performed.

4.5.5 Acceptance Criteria

This is a conditioning procedure only. There are no acceptance criteria. (See 4.7 for Electrical Performance requirements)

4.6 Vibration and Mechanical Shock

(See 4.8 Accelerated environmental and Vibration Flow Diagram)

4.6.1 Purpose

This test subjects a welded termination to variable vibration simulating accelerated exposure to actual vehicle conditions. Vibration and shock can cause mechanical fatigue failure.

NOTE: This section does not apply to components mounted on un-sprung portions of the vehicle, such as the wheel hub. Components mounted on un-sprung portions of the vehicle require special testing to ensure they can survive and function properly in the intended application.

4.6.2 Samples

Samples exposed to 4.5, Accelerated Environmental Exposure shall be tested per 4.6 Vibration and mechanical shock.

4.6.3 Equipment

- ⇨ Vibration Table
- ⇨ Vibration Controller
- ⇨ Accelerometers

4.6.4 Procedure

1. Verify conformance of each sample connector assembly to the Acceptance Criteria of the Dry Circuit Resistance or Voltage drop test. (See section 4.7)

2. Construct a suitable mounting apparatus using the following design criteria:

    a. The mounting apparatus must be constructed and secured to the vibration table to minimize added effects (harmonics, dampening, resonance, etc.).
    b. The weld under test may be mounted directly to the vibration table or to a suitable fixture. Refer to Figure 4.6.4.b. The free end of the wire/cable shall be secured to the table or fixture 100mm +/-10mm from the center of the weld bond using a suitable clamp or clip.

3. Should an application arise that does not lend itself to the situation described above, consult the Authorized Person. It is his or her responsibility to devise a suitable method for attaching the weld under test vibration apparatus.

4. Subject the CUT to 10 positive half-sine wave pulses (5~10 millisecond duration at 35 Gs force) in each of the three mutually perpendicular axes. Mechanical shock and vibration testing may be completed in sequence for each axis before proceeding to the next axis.

5. Unless otherwise specified in the test request/order all Welds Under Test shall be vibrated for 8 hours in each of the three mutually perpendicular axes (X,Y,Z). Vibrate the WUT using the vibration profile in Fig. 4.6.4.a

6. Inspect the WUT, and verify conformance to the Acceptance Criteria of Section 4.6.5

Frequency (Hz)	Power Spectral Density (g^2/Hz)
60.0	0.00100
200.0	1.50000
210.0	0.10000
1200.0	0.10000
Grms = 12.1	

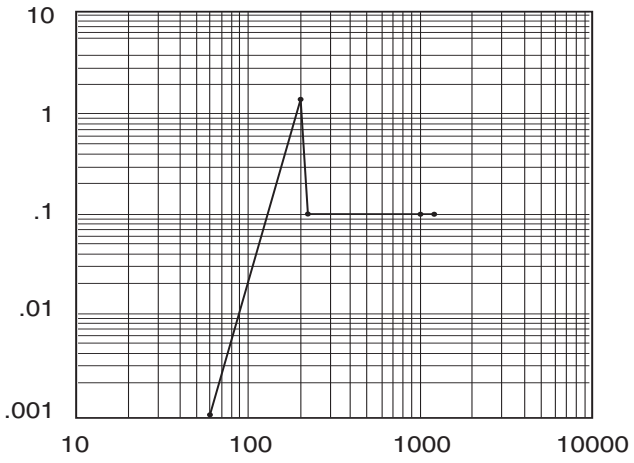
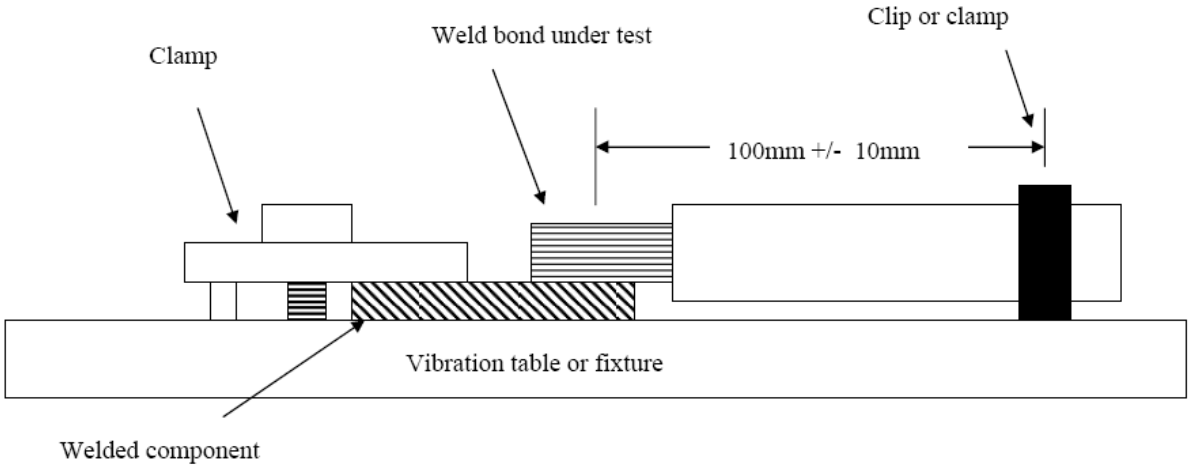


Figure 4.6.4.a For Components Coupled to Engine (Vibration class 2)



NOTE: Wires in multiple wire welds should be bundled and clamped as one cable

Figure 4.6.4.b Typical Vibration Test Sample mounting set-up

4.6.5 Acceptance Criteria

1. All WUT must meet the Acceptance Criteria of the Dry Circuit Resistance or Voltage drop test. (See section 4.7.1 or 4.7.2)

2. The welded components must not show (with the aid of 10X magnification) any evidence of deterioration, cracks, deformities, etc. that could affect their functionality.

4.7 Electrical Performance Test

4.7.1 Dry Circuit Resistance Test for Welded Terminations

NOTE: This test is intended to be used when the total cross sectional area of the wire/cable in the weld bond is ≤5 mm^2 prior to welding.

4.7.1.1 Purpose

1. This procedure covers measuring the electrical resistance of welded wire to component type termination under dry circuit conditions.

2. Dry circuit conditions require that the maximum voltage impressed across the test specimen be limited to 20 millivolts, and the maximum current through the sample be limited to 100 milliamperes.

NOTE: For dry circuit evaluation welds containing multiple wires, perform the resistance measurement on the smallest wire in the weld bond.

4.7.1.2 Samples

1. At least 20 specimens (10 minimum and 10 maximum WBH) for each weld width group shall be tested.

NOTE: Minimum and maximum WBH is based on the optimal developed weld height and width for that specific wire/component combination, +/- one WBH tolerance. See Appendix C Weld bond height tolerance table.

2. Prepare at least 1 additional specimen of each weld bond dimensional variation under test to be used as the deduct value in 4.7.1.4 steps 4~6. This “deduct” specimen shall have solder applied to the weld bond area. A sample length of 150 mm is recommended. However, any length >100 mm is acceptable as long as there is no effect on the weld bond during processing and handling of samples. The same length shall be used for all sample groups under test as for the deduct specimen.

3. Prepare resistance measurement points on the test samples at a point on the cable 100 ± 3 mm minimum from the rear edge of the terminal conductor grip.

NOTE: Any measurement point >100 mm is acceptable as long as the same measurement length +/- 3 mm is used for the deduct sample.

4. Apply solder to measuring point C, figure 4.7.1.4 (stripped end of wire) to obtain consistent readings.

4.7.1.3 Equipment

- Micro-ohmmeter

4.7.1.4 Procedure

1. Perform a visual inspection of components per paragraph 4.2.

2. Measurements shall be made on thoroughly dry samples without cleaning or rinsing of corrosion products.

3. Relative movement of samples should be minimized to reduce effects of movement on measured values.

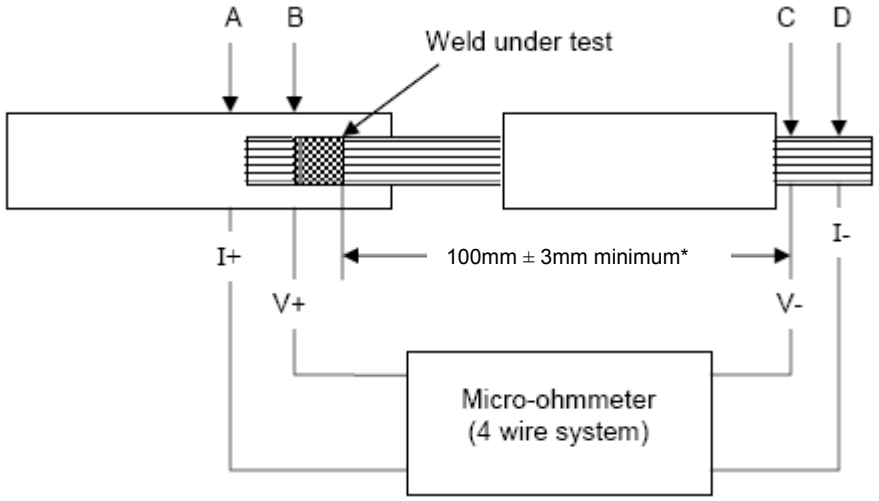
4. Measure and record the resistance of the specimen with the soldered weld bond. The measurement is made at a point 100 +/- 3 mm minimum from the rear edge of the terminal conductor grip.

NOTE: Any measurement point >100 mm is acceptable as long as the same measurement length +/- 3 mm is used for the deduct sample.

5. Measure and record the resistance between the cable measuring point C and point B on specimen under test, just in front of the weld bond area. (See Figure 4.7.1.4).

6. The weld bond resistance is equal to the overall resistance measured in step 5, less the resistance of the soldered sample measured in step 4.

NOTE: It is important that the deduct specimen measured in step 4 is the same length +/- 3 mm and material as those under test measured in step 5. The only difference must be the solder on the weld bond.



*Any measurement point >100mm is acceptable as long as the same measurement length +/-3mm is used for the deduct sample.

Figure 4.7.1.4 Dry Circuit Measurement Points

4.7.1.5 Acceptance Criteria

Upon completion of the Accelerated aging test (ENV), all samples prepared and tested at the minimum and maximum weld bond heights, based on each nominal weld bond width must not exceed the (mΩ) values shown in table 4.7.2.

NOTE: Minimum and maximum WBH is based on the optimal developed weld height and width for that specific wire/component combination, +/- one WBH tolerance. See Appendix C Weld bond height tolerance table.

NOTE: The 4.71 Dry Circuit test is intended to be used when the total cross sectional area of the wire/cable in the weld bond is ≤5 mm^2 prior to welding. Use 4.7.2, Voltage Drop test when the total cross sectional area of the wire/cable in the weld bond is >5 mm^2 prior to welding.

4.7.2 Voltage Drop Test for Welded Terminations

NOTE: This test is intended to be used for welded bond, wire/cable cross sectional area of >5 mm^2.

4.7.2.1 Purpose

1. This procedure defines measuring the voltage drop, of welded terminations under high energy conditions. It is to be used to validate terminal/wire combinations where the weld bond cross section is >5 mm^2.

2. The current through the specimen will be applied at a level per table 4.7.2. This current is applied to the sample under test so voltage drop of the weld bond can be measured. Power supply voltage will be allowed to float during this test.

NOTE: For multiple wire welds, high current evaluation, bundle the wire/cable and perform the mVD measurement on the cross sectional area of the total bundle. Test current level will be based on the total cross sectional area of all of the wire/cable in the weld.

4.7.2.2 Samples

1. At least 20 specimens (10 minimum and 10 maximum WBH) for each weld width group shall be tested.

NOTE: Minimum and maximum WBH is based on the optimal developed weld height and width for that specific wire/component combination, +/- one WBH tolerance. See Appendix C Weld bond height tolerance table.

2. These sample groups may also be used for the tensile test samples after the accelerated environmental exposure and voltage drop measurements are made.

3. Prepare 2 additional samples to be used to determine the deduct voltage drop as required in 4.7.2.4 steps 5~7. The welds on these “Deduct” specimens will be soldered and the voltage drop will be measured in the same manner as the sample groups under test. These “Deduct” specimens will be identical in length, wire type and terminal type to the other sample groups under test except the weld bond will be soldered. Use the average voltage drop measured on these 2 “Deduct” samples as the deduct value for this test.

4. A minimum specimen length of 150 mm is recommended however, any length >150 mm is acceptable as long as there is no effect on the weld bond during processing and handling of specimens. Longer wire length may be necessary if the specimens are powered in series for this test. It is important to use the same length for the deduct specimen as for those sample groups under test.

5. Prepare the voltage drop measurement points on the test specimens at a point on the cable 100 ± 3 mm from the rear edge of weld bond.

6. Apply solder to measuring point C, figure 4.7.2.4 (center strip or stripped end of wire) to obtain consistent readings.

NOTE: The same set of samples shall be consecutively exposed to the T/S exposure and be measured using the voltage drop procedures described in this specification.

4.7.2.3 Equipment

1. DC Power supply (0~20V. (200A min recommended)) or 0~20 V current as required.

2. Digital Volt meter

3. Non contact thermometer

4.7.2.4 Procedure

1. Perform a visual inspection of components per paragraph 4.2.

2. Relative movement of samples should be minimized to reduce effects of movement on measured values. This is an open air bench test. In an effort to maintain repeatability, care should be taken to avoid drafts from HVAC, open windows, etc.

3. Apply current (based on wire size) per table 4.7.2 at points A and D

4. Allow the temperature of sample(s) to stabilize (with current applied) as follows:

   Use a thermocouple or non contact thermometer to measure the temperature of the weld bond under test. The temperature is stable when the weld on the sample under test changes less than 2°C in 5 minutes.

NOTE: Applying the current load in series to all samples under test is recommended to reduce hook up variation and requires only one stabilization interval.

5. Measure and record the voltage drop of the samples with the soldered welds. The measurement is made at a point 100± 3 mm minimum from the rear edge of the weld bond. The average voltage drop value of these soldered samples will be used in step 7.

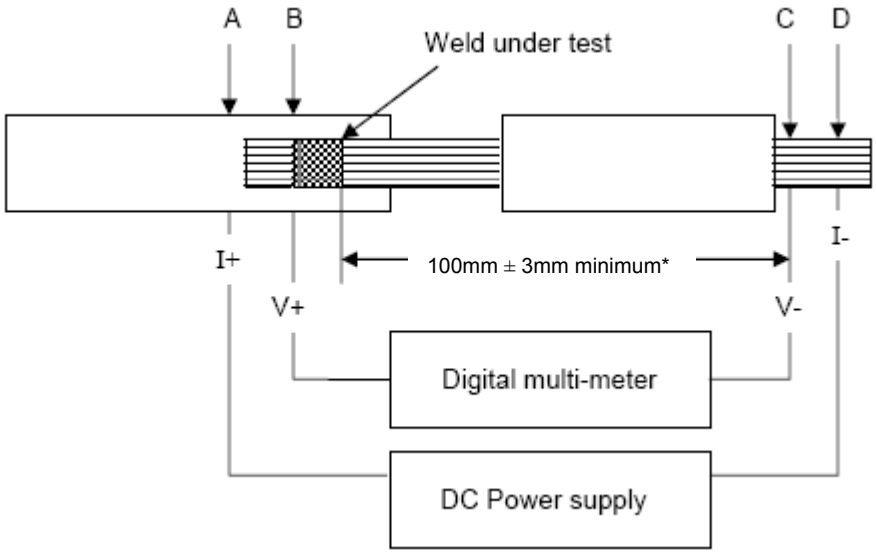
NOTE: Any measurement point >100mm is acceptable as long as the same length, ± 3mm is used for the deduct sample.

NOTE: If the specimens are connected and powered in series, include the soldered specimens with the sample group under test.

6. Measure and record the voltage drop on each specimen between the cable measuring point C and point B on the specimen, just in front of the weld. (See Figure 4.7.2.4)

7. Calculate and record the voltage drop as described above. The weld bond voltage drop is equal to the overall specimen voltage drop measured in step 6, minus the average voltage drop of the 2 soldered grip samples measured in step 5.

NOTE: Specimens may be connected in series and powered up all together as long as the “B” and “C” measurement points are accessible and do not interfere with measurement points on any other specimens wired in this series. Split bolts, eyelet terminals crimped the end of the specimen, or welds are acceptable methods for connecting 2 or more specimens in series for the purpose of applying current for voltage drop testing. Applying the test current in series to all samples at once will reduce set-up, measurement and environmental differences or set up errors.



* Any measurement point >100mm is acceptable as long as the same measurement length +/-3mm is used for the deduct sample.

Figure 4.7.2.4 Voltage drop power hook up and measurement points

4.7.2.5 Acceptance Criteria

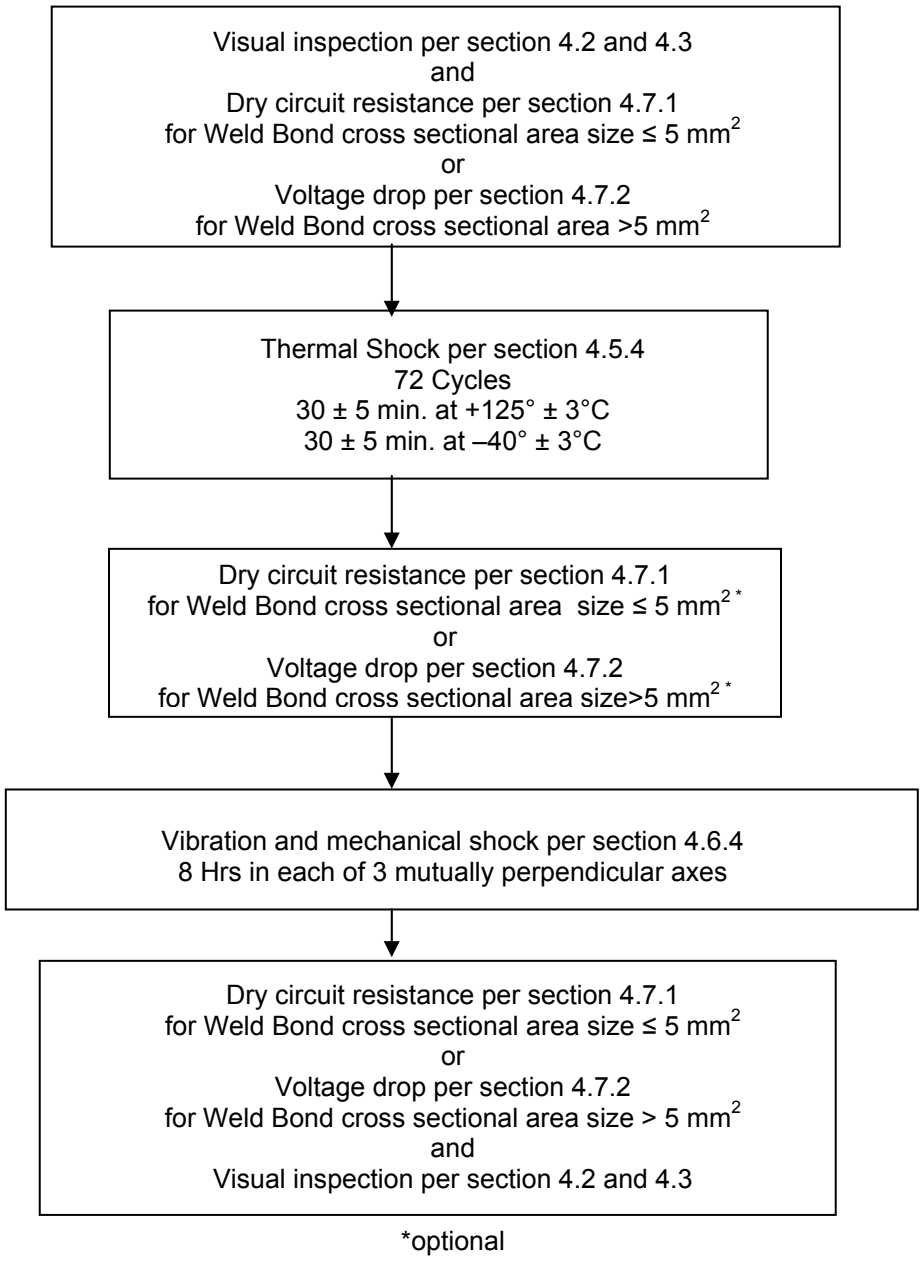
Maximum allowable Voltage Drop or Resistance shall be equal to or less than the values shown in table 4.7.2.

Weld Bond Cross Sectional area (mm^2)	Test Current	Maximum allowable mV Drop/A (mΩ)	Maximum Allowable mV Drop/A Change* (mΩ)
<.5	Use 4.7.1 Dry Circuit test method	1.0	.5
≤ 5	Use 4.7.1 Dry Circuit test method	.55	.33
>5 <13	5A per mm^2	0.15	0.09
≥13 <19	75A	0.11	0.07
≥19 <35	100A	0.08	0.05
≥35	100A	0.06	0.04

NOTE: 1mV/A = 1mΩ * Change from initial value

Table 4.7.2

Environmental conditioning sequence flow diagram



*optional

Figure 4.8 Accelerated Environmental and Vibration sequence [flow diagram]

NOTE: The purpose of taking the optional measurements after thermal shock is to identify failures and allow the test to be discontinued if failures are found.

5. VALIDATION REQUIREMENTS FOR WELDED WIRE/CABLE TERMINATION - SUMMARY

5.1 Validation Test Requirements

5.1.1 Purpose

The validation requirements listed in Table 5.1 shall be conducted to demonstrate the design and performance intent of the weld bond are met.

Test	Requirement Section or Paragraph Number	Design Validation (Yes/No)	Minimum Conformance to Tolerance
Weld Tooling and equipment identification traceable to Performance Testing	Appendix C	Y	100%
Wire/cable Weld Bond total cross sectional area after welding[1]	Appendix C	Y	100%
Appearance	4.2.5		
- end of conductor	4.2.5-2	Y	100%
- end of insulation	4.2.5-3	Y	100%
- insulation grip	4.2.5-5	Y	100%
- individual cable seal	4.2.5-7	Y	100%
Weld bond and insulation crimp geometry	Appendix C		
-WBH, WBW, WBL -ICH, ICW,	Appendix C	Y	100 %
- Cross -section requirements	4.3	Y	100%
Mechanical performance	4.4		
-Peel and Pull Force*	4.4.4	Y	Minimum value only
Electrical performance	4.7		
- For Power Applications: Use Accelerated Environmental Exposure (ENX) and Voltage drop test	4.5.4 and 4.6.4 4.7.2	Y	100%
- For Low Energy and Low Impedance Applications: Use Accelerated Environmental Exposure (ENX) and electrical dry circuit resistance test	4.5.4 and 4.6.4 4.7.1	Y	100%

* 4.4 may be performed after 4.7 when the same samples are used for both electrical and mechanical testing.
[1] The weld bond cross sectional area is the WBH X WBW. For other than rectangular welds, the weld bond cross sectional area shall be determined based on tooling geometry at a specific weld height.

Table 5.1 Tests to be used for validation

5.2 Special Applications and Exclusions

5.2.1 Special applications and variances from this specification require customer approval. Pull force testing and cross-sections [PTX] are required for all validations.

5.2.2 This specification is intended to validate only the welded wire termination performance.

5.3 Other Validation Methods

5.3.1 Reference [REF] - The application is the "same as" another similar application already validated to meet the customer requirements

5.3.2 “Same as" is defined as having the same:

– Material stock thickness
– Material alloy and temper
– The same surface finish
– The same terminal insulation grip wing dimensions and features [serrations, etc.]
– The same Wire/cable conductor core cross sectional area or construction.[1]
– The same insulation outside diameter

NOTE: SAE, ISO, DIN, and JIS wire types with the same size designation have different conductor core cross sectional area and must be validated as separate wire sizes.

5.3.3 Cables with the same conductor core construction, but differences in the insulation may be considered the “same” for welded bond termination validation purposes. The crimped Insulation grip must be reviewed against the cross section requirements for final validation.

[1] The “same as” wire construction is defined as the same stranding. Other stranding configurations must be tested on an individual basis.

APPENDIX A - DEFINITIONS

Authorized Person:

One person will be responsible as the final authority for releasing a given part for production and/or for testing that part. Such person may delegate authority for testing that part, or may retain the authority. The Authorized Person, as used in the Specification, is the person with authority for making the final decision as to any question arising during testing to this Specification or for any deviations from any requirement of this Specification. Such Authorized Person is responsible for documenting any deviation he/she authorizes from this Specification. This documentation must be included in the final test report.

The Authorized Person may be the customer responsible for specifying a part for use or, in the case of a “shelf item” part, the Authorized Person may be the supplier.

Cable:

An assembly made up of several strands of wire (the conductor) and its insulating covering manufactured to a specific configuration. See wire

Conductor:

A part of a cable which has the specific function of carrying electrical current.

Conductor Core Cross Sectional Area:

Strand count X the cross sectional area of each strand.

Crimping:

The process of using applicator tooling to bend insulation grip wings around the cable assembly to provide strain relief to the bond.

Design Validation:

Tests that are conducted to demonstrate that the design intent is met. Manufacturing must be aware of the weld design parameters and maintain them in production.

Grips:

(Syn.: Wings) Those parts of a terminal or component that are wrapped around the cable insulation layer providing good mechanical connection.

Insulation:

That part of a cable that electrically separates the conductor from the external environment.

Low Energy:

Applications which have an open circuit voltage of 5 volts or less. This definition is chosen to enable easy selection of the type of testing acceptable based on the electronic circuit application.

Low Impedance:

Applications that have very resistance-sensitive circuits.

Micrograph:

High magnification photography with sufficient resolution to clearly see all wire strands in the cross sectional evaluation process.

Power:

Applications that have an open circuit voltage greater than 5 volts. Typically these are lighting, resistance, motor, or relay circuits. Current levels may range from milli-amps to full cable rating.

Process Validation:

In-process tests, performed on production parts, which are used to demonstrate process capability and conformance to specification.

Special Applications:

Applications that fall outside the scope of this specification must have their requirements detailed in other appropriate specifications.

Sample Group:

An identically prepared group of specimens.

Specimen:

An individual part of a sample group

Strand:

One of the individual wires in a conductor.

Wings:

See “Grips”.

Wire:

Synonymous with cable and may also used to describe individual strands. See cable.

APPENDIX B - GLOSSARY OF TERMS

AIAG	Automotive Industry Action Group. Contact at AIAG, Box 77000, Detroit, Michigan 48277-0839. Phone (248) 358-3570.
DMM	Digital Multimeter
DVP&R	Design Verification Plan and Report
EWCAP	Electrical Wiring Component Applications Partnership. One of several consortia under USCAR,llc. Has the task of creating specifications for electrical components and interfaces.
ENX	Accelerated Environmental exposure.
FMEA	Failure Mode and Effects Analysis
FMVSS	Federal Motor Vehicle Safety Standard
IACS	International Annealed Copper Standard
ICH	Insulation Crimp Height
ICW	Insulation Crimp Width
mVD	Millivolt Drop.
MVSS	Motor Vehicle Safety Standard.
PEV	An abbreviation for “Previous Electrical Validation” (also implies calculation of resistance based upon test current and measured millivolt drop for Power applications.)
PPAP	Production Part Approval Process.
PTO	Pull Test Only
PTX	An abbreviation for “Pull Test and Cross Section.”
Rc	Resistance change
RH	Relative Humidity.
T/S	Thermal shock
USCAR,llc	United States Council for Automotive Research. A Limited Liability consortium of representatives from Ford, General Motors and Chrysler formed to promote joint research in non-competitive areas that can strengthen the US automotive industry. (www.uscar.org)
WBH	Weld bond height
WBL	Weld bond length
WBW	Weld bond width
WUT	Weld under test

APPENDIX C - WELD DEVELOPMENT AND GEOMETRY

1. Key components and variables in the development of a weld begin with gathering specific component, cable and tooling information including (but not necessarily limited to):

   - Cable construction (Number of strands, strand diameter, insulation thickness, etc)
   - Component Stock Thickness and configuration such as “U-up” or wall dimensions.
   - Component Base material Alloy and Temper
   - Component Insulation Grip Wing Length
   - Plating Type (cable or component) (Nickel, silver, etc)
   - Weld Dimensions (see 1.1.2)
   - Weld parameters (Energy, Pressure, Amplitude, Time, Energy)
   - Specific Ultrasonic tooling information (Tooling identification)

WARNING: Ultrasonic weld bond development is based on material condition of both the wire/cable and the component in the weld bond. The material must be clean and free from grease, dirt, chemicals, and corrosion. Tin plating on either the wire/cable or component in the weld bond is not suitable for ultrasonic welding.

2. The above parameters shall be uniquely controlled by specific test sample group identification numbers. This information shall be included in the test report.

3. The cross sectional area of the weld shall be measured. The appropriate weld dimensions are estimated by wire core compaction analysis. Generally, wire/cable core in the finished weld should have 100% +20/-5% of the cross sectional area of the un-welded wire core.

See Figure C 2 for WBH and WBW measurement location.

NOTE: The component cross sectional area is subtracted from the total weld bond cross sectional area to determine the wire/cable compaction in the weld bond.

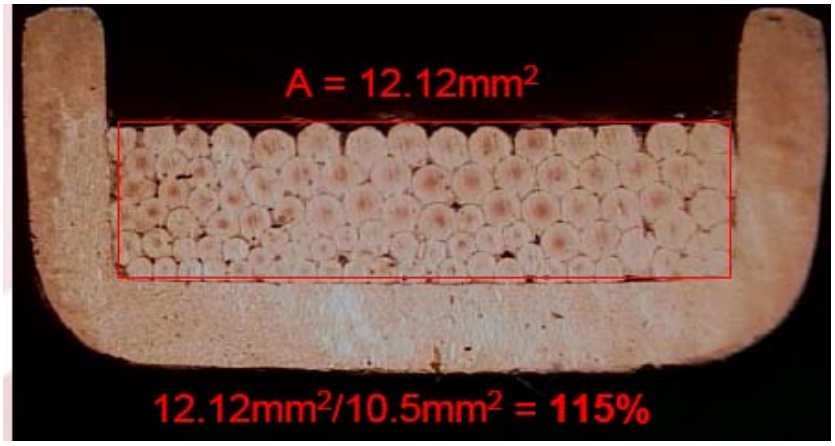
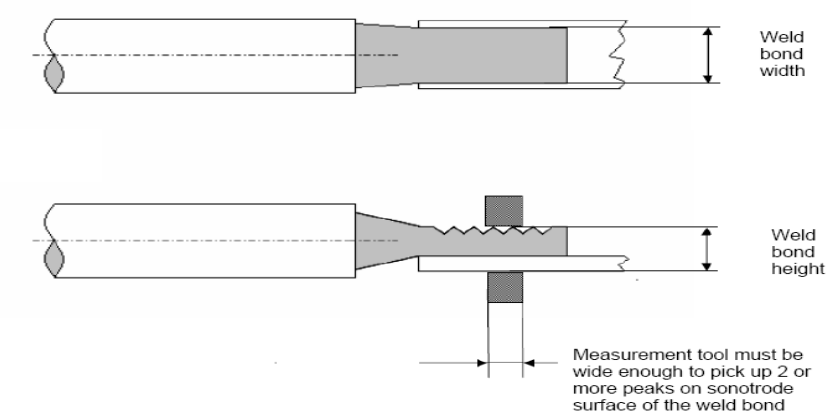


Figure C 1 Example cross sectional compaction analysis



NOTE: Measurement graphics courtesy of Lear Corporation

Figure C 2 WBW and WBH measurement location

4. This specification requires 2 WBH (minimum and maximum) for each nominal weld width group under test to pass electrical and mechanical tests.

NOTE: Minimum and maximum WBH is based on the optimal developed weld height and width for that specific wire/component combination, +/- one WBH tolerance.

See Table C, Weld bond height tolerance table.

Total cross sectional area of wire or cable in the weld bond under test	+/- tolerance
≤ 1mm2	0.05
> 1mm2 ≤ 5mm2	0.1
> 5mm ≤ 10mm2	0.15
> 10mm2	0.4

All dimensions in mm

Table C Weld Bond Height, tolerance

5. Weld quality is dependent on tool design, tool condition, and material condition as well as a amplitude, weld force and total weld energy. It is therefore important to recognize that the cross sectional area of the cable and component used in production is consistent with the area of the cable and component used in preparing samples for this test.

6. Insulation crimp height and width: (ICH, ICW)

   The insulation crimp height and width are based on the cable size (s) and terminal or component design. The insulation crimp dimensions are considered to be reference dimensions except when the crimped insulation grip affects fit and or function.

7. Strip length:

   The insulation strip length must be long enough to allow only metal to metal contact in the weld bond area and the insulation must be sufficient length to be captured by the insulation grip.

   If the application does not have an insulation grip feature the insulation shall be stripped to a length that allows sufficient metal to metal contact in the weld bond area to meet the tensile requirements, carry the intended specified current, and does not allow the wire core to interfere with other features in the application. Excess strip length must be avoided to prevent any unintended contact with the electrical conductor.

CAUTION: To insure all of the wires in a weld bond end at the same distance from the device or component feature such as the mounting hole in an eyelet, it may be necessary to use different insulation strip lengths in the same weld. These variable strip lengths may be necessary when multiple wires are welded in a common bond based on the wire position within the weld bond.

APPENDIX D - INFORMATIVE

Terminal part number	Supplier reference	Bolt or stud size	Wire/cable core cross sectional area range	Wire core bundle outside diameter range	Number of insulated wires
7009-1 835	Yazaki	M6	$5mm^2$~$17mm^2$		
7009-1836	Yazaki	M8			
7009-1731	Yazaki	M11			
7009-1833	Yazaki	M6			
100725-USW09	Lear	M6			
100731-USW09	Lear	M8	$5mm^2$~$20mm^2$	4~11mm	5~20
100745-XPL09	Lear	M11			
7009-1837	Yazaki	M6			
7009-1913	Yazaki	M6			
101925-SDF09	Lear	M6	$2.5mm^2$~$6.5mm^2$	4~7.5mm	5~15

APPENDIX E - REVISION RECORD

DATE	SECTION	SUMMARY OF CHANGES MADE	NOTES
Dec 2009		Initial release	