The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
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SAE/USCAR-3A

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STANDARD FOR TESTING AUTOMOTIVE MINIATURE BULBS

SUMMARY OF CONTENTS

IMPORTANT NOTE:
Sections which experienced substantial changes with this revision are noted in the above Table of Contents by an *italicized*

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1. SCOPE:

This procedure covers the laboratory testing of miniature incandescent bulbs for use in automotive illumination and signaling applications.

2. REFERENCE STANDARDS:

DaimlerChrysler, Ford, and General Motors Advanced Product Quality Planning and Control Plan Reference Manual
Measurement Systems Analysis Reference Manual (AIAG)
Potential Failure Mode and Effects Analysis Reference Manual (SAE J1739)
DaimlerChrysler, Ford, and General Motors Production Part Approval Process Manual
ANSI (C78.390)
ASTM B 117 (Standard Practice for Operating Salt Spray [Fog] Testing Apparatus)
DaimlerChrysler, Ford, and General Motors Quality System Requirements - QS-9000 Manual
SAE J573, Miniature Lamp Bulbs
SAE J1330, Photometry Laboratory Accuracy Guidelines

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

3. DIAGRAMS AND DEFINITIONS:

3.1 Appendices:

Diagrams are provided at the end of this standard to clarify the details of the test procedures. A Glossary of Terms is also included as Appendix A.

3.2 Test Types:

3.2.1 Investigative Tests: Investigative tests are frequently used to evaluate specific areas of the design. They are a tool for evaluating design alternatives, proposed improvements, cost reduction proposals, determining root causes of field problems, or design reliability. These tests are for design evaluation only, do not have a success/failure criteria, and are often run to failure. The failure criteria section will indicate if the tests are for investigative purposes only. These tests must be performed in case of the following events:

1. a new bulb design
2. a design or process change made to an existing bulb, which could affect the outcome of the test
3. an initial submission, under this USCAR Standard
4. an initial submission to a USCAR constituant

3.2.2 Validation Tests: Validation tests must be initially passed for the part to be approved for use. Any test that is not designated for investigative purposes is considered a validation test and will have a specific criteria value stated. These tests must be performed in the following events:

1. a new bulb design
2. a design or process change made to an existing bulb, which could affect the outcome of the test
3. the completion of one calendar year (all validation test data must be less than one year old)

4. GENERAL REQUIREMENTS:

4.1 Record Retention:

Supplier must maintain a file for the storage of laboratory reports and calibration records, and establish a record retention policy 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.

4.1.1 Objectives of Record Retention: The following are the main objectives for retention of test documents or records:

1. 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.

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

3. Comply with statutory requirements for the maintenance and retention of specific records.

4.1.2 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.

4.2 Sample Documentation and Retention:

Engineering test samples must be identified by ANSI Trade Number and serial number unless otherwise noted. Documentation must identify the type of test to be performed and describe special tests that are not a part of this specification. (See Appendix.)

4.2.1 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.

4.2.2 Sample Selection: Select samples at random from pieces that are subjected to production intent processing, including final packing.

4.2.3 Sample Retention: Samples tested to attain part approval must be retained by the bulb manufacturer for a period of time specified in the PPAP Manual.

4.3 Power Sources:

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

4.3.1 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.

4.3.2 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.

4.4 Equipment Tolerances:

Supplier must use test setups and equipment capable of measuring test parameters (expressed in nominals) within the limits found in table 1.

TABLE 1

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 4.5 [Measurement Accuracy]).

4.5 Measurement Accuracy:

Meters and gages used to assess the performance dependent variable, as defined by the basic function of the test sample, must be capable of measuring to one count less than the specified value. For example, even though a 0.1 mm and 0.10 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.

4.6 Test Repeatability and Calibration:

4.6.1 Equipment Repeatability: All measurement equipment used for product evaluation must be repeatable to within 20% of the part tolerance according to DaimlerChrysler, Ford, and General Motors Measurement Systems Analysis Reference Manual (AIAG).

4.6.2 Equipment Calibration: Equipment used for measurement or verification of measurement must be periodically calibrated to known standards. Calibration interval must be consistent with industry practices but may not be more than 18 months.

4.6.3 Laboratory Masters: Bulbs which are traceable to known standards are laboratory masters. Each supplier must use laboratory masters for comparison measurements, calibration of test equipment, and for evaluating long-term drift in test equipment.

4.7 Test Default Conditions:

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

1. Test the bulb with the base and filament parallel to the ground as shown in figure B1.

2. Perform tests or measurements at the following ambient conditions:

   Room Temperature: ≥20°C
   Atmospheric Pressure: 650 – 800 mm Mercury

3. Conduct tests or measurements using the bulb's rated voltage.

4. Season the bulbs for 1% of the rated design life, 10 hours maximum at rated voltage, or an equivalent period at a higher (forced) voltage as defined in section 6.2 (Accelerated Life). Note the seasoning method used on the test report.

5. Whenever bulbs are operated at higher than rated voltages, switch them on at their rated voltage for at least 50 milliseconds and then step up to the appropriate rated voltage. This will limit the inrush current to the design level.

6. All tests are to be conducted at rated voltage as published by the American National Standards Institute, Inc., (ANSI) in Special Report 25, ANSI Assigned Minieature Lamp Codes.

4.8 Test Sharing Within Bulb Families:

The results of tests performed on one bulb type may, in some cases, be used to indicate the capability of another bulb type within the same bulb family. For example, a crush test performed on a clear, S-8, wedge bulb type may be used as a demonstration of the glass strength of all clear, S-8, wedge bulb types made by the same process from the same glass from the same source. Sound judgment must guide this practice. Bulbs within the same bulb family that share components such as glass envelopes, lead wires, filaments, bases, fill gases, etc., may be able to share test results. The customer will be the final authority on whether this surrogate data may be used.

4.9 Test Failure Procedure:

Should a test failure occur on a validation test, 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.

4.10 Control Plans:

Supplier must maintain a control plan, consistent with DaimlerChrysler, Ford, and General Motors Advanced Product Quality Planning and Control Plan Reference Manual, for each bulb type (or bulb family), that contains appropriate controls to ensure that all the significant/critical characteristics covered by the tests in sections 5 and 6 are within specifications. The control plan must be reviewed with and approved by the USCAR Light Bulb Task Force. Additional controls may be added to the approved control plan and then subsequently deleted at the supplier's discretion, without USCAR Task Force approval. If any part of the approved control plan is modified or deleted, the plan must be reapproved.

4.11 Reliability Programs and Methods:

4.11.1 Reliability Growth and Ongoing Quality Improvements: Bulb 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 bulb or manufacturing process are made to eliminate the failure modes.

4.11.1.1 Notification of Process Changes: Suppliers must notify the customer of manufacturing process or design changes to determine if resubmission for PPAP approval is required.

4.11.2 Quality/Reliability Improvement Tools: Suppliers must use appropriate methods to improve the quality and reliability of their products in accordance with QS-9000. Examples of such methods are Field Return Programs, Design Failure Mode Analysis (DFMA), Process Failure Mode Analysis (PFMA), and Fault Tree Analysis (FTA) or Fishbone Diagrams. Further information on these methods is available from the Automotive Industry Action Group (AIAG).

4.12 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 bulb. Any bulb 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.

Interim approvals for bulbs will be handled on an individual basis designated by the individual automotive manufacturer.

5. PHYSICAL PERFORMANCE:

These tests are intended to measure the innate characteristics of the bulbs. All data must be recorded according to section 4.1 (Record Retention).

5.1 Physical Dimensions:

The purpose of this examination is to verify that all of the physical dimensions of the bulb are in agreement with the drawing.

5.1.1 Measurement Apparatus: The equipment used for this examination must be capable of determining the actual dimensions specified in the bulb drawing within the tolerance limits specified in section 4.5 (Measurement Accuracy). This equipment typically includes micrometers, calipers, gages, and optical profile projectors.

5.1.2 Procedure: Supplier must measure a minimum of 10 randomly selected bulbs using the appropriate equipment. Record the data according to section 4.1 (Record Retention).

5.1.3 Failure Criteria: Any bulb with a dimension(s) outside the specified drawing limits constitutes a failure.

Note: Light Center Length (LCL)

LCL is measured from the geometric center of the light source to a reference point on the bulb base (Ref. SAE J573). The base reference points for the two most common types of automotive bulbs are as follows:

- Bayonet Base.....top of base reference pins
- Wedge Base.....center of notch

Control of the LCL is required to ensure consistent and uniform light output from the various bulb applications on the vehicle.

5.2 Mean Spherical Candela:

5.2.1 Test and Measurement Apparatus: An integrating optical sphere with the appropriate power supply, optical detector, photometer, and traceable standard light source are required. The following test equipment or equivalent is recommended:

TABLE 2

Equipment	Model No.
20-inch Hoffman Integrating Sphere	IS-20-PS
Hoffman Photodetector	85-P
Hoffman System Photometer	TSP-83-A

5.2.2 Procedure: Randomly select 10 bulbs from the lot being tested. Season the bulbs according to section 4.7 (Test Default Conditions), step 4, then measure the MSCP at rated voltage in a properly calibrated photometer in accordance with accepted photometric procedures.

5.2.3 Failure Criteria: Any bulb with a MScd or current value outside the specification limits constitutes a failure.

5.3 External Visual Examination:

The purpose of this examination is to verify that the materials, design, construction, markings, and workmanship of the bulb are in accordance with the drawings and product design specification. Record the data according to section 4.1 (Record Retention).

5.3.1 Test and Measurement Apparatus: Use optical equipment having magnification capability of ≥1.5X.

5.3.2 Procedure: Examine a minimum of 10 randomly selected bulbs using the appropriate magnification device.

5.3.3 Failure Criteria: Any bulb that exhibits any of the following constitutes a failure:

1. Bulb design, identification, or markings (content, placement, and legibility) not in accordance with the applicable specification and/or drawing

2. Visible evidence of corrosion, contamination, breakage (including grossly bent or broken lead wires), defective, or damaged plating (peeling, flaking, or blistering), or exposed base metal

3. External wires not intact and aligned in their specified location or that exhibit sharp or unspecified bends

4. External wires not free of foreign material such as paint or other permanently adherent deposits

5.3.3 (Continued):

5. Evidence of any nonconformance with the drawing or applicable product design specification or absence of any required feature

6. Defects or damage resulting from manufacturing, handling, testing, or shipping that might impair the performance of the bulb

7. A fractured glass bulb

8. Glass missing from the press area of a wedge bulb, even if it does not affect the seal of the bulb

9. "Flash" on glass or plastic parts exceeding 0.20 mm unless otherwise noted on the drawing

5.4 Crush Test:

This test is intended to verify that the glass envelope of the bulb is strong enough to withstand normal handling and insertion operations.

5.4.1 Test and Measurement Apparatus: Use the following equipment, or equivalent, for the crush test:

TABLE 3

Equipment	Model
Chatillon Universal Test Stand	UTSE-2
Load Cell	550 lbs.
Crush Fixture	figure B2

5.4.2 Procedure: Place the test bulb in the appropriate crush fixture (see examples in fig. B2). Center the test bulb under the ram, start the ram down at 32 mm/min ± 5% (1.25 in./min) and record the force, in newtons, required to break the glass. Test a total of 50 bulbs selected at random from the lot being tested. Record the data according to section 4.1 (Record Retention).

5.4.3 Failure Criteria: The criteria for the 50-bulb sample are as follows:

1. Bulb types ≥16 mm (5/8 inch) in maximum diameter

   (a) Zero bulbs broken at less than 110 N (24.7 lbs)
   (b) A maximum of 5 bulbs broken at less than 155 N (34.8 lbs)

2. Bulb types less <16 mm (<5/8 inch) in maximum diameter and >5 mm (>3/16 inch)

   (a) Zero bulbs broken at less than 75 N (16.9 lbs)
   (b) A maximum of 5 bulbs broken at less than 100 N (22.5 lbs)

3. Bulb types ≥5 mm (3/16 inch) in maximum diameter

   (a) Zero bulbs broken at less than 35 N (7.9 lbs)
   (b) A maximum of 5 bulbs broken at less than 50 N (11.2 lbs)

5.5 Thermal Shock Test:

Stresses are produced in the glass of a bulb during the manufacturing process. The location and magnitude of these stresses affect the strength of the glass envelope. This test is intended to expose excess stresses remaining in the glass after the manufacturing process is complete.

5.5.1 Test and Measurement Apparatus: A Cole Palmer Laboratory Oven, Model Number 05015-50 or equivalent, is used for this test.

5.5.2 Procedure: Place 10 randomly selected, room-temperature bulbs in a hot liquid or solid medium for 10 minutes. Immediately after removal from the hot medium, submerge the samples for 1 minute in a cold liquid medium. The difference in temperature between the hot and cold mediums must be at least 96°C.

5.5.3 Failure Criteria: Upon drying, and again after a 5-day hold period, no bulbs may "smoke," "blacken," or otherwise fail to provide light output during a 60-second lightup at design voltage. Record the data according to section 4.1 (Record Retention).

5.6 Bayonet Base Retention:

This test is applicable to bulbs with metal bayonet bases. The objective is to evaluate the strength of the attachment between the glass bulb and the metal base.

5.6.1 Test and Measurement Apparatus: Use the following equipment, or equivalent, for testing base retention:

TABLE 4

Equipment	Requirements
Ratcheting torque wrench with dial readout to indicate maximum torque	0 to 2 Nm
Torque wrench sockets to fit the various metal bases	Base sizes: A1, B1, B2, & C2
Leather gloves or cloth	
Humidity chamber	50°C & 90-100% humidity

5.6.2 Procedure: Select 10 bulbs at random, condition them in a humidity chamber for 6 hours at 50°C and 90-100% relative humidity, and allow them to dry at room temperature for 1 hour. Hold the glass portion of the bulb in a leather glove or cloth, insert the metal base into the appropriate torque wrench socket and rotate the bulb until the metal base loosens from the glass envelope. Record the data according to section 4.1 (Record Retention).

5.6.3 Failure Criteria: A failure occurs if the base loosens from the glass envelope with less than the minimum torque noted in the following table:

TABLE 5
Bayonet Base Bulbs

Bulb Envelope	Base Type*	Min. Torque	Min. Torque
T-3-1/4	A1	0.5 (Nm)	4.43 (in-lbs)
T-3-1/2	A1	0.5 (Nm)	4.43 (in-lbs)
T-4-1/2	A1	0.5 (Nm)	4.43 (in-lbs)
G-6	B1, B2, C2	1.0 (Nm)	8.86 (in-lbs)
B-6	B1, B2, C2	1.0 (Nm)	8.86 (in-lbs)
S-8	B1, B2, C2	1.0 (Nm)	8.86 (in-lbs)

*SAE base types A1, B1, B2, and C2 correspond to IEC base types BA9s, BA15s, BA15d, and BAY15d, respectively.

5.7 Pin Removal Test:

This test is applicable to bulbs with metal bayonet bases. The objective is to evaluate the strength of the attachment between the metal base and the locator pins.

5.7.1 Test and Measurement Apparatus:

- Chatillon Scale – Model USTM or equivalent
- Metal box and test plate as shown in figures B3 and B4.

5.7.2 Procedure: Place test bulb in test plate. Place test plate and bulb on steel box as shown in figure B3. Set the test setup on the scale table center under the ram. Start the ram down and observe load required to remove the pins from the base. The ram speed shall be 32 mm/minute ± 10% (1.25 in/minute ± 10%). Perform this procedure on a total of 50 randomly selected bulbs. Record the data according to section 4.1 (Record Retention).

5.7.3 Failure Criteria: A failure of this test occurs if the pins of more than 5 bulbs are removed at a force less than 18 kg (40 lbs).

5.8 Wedge Base Retention:

This test determines the force required to separate the plastic base (where applicable) from the glass envelope in the direction of socket extraction. A margin safely above socket retention is required. This test applies to bulbs with plastic bases that are intended to be inserted into separate sockets (for example, S-8 Wedge or GT-8).

5.8.1 Measurement Apparatus: Use the following list of equipment or equivalent:

- Chatillon Digital Force Gage – Model LTCM-3
- Apparatus shown in figure B5

5.8.2 Procedure: Measure the force required to separate the base from the glass bulb on 10 randomly selected bulbs. Record the data according to section 4.1 (Record Retention).

5.8.3 Failure Criteria: The force measured must be no less than 4.5 kg (10 lbs).

5.9 Lead Wire Bend Test:

This test is applicable only to miniature bulbs with external wires designed to be soldered or welded to an assembly or subassembly (for example: wire terminal, bi-pin, etc.). It is intended to determine the ability of the bulb to withstand bending forces, which may occur during normal handling and assembly processes.

5.9.1 Test and Measurement Apparatus: Use a suitable fixture for securing the bulb and measure the bend angle specified.

5.9.2 Procedure: Randomly select 10 bulbs and bend the lead wire 90° at a point no more than 1.50 mm (0.060 in.) from the exit of the lead wire out of the glass. Bend the lead 180° in the opposite direction, then return the lead to its original position. Record the data according to section 4.1 (Record Retention).

5.9.3 Failure Criteria: Before and after the test, any evidence of mechanical damage or air leaks during a 60-second lightup at rated voltage will be considered a failure.

5.10 Lead Wire Pull Test:

This test is applicable only to miniature bulbs with external wires designed to be soldered or welded to an assembly or subassembly (for example: wire terminal, bi-pin, etc.). Its purpose is to determine the ability of the bulb to withstand pulling forces, which may occur during normal handling and assembly processes.

5.10.1 Test and Measurement Apparatus: Use a suitable fixture for securing the bulbs and apply the specified weight or force to the wire leads.

5.10.2 Procedure: Randomly select a total of 10 bulbs and apply a parallel force of 2.27 ± 0.14 kg (5.0 ± 0.1 lbs.) to each lead for 60 seconds. Record the data according to section 4.1 (Record Retention).

5.10.3 Failure Criteria: Before and after the test, any evidence of mechanical damage or air leaks during a 60-second lightup at rated voltage will be considered a failure.

5.11 Natural Amber Color Test:

This test is applicable to bulbs with natural amber glass. It is intended to be a standard method for measuring the color emitted by these bulbs.

5.11.1 Test and Measurement Apparatus: Use a colorimeter capable of taking a color measurement within two seconds and having an accuracy of at least ± 0.002 in terms of the 1931 CIE (Commission Internationale de l'eclairage) chromaticity coordinates.

5.11.2 Procedure: Select 20 bulbs from the test lot and test them according to the appropriate procedure below. Record the data according to section 4.1 (Record Retention).

1. For bulbs that have a visible difference in color over the glass envelope:

   a) Season the bulb according to section 4.7 (Test Default Conditions), step 4, and allow to cool to room temperature.

   b) Mount the bulb firmly with the filament(s) and mount structure plane perpendicular to the measurement axis as shown in figures B6a and B6b. The bulb must be positioned so that the measurement axis intersects the filament (major filament for a dual filament bulb).

   c) Measure the color emitted by the bulb after the filament (major filament for a dual filament bulb) has been operated at rated voltage for a period of 60 ± 3 seconds and again after a total operational time of 300 ± 3 seconds.

   d) Remove power from the bulb and allow it to cool at room temperature for a period of at least 10 minutes.

5.11.2 (Continued):

e) Mount the bulb firmly with the filament(s) perpendicular, and the plane of the mount structure at a 45° angle, with respect to the measurement axis so that the lower portion of the bulb is being viewed (see figures B6a and B6c).

f) Repeat step c.

g) Allow the bulb to cool and repeat steps b through f for the minor filament.

2. Optional procedure for demonstrating compliance to step 1 for bulbs that have no visible difference in color over the glass envelope:

a) Season the bulb according to section 4.7 (Test Default Conditions), step 4.

b) Mount the bulb firmly in a photometric sphere.

c) Measure the color emitted by the bulb after the filament (major filament for a dual filament bulb) has been operated at rated voltage for a period of 60 ± 3 seconds and again after a total operational time of 300 ± 3 seconds.

d) Allow the bulb to cool and repeat step c for the minor filament.

5.11.3 Failure Criteria: Any measurement outside the following 1931 CIE chromaticity coordinate boundaries (see fig. B7) constitutes a failure of this test:

y = 0.39 (red boundary)
y = 0.79 - 67x (white boundary)
y = x - 0.12 (green boundary)

5.12 Coated Amber Bulb Tests:

This test is applicable to bulbs with amber coating. It is intended to be a standard method for measuring color emission and coating durability.

5.12.1 Test and Measurement Apparatus: For integrated color measurements, use equipment as defined in section 5.2.1 (integrating optical sphere). For point method measurement, use a colorimeter or similar equipment capable of taking a color measurement within two seconds and having an accuracy of at least ±.002 in terms of the 1931 CIE chromaticity coordinates.

5.12.2 Procedure: Select 20 bulbs from the test lot and season according to section 4.7, step 4. Perform the tests listed below.

5.12.2.1 Integrated Color Test:

1. Place the bulb in an integrating optical sphere.
2. Measure the color emitted by the bulb after the filament (major filament for dual filament bulb) has been operated at rated voltage for a period of 60 ± 3 seconds.

5.12.2.1.1 Failure Criteria: Refer to section 5.11.3 for the failure criteria.

5.12.2.2 Visual Color Test: Visually inspect the color of the bulb for variation or inconsistencies. A tester may be used to aid this evaluation.

5.12.2.2.1 Failure Criteria: Color must be uniform as required by the approving engineer.

5.12.2.3 Point Color Test:

1. Using the test setup shown in figure B6, orient the bulbs to take point measurements at each of the points indicated in a, b, and c.

2. Energize the bulb at rated voltage direct current for 60 seconds ±3 seconds then measure the color while energized. Aim the colorimeter directly at the energized filament through the bulb envelop at point 1. Repeat this procedure reorienting the bulb to measure the color of points 2 through 7.

5.12.2.3.1 Failure Criteria: Refer to section 5.11.3.

5.12.2.4 Color Maintenance and Coating Durability Test:

1. Mount the bulb in Enclosure A of figure B15. Operate the bulbs for a 24-hour cycle consisting of the following segments, which run simultaneously:

   a. Temperature: The first 11 hours will be at room temperature. Increase temperature to 50°C for the next 4 hours. Drop the temperature to -40°C for the last 7 hours. Raise the temperature back to room temperature for the final hour.

   b. Humidity: The cycle will begin at 40% RH and remain constant for 5 hours. The humidity will increase to 98% for the next hour and remain at 98% humidity for the next 7 hours. Decrease the humidity to 40% for 2 hours. (The humidity is not controlled for the remainder of the cycle.)

   c. Bulb Cycle: The bulb will be operating at the following 60-minute duty cycle. (See pictorial in Appendix B, fig. B18.)

5.12.2.4 (Continued):

TABLE 6

Time (minutes)	Major Filament (13.0 V DC)	Minor Filament (14.5 V DC)
0 to 15	constant flash[1]	constant burn
15 to 25	15 / 15[2]	off
25 to 50	off	constant burn
50 to 55	constant flash	constant burn
55 to 60	off	off

[1] The term constant flashing represents the standard flashing cycle of 90 flashes/minute.
[2] The term 15/15 represents flashing consisting of 15 seconds flashing and 15 seconds off. (Flashing rate is 90 flashes per minute.)

2. Test each bulb for 10 complete cycles.

3. After the cycles have been completed, the bulb color will be measured according to section 5.12.2.1, section 5.12.2.2, and section 5.12.2.3.

5.12.2.4.1 Failure Criteria: Use the respective section's failure criteria. In addition, no white light can be emitted through cracks and areas of paint detachment.

5.12.2.5 Amber Coating Chemical Resistance Test:

1. Use the remaining 10 samples for this test. Season the bulbs according to section 4.7 (Test Default Conditions), step 4, and allow cooling to room temperature.

2. Wipe each bulb with a 6-inch square soft cotton cloth that has been saturated once in the following chemical listing in a container with 2 oz. of one of the test chemicals listed below.

3. Wipe the bulb within 5 seconds of removing the cloth from the test chemical.

4. Repeat wiping that same bulb with a different chemical listed below.

5. Repeat steps 2, 3, and 4 until all 10 bulbs have been wiped using all 17 chemicals.

6. After being wiped, each bulb shall be stored for 48 hours at room temperature and a relative humidity of 30% ± 10%.

7. At the end of the 48-hour period, the bulbs shall be wiped clean with a soft dry cotton cloth and visually inspected.

5.12.2.5 (Continued):

Chemical Listings:

1. Gasoline
2. Tar Remover
3. Power Steering Fluid
4. Windshield Washer Fluid
5. Anti-freeze
6. Dry Gas
7. Wax Remover
8. Engine Cleaner
9. Engine Oil
10. Transmission Fluid
11. Grease
12. Diesel Fuel
13. Brake Fluid
14. 50% isopropyl alcohol/50% water
15. Glass Cleaner

5.12.2.5.1 Failure Criteria: The bulbs shall not show any changes. Illuminate the bulb. No white light can be emitted through cracks and areas of point detachment.

5.13 Resonant Frequencies:

Each bulb design has natural resonant frequencies. If the bulb is excited at one or more of these frequencies over long periods of time, the filament could be damaged because of metal fatigue at stress concentration points. This test is intended only to identify those resonant frequencies of a seasoned bulb for use in bulb assembly design.

5.13.1 Test and Measurement Apparatus: Use the following equipment, or equivalent, to determine the resonant frequency of the bulb:

TABLE 7

Equipment	Requirements
Closed loop dynamic vibration equipment and auxiliary controller capable of vibrating in sinusoidal mode	Variable from 10 - 2000 Hz with tolerance of ± 4.0 dB and min. of 227 kg (500 lbs) force
Strobe light to "freeze" the vibrating filament	
Fixture to firmly mount the bulb to the vibration table	Bulb to be mounted with filament in both the parallel and perpendicular positions with respect to the ground

5.13.2 Procedure: Select 10 bulbs from the test lot and test them as follows:

1. After seasoning (sec. 4.7 [Test Default Conditions], step 4), mount the bulb firmly in the fixture with the filament and main bulb axis parallel to the ground.

2. Sweep the range from 50 to 1500 Hz and back to 50 Hz (15 minutes nominal each direction) with a 5.0 g (.176 ounces) vertical input while using a strobe light to "freeze" the vibration and to permit identification of all the resonant frequency ranges.

3. Record the range, both the starting and stopping frequencies, of each resonant harmonic according to section 4.1 (Record Retention). For purposes of this test, resonance starts when the filament or mount structure is moved approximately 1 filament coiled diameter (perpendicular to the axis of the filament) from its normal "static" position. It continues until the filament resumes its static position as shown in figure B8.

4. Repeat steps 1 through 3 with the filament mounted vertically to the ground.

5.13.3 Failure Criteria: There is no failure criteria. This test is for investigative purposes only.

5.14 Aged Resonant Frequency Test:

Each bulb design has a natural resonant frequency that, if present over long periods of time, could damage or destroy the filament due to metal fatigue at stress concentration points. This test is intended only to identify those resonant frequencies of an aged bulb for use in bulb assembly design.

5.14.1 Test and Measurement Apparatus: Use the following equipment, or equivalent, to determine the resonant frequency of the bulb:

TABLE 8

Equipment	Requirements
Closed loop dynamic vibration equipment and auxiliary controller capable of vibrating in sinusoidal mode	Variable from 10 - 2000 Hz with tolerance of ± 4.0 dB and min. of 227 kg (500 lbs) force
Strobe light to "freeze" the vibrating filament	
Fixture to firmly mount the mounted bulb to the vibration table	Bulb to be with filament in both the parallel and perpendicular positions with respect to the ground

5.14.2 Procedure: Randomly select 10 bulbs from the test lot and test them as specified below.

1. Season the bulbs at rated or forced voltage for 80% of design life.

2. Mount the bulb firmly in the fixture with the filament and main bulb axis parallel to the ground.

3. Sweep the range from 50 to 1500 Hz and back to 50 Hz (15 minutes nominal each direction) at 5.0 g (176 ounces) while using a strobe light to "freeze" the vibration and to permit identification of all the resonant frequency ranges.

4. Record the range, both the starting and stopping frequencies, of each resonant harmonic according to section 4.1 (Record Retention). For purposes of this test, resonance starts when the filament or mount structure is moved approximately 1 filament coiled diameter (perpendicular to the axis of the filament) from its normal "static" position. It continues until the filament resumes its static position as shown in figure B8.

5. Repeat steps 1 through 3 with the filament mounted vertically to the ground.

5.14.3 Failure Criteria: There is no failure criteria. This test is for investigative purposes only.

5.15 Salt Spray Test:

This test is applicable to endcapped cartridge bulbs. The objective is to evaluate the integrity of the metal endcaps when subjected to a salt spray.

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

5.15.2 Procedure: Perform a salt spray test according to ASTM B117 for 24 hours on 10 randomly selected bulbs.

5.15.3 Failure Criteria: The samples shall exhibit no red rust after the test.

5.16 Wire Loop Pull Test:

This test is applicable to wire loop cartridge bulbs. The objective is to evaluate the strength of the wire loop and glass interface.

5.16.1 Test and Measurement Apparatus: Use the following equipment, or equivalent, for the pull test:

TABLE 9

Equipment	Model
Chatillon Universal Test Stand	UTSE-2
Load Cell	10 lbs.
Pull Fixture	A hook that evenly distributes the load across the wire loop

5.16.2 Procedure: Perform an axial pull of 30 N (6.74 lbs) for 1 minute on each wire loop of 10 randomly selected bulbs.

5.16.3 Failure Criteria: Any bulb that fails to operate in a normal manner for a minimum of 60 seconds, at rated voltage, at the conclusion of the test shall be considered a failure and shall constitute a failure of the entire test group.

5.17 Heat Test:

The Heat Test is intended to ensure that bulbs with plastic bases will not distort or out-gas to cause a fog precipitate to form on reflectors or lenses of a bulb assembly in which they may be used. It is not intended to measure the amount of fog condensate or explore the limits of bulb performance but to establish an acceptance level, which relates to practical applications. It is recommended that each bulb application be tested under its own design conditions. This test is beyond the scope of this standard.

5.17.1 Test and Measurement Apparatus: Enclosures shown in figure B15, modified to include removable clear glass as the left wall of the enclosure, are to be used to run this test. The enclosure bulb mounting is to be constructed of materials, such as metal and ceramic, that will not out-gas during the test. The enclosure is to be placed in a temperature-controlled chamber that can maintain 50° ± 5°C. An apparatus for measuring light transmitted through the clear glass wall of the enclosure is required. It must include a standard light source, which may be either an accurate rated bulb or white light source meeting CIE Illuminant A (2854K) standards, a method of holding the glass, and a linear photometric receptor.

5.17.2 Procedure: Perform this test on 5 representative bulbs for each of the test conditions specified in table 11 in section 6.7.2. The glass is to be cleaned with glass cleaner and alcohol before testing each bulb. Using the standard light source, measure the amount of light transmitted through the glass wall of the enclosure. Mount the bulb in the enclosure, place the enclosure in the test chamber, bring the test chamber to 50°C, and operate the bulb as specified in table 11 in section 6.7.2 for 2 hours. After this two-hour period, allow the enclosure to cool to room temperature. Remeasure the light transmitted through the glass wall of the enclosure in an identical manner as before the two-hour test. Inspect the bulb base and the bulb envelope. Calculate and record the change in transmittance using Equation 1:

$$\Delta T_R = \left(1 - \frac{I_2}{I_1}\right)100 \qquad \text{(Eq.1)}$$

where:

ΔT_R = Percent change in transmittance
I_1 = Initial light measurement
I_2 = Light measured after the test

5.17.3 Failure Criteria: After the test, the bulb base must not be distorted and must be removable from its socket in a normal manner, e.g., normal force to remove. The bulb must function normally, and the labeling must be legible. The change in transmittance test is for investigative purposes and does not have a failure criteria.

6. DURABILITY TESTS:

These tests are intended to evaluate the durability of the bulbs and their components under typical and extreme operating conditions on the vehicle. Record all data according to section 4.1 (Record Retention).

6.1 Correlation Between Laboratory Life at Rated and Forced Voltage:

This test determines the correlation between life at rated voltage and life at a forced voltage. It does not include any of the "life shortening" conditions (i.e., high temperature, vibration, shock, etc.) encountered on a vehicle.

6.1.1 Test and Measurement Apparatus: Use the following equipment and racks, or equivalent, for this test:

1. Bulb sockets firmly mounted on racks so that the filament is parallel to the ground and reliably provides electrical contact with the bulb
2. Power supplies capable of operating the bulbs continuously at rated voltage and compensating for the reduced power requirements within 1 minute of bulb burnout
3. Power supplies capable of operating the bulbs continuously at 150% of rated voltage

6.1.2 Procedure: Select 20 consecutively manufactured samples. Operate 10 samples at room temperature and rated voltage. Burn the bulbs for 23-1/2 hours each day and a 1/2 hour off each day. Monitor the bulbs at least once each day and record the amount of hours for each bulb to fail according to section 4.1 (Record Retention). Time of failure should be recorded as the last time the bulb was known to be lit. Calculate the average, B_3, B_{10}, B_{50}, B_{63} lives for the test group. (Note: This test may be halted at 6000 hours of on-time.)

Operate the other 10 samples at room temperature and forced voltage to a maximum of 150% of rated voltage. Monitor the bulbs at least once every hour and record the amount of hours for each bulb to fail according to section 4.1 (Record Retention). Time of failure should be recorded as the last time the bulb was known to be lit. (Note: This test may be halted at 9000 hours of equivalent on-time at rated voltage.) Calculate the average, B_3, B_{10}, B_{50}, B_{63} lives for the test group.

Compare the results from the two groups and determine a correlation factor.

6.1.3 Failure Criteria: Life at rated voltage must meet product specifications.

6.2 Accelerated Life:

This test provides a means of rapidly determining the amount of time for a bulb to fail when it is operated at rated voltage. This test must correlate to the life test at rated voltage (sec. 6.1 [Correlation between Laboratory Life at Rated and Forced Voltage]).

6.2.1 Test and Measurement Apparatus: The following equipment and racks, or equivalent, are required for this test:

1. Bulb sockets firmly mounted on racks so that the filament is parallel to the ground and reliably provides electrical contact with the bulb
2. Power supplies capable of operating the bulbs continuously at 150% of rated voltage

6.2.2 Procedure: Mount 50 randomly selected samples on the test rack. Operate at room temperature and forced voltage to a maximum of 150% of rated voltage. Monitor the bulbs and record the amount of hours for each bulb to fail according to section 4.1 (Record Retention). Time of failure should be recorded as the last time the bulb was known to be lit. (Note: This test may be halted at 9000 hours of equivalent on-time at rated voltage.)

6.2.3 Failure Criteria: The results of this test must statistically correlate to the results of the life test at rated voltage (sec. 6.1 [Correlation Between Laboratory Life at Rated and Forced Voltage]) and satisfy the requirements on the product drawing or specification.

6.3 Luminous Intensity Maintenance:

The objective of this test is to determine the degradation in light output (MScd) as a function of operating time. This test may be run in conjunction with either section 6.1 (Correlation Between Laboratory Life at Rated and Forced Voltage) or section 6.2 (Accelerated Life test) and section 5.2 (Mean Spherical Candela test).

6.3.1 Test and Measurement Apparatus: The equipment for this test is noted in the following sections of the life and mean spherical candela tests:

- Section 5.2.1 (Mean Spherical Candela Measurement Apparatus)
- Section 6.1.1 (Correlation Between Laboratory Life at Rated and Forced Voltage Test and Measurement Apparatus), or Section 6.2.1 (Accelerated Life Test and Measurement Apparatus)

6.3.2 Procedure: After selecting and seasoning (sec. 4.7 [Test Default Conditions], step 4) 10 bulbs at random from the test lot, proceed as follows:

Measure the MScd of each test bulb (sec. 5.2.2 [Mean Spherical Candela]).

Option 1
Age the bulbs at rated voltage (sec. 6.1.2 [Correlation Between Laboratory Life at Rated and Forced Voltage]) and measure the MScd at intervals of 25%, 50%, 75%, and 90% of design life.

Option 2
Age the bulbs at forced voltage, not to exceed 150% of rated voltage, and remeasure MScd at suitable intervals to provide at least 4 approximately equal-spaced intervals during the expected life of the bulb. Record the data according to section 4.1 (Record Retention).

6.3.3 Failure Criteria: At 75% of design life, the luminous intensity must be $\geq$80% of the initial luminous intensity.

6.4 Vibration Durability Test:

The objective of this test is to verify that the design and construction of the bulb are sufficiently robust to withstand vehicle vibrations. This is an accelerated test for the worst case orientation of the bulb filament.

6.4.1 Test and Measurement Apparatus: The following equipment, or equivalent, is required for vibration durability:

1. Closed loop dynamic vibration equipment and controller capable of vibrating the bulbs from 50 to 1000 Hz in a random mode according to the accompanying test profile

2. Fixture to mount the bulbs firmly to the vibration table in such a manner that voltage can be applied to the bulbs during the test.

6.4.2 Procedure: Randomly select 20 bulbs from the test lot and test them as indicated below. Test each filament of a dual filament bulb separately. Record the data according to section 4.1 (Record Retention).

1. Season the bulbs at rated or rated voltage (sec. 4.7 [Test Default Conditions], step 4).
2. Mount the bulbs firmly in the fixture with filaments as follows:
   - Half of the samples positioned with the filament parallel to the ground
   - Half of the samples positioned with the filament perpendicular to the ground
3. Vibrate the bulbs using the test profile for a total of 6 hours in the following manner:
   a) Two hours – unlit
   b) Two hours – lit at rated voltage
   c) Two hours – unlit

Use the following breakpoints to define the random vibration input to the test specimen:

TABLE 9

Break Point	Frequency (Hz)	Amplitude (G^2/Hz)
1	50	0.080
2	400	0.080
3	650	0.0025
4	1000	0.0025

The total resulting acceleration level is 5.8 G_{rms}

6.4.3 Failure Criteria: Any bulb that fails to operate in a normal manner during the test for any length of time is considered a failure and shall constitute a failure of the entire test group. Any bulb that fails to operate in a normal manner for a minimum of 60 seconds, at rated voltage, at the conclusion of this test shall be considered a failure and shall constitute a failure of the entire test group. Ensure that both filaments of a dual filament bulb operate at the conclusion of this test.

6.5 Shock Test:

This test is used to determine the ability of the bulb to withstand mechanical shock resulting from rough handling, transportation, and field operation including trunk and hood "slams." Severe shocks may disturb the normal operating characteristics of the bulb, and severe or repetitive shocks may permanently damage or destroy the filament.

6.5.1 Test and Measurement Apparatus: The shock test fixture is shown in figures B9 through B14.

6.5.2 Procedure: Select 40 bulbs at random from the test lot and season them (sec. 4.7 [Test Default Conditions], step 4). Securely mount (reference figs. B9 through B11) each test bulb through the appropriate clamping fixture at the end of the cam actuated lever arm. Make sure that the counter is at zero and the low current filament monitoring circuit is operational. Turn on the electric motor drive and let the equipment apply 100 shock pulses. The shock pulse must have a duration of at least 1 millisecond and reach at least 800 g's for bulbs $\geq$16mm ($\geq$5/8inch) in maximum diameter. The shock pulse must have a duration of at least 0.5 millisecond and reach at least 400 g's for bulbs <16mm (<5/8inch) in diameter. Unless otherwise noted in the product design specification or on the drawing, test 10 bulbs under each of the following conditions, recording data as specified in section 4.1 (Record Retention):

1. Filament parallel to the ground and "off"
2. Filament perpendicular to the ground and "off"
3. Filament parallel to the ground and "on" at rated voltage
4. Filament perpendicular to the ground and "on" at rated voltage

6.5.3 Failure Criteria: The criteria for each group of bulb samples is as follows:

1. No "open" filament or damage to any part of the bulb (i.e., base or glass) during or after 10 shock pulses

2. No more than 2 failures of any kind (i.e., open filaments or damaged bulbs) during or after 100 shock pulses

6.6 Aged Vibration Durability Test:

The objective of this test is to determine the effect of bulb filament aging on vibration durability.

6.6.1 Test and Measurement Apparatus: Use the following equipment, or equivalent, for the operating life test:

1. Closed loop dynamic vibration equipment and controller capable of vibrating the bulb(s) from 50 to 1000 Hz in random mode according to the accompanying test profile (see Test Profile chart in section 6.6.2).

2. Fixture to mount the bulbs firmly to the vibration table with the filament and main bulb axis parallel to the ground in such a manner that voltage can be applied to the bulbs during the test

6.6.2 Procedure: Randomly select 20 bulbs from the test lot and test them as specified below. Record the data according to section 4.1 (Record Retention).

1. Age the bulbs at forced or rated voltage for 80% of design life.

2. Mount the bulbs firmly in the fixture as described below:

   - Half of the samples positioned with the filament parallel to the ground
   - Half of the samples positioned with the filament perpendicular to the ground

3. Vibrate the bulbs using the test profile for a total of 12 hours in the following manner:

   a) Two hours – unlit
   b) Two hours – lit
   c) Four hours – unlit
   d) Two hours – lit
   e) Two hours – unlit

Use the following breakpoints to define the random vibration input to the test specimen:

TABLE 10 - Test Profile

Break Point	Frequency (Hz)	Amplitude (G^2/Hz)
1	50	0.080
2	400	0.080
3	650	0.0025
4	1000	0.0025

The total resulting acceleration level is 5.8 G_{rms}

6.6.3 Failure Criteria: There is no failure criteria. This test is for investigative purposes only.

6.7 Reliability Test:

The reliability test, a life test, is intended to establish reliability of bulbs to .99 at 50% confidence. Using the Bayes Formula, a sample size of 50 is required. This test may or may not correlate to actual bulb reliability on vehicles.

6.7.1 Test and Measurement Apparatus: Use the following equipment, or equivalent, for this test:

- Bulb sockets firmly mounted in enclosures (fig. B15) so that the filament is parallel to the ground and reliable electrical contact is provided to the bulb
- Power supplies capable of operating the bulbs continuously at rated voltage and compensating for the reduced power requirements within 1 minute of bulb burnout (constant burn tests)
- Power supplies capable of duplicating vehicle inrush current, minimum of 5 times design current for 50 milliseconds, and maintaining rated voltage during the test cycle (flashing tests)

6.7.2 Procedure: Run this test as specified in section 6.1.2, paragraph 1 (Correlation Between Laboratory Life at Rated and Forced Voltage), except test the bulb in an enclosure at a constant burn or flash rate as shown in table 11.

TABLE 11

Bulb Family	Constant Burn	Flash	Enclosure
T - 1 3/4	X		A
T - 2 3/4		X	A
T - 3 1/4		X	A
T - 5	X		B
S-8/GT-8 Major and Minor*	X (minor)	X (major)	B
S-8/GT-8 Major and Minor*	X (both)		B
Cartridge	X		C
B6/G6/Others	X		B

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

For the tests requiring flashing, the flash rate must be between 75 and 105 flashes per minute, and the percent current "on-time" must be between 40 and 65%. Both the flashing and constant burn test must be active for 23-1/2 hours and inactive for 1/2 hour every day.
(Note: This test may be halted at 6000 hours of on-time.)

Calculate the life of the bulb in the flashing test as the total current "on-time." Run the test until 5 like failures occur. At the conclusion of the test, construct a weibull plot and calculate the B_3, B_{10}, B_{50}, and B_{63} life. Report and replace a bulb failure within the first hour of the test but do not include it in the life calculations.

6.7.3 Failure Criteria: The life of these bulbs must meet product specifications.

7. QUALITY/RELIABILITY PROGRAMS:

7.1 Reliability Growth:

Bulb suppliers must establish and implement a plan to improve demonstrated product reliability for reaching stated goals. Suppliers may use the Duane or other appropriate reliability growth plan to accomplish this task. True reliability growth occurs when design changes to the bulb design or manufacturing process are made to eliminate the predominate failure modes that are identified by the field return program and the ongoing reliability assurance test program.

7.2 Ongoing Quality Improvements:

The bulb suppliers must establish and implement a plan to improve the demonstrated product quality. They must establish procedures for analyzing and correcting end-of-line defects. Pareto charts will help develop the detailed plans that are required to correct the most frequently occurring defects.

7.3 Quality/Reliability Improvement Tools:

7.3.1 Field Return Program: Suppliers must establish and implement a procedure for analyzing and correcting field return defects. Suppliers and customers will establish the proper frequency of an analysis. Suppliers must use Pareto charts to help develop the detailed plans that are required to correct the most frequently occurring problems. Actual analysis and corrective action plans must be available upon request by the customer.

7.3.2 Design Failure Mode Analysis (DFMA): The DFMA procedure analyzes the design of each piece part and is used to develop Key Product Characteristics. Suppliers must create a DFMA for each bulb part number supplied to the customer. These analyses are "living" documents that should be modified as knowledge about the product and process is accumulated. Once Production Part Approval Process (PPAP) approval has been obtained, revision levels showing dates and explanations of changes must be maintained. Suppliers should use the forms and methodology published in the Potential Failure Mode and Effects Analysis Reference Manual (SAE J1739) and AIAG.

7.3.3 Process Failure Mode Analysis (PFMA): The PFMA assumes the product is adequate as designed and seeks to verify that the manufacturing and assembly controls are adequate to provide a quality product. The PFMA is used to develop Key Control Characteristics. Suppliers must create a PFMA for each bulb part number supplied to the customer. These analyses are "living" documents that should be modified as knowledge about the product and process is accumulated. Once PPAP approval has been obtained, revision levels showing dates and explanations of changes must be maintained. Suppliers should use the forms and methodology published by the AIAG.

7.3.4 Fault Tree Analysis (FTA) or Fishbone Diagrams: Suppliers are urged to use the FTA or fishbone diagram on new and existing processes. This technique is a top down approach that is used to trace known failure modes back to their source. To use this technique, the supplier should start with the bulb performance requirements in this document and assess the potential failure modes. Once the bulbs are in production, suppliers should identify the root cause of end-of-line and field return failures to modify the FTA or fishbone diagrams.

8. REPORT REQUIREMENTS:

8.1 Calibration Sheets:

Reference must be made to measurement standards through calibration sheets and/or lab masters.

8.2 Data Requirements:

The supplier must record data in accordance with section 4.1 (Record Retention). All original data is to be retained with the laboratory copy of the test report.

8.2.1 Data Graphics: Data graphics including graphs, bar charts, etc., must be drawn when required by the test. Examples of typical data graphics include the following:

- Normal probability plots as shown in figure B16
- Weibull life curves as shown in figure B17

GLOSSARY OF TERMS

AVERAGE LIFE: The sum of the hours it takes for each bulb to fail in a given test divided by the number of bulbs in that test.

BAYES FORMULA:

$$R_C = (1 - C)^{\frac{1}{N+1}} \qquad \text{(Eq.A1)}$$

where:

R_C is the reliability at confidence level C
N is the sample size

The above formula is based on a zero failure plan and is nonparametric (no distribution function is assumed). If failures occur, test a larger sample to ensure the same reliability level.

B_x LIFE: B_x life represents the time for a certain percent of the bulbs to have experienced a failure. For example, a $B_{(10)}$ would indicate a point in time where 10% of the bulbs have experienced a failure. $B_{(10)}$ is equivalent to a reliability value of 90% (R=.90).

BULB: An indivisible assembly that contains a source of light or filament and is normally used in a lamp assembly.

CUSTOMER: The organization purchasing bulbs. In the event it is a first tier buyer, the automobile manufacturer will also be considered the customer.

DESIGN VOLTAGE: The direct current (D.C.) voltage at which the bulb is designed to operate and at which the operating characteristics of the lamp are determined.

FORCED VOLTAGE: A voltage that is higher than a bulb's design voltage. It is often used to accelerate life testing.

LAMP: A divisible assembly that contains a bulb or other light source and sometimes an optical system, such as a lens and/or reflector, and provides a lighting function.

LEAD WIRE: The conductive wire that extends out of the glass envelope and provides electrical contact to the lamp socket, printed circuit, etc.

LIGHT CENTER LENGTH (LCL): The location of the filament with reference to a specified point on the bulb base.

LUMENS: The amount of light emitted by a bulb. Lumens may be converted to MSCP by dividing by 12.57.

MEAN SPHERICAL CANDELA (MScd): The average value of the luminous intensity (candle power) of a light source that emits light in all directions.

MINIMUM LIFE: Equal to 40% of rated design life.

RATED DESIGN LIFE: Estimate of the average life of the entire product of a particular bulb.

TEST LOT: The production group of bulbs from which test samples are selected.

TRADE NUMBER: The identification number assigned to a specific bulb by the American National Standards Institute (ANSI). Included in this registration are the physical and electrical characteristics, including glass envelope and base type, design voltage, MScd, life, etc. The addition of a letter after the number indicates a variance in the basic lamp construction while still maintaining the lamp's operating characteristics (i.e., NA = natural amber).

APPENDIX B
REVISIONS

This standard was approved by the USCAR/EWCAP Light Bulb Group in December 1999. Any revisions since that date have been incorporated into the specification. Revisions which altered the content of the specification are recorded below:

DATE	SECTION	SUMMERY OF CHANGES MADE*	NOTES
12-99	See note	See Table of Contents. All sections which experience major content changes are note with italics.	

*X was Y indicates that the word or value "Y" has been changed to become "X"

APPENDIX C
GRAPHICS, CHARTS, ETC.

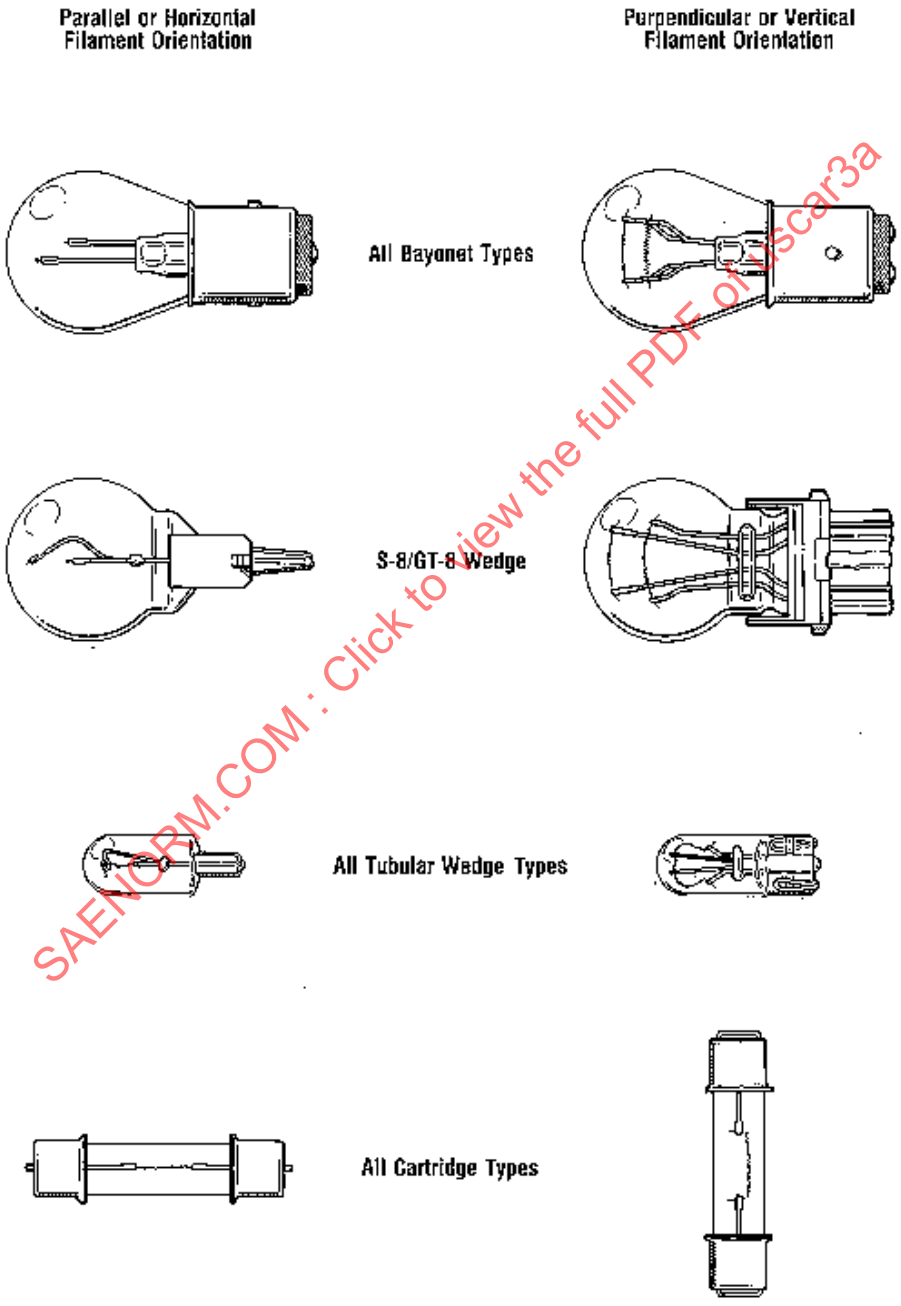


FIGURE B1 - Filament Orientation

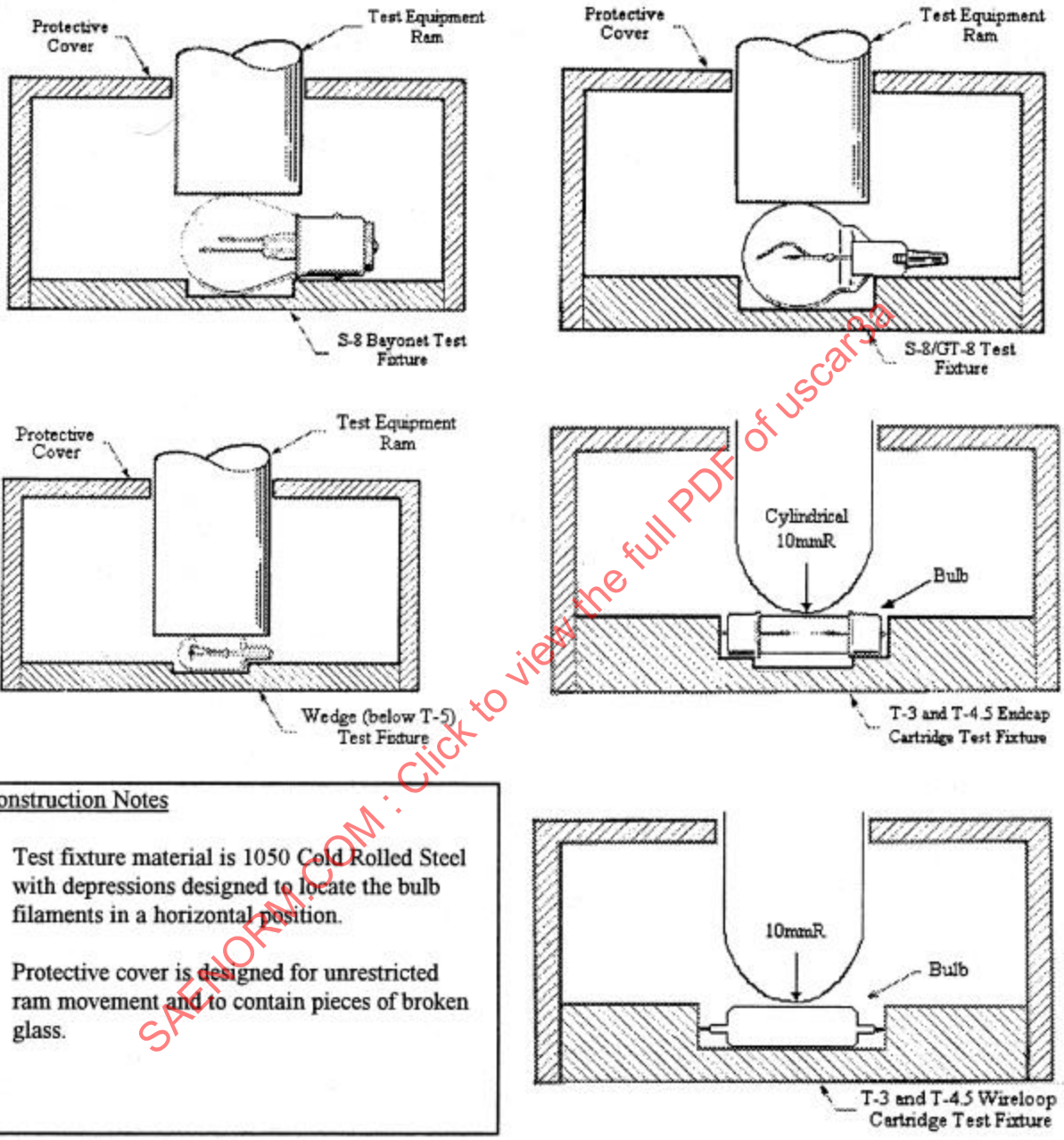


FIGURE B2 - Crush Test Fixtures

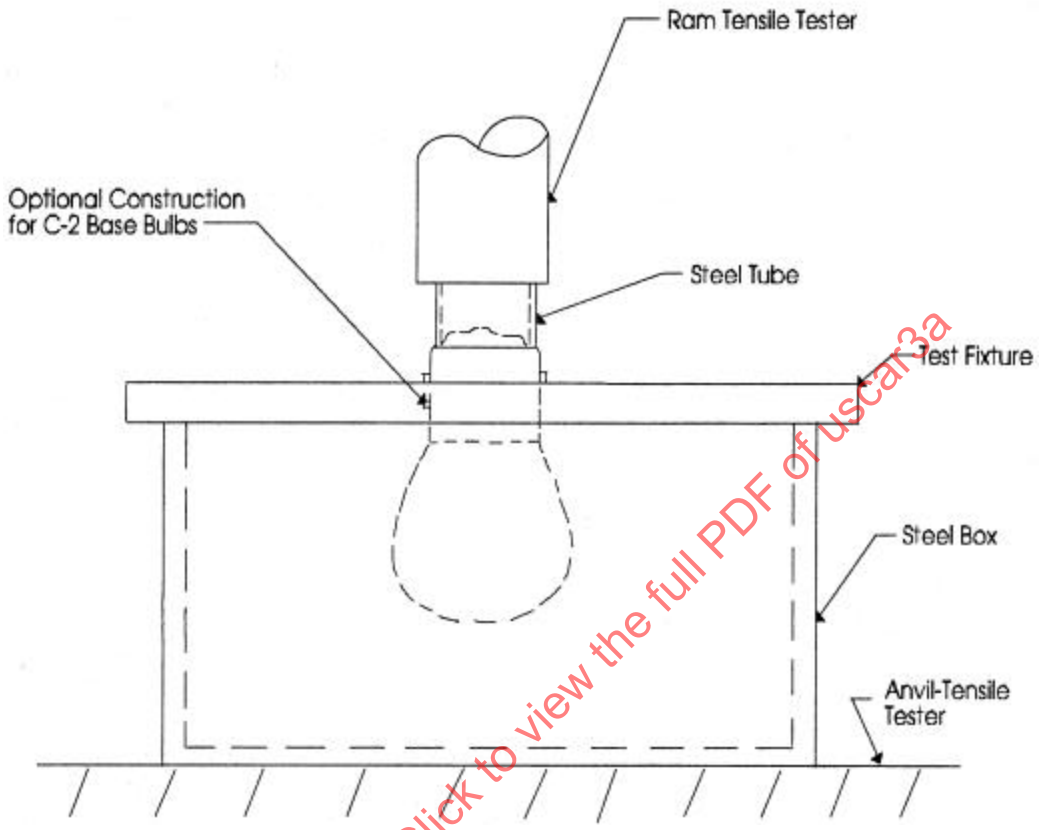


FIGURE B3 - Pin Removal Test (B-1, B-2, and C-2 Base Types)

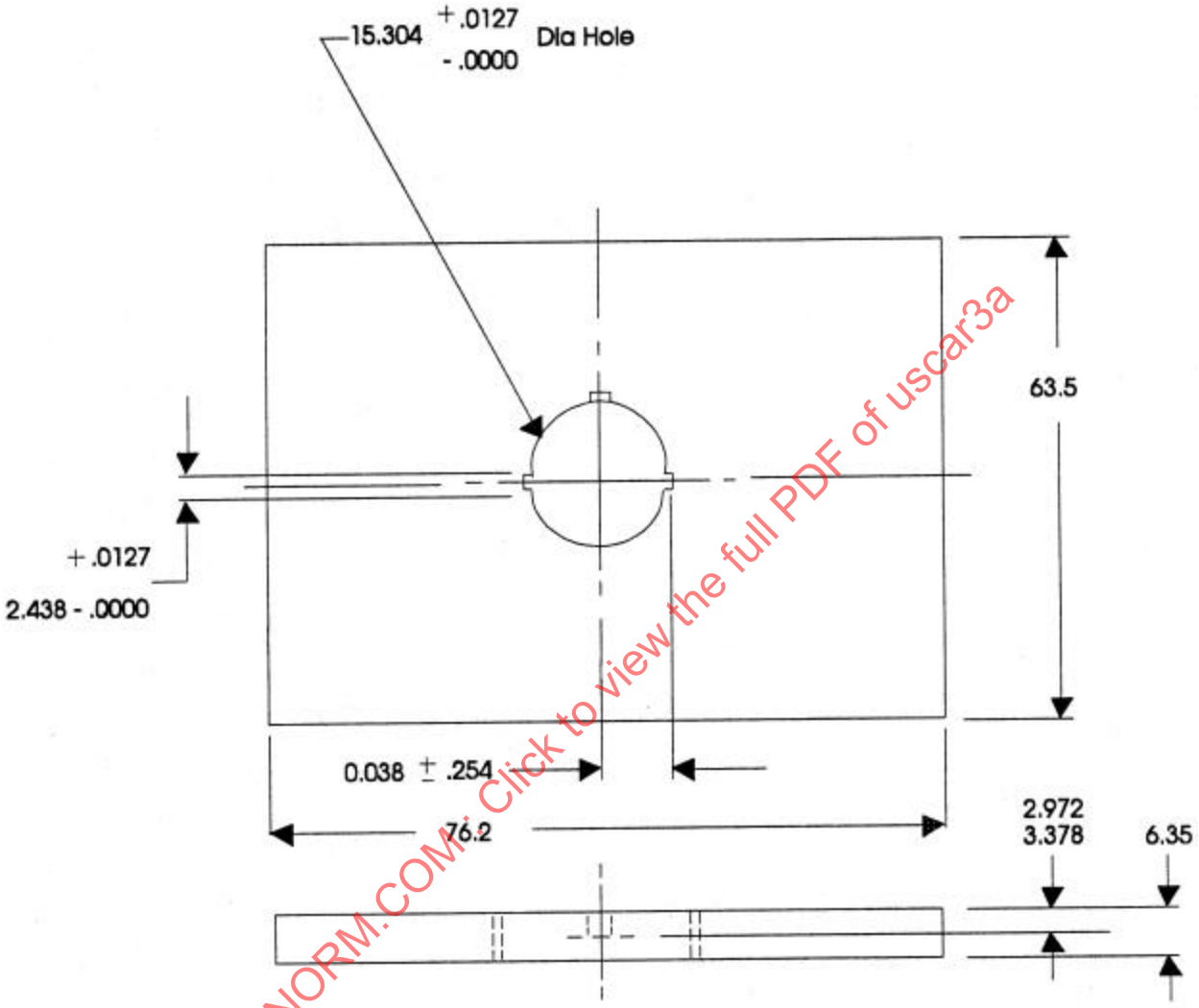
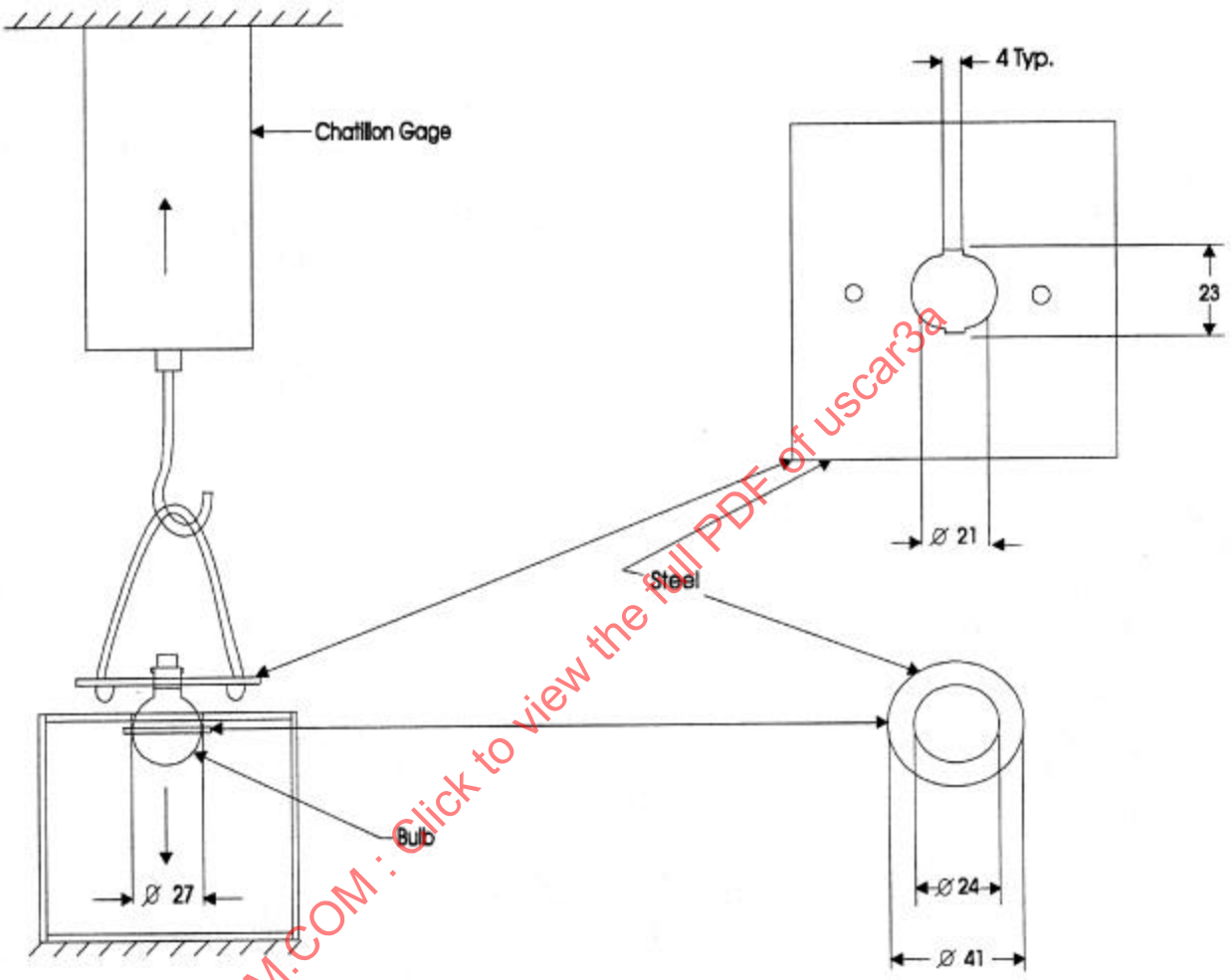


FIGURE B4 - Pin Removal Test (B-1, B-2, and C-2 Base Types)
Material: Hardened Steel



Note: Dimensions are in millimeters

FIGURE B5 - Wedge Base Retention Fixture

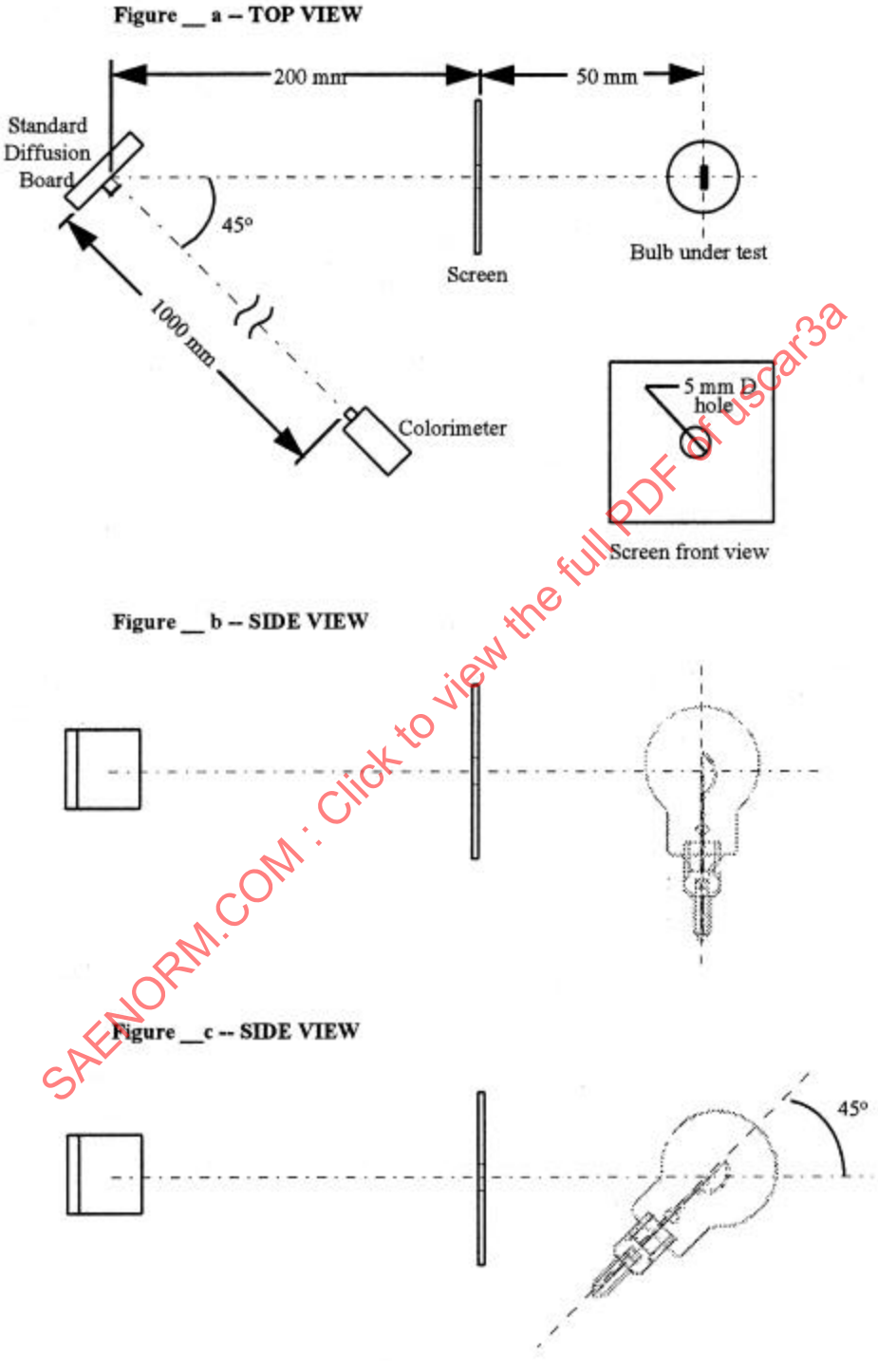


FIGURE B6 - Natural Amber Test

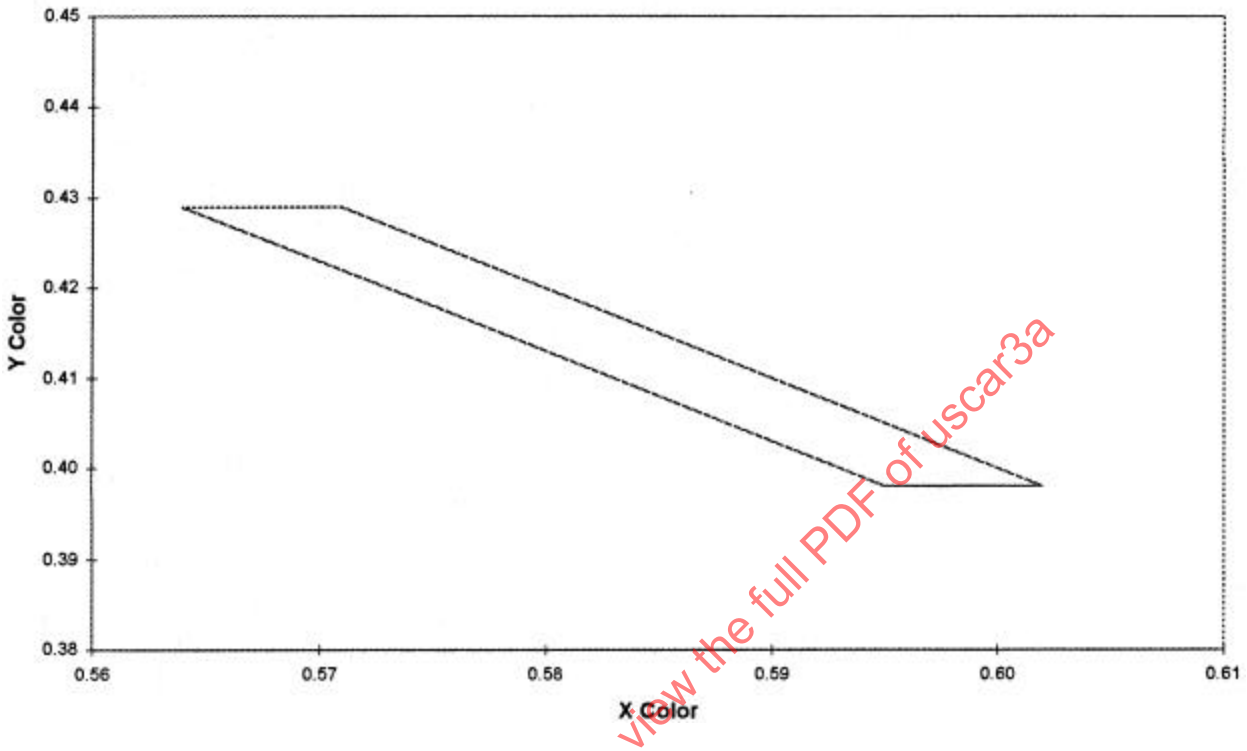


FIGURE B7 - Natural Amber Color Boundaries - 1931 CIE Coordinate System