Performance Specification for Automotive Wire Harness Retainer Clips

SAE/USCAR-44
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PERFORMANCE SPECIFICATION FOR AUTOMOTIVE WIRE HARNESS RETAINER CLIPS

RATIONALE

Notice about interim revisions: Editorial updates or clarifications may be made as "interim revisions" if the EWCAP review team determines that a formal revision is not needed. Interim revisions are documented as "revision letters" and are available online on the USCAR website. The link is: http://ewcap.uscarteams.org/revisions.html.

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1. SCOPE

This specification describes a method and acceptance criteria for testing automotive wire harness retainer clips. Retainer clips are plastic parts that hold a wire harness or electrical connector in a specific position. Typical plastic retainers work by having a set of “branches” that can be inserted into a hole sized to be easy to install but provide acceptable retention. This specification tests retainer clips for mechanical retention when exposed to the mechanical and environmental stresses typically found in automotive applications over a 15-year service life. This specification has several test options to allow the test to match to the expected service conditions. The variability of applications typically arises a) from different ambient temperatures near the clip, different proximity to automotive fluids, different exposure to standing water or water spray and different thicknesses of the holes that the clip is inserted into. Clips are typically inserted into sheet or rolled metal from 0.6mm to 8mm thick so this specification focuses on that range. Outside of this range requires a custom test.

The procedures described in this document have been evaluated for the design types shown in Table 2.3. Use of USCAR-44 for other than a design shown in Table 2.3 may or may not produce acceptable test correlation to actual experience but USCAR has not reviewed any data. USCAR-44 can be used at all phases of development, production, and field analysis since it is a performance test and not a process validation or quality assessment.

No retainer may be represented as having met USCAR/EWCAP specifications unless conformance to all applicable requirements of this specification have been verified and documented. All required verification and documentation must be provided by the supplier of the part. If testing is performed by another source, it does not relieve the primary supplier of responsibility for documentation (DVP&R) of all test results and for verification that all samples tested met all applicable acceptance criteria.

2. TEST REQUIREMENTS

The tests in each section must be performed in the order given unless otherwise specified in the test request/order. Construction details for selected test fixtures and equipment are provided in this specification.

If the products tested to 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. 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 variance (with supporting data) to the equipment or procedures contained in this specification. Any such deviation must be documented and included in the final test report. Moisture content or all CUT must be documented in the final test report (unless agreed to be not recorded).

Apply the flow chart in Figure 2 to determine whether USCAR-44 is applicable to the CUT and what tests must be run.

DETERMINE BASIC APPLICABILITY

1) Determine the type of design the CUT represents per Table 2.3.

2) Determine if CUT is applicable for USCAR-44 testing and proceed only if applicable.

↓

EVALUATE TEMPERATURE CLASS

1) Determine the Component Temperature Class to be tested to per Table 2.4.

2) Determine the applicable testing sequence for the selected temperature class. (i.e. paths A, B, C, and F for all temp classes. Add E, G, and H as directed per Table 2.4.)

↓

IDENTIFY THICKNESS AND TOLERANCE OF OPENING IN MATING PANEL

1) Determine from drawing or test requester whether the dimensional tolerance of mating hole opening >0.6mm. Add test path "D" if the tolerance range exceeds 0.6mm.

2) Determine what thickness of mating hole the part is to be vaidated for. Arrange for test panels to be made in the applicable thickness for that validation. Ref. Table 5.3.2.

↓

EVALUATE SEALING CLASS

1) Look-up the intended Water Sealing Class as provided by test requester in Table 2.5.

2) Schedule testing applicable to that sealing class. (i.e. perform no additional testing for class S1, add test path J for class S2 and add test path K in additon for class S3).

↓

EVALUATE APPLICABLE EQUIVALENCE APPROVALS

1) Determine if any tests have been run on parts of identical design and material. (Ref. 2.6).

2) Exclude testing for test paths B, C, D, E, G, and H where identical parts have successfully passed USCAR-44.

↓

DETERMINE TEST REQUIREMENTS

1) Compile the list of test paths needed

2) Determine test sample requirements based on sample size requirements per Table 2.1.

FIGURE 2 - FLOW CHART FOR DETERMINING TESTS TO BE RUN

2.1 Test Schedule

TABLE 2.1 - TEST SCHEDULE

	First Insertion	1st and 2nd Removal	Insertion in min. hole	Retention in max. hole	Retention at high temp.	Shear Force Tolerance	Retention at end-of-life	Fluid Resistance	Sealing (Static)	Sealing (Spray)	Tie Strap Strength	Offset deflection
Test Sequence ID (Sample Size min.) [d]	**A** 30	**B** 30	**C** 30	**D** 30	**E** 12	**F** 30	**G** 12	**H** 2	**J** 15[c]	**K** 10[g]	**L** 60[f,i]	**M** 20[f]
General (Ref. Section 5.1)	1	1	1	1	1	1	1	1	1	1	1	1
Visual Inspection (Ref. 5.2)	2	2[h]	2	2	2	2	2	2, 4	2, 4	2, 5	2, 5	2, 5
Condition to dry-as-molded (Ref 5.3.3)	3											
Humidity Conditioning (Ref. 5.3.3)		3	3	3		3				3	3	3
Clip Insertion Force (Ref. 5.3.3 A)	4	4,6	4[a]	4	3		3[j]					
Clip Removal Force (Ref. 5.3.3 B)		5,7		5[b]	4[e]		6					
Shear Force (Ref. 5.4)						4						
Temperature / Humidity (Ref. 5.5)							4					
High Temperature Exposure (Ref. 5.6)							5					
Automotive Fluids Exposure (Ref. 5.7)								3				
Sealing - Static (Ref. 5.8)									3			
Sealing - High Pressure Spray (Ref. 5.9)										4		
Loop tensile strength (Ref. 5.10)											4	
Offset / standoff load test (Ref. 5.11)												4

NOTES:

[a] Make test plate using smallest allowed hole size per the supplied interface drawing.
[b] Required only if overall mating hole tolerance >0.6mm. Test plate to have largest allowed hole tolerance.
[c] 15 piece total sample size ample size: 5 pieces for each axis. Use new sample for each of x, y, and z axis testing.
[d] Minimum sample size is 30 pieces or one piece per tool cavity (whichever is larger) unless noted differently. Include one additional sample for long-term retention per section 5.2.1.
[e] Testing for retention to be performed while CUT is in an oven at 80^{o}C (see 5.6.2). Special equipment is required.
[f] The need for this test is design-dependent. Perform this test only when directed.
[g] 10 piece sample represents 5 pieces loaded in spray direction and 5 pieces loaded opposite spray direction.
[h] Do not perform a final inspection on parts that have been removed; damage is expected after removal.
[i] If UL 62275 has been run, omit section 5.10.3.1. Sample size is reduced to 30 for test 5.10.3.2.
[j] Hand insertion of CUT is allowed with no measurement taken since intent of test is unrelated to insertion.

The sequence of USCAR-44 tests is shown in Table 2.1. To be USCAR-44 compliant, the CUT must meet all applicable test requirements at the level appropriate for the intended use. The intended use must be listed in the test request by specifying application levels per Tables 2.4 and 2.5. The numbers in the matrix of Table 2.1 represent the order the tests run in the test sequence.

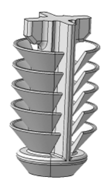
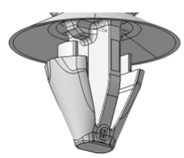
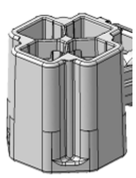
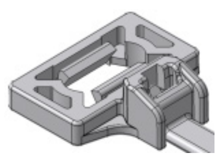
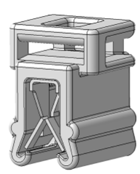
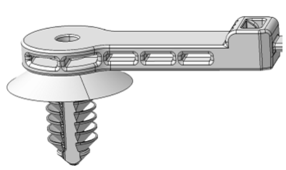
2.2 Test Paths: Required and Optional

The far right column of Tables 2.4 and 2.5 show what test paths must be performed or applied to be validated for that listed temperature, sealing class, or re-use level.

2.3 Applicability to design variants

USCAR-44 is written and illustrated for the “fir tree” design type. Table 2.3 describes how to apply USCAR-44 to designs other than fir trees.

TABLE 2.3 - APPLICABILITY TO TESTS TO VARIOUS RETAINER DESIGNS

Design Type	Typical Part Illustration	How USCAR-44 is applied differently to this class	Test changes required in for this part class
Fir Tree		No difference	Test paths L applicable only for designs with cable tie. Path M applicable to offset parts only.
Arrowhead		No difference	Test plate must match application thickness.
Stud-mount	 	No difference	Custom test plan needed. Recommendations are: delete Path F, test and use exact thread intended for production.
Edge-biter Clip (attaches to an edge, not a hole)		USCAR-44 cannot be used as-written but can be the basis of custom tests developed using engineering assessment.	Custom test plan needed. Recommendation is that test panel should match actual vehicle design.
Retainer with integral wire tie strap		Optional test to evaluate cable tie strength. Can also be certified separately using UL62275.	Add Test Path L as requested.
Retainer with offset between and wire bundle		Test Path M is applicable only to offset parts.	Add Test Path M only if requested and criteria for acceptance provided.

2.4 Temperature Classifications

Components to be tested must be assigned a temperature class from the table below according to the environment in the intended vehicle application. Use the class with a temperature at or above the ambient range.

TABLE 2.4 - COMPONENT TEMPERATURE CLASSES

Temperature Class	Temperature Range	Typical Application	Typical Materials in Class[2]	Test Paths per Table 2.1
T1	-40° C to + 85° C	Cabin (lower than IP), trunk, doors	POM, PA66	A B C F
T2	-40° C to +100° C	IP top, headliner	POM, PBT, PA66	A B C F
T3	-40° C to +125° C	Engine compartment	POM, PBT, PA66	A B C E F G H
T4[1]	-40° C to +150° C	Hotter on-engine applications	PA46, Flex PPS	A B C E F G H
T5[1]	-40° C to +175° C	Special high-temp applications	Flex PPS	A B C E F G H

[1] T4 and T5 test sequences are identical except for the oven temperature in Section 5.6 (where the setting equals the highest temperature of the target temperature class).
[2] Listing of “Typical Materials for this class” is for reference only and is not a product endorsement.

2.5 Water Sealing Classifications

Components to be tested must be assigned a class from the table below according to the expected environment in the intended vehicle application.

TABLE 2.5 - COMPONENT SEALING CLASSES

Seal Class	Description of Class	Typical Application	Test Paths Required per Table 2.1
S1	Unsealed	S1 is applicable for use in passenger compartment and dry vehicle areas.	No additional testing required
S2	Sealed - Static	S2 applicable for applications exposed to vehicle exterior.	J
S3	Sealed - High Pressure Spray	S3 is applicable for locations at-risk to direct water spray.	J K

2.6 Validation by Equivalence

If a part is identical to the CUT in retainer design and material (where CUT differs only in the design features unrelated to the retainer section), a “validation by equivalence” is allowed for some tests that eliminates some testing.

Instructions for equivalent parts: Exclude testing for test paths B, C, D, E, G, and H if identical parts have successfully passed that section of USCAR-44. Note that test path A is always required.

2.7 Specification of Test Level

To specify testing per USCAR-44, it is recommended to use the following wording be used to give a consistent format. “Test to USCAR-44 (revision number, if applicable) per Temperature class Tx, Sealing class Sy, and thickness range t1~t2” (where x is the desired temperature class per 2.4, y is the desired sealing class per 2.5) and t1 and t2 are the minimum and maximum thicknesses for a specific range per Table 5.3.2.

2.8 Test Plan Approval

The test request shall identify the tests to be performed, including any additional non-USCAR tests. Any revisions or deviations from tests in USCAR-44 must be noted. The customer has the final decision on whether to accept a test result for production part validation. Typically approval is awarded by passing testing on parts made from a prototype mold providing the mold has the same dimensions and material as the production part mold. Also, it is typical that passing all testing using steel test plates typically allows validation for use in both steel and aluminum applications.

2.9 Test Request Instructions

Instructions must be included in the test request/order concerning applicable tests and the order in which the tests are to be performed if different than outlined by this specification in Table 2.1. Note that test paths L and M must be specifically called out if desired since they are not referenced in any mandatory test path.

2.10 Unique Requirements

If user requirements are different than what is described in this specification, instructions must be given in the test request for what changes are needed, including definition of the conditions under which those limits apply.

3. REFERENCED DOCUMENTS

3.1 Documents Required to Perform Tests

- Engineering drawing for CUT (containing required information per Section 3.3)

3.2 Documents Helpful to Perform Tests

- USCAR / EWCAP-007 Connector Clip Mating Hole. Available online at: http://www.uscar.org/guest/teams/10/Electrical-Wiring-Component-Applications-Partnership (select the “Clip Slot bases and sheet-metal” section in the middle column).

- SAE/USCAR-2: Performance Specification for Automotive Electrical Connectors. Section 5.4.5 (Miscellaneous Component Engage/Disengage Force). USCAR-2 includes a specification for connector clip slot testing. This specification can be purchased at: http://standards.sae.org/uscar2-6/

- SAE/USCAR-25: Electrical Connector Assembly Ergonomic Design Criteria. Current version can be purchased at: http://standards.sae.org/uscar25-3/

- AIAG: Measurement Systems Analysis (Product Code: MSA-4) http://www.aiag.org/store/publications/details?ProductCode=MSA-4

- ISO TS16949: Automotive Quality Management Standard http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=52844

- UL 62275 – Cable Tie Test Specification. This specification may be required by customer for retainers integrated with a cable tie in addition to USCAR-44. UL 62275 can be purchased at www.ul.com.

3.3 Part Details

A part drawing or other specification describing the CUT must contain or reference the following to allow USCAR-44 testing to be properly specified. :

- Dimensional requirements of the mating hole (preferably per a EWCAP-007 reference) including thickness. Note that USCAR-44 tests use nominal, minimum, and sometimes maximum tolerance for hole dimensions so tests cannot be run without having a fully-toleranced drawing describing the target sheet metal interface.

- Temperature and Water Sealing class for which the part is intended.

4. GENERAL REQUIREMENTS

4.1 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 TS16949 and AIAG policies and practices.

4.2 Sample Documentation

All test samples shall be identified in accordance with the requirements of ISO TS16949 and the AIAG PPAP. When documenting about specific parts of the CUT, use the names in Figure 4.2 to avoid confusion about what is being described.

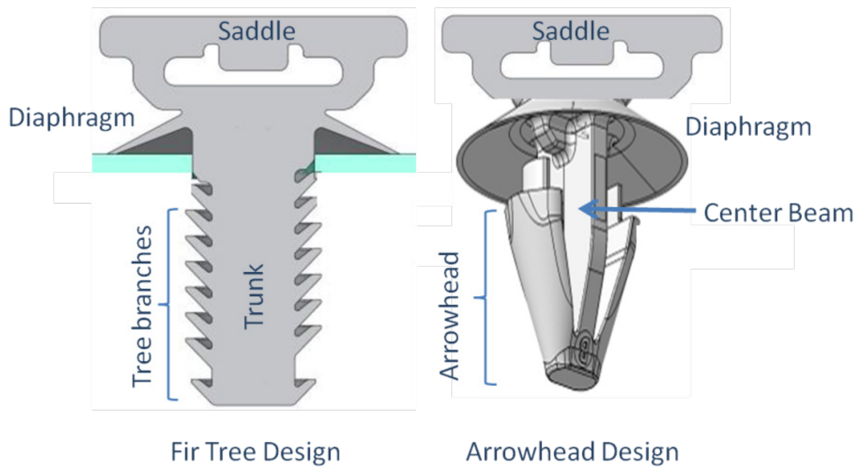


FIGURE 4.2 - NAMES FOR PARTS OF FIR-TREE AND ARROWHEAD CLIP TYPES

4.3 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.

4.4 Default Test Parameters

4.4.1 Default Tolerances

Default Tolerances, expressed as a percentage of the nominal value, are shown in Table 4.4.1.

TABLE 4.4.1 - DEFAULT TOLERANCES

ATTRIBUTE AND TOLERANCE	ATTRIBUTE AND TOLERANCE	ATTRIBUTE AND TOLERANCE
Temperature = ± 3 °C Voltage = ± 5% Current = ± 5% Resistance = ± 5% Length = ± 5%	Time = ± 5% Force = ± 5% Frequency = ± 5% Flow Rate = ± 5% Relative Humidity = ± 5%	Sound = ± 5% Speed = ± 5% Pressure = ± 5% Vacuum = ± 5%

4.4.2 Default Test Conditions

When specific test conditions are not given elsewhere in this specification, the following conditions apply:

Room Temperature = 23 ± 5° C
Relative Humidity = 50%. (RH applies to extraction testing test and samples. RH is uncontrolled for other tests)

4.5 Equipment Requirements

Neither this list nor the list in each test section is all-inclusive. It is meant to highlight specialized equipment or devices with particular accuracy requirements.

TABLE 4.5 - EQUIPMENT

ITEM	DESCRIPTION	REQUIREMENTS
1.	Insertion/retention force tester capable of 25mm/min with heated sample chamber	1% accuracy of reading and capable of collecting force-displacement data @3K/s sampling rate. Capable of maintaining sample at 80C.
2.	Temperature chamber	1) -40°C to +175°C or as required by Temperature Class 2) 0% to 95% RH (at 85C)
3.	Static leak test equipment	Custom water column and plate. See Section 5.8
4.	High pressure spray equipment	Custom fixture and spray head. See Section 5.9

4.6 Measurement Resolution

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.

4.7 Test Repeatability & Calibration

All equipment used for test sample evaluation shall be calibrated and maintained according to the applicable standards and requirements set forth by ISO TS16949 and the AIAG publication Measurement Systems Analysis Reference Manual. Copies of this Manual can be obtained from the AIAG. Documentation is to be recorded and retained in accordance with Section 4.1 of this specification.

4.8 Conformance Determination

Conformance shall be determined by the specified requirements of the test being conducted. All samples must satisfy the requirements regardless of sample age, test cycles, or test temperature.

4.9 Disposition of Samples

Should a premature non-conformance occur during a test, contact the Authorized Person to determine if the test is to be continued to gain additional product experience or if testing is to be suspended or terminated. When contact cannot be immediately made, the type of test shall determine the disposition of the samples. If the test order is for sample approval or validation, stop the test until the requested person is contacted. If the test must be stopped or terminated for any other reason (safety, equipment failure, etc.) the Authorized Person must be contacted for concurrence before the test is restarted. The test request/order should specify sample disposition at the conclusion of the testing.

4.10 Part Endurance

Successful completion of the requirements of this specification is intended to demonstrate that the design and construction of the components tested are capable of operating in their intended vehicle environment and application for 200,000 miles.

5. TEST PROCEDURES AND ACCEPTANCE REQUIREMENTS

5.1 General Component Requirements

The tests detailed in this specification are not expected to stress any part beyond its anticipated application limit, except where tests to failure are specified. Should any conflicts or questions arise concerning procedures and/or requirements, contact the Authorized Person for direction and note in the test report any individualized interpretations of these requirements that were made.

5.1.1 Dimensional Characteristics

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

5.1.2 Material Characteristics

Parts are intended to be tested in their "as furnished for vehicle assembly" condition. However, any part can be submitted for testing.

5.2 Visual Inspection

5.2.1 Purpose

This test is used to document the physical appearance of test samples. Examinations in most cases can be accomplished by a person with normal or corrected vision, and normal color sensitivity, under typical lab lighting. Photographs 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.

5.2.2 Equipment

- ⇨ Camera
- ⇨ Video recorder
- ⇨ Magnification apparatus (as required)

5.2.3 Procedure

1. Inspect for defects, lack of function, and obvious non-conformance to product drawing by visually examining each test specimen prior to testing and/or conditioning. Note in detail any manufacturing or material defects such as cracks, incomplete fill, flash, etc. Take pictures and/or video of representative samples to be tested. Keep a properly labeled control sample.

2. After testing and/or conditioning, re-examine each test sample and note any observable changes, such as swelling, corrosion, discoloration, contact plating wear, physical distortions, cracks, loss of mechanical function evident, etc.

3. Compare the tested and/or conditioned samples to the control samples, the videos, and/or the photographs. Record any differences in the test report.

5.2.4 Acceptance Criteria

CUT must not show evidence of deterioration, cracks, deformities, etc. that could affect its functionality. Additional procedure-specific criteria may be listed in each test. Note that no inspection is performed after extraction testing (5.3.3) since mechanical damage is expected and intended in the fir “branches” after extraction.

5.3 Insertion and Removal Force

5.3.1 Purpose

Insertion and removal forces are measured to determine whether a CUT is easily inserted and sufficiently retained. This test is designed so that a successful validation in a single test panel thickness validates the CUT for a range of panel thicknesses. Table 5.3.2 shows the applicable thickness ranges. (Note that thickness ranges apply to fir tree designs only; other designs, notably arrowhead designs are sensitive to test panel thickness). The test requester may request use of a specific test panel thicknesses in addition to testing called-out in USCAR-44.

5.3.2 Equipment

1. Crosshead-style tensile and compression force tester capable of crosshead movement at 25 mm/min. Data recording equipment must be available with peak force identification or (preferably) force-displacement graphing capability.

2. Test panels matching the intended allowable mating openings as described in the supplied part drawing. Refer to Figure 5.3.2 that shows a typical generic test panel drawing. Drawing must indicate the hole shape, nominal hole size, and tolerance. Test requests not having this information cannot be tested. Note that any shape hole is allowed using this method. An oval hole is shown only as an example. Holes in test plates for force testing must not be painted. Determine the thickness range to be validated and select the correct thickness per Table 5.3.2.

TABLE 5.3.2 - TEST PANEL VALIDATION RANGE FOR FIR TREE DESIGNS

ITEM	FOR VALIDATION IN THIS RANGE	USE TEST PLATE THICKNESS OF:	APPLICABILITY NOTES	COMMENTS
1.	0.6mm ~ 1.8mm[1]	1.8mm ±0.025	CUT must be inserted in same direction as the stamping punch[3,4]	Recommended testing for all CUTs; 1.8mm is the most common test panel.
2.	0.6mm ~ 4.0mm	4.0mm ±0.025	Applicable when inserted into thick metal such as truck frames[3,4]	Use when retainer will be inserted into thick stock material.
3.	4.0mm ~ 6.0mm	6.0mm ±0.025	Recommended only when specific customer request is made[3,4]	Uncommon (use if directed).
4.	6.0mm ~ 8.0mm	8.0mm ±0.025	Recommended only when specific customer request is made[3]	Uncommon (use if directed).
5.	Threaded holes ≥12.7mm deep	Threaded hole 12.7mm depth	Applies to threaded holes[2,4]	Each thread must be separately validated.
6.	Threaded studs	Test plate must match nominal interface per part drawing	Applies to threaded studs[2,4]	Use stud with minimum thread engagement length listed on part drawing for extraction test.

Notes for Table 5.3.2:

[1] Panels < 1.8mm are not recommended due to risk of damage in extraction test. No testing in damaged panels is allowed.

[2] Only exact thread used in test is validated; each thread configuration must be tested separately. Refer to EWCAP-007 for industry-standard thread designs.

[3] Insertion in the direction opposite of the stamping punch is not validated using the standard test plate. A production-intent panel is required.

[4] Customer must furnish an applicable test panel if CUT is to be used in a non-typical application or location.

NOTE: Only the manufacturing <u>tolerances</u> of the test plate are defined in this figure. Nominal dimensions of the test plate opening come from the test plate drawing or customer input.

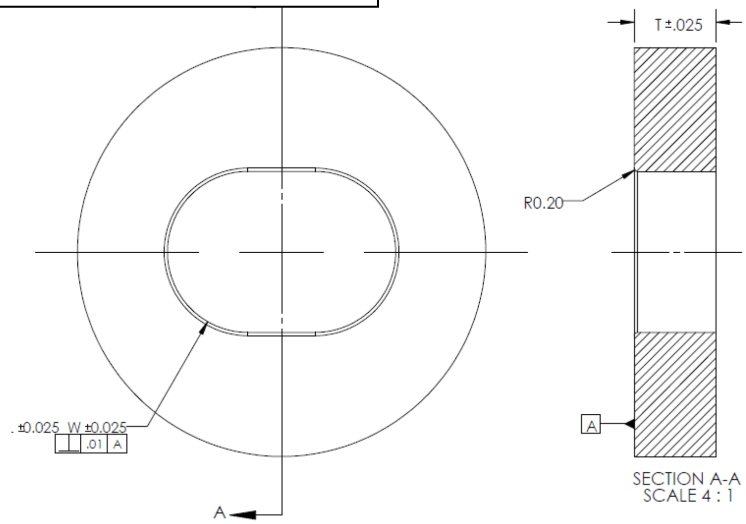


FIGURE 5.3.2 - SAMPLE TEST PANEL SHOWING REQUIRED TEST PLATE TOLERANCES (IN MM)

5.3.3 Procedure

CONDITIONING

When “Dry-as-molded Conditioning” is specified in Test Sequence (Table 2.1), condition all test specimens by placing samples in a sealed bag within 5 minutes of being molded and performing test within 48 hours. This will produce a part with under 0.5% moisture.

When “Humidity Conditioning” is specified in the test sequence in Table 2.1, condition all test specimens for a minimum of 48 hours at 23C and 50%RH. Since lab ambient is required to be 50%RH +/- 5%, humidity conditioning simply means the CUT must be in the lab for 48 hours prior to testing. This conditioning assures unusually dry parts are not used. (Humidity-conditioned parts are required since dry parts artificially increase retention values).

5.3.3.A INSERTION FORCE

1. Number each component to be tested.

2. Secure the applicable test fixture for the component to be tested and the test being run (i.e. min diameter and nominal hole size). Secure fixture so proper alignment is maintained during test. (Straight-in engagement and extraction is critical to avoid side loads and binding which can affect force measurements.) Confirm per Figure 5.3.2 that the correct test fixture thickness is used. Refer to Figure 5.3.3.A for an illustration of the alignment required. Assure that the test panel side with the radius is facing the CUT.

3. Grip the part above the diaphragm (defined in Figure 4.2), if present. If a diaphragm does not exist on the part, grip the part above fir tree branches. Assure alignment is over and perpendicular to the test plate hole. Insert each CUT fully into its applicable fixture as specified by Table 2.1 at a rate of 25 mm/min. Leave CUT in the fixture for Test Paths B and C. (Note: test speed of 25mm/min. was selected to be consistent with non-automotive test procedures for retainer clips such as the UL specs.).

4. Record the peak force required to completely seat the CUT in the fixture. For example using Figure 5.3.3.A, contact diaphragm and stop; do not create a “bottomed out” condition. Calculate mean, standard deviation, and mean minus 3s values. The (mean – 3s) value will be used to verify conformance to the Acceptance Criteria of Section 5.3.4.

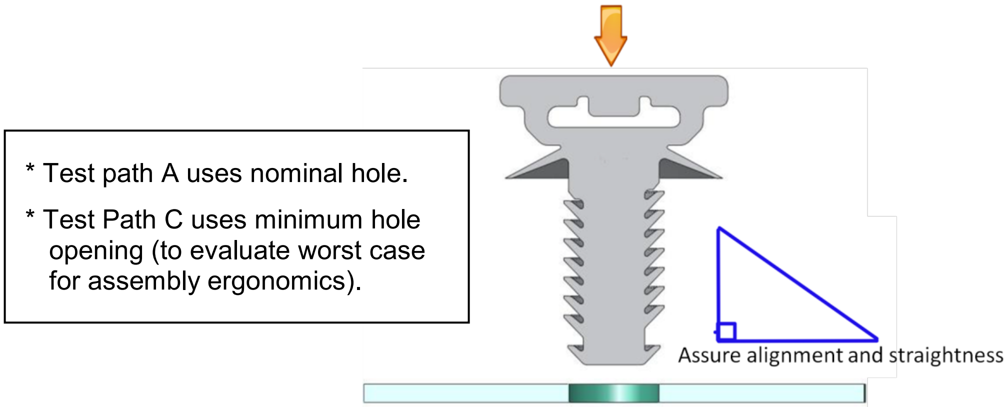


FIGURE 5.3.3.A - TEST SET-UP BEFORE PUSH IN

5.3.3.B REMOVAL FORCE

*** CAUTION *** the following step may result in sample breakage. Adequate shielding and personnel safeguards must be employed to ensure the safety of persons and property in the vicinity of the test.

1. Insert CUT into test fixture by hand or machine (as preferred in lab) if there is no step in Table 2.1 to machine-insert per Step 5.3.3.A.
2. If testing per Test path E (retention with part at 80C using nominal hole), place CUT that has already been inserted in the test plate in an oven at 80°C until temperature is stable. (Skip this step if not performing Test Path E.)
3. Remove the CUT from the test plate by pulling with force tester at a rate of 25mm/min. Continue until the CUT is removed from the test fixture. Refer to Figure 5.3.3.B.
4. Record the peak force to disengage the component from its fixture. For sample sizes of 30 or larger, calculate mean, standard deviation (“s”), and lower or upper 3 sigma values (mean ± 3s). These calculated values will be used to determine conformance per the Acceptance Criteria of Section 5.3.4.
5. Record Failure Mode (e.g. Branch Deflection, Trunk Fracture, Saddle Fracture) refer to definitions in Appendix A.
6. Follow Table 2.1 to determine the next step (either to stop or perform additional insertion and removal cycles.

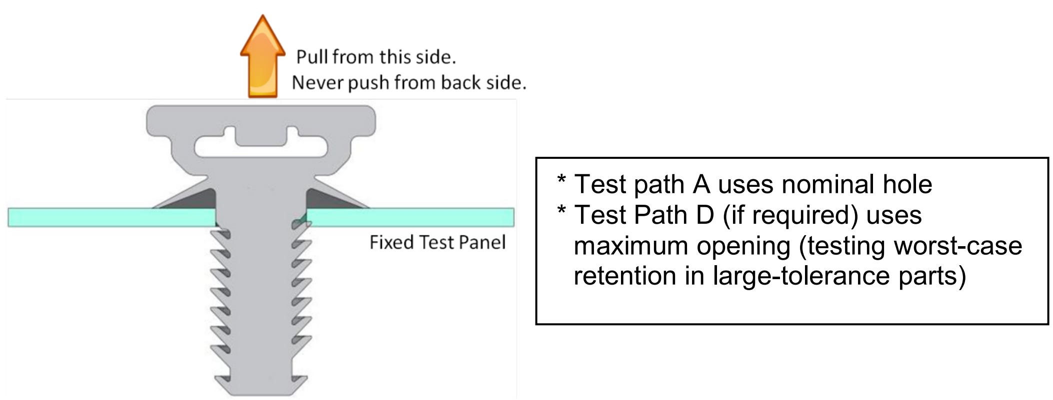


FIGURE 5.3.3.B - TEST SET-UP AFTER STEP 5.3.3B #2 (BEFORE PULL OUT)

5.3.4 Acceptance Criteria

The limits shown in Table 5.3.4 shall be met for the tests performed. A successful validation in a steel test plate provides validation for both steel and aluminum applications.

TABLE 5.3.4 - INSERTION AND REMOVAL FORCE CRITERIA

Criteria #	Test Sequence and Test panel dimension used	Hole size in test plate	Applicable Test Path	Force criterion (N)	
				Insert	Remove
1	1st Insertion	Nominal hole	Test Path "A"	45 max.[1]	Not performed
2	1st Removal	Nominal hole	Test Path "B"	No requirement	110 min.[1]
3	2nd Removal	Nominal hole	Test Path B"	No requirement	Report only
4	1st Insertion	At tolerance limit for smallest hole	Test Path "C"	45 max[2]	Not performed
5	1st removal	At tolerance limit for largest hole	Test Path "D"	No requirement	110 min.[2]
6	1st removal (with part at 80°C)	Nominal hole	Test Path "E"	No requirement	75 min.[2]
7	1st removal (after endurance cycle)	Nominal hole	Test Path "G"	No requirement	77 min.[2, 3]

[1]Tests with 30 or more samples, apply criteria to calculated value of (X-3s) for max. values and (X+3s) for min. values.

[2] For tests with fewer than 30 samples, all CUTs must meet value shown.

[3] Criteria for post-environmental extraction is reduced 30% from the specification for unaged parts. The 77N in line 7 above is calculated as = 70% X 110N = 77N.

5.4 Shear Force Test

5.4.1 Purpose

This test evaluates the ability of the clip to withstand side loads expected in service.

5.4.2 Equipment

1. Tensile tester (typically same as used for insertion force testing)
2. Solid mandrel of applicable diameter to CUT as shown in Figure 5.4.3A for simple cable tie designs (refer to UL 62275 for guidance on which diameter of mandrel to use).
3. Pushing probe to localize applied force as shown in Figure 5.4.3.B.
4. Test plate with applicable thickness and nominal hole (opening) size.

5.4.3 Procedure

1. Determine whether CUT has a simple cable tie attachment or "other" configuration using Figures 5.4.3.A and 5.4.3.B as a reference. The test method will be different in step 3 based on the design type.

2. Insert the CUT in the nominal test plate (acceptable by hand or machine).

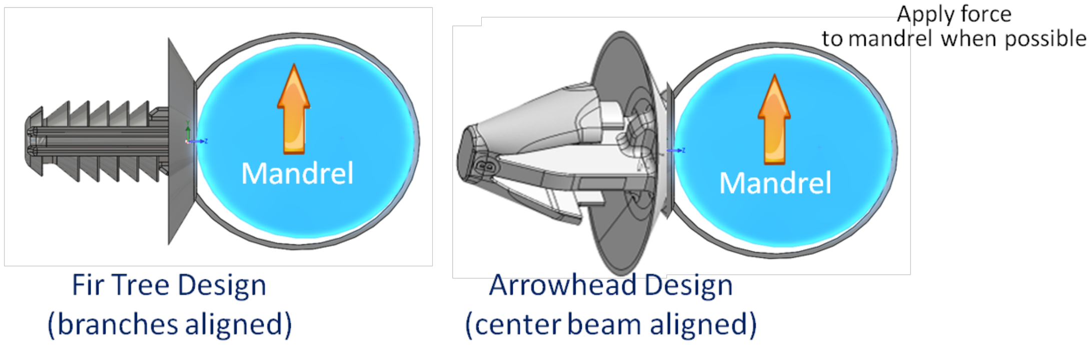


FIGURE 5.4.3.A - SHEAR STRENGTH TEST SET-UP FOR SIMPLE CABLE TIES USING MANDREL

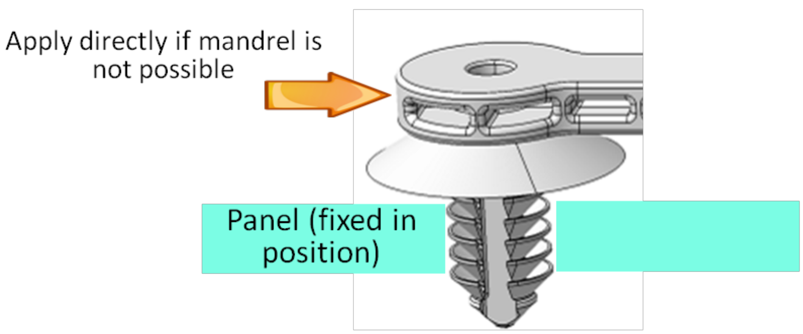


FIGURE 5.4.3.B - SHEAR STRENGTH TEST SET-UP FOR CONFIGURATIONS WITHOUT MANDREL

NOTE: Test requester may request this test to be run with the force applied at different positions and/or using a pull instead of push force. Note any special test configurations used like these in the report. If no special instructions are given, apply force in step 3A or 3B with fir tree branches aligned or center beam aligned (whichever is applicable per design of CUT) as illustrated in Figure 5.3.4.A.

3. A) For simple cable tie designs: Insert mandrel and tighten to the cable tie. Refer to Figure 5.4.3A. Apply a side load force to CUT as shown by the arrow in Figure 5.4.3A. This location simulates a side load being created from a wire bundle being pulled perpendicular to mounting plate. Pull at 25 mm/minute until part fails.

   B) For “other” designs where the mandrel is not able to apply a shear force: Apply a side load force to each CUT as shown by the arrow in Figure 5.4.3.B. This location simulates a side load being applied in the worst case for the given configuration. Pull at 25 mm/minute until part fails.

4. Record

   a) Whether 110N force was reached prior to failure. If CUT failed prior to 110N, identify any unique conditions and mode of failure.

   b) The maximum force measured at any point in the test.

5.4.4 Acceptance Criteria

1. CUT must withstand 110N applied side load force. Exception: For designs where the strength of the integral strap is less than 110N (such as the T18 tie strap), CUT must withstand applied side load equal to the strap strength.

2. Components shall not be displaced from the test plate during the test while force is equal to or under 110N.

5.5 Cyclic Temperature/Humidity

5.5.1 Purpose

This step conditions the CUT to simulate actual operating conditions using temperature and humidity as accelerated aging methods. This is only conditioning and is not a test. Therefore, this section has no criteria. Note that other aging conditions can be added, as applicable to the conditions the CUT will experience. These should be performed in addition to the USCAR-44 procedure below and documented in the test report.

5.5.2 Equipment

1. Temperature/Humidity Chamber capable of relative humidity between 0% ~ 95% and temperature from -40^{o} C ~ T_{max} (where T_{max} is the maximum temperature of the Temperature Class selected by the test requester from Table 2.4).

2. Stainless mounting plate. (A stainless steel test panel is preferred to avoid corrosion.)

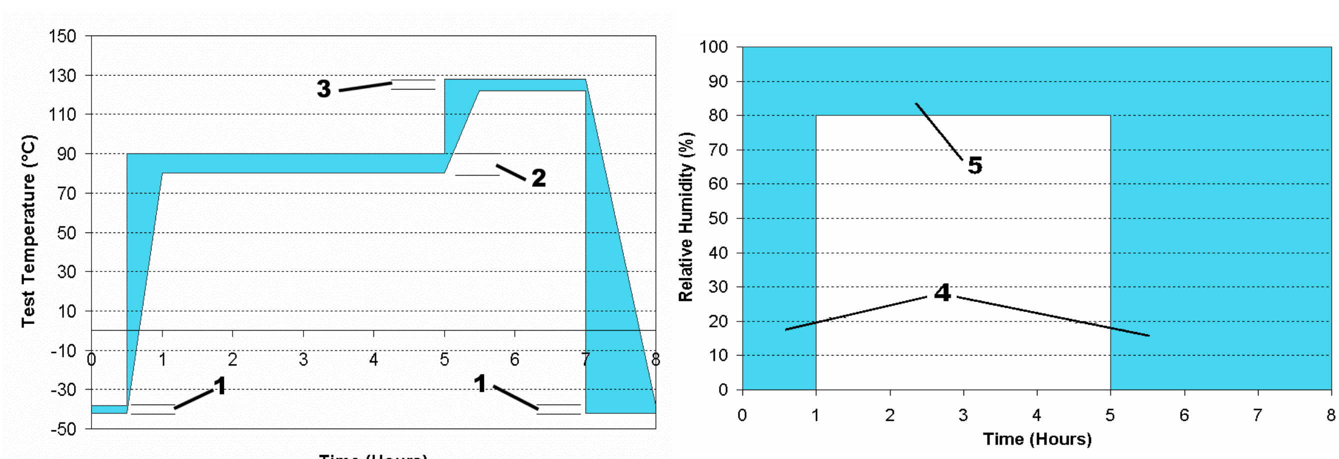
5.5.3 Procedure

1. Place the samples (mounted in test panels) in the chamber so that there is no obstruction to air flow across and around the samples and the samples are not touching each other.

2. Using the Temperature Class selected for the intended application of the CUT (from the choices given in Table 2.4), set the chamber's T_{max} to the maximum temperature applicable to that class. Allow the chamber to stabilize before proceeding. Refer to item 3 in Figure 5.5.3.

3. Expose the test samples to 40 cycles of the environmental schedule shown in Figure 5.5.3. The blue-shaded area defines the allowable settings. Temperature and humidity transition times longer than shown may be used by adding time so the dwell or "soak" times are maintained. The cycle begins with the CUT at -40^{o}C and uncontrolled relative humidity. Completion of the sequence shown in Figure 5.5.3 constitutes one cycle.

4. At the conclusion of the test, continue with test sequence per Table 2.1.



Key: **1** (-40)°C± 3^{o} **2** (80 – 90)°C **3** T_{max} = Max temp value in Table 2.4 ± 3^{o} (Class T3 shown for illustration)
4 Relative Humidity is uncontrolled. Do not vent chamber at hour 5. **5** 80 to 100% Relative Humidity from 1 to 5 hours

FIGURE 5.5.3 - TEMPERATURE/HUMIDITY – DEFINITION OF ONE CYCLE

5.5.4 Acceptance Criteria

This is an aging test and has no criteria. Conformance of each CUT is determined per the evaluation method identified in the Test Sequence of Table 2.5.

5.6 High Temperature

5.6.1 Purpose

This step conditions to simulate the effects of long-term exposure to elevated temperature on components. Thermal aging may cause changes in plastic materials including brittleness and stress relaxation. These changes may be detrimental to physical performance.

5.6.2 Equipment

Temperature Chamber capable of Temperature Class selected from Table 2.1

5.6.3 Procedure

1. Number each CUT, if not already done in a previous step.

2. Set the maximum chamber temperature to the temperature of the class requested per Table 2.4. Allow the chamber to stabilize temperature before proceeding.

3. Place the samples in the chamber so that there is no obstruction to air flow across and around the samples.

4. Leave the samples in the chamber for 1008 hours.

5. At the conclusion of the exposure, let CUT come to room temperature and stabilize prior to the next test. The time shall be no less than 24 hours.

6. Evaluate the CUT per the test sequence in Table 2.1.

5.6.4 Acceptance Criteria

This is an aging test and therefore has no criteria. Verify conformance of each CUT per corresponding section as identified in the Test Sequence.

5.7 Resistance to Automotive Fluids Test

5.7.1 Purpose

This test evaluates the material compatibility of a CUT by being immersed in fluids commonly found in and around road vehicles. Apply this test only for temperature class T3 (125C) and higher.

5.7.2 Equipment

1. Laboratory fume hood

2. Beakers (stainless or glass)

3. Heating device capable of safely heating fluids to temperatures indicated in Table 5.7.3.

5.7.3 Applicability

Apply this test only for temperature class T3 (125C) and higher.

5.7.4 Procedure

1. Number each sample.

2. Dispense and stabilize fluids at the temperature indicated

TABLE 5.7.3 - FLUID EXPOSURE SCHEDULE

Fluid	Specification and Source	Test Temp. (°C)
Gasoline	Commercially available No lead regular (87 octane)	23 ± 5
Diesel fuel	Commercially available #2 grade	23 ± 5
Engine oil	Commercially available (any viscosity)	50 ± 3
Ethanol	Commercially available E85	23 ± 5
Automatic transmission fluid	Dexron VI (Commercially available)	50 ± 3
Engine Coolant	50% ethylene glycol + 50% distilled water percent by volume	50 ± 3
Brake Fluid Mixture	SAE RM-66-XX (where “XX” is latest available fluid) or ISO 4926. From: Greening Associates Inc., 313-366-7160 Ext. 200. www.greeninginc.com	50 ± 3
Diesel Exhaust Fluid (DEF)	API certified per ISO22241, commercially available	23 ± 5
Salt water	5% NaCl (by weight) mixed in tap water	23 ± 5

3. Completely submerse 1 sample in each fluid in Table 5.7.3 for 30 minutes. Use a new sample for each fluid.

4. At the conclusion of the submersion period, remove the sample from the fluid. Do not shake off any excess fluid. Be careful to not splash fluid on unintended surfaces. Leave the samples wet and store them in a suitable container at ambient temperature for 7 days. Do not allow samples submersed in different fluids to touch each other. Do not allow any dissimilar fluids to intermingle.

5. At the conclusion of the storage period, dry CUT.

5.7.5 Acceptance Criteria

Verify conformance of CUT per corresponding measurement section as identified in Section 2.1 Test Sequence.

NOTE: Customer is encouraged to accept generic test results for all retainers using a specific resin material. This test may be performed by a material supplier independently of testing for a specific part.

5.8 Water Leak – Static Pressure

5.8.1 Purpose

This test evaluates the sealing capability of a sealed CUT with S2 or S3 classification subjected to a specified pressure differential between the inside and outside of the sealed area. It uses a column of water as the pressure source. This test typically is used for validation of plastic two-shot or overmolded sealed clip designs for fastening applications.

5.8.2 Equipment

1. Test plate capable of sealing against the water column. Refer to Figure 5.8.3.A.
   - Test plate must be fabricated to the thinnest dimension allowed in the part drawing.
   - Test fixture must have the hole (opening) match the largest allowed for the CUT (including tolerance).
   - The holes must be painted or coated to match the production-intent coating or approved coating per test requester.
2. Water column per Figure 5.8.3.B.
   - The column used must be able to contain 150mm of water
   - The column must be suitable for hydrostatic pressure testing.
3. Low-friction pulley mechanism. Refer to Figure 5.8.3.C for a typical side-load pulley configuration

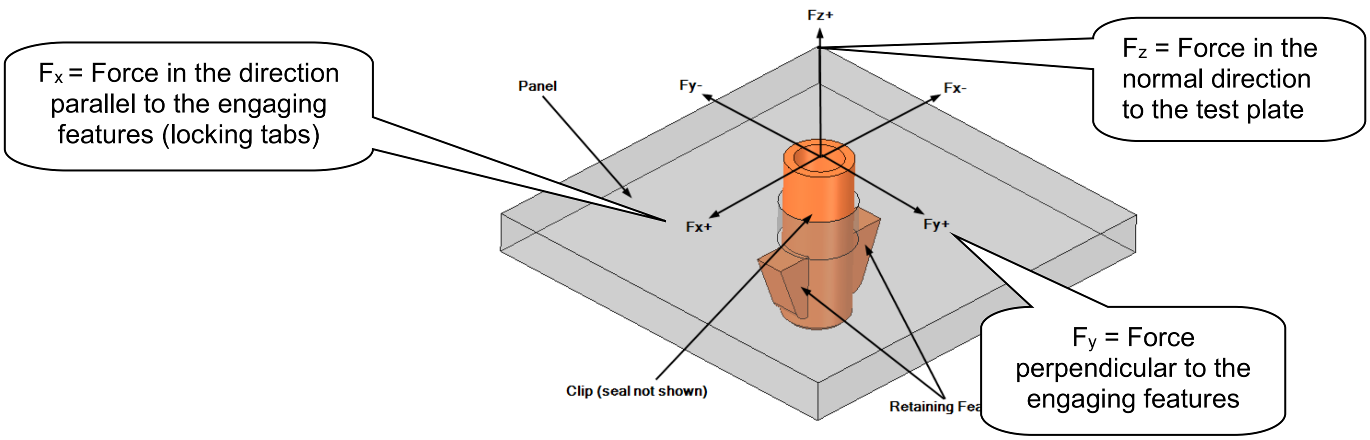


FIGURE 5.8.3.A - TEST PLATE FOR LEAK TEST - LOADING DIRECTIONS

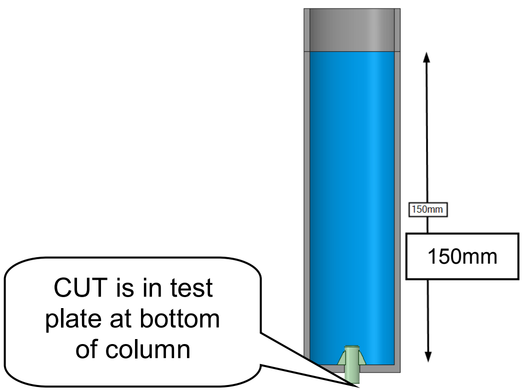


FIGURE 5.8.3.B - WATER COLUMN ASSEMBLY FOR LEAK TEST

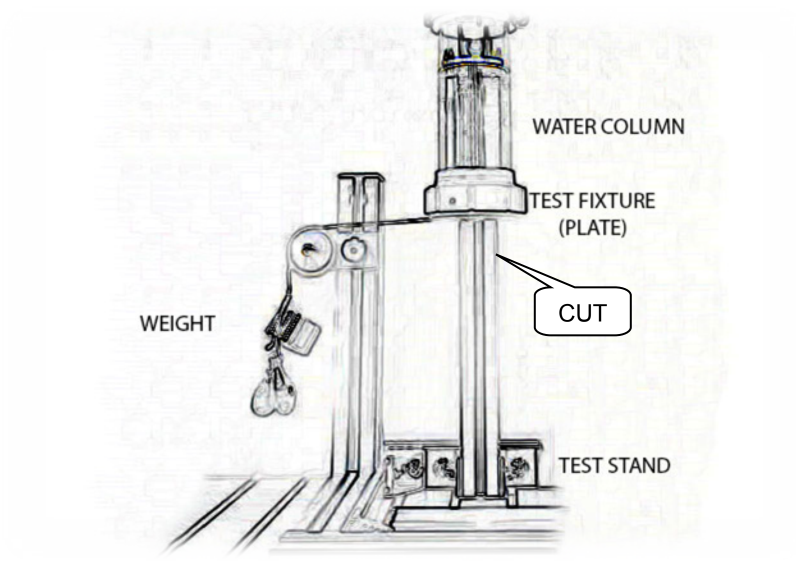


FIGURE 5.8.3.C - LEAK TEST SIDE-LOAD IN X OR Y DIRECTION (TEST FIXTURE AND WATER COLUMN)

5.8.3 Procedure

1. Number each CUT.
2. Install CUT in test panel.
3. Assemble the test panel with CUT installed to the water column.
4. Apply a side load by attaching a string (shown in Figure 5.8.3.C) so that it applies a force of 5N in the F_y direction as seen in (directions are defined in Figure 5.8.3.A). Note that the string must be routed over a low-friction pulley prior to suspending the weight.
5. Place dry white tissue paper at the base of the test stand to aid in leak detection.
6. Slowly fill column with water until 150mm height above the CUT is reached. Avoid pouring the fluid directly onto the underside of the test part. A dye can be added to the water to assist in leak detection.
7. Continue test for 24 hours. Regularly inspect white tissue paper for evidence of water and look for leaks.
8. If a leak occurs, record the last time where there was no sign of a leak.
9. If water is seen on the tissue paper, check the CUT for visible flaws and seal deformation and note findings.
10. Disassemble the column, fixture, and component if applicable.
11. Using a new sample, repeat test in the F_x and F_z directions. For the z-direction test, place the tissue of Step 5 above the weights on a plate.

5.8.4 Acceptance Criteria

No water is allowed on tissue paper from inspection in step 5.8.3 #8 is permitted.

5.9 Water Leak - High Pressure Spray

5.9.1 Purpose

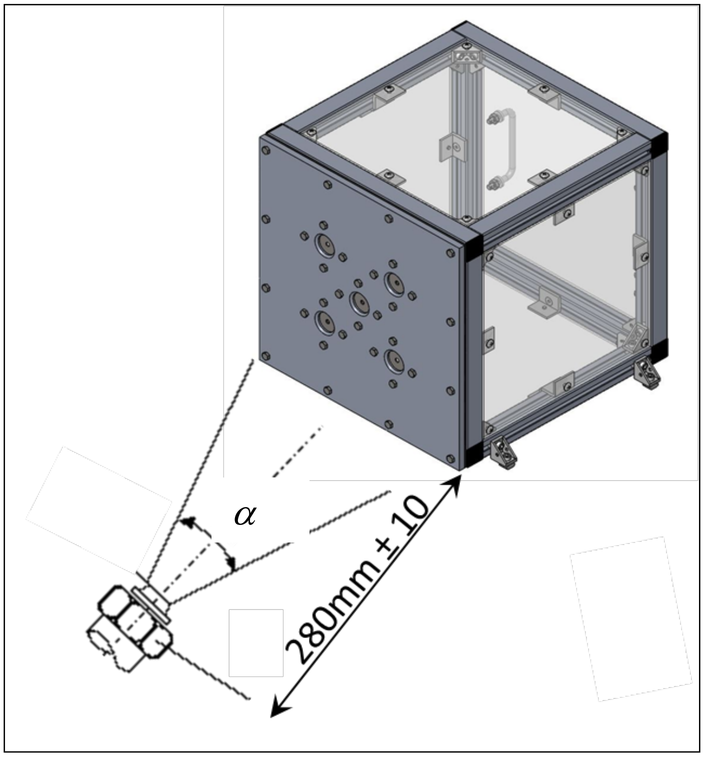
The purpose of this test is to determine the ability of sealed (S3 sealing classifications) retainer clips to withstand high pressure spray during use. Such conditions may be encountered where there is direct road splash or in cases where high-pressure washing may be expected. Perform this test for Sealing Class S3 only.

5.9.2 Equipment

1. High pressure sprayer capable per Table 5.9.2
2. Fan jet nozzle per Figure 5.9.2 and Table 5.9.2
3. Test plate. Test plates to be used for testing shall be representative of the application for which the part is used. The test plates shall be of thickness specified per print. Test plate must have the same attributes as shown in item 2 of Section 5.8.2.
4. Holding Fixture
    - The water spray test fixture consists of either a flat plate or an enclosure.
    - If a flat plate is used, the plate should be large enough to prevent overspray during testing from contacting the back surface of the test plate.
    - Flat plate or enclosure must be able to accommodate interchangeable test plates for different hole sizes and thicknesses as determined by the application.
    - Table 5.9.2 defines the spray test configuration.
    - Figure B1 in Appendix B shows an example of an acceptable enclosure
    - Figure B2 in Appendix B shows an example of the CUT sample placement detail.

TABLE 5.9.2 - SPECIFICATION FOR HIGH PRESSURE SPRAY TESTING

Nozzle Distance to enclosure	Nozzle Angle (α dimension)	Water Flow Rate	Water Pressure	Water Temperature	Exposure Time
280mm (~11")	25° ±5°	5 to 16 L/min	8,000 to 10,000 KPa	Uncontrolled (Ambient)	60 sec.



(See Table 5.9.2 for spray angle value, α)

FIGURE 5.9.2.A - SPRAY NOZZLE ARRANGEMENT RELATIVE TO ENCLOSURE

5.9.3 Procedure

1. Number each CUT. Divide into 2 groups (5 for front-orientation and 5 for back-orientation).
2. Mount the CUT onto the applicable holes in the fixture on the enclosure. Orient CUT so samples marked for front-orientation get sprayed from the front and back-orientation get sprayed from the back side. Assure interior of enclosure is dry.
3. Set-up as shown in Figure 5.9.2.A. Initiate spray and start a timer. Assure each CUT gets direct spray.
4. Stop the spray after 60 seconds.
5. Inspect for presence of water on "dry" side of test fixture and record results.
6. Remove sample, dry the enclosure as required
7. Repeat steps 2 through 5 for all components to be tested as necessary.

5.9.4 Acceptance Criteria

CUT must not have any leakage of water through sealed area onto "dry" surface.

5.10 Cable Tie Loop Strength

5.10.1 Purpose

There are two tests.

1) The split mandrel test 5.10.3.1 determines the strength of the bundle tie lock in ideal conditions.

2) The solid mandrel test 5.10.3.2 evaluates the bundle tie lock and loop-to-saddle structure for its ability to withstand applied forces in automotive configurations.

5.10.2 Equipment

1. Two test mandrels (solid mandrel and split mandrel). The diameter of the mandrels used must match an allowed wire bundle diameter for the CUT.
2. Holding Fixture(s) as required.
3. Tensile Test equipment with force vs. time recording capability.

5.10.3 Procedure

5.10.3.1 Split Mandrel

1. Assemble 30 pieces (half sample size) so split mandrel is tied by the tie strap on the CUT. Fasten as appropriate for the attachment type on CUT to grip the mandrel per Figure 5.10.3.1. Typically, this will be at the 3 O'clock position. Cut off the remaining cable tie tail.

2. Install, using fixtures as needed on the tensile tester to pull. Use the UL 62275 method as a reference

3. Pull at 25mm/minute. For the split mandrel, this is done by separating the mandrels.

4. Continue until part breaks.

5. Record the "split mandrel failure mode," location and highest recorded force. Select and record the applicable failure mode from this list: Pawl Pull Through, Pawl Broke Out, Pawl Released, Strap Fractured, or Other.

6. Calculate the standard deviation ("s"), and lower 3 s value (mean - 3s) of the pull-to-failure data.

7. Calculate 70% of this value for use in the next test. If an alternate test is used in place of this section with customer approval, calculate 70% of the lower 3 s value for that data set.

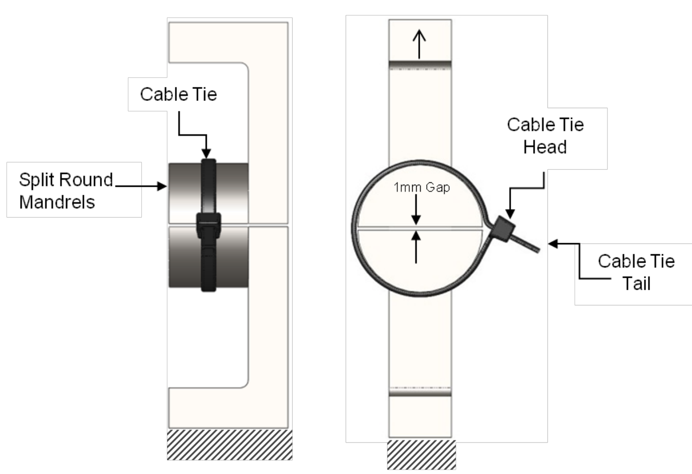


FIGURE 5.10.3.1 - LOOP TENSILE TEST ARRANGEMENT (SPLIT MANDREL)

5.10.3.2 Solid Mandrel Load Test (performed on half the sample group)

1. Stabilize part 48 hours (min.) at room ambient (50%RH).
2. Assemble tie strap to solid mandrel per Figure 5.10.3.2. Fixture the branches of the CUT so the branches are retained securely and are not able to fail in the test (since this test evaluates the transition from saddle to loop only).
3. Install on the tensile tester to pull. Fix the fir-tree branches (or retention mechanism) so they cannot move.
4. Pull at a speed of 25mm/minute until the part breaks.
5. Record mode, location, and maximum load.
6. Calculate the standard deviation (“s”), and lower 3 s value (mean - 3s) of the pull-to-failure data.

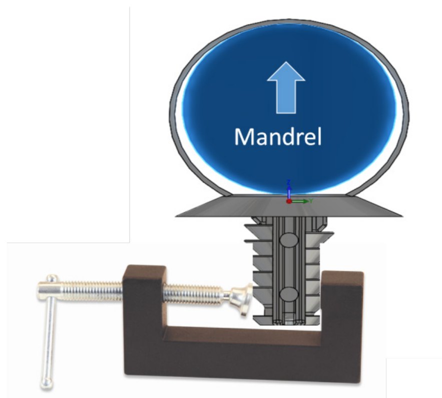


FIGURE 5.10.3.2 - LOAD TEST ARRANGEMENT (SOLID MANDREL)

5.10.4 Acceptance Criteria

1. The “mean-3 sigma” load as calculated in the split mandrel procedure (5.10.3.1), must meet the requirement set by the test requester. This is called the “split mandrel rating.”

2. The “mean-3 sigma” load measured in the solid mandrel test (5.10.3.2) must have a value 70% of or more than the “mean-3 sigma” load, as calculated in the split mandrel procedure (5.10.3.1). NOTE: Per agreement with customer, a different test may be used in lieu of 5.10.3.1. If an alternate method is used, use that value in the calculation in place of the 5.10.3.1 result. In equation form the requirement is:

$$(Value\ from\ 5.10.3.2\ \text{step6}) \geq (Value\ from\ 5.10.3.1\ \text{step7}) \qquad \boxed{(1)}$$

Example: If a split mandrel “mean - 3s” calculation results in a value of 220N then the solid mandrel “mean - 3s” must exceed 156N since 220*0.7=156)

5.11 Offset (standoff) strength

5.11.1 Purpose

This test evaluates the ability of the clip to withstand offset bending loads expected in service. Larger bundles can distort clips, causing them to be out of design position. This test applies only to the configuration shown (where the deflection is upward) so different orientations must be tested uniquely to apply forces in the intended direction. This test may be removed at customer discretion based on need in application. Any deviation must be noted in the test report.

5.11.2 Equipment

1. Tensile tester (typically same as used for insertion force testing)
2. Pushing probe to localize applied force as shown in Figure 5.11.3
3. Holding fixtures. As required. Typically, the insertion and extraction test plate can be used.

5.11.3 Procedure

1. Number each component to be tested.
2. Fully insert the CUT in an applicable fixture. Refer to Figure 5.11.3 for a typical configuration. The customer may request a special test plate with clearances for motion.
3. Apply a force to each CUT at a point specified by the customer. Continue until 50N is reached. One example is shown by the gold arrow in Figure 5.11.3A. Use a speed of 25 mm/min. If directed, re-test using reverse direction.

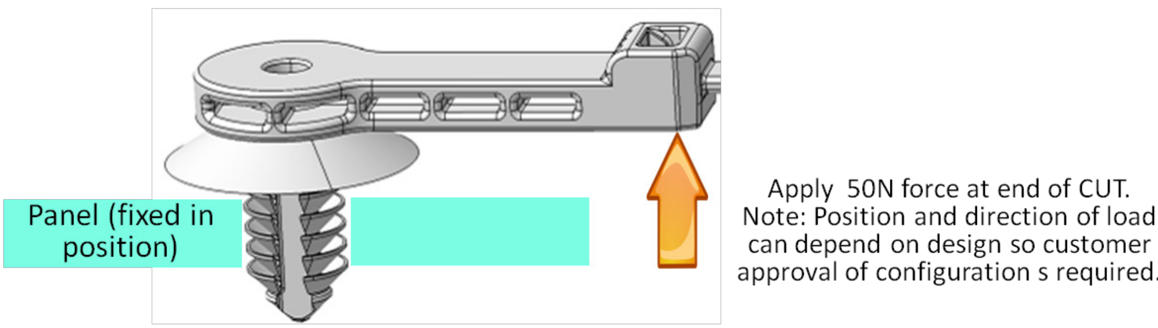


FIGURE 5.11.3A - OFFSET DEFLECTION TEST SET-UP

4. Measure deflection angle (α) as described in final position of Figure 5.11.3. If angle measurement is not instrumented for direct reading, calculate angle (α) using trigonometry assuming beam is straight and all deflection is at the base.
5. Record the deflection angle at 50N load.

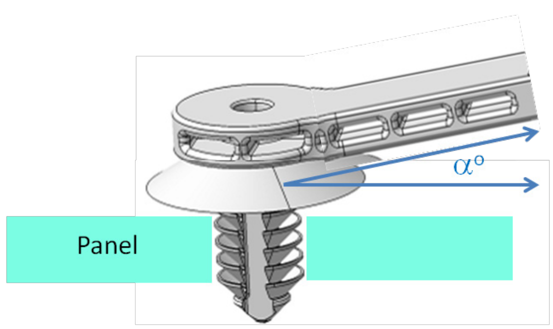


FIGURE 5.11.3B - OFFSET DEFLECTION TEST FINAL POSITION

5.11.4 Acceptance Criteria

When the 50N force is applied, report the offset angle (α) of the retainer clip. Deflection angle and part position must meet customer requirements.

6. APPENDIX

6.1 APPENDIX A: DEFINITIONS AND ABBREVIATIONS

Definitions:

Acceptance Criteria:
Generally the final section in each test description. It specifies the minimum requirements that all test samples must meet during or at the conclusion of that test.

Authorized Person:
One person responsible, as the final authority for answering questions on interpretation of the test to a given part for a specific customer.

Disengage Force:
The force required to disengage a retainer into a mating plate.

Engage Force:
The force required to insert a retainer into a mating plate.

Extraction Failure Mode:
The specific type of failure during extraction testing. These are the most common: Branch Deflection (branch moved to a location that is not; not effective), Trunk Fracture (mechanical failure of the trunk), or Saddle Fracture (mechanical failure at the saddle). Figure 4.2 shows the location of these features on typical parts.

Soak:
Refers to a time period during which the component under test is exposed to stated environmental conditions, such as temperature, humidity, current flow, etc. This exposure may be for the purpose of conditioning the sample prior to another test, or may itself form part of a given test.

Split Mandrel Failure Mode:
The specific type of failure split mandrel testing. Applicable failure modes are defined as: Pawl Pull Through (pawl pulling); Pawl Broke Out (pawl broke); Pawl Released (pawl in place at failure); Strap Fractured (pawl not a factor in failure); or Other.

Abbreviations:

AIAG	Automotive Industry Action Group. To contact at AIAG, write Box 77000, Detroit, Michigan 48277-0839 or phone (248) 358-3570. Website www.aiag.org
CUT	Component Under Test
DVP&R	Design Verification Plan and Report
EWCAP	Electrical Wiring Component Applications Partnership. One of several sub-groups of USCAR. Has the task of commonizing electrical components and interfaces. Website: www.uscar.org/guest/teams/10/Electrical-Wiring-Component-Applications-Partnership/
PPAP	Production Part Approval Process.
RH	Relative Humidity.
USCAR	United States Council for Automotive Research LLC. USCAR is a consortium of representatives from Ford, General Motors, and Chrysler that promotes joint research in pre-competitive areas that can strengthen the US automotive industry. Website: http://www.uscar.org/guest/index.php

6.2 APPENDIX B: SPRAY ENCLOSURE DETAIL

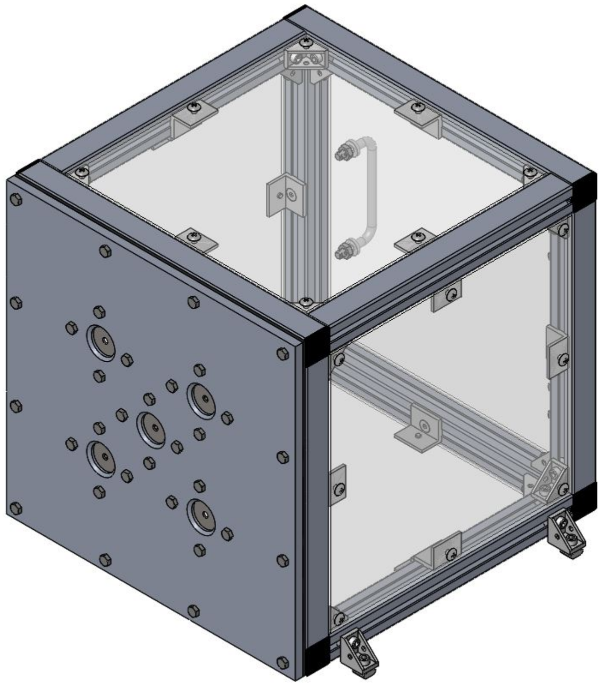


FIGURE B1 - SPRAY ENCLOSURE EXAMPLE

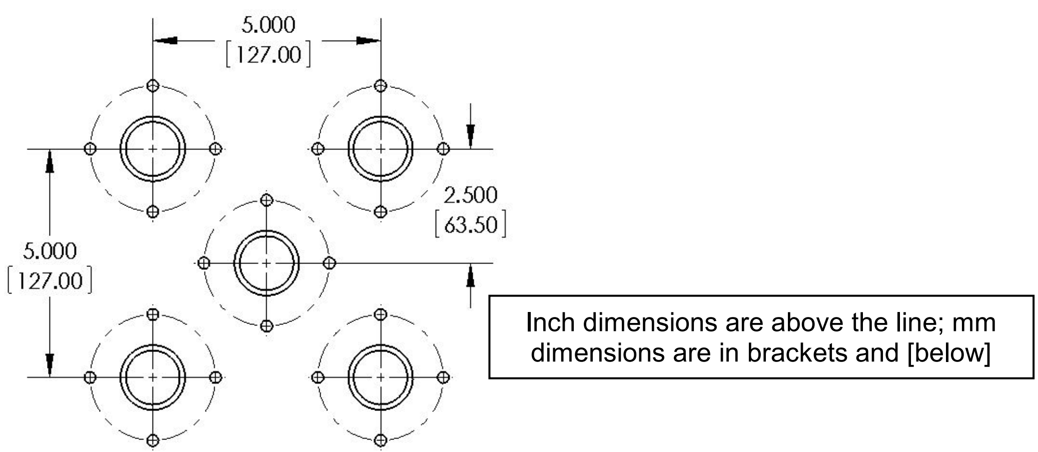


FIGURE B2 - CUT LOCATION PATTERN FOR SPRAY FIXTURE

6.3 APPENDIX C: SPRAY EQUIPMENT RESOURCES

This appendix offers additional information useful when procuring the high pressure spray equipment used in this specification. The equipment specification was selected to allow equipment used for testing to international standards such as ISO 16750-3 to be compatible with USCAR-44 testing. This allows labs to evaluate parts globally. This section can assist in converting the international specification values into values typically found in the United States.

TABLE C-1 - FLUID SPRAY COMPARISON AND CONVERSION (REFERENCE TABLE 5.7.2)

Type of Measurement	Callout in USCAR-44	Equivalent Units (Gal. and PSI*)	Callout in ISO 20653 IPX9K. (Ref only)
Water Flow	5 to 16 L/min	1.3 – 4.2 gal/min	14 to 16 L/min. (USCAR-44 allows smaller spray units to be used. It works since CUT is small.
Water Pressure	8,000 to 10,000 KPa	1160 – 1450 psi	8,000 to 10,000 KPa. Values are common
Nozzle spray angle	$25^{o} \pm 5^{o}$	$25^{o} \pm 5^{o}$	$30^{o} \pm 10^{o}$. (USCAR-44 matches commonly available spray tips.)

Note that requirements were established to align with commonly available electric high pressure spray units using 25 degree tip.

* Conversion to English units is given for convenience when specifying equipment in North America where English units are common.

6.4 APPENDIX D: REVISIONS

DATE	SECTION	SUMMARY OF CHANGES MADE *	NOTES
3/2017		Initial Release of USCAR-44	