

Specification for Testing Automotive Light Bulb Sockets

**SAE/USCAR-15 REVISION 4
MAY 2020**

ISBN: 978-1-4686-0193-0





SAE/USCAR-15 REVISION 4

Issued
Revised

2004-11
2020-05

SPECIFICATION FOR TESTING AUTOMOTIVE LIGHT BULB SOCKETS

TABLE OF CONTENTS

1.	SCOPE.....	5
2.	REFERENCE STANDARDS.....	5
3.	GENERAL REQUIREMENTS.....	6
3.1	Record Retention	6
3.1.1	Objectives of Record Retention	6
3.1.2	Retention Methods	6
3.2	Sample Documentations and Retention	6
3.2.1	Required Data Package	6
3.2.2	Sample Selection	7
3.2.3	Sample Retention.....	7
3.3	Physical Characteristics	7
3.3.1	Dimensional Characteristics	7
3.3.2	Material Characteristics.....	7
3.4	Power Sources.....	7
3.4.1	Output Current	7
3.4.2	Output Voltage	7
3.5	Equipment Tolerances	8
3.6	Measurement Accuracy	8
3.7	Test Repeatability and Calibration	8
3.7.1	Equipment Repeatability	8
3.7.2	Equipment Calibration.....	8
3.8	Test Default Conditions.....	8
3.8.1	Environmental	8
3.8.2	Wires for Test.....	8
3.8.3	Test Voltage/Current.....	8
3.8.4	Mating Connectors	9
3.9	Test Sharing within Socket Families	9
3.10	Test Failure Procedure.....	9
3.11	Control Plans.....	9
3.12	Reliability Programs and Methods	9
3.12.1	Reliability Growth and Ongoing Quality Improvements	9
3.12.2	Notification of Process/Product Changes	9
3.12.3	Quality/Reliability Improvement Tools.....	10
3.13	Hazardous Material Restriction	10
3.14	Test and Acceptance Requirements.....	10
3.14.1	Visual Inspection	10
4.	ELECTRICAL PERFORMANCE.....	10
4.1	Voltage Drop	10
4.1.1	Test and Measurement Apparatus.....	10
4.1.2	Procedure.....	10
4.1.3	Acceptance Criteria.....	12

The research data, analysis, conclusion, opinions and other contents of this document are solely the product of the authors. Neither the SAE International (SAE) nor the United States Council for Automotive Research (USCAR) certifies the compliance of any products with the requirements of nor makes any representations as to the accuracy of the contents of this document nor to its applicability for purpose. It is the sole responsibility of the user of this document to determine whether or not it is applicable for the purposes.

Copyright © 2020 USCAR

All rights reserved.

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

Full document details: SAE USCAR15-4



Documents

Printed in U.S.A.
Document Sharing Hub

4.2	Isolation Resistance	12
4.2.1	Test and Measurement Apparatus.....	12
4.2.2	Procedure.....	12
4.2.3	Acceptance Criteria.....	13
4.3	Temperature Rise	13
4.3.1	Equipment	13
4.3.2	Procedure.....	13
4.3.3	Acceptance Criteria.....	13
4.4	1008 Hour Current Cycle	13
4.4.1	Equipment	14
4.4.2	Procedure.....	14
4.4.3	Acceptance Criteria.....	14
5.	MECHANICAL PERFORMANCE	14
5.1	Bulb Insertion/Removal Force.....	14
5.1.1	Wedge Base Bulb Sockets	14
5.1.2	Bayonet Base Bulb Sockets.....	18
5.2	Socket Insertion/Removal Torque/Force	20
5.2.1	Test and Measurement Apparatus (Twist-In Sockets).....	20
5.2.2	Procedure (Twist-In Sockets).....	20
5.2.3	Acceptance Criteria (Twist-in Sockets).....	21
5.2.4	Test and Measurement Apparatus (Snap-in Sockets).....	21
5.2.5	Procedure (Snap-in Sockets).....	21
5.2.6	Acceptance Criteria (Snap-in Sockets).....	21
5.3	Connector Insertion/Removal Force	21
5.4	Bulb Wobble.....	21
5.4.1	Test and Measurement Apparatus.....	22
5.4.2	Procedure.....	22
5.4.3	Acceptance Criteria.....	22
5.5	Socket Strength.....	22
5.5.1	Test and Measurement Apparatus.....	22
5.5.2	Procedure.....	22
5.5.3	Acceptance Criteria.....	23
5.6	Terminal Retention.....	23
5.7	System Seal Integrity	23
5.7.1	Test and Measurement Apparatus.....	23
5.7.2	Procedure.....	24
5.7.3	Acceptance Criteria.....	25
5.8	Wire to Terminal Crimp	25
5.9	Vibration	26
5.9.1	Test and Measurement Apparatus*	26
5.9.2	Procedure.....	27
5.9.3	Acceptance Criteria*	28
5.10	Mechanical Shock	28
5.10.1	Test and Measurement Apparatus.....	29
5.10.2	Procedure.....	29
5.10.3	Acceptance Criteria.....	29
5.11	Unintended Mechanical Locking Between Socket and Bulb Terminals.....	29
5.11.1	Test and Measurement Apparatus.....	30
5.11.2	Procedure.....	30
5.11.3	Acceptance Criteria.....	31
5.12	socket extension handle mechanical robustness	31
5.12.1	Axial Pull Test	31
5.12.2	Axial Push Test	32
5.12.3	Side Load Push Test.....	32
5.12.4	Torque Robustness.....	33

6.	ENVIRONMENTAL PERFORMANCE	34
6.1	Thermal Shock	34
6.1.1	Test and Measurement Apparatus	34
6.1.2	Procedure	35
6.1.3	Acceptance Criteria	35
6.2	Power Temperature Cycling	35
6.2.1	Purpose	35
6.2.2	Test and Measurement Apparatus	35
6.2.3	Procedure	35
6.2.4	Acceptance Criteria	36
6.3	High Temperature Exposure	37
6.3.1	Test and Measurement Apparatus	37
6.3.2	Procedure	37
6.3.3	Acceptance Criteria	37
6.4	Fluid Resistance	37
6.4.1	Equipment	37
6.4.2	Procedure	37
6.4.3	Acceptance Criteria	38
6.5	Outgassing	38
6.5.1	Test and Measurement Apparatus	38
6.5.2	Procedure	39
6.5.3	Acceptance Criteria	39
6.6	Ozone Resistance	39
6.6.1	Test and Measurement Apparatus	40
6.6.2	Procedure	40
6.6.3	Acceptance Criteria	40
6.7	Salt Spray	40
6.7.1	Test and Measurement Apparatus	40
6.7.2	Procedure	40
6.7.3	Acceptance Criteria	40
6.8	Temperature/Humidity Cycling	41
6.8.1	Test and Measurement Apparatus	41
6.8.2	Procedure	41
6.8.3	Acceptance Criteria	41
7.	LONG-TERM USAGE	41
7.1	Long-Term Usage Test for DRL and Rear Fog Lamp Applications	41
7.1.1	Procedure	42
7.1.2	Acceptance Criteria	42
8.	TEST REQUIREMENTS FOR QUALIFYING NEW BULB SUPPLIERS IN PREVIOUSLY APPROVED SOCKETS	43
APPENDIX A - ABBREVIATIONS		44
APPENDIX B - GLOSSARY		45
APPENDIX C - DESIGN GUIDELINES		47
APPENDIX D - FIGURES		48
APPENDIX E - FLOWCHART		65
APPENDIX F - LONG-TERM USAGE TEST SEQUENCE FOR DRL AND REAR FOG LAMP APPLICATIONS		66
APPENDIX G - ANNUAL TEST SEQUENCE		67

APPENDIX H - FLUID SOURCES	68
APPENDIX I - BULB SUPPLIER CONTACT INFORMATION.....	69
APPENDIX J - REVISIONS	70

1. SCOPE

This specification establishes the requirements and test procedures for automotive miniature bulb retention devices, including wedge base sockets with integral connectors, direct wire wedge base sockets, bayonet base sockets with integral connectors, direct wire bayonet base sockets, wedge base and bayonet base sockets with circuit plate assemblies, and associated interfaces.

Tests shall follow the sequence shown in the flow charts in Appendices E and F whenever the following occurs:

- New design.
- Design, material, or process change made to an existing device, which could affect the outcome of the test.

The test sequences shown in Appendix G shall be run annually.

NOTE: Production process control data collected at a shorter interval, per an approved control plan, may be substituted if approved by customer's responsible engineer and purchasing representative.

2. REFERENCE STANDARDS**

- AIAG/APQP-2: Fiat Chrysler Automobiles (FCA), Ford, and General Motors Advanced Product Quality Planning and Control Plan Reference Manual
- AIAG/MSA-3: Measurement Systems Analysis Reference Manual
- AIAG/FMEA-3: Potential Failure Mode and Effects Analysis Reference Manual (SAE J1739)
- AIAG/PPAP-3: FCA, Ford, and General Motors Production Part Approval Process Manual
- ASTM B117 (Standard Practice for Operating Salt Spray [Fog] Testing Apparatus)
- FCA, Ford, and General Motors Quality System Requirements—QS-9000 Manual
- SAE/USCAR-2: Performance Standard for Automotive Electrical Connector Systems
- SAE/USCAR-3: Specification for Testing Automotive Miniature Bulbs
- SAE/USCAR-12: Wiring Component Design Guidelines
- SAE/USCAR-21: Performance Specification For Cable-To-Terminal Electrical Crimps
- AIAG Fundamental Statistical Process Control Reference Manual
- SAE J573 Miniature Lamp Bulbs
- IEC 60061-1: Lamp Caps
- IEC 60061-2: Lampholders
- IEC 60061-3: Gauges
- IEC 60068-2-14: Nb Basic Environmental Testing Procedure
- IEC 60068-2-29: Test Eb, Bump

- UN R.E.5 Consolidated Resolution on the common specification of light source categories (R.E.5)
- SAE J1330: Photometry Laboratory Accuracy Guidelines
- FCA, Ford Motor Company and General Motors Supplier Quality Requirements

**Copies of the AIAG Manuals can be obtained from AIAG (Automotive Industry Action Group) by calling (248) 358-3570 or by writing to AIAG, Dept. 77839, Post Office Box 77000, Detroit MI 48277-0839, Attn: Customer Service.

Unless otherwise specified or required by law, suppliers shall use the most recent versions of any applicable reference documents or standards.

Revisions to these reference standards that drive design or process changes to existing products shall be reviewed for exemption with OEM on an individual basis.

3. GENERAL REQUIREMENTS

3.1 Record Retention

Supplier must maintain a file for the storage of laboratory reports and calibration records and establish a Record Retention policy per QS9000 concerning these records. These records need not follow a standard format but must present the required data in an orderly and professional manner. The file must be made available to any and all customer personnel upon request, including, but not limited to, representatives from the following functions: product engineering, purchasing, quality, and reliability.

3.1.1 Objectives of Record Retention

The following are the main objectives for the retention of test documents or records:

- Retention of records that will evidence compliance so the supplier can appropriately respond when, or if, product compliance is challenged. Files must exist for the storage of all laboratory records, data, and calibration records. The files must be available at any time for audit or inspection.
- Retention of records as needed to assist in evidencing the exercise of “due care” in matters relating to product compliance, government requirements, or product liability.
- Compliance with statutory requirements for the maintenance and retention of specific records.

3.1.2 Retention Methods

Methods of retention may include retention of original documents, the use of film, or electronic storage equipment. Store records so that they are accessible in a reasonable amount of time. Storage areas should provide adequate protection from unauthorized access, moisture, and fire.

3.2 Sample Documentations and Retention

Bulbs must be identified by ANSI trade number and manufacturer. Sockets must be identified by manufacturer part number. Documentation must identify the type of test performed and describe special tests that are not a part of this specification.

3.2.1 Required Data Package

Supplier must submit the data package for the appropriate level of submission to the customer’s responsible engineer and purchasing division for approval signatures.

3.2.2 Sample Selection

Socket assemblies referenced in this specification are to be selected from the same test lot. The minimum test lot is defined as a minimum of one hour of production. Test sockets are to be subjected to production intent processing, including final packaging. All cavity combinations shall be included in the test samples.

For example: A test sample size of ten would consist of one sample piece being removed from the test lot, at equal intervals during the production run. It is important that the test samples are identified as to location, within the test lot, throughout all testing.

Sample test quantities are specified in Appendices E, F, G, USCAR-2, and USCAR-21.

3.2.3 Sample Retention

Samples tested to obtain part approval must be retained by the socket manufacturer for the period of time specified in the AIAG/PPAP-3: FCA, Ford, and General Motors Production Part Approval Process Manual.

3.3 Physical Characteristics

Socket identification, markings, absence of any required feature, or any other evidence of nonconformance with the drawing or applicable product design specification shall be cause for rejection.

Parts shall not exhibit defects or damage resulting from manufacturing, handling, in process testing, or shipping that might impair the performance of the socket.

Flash shall not exceed 0.20 mm unless otherwise noted.

3.3.1 Dimensional Characteristics

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

3.3.2 Material Characteristics

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

3.4 Power Sources

Supplier must use voltage regulated direct current (DC) Power Sources for all tests to simulate an automotive battery and charging system.

3.4.1 Output Current

The power source must be capable of supplying a continuous output current as required by the design loads, including inrush current. When required to simulate automotive inrush current conditions, an automotive battery or batteries with sufficient Cold cranking amps may be connected in parallel with the power supply.

3.4.2 Output Voltage

The power source must be capable of supplying an output voltage that must not deviate more than 1.0 V from the nominal setting over the entire load range, including surges. The power source must recover 63% of its maximum excursion within 5.0 ms. Ripple voltage must not exceed 300 mV peak to peak.

Power supplies used for photometric measurements must conform to SAE J1330.

3.5 Equipment Tolerances

Supplier must use test setups and equipment capable of measuring test parameters (expressed in nominals) within the limits found in the equipment tolerances table.

Equipment tolerances table

Test Chamber Temperature	nominal ± 3 °C
Time	nominal $\pm 0.5\%$
Forces	nominal ± 0.01 N
Distances	nominal ± 0.01 mm
Voltages	nominal ± 0.01 V for photometrics
	nominal ± 0.1 V for all other tests
Mean Spherical Candela	nominal $\pm 2.0\%$

NOTE: Not to be used for performance dependent variable; see 3.6.

3.6 Measurement Accuracy

Meters and gauges used to assess the performance dependent variable, as defined by the basic function of the test sample, must have a smallest unit of measure one order of magnitude less than the least significant digit specified. For example, even though a 0.6 mm and 0.60 mm wire might be the same diameter, calipers capable of 0.01 mm resolution may be used to measure the first wire, but a micrometer with 0.001 mm resolution is needed for the second wire.

3.7 Test Repeatability and Calibration

3.7.1 Equipment Repeatability

All measurement equipment used for product evaluation must be repeatable to within 10% of the part tolerance according to FCA, Ford, and General Motors AIAG publications Measurement Systems Analysis Reference Manual and Fundamental Statistical Process Control Reference Manual.

3.7.2 Equipment Calibration

Equipment re-calibration/re-certification timing shall be calculated based on the capability of any individual instrument to retain its Manufacture Stated Accuracy between recall periods. However, test equipment must be calibrated within 1 year prior to test.

3.8 Test Default Conditions

When specific test conditions are not given, the following conditions apply:

3.8.1 Environmental

- Room temperature = 23 °C ± 5 °C
- Relative Humidity = Ambient

3.8.2 Wires for Test

0.5 mm² wire per ISO 6722-1.

3.8.3 Test Voltage/Current

Voltage = 14.0 VDC + 0.1/-0.0 VDC

Current = Socket classification table, as seen below.

Socket classification table

Socket Classification	Used with Bulb Type	Voltage Test Device	Test Current (Amps) $\pm$ 1%	
			Major	Minor
I	S8Wedge/GT8	Shorted S8/GT8	2.4	0.6
II	T3 1/4 & T5	Shorted W2 Bulb	1.5	N.A.
III	T1 3/4	Shorted W1 Bulb	0.3	N.A.
IV	T20	Shorted T20 Bulb	2.4	0.6
V	H21W, P21W, PY21W, P21/5W, P21/4W	Shorted H21W, P21W, PY21W, P21/5W, P21/4W Bulb	1.9	0.5 for P21/5W, 0.4 for P21/4W
VI	R5W	Shorted R5W	0.5	N.A.
Other*				

*For other bulb type sockets, test currents and voltage test devices shall be agreed to by the OEM customer.

3.8.4 Mating Connectors

Mating connectors shall meet the requirements of SAE/USCAR-2 and follow the design guidelines set in SAE/USCAR-12.

3.9 Test Sharing within Socket Families

The results of tests performed on one socket type may, in some cases, be used to indicate the capability of another socket type within the same socket family. For example, a chemical wipe test performed on an axial versus right angle socket, manufactured out of the same material, may be used as a demonstration of the material qualification. Sound judgment must guide this practice. Sockets within the same socket family that share components such as contacts, lead wires, terminals, bases, etc., may be able to share test results. The customer will be the final authority on whether this surrogate data may be used.

3.10 Test Failure Procedure

Should testing result in a failure, contact the requesting party to determine if the test is to be continued to gain additional product experience or if testing is to be suspended. When contact cannot be immediately made, stop the test until the requesting party can be contacted.

3.11 Control Plans

Supplier must maintain a control plan, consistent with AIAG/APQP-2: FCA, Ford, and General Motors Advanced Product Quality Planning and Control Plan Reference Manual, for each socket type, or socket family, that contains appropriate controls to ensure that all the significant and critical characteristics covered by the tests in this specification are met.

3.12 Reliability Programs and Methods

3.12.1 Reliability Growth and Ongoing Quality Improvements

Socket suppliers must establish and implement a plan to improve demonstrated product quality and reliability. They must establish procedures for analyzing and correcting end-of-line defects and predominant failure modes identified by the field return program. True reliability growth occurs when design changes to the socket or manufacturing process are made to eliminate the failure modes.

3.12.2 Notification of Process/Product Changes

Suppliers must refer to the "Customer Notification and Submission Requirements" section of the AIAG PPAP manual to determine if resubmission for PPAP approval is required.

3.12.3 Quality/Reliability Improvement Tools

Suppliers must use appropriate methods to improve the quality and reliability of their products in accordance with AIAG/Q7-K: FCA, Ford Motor Company and General Motors QS-9000 Supplier Quality Requirements. Examples of such methods are Field Return Programs, Design Failure Mode Effects Analysis (DFMEA), Process Failure Mode Effects Analysis (PFMEA), and Fault Tree Analysis (FTA), or Fishbone Diagrams. Further information on these methods is available from the Automotive Industry Action Group (AIAG).

3.13 Hazardous Material Restriction

Any regulated substance that is identified by any federal, state, provincial, or local government unit or automotive manufacturer, shall not be used in the manufacturing process of any socket. Any socket manufacturer that is currently supplying hazardous material in a component will submit a timeline to General Motors, Ford, and FCA for the removal of said product.

3.14 Test and Acceptance Requirements

3.14.1 Visual Inspection

Parts shall not exhibit visible evidence of corrosion, contamination, breakage, defective, or damaged plating (peeling, flaking, or blistering).

4. ELECTRICAL PERFORMANCE

4.1 Voltage Drop

The voltage drop test is performed to ensure the integrity of the electrical connection of socket construction.

4.1.1 Test and Measurement Apparatus

- D/C power supply.
- Digital multi-meter or equivalent.
- Voltage test device, as illustrated in Appendix D, Figure 1.

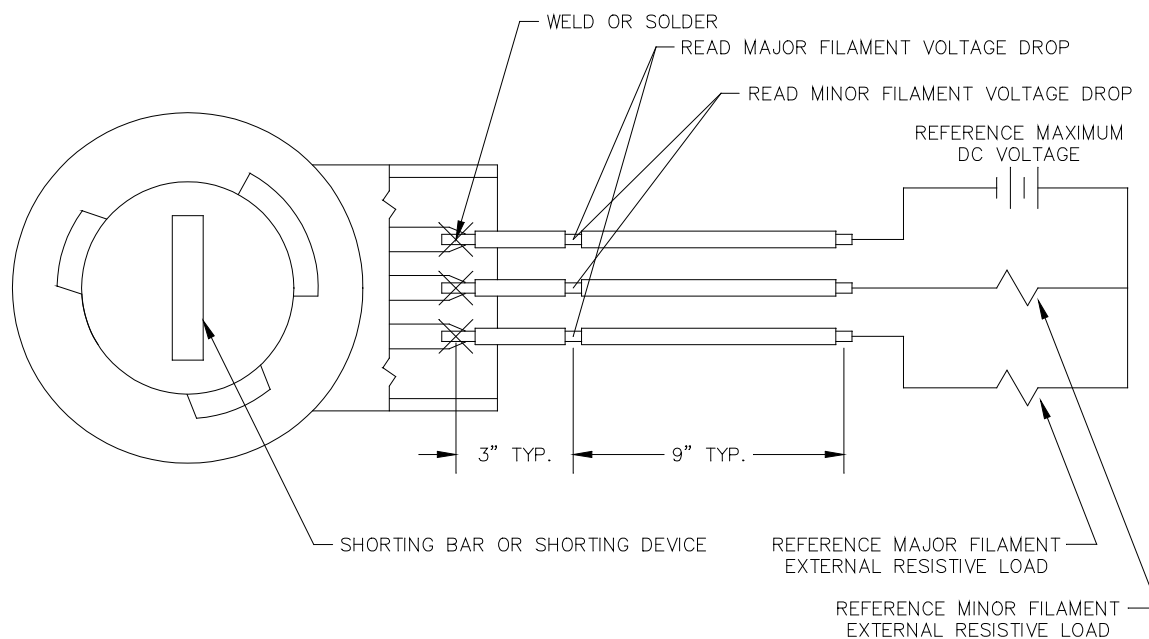
4.1.2 Procedure

4.1.2.1 Connector-less and Connector Type Sockets

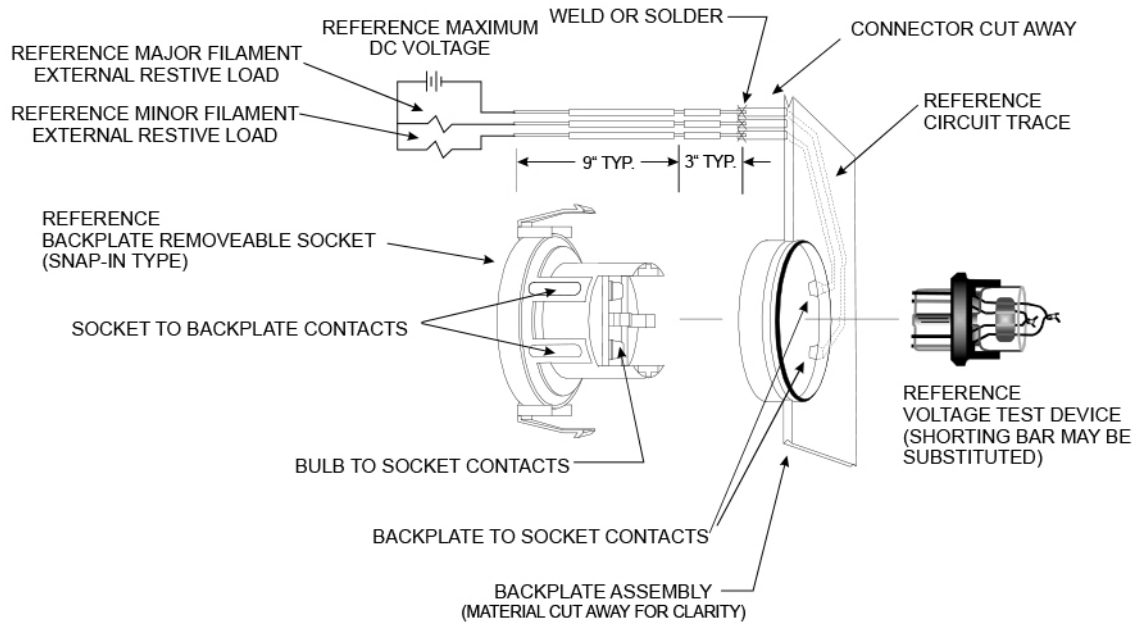
1. Determine and record millivolt drop across voltage test device at test current.
2. Install the required voltage test device.
3. Complete the circuit shown in the voltage drop circuit diagram figure, seen below.
4. Attach the millivolt leads. All millivolt leads must be no larger than 0.060 mm² (30 AWG).
5. Power the circuit at reference maximum operating current (per socket classification table, as defined in 3.8.3) and wait 5 minutes minimum to ensure that the test current stabilizes at the appropriate value.
6. Measure and record the voltage drop across each circuit (per sketched figure).
7. Subtract millivolt drop recorded in step 1 from value recorded in step 6.

4.1.2.2 Circuit Plate Assemblies

1. Determine and record millivolt drop across voltage test device at test current.
2. Test one socket location at a time.
3. Install voltage test device.
4. Complete the circuit as shown in voltage drop figure for circuit plates, seen below.
5. Connect wires to the circuit plate harness connector contacts.
6. Attach the millivolt leads. All millivolt leads must be no larger than 0.060 mm² (30 AWG).
7. Power the circuit at reference maximum operating current (per socket classification table, as defined in 3.8.3) and wait 5 minutes minimum to ensure that the test current stabilizes at the appropriate value.
8. Measure and record the voltage drop across each circuit (per sketched figure).
9. Subtract millivolt drop recorded in step 1 from value recorded in step 6.
10. Repeat steps 2 through 9 for each socket location.



Voltage drop circuit diagram figure



Voltage drop figure for circuit plates

4.1.3 Acceptance Criteria

For connector and connector-less sockets:

The voltage drop across each complete circuit (i.e., within each socket, and between wire harness and connector), must not exceed 10 millivolts per amp (mV/A) for initial voltage drop test samples prior to any other testing, and 50 mV/A for samples after they have been subjected to other tests.

For circuit plates assemblies with removable and non-removable sockets/bulb holders:

The voltage drop across each complete circuit must not exceed 60 millivolts per amp (mV/A) for initial voltage drop test samples prior to any other testing, and 120 mV/A for samples after they have been subjected to other tests.

4.2 Isolation Resistance

This test verifies that the electrical resistance between any two circuits in a socket/circuit plate assembly and connector system will be sufficient to prevent detrimental electrical conductivity. This test shall be done on sealed and unsealed socket systems.

4.2.1 Test and Measurement Apparatus

Megohmmeter.

4.2.2 Procedure

1. Engage appropriate USCAR approved connector with wires to connector type sockets. Connector-less sockets use wires coming from the socket for this test.
2. Connect the Megohmmeter, set to 500 VDC, to the bared conductor ends from any pair of adjacent terminals in the connector system.
3. Use the Megohmmeter to measure the resistance between the adjacent terminals. Apply the test voltage continuously for at least 15 seconds.

4. Record the minimum resistance measured.
5. Repeat steps 1 to 4 above so that each terminal in the connector system is measured against all adjacent terminals.

4.2.3 Acceptance Criteria

The resistance between every combination of any two adjacent terminals must exceed 20 MΩ at 500 VDC. This includes terminals that may be separated by one or more vacant terminal cavities.

4.3 Temperature Rise

This test is used to determine the temperature rise of the socket-to-bulb interface operated at the maximum operating current.

4.3.1 Equipment

- DC power supply (0 to 20 VDC at 0 to 150 A).
- Reference resistive load.
- Thermocouples (Type “J” or “T”) and temperature indicator.
- Voltage test device, as illustrated in Appendix D, Figure 1. (Shorted bulb shall be used for this test. Optional solid metal shorting bar shall not be used for this test.)

4.3.2 Procedure

1. Install the voltage test device.
2. Provide electrical power to the socket in the normal manner for the socket design (i.e., a connector interface socket would be powered via its standard mating connector).
3. Complete the circuit with an external resistive load to power the circuit at the current listed in the socket classification table, as defined in 3.8.3.
4. Temperature rise is monitored by welding or bonding a thermocouple to the backside of the socket terminal as close as possible to the test device interface. Make sure not to restrict or interfere with the contact area. See Appendix D, Figure 2.
5. Temperature rise must be recorded for all contact interfaces. Separate sockets may be used for each tested contact.
6. Place test samples in non-circulating air environment at room temperature and apply power. After the interface temperature stabilizes for 30 minutes, record the temperature.

4.3.3 Acceptance Criteria

The measured temperature at all terminal interfaces shall not exceed the maximum allowable temperature rise of 50 °C.

4.4 1008 Hour Current Cycle

This test simulates the main function of the socket/circuit plate assembly over the expected life of the vehicle. Current cycling is an accelerated aging test that electrically heats the socket/circuit plate assembly interfaces, and then allows them to cool under no current conditions, causing expansion and contraction that may affect connection resistance due to wear, oxidation, inter-metallic growth, and stress relaxation.

4.4.1 Equipment

- Digital multimeter (DMM).
- DC power supply (0 to 20 VDC at 0 to 150 A, timer controlled).
- Current shunts (size as required, $\pm 1\%$).
- Thermocouples (type "J" or "T").
- Data logger (as required).

4.4.2 Procedure

1. Assemble the circuit per 4.1 in a draft-free environment.
2. Use a timer-controlled power supply to provide 45 minutes "ON" and 15 minutes "OFF" at the maximum test current determined per socket classification table, as defined in 3.8.3.
3. Measure and record the voltage drop across each circuit.
4. Test at 23 °C. (room temperature). The ambient temperature sensor must be placed on the same plane as the test samples, 30 to 60 cm from the nearest sample.
5. Turn "ON" the power supply, DMMs, and data logger.
6. After 40 minutes into the first "ON" cycle, record voltage and calculate millivolt drop readings for each socket/circuit plate assembly.
7. Cycle for 1008 hours. Record readings at least once daily or as specified by requestor, 40 minutes into an "ON" cycle.
8. At the conclusion of the test, 40 minutes into the final "ON" cycle, take the final reading.

4.4.3 Acceptance Criteria

Millivolt readings must not exceed the "after test" acceptance criteria in the voltage drop section at any time during the test.

5. MECHANICAL PERFORMANCE

5.1 Bulb Insertion/Removal Force

NOTE: For wedge base bulb sockets:

In Test Sequence 3, the bulb removal test is required after the mechanical shock test. This is a single bulb removal cycle of the bulb that has been with the socket throughout Test Sequence 3. This test is conducted at room temperature. Following this test, the minimum gauge removal test is completed on the same sockets for five-gauge removal cycles. The bulb removal and the minimum gauge removal forces must be recorded for each cycle.

If any bulb filaments fail during the mechanical shock test, do a single bulb removal cycle of the bulb that has been with the socket throughout Test Sequence 3 and record the removal force. Insert a new bulb into the socket, repeat the mechanical shock test, and record the result. Remove the replacement bulb and record the removal force. Complete the minimum gauge removal force test on the socket for five cycles and record the removal force for each cycle.

5.1.1 Wedge Base Bulb Sockets

This test is to verify that the socket/circuit plate assembly provides adequate bulb retention capabilities, while avoiding excessive installation force.

To qualify sockets as compliant with this specification, they must meet or exceed the acceptance criteria using any USCAR compliant bulb in its category from each bulb supplier.

This test will be run in combination with light sources from the various light source suppliers. Each socket and bulb combination is a separate qualification. Failure to meet the acceptance criteria for one combination does not constitute rejection of the socket when used with other suppliers' light sources.

See Appendix I for a list of light source suppliers.

5.1.1.1 Test and Measurement Apparatus

- Maximum material condition bulb gauge.
- Minimum material condition bulb gauge.
- Material and finish for gauges shall be: Steel with a ground surface finish $0.06 \mu\text{m} \pm 0.01 \mu\text{m}$ ($1.524 \text{ nm} \pm 0.254 \text{ nm}$).
- Bulbs from each supplier.
- Chatillon force gauge or equivalent.
- Appropriate mechanism to hold socket securely.
- T20 minimum and maximum material gauges and other wedge base bulb type minimum.
- and maximum gauges shall meet the requirements as defined in IEC 60061-3.

NOTE: Refer to IEC 60061-1 for additional bulb dimensional details that may be required for gauge construction that are not included in IEC 60061-3.

5.1.1.2 Procedure

Using maximum/minimum material bulb gauge:

1. Mount socket in appropriate mechanism to hold it securely.
2. Using the force gauge, fully seat, at a rate of 50 mm/min, the maximum material bulb gauge into the socket.
3. Record the maximum force in newtons. *****Caution***** Do not over-insert gauge.
4. Using the force gauge, remove the bulb gauge at a rate of 50 mm/min from socket.
5. Record the force required to remove the bulb gauge.
6. Repeat steps 2 through 5 for a total of five times per socket.
7. Insert a minimum material bulb gauge into socket.
8. Using a force gauge, remove the bulb gauge at a rate of 50 mm/min from socket.
9. Record the force required to remove the bulb gauge.
10. Repeat steps 7 through 9 for a total of five times per socket.

Using bulbs:

Part 1: Room Temperature Bulb Removal Test with Non-Energized Bulbs

NOTE: Room temperature is defined in 3.8.1.

1. Mount socket in appropriate mechanism to hold it securely.
2. Randomly select ten bulbs of the same base configuration and ten sockets to be tested. Each bulb will remain with its paired socket throughout the test.
3. Using the force gauge fully seat each bulb, at a rate of 50 mm/min, into a socket.
4. Record the maximum force in newtons. *****Caution***** Do not over insert bulb.
5. Using a force gauge remove bulb at a rate of 50 mm/min from socket.
6. Record the force required to remove the bulb.
7. Repeat steps 3 through 6 for a total of five times per socket.
8. Repeat steps 1 through 7 for each manufacturer's bulb type that is to be qualified for use in the socket.

Part 2: Hot Bulb Removal Test with Energized Bulbs

NOTE: Use caution when conducting this test to ensure that hot bulbs are not touched by unprotected hands to prevent possible injury.

1. Install the same sockets that were tested in Part 1 into the outgassing test enclosure appropriate for the bulb type, as defined in the outgassing test conditions table in 6.5.2. Half of the samples shall be installed with horizontal filaments and half with vertical filaments. Note the filament orientation along with the sample number of each socket.
2. Energize all the bulb filaments in the bulb simultaneously at 14.1 VDC for 30 minutes at ambient room temperature. Confirm by measurement that the voltage applied to each filament is 14.1 VDC.
3. Install the enclosure into the bulb removal force test fixture while maintaining 14.1 VDC to the bulb filaments.
4. Remove one wall of the outgassing test enclosure to enable access to the bulb.
5. Determine the bulb removal force using one bulb removal pull test.
6. Remove the applied voltage from the bulb and let the socket cool down for at least 1 hour.

Part 3: Room Temperature Bulb Removal Test with Non-Energized Bulbs

1. Conduct the same test procedure as in Part 1 with 5 insertions and removals per socket, using the same bulb that was paired with the socket throughout the test.
2. If 5.1.1.3, number 7, is not met for Part 3, the same bulbs shall be installed into the same sockets (note which bulb was tested with which socket during the original testing and repeat the same pairing) and the heating cycle in Part 2 shall be conducted again inside the test enclosure without the requirement for bulb removal during the time when the bulb and socket are hot. The bulb and socket shall then be allowed to cool down to room temperature for at least 1 hour and the test procedure in Part 1 shall be conducted again with removal forces recorded. The removal forces at the end of this second heat up and cool down test cycle shall be compared against the requirements in 5.1.1.3, number 7. Record and present all test measurements.

5.1.1.3 Acceptance Criteria

Using Maximum/Minimum Material Bulb Gauge:

1. Using a maximum material condition bulb gauge, the maximum allowable insertion force is 75.0 N for S8/GT8, 45.0 N for W-2, and 60.0 N for T-20.
2. Using the maximum material condition bulb gauge the maximum removal force is 65.0 N for S8/GT8, 42.0 N for W-2, and 60.0 N for T-20.
3. Using a minimum material condition bulb gauge, the minimum required removal force is 15.0 N for S8/GT8, 5.0 N for W-2, and 10.0 N for T20.
 - a. Acceptance criteria "4" is used for the bulb removal force test and the minimum material condition bulb gauge removal test that is required following the mechanical shock test in test sequence 3.
4. The minimum required removal force for removing the bulb after the mechanical shock test in test sequence 3 and also a minimum material condition bulb gauge inserted into the socket after the original test bulb is removed is 11.1 N for S8/GT8, 3.7 N for W-2, and 10.0 N for T20.
5. T20 bulbs: Insertion and removal forces must meet the requirements as defined in IEC 60061-2: Lamp Holders.

Using Bulbs:

NOTE: This information is required for initial PPAP submissions and any material changes. A failure on this testing with a particular supplier's bulb does not constitute a complete failure of the socket; only a failure with that particular bulb supplier's bulb. The pass and fail information will be used by lamp assembly designers and OEM customers when specifying bulb/socket combinations.

1. The maximum allowable insertion force is 75.0 N for S8/GT8, 45.0 N for W-2, and 60.0 N for T20 bulbs. These are the acceptance criteria for Parts 1 and 3 of the bulb removal testing in 5.1.1.2 and also for the measurements before and after thermal aging in 7.1.
2. The maximum removal force is 65.0 N for S8/GT8, 42.0 N for W-2, and 60.0 N for T20 bulbs. These are the acceptance criteria for Parts 1 and 3 of the bulb removal testing in 5.1.1.2 and for the measurements after vibration testing in 6.9 and before and after the thermal aging in 7.1.
3. The minimum required removal force is 15.0 N for S8/GT8, 5.0 N for W-2, and 10.0 N for T20 bulbs. These are also the requirements for Parts 1 and 3 of the bulb removal testing in 5.1.1.2.
4. The minimum required removal force for removing the bulb during the hot portion of the bulb removal test in 5.1.1.2, is 11.1 N for S8/GT8, 3.7 N for W-2, and 10.0 N for T20 bulbs. In addition, the bulb removal force measured in Part 2 of the bulb removal testing in 5.1.1.2, shall not decrease by more than 10% when compared to the bulb removal force measured for the same socket and bulb combination in Part 1 of the bulb removal testing in 5.1.1.2.
5. The minimum required removal force for removing the bulb after the mechanical shock test in Test Sequence 3 and also a minimum material condition bulb gauge inserted after the original test bulb is removed is 11.1 N for S8/GT8, 3.7 N for W-2, and 10.0 N for T20 bulbs.
6. The minimum required removal force for removing the bulb after the thermal aging exposure in 7.1 is 11.1 N for S8/GT8, 3.7 N for W-2 and 10.0 N for T20 bulbs.
7. The final room temperature bulb removal force measurements for each socket and bulb combination for Part 3 shall be within 5% of the original room temperature bulb removal force measurements measured in Part 1.
8. All data shall be presented to the OEM customer for review.

5.1.2 Bayonet Base Bulb Sockets

5.1.2.1 Test and Measurement Apparatus

- Maximum material condition bulb gauge.
- Minimum material condition bulb gauge.
 - Material and finish for gauges shall be: Steel with a ground surface finish $0.06\ \mu\text{m} \pm 0.01\ \mu\text{m}$ ($1.524\ \text{nm} \pm 0.254\ \text{nm}$).
- Bulbs from each supplier.
- Chatillon force gauge or equivalent.
- Appropriate mechanism to hold socket securely.
- Minimum diameter cylindrical pin representing the minimum size bulb base electrical contact.
- Maximum diameter cylindrical pin representing the maximum size bulb base electrical contact .
 - Material and finish for gauges shall be: Steel with a ground surface finish $0.06\ \mu\text{m} \pm 0.01\ \mu\text{m}$ ($1.524\ \text{nm} \pm 0.254\ \text{nm}$)

NOTE: For gauge dimensional details, refer to IEC 60061-3. Also refer to IEC 60061-1 for dimensional details that may be needed for gauge construction that are not included in IEC 60061-3.

NOTE: For bayonet base bulb sockets:

In Test Sequence 3, the test described in 5.1.2.2 to determine if the locked bulb can defeat the lock with 0.57 N-m applied must be conducted after the mechanical shock test with the same bulb that has been in the socket throughout Test Sequence 3. This is a single bulb removal test of the bulb that has been with the socket throughout Test Sequence 3. This test is conducted at room temperature. Following this test, the minimum material bulb gauge installation and lock torque test described in 5.1.2.2 is completed on each socket for five-gauge installation and removal cycles. The minimum material bulb gauge installation torque and lock torque test pass or fail status must be recorded for each cycle.

If any bulb filaments fail during the mechanical shock test, for those sockets only, conduct the test described in 5.1.2.2 to determine if the locked bulb that was in the socket since the start of Test Sequence 3 can defeat the lock with 0.57 N-m applied. This test must be conducted after the mechanical shock test with the same bulb that has been in the socket throughout Test Sequence 3. Then install a new bulb into the socket and redo the mechanical shock test and record the results. After the mechanical shock test is complete, apply 0.57 N-m removal torque to the bulb to determine if the bulb remains locked. Record the results. Remove the bulb and complete 5.1.2.2 for gauge installation and locked gauge removal torque with the minimum material condition bulb gauge for five cycles. For each socket, record the installation torque, and determine if the locked gauge stays locked in place with 0.57 N-m removal torque applied.

At the end of Test Sequence 3, after the bulb and minimum material bulb gauge removal tests, conduct the test in 5.1.2.2.

5.1.2.2 Procedure

Torque Measurements Using Maximum/Minimum Material Bulb Gauge:

1. Mount socket in appropriate mechanism to hold it securely.
2. Using the maximum material force gauge, fully seat the gauge, at a rate of 50 mm/min, into the socket.
3. Stop the insertion when the gauge bottoms out.
4. *****Caution***** Do not over-insert gauge.

5. Using a torque gauge, twist the gauge clockwise to the locked position.
6. Record the torque required to reach the lock position.
7. *****Caution***** Do not over-torque the gauge.
8. Using the torque gauge, twist the gauge counterclockwise at a torque of 0.57 N-m.
9. Bulb gauge must not unlock with 0.57 N-m applied.
10. Push downward on gauge until bulb gauge unlocks.
11. Remove gauge.
12. Repeat steps 2 through 11 for a total of five times per socket.
13. Insert a minimum material bulb gauge into socket.
14. Repeat steps 2 through 11 for a total of five times per socket.

Terminal Spring Force:

NOTE: This test requires the creation of two cylindrical gauge pins, one representing the minimum material condition of the bayonet bulb base electrical contact and one representing the maximum material condition of the bayonet bulb base electrical contact. Refer to IEC 60061-1 for the minimum and maximum dimensions for the bayonet bulb base electrical contacts.

1. Mount socket in appropriate mechanism to hold it securely.
2. Using automated test equipment, which is meant for precise compressive force measurements, insert the minimum diameter cylindrical metal pin into the socket at a rate of 50 mm/minute, pushing the terminal spring to the first of the two locations required for measurement of the spring force for the particular socket type in IEC 60061-2, Lamp Holders. Ensure that the pin does not touch the socket side walls during the insertion force test.
3. Record the spring deflection force measured for the minimum diameter cylindrical metal pin at the first of the two measurement locations.
4. Continue inserting the minimum diameter cylindrical metal pin at rate of 50 mm/minute into the socket until the pin reaches the second of the two locations required for measurement of the spring force for the particular socket type in IEC 60061-2, Lamp Holders.
5. Record the spring deflection force measured for the minimum diameter cylindrical metal pin at the second of the two measurement locations.
6. Repeat steps 2 through 6 for a total five times per socket.
7. Insert the maximum diameter cylindrical metal pin into the socket.
8. Repeat steps 2 through 6 for a total of five times per socket.

5.1.2.3 Acceptance Criteria

Using Minimum and Maximum Gauges to Measure Installation Torque and Lock Defeat Torque:

This acceptance criteria is for all tests with gauges, including those at the end of Test Sequence 3.

1. Installation torque is reference information that is to be supplied as part of the test report.
2. Lock defeat torque must be greater than 0.57 N-m for each socket and each cycle of testing.

Using Bulbs to Measure Lock Defeat Torque:

This criteria is for the tests at the end of Test Sequence 3 that involve measurements with bulbs.

1. Lock defeat torque must be greater than 0.57 N-m for each socket and each cycle of testing.

Using Pins to Measure Terminal Spring Force:

NOTE: This acceptance criteria applies for both Test Sequence 1 and Test Sequence 3.

1. Refer to IEC 60061-2 requirements for the spring deflection points for the spring force measurements. Supplier must explicitly cite these spring deflection force measurement locations on the test report using a pictorial similar to that in IEC 60061-2. The maximum allowable downward insertion force for P21W(BA15s), PY21W(BAU15s), P21/5W(BAY15d), P21/4W(BAZ15d), R5W(BA15s), and H21W(BAY9s) is 20 N.
2. Refer to IEC 60061-2 requirements for the spring deflection points for the spring force measurements. Supplier must explicitly cite these spring deflection force measurement locations on the test report using a pictorial similar to that in IEC 60061-2. The minimum allowable downward insertion force for P21W(BA15s), PY21W(BAU15s), P21/5W(BAY15d), P21/4W(BAZ15d), and R5W(BA15s) is 5 N. The minimum allowable downward insertion force for H21W(BAY*9s) is 3 N.

5.2 Socket Insertion/Removal Torque/Force

The device must fasten into the lamp assembly in a positive and secure manner.

5.2.1 Test and Measurement Apparatus (Twist-In Sockets)

1. Test panel with maximum material thickness and minimum dimension socket hole.
2. Test panel with minimum material thickness and maximum dimension socket hole.
3. Torque wrench capable of 5.7 N-m maximum with 0.05 N-m accuracy.

5.2.2 Procedure (Twist-In Sockets)

1. Insert socket into the maximum material thickness test panel.
2. Rotate socket with torque wrench until fully installed.
3. Record maximum force in N-m.
4. Unlock socket locking mechanism, if applicable.
5. Rotate socket (removal direction) with torque wrench until fully uninstalled.
6. Record maximum force in N-m.
7. Repeat steps 1 and 2 and 4 to 6 using minimum material thickness test panel.

5.2.3 Acceptance Criteria (Twist-in Sockets)

5.2.3.1 Maximum Material Thickness Panel

1. The maximum rotational torque for fully installing a socket in a maximum material condition application panel is 2.0 N-m for S8wedge or bayonet/GT8/T20 type and 1.3 N-m for W-2 type and H21W type.
2. The maximum rotational torque to remove a socket (with any operator actuated locking feature disengaged), in a maximum material condition application panel is 3.0 N-m for S8 wedge or bayonet/GT8/T20 and 2.5 N-m for W-2 type and H21W type.

5.2.3.2 Minimum Material Thickness Panel

The minimum rotational torque to remove a socket (with any operator actuated locking feature disengaged), in a minimum material thickness application panel is 1.0 N-m for S8wedge or bayonet/GT8/T20 and 0.7 N-m for W-2 type and H21W type.

5.2.4 Test and Measurement Apparatus (Snap-in Sockets)

1. Test panel with maximum material thickness and minimum dimension socket hole or mating circuit plate assembly.
2. Test panel with minimum material thickness and maximum dimension socket hole or mating circuit plate assembly.
3. Force gauge capable of 50.0 N.

5.2.5 Procedure (Snap-in Sockets)

1. Insert socket into maximum material thickness test panel at rate of 50 mm/min until snaps are fully engaged.
2. Record maximum installation force in N.
3. Disengage locking feature using force gauge applied on the snap 3 to 5 mm from the installation side of the test panel.
4. Record force necessary to unlock in N.
5. Repeat for each snap location.
6. Repeat steps 1 and 3 to 5 for a minimum material thickness test panel.

5.2.6 Acceptance Criteria (Snap-in Sockets)

1. The insertion force shall not exceed 40.0 N for unsealed sockets and 75.0 N for sealed sockets.
2. The lock disengagement force shall be between 5.0 N and 22.5 N.

5.3 Connector Insertion/Removal Force

Must meet connector-connector mating/un-mating force requirements of SAE/USCAR-2.

5.4 Bulb Wobble

This test is to ensure that the socket provides adequate support for the applicable bulb to retain the filament in the desired location, which will limit undo filament vibration or impact.