SAE International™

SAE/USCAR-15

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Specification For Testing Automotive Miniature Bulb Socket/Circuit Plate Assemblies

SUMMARY OF CONTENTS

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1. SCOPE

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

Tests shall follow the sequence shown in the flow charts in Appendix E whenever the following occurs:

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

Tests marked 'Yearly' in the following Test Schedule Table shall be run annually. Each test shall be run on 10 samples minimum; tests may be grouped, as supplier prefers, to reduce sample quantity or facilitate scheduling. Production process control data collected at a shorter interval per an approved control plan, may substituted if approved by customer's responsible engineer and purchasing representative.

Test Schedule Table

Test Title	Yearly
Voltage Drop	X
Isolation Resistance	
Temperature Rise	
1008 Hour Current Cycle	
Bulb Insertion/Removal Force	X
Socket Insertion/Removal Torque	X
Connector Insertion/Removal Force	X
Bulb Wobble	X
Socket Strength	X
Terminal Retention	X
System Seal Integrity	X
Wire To Terminal Crimp	X
Conductor Crimp Tensile Strength Requirement	X
Vibration	X
Mechanical Shock	
High Temperature Exposure	
Thermal Shock	
Cold	
Fluid Resistance	
Outgassing	
Salt Spray	
Ozone Resistance	
Temperature/Humidity Cycling	

2. REFERENCE STANDARDS

- AIAG/APQP-2: DaimlerChrysler, 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: DaimlerChrysler, Ford, and General Motors Production Part Approval Process Manual
- ASTM B117 (Standard Practice for Operating Salt Spray [Fog] Testing Apparatus)
- DaimlerChrysler, 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
- AIAG Fundamental Statistical Process Control Reference Manual
- SAE J573 Miniature Lamp Bulbs
- IEC 60061-1 Lamp Caps
- EEC R37
- SAE J1330 Photometry Laboratory Accuracy Guidelines
- Q7-K: DaimlerChrysler, Ford Motor Company and General Motors QS-9000 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 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 retention of test documents or records:
Retain records that will evidence compliance so that 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.

Retain records as needed to assist in evidencing the exercise of “due care” in matters relating to product compliance, government requirements, or product liability.

Comply 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. (See Appendix.)

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 one hour of production. Test sockets are to be subjected to production intent processing, including final packaging.

For example: A test sample size of 10 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.

3.2.3. Sample Retention

Samples tested to attain part approval must be retained by the socket manufacturer for a period of time specified in the AIAG/PPAP-3: DaimlerChrysler, 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. Where 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 volt from the nominal setting over the entire load range (including surges). The power source must recover 63% of its maximum excursion within 5.0 milliseconds. 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 ± 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 ± 2.0%

NOTE: Not to be used for performance dependent variable; see section: Measurement Accuracy.

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 DaimlerChrysler, 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 one-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 +/- 5°C
- Relative Humidity = Ambient

3.8.2. Wires For Test

20-gauge wire

3.8.3. Test Voltage/Current

Voltage = 14.0 V dc + 0.1/ - 0.0 V dc
Current = Socket classification table

Socket Classification Table

SOCKET CLASSIFICATION	USED WITH BULB TYPE	VOLTAGE TEST DEVICE – SHORTED BULB	TEST CURRENT (amps) +/- 1%	
			MAJOR	MINOR
I	S8 Wedge/GT8	S8/GT8 Voltage Test Device Figure	2.4	0.6
II	T3 ¼ & T5	Shorted W2 Bulb	1.5	N.A.
III	T1 ¾	Shorted W1 Bulb	0.3	N.A.
Other*				

*For other bulb type sockets, test currents shall be agreed to by the 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: DaimlerChrysler, 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: DaimlerChrysler, 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 DaimlerChrysler 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 described in the Socket Classification Table and illustrated in Appendix D, Voltage Test Device Figure.

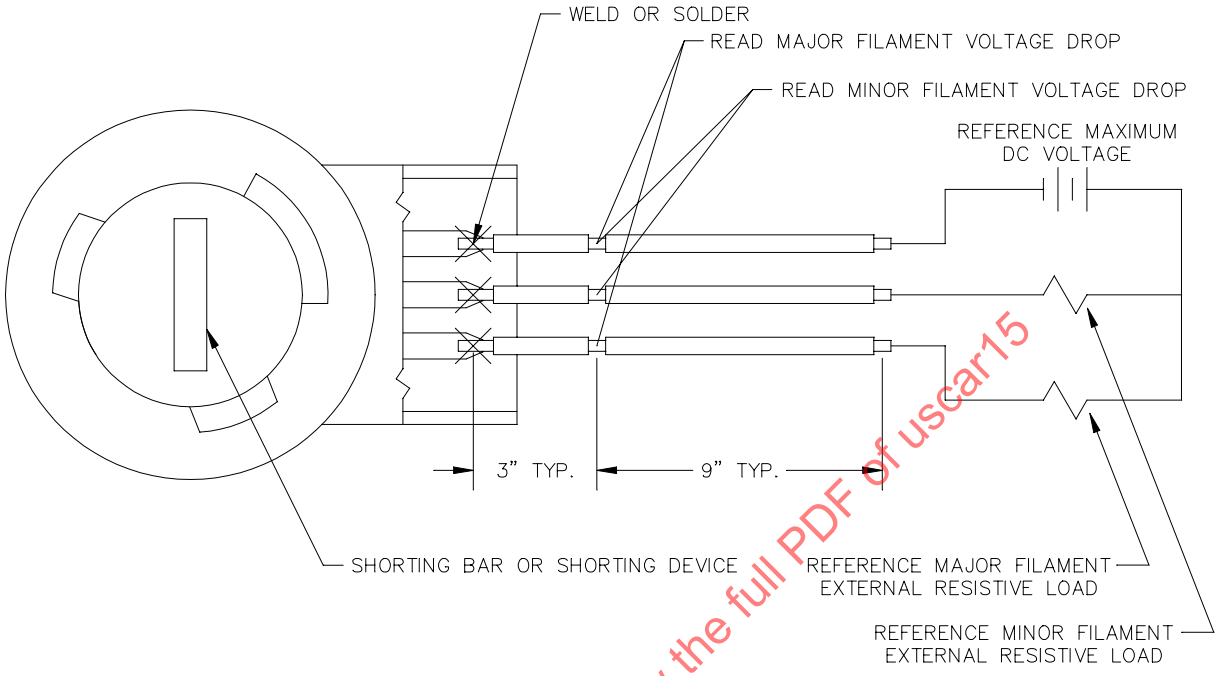
4.1.2. Procedure

4.1.2.1. Connector-less and Connector Type Sockets

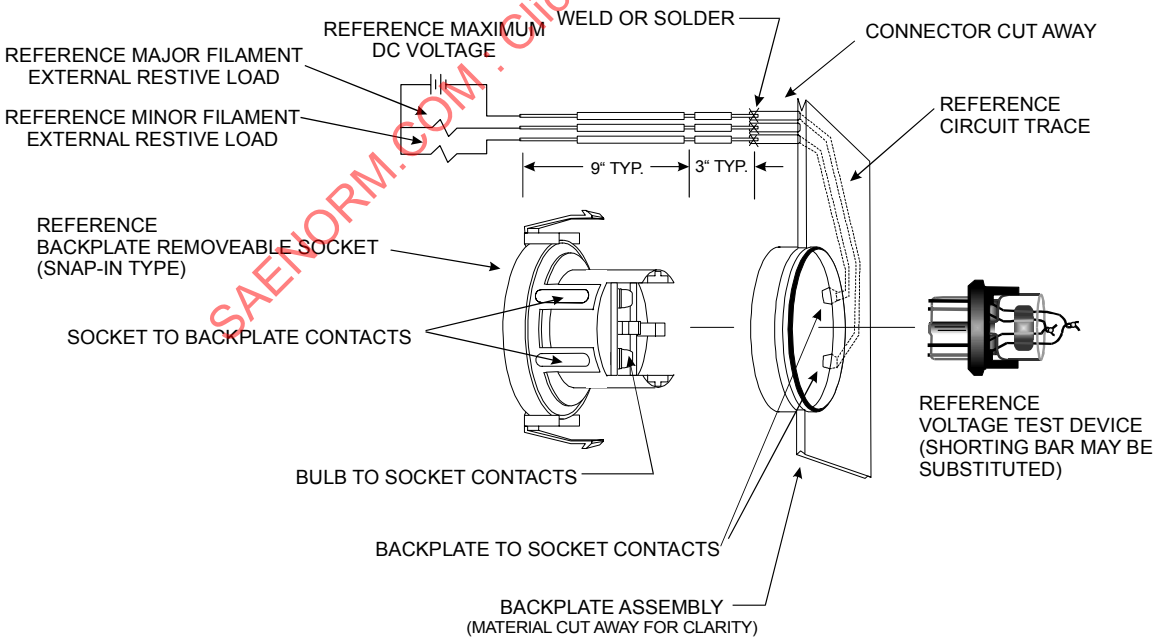
1. Determine and record millivolt drop across Voltage Test Device at test current.
2. Install the required Voltage Test Device.
3. Complete the circuit as shown in the diagram below.
4. Attach the millivolt leads. All millivolt leads must be no larger than 0.060 mm^2 (30 AWG).
5. Power the circuit at reference maximum operating current (per Socket Classification Table) 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.
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 mm^2 (30 AWG).
7. Power the circuit reference maximum operating current (per Socket Classification Table) 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

Megohmeter

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 Megohmeter, set to 500 VDC, to the bared conductor ends from any pair of adjacent terminals in the connector system.
3. Use the Megohmeter to measure the resistance between the adjacent terminals. Apply the test voltage continuously for at least 15 sec.
4. Record the minimum resistance measured.
5. Repeat steps 1-4 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 Megohms at 500 VDC. This includes terminals that may be separated by 1 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 (0-20 VDC @ 0-150A)
- Reference resistive load
- Thermocouples (Type “J” or “T”) and temperature indicator
- Temperature Chamber
- Voltage Test Device - Socket Classification Table – (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 as listed in the Socket Classification Table.
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 current listed in the Socket Classification Table.
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 figure Temperature Rise Thermocouple Placement.
5. Temperature Rise must be recorded for all contact interfaces. Separate sockets may be used for each tested contact.
6. Place test samples in the temperature chamber at 85°C 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 of 105°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 which electrically heats the socket/circuit plate assembly interfaces, 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 (0-20 VDC @ 0-150 A, timer controlled)
- Current shunts (Size as required, ± 1%)
- Thermocouples (Type "J" or "T")
- Data Logger (As required)

4.4.2. Procedure

1. Assemble the circuit per section: Voltage Drop, in a draft free environment. Use a timer controlled power supply to provide 45 minutes 'ON' and 15 minutes 'OFF' at the maximum test current previously determined per Socket Classification Table. Measure and record the Voltage Drop per section: Voltage Drop.
2. 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.
3. Turn 'ON' the power supply, DMM's, and data logger.
4. After 40 minutes into the first 'ON' cycle, record millivolt drop readings for each socket/circuit plate assembly.
5. Cycle for 1008 hours. Record readings at least once daily, 40 minutes into an 'ON' cycle.
6. 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 section: Voltage Drop at any time during the test.

5. MECHANICAL PERFORMANCE

5.1. Bulb Insertion/Removal Force

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

5.1.1. Test and Measurement Apparatus

- Maximum material condition bulb gauge
- Minimum material condition bulb gauge
- Chatillon force gauge or equivalent
- Appropriate mechanism to hold socket securely

Note: Refer to IEC 60061-1 Lamp Caps

5.1.2. Procedure

1. Mount socket in appropriate mechanism to hold it securely.
2. Using force gauge fully seat, at a rate of 50 mm/min., the maximum material bulb into the socket.
3. Record the maximum force in newtons.

Caution Do not over insert gauge.

4. Using a force gauge remove 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 5 times per socket.
7. Insert a minimum material bulb gauge into socket.
8. Using a force gauge remove 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 5 times per socket.

5.1.3. Acceptance Criteria

A. Using a maximum material condition bulb gauge, the maximum allowable insertion force is 75.0 N (16.8 lbs) for S8/GT8 and 45.0 N [10.0 lbs.] for W-2
B. Using the maximum material condition bulb gauge the maximum removal force is 65.0 N (14.6 lbs) for S8/GT8 and 42.0 N (9.4 lbs) for W-2.
C. Using a minimum material condition bulb gauge, the minimum required removal force is 15.0 N (3.4 lbs) for S87/GT8 and 5.0 N (1.0 lbs) for W-2.

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 / 50.0 in.-lb. maximum with 0.5 in.-lb. 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 or in.-lbs.
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 or in.-lbs.
7. Repeat steps 1-2 and 4-6 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 [17.7 in.-lb.] for S8/GT8 type and 1.3 N-M [11.5 in.-lb.] for W-2 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 [26.6 in.-lb.] for S8/GT8 and 2.5 N-M [22.0 in.-lb.] for W-2 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 condition application panel is 1.5 N-M [13.0 in.-lb.] for S8/GT8 and 0.8 N-M [7.0 in.-lb.] for W-2 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, [11.0 lbs].

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 or lbs.
3. Disengage locking feature using force gauge applied on the snap at a distance of 3mm to 5mm from the installation side of the test panel.
4. Record force necessary to un-lock in N or lbs.
5. Repeat for each snap location.
6. Repeat steps 1 and 3-5 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 [9.0 lbs] for unsealed sockets and 75.0 N [16.8 lbs] for sealed sockets.
2. The lock disengagement force shall be between 5.0 N and 22.5 N. [1 lb and 5 lbs.]

5.3. Connector Insertion/Removal Force

Must meet connector-connector mating/unmating force requirements of SAE/USCAR-2 Performance Specification For Automotive Electrical Connector Systems.

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.

5.4.1. Test and Measurement Apparatus

- Force Tester with Peak Reading Feature
- Minimum material condition application panel gauge
- Minimum material condition Bulb Focal Length Gauge.
- Refer to SAE J573 Miniature Lamp Bulbs and ECE R37 for focal length dimension

5.4.2. Procedure

1. Rigidly hold the socket and install a minimum material condition focal length gauge in the socket.
2. Apply a 4.5 N force for Type 1 sockets (per Socket Classification Table) 2.2 N force for Type 2 sockets (per Socket Classification Table) and 1.1 N for Type 3 sockets (per Socket Classification Table) in each of four directions to the gauge at the focal length, perpendicular and parallel to the bulb filament, and perpendicular to the socket axis (as shown in Figure Bulb Wobble).
3. Record gauge movement as measured in each of the four directions.

5.4.3. Acceptance Criteria

The maximum allowable movement at the filament location of the focal length gauge in any direction is 1.5 mm.

5.5. Socket Strength

This test is to ensure that the socket with its component parts has adequate strength to withstand normal handling forces without functional damage, distortion, or disassembly.

5.5.1. Test and Measurement Apparatus

- Insertion/ Extraction Force / Torque Testers with Peak Reading Feature
- Reference Minimum / Maximum material condition application panel gauges

5.5.2. Procedure

5.5.2.1. Axial/Lateral Load

1. Install the socket in a reference minimum material condition application panel gauge.
2. Apply a 120 N force in each of four directions on axial sockets and two directions on right angle sockets to the socket as shown in Figures Socket Strength (Right Angle) and Socket Strength (Axial).
3. Apply a 120 N axial removal force to the socket as shown in figures Socket Strength (Right Angle) and Socket Strength (Axial).

5.5.2.2. Torsional Load -Twist-In Sockets

Rotate socket using a torque wrench until it reaches the accepted minimum torque (See section Acceptance Criteria), or until it goes beyond the stop position.

5.5.3. Acceptance Criteria

A. Visually inspect the socket for signs of functional damage, distortion, or component disassembly.
B. The socket must be free of defects that could affect its electrical, mechanical, or long-term performance.
C. Any signs of functional damage shall indicate failure.
D. Minimum torque to go beyond stop position must exceed 6.0 N-M for S8/GT8 type socket/circuit plate assemblies.
E. Minimum torque to go beyond stop position must exceed 2.0 N-M for T3 ¼ and T5 type socket/circuit plate assemblies.

5.6. Terminal Retention

Must meet connector mechanical test extraction force requirements of SAE/USCAR-2 Performance Specification For Automotive Electrical Connector Systems; see subsection: Extraction Force of section: Terminal-Connector Insertion/Extraction Force.

5.7. System Seal Integrity

This test evaluates the sealing capability of a sealed connector type or sealed connector-less socket systems when subjected to a specified pressure differential between the inside and outside of the sealed area.

This test is to be used for sealed socket systems only.

5.7.1. Test and Measurement Apparatus

- Pressure/Vacuum Source (Regulated)
- Container (for sample immersion)
- Megohmeter (0.5% accuracy, Full Scale)
- Temperature Chamber (85° C)
- Test Fixture: (See Socket Pressure/Vacuum Test Figure 3)
- Florescent dye and ultraviolet lamp

5.7.2. Procedure

1. Use the smallest conductor size and insulation type for the socket or USCAR approved connector.
2. Install the socket assembly into the test fixture.
3. Prepare enough salt water solution to completely submerge all samples below the surface. Use tap water and add 15 to 16 grams of table salt per liter of water to make an approximate 5% solution. Add an appropriate ultraviolet dye to assist in the visual inspection for any ingress of solution into the test samples.
4. Slowly increase the air pressure inside the test fixture until the gauge reads 30 KPa
5. Apply a 45 N force at an increasing rate of 4.5 N per second, for 10 seconds, per figures Socket Strength (Right Angle) and Socket Strength (Axial).
6. Observe at 15 seconds elapse time, and repeat step 5 in each of the other 3 directions on axial sockets, and in the other 1 direction on angle sockets.
7. Record pressure after all pull directions.
8. Evaluate per acceptance criteria to determine continuance of test.
9. Reset pressure to 30 KPa.
10. Completely submerse test fixture and socket assembly into a container of the room temperature salt water solution. Use care to avoid submersing any wire ends.
11. Observe samples for 15 seconds, refer to acceptance criteria.
12. Switch the regulated source from pressure to vacuum and slowly apply 30 KPa of vacuum.
13. Remove from the salt water solution, shake off excess fluid and then carefully dry all exterior surfaces.
14. Repeat steps 5 and 6.
15. Record vacuum after all pull directions.
16. Perform the Isolation Resistance test.
17. Allow test enclosure to equalize with atmosphere.
18. Remove socket from test fixture, (when applicable remove connector), and visually inspect for evidence of water using the ultraviolet light. When disconnecting the samples, use care not to allow any residual solution to enter the interior of the socket and/or mating connector.
19. Reconnect socket and connector, then re-install socket assembly into the test fixture. Place the test fixture in a temperature chamber. Soak at 85°C, for 70 hours.
20. After the heat soak, remove the samples from the Chamber and immediately repeat steps 3-18, except limit pressure in Steps 4 and 9, and vacuum in Step 12, to 15 KPa
21. Inspect socket/circuit plate assembly circuit paths for evidence of water/moisture inclusion.

5.7.3. Acceptance Criteria

A. When samples are subjected to positive pressure, no air bubbles shall break to the surface. There shall be no more than 10% loss in the pressure that is initially applied.
B. After samples are subjected to vacuum, all must meet the Acceptance Criteria of the Isolation Resistance test.
C. Remove socket from test fixture, (when applicable remove connector), and using ultraviolet light, confirm no evidence of water. When disconnecting the samples, use care not to allow any residual solution to enter the interior of the socket and/or mating connector.

5.8. Wire to Terminal Crimp

Sockets that include wire must comply with the following requirements.

5.8.1. Test and Measurement Apparatus

- Wire Pull Tester

5.8.2. Procedure

1. The wire must be stripped to the appropriate length so that the insulation does not contact the conductor grip.
2. Pull a minimum of five random right angle bends, at a pull force of 25.0 N, when gripped 30.0 mm from the insulation crimp.

5.8.3. Acceptance Criteria

1. There shall be no signs of tearing or cracking in the grip of the transition area between the terminal body and the terminal grip.
2. No part of insulation shall be released from the crimp.

5.9. Conductor Crimp Tensile Strength Requirement

Sockets that include wire must meet the following tensile strength requirement. This is a test of the wire to terminal interface. This test can be performed on conductor and wire, outside of socket assembly.

5.9.1. Test and Measurement Apparatus

Wire Pull Tester

5.9.2. Procedure

1. The tensile test is to be performed without crimping the insulation grip.
2. Secure assemblies into Pull test fixture so that conductor tensile will be evaluated.
3. Pull wire out at a rate of 25.4mm (1 inch) per minute.

5.9.3. Acceptance Criteria

The minimum tensile strength of the conductor grip crimped onto the wire is as follows:

18 gauge wire	111.0 N (25.0 lbs)
20 gauge wire	89.0 N (20.0 lbs)
22 gauge wire	62.0 N (14.0 lbs)

5.10. Vibration

The objective of this test is to verify that the design and construction of the lamp socket assembly or connector plate assembly is sufficiently robust to withstand normal vehicle Vibration.

5.10.1. Test and Measurement Apparatus

- Close loop Vibration controllers which are capable of maintaining a tolerance of +/- 4.0 dB from the nominal, over the entire range of 10 to 2000 Hz.
- Mounting fixture that will rigidly hold the socket/circuit plate assembly.
- Volt meter
- DC Power Supply (0-20 VDC @ 0-150A)
- Reference resistive load
- Thermocouples (Type “J” or “T”)
- Voltage Test Device - Socket Classification Table

5.10.2. Procedure

1. Mount assemblies rigidly in the fixture with filaments parallel to the ground in such a manner that voltage can be applied to the socket during the test.
2. Install appropriate Voltage Test Device, according to Socket Classification Table. Shorted bulb shall be used for this test. Optional solid metal shorting bar shall not be used for this test. (In the case of S8 and GT8, this test procedure shall be run using both glass base and plastic base type bulbs.)
3. The Temperature Rise will be monitored by thermocouples placed as close as possible to the powered contact area (bulb and terminal area) on the terminals without restricting or interfering with the contact area.
4. A thermocouple shall be placed on each of the positive and the negative energized terminals (on one sample only).
5. Vibrate the assemblies using the test profile (Table Vibration Profile) for a total of 6 hours, in a plane perpendicular to the ground, with the major filament powered at 14.0 V and monitor voltage for continuity.

5.10.3. Test Profile

1. See table Vibration Profile
2. The breakpoints that should be used to define the random Vibration input to that test specimen are specified in Vibration Profile table

Vibration Profile Table

Frequency (Hz)	Magnitude (G^2/Hz)	Slope Between Points (dB/Octave)
*10	0.070	
*20	0.070	10 → 20 ------- (0.0)
40	0.020	20 → 40 --------(-5.42)
350	0.020	40 → 350 -------- (0.0)
550	0.005	350 → 550 -------- (-9.20)
700	0.001	550 → 700 --------(-20.02)
750	0.0001	700 → 750 -------- (-100.12)
2000	0.0001	750 → 2000 -------- (0.0)

Root mean square G power level = 3.2G
Maximum G level limited to 3 times the RMS level
Tolerance: =+/- 4.0 dB from 10 to 2000 Hz
*= Liner slopes on log-log plot only

5.10.4. Acceptance Criteria

1. Continuity – The mated lamp/socket assembly or circuit plate assembly shall not experience any intermittence or an increase of 0.5 volts across the lamp socket/ circuit plate contacts for a maximum of 2 milliseconds. (Testing determined this value as the minimum visible to the naked eye.) Continuity shall be monitored during the Vibration test.
2. The lamp socket/circuit plate assembly with the bulb installed shall not exceed a maximum temperature of 85° C at the contact interface while vibrating.
3. After completion of test, lamp socket/circuit plate assembly shall meet requirements of sections: Bulb Insertion/Removal Force and Voltage Drop.

5.11. Mechanical Shock

This test examines the bulb to socket interface under typical automotive conditions.

5.11.1. Test and Measurement Apparatus

- Volt meter
- Shock tester with appropriate fixture (Must have accelerometer capabilities)
- DC Power Supply (0-20 VDC @ 0-150A)
- Reference resistive load
- Thermocouples (Type “J” or “T”)
- Voltage Test Device - Socket Classification Table

5.11.2. Procedure

1. Mount the socket rigidly in the drop test fixture.
2. Power the circuit at reference maximum operating current (per Socket Classification Table) and wait 30 minutes minimum to ensure that the test current stabilizes at the appropriate value.
3. Monitor for circuit interruption.
4. Subject the assembly to three half sine shock pulses in each direction along three mutually perpendicular axes at a level of 20 ± 5 G peak, 11 ± 2 milliseconds duration.

5.11.3. Acceptance Criteria

The assembly shall not experience any intermittence greater than 2.0 milliseconds.

6. ENVIRONMENTAL PERFORMANCE

6.1. High Temperature Exposure

This test examines the effects of long term High Temperature Exposure, typical of automotive environments.

6.1.1. Test and Measurement Apparatus

- Heat chamber
- Power supply
- Maximum and minimum material test plaques
- Appropriate data logger

6.1.2. Procedure

1. Place the assemblies in the test chamber.
2. Power the highest wattage filament at 14.0 Vdc.
3. Subject the assemblies to 85°C for 1008 hours.
4. Allow assemblies to cool to room temperature before performing any other tests.

6.1.3. Acceptance Criteria

1. The lamp socket/circuit plate assembly shall meet the requirements of section: Voltage Drop.
2. The socket/circuit plate assembly shall show no evidence of visible fractures, warpage or deformation.
3. Per section: Bulb Insertion/Removal Force, using minimum material bulb gauge verify minimum removal force is 11.1N (2.5 lbs) for S-8/GT-8 type, and 3.7N (0.8 lbs) for W-2 type.

6.2. Thermal Shock

This test is to stress the material and assembly to temperature extremes. This test is to be run on all lamp socket/circuit plate assemblies.

6.2.1. Test and Measurement Apparatus

- Air Circulating Heat Chamber
- Air Circulating Cold Chamber

6.2.2. Procedure

1. The lamp socket assembly shall withstand a total of 125 cycles (125 hours) of exposure cycling between -40°C (air circulating chamber) and 85°C (air circulating chamber) with 29 minute dwell at each temperature and 2 minutes maximum transfer time between temperatures.
2. Samples shall not be powered.

6.2.3. Acceptance Criteria

After Thermal Cycling, the lamp socket/circuit plate assembly shall meet the requirements of section: Voltage Drop.

6.3. Cold

This test is to verify that the bulb to socket interface dies not change after exposure to cold.

6.3.1. Test and Measurement Apparatus

Cold chamber

6.3.2. Procedure

1. Insert bulbs in sockets.
2. Place lamp socket/circuit plate assemblies in Cold chamber.
3. Maintain the sockets at -40˚ for 120 hours.
4. Samples shall not be powered.
5. After 120 hours soak, remove samples from test chamber and allow samples to reach room temperature .
6. Run Bulb Insertion/Removal.

6.3.3. Acceptance Criteria

After exposure, a lamp socket/circuit plate assembly shall meet the requirements of section: Bulb Insertion/Removal.

6.4. Fluid Resistance

This test evaluates the material compatibility when immersed in various fluids commonly found in and around road vehicles.

6.4.1. Equipment

- Laboratory Fume Hood
- Stainless steel tanks or Pyrex beakers
- Explosion-proof Heat Chamber

6.4.2. Procedure

1. A minimum of 1 socket/circuit plate assemblies per test fluid are required. Assembly must include all applicable Wedges (TPAs, PLRs, etc.), Seals, etc.
2. Completely submerse at least 1 test sample in each fluid listed below for 30 minutes. Fluids are to be stabilized at specified temperatures. Each sample is to be submersed in one fluid only, unless otherwise requested.

CAUTION: Follow all Federal, state, and local safety regulations, standards, and procedures when performing this test.

Fluid Table

FLUID TYPE	FLUID DESCRIPTION	STABLIZATION TEMPERATURE
Brake Fluid	SAE RM66-04	50° C
Oil	ASTM IRM-902	50° C
Gasoline	ASTM Ref. Fuel C	25° C
Engine Coolant	ASTM Serv. Fluid 104	100° C
Automatic Transmission Fluid	Citgo #33123	50° C
Windshield Washer Solvent	50% Isopropyl Alcohol + 50% Water	25° C
Power Steering Fluid	ASTM IRM-903	50° C
Diesel Fuel	90% IRM 903 + 10% P-Xylene	25° C
E85 Ethanol Fuel	85% Ethanol + 15% ASTM reference fuel C	25° C
Tar Remover	45% Xylene + 55% Petroleum base mineral spirits	25° C
Engine Cleaner	Tital Bafal – Parafin wax CH4, Ethylene Glycol, Benzene, detergent	25° C
Grease	Petroleum base	25° C

3. At the conclusion of the submersion period, remove the sample from the fluid. Do NOT shake off any excess fluid. Leave the samples "wet" and store them in a suitable area at room temperature for one week. Do not allow samples submersed in different fluids to touch each other and do not allow any dissimilar fluid drippings to intermingle.
4. At the conclusion of the storage period, samples may be dried sufficiently to allow inspection and to avoid contamination of test apparatus.

6.4.3. Acceptance Criteria

There must be no visible degradation, swelling, cracking, or loss of mechanical function evident on any test sample, examined with the aid of a 10X magnifying glass.

6.5. Outgassing

The Outgassing Test is intended to ensure that the socket/circuit plate assembly will not distort or out-gas to cause a fog precipitate to form on reflectors or lenses of a lamp assembly in which they may be used.

6.5.1. Test and Measurement Apparatus

- Enclosures shown in figure Heat Test Enclosures, modified to include removable clear glass (see figure Heat Test Enclosure). The enclosure socket/circuit plate assembly mounting is to be constructed of materials, such as metal and ceramic that will not outgas during the test.
- Air circulating heat chamber.
- Power supply.

6.5.2. Procedure

Perform this test on representative socket/circuit plate assemblies for the relevant test condition specified in the Outgassing Test Conditions Table and quantities per Appendix flow chart. The glass is to be cleaned with glass cleaner and alcohol before testing each socket/circuit plate assembly. Mount the socket/circuit plate assembly in the enclosure.

Option 1: Place the enclosure in the test chamber and bring the test chamber to 50°C. Energize the bulb at 14 Volts in the socket/circuit plate assembly as specified in Outgassing Test Conditions Table for 10 days. After this 10 day period, discontinue voltage and allow the enclosure to cool to room temperature.

Option 2: On test bench, at ambient temperature (23.5°C ± 5°C). Energize the bulb at 14 Volts in the socket/circuit plate assembly as specified in Outgassing Test Conditions Table for 30 days. After this 30 day period, discontinue voltage.

Outgassing Test Conditions Table

Bulb Family	Test Load (Bulb Trade Number)	Continuous On	Flashing	Enclosure
T - 1 ¾	74	X		A
T - 2 ¾	24		X	A
T - 3 ¼	175		X	A
T – 5	921	X		B
S-8/GT-8 Major and Minor*	3457	X (minor)	X (major)	B
S-8/GT-8 Major and Minor*	4157	X (major)		B
Others*	Supplied by OEM lighting engineer	X (minor)	X (major)	B

*Both filaments must be tested simultaneously on the same bulbs.

6.5.3. Acceptance Criteria

After the test, the socket must not be distorted. The socket must function normally, and the labeling must be legible. Any indication of Outgassing on the glass is a failure.

6.6. Salt Spray

This test is applicable to sealed socket/circuit plate assemblies. The objective is to evaluate the integrity of the sealed socket/circuit plate assemblies when subjected to a Salt Spray.

6.6.1. Test and Measurement Apparatus

Use the test equipment described in ASTM B117, Standard Practice for Operating Salt Spray (Fog) Testing Apparatus.

6.6.2. Procedure

1. Attach the lamp socket/circuit plate assembly to be tested to minimum material test fixture. Test the lamp socket/circuit plate assembly in car position.
2. Perform a Salt Spray test according to ASTM B117 for 96 hours on assemblies, per the following:
   a. Place a sealed socket/circuit plate assembly in a minimum material test fixture, in a constant temperature oven of 35˚C.
   b. For duration of the test, power sockets/circuit plate assemblies, with bulbs installed, for 45 minutes on and 15 minutes off.
   c. Spray the socket with a salt solution, per ASTM B117, for 47 hours.
   d. After 47 hours, turn off Salt Spray and power.
   e. Allow socket to dry (un-powered) for 1 hour.
   f. Repeat c through e for a total test time of 96 hours.
   g. Remove samples from test chamber.
3. Measure the assemblies immediately after removing from the test chamber.

6.6.3. Acceptance Criteria

After Salt Spray testing, the socket/circuit plate assembly must meet all requirements of sections: Isolation Resistance. Visually inspect for functional damage, distortion and ensure that any labeling is still legible.

6.7. Ozone Resistance

This test is to evaluate the socket/circuit plate assembly resistance to Ozone.

6.7.1. Test and Measurement Apparatus

Ozone chamber

6.7.2. Procedure

1. Check Voltage Drop per Voltage Drop section.
2. Suspend the socket/circuit plate assembly in the sealed chamber maintained at 50 ± 5ppm for 24 hours.
3. Remove the sockets, then leave at room temperature for 24 hours.
4. Check samples per sections Voltage Drop and Isolation Resistance.

6.7.3. Acceptance Criteria

Socket/circuit plate assembly must be free of visible damage or degradation (including labeling). The socket/circuit plate assembly must pass section: Isolation Resistance and section: Voltage Drop.

6.8. Temperature/Humidity Cycling

This test will evaluate the electrical integrity of the socket/circuit plate assembly in high humidly/temperature environments.

6.8.1. Test and Measurement Apparatus

Environmental chamber capable of high and low temperatures and humidity.

6.8.2. Procedure

1. Run Voltage Drop baseline per section Voltage Drop.
2. The lamp socket/circuit plate assembly shall withstand 15 cycles of the following exposure.

    - 16 HRS at 95% relative humidity at 38°C
    - 2 HRS at -40°C
    - 2 HRS at 85°C
    - 4 HRS at Room Ambient

3. Check samples per Voltage Drop Test.

**Note: Store test assemblies in a humidity chamber, exposed to 95% relative humidity at 38°C, any time active testing is not in progress, such as over weekends and holidays.

6.8.3. Acceptance Criteria

The lamp socket/circuit plate assembly shall meet the requirements of section: Voltage Drop immediately after conditioning.

APPENDIX A: ABBREVIATIONS

°C – Degree(s) Centigrade

AIAG – Automotive Industry Action Group

ANSI – American National Standards Institute

ASTM – American Society for Testing and Materials

dB - Decibels

DC – Direct Current

DFMEA – Design Failure Mode Effects Analysis

DMM – Digital Multi Meter

EWCAP – Electrical Wiring Component Application Partnership

FTA – Fault Tree Analysis

In-lb – Inch pound(s)

kPa – Kilopascal

lb - Pound

mm – millimeter

Mv – Millivolt

mv/A – Millivolt per amphere

N - Newton

N-M – Newton-Meters

PFMEA – Process Failure Mode Effects Analysis

PLR – Positive Lock Reinforcement.

PPAP – Production Part Approval Process

PSIG – Pound Per Square Inch

SAE – Society of Automotive Engineers

TPA – Terminal Position Assurance (See PLR)

USCAR – United States Council for Automotive Research

VDC – Volts Direct Current

Wedge/Spacer – See PLR

APPENDIX B: GLOSSARY

Bulb Holder – (See Socket)

Bulb-to-Socket Insertion Force – The force required to completely seat the bulb into the socket.

Circuit plate assembly- A device using printed circuitry, microchips, electric wiring and connections that is intended to hold the one or more bulbs in a specific location and position when assembled to a lamp.

Connector – An electrical interface device that mates with a socket (Reference SAE USCAR-2 Performance Standard for Automotive Electrical Connector Systems).

Connector Mating Force – The force required to completely seat the male connector into the female socket connection.

Connector Socket – A socket requiring a mating connector.

Connector-less Socket – A socket which does not require a mating connector and has built in wire leads.

Contact – The junction of two electrical conductors through which a current passes.

Contact Force – Force between 2 electrical conductors.

Contact Resistance – Electrical resistance between 2 conductors.

Direct connect wedge base socket (Connector-less Type)- A device, including a terminated connection, that holds a wedge base bulb in a specific location and position when assembled to a lamp, integral to a wire harness.

Female Terminal – The electrical receptacle that receives the male blade or pin.

Flash – Excess material that is found on components at the parting lines. Usually the result of plastic seeping in between the sections of a mold.

Insertion Torque – The rotational force required to fully install a socket into its mating panel.

Isolation Resistance – The ability of the socket/circuit plate assembly to retard current leakage between conductors.

Male Connector – The connector that houses the female terminal(s).

Male Terminal – The metal blade or pin that inserts into the female terminal.

Miniature Bulb – Miniature incandescent bulbs for use in automotive illumination and signaling applications. (Reference SAE USCAR-3 Specification for Testing Automotive Miniature Bulbs)

PLR – Positive Lock Reinforcement. Also known as a Wedge, Spacer or Terminal Position Assurance (TPA) feature. It is installed or seated after the terminals are inserted into their housing to assure that the terminals are properly positioned. It either reinforces the primary terminals locking mechanism or provides a separate redundant terminal lock.

Socket – Miniature bulb retention device.

Terminal Retention Force – The Maximum force that can be exerted on an individual contact (terminal) without dislodging it from its proper installed position.

Test Lot – The production group of sockets from which test samples are selected. The minimum "Test Lot" is defined as one hour of production.

Wedge base socket (Connector Type)- A device that holds a wedge base bulb in a specific location and position when assembled to a lamp. Vehicle wiring requires a connector to mate to socket.

APPENDIX C: DESIGN GUIDELINES

This section gives general guidelines to be used during the socket/circuit plate assembly design stage. Various guidelines may not apply in all situations. Therefore, sound engineering judgment must be used in their application. Consider these guidelines as the basis for socket/circuit plate assemblies DFMEA's.

- Incorporate a positive lock reinforcement (PLR) feature on any snap together plastic finger-retaining feature, which is intended to hold the socket together, on all new socket assemblies. The device should be designed so that the assembly must be fully assembled before the PLR can be seated. This is to insure that the socket will not come apart through its life.

- Avoid parting lines on sealing surfaces. If parting lines cannot be avoided, sealing surface must be flat across mold parting lines and steel match lines.

- When using a multiple rib peripheral seal, design so that the sealing surface incorporates full utilization of all functional ribs in the worst-case statistical dimensional stack-ups.

- Avoid holes for seals that are irregular in shape or have interior corners.

- Design the socket to minimize light blockage between the filament and reflector.

- Use only USCAR recommended terminal systems in the socket to wire connector interface in new socket designs.

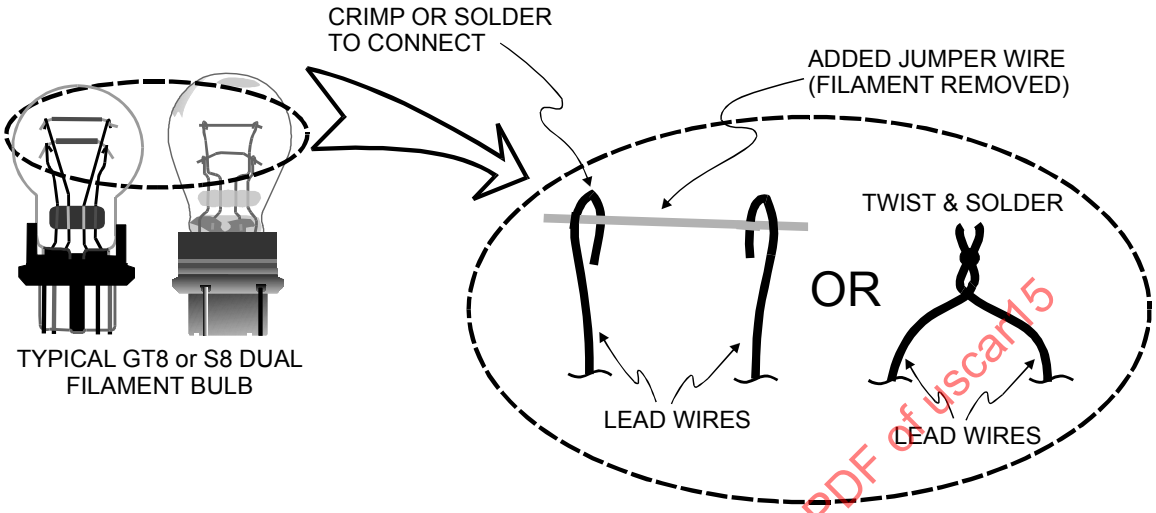
- On dual filament sockets, label terminal function on the connector/wire lead side of the socket. (Major, Minor, Gnd (Ground))

- When bulb contact terminal is inserted into the socket it should be protected by plastic or metal such that any insertion manipulation of the bulb cannot bend or change the original configuration of the terminal.

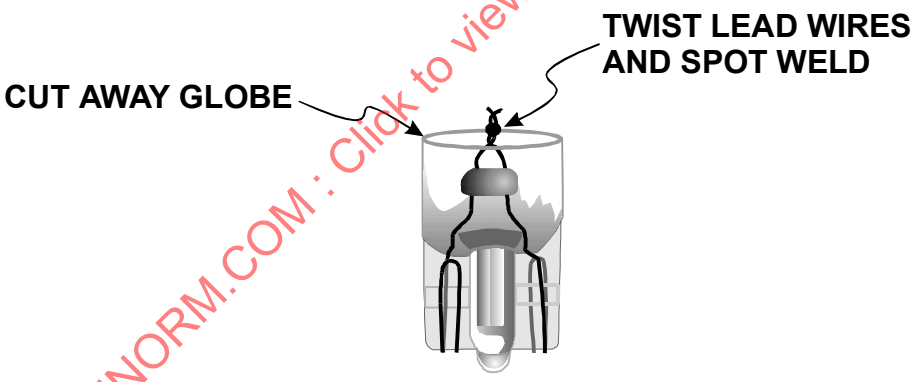
- All new W-2 wedge base bulb sockets should incorporate a wire-straightening feature to align the contact wire of the bulb with the appropriate socket contact terminal during bulb insertion. If this feature is not available then the socket terminal should be designed so that it will contact an out of position bulb lead wire.

- Insertion of the bulb into the device must be "user friendly" and require minimum effort and care from the user in regard to aligning the bulb prior to insertion. The design should be such that the bulb cannot be installed improperly, e.g., behind contact terminals.

APPENDIX D: FIGURES



S8/GT8 Voltage Test Device Figure



W2 Base Voltage Test Device Figure

Figure 1: W2 Base Voltage Test Device Figure

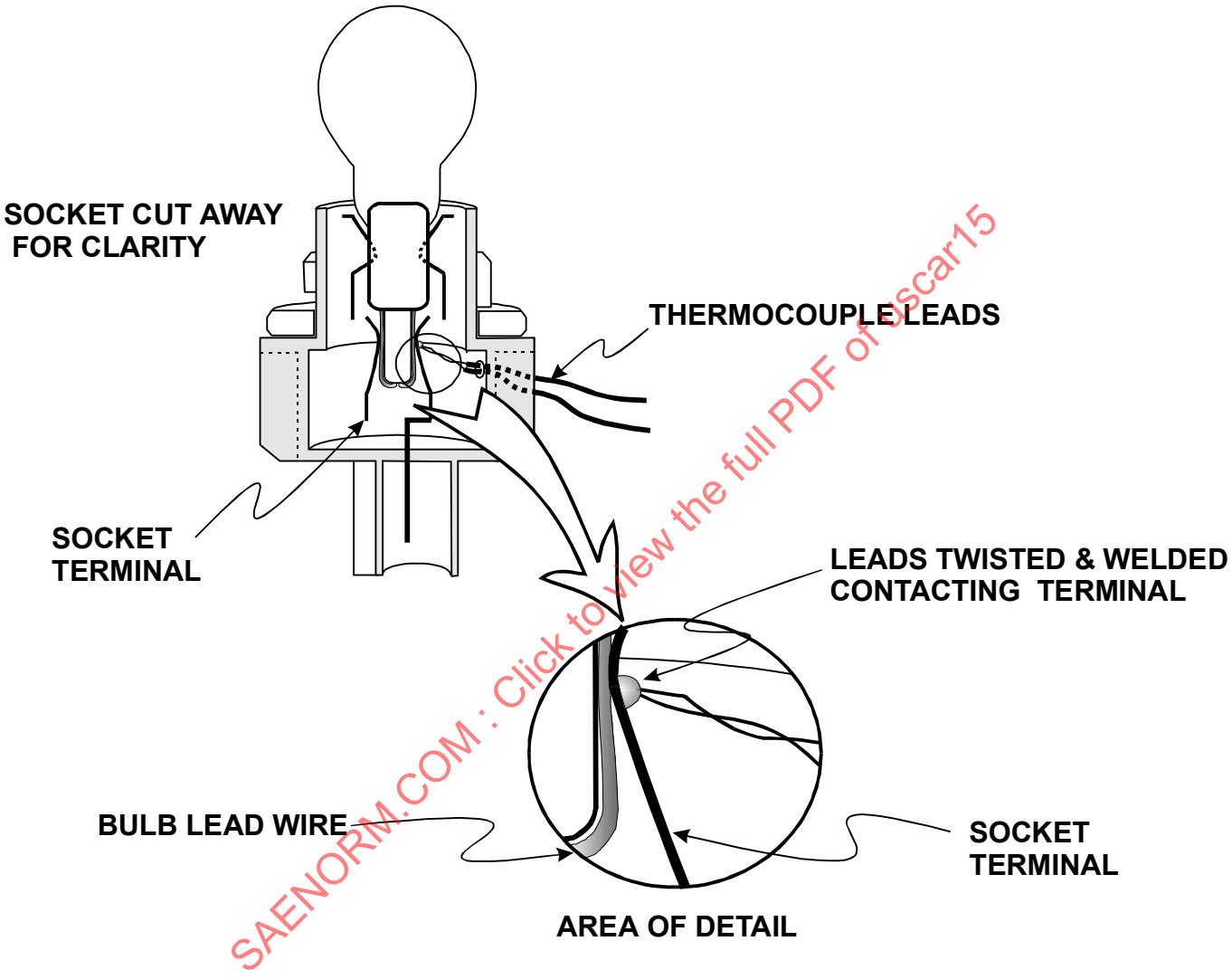


Figure 2: Temperature Rise Thermocouple Placement
(Socket design shown for reference only)

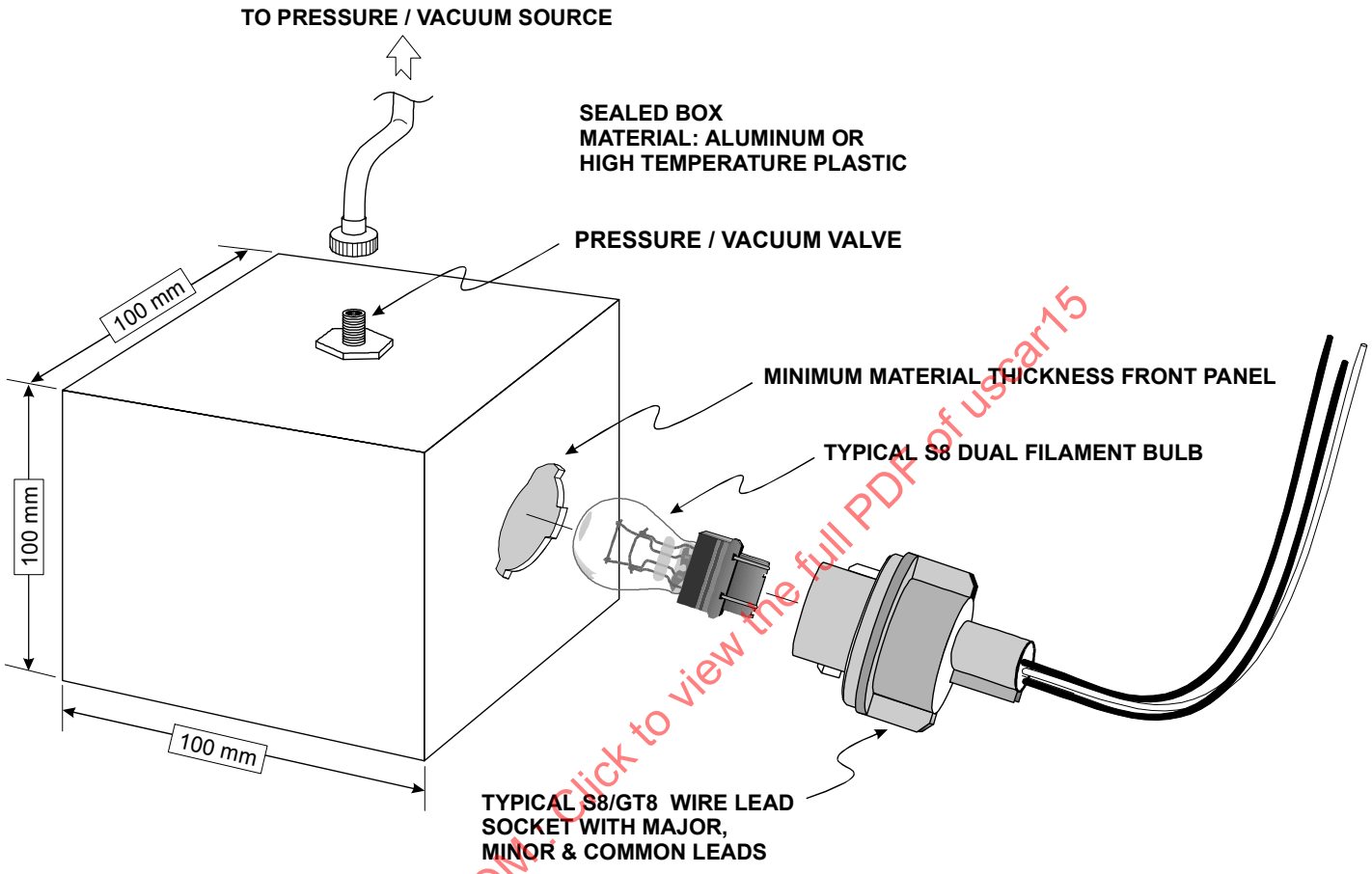


Figure 3: Socket Pressure/Vacuum Test Fixture
The separate socket is shown. Fixture for circuit plate assembly to accommodate that design.
(Dimensions are for reference only)

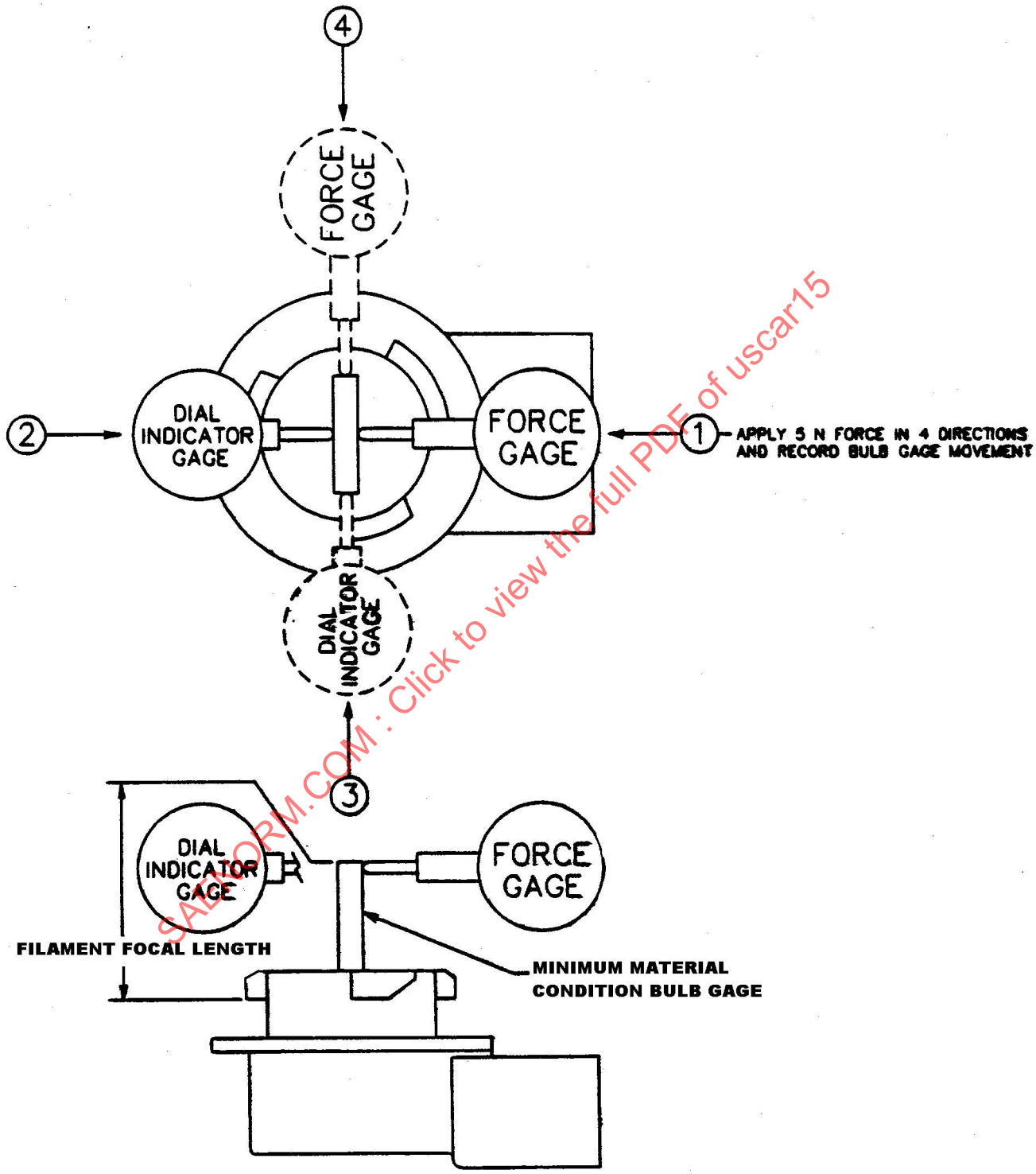


Figure 4: Bulb Wobble

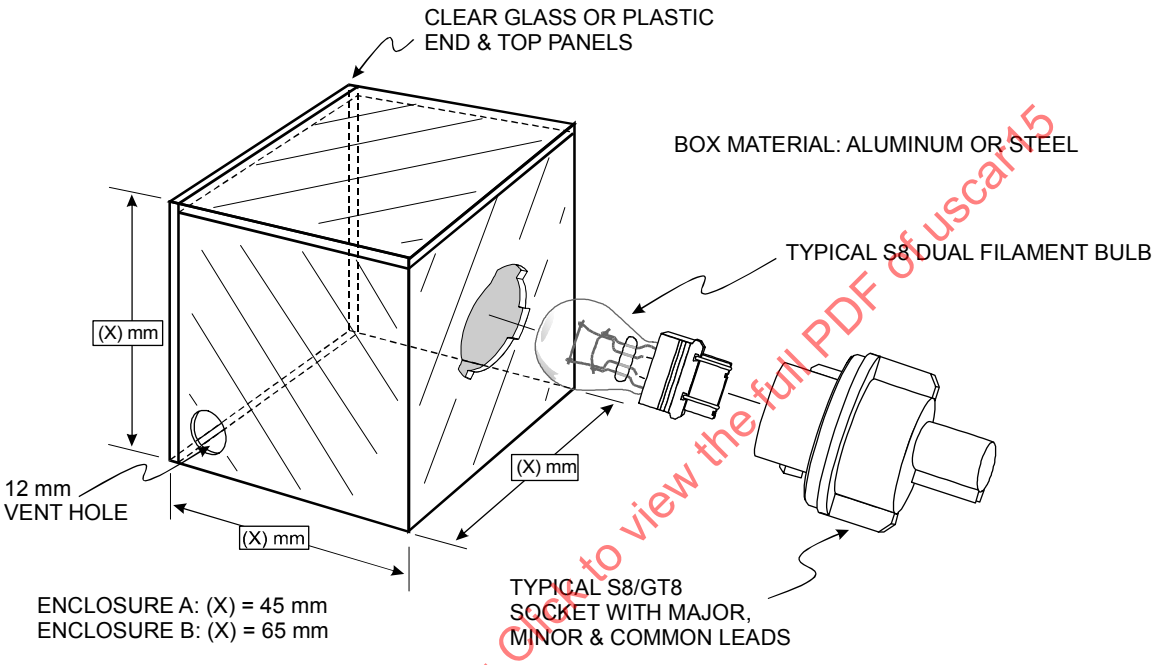


Figure 5: Outgassing
Separate socket shown. Enclosure for circuit plate assembly to accommodate that design.