

L-S-300C  
March 20, 1979  
SUPERSEDING  
Fed. Spec. L-S-300b  
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FEDERAL SPECIFICATION

SHEETING AND TAPE, REFLECTIVE: NONEXPOSED LENS

This specification was approved by the Commissioner, Federal Supply Service, General Services Administration, for the use of all Federal agencies.

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers flexible, colored, reflective sheeting and tape designed to enhance nighttime visibility of signs and objects.

1.2 Classification.

1.2.1 Types. The reflective material shall be of the following types as specified (see 6.2):

Type I - Sheeting, reflective (sheets or rolls).  
Type II - Tape, reflective (rolls).

1.2.2 Reflectivities, colors, classes and durabilities. The reflectivities, colors, classes and durabilities shall be as designated in table VIII, if applicable, for each product.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issues in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

Federal Specification:

PPP-B-636 - Boxes, Shipping, Fiberboard.

Federal Standards:

Fed. Test Method Std. No. 141 - Paint, Varnish, Lacquer and Related Materials, Methods of Inspection, Sampling, and Testing.

Fed. Test Method Std. No. 370 - Instrumental Photometric Measurements of Retroflective Materials and Retroflective Devices.

(Activities outside the Federal Government may obtain copies of Federal Specifications, Standards, and Handbooks as outlined under General Information in the Index of Federal Specifications and Standards and at the prices indicated in the Index. The Index, which includes cumulative monthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

(Single copies of this specification and other Federal Specifications required by activities outside the Federal Government for bidding purposes are available without charge from General Services Administration Business Service Centers in Boston; New York; Philadelphia; Washington, DC; Atlanta; Chicago; Kansas City, MO; Fort Worth; Houston; Denver; San Francisco; Los Angeles; and Seattle, WA.

(Federal Government activities may obtain copies of Federal Specifications, Standards, and Handbooks and the Index of Federal Specifications and Standards from established distribution points in their agencies.)

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Military Standard:

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.

(Copies of Military Specifications and Standards required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless a specific issue is identified, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials (ASTM) Standards:

- G 22 - Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Exposure of Nonmetallic Materials.
- E 97 - Standard Method of Test for 45-Deg, 0-Deg Directional Reflectance of Opaque Specimens by Filter Photometry.
- D 2794 - Standard Method of Test for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

Munsell Book of Color

(Application for copies should be addressed to the Munsell Color Company, 2441 North Calvert Street, Baltimore, MD 21218.)

National Motor Freight Traffic Association, Inc., Agent:

National Motor Freight Classification.

(Application for copies should be addressed to the American Trucking Associations, Inc., Traffic Department, 1616 P Street, N.W., Washington, DC 20036.)

Uniform Classification Committee, Agent:

Uniform Freight Classification.

(Application for copies should be addressed to the Uniform Classification Committee, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

3. REQUIREMENTS

3.1 Qualification. Sheeting and tape furnished under this specification shall be a product which has been tested in accordance with the qualification tests described in section 4 of this specification and have been listed on, or approved for listing on, the applicable Federal Qualified Product List (see 6.4).

3.2 Qualification samples. The qualification sample submitted by the manufacturer shall be identified for the purpose of comparing with material subsequently submitted for acceptance. Within experimental limits, qualification and acceptance samples should be identical. Any lot or lots found not to be identical with the qualified sample shall be rejected.

3.3 Construction and appearance. The reflective sheeting and tape shall consist of a smooth, flat exterior film with retroreflective elements having a uniform homogeneous appearance.

3.4 Materials.

3.4.1 Exterior film. The exterior film shall be a transparent, flexible, smooth-surfaced weather-resistant material.

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**3.4.2 Retroreflective elements.** The retroreflective elements, shall be embedded or suspended beneath the exterior film so as to form a nonexposed optical retroreflective system.

**3.4.3 Backing.** When specified, the backing shall be as follows: The backing for the classes 1, 2, 3, 4, and 5 shall be as specified, respectively in 3.4.3.1, 3.4.3.2, 3.4.3.3, 3.4.3.4, and 3.4.3.5. The adhesive backing of the reflective sheeting and tape shall produce a bond such that a 1 inch (2.54 cm) wide strip shall support a 1-3/4 pound (0.79 kg) weight for classes 1, 2, and 3, and a 1 pound (0.45 kg) weight for class 4 for 5 minutes without the strip peeling for a distance of more than 2.0 inches (5.08 cm) when applied to a smooth aluminum surface and tested as specified in table VI.

**3.4.3.1 Class 1.** The adhesive backing for the class 1 reflective sheeting and tape shall have a pressure-sensitive adhesive which requires no heat, solvent, or other preparation for adhesion to smooth, clean surfaces.

**3.4.3.2 Class 2.** The adhesive backing for the class 2 reflective sheeting and tape shall have a tack-free adhesive which shall be activated by applying heat and pressure to the material. The temperature necessary to form a durable permanent bond shall be a minimum of 175°F (80°C). The class 2 material shall be positionable under normal shop conditions and at substrate temperatures up to 100°F (38°C) and without damage to the material when tested in accordance with table VI. The class 2 material may be perforated to facilitate removal of air in heat-vacuum laminators, but the perforations must be of size and frequency such that they do not cause objectionable blemishes when the sheeting is printed.

**3.4.3.3 Class 3.** The adhesive backing for the class 3 reflective sheeting and tape shall have a positionable pressure-sensitive adhesive which requires no heat, solvent, or other preparation for adhesion to smooth, clean surfaces. The class 3 material shall be positionable to standard conditions and 100°F (38°C) without damage to the material when tested in accordance with table VI.

**3.4.3.4 Class 4.** The adhesive backing for the class 4 reflective sheeting and tape shall have a low temperature pressure-sensitive adhesive that permits sheeting application at temperatures down to -10°F (-23°C) without the aid of heat, solvent, or other preparation for adhesion to smooth, dry, clean surfaces when tested in accordance with table VI.

**3.4.3.5 Class 5.** The backing for class 5 reflective sheeting and tape shall be a nonadhesive backing made of a material commercially used for this type of product.

**3.4.4 Liner.** For classes 1, 2, 3, and 4 material, the adhesive backing of the reflective sheeting and tape shall be completely covered by a protective liner. The liner may be marked on the exposed side with manufacturer's identification, application instructions, and other information commonly included in the manufacturer's commercial product. The liner shall be removable from the adhesive backing without soaking in water or other solvents. During removal, the liner shall not break or tear and shall not remove the adhesive from the backing when tested as specified in table VI.

**3.5 Daytime color.** The daytime color of the sheeting and tape shall be as specified and shall conform to requirements of table IA or IB (as applicable) when tested as specified in either 4.4.8.1 or 4.4.8.2.

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TABLE IA. Color specification limits and reference standards (reflectivities 1, 3, and 4)

Standard Reflectivities 1, 3, and 4												
Color	Chromaticity Coordinates <sup>a</sup>								Reflectance Limit		Ref. Std.	
	1		2		3		4		Y			
	x	y	x	y	x	y	x	y	Min.	Max.		
White	.305	.290	.350	.342	.321	.361	.276	.308	35.0	----	6.3GY 6.77/0.8	
Gold	.433	.390	.475	.420	.452	.450	.410	.420	20.0	30.0	.55Y 5.38/7.4	
Brown	.445	.353	.604	.396	.556	.443	.445	.386	4.0	9.0	5YR 3/6	
Yellow	.482	.450	.532	.465	.505	.494	.475	.485	29.0	45.0	1.25Y 6/12	
Orange	.535	.375	.607	.393	.582	.417	.535	.399	18.0	30.0	2.5YP 5.5/14.0	
Red	.602	.317	.664	.336	.644	.356	.575	.356	8.0	12.0	8.2R 3.78/14.0	
Dark red	.622	.311	.688	.311	.659	.341	.622	.341	5.0	9.0	6.8R 3.56/14.6	
Green	.130	.369	.180	.391	.155	.460	.107	.429	3.5	9.0	.65BG 2.84/8.45	
Blue	.147	.075	.176	.091	.176	.151	.106	.113	1.0	4.0	5.8PB 1.32/6.8	

TABLE IB. Color specification limits and reference standards (reflectivity 2)

standards (reflectivity 2)											
Color	Chromaticity Coordinates <sup>a</sup>								Reflectance Limit Ref. Std.		Munsel Papers
	1		2		3		4		Y		
	x	y	x	y	x	y	x	y	Min.	Max.	
White	.303	.287	.368	.353	.340	.380	.274	.316	27.0	----	5PB 7/1
Yellow	.498	.412	.557	.442	.479	.520	.438	.472	15.0	40.0	1.25Y 6/12
Orange	.550	.360	.630	.370	.581	.418	.516	.394	14.0	30.0	2.5YR 5.5/14
Red	.613	.297	.708	.292	.636	.364	.558	.352	2.5	11.0	7.5R 3/12
Green	.030	.380	.166	.346	.286	.428	.201	.776	3.0	8.0	10G 3/8
Blue	.144	.030	.244	.202	.190	.247	.066	.208	1.0	10.0	5.8PB 1.32/6.8

<sup>a</sup> The four pairs of chromaticity coordinates determine the acceptable chromaticity on the CIE diagram.

3.6 Performance. Sheeting and tape material shall comply with all the requirements specified in this section.

3.6.1 Flexibility. When tested as specified in table VI, the reflective sheeting and tape shall show no evidence of cracking, peeling, or delamination.

3.6.2 Solvent resistance. When tested as specified in table VI, the reflective sheeting and tape shall show no evidence of dissolving, puckering, or blistering.

3.6.3 Impact resistance. When tested as specified in table VI, the reflective sheeting shall show no evidence of cracking or delamination.

3.6.4 Retroreflective photometric performance (RPP). When tested as specified in table VI, the photometric performance shall be determined in specific intensity per unit area (SIA). The SIA values of the reflective sheeting and tape shall be not less than the values specified in tables II through V for each reflectivity and color, as applicable. The reflectivity of the sheeting and tape shall be as specified in table VIII, if applicable, and 6.2.

TABLE II. Specific Intensity per unit Area (SIA): Minimum Reflectivity 1 Sheeting and Tape

Observation Angle <sup>a</sup>	Entrance Angle <sup>a</sup>	White	Gold	Brown	Yellow	Orange	Red	Dark red	Green	Blue
0.2	-4	70.0	50.0	1.0	50.0	25.0	14.5	14.0	9.0	4.0
0.2	+30	30.0	16.0	0.3	22.0	7.0	6.0	6.0	3.5	1.7
0.5	-4	30.0	16.0	0.3	25.0	13.5	7.5	7.0	4.5	2.0
0.5	+30	15.0	10.0	0.2	13.0	4.0	3.0	3.0	2.2	0.8
2.0	-4	1.7	1.2	0.02	1.2	0.6	0.3	0.3	0.2	0.1
2.0	+30	1.4	1.0	0.02	1.0	0.5	0.2	0.2	0.14	0.08

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TABLE III. Specific Intensity per unit Area (SIA): Minimum  
Reflectivity 2 sheeting and tape.

Observation Angle°	Entrance Angle°	White	Yellow	Orange	Red	Green	Blue
0.2	-4	250.0	170.0	100.0	45.0	45.0	20.0
0.2	+30	150.0	100.0	60.0	25.0	25.0	11.0
0.5	-4	95.0	62.0	30.0	15.0	15.0	7.5
0.5	+30	65.0	45.0	25.0	10.0	10.0	5.0
2.0	-4	4.0	3.0	1.1	0.7	0.5	0.3
2.0	+30	3.0	1.8	0.5	0.3	0.2	0.1

TABLE IV. Specific Intensity per unit Area (SIA): Minimum  
Reflectivity 3 sheeting and tape.

Observation Angle°	Entrance Angle°	White	Gold	Yellow	Orange	Red	Green	Blue
0.2	-4	50.0	25.0	25.0	13.0	10.0	5.0	3.8
0.2	+30	12.0	7.0	7.0	4.0	3.0	2.0	1.5
0.5	-4	15.0	13.0	10.0	6.0	5.0	3.0	2.0
0.5	+30	6.0	3.0	3.0	2.5	1.0	1.0	0.8
2.0	-4	4.0	3.2	2.2	1.9	1.6	1.0	0.6
2.0	+30	2.2	1.0	1.0	0.7	0.6	0.3	-

TABLE V. Specific Intensity per unit Area (SIA): Minimum  
Reflectivity 4 sheeting and tape.

Observation Angle°	Entrance Angle°	White	Yellow	Orange	Red	Green	Blue
0.2	-4	250.0	170.0	70.0	35.0	30.0	20.0
0.2	+30	95.0	64.0	26.0	13.3	11.4	7.6
0.5	-4	200.0	136.0	56.0	28.0	24.0	18.0
0.5	+30	60.0	40.0	17.0	8.4	7.2	4.8
2.0	-4	8.0	6.0	2.2	1.4	1.0	0.6
2.0	+30	6.0	3.6	1.0	0.6	0.4	0.2

3.6.4.1 Wide entrance angularity. When specified, the SIA values at 50° entrance shall be 1.0 percent of the specified minimum values at 0.2° observation and -4° entrance angles for all reflectivities (see 6.2).

3.6.5 Accelerated weathering. When tested as specified in table VI, for the number of hours (durability) specified in table VIII, the reflective sheeting and tape shall:

- Show "good" colorfastness or better.
- Show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 1/32 inch (0.08 cm) shrinkage or expansion.
- Retain not less than 50 percent of the SIA values specified in tables II, IV, and V for reflectivities 1, 3, and 4 respectively; not less than 80 percent of the SIA value specified in table III for reflectivity 2.
- Not be removable from the aluminum panels without damage.

3.6.5.1 Rainfall. After accelerated weathering as specified in 3.6.5, the SIA value of the reflective sheeting, when subjected to the rainfall test, shall not be reduced by more than 10 percent of the dry measured SIA values of the weathered sample.

3.6.6 Resistance to heat, cold, and humidity. When tested as specified in table VI, the reflective material shall not crack, peel, chip, or delaminate from the test panel.

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3.6.7 Shrinkage. When tested as specified in table VI, the reflective material shall not shrink more than 1/32 inch (0.08 cm) in 10 minutes nor more than 1/8 inch (0.32 cm) in 24 hours.

3.6.8 Fungus resistance. After inoculation with the test organism, Aspergillus niger, and incubation for 14 days, the reflective sheeting and tape shall show no fungus growth. After completion of the incubation and after being wiped clean, the reflective sheeting and tape shall retain the full SIA values as specified in tables II through V. The sheeting and tape shall not be removable from the aluminum panels without damage.

3.6.9 Specular gloss. When tested as specified in table VI, the reflective sheeting and tape shall have a specular-gloss reading of not less than 40.

### 3.7 Form, design, and dimensions.

3.7.1 Sheets. When the reflective material is in sheet form, the design and dimensions shall be as specified (see 6.2), within a tolerance of  $\pm 1/8$  inch (0.32 cm). Sheeting shall be of any width over 6 inches (15.2 cm). The corners of the sheets shall be square (90°) to a tolerance of  $\pm 0.15^\circ$ .

3.7.2 Rolls. When furnished in rolls, the reflective material shall be evenly and tightly wound on a core of sufficient rigidity to prevent distortion of the roll. The length and width of the rolls shall not be less than specified (see 6.2). Tapes shall be in widths up to and including 6 inches, plus or minus 1/16 inch (15.2 cm, plus or minus 0.16 cm). Rolls of reflectivity 1, 2 and 4 materials shall contain not more than an average of four pieces and no roll shall contain more than five pieces per 50 yards (45.72 m) length. Rolls of reflectivity 3 material shall contain not more than an average of six pieces per 50 yards (45.72 m) length, and no roll shall contain more than seven pieces per 50 yards (45.72 m) length.

3.7.3 Thickness. The thickness of the reflective material (excluding class 5 material) without the protective liner shall be not more than 0.012 inch (0.03 cm) for reflectivities 1, 2, and 3 and 0.025 inch (0.06 cm) for reflectivity 4.

3.8 Instructions. Instructions defining a step-by-step procedure for application of the reflective sheeting and tape shall be furnished by the supplier and shall be included with each package of reflective material. Any restrictions on the application procedure or any precautions to be exercised regarding surface preparation and application temperature shall be included in the instructions.

3.9 Workmanship. The reflective sheeting and tape shall be free of ragged edges, cracks, pits, or dirt. The occurrence of defects shall not exceed the specified quality levels in section 4. Splices shall be strong enough to withstand normal handling and be of the lap type except for class 2 sheeting in which the butt type splice shall be required. The reflective sheeting shall be flat and smooth and free of fluted edges, puckers, wrinkles, or creases.

3.10 Processability. The reflective sheeting shall be compatible with applicable normal handling practices. Sheets shall be flat. Sheets cut from rolls shall not show excessive edge curl which would hinder printing or application to blanks. Normal variations in humidity shall not engender excessive curl.

The reflective material must be capable of being printed by the conventional silk screen process method with process pastes furnished by the sheeting manufacturer or recommended independent manufacturers.

## 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein.

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## 4.2 Qualification.

4.2.1 Qualification tests and inspections. Qualification tests and inspections shall consist of all tests and inspections specified in 4.3 and 4.4.

4.2.2 Qualification sample. The sampling procedure shall be as specified in 4.3.4, utilizing one sample unit for qualification testing.

4.2.3 Failure to qualify. Sheeting and tape failing to comply with any of the performance requirements and tests specified in 4.3.4 shall fail to qualify.

4.3 Quality conformance inspection. Sampling for inspection shall be performed in accordance with MIL-STD-105, except where otherwise indicated hereinafter.

4.3.1 Component and material inspection. In accordance with 4.1 above, components and materials shall be tested in accordance with all the requirements of referenced specifications, drawings, and standards unless otherwise excluded, amended, modified, or qualified in this specification or applicable purchase documents.

### 4.3.2 Inspection of the end item.

4.3.2.1 Visual examination of the end item. The reflective material shall be examined for the defects listed below. The lot size for purposes of sampling shall be expressed in units of 1 yard (0.91 meter) each or one sheet each, as applicable. An approximately equal number of units shall be examined from each roll or bundle of sheets. The inspection level (sample size) shall be I and the acceptable quality level (AQL) shall be 1.5 percent defective. The defects found shall be counted regardless of their proximity to each other. In rolls, a continuous defect shall be counted as one defect for each sample unit or fraction thereof in which it occurs.

<u>Examine</u>	<u>Defect</u>
Adhesive backing	Backing not completely and evenly covered with adhesive.
Liner	Missing. Does not completely cover back of sheeting or tape.
Color	Not color specified.
Design and form	Not type specified. Sheets not cut as specified (type I). Sheet not one piece (type I).
Appearance	Surface of exterior film not smooth. Any tear, cut, hole, crack, blister, dirt, crease, scales, or pits. Any edge ragged, nicked, crushed, or uneven. Sticky edges. Any solid lump. $\frac{1}{/}$ Any spot, stain, or streak more than 1 inch (2.54 cm) in its longest dimension. $\frac{1}{/}$ Excessive curl, edge ripple, or delamination from the adhesive backing. Not uniform and homogenous.
Reflective elements	Not embedded or suspended beneath the film.

$\frac{1}{/}$  Clearly visible at normal inspection distance (approximately 3 feet) (91.4 cm).

4.3.2.2 Examination for defects in put-up of rolls. The sample unit shall be one roll. The lot shall be expressed in units of one roll. The inspection level shall be S-3 and the acceptable quality level (AQL) shall be 6.5 percent defective.



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<u>Examine</u>	<u>Defect</u>
Assembly of roll	End of roll not secured. Not wound evenly and tightly. Core missing, loose, distorted, or broken. Not tightly wound on a core.
Unwinding of roll (examine both sides)	When unwinding, material sticks together, causing tearing or injury to any surface. Average of more than four pieces per 50 yards (45.72 meters) of material in roll (reflectivity 1, 2 and 4 material). More than five pieces (reflectivity 1, 2, and 4 material) or more than seven pieces (reflectivity 3 material) in any 50-yard (45.72 meter) length of material in the roll.
Splices	Not strong enough to withstand normal handling. Not of the lap type except for class 2 sheeting. Class 2 sheeting not of the butt type.

4.3.2.3 Dimensional examination of the end item. The end item shall be examined for defects in dimensions (see 3.7). The sample unit for this examination shall be one sheet for type I and one roll for types I and II when applicable. Any dimensions, except for length of rolls, which is more or less than that specified shall be classified as a defect. The lot shall be expressed in units of one roll or sheet. The inspection level shall be S-2 and the acceptable quality level (AQL) shall be 4.0 defects per 100 units.

4.3.2.3.1 Length of individual rolls. During the visual examination in 4.3.2.1, each roll in the sample shall be examined for length. Any length found to be more or less than that specified by more than 5 yards (4.57 meters) shall be classified as a defect. The lot shall be unacceptable if two or more roll length defects occur.

4.3.2.3.2 Average length of rolls. The lot shall be unacceptable if the average length of the rolls in the sample is less than that specified (see 6.2).

4.3.3 Examination of preparation for delivery. An examination shall be made to determine that the packaging, packing, and marking comply with the requirements of section 5. The sample unit shall be one shipping container. Sampling shall be in accordance with MIL-STD-105. The inspection level shall be S-2 with an AQL of 4.0 percent defective.

4.3.4 Testing. Each lot of the end item shall be tested for the characteristics footnoted in table VI (see 3.4.3, 3.4.4, 3.6.1, 3.6.4, and 3.5). The qualification sample shall be tested for all of the characteristics listed in table VI. When sampling for test purposes, the lot size shall be expressed in units of 1 square yard and the sample size (number of sample units) shall be as specified in table VII. The sample unit shall be 1 square yard or square meter of reflective material. In the event that the sheets ordered are not of the minimum dimensions required for testing, the manufacturer shall furnish, from the same manufacturing lots and materials, 1 square yard of the material with the minimum width of 12 inches (30.5 cm) for performing tests. The lot shall be unacceptable if one or more units fail to meet the requirements specified. The number of determinations per sample unit, as well as the reporting of test results, shall be as required by the referenced test method as otherwise indicated in table VI. All test reports shall contain the individual values utilized in expressing the final result.



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TABLE VI. Instructions for testing

Characteristic	Specification reference		Number determinations per/sample unit	Results reported as	
	Require-ment	Test Method		Pass or fail	Numerically to nearest
Adhesion, initial, 1/	3.4.3	4.4.4	2	X	
Positionability (classes 2 and 3)	3.4.3.2 and 3.4.3.3	4.4.3	1	X	
Adhesion, cold temperature (class 4)	3.4.3.4	4.4.4.1	2	X	
Removability of liner <sup>1/</sup>	3.4.4	4.4.4	2	X	
Flexibility 1/	3.6.1	4.4.5	1	X	
Solvent resistance	3.6.2	4.4.6	1 each solvent	X	
Impact resistance	3.6.3	4.4.13	1	X	
RPP 1/	3.6.4	4.4.7	Ave. of 3 readings		0.1
Color <sup>1/</sup>	3.5	4.4.8	1		0.001
Resistance to accelerated weathering	3.6.5	4.4.9			
RPP	3.6.5	4.4.9.3	Ave. of 3		0.1
RPP during rainfall	3.6.5.1	4.4.9.4	Ave. of 3		0.1
Shrinkage or expansion	3.6.5	4.4.9.2	1		1/64 in. (.04 cm)
Colorfastness	3.6.5	4.4.9.1	1	X	
Adhesion	3.6.5	4.4.9.5	1		1/32 in. (.08 cm)
Resistance to heat, cold and humidity	3.6.6	4.4.10			
Resistance to heat	3.6.6	4.4.10.1	1	X	
Resistance to cold	3.6.6	4.4.10.2	1	X	
Resistance to humidity	3.6.6	4.4.10.3	1	X	
Shrinkage	3.6.7	4.4.11	1		1/64 in. (.04 cm)
Fungus resistance	3.6.8	4.4.12	3	X	
Specular gloss	3.6.9	4.4.14	1	X	

<sup>1/</sup> Characteristic shall be tested for acceptance of end item.

TABLE VII. Lot and sample sizes

Lot size (square yards or square meters)	Sample size (square yards or square meters)
800 or less	2
801 up to and including 22,000	3
22,001 or more	5

#### 4.4 Test methods.

4.4.1 Test conditions. Unless otherwise specified herein, all applied and unapplied test samples and specimens shall be conditioned at the standard condition specified in FED-STD-141 for 24 hours prior to testing.

4.4.2 Test panels. Unless otherwise specified herein, when tests are to be performed using test panels, the specimens of reflective material shall be applied to smooth 0.020 in (0.051 cm) min. thick aluminum panels cut from aluminum sheets. The aluminum shall be degreased and lightly acid etched before the specimens are applied. The specimens shall be applied to the panels in accordance with the furnished instructions.

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**4.4.3 Positionability.** Prepare three test samples 2" x 5" (5.1 x 12.7 cm). Precondition reflective sheeting samples, test panels, and a test weight maintained at 38°C (100°F) in an oven. The test weight shall have a 1 square inch (6.5 sq cm) circular flat base and shall weigh 400 grams. The samples shall have one end creased back to form a tab. After 1 hour of preconditioning, remove the adhesive liner and place the sample in contact with the test substrate, adhesive side down; then gently place the test weight on the center of the flat portion of the reflective specimen and leave it in place for 30 seconds. Remove the test weight by lifting vertically without tipping or sliding. Then immediately attempt to remove the reflective film manually. Any damage to the reflective film or removal of adhesive constitutes failure.

**4.4.4 Adhesion test.** Subject two 2- by 6-inch (5.1- by 15.2-cm) pieces of the reflective material to a temperature of 160°F (71°C) and a pressure of 2.5 pounds per square inch (.176 kg/sq cm) for 4 hours. Bring the materials to equilibrium at standard conditions and cut one 1- by 6-inch (2.54- by 15.2-cm) adhesion specimen from each piece and remove the liner by hand without the use of water or other solvents. During removal of the liner, it shall be noted whether any liner breaks or tears or removes any adhesive from the backing. Apply 4 inches (10.1 cm) of one end of each specimen to a test panel. Condition as specified in 4.4.1. Suspend the panels in a horizontal position with the specimen facing downward. Attach a 1-3/4 pound (0.79 kg) weight (classes 1, 2, and 3) or a 1 pound (0.45 kg) weight (class 4) to the free end of each specimen and allow it to hang free at an angle of 90° to the panel surface for 5 minutes. At the end of the 5 minute period, check the distance of peeling. Failure of any one specimen shall constitute failure of the test. In addition, the class 4 reflecting sheeting and tape shall be tested for low temperature adhesion in accordance with 4.4.4.1.

**4.4.4.1 Low temperature adhesion (class 4).** The test specimen shall be 3 inches by 6 inches (7.6 by 15.2 cm). One specimen along with a 4 by 8 inch (10.1 by 20.3 cm) etched aluminum test panel shall be conditioned at -10°F (-23°C) for 1 hour and the test performed as follows:

Apply the specimen to the panel, making sure the panel is dry, and condition for 30 minutes at -10°F (-23°C). Without the aid of a tool, the reflective material shall not be removable from the panel without damage.

**4.4.5 Flexibility at standard conditions.** The reflective material, with the liner removed and conditioned for 24 hours at 72°F (23°C) and 50 percent relative humidity, shall be sufficiently flexible to show no cracking when slowly bent, in one second's time, around a 1/8 inch (3.2 mm) mandrel with adhesive contacting the mandrel. Test samples shall be 2-3/4 inch (7.0 cm) by 11 inches (27.9 cm). Any evidence of cracking, peeling, or delamination shall constitute failure. NOTE: For ease of testing, spread talcum powder on adhesive to prevent sticking to the mandrel.

**4.4.6 Solvent resistance.** Determine the resistance of the reflective material to the solvents specified herein by immersing one test specimen in a glass exposure container, for each solvent separately, at room temperature. Specimens, each 1 by 6 inches (2.54 by 15.2 cm), shall be applied to test panels. Solvents and immersion time shall be as follows:

<u>Solvents*</u>	<u>Immersion time</u>
Kerosene and turpentine	10 minutes
Toluol, xylol, and methyl alcohol	1 minute

\*WARNING: These solvents are flammable and toxic.  
Avoid inhalation and prolonged skin contact.  
Do not expose to open flame or sparks.

At the end of the immersion period, remove the test panels from the exposure containers and allow to dry before examining for evidence of puckering, blistering, or dissolving of the exterior film and adhesive. Failure of any solvent shall be cause for rejection of the lot.

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4.4.7 Retroreflective photometric performance (RPP). The photometric performance shall be determined in accordance with Federal Test Method Standard 370.

- (a) The photometric performance shall be determined in specific intensity per unit area (SIA).

Calculations for the SIA performance values shall be determined using the following formula:

$$SIA = K \frac{R_1 (D')^2}{A R_2}$$

where

$R_1$  = The reading of the photoreceptor while measuring the illuminance at the observation position.

$R_2$  = The reading of the photoreceptor while measuring the normal illuminance at the face of the retroreflective sample.

$D'$  = Distance between the center of the photoreceptor's entrance aperture and the reference center.

$A$  = Surface area of the sample.

$K$  = Photoreceptor's color correction factor.

- (b) English units shall be used in specifying the photometric performance of the test samples.

The units are in candelas per foot candle per square foot.

- (c) The photometric performance values of the test samples shall be in accordance with the values in tables II, III, IV, and V.
- (d) The observation angles shall be 0.2°, 0.5°, and 2.0°.
- (e) The entrance angles shall be -4° and 330° (50° when specified, see 6.2).
- (f) The datum mark's orientation angle shall be random except as required and shall be so specified.
- (g) The presentation angle shall be 0°.
- (h) The test distance ( $D'$ ) shall be 50 feet except that 100 ft. may be used for the 0.2° and 0.5° observation angle measurements.
- (i) The maximum effective area of the test sample shall be 1 square foot. The maximum dimension of the test sample shall be not greater than 1.5 times the minimum dimension.
- (j) The photoreceptor's maximum angular aperture shall be 10 minutes of arc.
- (k) The light projector's maximum angular aperture shall be 10 minutes of arc.
- (l) The reference center of the test sample shall be the geometric center.
- (m) The reference axis of the test sample shall be defined if it is not perpendicular to the surface of the sheeting.

4.4.8 Color. Conformance to color requirements shall be determined by instrumental method of 4.4.8.1 or, when specified, by alternate instrumental method of 4.4.8.2.

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**4.4.8.1 Instrumental method.** Determine the color of the reflective material in accordance with ASTM E-97. (Geometric characteristics must be confined to illumination incident within 10 deg. of, and centered about, a direction of 45 deg. from the perpendicular to the test surface, viewing is within 15 deg. of, and centered about, the perpendicular to the test surface. Conditions of illumination and observation must not be interchanged). The standards for calibrating the test apparatus shall be the Munsell Papers designated in table I. They must be recently calibrated on a spectrophotometer. The test instrument shall be one of the following:

1. Gardner Multipurpose Reflectometer or Model XL20 and XL23 Color and Color Difference Meter.
2. Gardner Models AC-2a or XL30 Color Difference Meter.
3. Neeco Model V Colormaster
4. Hunterlab D25 Color Difference Meter.

**4.4.8.2 Alternate instrumental method.** When specified, color shall be tested in conformance with requirements and instrumental test method of contract.

**4.4.9 Resistance to accelerated weathering.** The reflective material shall be tested for color fastness, retroreflective photometric performance, shrinkage, and adhesion after exposure in accordance with ASTM G-23, type E or EH with humidifier off, for the hours specified in table VIII. The material shall be applied to three test panels 2-1/2 to 3 inches wide by at least 6 inches long, trimmed flush to the edges of the panel, and placed in the weatherometer with the reflective material facing the light source. After exposure, the panels shall be washed in a 5 percent HCl solution for 45 seconds, rinsed thoroughly with water, blotted with a soft clean cloth, brought to equilibrium at standard conditions and tested as specified in 4.4.9.1, 4.4.9.2, 4.4.9.3, 4.4.9.4, and 4.4.9.5. Prior to testing, the specimens shall be visually examined for evidence of cracking, sealing, pitting, or blistering.

**4.4.9.1 Colorfastness.** One specimen, exposed and prepared as specified in 4.4.9, shall be wet out with a mild detergent and water solution and compared with a similarly treated unexposed specimen under natural (North sky) daylight or artificial daylight having a color temperature of 7500° Kelvin. The colorfastness shall be evaluated as follows:

- Excellent - No perceptible change in color.
- Good - Perceptible but no appreciable change in color.
- Fair - Appreciable change in color.

Appreciable change in color means a change that is immediately noticeable in comparing the exposed specimen with the original comparison specimen. If closer inspection or a change of angle of light is required to make apparent a slight change in color, the change is not appreciable.

**4.4.9.2 Shrinkage or expansion.** Shrinkage or expansion shall be determined by measuring the distance between the edge of the reflective material and its closest edge of the panel. One specimen shall be measured on all four edges and any edge which exhibits shrinkage or overlap of more than 1/32 inch (0.08 cm) shall constitute failure with respect to shrinkage or expansion.

**4.4.9.3 Retroreflective photometric performance after accelerated weathering.** Each specimen exposed and prepared as specified in 4.4.9, shall be tested for photometric performance as specified in 4.4.7 except that measurements shall be made only at angles of 0.2° observation and minus 4° and plus 30° entrance. One determination shall be made on each specimen and the reflective intensity shall be the average of the determinations.

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**4.4.9.4 Retroreflective photometric performance (RPP) during rainfall.** After the test in 4.4.9.3, the photometric performance during rainfall shall be determined as follows using the water nozzle and test setup shown in figure 1.

Place the specimens in a upright position 6 inches (15.2 cm) below and 4 inches (10.1 cm) in front of the nozzle as shown in figure 1.

Apply sufficient water pressure so that the upper surface of the spray envelope strikes the top of the specimen.

With water falling on the specimen, measure the SIA values at angles of 0.2° observation and minus 4° entrance only, as specified in 4.4.7, except that the measurement shall be made on each specimen and the RPP during rainfall shall be the average of the three determinations.

**4.4.9.5 Adhesion after accelerated weathering.** One specimen shall be tested for adhesion after accelerated weathering as follows.

With a test spatula, evenly strike the film with short sharp jabs. Sheeting and adhesive removal of more than 3/16 inch (.48 cm) by a single jab shall constitute failure. The blade of the testing spatula shall be 1-1/2 inch (3.8 cm) long and 9/16 inch (1.4 cm) wide at the square end and sharpened at a 30° angle. Hold the test spatula at a 45° angle to the test panel with the beveled edge down supporting the blade with index finger.

**4.4.10 Resistance to heat, cold, and humidity.** Resistance to heat, cold, and humidity shall be determined by the procedures in 4.4.10.1, 4.4.10.2, and 4.4.10.3. Three specimens shall be applied to aluminum test panels and one applied specimen shall be subjected to each of the conditions. The length of the test specimen shall be 6 inches (15.2 cm) and the width shall be the full width of the tape up to 3 inches (7.6 cm) wide. Material over 3 inches (7.6 cm) in width shall cut to 3 inches (7.6 cm). After each test, the specimen shall be examined for any evidence of cracking, peeling, chipping, or delamination from the test panel.

**4.4.10.1 Resistance to heat.** One of the specimens specified in 4.4.10 shall be exposed in an oven at  $160^{\circ} \pm 5^{\circ}\text{F}$  ( $71^{\circ} \pm 3^{\circ}\text{C}$ ) for 24 hours, conditioned at standard conditions for 2 hours, and then examined as specified in 4.4.10.

**4.4.10.2 Resistance to cold.** One of the specimens specified in 4.4.10 shall be exposed to an air temperature of  $-70^{\circ} \pm 5^{\circ}\text{F}$  ( $-57^{\circ} \pm 3^{\circ}\text{C}$ ) for 72 hours, conditioned at standard conditions for 2 hours, and then examined as specified in 4.4.10.

**4.4.10.3 Resistance to humidity.** One of the specimens specified in 4.4.10 shall be subjected to 100 percent relative humidity at a temperature of  $75^{\circ}\text{--}80^{\circ}\text{F}$  ( $23^{\circ}\text{--}27^{\circ}\text{C}$ ) in accordance with method 6201 of FED-STD-141 for 24 hours. The panel shall be removed from the humidity chamber, conditioned at standard conditions for 24 hours, and then be examined as specified in 4.4.10.

**4.4.11 Shrinkage.** The specimen shall be a 9 by 9-inch (22.9 by 22.9-cm) piece of the reflective material at standard conditions. The liner shall be removed and the specimen shall be placed on a flat surface with the adhesive side up. Ten minutes after liner removal, and again after 24 hours, the dimensions of the specimen shall be measured to determine the amount of shrinkage.

**4.4.12 Fungus resistance.** Determine the fungus resistance of the reflective material by the following method.

**4.4.12.1 Test organism.** The test organism used in this test shall be *Aspergillus niger*, ATCC NO. 6275, QM324, or QM458 (see 6.3). Cultures of this organism shall be carefully maintained on a potato-dextrose agar medium and promptly renewed if there is evidence of contamination. The stock cultures may be kept for not more than 4 months in a refrigerator at a temperature from  $3^{\circ}$  to  $10^{\circ}\text{C}$  ( $37.4^{\circ}$  to  $40^{\circ}\text{F}$ ). Subcultures incubated at  $28^{\circ}$  to  $30^{\circ}\text{C}$  ( $82.4^{\circ}$  to  $86^{\circ}\text{F}$ ) for 10 to 14 days shall be used in preparing the inoculum.

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4.4.12.2 Culture medium. The culture medium shall have the following composition:

$\text{NaNO}_3$	- 3.0 grams
$\text{K}_2\text{HPC}_4$	- 1.0 grams
$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	- 0.5 gram
KCl	- 0.25 gram
Agar	- 15.0 grams

Distilled water to make 1,000 ml.

The pH shall be 5.5 to 6.5; if otherwise, adjust to that range with HCl or NaOH. After mixing, the ingredients shall be sterilized by autoclaving for 15 minutes at 15 psi (121°C). Under sterile conditions, the medium shall be poured into six 150 by 20 mm petri dishes, about 65 ml per dish, and allowed to harden.

4.4.12.3 Inoculum. Add about 10 ml of sterile, distilled water containing about 0.005 percent of a nontoxic wetting agent to a subculture (10 to 14 days old) of the test organism in a ripe, fruiting condition. The spores shall be forced into suspension with a sterile camel's hair brush (or other suitable means) and diluted to 100 ml with sterile, distilled water.

4.4.12.4 Preparation of specimens. Cut three 3 by 3-inch (7.6 x 7.6-cm) specimens from the sample and apply to test panels with the reflective surface up. Completely immerse the test specimens in a leaching tank of continuously flowing water for 24 hours and then remove and dry. The leaching tank shall be large enough to hold an amount of water weighing not less than 50 times the weight of the specimens. The water entering the tank shall not fall directly on the specimens and shall flow at a rate of 5 to 10 liters per hour. The pH of the water shall be in the range of 6.0 to 8.0.

4.4.12.5 Inoculation. Under aseptic conditions, dip each specimen in 70 percent ethanol for a few seconds, rinse in distilled water, and place firmly on the surface of the solidified agar medium contained in the petri dishes. Place specimens with the reflective surface facing up, one specimen to each dish. With a sterile pipette, distribute 1.0 to 1.5 ml of inoculum over the surface of each specimen and the surrounding medium.

4.4.12.6 Incubation period. The period of incubation shall be 14 days at a temperature of 29° to 32°C (84.2° to 89.6°F) and 85 to 90 percent relative humidity.

4.4.12.7 Control. Test three control specimens of untreated, porous-grade filter paper with the specimens of the reflective material to check the viability of the inoculum. At the end of the incubation period, the controls should be covered with fungus growth.

4.4.12.8 Test results. Upon completion of the incubation period, examine the specimens visually for fungus growth. Wipe the specimens with a soft cloth wet with a 70 percent ethanol solution. Condition the specimens at standard conditions for 48 hours. Test the specimens in accordance with 4.4.7, and when finished, attempt to remove specimen from the test panel.

4.4.13 Impact resistance. Apply the sheeting to a standard aluminum panel 3 inches by 6 inches (7.6 by 15.2 cm) in length. Utilizing the test instrument and procedures described in ASTM D-2794, subject the specimen to 10 inch-pounds (11.5 cm kg) of forward impact (the panel is struck on the sheeting side).

4.4.14 Gloss. Conduct the gloss test as specified in method 6103 of FED-STD-141, using specimens of the test material applied to plane glass or metal or to other suitable plane surface.



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## 5. PREPARATION FOR DELIVERY

5.1 Packaging. Packaging shall be level A or commercial, as specified (see 6.2).

### 5.1.1 Level A.

5.1.1.1 Sheets. Sheets of one description only, in the quantities specified (see 6.2), with instructions (see 3.8), shall be packaged in a snug-fitting folding or metal stayed paperboard box or in a fiberboard box conforming to PPP-B-636, class domestic, style optional. The boxes shall be closed and secured to prevent accidental opening.

5.1.1.2 Rolls. Each roll of sheeting or tape of one description only, with instructions (see 3.8), shall be packaged in a close-fitting box conforming to PPP-B-636. The boxes shall be closed in accordance with the appendix to PPP-B-636. Rolls 1 inch or less in width shall be packaged in a paperboard box. The box shall be securely closed to prevent accidental opening.

5.1.2 Commercial. Sheets and rolls of reflective material, as specified in the contract or order, shall be packaged in accordance with normal commercial practice. The complete package shall be designed to protect the item against damage during shipment, handling and storage.

5.2 Packing. Packing shall be level A or commercial, as specified (see 6.2).

5.2.1 Level A. Sheets or rolls of reflective material of like description, packaged as specified in 5.1.1, shall be packed in quantities as specified in the contract or order in a close-fitting box conforming to PPP-B-636, class weather resistant, style optional. Closure and waterproof sealing of the boxes shall be in accordance with the appendix to PPP-B-636. Alternatively, cleated plywood, wire bound or nailed wood boxes shall be acceptable shipping containers when lined with a waterproof barrier material. The edges of the barrier material shall be sealed with waterproof tape or adhesive.

5.2.2 Commercial. Sheets and rolls of reflective material, packaged as specified in 5.1.2, shall be packed in fiberboard boxes that will assure acceptance by common carrier and provide product protection against loss and damage during multiple shipments, handling and storage. The shipping container shall be in compliance with the National Motor Freight Classification and Uniform Freight Classification.

5.3 Marking. Marking shall be as specified in the contract or order (see 6.2).

## 6. NOTES

6.1 Intended use. The reflective sheeting and tape are intended for use in reflectorizing surfaces such as signs, markers, and vehicles to assure their visibility at night under normal as well as under blackout conditions, when exposed to a source of light, and whether dry or totally wet by rain.

6.1.1 Application. The reflective sheeting and tape are intended for application directly to smooth, clean, nonporous, painted or unpainted corrosion and weather-resistant surfaces. Also, by selected options, including class 5 backing, applications can be made to corrugated or riveted surfaces, fabrics and flexible plastic surfaces. Application must be in accordance with the reflective material manufacturer instructions.

### 6.1.2 Classes of adhesive backing.

6.1.2.1 Class 1. This is a pressure-sensitive adhesive of the aggressive tack type. It is designed to be a permanent type and used for general purposes. Under some circumstances, it is subject to premature contact and attendant difficulties during application. These difficulties may be countered by various ways, such as appropriate scoring of the liner, technique of placement, wet method of application (dilute detergent), and other methods that may be furnished by suppliers.



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6.1.2.2 Class 2. This is intended for mounting by a heat-vacuum process, e.g., as in volume manufacture of signs and markers.

6.1.2.3 Class 3. This material is intended for use in lieu of class 1, when desired. Its pressure-sensitive adhesive is of a type which confers a degree of positionability to the material during its application and prior to final attachment. The need for this class material is generally governed by the user's experience and consideration of various factors, e.g., size and shape of the sign or marker, temperature during applications, skill of worker.

6.1.2.4 Class 4. This adhesive is intended for use where application of the material must be made at lower temperatures, as designated for this class, at which class 1 will not adhere.

6.2 Ordering data. Purchasers should select the preferred options permitted herein, and include the following information in procurement documents:

- (a) Title, number, and date of this specification.
- (b) Type and class required (see 1.2 and table VIII, if applicable).
- (c) Color required (see table VIII, if applicable).
- (1) Applicable color test method and coordinate limits (see 3.5).
- (d) Appropriate reflectivity (see table VIII, if applicable).
- (e) Durability as applicable (see table VIII).
- (f) Wide entrance angularity, if required (see 3.6.4.1).
- (g) Design and dimensions of sheets (see 3.7.1).
- (h) Width and length of rolls (see 3.7.2).
- (i) Selection of applicable levels of packaging and packing (see 5.1 and 5.2).

NOTE: Selection of the material to be procured from among the various options in this specification, can best be made in a given application by a highway or other engineer experienced in the use of retroreflective materials.

6.3 Fungus test organism. The organism used in the fungus resistance test (see 4.4.12) may be obtained upon request from the American Type Culture Collection (ATCC), 12301 Parklawn Drive, Rockville, MD 20852; or NLABS Culture Collection of Fungi (QM), Department of Botany, University of Massachusetts, Amherst, MA 01002.

6.4 The attention of suppliers and procuring activities is called to the requirements for qualification as provided in section 3 of this specification GSA Reg. 1-II-201.03 which provides that solicitations for bids by advertising shall contain, in substance, the following statement: In the procurement of products requiring qualification, bids secured through formal advertising will be considered only for such products as have, prior to the bid opening date, been tested and approved for inclusion in the qualified products list whether or not such products have actually been so listed by that date. Manufacturers are urged to communicate with the Chemical Technology Division, Federal Supply Service, General Services Administration, Washington, DC, 20406, and arrange to have the product they propose to offer tested for qualification. (Time may not permit qualification for eligibility under this invitation, but products which qualify would be eligible under future invitations.)

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6.5 The requirements in sections 3 through 5 and notes on ordering data in section 6 of this specification are applicable to table VIII. Each product number represents a product which may be qualified. Table VIII does not include all available products possible from the combinations covered by this specification.

TABLE VIII. Product requirements

Product number	Reflectivity	Color	Sacking	Durability (hrs)
1	1	White	Class 1	1,000
2	1	Gold	Class 1	1,000
3	1	Brown	Class 1	1,000
4	1	Yellow	Class 1	1,000
5	1	Orange	Class 1	1,000
6	1	Red	Class 1	1,000
7	1	Dark Red	Class 1	1,000
8	1	Green	Class 1	1,000
9	1	Blue	Class 1	1,000
10	1	White	Class 3	1,000
11	1	Yellow	Class 3	1,000
12	1	Dark Red	Class 3	1,000
13	1	White	Class 4	1,000
14	1	Yellow	Class 4	1,000
15	1	Red	Class 4	1,000
16	1	White	Class 2	1,000
17	1	Gold	Class 2	1,000
18	1	Brown	Class 2	1,000
19	1	Yellow	Class 2	1,000
20	1	Orange	Class 2	1,000
21	1	Red	Class 2	1,000
22	1	Dark Red	Class 2	1,000
23	1	Green	Class 2	1,000
24	1	Blue	Class 2	1,000
25	2	White	Class 1	2,200
26	2	Yellow	Class 1	2,200
27	2	Orange	Class 1	500
28	2	Red	Class 1	2,200
29	2	Green	Class 1	2,200
30	2	Blue	Class 1	2,200
31	4	White	Class 1	250
32	4	Yellow	Class 1	250
33	4	Orange	Class 1	250
34	4	Red	Class 1	250
35	4	White	Class 5	250
36	4	Yellow	Class 5	250
37	4	Orange	Class 5	250
38	4	Red	Class 5	250

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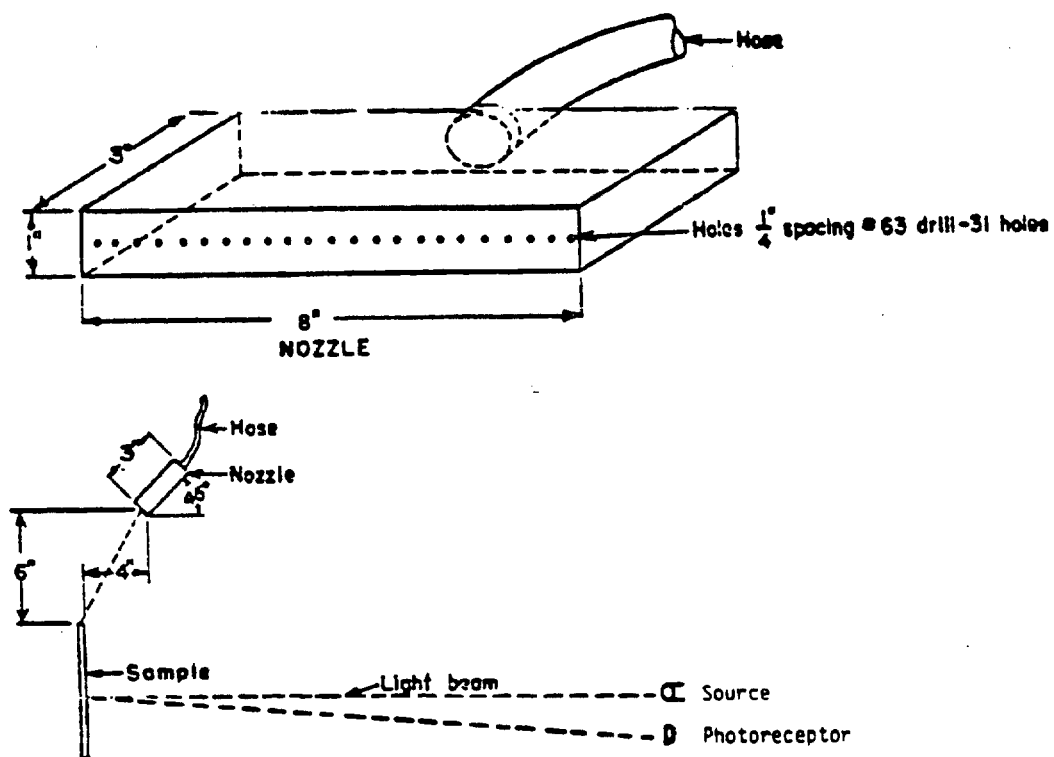


FIGURE 1. Test set up for rainfall test  
(source and photoreceptor in horizontal plane)

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Military custodian:

Army - GL  
Navy - AS  
Air Force - 99

Preparing activity:

GSA-FSC

Civil Agency Coordinating Activities:

Review activities:

Army - MD, MI  
Navy - CG

DOT-FHW  
USDA-FS

User activities:

Army - ME, AT, CE, EL  
Navy - MC

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