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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J2139

REV. MAR2001

Issued 1994-01
Revised 2001-03

Superseding J2139 JAN1994

Submitted for recognition as an American National Standard

(R) Tests for Signal and Marking Devices Used on Vehicles 2032 mm or More in Overall Width

1. ***Scope—***This SAE Recommended Practice provides standardized laboratory tests, test methods, and performance requirements applicable to signal and marking devices used on vehicles 2032 mm or more in overall width.

2. ***References***

2.1 **Applicable Publications—**The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J387—Terminology—Motor Vehicle Lighting
SAE J575—Tests for Motor Vehicle Lighting Devices and Components for Use on Vehicles Less than 2032 mm in Overall Width
SAE J576—Plastic Materials for Use in Optical Parts Such as Lenses and Reflectors of Motor Vehicle Lighting Devices
SAE J577 JUN1973—Vibration Test Machine
SAE J578—Color Specification
SAE J1330—Photometry Laboratory Guidelines
SAE J1455—Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design
SAE J1889—LED Lighting Devices
SAE J2357—Application Guidelines for Electronically Driven and/or Controlled Exterior Automotive Lighting Equipment

2.1.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 117—Method of Salt Spray (Fog) Testing
ASTM C 150-84—Specification for Portland Cement
ASTM E 308-85—Standard Method for Computing the Colors of Objects by Using the CIE System

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3. Definitions

3.1 Discharge Signal Lighting (DSL) System—A vehicular lighting system used in signal and marking applications. The DSL system is composed of a discharge light source, interconnecting wiring, and a signal or marking lighting assembly.

3.2 Discharge Light Source—An electric light source in which light is produced by a stabilized electric discharge through an ionized gas. The light source consists of a sealed glass/tube envelope wall and ballast. The size, shape, and color will depend on the application. (For example, but not limited to: neon, or fluorescent lamps.)

3.3 Light Emitting Diode (LED) Lighting Device—A lighting device in which light is produced by an LED or an array of LED's.

3.4 Lighting Device Light Center—The geometric center of the light source or sources used to illuminate the device function or the geometric center of the illuminated area if the light output is produced indirectly.

3.5 Incandescent Lighting Device—A lighting device in which light is produced by a filament being heated to incandescence by an electrical current.

3.6 Integrated Electronic Component—Electronic component(s) integrated within the housing of the lamp assembly or physically inseparable from the lighting device used to produce the desired output.

3.7 Sample—Samples submitted for test shall be representative of the device as regularly manufactured and marketed. Each sample shall be securely mounted on the test fixture in its design position and shall include all accessory equipment necessary to operate the device in its normal manner.

3.8 Sealed Lighting Devices—Lighting devices that do not allow the passage of gas or water between the interior environment and the exterior environment.

3.9 Test Fixture—Fixture specifically designed to support the device in its designed operating position during a laboratory test.

3.10 Vibration Test Fixture—A fixture specifically designed to support the device in its operating position during the vibration test. The fixture shall not have a resonant frequency in the test range.

***4. Tests*—**The following sections describe the individual tests which need not be performed in any particular sequence, except as noted in the test procedure. Unless otherwise specified all tests will be done at an ambient room temperature of 25 °C ± 5 °C. The completion of the tests may be expedited by performing the tests simultaneously on separately mounted samples.

However, it is recommended that the design of each device be evaluated to determine if the vibration test or the warpage test affect other tests, in which case, those tests shall be performed first.

4.1 Vibration Test—This test evaluates the ability of the sample device to resist damage from vibration-induced stresses. This test is not intended to test the vibration resistance of bulb filaments, but may be used to evaluate the effects of vibration-induced stresses on shock-mounted devices.

4.1.1 VIBRATION TEST EQUIPMENT

4.1.1.1 See SAE J577 JUN73 for details of vibration test machine.

4.1.2 VIBRATION TEST PROCEDURES

4.1.2.1 The DUT (Device Under Test), as mounted on the support supplied, shall be bolted to the anvil end of the table of the vibration test machine and vibrated at 750 cpm ± 10 cpm through a distance of 3 mm ± 0.25 mm. The table shall be spring mounted at one end and fitted with steel calks on the underside of the other end. These calks are to make contact with the steel anvil once during each cycle at the completion of the fall. The rack shall be operated under a spring tension of 27.3 kg to 31.7 kg.

4.1.2.2 Test duration is 60 +1/–0 minutes.

4.2 Moisture Test

4.2.1 WATER-SPRAY MOISTURE TEST—This test procedure shall be used to test the ability of the device to resist moisture leakage into the device from a water spray and to determine the drainage capability of the device with drain holes or other exposed openings in the device. Devices tested to 4.2.2 and complying with 5.2.2 of this document can be excluded from this test.

4.2.1.1 Water-Spray Moisture Test Equipment

4.2.1.1.1 The water-spray cabinet shall be equipped with one or more nozzles which provides a solid cone of water spray of sufficient included angle to completely cover the DUT. The centerline of the nozzle shall be directed downward at an angle of 45 degrees ± 5 degrees to the vertical axis of the rotating test platform.

4.2.1.1.2 The precipitation rate of the water spray at the DUT shall be 2.5 +1.6/–0.0 mm minimum per minute as measured with a vertical cylindrical collector centered on the vertical axis of rotation. The collector shall be 100 mm high and the inside diameter shall be a minimum of 140 mm.

4.2.1.1.3 The DUT shall rotate about its vertical axis at a rate of 4.0 rpm ± 0.5 rpm.

4.2.1.2 Water-Spray Moisture Test Procedures

4.2.1.2.1 The DUT shall be mounted and tested in the design position and in accordance with the manufacturer's instructions.

4.2.1.2.2 All drain holes, slots, and other openings shall remain open during the test.

4.2.1.2.3 Devices which have a portion protected in service may have that portion of the exterior surface of the DUT protected in the same manner during the test.

4.2.1.2.4 The test duration shall be a minimum of 12 hours.

4.2.1.2.5 The DUT shall be lighted for the first 5 minutes ± 0.25 minutes of each hour.

When multiple function lamps are tested, the following shall apply:

a. Only the major filament or major light source shall be lighted.
b. If more than one light source is used in the device, then the major function of the device or major light source only of each shall be lighted.

All DUT's should be energized at design voltage ±0.1 volts.

4.2.1.2.6 At the end of the water-spray test period, the rotation, the electrical supply, and the water spray shall be turned off and the DUT allowed to drain for a maximum of 1 hour in the closed cabinet.

4.2.1.2.7 Upon completion of the drain period, the interior of the DUT shall be observed for moisture accumulation. If a standing pool of water has formed, or can be formed by tapping or tilting the DUT, the accumulated moisture shall be extracted and measured.

4.2.1.2.8 Alternate Method for Determining Moisture Accumulation Within the Device—The DUT before testing shall be weighed and the weight in grams recorded. Upon the completion of the drain period, the DUT shall be wiped dry of any exterior moisture and the DUT reweighed to determine the amount of water inside.

4.2.2 WATER-SUBMERSION MOISTURE TEST—This test procedure shall be used to test devices designed to be sealed lighting devices.

4.2.2.1 Water-Submersion Moisture Test Equipment

4.2.2.1.1 A tank large enough to completely submerge the DUT to a depth of 50 mm measured from the top of the device is required.

4.2.2.1.2 The tank shall be filled with a mixture of water and wetting agent. The concentration of the mixture shall be sufficient to eliminate air bubble formation on the surface of the DUT.

4.2.2.2 Water-Submersion Moisture Test Procedures

4.2.2.2.1 The DUT shall be maintained at ambient room temperature until conditions have stabilized before testing.

4.2.2.2.2 The DUT shall be completely submerged to a depth of not less than 50 mm measured from the top of the device.

4.2.2.2.3 Test duration shall be a minimum of 1 minute.

4.2.2.2.4 The DUT shall be observed for air bubbles forming or escaping from the sealed portion of the DUT.

4.2.2.2.5 Throughout the test, the tank temperature shall be maintained at 70 °C + 5 °C/–0 °C.

4.3 Dust Test—This test evaluates the ability of the device to resist dust penetration, which could significantly affect the photometric output. Devices tested to 4.2.2 and complying with 5.2.2 of this document can be excluded from this test.

4.3.1 DUST TEST EQUIPMENT

4.3.1.1 The interior of the test chamber shall be cubical in shape with measurements of 0.9 to 1.5 m per side. The bottom of the hopper may be cone shaped to aid in the collection of the dust.

4.3.1.2 The internal chamber volume, not including a hopper-shaped bottom, shall be 2 m^3 maximum and shall be charged with 3 to 5 kg of the test dust.

4.3.1.3 The chamber shall have the capability of agitating the test dust by means of compressed air or blower fans in such a way that the dust is diffused throughout the chamber.

4.3.1.4 The test dust used shall be fine-powdered cement in accordance with ASTM C 150.

4.3.2 DUST TEST PROCEDURES

4.3.2.1 The DUT shall be mounted and tested in the design position and in accordance with the manufacturer's instructions.

4.3.2.2 All drain holes, slots, and other openings shall remain open during the test.

4.3.2.3 Devices which have a portion protected in service may have that portion of the exterior surface of the DUT protected in the same manner during the test.

4.3.2.4 Before the dust test, the luminous intensity at H-V shall be measured and the intensity recorded.

4.3.2.5 The mounted DUT shall be placed no closer than 150 mm from a wall of the dust chamber. Devices with a length exceeding 600 mm shall be horizontally centered in the test chamber.

4.3.2.6 The test dust shall be agitated as completely as possible by compressed air or blower(s) for 2 to 15 seconds at intervals of 15 minutes. The dust shall be allowed to settle between agitation periods.

4.3.2.7 The test duration shall be a minimum of 5 hours.

4.3.2.8 The DUT shall be lighted for the first 1 minute ± 0.25 minute of each hour.

When multiple function lamps are tested, the following shall apply:

a. Only the major filament or major light source shall be lighted.
b. If more than one light source is used in the device, the major function of the device or major light source only of each shall be lighted.

All DUT's should be energized at design voltage ±0.1 Volts.

4.3.2.9 Upon completion of the dust test, the exterior of the lamp shall be cleaned and the luminous intensity at H-V measured.

4.4 Corrosion Test—This test evaluates the ability of exterior-mounted devices to resist salt corrosion which would impair the functional characteristics of the device.

4.4.1 CORROSION TEST EQUIPMENT

4.4.1.1 A salt-spray (fog) cabinet, operating at the conditions specified by ASTM B 117 shall be used.

4.4.2 CORROSION TEST PROCEDURES

4.4.2.1 The DUT shall be mounted and tested in the design position and in accordance with the manufacturer's instructions.

4.4.2.2 All drain holes, slots, and other openings shall remain open during the test.

4.4.2.3 Devices which have a portion protected in service may have that portion of the exterior surface of the DUT protected in the same manner during the test.

4.4.2.4 The test duration shall be a minimum of 248 hours.

4.4.2.5 The DUT shall be lighted for the first 5 minutes ± 0.25 minutes of each hour.

When multiple function lamps are tested, the following shall apply:

a. Only the major filament or major light source shall be lighted.
b. If more than one light source is used in the device the major function of the device or major light source only of each shall be lighted.

All DUT's should be energized at design voltage ±0.1 volts.

4.4.2.6 At the end of the corrosion test, the electrical supply shall be turned off and the DUT removed from the test cabinet and allowed to dry for 1 hour.

4.5 Photometry Test—This test measures the luminous intensities at test points throughout the light distribution pattern as specified by the applicable SAE Publication for the sample device.

4.5.1 PHOTOMETRIC TEST EQUIPMENT

4.5.1.1 The positioner (goniometer) configuration shall be capable of positioning the sample device at the test point position specified in the applicable SAE Publication. The recommended goniometer configuration is specified as Type A as shown in Figure B1 of SAE J1330. Other systems may be used to achieve equivalent positioning, but it will be necessary at compound angles greater than 5 degrees from "H-V" to calculate the position which is equivalent to that of the recommended goniometer.

4.5.1.2 The photometer system shall consist of a sensor, amplifier, and indicator instrument. The system shall be capable of providing the luminous intensity reading (candela) of the output of the device being tested.

4.5.1.3 The sensor, unless otherwise specified, shall have a maximum effective area that will fit within a circle whose diameter is equal to 0.009 times the actual test distance from the light source of the device to the sensor. The sensor effective area is the actual area of intercepted light striking the detector surface of the photometer. For systems with lens(es) that change the diameter of the intercepter light beam before it reaches the actual detector surface, the maximum size requirements shall apply to the total area of light actually intercepted by the lens surface. The sensor shall be capable of intercepting all direct illumination from the largest illuminated dimension of the sample device at the test distance.

4.5.1.4 The color response of the photometer sensor shall be corrected to that of the 1931 CIE Standard observer (2 degree) Photopic Response Curve (ASTM E 308).

4.5.2 PHOTOMETRIC TEST PROCEDURE

4.5.2.1 The DUT shall be mounted and tested in the design position(s) or as mounted on the vehicle in accordance with the manufacturer's instruction.

4.5.2.2 Unless otherwise specified, accurate, rated bulbs shall be used. They shall be selected for accuracy as specified in SAE J387 and shall be operated at their design mean spherical candlepower.

4.5.2.3 Where special bulbs are used, they shall be aged in accordance with SAE J387 and operated at their design mean spherical candlepower.

4.5.2.4 If the design value of the mean spherical candlepower is not available or the light source is an integral part of the device, operate the light source (bulb filament) at its specified design voltage.

4.5.2.5 If the design mean spherical candlepower of the bulb is intentionally modified from specifications for a device through internal or external circuitry, operate the bulb with the voltage-modification circuitry attached and with the specified design voltage applied to the input of the modification circuitry.

4.5.2.6 The test distance for measuring the luminous intensity shall be made at equal to, or greater than, the minimum test distance between the center of the light source (or the face of a reflex reflector) and the photometer sensor as specified in the SAE Publication applicable to the function of the sample device.

4.5.2.7 The locations of test points are specified in the applicable SAE Publication. The following nomenclature shall apply:

4.5.2.7.1 The letters "V" and "H" designate the vertical and horizontal planes intersecting both the center of the device light source (or center of a reflex reflector) and the goniometer axis.

4.5.2.7.2 A device using a bulb that has a major and a minor light source shall be oriented with respect to its major light source.

4.5.2.7.3 "H-V" designates the zero test point angle at the intersection of the "H" and "V" planes. Unless otherwise specified, this intersection shall be parallel to the longitudinal axis of the vehicle in the case of front and rear function devices and shall be horizontal and perpendicular to the longitudinal axis of the vehicle in the case of side function devices. The letters "U," "D," "L," and "R" (up, down, left, and right, respectively) designates the angular position in degree from the H-V planes to the goniometer as viewed from a lamp or to the source of illumination as viewed from a reflex reflector.

4.5.2.7.4 The horizontal angle of the test point ("L" left and "R" right) is the angle between the vertical plane and the projection of the light ray from the device onto the horizontal plane.

4.5.2.7.5 The vertical angle of the test point ("U" up and "D" down) is the true angle between the horizontal plane and the light ray from the device.

4.5.2.7.6 The direction of an angular test point can be visualized when an observer stands behind the device and looks in the direction of the emanating light beam towards the photometer sensor when the device is properly aimed with respect to H-V.

4.5.2.8 Photometric measurements shall be made with the light source(s) steady burning. The luminous intensity measurements, in candela, shall be recorded for each of the test points and zones specified for that function of the device being tested.

4.6 Warpage Test for Devices With Plastic Components—This test evaluates the ability of the plastic components of the sample device to resist warpage due to ambient heat and heat from the light source.

4.6.1 WARPAGE TEST EQUIPMENT

4.6.1.1 A circulating air oven.

4.6.2 WARPAGE TEST PROCEDURE

4.6.2.1 The DUT shall be mounted and tested in the design position in accordance with the manufacturer's instructions.

4.6.2.2 The oven temperature shall be maintained between 46 °C and 49 °C throughout the test.

4.6.2.3 The DUT shall be positioned at or near the center of the oven.

4.6.2.4 Unless otherwise specified, the light source(s) shall be operated at design voltage specified by the device manufacturer and cycled as specified in Table 1.

TABLE 1—CYCLE TIMES (MINUTES)

Device Type	Steady Burn	5 On — 5 Off	Steady Flash
Clearance	x		
Identification	x		
Side Marker	x		
Tail	x		
Stop		x	
Front and Rear Turn Signal			x
Side Turn Signal			x
High-Mounted Stop		x	
Back Up		x	
License Plate	x		
Non Headlamp DRL	x		

4.6.2.5 Test duration is 1 hour.

4.6.2.6 The flash rate shall be between 80 and 100 flashes per minute with a 50% ± 2% on time.

4.6.2.7 Devices with multiple functions shall be tested with all functions simultaneously operating as specified, except for the backup function, which shall be tested separately. Stop and turn signal lamp combinations shall be tested as a stop lamp function only.

4.7 Humidity-Temperature Test—This test is for lighting devices including, but not limited to, LED's and Discharge Signal Lighting Systems (DSL's) with Integrated electronic components. It is a combination test designed to verify operation throughout extremes of temperature and under conditions of high humidity.

4.7.1 HUMIDITY-TEMPERATURE TEST EQUIPMENT—Must be capable of performing the testing described in the temperature profile shown in Figure 1. Note that the 90% Relative Humidity requirement is applied only during the 38 °C part of the profile.

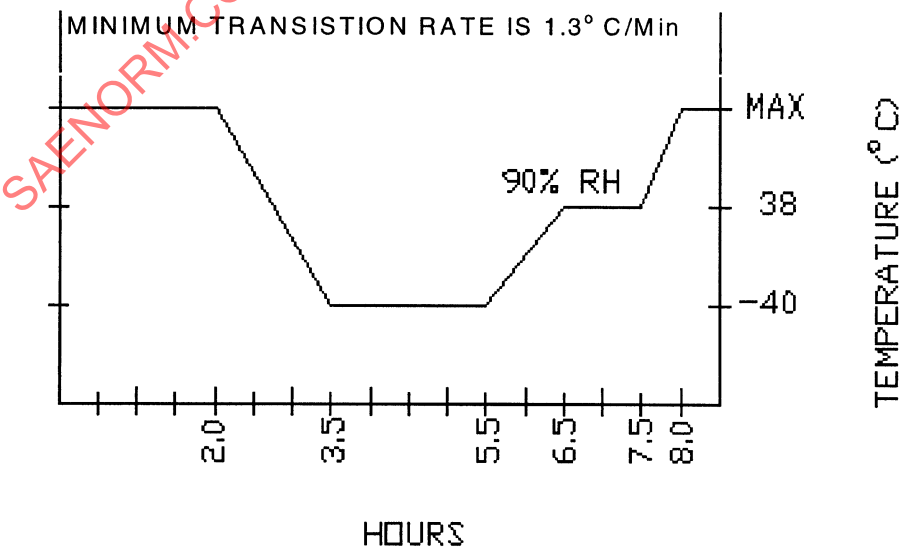


FIGURE 1—COMBINED HUMIDITY—TEMPERATURE PROFILE

4.7.2 HUMIDITY-TEMPERATURE TEST PROCEDURE

4.7.2.1 The DUT shall be mounted and tested in the design position(s) or in accordance with the manufacturer's instructions.

4.7.2.2 All drain holes, slots, and openings shall remain open during the test.

4.7.2.3 Devices which have a portion protected in service may have that portion of the DUT protected in the same manner during the test.

4.7.2.4 The DUT need not be energized during the test cycle illustrated in Figure 1. The maximum test temperature selected shall be appropriate to that expected for the location and use of the device and may not be less than 76 °C.

Note that SAE J1455 offers environmental temperature extreme summary tables that may aid in selecting an appropriate maximum temperature. The maximum temperature should be documented in the test report. A minimum of one eight-hour cycle is to be completed. The number of cycles should also be documented in the report.

4.8 Voltage Regulation Tolerance Testing—This test is for lighting devices containing integrated electronic components used to modify the vehicle voltages needed to energize LEDs, Discharge Signal Lighting Systems (DSL's), Discharge Light Sources or Incandescent Lighting Devices.

4.8.1 VOLTAGE REGULATION TOLERANCE TEST EQUIPMENT—This equipment must be capable of providing the DC voltages as referenced in 4.8.2.2 for 12 volt systems and 4.8.2.3 for 24 volt systems. The DC power supply should meet the following specifications:

4.8.1.1 *Line Regulation*—±0.1%

4.8.1.2 *Ripple and Noise*—0.4% maximum

4.8.1.3 *Stability*—±0.1%

4.8.2 VOLTAGE REGULATION TEST PROCEDURE

4.8.2.1 The DUT shall be mounted and tested in the design position(s) in accordance with the manufacturer's instructions.

4.8.2.2 The DUT shall be subjected to the test conditions for 12 volt systems shown in Table 2:

TABLE 2—VOLTAGE CONDITIONS

Condition	DC Voltage	Application Time
Minimum Normal Operating Vehicle Voltage	7.0 V	2 minutes
Jumper Starts	24.0 V	2 minutes
Reverse Polarity	–12.0 V	2 minutes

4.8.2.3 The DUT shall be subjected to the following test conditions for 24.0 volt systems as shown in Table 3:

TABLE 3—VOLTAGE CONDITIONS

Condition	DC Voltage	Application Time
Minimum Normal Operating Vehicle Voltage	18.0 V	2 minutes
Jumper Starts	48.0 V	2 minutes
Reverse Polarity	–24.0 V	2 minutes

4.9 Vehicle Transient Voltage Tests—These tests are to insure that transient (short duration) voltage changes do not cause failure in lighting devices containing integrated electronic circuits which are necessary for proper operation of the device.

4.9.1 VEHICLE TRANSIENT VOLTAGE TEST EQUIPMENT

4.9.1.1 The vehicle Transient Voltage Test Equipment shall be capable of meeting the requirements cited in Tables 4 and 5 for the following requirements: Load Dump, Inductive Load Switching, and Mutual for 12 and/or 24 volt applications.

NOTE— Source resistance (ohms) may be changed where applicable in following tables.

TABLE 4—TYPICAL 12 V VEHICLE TRANSIENT VOLTAGE CHARACTERISTICS

Lines	Type	Source (ohms)	Rise (µs)	Open Circuit Equation	Repetition	Energy
Power	Load Dump	0.4	100	$14+86e^{(-t/0.4)}$	5 Pulses at 10 s intervals	(1)(2)
I/O - (3)	Inductive Switching	20	1	$14\pm600e^{(-t/0.001)}$	10 Pulses at 1 s intervals	(3)(2)
I/O All	Mutual	50	1	$14\pm300e^{(-t/0.000015)}$	10 Pulses at 1 s intervals	(2)

1. The alternator is capable of outputting much more energy than can be absorbed by commonly used electronic clamping devices. Therefore, when clamping devices are used in electronic modules, caution must be used in the design of the vehicle electrical system to insure the energy limitations of each clamping device are observed (see Appendix B in SAE J1455 AUG94).
2. The transient waveforms described previously in mathematical form may actually be implemented by diode OR-ing or "combining" a DC and transient voltage.
3. This transient applies to those I/O lines which may be connected to unclamped inductive loads. In addition, the energy available will be 0.5LI^2 where I is the current through the inductor in amps and L is the inductance in henries.

TABLE 5—TYPICAL 24 V VEHICLE TRANSIENT VOLTAGE CHARACTERISTICS

Lines	Type	Source (ohms)	Rise (µs)	Open Circuit Equation	Repetition	Energy
Power	Load Dump	0.8	100	$28+122e^{(-t/0.4)}$	5 Pulses at 10 s intervals	(1)(2)
I/O - (3)	Inductive Switching	20	1	$28\pm600e^{(-t/0.001)}$	10 Pulses at 1 s intervals	(3)(2)
I/O All	Mutual	50	1	$28\pm300e^{(-t/0.000015)}$	10 Pulses at 1 s intervals	(2)

1. The alternator is capable of outputting much more energy than can be absorbed by commonly used electronic clamping devices. Therefore, when clamping devices are used in electronic modules, caution must be used in the design of the vehicle electrical system to insure the energy limitations of each clamping device are observed (see Appendix B in SAE J1455 AUG94).
2. The transient waveforms described previously in mathematical form may actually be implemented by diode OR-ing or "combining" a DC and transient voltage.
3. This transient applies to those I/O lines which may be connected to unclamped inductive loads. In addition, the energy available will be 0.5LI^2 where I is the current through the inductor in amps and L is the inductance in henries.

4.9.1.2 *Vehicle Transient Voltage Test Circuit*—The circuit in Figure 2 is an example of the basic setup for Transient Voltage Testing, which can also be modified to perform Load Dump, Inductive and Mutual Switching. Values for the circuit components can be determined by using the equations in Tables 4 and 5. Note that all 3 types of test circuits mentioned are designed to have simulated resistance, not just the alternator resistance alone. The reason for this is that actual alternator source resistance by itself is approximately 0.25 ohms – and the realistic load resistance on the rest of the truck system varies. It includes harness system component resistance and other device resistance - connected in parallel on common lines. These devices will all dissipate a part of the total energy. Therefore, surge current should be limited when testing a single device by using series resistance as noted on test circuit.

NOTE— For Inductive Switching and Mutual Testing, the 3 ohms series resistor type and value has to be changed to Non-Inductive, 20 and 50 ohms respectively.

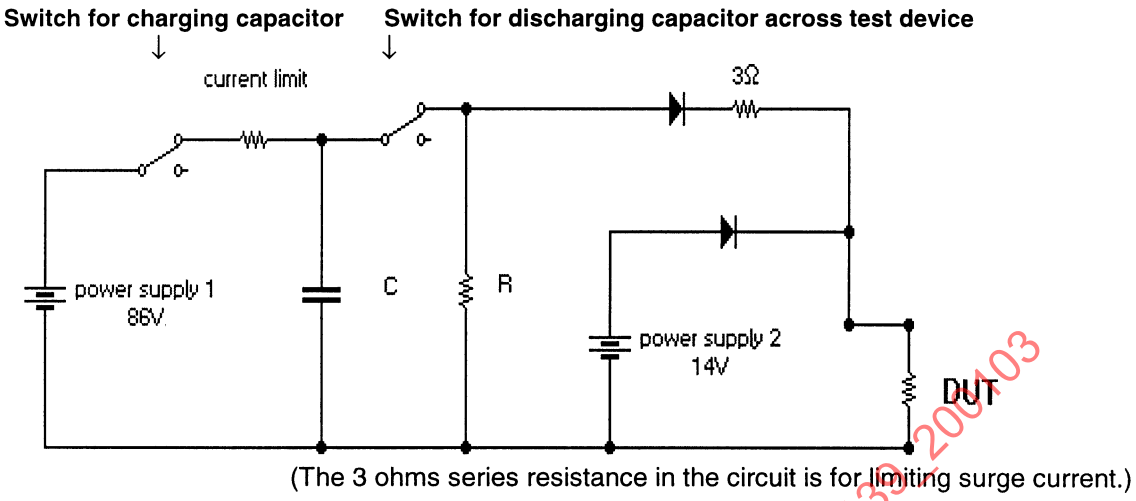


FIGURE 2—LOAD DUMP TESTING CIRCUIT

The first equation in Table 4 shows the Load Dump calculation represented by the exponential function for the discharging of a capacitor.

This equation may be simplified as follows:

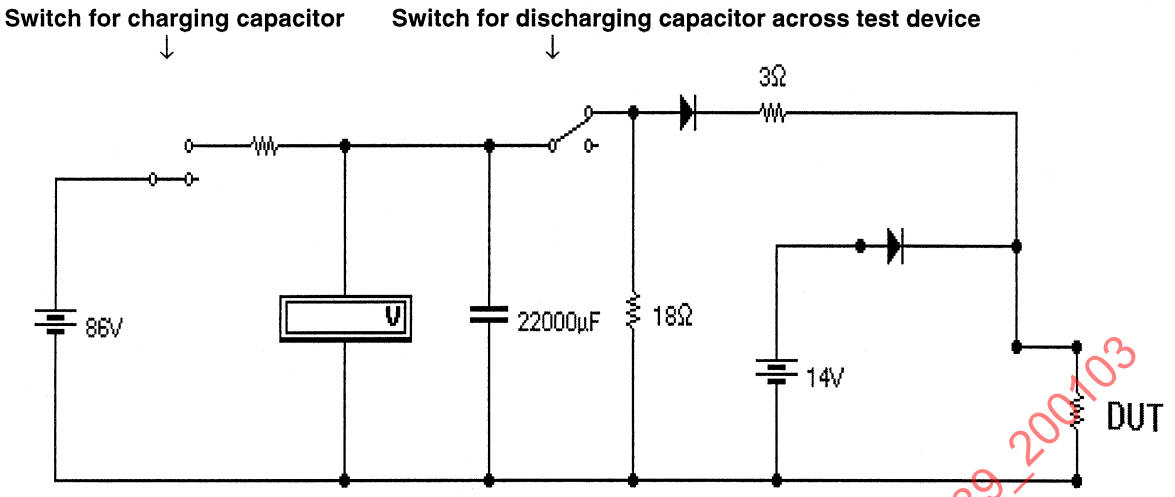
$$Vc = Vi\, e^{(-t/T)} \qquad \text{(Eq. 1)}$$

where:

Vc = Capacitor Voltage at any particular time
Vi = Initial Voltage
e = 2.7183 (base of natural logarithms)
T = RC time constant
t = Particular time which Vc is desired

In Table 4, the load dump equation shows 14 volts as the DC output voltage used for nominal 12 volt systems; 86 volts is the peak voltage for the short duration described by the equation 0.4 = T or RC. To design a circuit with the proper time duration, it is necessary to select a capacitor value for C. Figure 3 shows an example using a 22 000 µF capacitor. We can calculate a resistor value R using the formula T = RC.

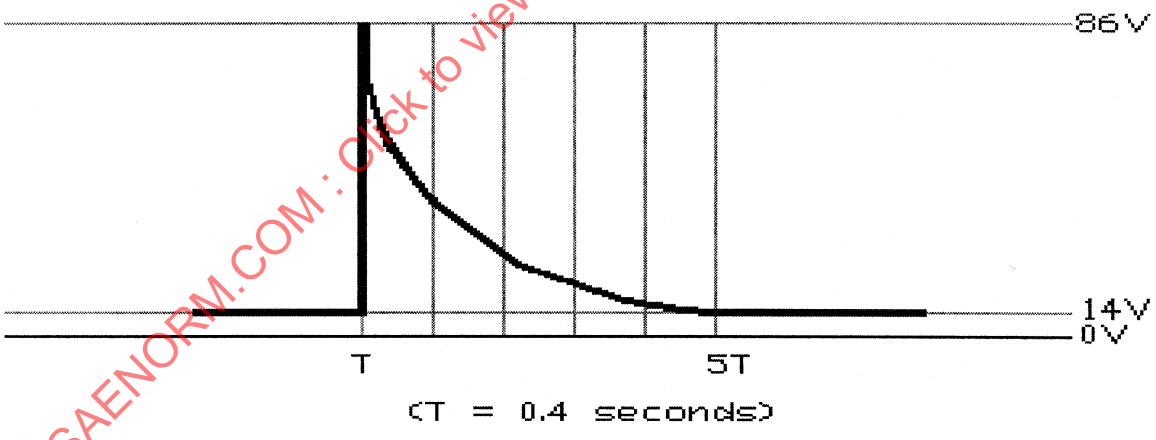
EXAMPLE—T = RC
0.4s = R(22000µF)
R=18Ω



(V in box, is a digital voltmeter. The 3 ohms series resistance in the circuit is for limiting surge current.)

FIGURE 3—EXAMPLE OF A LOAD DUMP TESTING CIRCUIT

The oscilloscope screen in Figure 4 displays the voltage that the DUT will see during a load dump pulse on a 12 volt (14.0-Volt) system. These scope measurements are made at the DUT connection point without the DUT attached.



Note: It takes approximately 5 time constants (5T) to charge or discharge a capacitor.

FIGURE 4—TRANSIENT VOLTAGE CAPACITOR DISCHARGE

NOTE— It takes approximately 5 time constants (5T) to charge or discharge a capacitor.

4.9.2 VEHICLE TRANSIENT VOLTAGE TEST PROCEDURE

4.9.2.1 The DUT shall be mounted and tested in the design position and in accordance with manufacturer's instructions.

4.9.2.2 The DUT shall be subjected to the transient voltages outlined in Table 4 (12 volt system) or Table 5 (24 volt system).

4.9.2.3 The DUT shall be subjected to the repetition of pulses as shown in Tables 4 and 5.

4.9.2.4 A single test device need not be subjected to all of the test voltages. Several identical devices may be used; however, all test results must be included in the report.

4.10 Thermal Cycle Test—This test is necessary to insure proper operation of devices containing integrated electronic circuits under temperature extremes. Such extremes may be caused by factors such as: climatic, environmental or seasonal cycles; heat from vehicle sources such as the engine and drivetrain components; heat from the lighting device itself and/or thermal stress caused by repeated temperature cycling.

4.10.1 THERMAL CYCLE TEST EQUIPMENT

4.10.1.1 An Environmental Chamber capable of the temperature ranges at the required transition rates.

4.10.2 THERMAL CYCLE TEST PROCEDURE

4.10.2.1 *Mounting*—The DUT shall be mounted in the design position in accordance with the manufacturer's instructions.

4.10.2.2 *Cycle*—The test cycle shall be in accordance with **SAE J1889 - Thermal Cycle Test**. The minimum temperature shall be –40 °C and the maximum temperature shall be not less than 49 °C. The maximum temperature used shall be documented in the report. SAE J1455 may be referenced as a guideline for selecting an appropriate maximum temperature above 49 °C.

4.10.2.3 *Number of Test Cycles*—A minimum of five (5) cycles is required. The number of cycles shall be documented in the report.

4.10.2.4 *Device Operation*—The DUT shall be tested to Table 1 (Reference 4.6.2.4).

5. Performance Requirements

5.1 Vibration Test Requirements

5.1.1 Upon completion of the test, the DUT shall be examined. Any device showing evidence of material physical weakness, lens or reflector rotation, displacement or rupture of parts except bulb failures, shall be considered to have failed, except that rotation of lens or reflector shall not be considered as a failure when tests show compliance with specification despite such rotation.

5.2 Moisture Test Requirements

5.2.1 WATER SPRAY REQUIREMENTS

5.2.1.1 Devices tested to 4.2.2 and complying with 5.2.2 of this document can be excluded from this test.

5.2.1.2 The accumulation of moisture shall not exceed 2.0 ml.

5.2.1.3 Alternate Requirement for Water Spray

5.2.1.3.1 The increase in mass from the accumulation of moisture shall not exceed 2.0 g.

5.2.2 WATER SUBMERSION REQUIREMENTS

5.2.2.1 A DUT producing a steady flow of air bubbles, or the formation of three or more air bubbles in any 10 second period from anywhere on or around the device, is considered a failure. Bubbles from air trapped outside the housing of the DUT shall not be considered a failure.

5.3 Dust Requirements

5.3.1 After removal from the Dust Chamber the DUT shall be visually examined for dust intrusion which could affect the photometry performance of the DUT. If such dust intrusion is found, the measured luminous intensity of the DUT shall not be less than 90% of the DUT tested without any dust intrusion. Devices tested to 4.2.2 and complying with 5.2.2 of this document can be excluded from this test.

5.4 Corrosion Requirements

5.4.1 After removal from the Salt-Spray Cabinet and after the 1 hour drying period, the DUT shall be visually examined for corrosion which could affect other tests contained in this document. If such corrosion is found, the affected test(s) shall be performed on the corroded sample to insure compliance.

5.5 Photometric Requirements

5.5.1 The luminous intensity values shall be within the limits specified in the applicable SAE Technical Report for the function being tested.

5.6 Warpage Requirements

5.6.1 Upon completion of the test, the DUT shall be visually examined for warpage of plastic components. If warpage is observed that could result in failure of other tests contained in this document, the test(s) shall be performed on the warped sample to insure compliance.

5.7 Humidity-Temperature Test Requirements

5.7.1 Upon completion of the test cycles, the DUT shall be visually examined for proper operation. If there is visual evidence of change which could result in failure of the other tests contained in this document, the test(s) shall be performed to insure compliance.

5.8 Voltage Regulation Testing Requirements

5.8.1 At the conclusion of the test the DUT shall remain operational. Some distortion of plastic parts is acceptable. If there is visual evidence of change which could result in failure of the other tests contained in this document, the test(s) shall be performed to insure compliance.

5.8.2 The DUT need not light during the reverse voltage exposure, however it shall remain operational when correct polarity is restored.

5.9 Vehicle Transient Voltage Test Requirements

5.9.1 At the conclusion of the repetitions specified for each transient voltage, the DUT must be operational. Light output may change only during the application of the transient voltage.