OCEAN ENGINEERING DIVISION
UNITED STATES COAST GUARD
WASHINGTON, D.C.

SPECIFICATION G-SEC-393A
HIGH INTENSITY RETROREFLECTIVE FILM FOR USE ON MARITIME AIDS TO NAVIGATION

CHANGE 1

The following changes have been made to the specification:

1. Add the following paragraph:

   3.4.2.1 Margins. The side margins about the retroreflective characters (from edge of character to the edge of the backing film) shall be as follows:

Character Size	Margin (inches)	Character Size	Margin (inches)
6	½	12	1-¼
8	¾	16	1-½
10	1	24	1-¾

   Margins above and below the characters shall be no less than ½ inches.

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UNITED STATES COAST GUARD

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SPECIFICATION G-SEC-393A

HIGH INTENSITY RETROREFLECTIVE FILMS FOR USE ON MARINE AIDS TO NAVIGATION

1.0 SCOPE

1.1 Purpose. This specification describes the requirements for high intensity retroreflective, elastomeric films used as sign face materials on aids to navigation in the navigable waters of the United States.

1.2 Deliverables. Products provided under this specification shall be conformable films, with pressure-sensitive adhesive, as described in section 3, below. Items include:

a. 50-yard rolls in widths of 1, 2, 3, 4, 6, and 12 inches, and in white, yellow, orange, red, and green colors; and

b. Letters and numbers of 6, 8, 10, 12, 16, and 24 inches in height, and in white, red, and green colors.

2.0 APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are needed to meet the requirements specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, users of this specification are cautioned that they must meet all specified requirements of the documents cited in sections 3 and 4 of this specification, whether or not the documents are listed.

2.2. Government documents.

2.2.1. Specifications, standards, and handbooks. The following specification forms a part of this document to the extent specified herein.

COAST GUARD

G-ECV-450 Fabrication of Ionomer Foam Buoys.

(Copies of this specification are available from Commandant (G-SEC-2), U.S. Coast Guard, 2100 Second Street, SW, Washington, DC 20593-0001).

2.2.2 Other Government documents, drawings, and publications. The following Government document and drawing form a part of this document to the extent specified herein.

FEDERAL HIGHWAY ADMINISTRATION

Standard Alphabets for Highway Signs,
1966 Edition.

(Copies of this document are available from the Federal Highway Administration, Office of Highway Safety (HHS-10), Washington, DC 20590)

COAST GUARD DRAWING

G-ECV-121169	1995 Type, 5CFR and 5NFR, Unlighted Foam Buoys.

(Copies of this drawing are available from Commandant (G-SEC-2), U.S. Coast Guard, 2100 Second Street, SW, Washington, DC 20593-0001).

2.3 Non-Government Publications. The following documents form a part of this document to the extent specified herein.

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

H850	U.S. Product Standard 1-83; Construction & Industrial Plywood.

(Application for copies should be addressed to APA - The Engineered Wood Association, 7011 South 19th Street, P.O. Box 11700, Tacoma, WA 98411-0700.)

AMERICAN SOCIETY FOR QUALITY CONTROL (ASQC)

ANSI/ASQC Z1.4	Sampling Procedures and Tables for Inspection by Attributes.

(Application for copies should be addressed to the American Society for Quality Control, 310 West Wisconsin Avenue, Milwaukee, WS 53203.)

AMERICAN SOCIETY FOR TESTING (ASTM)

ASTM D 4956	Retroreflective Sheeting for Traffic Control.
ASTM D 1248	Polyethylene Plastics Molding and Extrusion Materials.

(Application for copies should be addressed to the American Society for Testing & Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428.)

2.4 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3.0 REQUIREMENTS

3.1 General. Rolls of retroreflective films and retroreflective characters supplied under this specification shall meet all requirements for Type III or Type V Sheeting with Class 4 adhesive and a protective liner as described in ASTM D 4956, in Supplementary Requirement S.1 of ASTM D 4956 (Fungus Resistance), and the additional requirements listed herein. The terms "films" and "sheeting" shall be understood to refer to both roll-type products and characters (letters and numbers), and may be used interchangeably.

3.2 Application. Films shall be conformable, and shall be suitable for application to dented, weathered, and/or irregular surfaces that have been wiped clean. The films are intended for application to several different surfaces, including:

a. Plywood - A-C Exterior, A-B Marine, or Medium Density Overlay (single-sided) (APA H850);
b. Corrosion resistant aluminum sheet - such as aluminum alloy 6061-T6;
c. Cast elastomeric (vinyl) sheeting;
d. Mild steel painted with aliphatic acrylic urethane;
e. Medium density, rotationally molded polyethylene - Type II, Class A, Category 3 (ASTM D 1248); and
f. Densified ionomer foam (G-ECV-450).

The use of a separate primer for application to ionomer foam is permitted. The primer, if required, shall be available from the manufacturer of the retroreflective film as a commercially procurable item by the individual U.S. Coast Guard units which have responsibility for ionomer foam buoys. Application to any of the other five materials listed above shall not require the aid of heat, solvent, or other preparation for adhesion to dry, clean surfaces.

3.3 Environment. The films supplied under this specification shall withstand a marine environment as defined by:

a. Temperature range of -40_ to +120_F (-40_ to +49_C);
b. Humidity range from 0 to 100 per cent;
c. Winds up to 100 knots (185 km/hr);
d. Salinity extremes (salt spray);
e. Sunlight exposure up to 5000 MJ/m^2 per year;
f. Guano deposits; and
g. Mold and fungus growth.

Films applied in accordance with the manufacturer's instructions to the surface materials listed in 3.2.a through 3.2.c, above (signage), shall not loosen, lift, peel, or bubble when exposed to a marine environment for five years. Films applied in accordance with the manufacturer's instructions to the surface materials listed in 3.2.d through 3.2.f, above (buoys), shall not loosen, lift, peel, or bubble when exposed to a marine environment for two years.

3.4 Physical properties.

3.4.1 Appearance. The film shall be free of ragged edges, cracks, scales, pits, blisters, and dirt. The pattern of the retroreflective material shall appear uniform across the film surface. The backing of the film shall be completely and evenly covered with the adhesive.

3.4.2 Characters. Letters and numbers shall meet the requirements of the Federal Highway Administration Standard Alphabets for Highway Signs, Series C, with filleted inside corners. Characters shall be kiss-cut, and covered with a translucent pre-spacing/pre-masking film, as diagramed in figure 1, below.

Figure 1 - Retroreflective Film Characters

3.4.3 Dimensions.

3.4.3.1 Thickness. The film thickness, without the protective liner, shall not exceed 0.020 inches (0.508mm).

3.4.3.2 Width and length. Rolls of film shall have widths within 0.125 inches (3.2mm) of the size ordered. The roll length shall equal or exceed the length ordered.

3.5 Environmental Properties.

3.5.1 Resistance to weathering. The film shall be weather resistant. After five years exposure on a south-facing, vertical surface, in the marine environment of South Florida, the film shall retain a minimum coefficient of retroreflection as specified in Table 11 of ASTM D 4956.

3.5.2 Colorfastness. After five years exposure on a south-facing, vertical surface, in the marine environment of South Florida, the film shall conform to the requirements of Table 10 and either Table 2 (Type III) or Table 8 (Type V) of ASTM D 4956, with regard to color retention.

3.5.3 Resistance to heat, cold, and humidity. The film shall not crack, peel, chip or delaminate when exposed to the marine environment for five years.

3.5.4 Solvent resistance. Neither the film nor the adhesive shall dissolve, pucker or blister when exposed to turpentine, mineral spirits, or isopropyl alcohol.

3.5.5 Storage stability. The film shall meet the requirements of this specification after being stored in a warehouse at 50 to 90_F and 30 to 50% relative humidity for twelve months.

4.0 VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. First article test (section 4.2).
b. Conformance inspection (section 4.3).

4.1.1 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in ASTM D 4956.

4.2 First article test. The U. S. Coast Guard will be responsible for the performance of the first article tests. These tests will be performed on each size and color product offered in response to a contract or purchase order based on this specification. First article test requirements are listed in Table I.

Table I
First Article Tests

Inspection	Requirement	Test method
Coefficient of Retroreflection	ASTM D 4956	ASTM D 4956
Daytime Color	ASTM D 4956	ASTM D 4956
Weather Resistance	ASTM D 4956	ASTM D 4956[1]
Colorfastness	ASTM D 4956	ASTM D 4956[2]
Shrinkage	ASTM D 4956	ASTM D 4956
Flexibility	ASTM D 4956	ASTM D 4956
Liner Removal	ASTM D 4956	ASTM D 4956
Adhesion	ASTM D 4956	ASTM D 4956
Impact Resistance	ASTM D 4956	ASTM D 4956
Specular Gloss	ASTM D 4956	ASTM D 4956
Fungus Resistance	ASTM D 4956[3]	ASTM D 4956[3]
Adhesion[4]	3.2 & 3.3	4.5
Appearance	3.4.1	4.4
Characters	3.4.2	4.4
Dimensions	3.4.3	4.4
Resistance to heat, cold and humidity	3.5.3	4.6
Solvent resistance	3.5.4	4.6

Notes: [1&2] Use of five-year, natural weathering, on south-facing, vertical surfaces, in the South Florida marine environment is prefered to artificial weathering.
[3] See Supplementary Requirement S.1 to ASTM D 4956.
[4] Adhesion to various additional materials used as marine aids to navigation signage or for manufacture of buoys.

4.2.1 Order of inspections and tests. First article tests will be completed in the following order:

a. Visual inspection (see 4.4)
b. All inspections and examinations in ASTM D 4956, including Supplementary Requirement S.1
c. Adhesion tests (see 4.5)
d. Environmental tests (see 4.6)

4.2.1.1 Acceptance/rejection criteria. Failure of any one sample to meet the requirements of ASTM D 4956 for daytime color and colorfastness shall constitute a failure of the first article tests for all materials of a given color. Failure of any one sample to meet all other requirements outlined in ASTM D 4956 shall constitute a failure of all materials submitted for acceptance. The acceptance/rejection criteria for visual inspection, adhesion and environmental tests are outlined in their respective sections of this specification.

4.3 Conformance inspection. Conformance inspection shall consist of the visual inspection detailed in 4.4. Acceptance/
rejection criteria shall be as specified in 4.4.1.

4.3.1 Sampling for conformance inspection. The number of units in the sample size for conformance inspection of a given lot shall be in accordance with ANSI/ASQC Z1.4, Level S-3.

4.3.3.1 Lot/Unit. The term "lot" refers to all retroreflective materials, rolls and characters, manufactured in one production run from a common source of material. The term "unit" refers refer to a single 50 yard roll, in the width ordered, or a package of characters, in the quantity specified in the contract of order for unit packages.

4.4 Visual inspection. Sample rolls and characters shall be visually inspected for compliance with the requirements outlined in 3.4 through 3.4.3.2. The entire roll of each sample shall be inspected. The thickness and width of rolls, and character dimensions shall be measured to the nearest 0.005 inch. Roll lengths shall be measured to the nearest 1 inch. Table II outlines the acceptance/rejection criteria for the visual inspection.

Table II
Visual Inspection
Acceptance/Rejection Criteria

Examine	Defects
Appearance	Surface pattern of film is not uniform. Any tear, cut, hole, crack, blister, dirt, scale, crease, or pits in the film. More than one spot, stain, or streak of any size on a single character. (See note.) More than one spot, stain, or streak of any size per 5-yard segment of a 50 yard roll. (See note.) Ragged or sticky edges. Any solid lump. (See note.) Any spot, stain or streak with a maximum dimension greater than 1 inch.
Characters	Does not meet dimensional requirements of FHWA Standard Alphabets for Highway Signs, Series C. Inside corners are not filleted. Are not kiss-cut. Do not have translucent pre-spacing/pre-masking film.
Thickness	Film thickness (without liner) exceeds 0.020 inch.
Width	Measured width of a roll is not within 0.125 inch of the specified width.
Length	Measured length of a roll is less than 50 yards.

Note: Clearly visible at a normal inspection distance of approximately three feet by an individual with normal or corrected 20/20 vision.

4.4.1 Acceptance/Rejection Criteria. One defect, as defined in Table II, shall constitute a failure of the entire inspection for all materials in a given lot.

4.5 Adhesion. Adhesion of retroreflective films to various materials used as signage substrates for aids to navigation shall be tested to determine conformance to 3.2 and 3.3. Determine the adhesion properties of the films to the various materials listed in 4.5.1 by the procedures described in 4.5.2 and 4.5.3.

4.5.1 Test panels. Test panels shall include each of the materials listed in 3.2, above. Test panels shall be prepared in the following manner:

a. Dry, clean, group 3 AC exterior grade plywood (APA H850). Rough edges produced by cutting may be lightly sanded or filed. Surface sanding is not permitted;
b. Aluminum sheet, prepared in accordance with 8.2 of ASTM D 4956;
c. Cast vinyl sheet, applied in accordance with the manufacturer's instructions to a plywood panel;
d. Mild steel plate painted with aliphatic acrylic urethane;
e. Medium density polyethylene panel, conforming to Type II, Class A, Category 3, in ASTM D 1248;
f. Cylindrical section of ionomer foam, conforming to item 2 of Drawing 121169, and manufactured in accordance with G-ECV-450C.

4.5.2 Standard condition peel test. Apply four each 1 inch by 9 inch film samples to the six types of test panels (total of 24 samples). Bond 7 inches of one end of each sample to the test panels. Condition in accordance with 8.1 of ASTM D 4956 and then attach a 1-lb (0.45-kg) weight to the free end 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 measure the distance of peeling. If the distance of peeling is greater than 2.0 inches (51mm), the sample fails. Repeat this test with the conditioning period increased to 72 hours.

4.5.3 Low temperature peel test. Condition test panels and twenty four 1 inch by 9 inch film samples at +20_F (-7_C) for 4 hours. Apply four 1 inch by 9 inch samples each to the six types of test panels. Bond 7 inches of one end of each sample to the panels. Condition at +20 (+3/-0)_F (-7 (+2/-0)_C) and 50 5% relative humidity for 24 hours. While maintaining these conditions of temperatue and humidity, attach a 0.5-lb (0.22-kg) weight to the free end an 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 measure the distance of peeling. If the distance of peeling is greater than 2.0 inches (51 mm), the sample fails.

4.5.4 Acceptance/rejection criteria. Failure of any one sample to meet all the requirements for adhesion, as defined by a failure of the tests outlined in 4.5.2 and 4.5.3, shall constitute a failure of this test for all materials in a given lot.

4.6 Environmental tests. The environmental tests outlined in this section shall be used to determine the ability of films to withstand conditions encountered during service in a marine environment, as described in 3.3. Successful completion of these tests shall be considered as demonstrating conformance to 3.5.3 and 3.5.4.

4.6.1 Resistance to heat, cold, and humidity. Determine the resistance of the films to heat, cold, and humidity by the procedures described in 4.6.1.1 through 4.6.6.3. Prepare three pairs of test samples; each pair consisting one each 9 inch by 9 inch samples bonded to aluminum and plywood test panels. Prior to conducting the tests, condition the test samples in accordance with 8.1 of ASTM D 4956.

4.6.1.1 Resistance to heat. Heat one pair of samples in an oven at 120 5_F (49 3_C) for 24 hours. Visually inspect the samples after they have cooled to room temperature.

4.6.1.2 Resistance to cold. Expose one pair of samples to an air temperature of -40 5_F (-40 3_C) for 24 hours. Visually inspect the samples after they have warmed to room temperature.

4.6.1.3 Resistance to humidity. Subject one pair of samples to 100% relative humidity and a temperature of 73 4_F (23 2_C) for 24 hours. Remove the panels from the humidity chamber. Allow the panels to dry at room temperature. Visually inspect the samples after they have dried.

4.6.2 Solvent Resistance. Determine the resistance of the films to the solvents specified herein by immersing one test sample in a glass container, for each solvent separately, at room temperature. Samples, each 1 by 6 inches, shall be applied to aluminum test panels. Solvents and immersion time shall be as follows:

Solvent*	Immersion time
Turpentine	10 minutes
Mineral Spirits	10 minutes
Isopropyl 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 panels from the exposure containers and allow to dry before visual inspection.

4.6.3 Acceptance/Rejection Criteria. A sample exhibiting any evidence of cracking, peeling, chipping, blistering, pitting, delamination, or dissolving of the film or adhesive at the conclusion of the environmental tests shall constitute a failure of the entire qualification procedure.

5.0 PACKAGING

5.1 Packaging. Packaging requirements, and description of unit packs, shall be as specified in the contract or order.

5.2 Marking. Unless otherwise specified in the contract or order, marking shall be in accordance with MIL-STD-129.

6.0 REMARKS

6.1 Coast Guard verification. The U. S. Coast Guard reserves the right to perform any and all inspections and tests described in this specification, including both first article tests and conformance inspections. In particular, the U. S. Coast Guard reserves the right to test film which has been stored in a warehouse at 50 to 90_F and 30 to 50% relative humidity for twelve months. These films shall meet all the requirements of the qualification inspection procedure, as specified in 3.6.3. The U. S. Coast Guard may also evaluate the weather resistance and colorfastness of films which have been exposed to natural weathering either as part of a test or under actual service conditions. Failure of film to meet the requirements of this specification, as outlined in the applicable acceptance/rejection criteria for the first article tests, shall be grounds for termination of a contract or purchase order.

SPECIFICATION FOR
HIGH-INTENSITY RETROREFLECTIVE FILM
FOR USE ON
MARINE AIDS TO NAVIGATION

SPECIFICATION NO. G-SEC-393A

MAY 1996

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