SAE International™ SURFACE VEHICLE STANDARD

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(R) Emergency Warning Device and Emergency Warning Device Protective Container

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1. ***Scope***—This SAE Standard provides test procedures and performance requirements for emergency warning devices (triangular shape), without self-contained energy sources, that are designed to be carried in motor vehicles and used to warn approaching traffic of the presence of a stopped vehicle, except for devices designed to be permanently affixed to the vehicle, and provides test procedures and performance requirements for protective containers for such emergency warning devices.

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2. References

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

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

SAE J576—Plastic Materials for Use in Optical Parts Such as Lenses and Reflectors of Motor Vehicle Lighting Devices
SAE J759—Lighting Identification Code
SAE J2139—Tests for Lighting Devices and Components used on Vehicles 2032 mm or more in Overall Width

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

ASTM E 308—Practice for computing the colors of objects by using the CIE system
ASTM E 811—Practice for measuring colorimetric characteristics of retroreflectors under nighttime conditions
ASTM E 991—Practice for color measurement of fluorescent specimens
ASTM E 1164—Practice for obtaining spectrophotometric data for object-color evaluation
ASTM E 1347—Standard test method for color and color-difference measurement by tristimulus (filter) colorimetry
ASTM E 1349—Test method for reflectance factor and color by spectrophotometry using bi-directional geometry

2.1.3 ECE PUBLICATIONS—Available from International Telecommunications Union (ITU), Place des Nations, CH-1211 Geneva 20, Switzerland

ECE Regulation no. 27 Advance-warning triangles

2.1.4 NIST PUBLICATION—Available from National Institute for Standards and Technology, 5285 Port Royal Road, Springfield, VA 22161

NBS Technical Note 594-12—The Translucent Blurring Effect- Method of Evaluation and Estimation

2.2 Related Publications

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

SAE J578—Color Specification
SAE J594—Reflex Reflectors

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

ASTM E 809—Practice for measuring photometric characteristics of retroreflectors

2.2.3 NHTSA PUBLICATION—Available from National Highway Traffic Safety Administration, 400 Seventh Street SW, Washington, DC, 20024-0002.

Federal Motor Vehicle Safety Standard No. 125—Warning devices—available as 49 CFR 5712.125

2.2.4 FHWA PUBLICATION—Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Federal Highway Administration Parts and Accessories Necessary for Safe Operation, Subpart "H," 393.95, Emergency Equipment

3. Definitions

3.1 Emergency Warning Device—A triangular shaped device placed on the highway to warn the driver of an approaching vehicle of a stationary hazard (disabled vehicle) by reflection of light from the headlamps of the approaching vehicle at night or by a fluorescent area in the daytime.

3.2 Emergency Warning Device Protective Container—A reusable container sometimes provided or used with the emergency warning device. The container is intended to protect the fluorescent area of the device from deterioration due to prolonged exposure to daylight. Such containers may be capable of storing and protecting one, two, or three emergency warning devices. The device may be folded or collapsed into a smaller size and shape for storage in the protective container.

3.3 Fluorescent—The property of emitting visible light due to the absorption of radiation of a shorter wavelength, which may be outside the visible spectrum.

***4. Identification Code*—**Emergency warning devices may be identified by the code W4 in accordance with SAE J759.

5. Tests

5.1 Samples Submitted for Test

5.1.1 EMERGENCY WARNING DEVICE—Sample submitted for test shall be representative of the device as regularly manufactured and marketed.

5.1.2 EMERGENCY WARNING DEVICE PROTECTIVE CONTAINER—Sample submitted for test shall be representative of the container as regularly manufactured and marketed.

5.1.3 SINGLE SAMPLE USED FOR ALL TESTS—The following tests shall all be performed on a single device. The only exceptions to this are (a) the provision in 5.3.3.1 for testing the color of a disc of identical material rather than a portion of or a specimen removed from the sample device, (b) the stability test as noted in 5.4, and (c) the opacity test on the protective container.

5.1.4 TEST SEQUENCE (CONDITIONING)—The conditioning tests described in 5.2.1 through 5.2.5 shall all be performed on the single device, and shall be performed in the order listed. Only following these tests shall the device be tested for color, reflectance, and fluorescence. After each conditioning test in the sequence, the device shall be returned to ambient laboratory air at 25 °C ± 5 °C for at least 2 h.

5.1.5 TESTS FOR COLOR, REFLECTANCE, AND FLUORESCENCE—The tests for color, reflectance, and fluorescence described in 5.3.1 through 5.3.3 may be performed in any order desired, however, they shall be performed after the conditioning tests on the same device.

5.1.6 TESTING IN FOLDED OR FUNCTIONAL POSITION—Some of the conditioning tests are specified as being performed on the device in the folded or stored position. For these tests, the device shall be folded per the manufacturer's instructions but otherwise still standing on its own base as much as is possible, and shall not be inside any protective container. For tests in the folded position, the device shall be unfolded at the end of the test. For tests in the functional position, the device shall be folded and then unfolded at the end of the test. This entire requirement does not apply to devices that cannot be folded or collapsed.

5.1.7 STABILITY TEST PERFORMED ON A SEPARATE DEVICE—The stability test described in 5.4 may be performed on a separate device other than the device conditioned and then tested for color, reflectance, and fluorescence.

5.2 Physical Tests

5.2.1 LOW TEMPERATURE TEST—The device in its folded position shall be conditioned at –40 °C ± 3 °C for at least 16 h in a circulating air chamber, using ambient air which would have had not less than 30% and not more than 70% relative humidity at 25 °C ± 5 °C.

5.2.2 HIGH TEMPERATURE TEST—The device in its folded position shall be conditioned at 65 °C ± 3 °C for at least 16 h in a circulating air chamber, using ambient air which would have had not less than 30% and not more than 70% relative humidity at 25 °C ± 5 °C.

5.2.3 HUMIDITY TEST—The device in its functional position shall be conditioned at 38 °C ± 3 °C and 90% minimum relative humidity for at least 16 h.

5.2.4 CORROSION TEST—The device shall be tested in either its folded or functional position in accordance with the corrosion test in SAE J2139, except that the test duration shall be 4 h.

5.2.5 SUBMERSION TEST—The device in its functional position shall be immersed for at least 2 h in water at a temperature of 38 °C ± 3 °C at a depth of at least 150 mm as measured from the top of device.

5.3 Photometric and Color

5.3.1 RED REFLEX REFLECTOR—Prevent the orange fluorescent material from affecting the photometric measurements of the reflectivity of the reflex reflector by masking. Each face of the device shall be tested in its functional position in accordance with SAE J2139, except that the measurements shall be compared to the photometric requirements of Table 1. The total area of each face of the device shall be photometered either in whole or in parts with particular caution regarding beam uniformity.

TABLE 1—PHOTOMETRIC REQUIREMENTS FOR THE RED REFLEX REFLECTOR ALL VALUES IN MILLICANDELA PER LUX

Entrance Angles	V-10U	H-30L	H-20L	H-V	H-20R	H-30R	V-10D
0.2 degree observation angle	7430	745	3715	7430	3715	745	7430
1.5 degree observation angle	74	7	37	74	37	7	74

5.3.2 TEST FOR COLOR AND LUMINANCE FACTOR (β) OF THE ORANGE FLUORESCENT MATERIAL

5.3.2.1 Prevent the red retroreflective material from affecting the measurement of the color and luminance factor of the orange fluorescent material by masking.

5.3.2.2 Using 45/0 geometry, determine the luminance factor, β, and the chromaticity coordinates, x and y, in accordance with ASTM E 991 and ASTM E 308. Characteristics of the measurement instrumentation shall follow ASTM E 1164, E 1347, and E 1349. Note that the specimen must be illuminated by a source approximating D65 and the rating of the source must be measured or certified spectroradiometrically to be less than 15 as determined by means of the equation given in ASTM E 991.

5.3.2.3 The backing behind the specimen shall be matte black. The wavelength range of illumination shall be from 300 to 760 nm. Diameter of the illumination aperture shall be at least 16 mm. Diameter of the detector aperture shall initially be approximately equal to the diameter of this illumination aperture and shall be reduced in size incrementally until the luminance value becomes constant. When the value becomes constant, the tristimulus values, x, y, and z, shall be calculated for 5 nm intervals in accordance with ASTM E 308. See also NBS Technical Note 594-12.

5.3.2.4 The luminance factor β may be obtained by either of the following:

5.3.2.4.1 By dividing the luminance L of the sample by the luminance L_0 of a perfect diffuser whose luminance factor β_0 is known under identical conditions of illumination and observation; the luminance factor β of the sample then results from this formula:

$$\beta = \beta_0(L/L_0) \quad \text{(Eq. 1)}$$

5.3.2.4.2 When the color of the fluorescent material has been colorimetrically determined from the ratio of the tristimulus value Y of the sample and the tristimulus value of the perfect diffuser Y_0, the luminance factor β of the sample then results from this formula:

$$\beta = Y/Y_0 \quad \text{(Eq. 2)}$$

5.3.2.5 Whenever possible, measurement shall be made on an area that does not contain writings or markings.

5.3.3 TEST FOR COLOR OF RED RETROREFLECTIVE MATERIAL—Determine the chromaticity coordinates, x and y, in accordance with ASTM E 811 and ASTM E 1347, at 0.2 degree observation angle and 5 degrees entrance angle. Source and receptor angular apertures shall each subtend not more than 10 min of arc. Illuminant shall be CIE Standard Source A. Color test method shall be ASTM E 308.

5.3.3.1 Alternate specimen for Red Color Test—Alternatively, manufacturers of emergency warning devices may, as an optional test procedure, evaluate the color of the retroreflective area by measuring the color of the light transmitted through a disc molded of the same material and dye formulation as the retroreflector. The thickness of the disc should be not greater than two times the average thickness of the retroreflector as measured at six test points from the face of the lens to the apices of the retroreflecting elements. If the thickness of the retroreflectors varies, the thickness of the disc shall be based upon the retroreflector with the least average thickness. Illuminant shall be CIE Standard Source A. Color test shall be ASTM E 308.

5.3.4 TEST FOR OPACITY OF THE EMERGENCY WARNING DEVICE PROTECTIVE CONTAINER—Cut one specimen each from the thinnest wall area and from the thinnest corner of the same sample container. Place the specimens, in turn, in the specimen position of a UV-through-visible spectrophotometer capable of measurement in the 300 to 540 nm wavelength range. Measure the percent transmittance at wavelength intervals of 10 nm within this range, and determine the average transmittance within the range.

5.4 Stability Test (Wind Test)

5.4.1 WIND VELOCITY, DIRECTION, AND DURATION—The device in its functional position shall be placed on a horizontal brushed concrete surface both with and against the brush marks and subjected to a horizontal wind of 17.9 m/s +0.0/–0.9 m/s. The wind shall be directed for 3 min minimum in each position; perpendicular to the device face, first on one face and then the other face.

5.4.2 MINIMUM DIMENSIONS OF WIND TUNNEL—The minimum size and configuration of the wind tunnel shall be such that when the device, on the brushed concrete surface, is placed on the floor of the tunnel with the triangular portion normal to the wind flow, there shall be a minimum of 150 mm clearance from any point on the triangle to any wall surface, excluding the floor.

5.4.3 ROUGHNESS OF CONCRETE SURFACE—Determination of the roughness of the brushed concrete surface by the “Sandy Beach Method” (ECE-R27, Annex 4) which describes the geometric roughness of the brushed concrete surface on which the warning triangle is placed during the test of stability as required.

5.4.3.1 This test is carried out by means of using round-grain, dry sand having a grain size between 0.160 mm and 0.315 mm. The volume to be used is 25.00 mL ± 0.15 mL. The sand is spread out over the brushed concrete surface where the test is carried out by means of a flat, circular disc with a minimum diameter of 65 mm, one side of which is covered with a sheet of rubber having a thickness of 1.5 mm to 2.5 mm and the other provided with an appropriate handle. The brushed concrete surface on which the test is to be carried out must be dry and brushed with a soft brush to remove any dirt or loose sand.

5.4.3.2 The sand which has been firmly filled into an appropriate receptacle is then poured out onto the surface to be tested in a single heap. The sand is then carefully spread out on the surface by means of repeated circular movements of the rubber-faced disc so as to form a round area of sand covering the concrete surface.

5.4.3.3 Two diameters, at right angles to one another, of the sand thus formed are then measured, and the mean determined. Six tests of this kind are carried out on the brushed concrete surface, with the parts to be tested being distributed over the surface to be tested as evenly as possible. The mean of the results of the six tests shall be greater than 240 mm, and less than 270 mm.

5.4.4 WIND VELOCITY AND TEMPERATURE—The device is to be supported by the brushed concrete surface within the tunnel, with the triangular portion first oriented in a direction normal to the wind flow, then turned 180 degrees and retested. The velocity of the steady-state wind in the wind tunnel shall be 17.9 m/s +0.0/–0.9 m/s as measured at the approximate location of each of the three corners of the triangle, and at the geometric center, prior to locating the brushed concrete surface and the triangle into the tunnel. The temperature of the air stream shall be 25 °C ± 5 °C.

5.4.5 DETERMINING DEGREE OF TILT—During the 3-min wind test, the device shall be videotaped against a background mask having a series of angular marks indicating the degree of tilt. The degree of tilt is determined by reviewing the videotape and taking the average of the maximum and minimum angular oscillations of the triangle tip. In construction of the mask, insure that the effects of parallax are accounted for.

6. Requirements

6.1 Material—The plastic material used in optical parts shall meet the requirements of SAE J576.

6.2 Physical Tests—After testing in accordance with Section 5 and the referenced test procedures of SAE J2139 with the modifications detailed in this document, device shall meet the following requirements:

6.2.1 LOW TEMPERATURE TEST—After testing in accordance with 5.2.1, device shall show no visible deterioration that could inhibit its functional performance.

6.2.2 HIGH TEMPERATURE TEST—After testing in accordance with 5.2.2, device shall show no visible deterioration that could inhibit its functional performance.

6.2.3 HUMIDITY TEST—After testing in accordance with 5.2.3, device shall show no visible deterioration that could inhibit its functional performance.

6.2.4 CORROSION TEST—After testing in accordance with 5.2.4, device shall show no visible deterioration that could inhibit its functional performance. Visible corrosion is permitted so long as the functional performance of the device is not affected.

6.2.5 SUBMERSION TEST—After testing in accordance with 5.2.5, device shall show no visible deterioration that could inhibit its functional performance. Furthermore, there shall be no visible moisture within the device at the conclusion of the test.

6.3 Photometric and Color

6.3.1 RED REFLEX REFLECTOR—Each face of the device shall meet the photometric requirements of Table 1.

6.3.2 ORANGE FLUORESCENT MATERIAL (COLOR AND LUMINANCE FACTOR (β))

6.3.2.1 Orange Fluorescent Material (Color)—The chromaticity coordinates x, y of the orange fluorescent material shall fall within the spectrum locus and the boundaries defined by Equations 3 to 5:

$$\text{Yellow} \qquad y = 0.49x + 0.17 \qquad \text{(Eq. 3)}$$

$$\text{White} \qquad x + y = 0.93 \qquad \text{(Eq. 4)}$$

$$\text{Red} \qquad y = 0.35 \qquad \text{(Eq. 5)}$$

6.3.2.2 Orange Fluorescent Material (Luminance Factor (β))—The luminance factor of the orange fluorescent material shall be at least 30% ($\beta \geq 0.30$).

6.3.3 RED RETROREFLECTIVE MATERIAL (COLOR)—The chromaticity coordinates x, y of the red retroreflective material shall fall within the spectrum locus and the boundaries defined by the Equations 6 and 7:

$$\text{Yellow} \qquad y = 0.33 \qquad \text{(Eq. 6)}$$

$$\text{Purple} \qquad x + y = 0.98 \qquad \text{(Eq. 7)}$$

6.3.4 OPACITY OF THE EMERGENCY WARNING DEVICE PROTECTIVE CONTAINER—After testing the emergency warning device protective container in accordance with 5.3.4, for wavelengths from 300 to 540 nm, average transmittance shall be not greater than 0.2%.

6.4 Stability Test (Wind Test)—After testing the device in accordance with 5.4:

No part of the device shall slide more than 75.0 mm from its initial position, and
Its triangle portion shall not tilt to an average position that is more than 10 degrees from the vertical, and
Its triangle portion shall not rotate when viewed from above more than 10 degrees in either direction from the initial position.

6.5 Design Requirements

6.5.1 SHAPE AND POSITION FROM ROAD SURFACE—The emergency warning device shall form an equilateral triangle and each side shall display both a daytime and a nighttime warning area. The device shall stand in a plane not more than 10 degrees from the vertical, with the lower base of the triangle horizontal and not less than 25 mm above the road surface.

6.5.2 ERECTED AND RETRIEVED WITHOUT TOOLS—The emergency warning device shall be manufactured so as to be erected for use in its functional position and folded and replaced in its protective container or storage compartment without the use of any tools.

6.5.3 EMERGENCY WARNING DEVICE PROTECTIVE CONTAINER—Each emergency warning device protective container shall provide protection from damage and deterioration by exposure to daylight for one, two, or three emergency warning devices. The container shall be reusable and shall not require the use of any tools to remove or to replace the emergency warning devices.

6.5.4 DAYTIME WARNING—The daytime warning shall be an orange fluorescent area meeting the color and luminance requirements specified.

6.5.5 NIGHTTIME WARNING—The nighttime warning shall be a red retroreflective area meeting the color and photometric requirements specified.

6.5.6 SIZE OF TRIANGLE PORTION—Each of the three edges of the triangular portion of the device shall not be less than 430 mm and not more than 560 mm and not less than 50 mm wide and not more than 75 mm wide. See Figure 1.

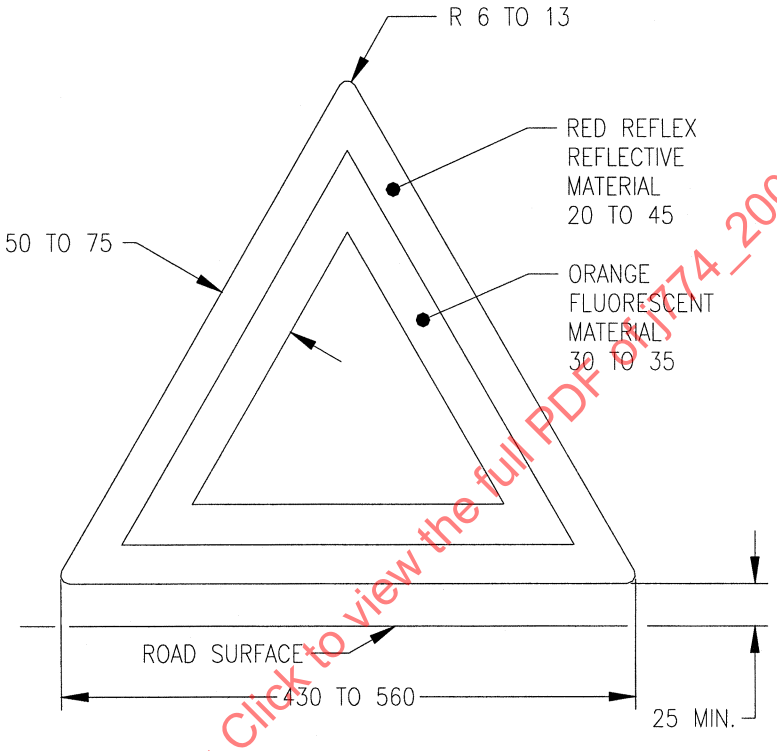

FIGURE 1—SIZE AND SHAPE OF DEVICE

6.5.7 SIZE OF OUTER AND INNER BORDERS—Each face of the triangular portion of the device shall have an outer border of red reflex reflective material of uniform width not less than 20 mm and not more than 45 mm wide and an inner border of orange fluorescent material of uniform width not less than 30 mm and not more than 35 mm wide. The area within the inner border shall be open. See Figure 1.

6.5.8 SIZE OF CORNER RADIUS—Each vertex of the triangular portion of the device shall have a radius of not less than 6 mm and not more than 13 mm. See Figure 1.

6.5.9 INSTRUCTIONS TO BE INCLUDED ON DEVICE—Each emergency warning device shall have instructions for its erection and display. The instructions shall be either indelibly printed on the device or attached in such a manner that they cannot be easily removed.

6.5.10 RECOMMENDATION TO BE INCLUDED ON DEVICE—The instructions shall include a recommendation that the driver activate the vehicular hazard warning signal lamps before leaving the vehicle to erect or retrieve the warning devices.

6.5.11 ILLUSTRATION TO BE INCLUDED ON DEVICE—Instructions on the device shall include an illustration indicating the recommended positioning of the device when used as a set of three on a non-divided highway. Dimensions on the illustration are required to include units of meters and paces. Units of feet are optional but not required. See Figure 2.

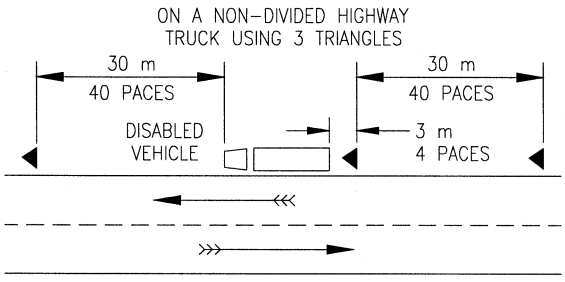

FIGURE 2—USAGE DIAGRAM, THREE DEVICES, NON-DIVIDED HIGHWAY

6.5.12 INSTRUCTIONS TO BE INCLUDED WITH CONTAINER—Each emergency warning device protective container shall have instructions for the erection and display of emergency warning devices. The instructions shall be either indelibly printed in or on the container or attached in such a manner that they cannot be easily removed.

6.5.13 RECOMMENDATION TO BE INCLUDED WITH CONTAINER—The instructions shall include a recommendation that the driver activate the vehicular hazard warning signal lamps before leaving the vehicle to erect or retrieve the warning devices.

6.5.14 ILLUSTRATIONS TO BE INCLUDED WITH CONTAINER—Instructions on the container shall include illustrations indicating the recommended positioning of the device when used as a single device and when used as a set of three on either a divided or a non-divided highway. Dimensions on the illustration are required to include units of meters and paces. Units of feet are optional but not required. See Figures 2, 3, and 4.

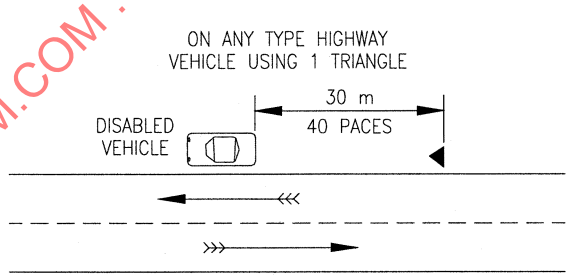

FIGURE 3—USAGE DIAGRAM, SINGLE DEVICE