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FEDERAL SPECIFICATION

PLASTIC SHEET AND FILM, FEP-FLUOROCARBON, EXTRUDED

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 extruded, unfilled, unpigmented, FEP-fluorocarbon sheet and film.

1.2 Classification.

1.2.1 Types and classes. The FEP-fluorocarbon sheet and film shall be of the following types and classes, as specified (see 6.2)

Type I	- General purpose sheet and film
Type II	- Cementable film
Class 1	- One side cementable
Class 2	- Two sides cementable
Type III	- Special film for applications requiring unusual flex or extreme thermal and chemical service
Type IV	- Special film for mold release applications

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

(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, US 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.)

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

D 149 - Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies
D 150 - A-C Loss Characteristics and Dielectric Constant (Permittivity) of Solid Electrical Insulating Materials
D 257 - D-C Resistance or Conductance of Insulating Materials
D 374 - Thickness of Solid Electrical Insulation
D 882 - Tensile Properties of Thin Plastic Sheeting
D 1505 - Density of Plastics by the Density-Gradient Technique
D 1708 - Tensile Properties of Plastics by Use of Microtensile Specimens
D 1922 - Propagation Tear Resistance of Plastic Film and Thin Sheeting

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

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, NW, 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 Material. The FEP-fluorocarbon material shall be flexible unsupported sheet or film made from a copolymer of tetrafluoroethylene and hexafluoropropylene and be without pigment, filler, or plasticizer.

3.2 Property values. The sheet and film shall conform to the property values specified in table I, when tested in accordance with the applicable procedure of 4.3. In addition, types I and II sheet and film shall conform to the electrical property values specified in table II, when tested in accordance with the applicable procedure of 4.3.

TABLE I. Property values[1/], excluding electrical

Property 1/	Values			
	Type I	Type II	Type III 3/	Type IV 4/
Density, grams per milliliter	2.13-2.17	2.13-2.17	2.13-2.17	2.13-2.17
Tensile strength, MPa (psi) min thickness				
0.01mm (0.0005 in.)	13.8 (2000)	13.8 (2000)	-	11.0 (1600)
0.02mm (0.001 in.)	17.2 (2500)	17.2 (2500)	17.2 (2500)	14.5 (2100)
Ultimate elongation, percent, min. thickness				
0.01mm (0.0005 in.)	175	175	-	150
0.02mm (0.001 in.)	200	200	250	200
Above 0.02 to 2.4 mm (0.001 to 0.095 in.)	250	250	250	200
Tear strength, Elmendorf, grams per 0.02 mm (1 mil), min thickness				
0.01 to 0.02mm (0.0005 to 0.001 in.)	75	75	-	75
0.05 to 0.50mm (0.002 to 0.020 in.)	90	90	40[4/]	75

1/Metric unit abbreviations: MPa = megapascal, mm = millimeter

2/Type III film is supplied only in thicknesses 0.12 through 2.4mm (0.005 through 0.095 in.)

3/Type IV is available only in thicknesses of 0.01 and 0.02mm (0.0005 and 0.001 in.)

4/Tear strength value is 30 for thickness of 0.12 (0.005 in.) for Type III

TABLE II. Electrical property values[1/] (applicable to types I and II sheet and film only)

Property	Values Types I and II
Dielectric strength, volts per 0.02mm (1 mil), min.	
Nominal thickness, mm (inch)	
0.01 (0.0005 inch)	4000
0.02 (0.001 inch)	4000
0.05 (0.002 inch)	3500
0.07 (0.003 inch)	3000
0.12 (0.005 inch)	2500
0.25 (0.010 inch)	1800
0.35 (0.014 inch)	1600
0.50 (0.020 inch)	1400
Dielectric constant, max	
at 10^3 Hz	2.15
at 10^6 Hz[2/]	2.15
Dissipation factor, max	
at 10^3 Hz	0.0003
at 10^6 Hz[2/]	0.0006
Volume resistivity ohm-centimeters, min	10^{17}

[1/] Metric unit abbreviations: mm = millimeter, Hz = hertz

[2/] Test required only when specified by procuring agency (see 6.2)

3.3 Lengthwise change in dimensions. The lengthwise change in dimensions of the sheet or film when exposed to a temperature of 200° ± 2° C (392° ± 3.6° F) for 30 ± 1 minutes shall not exceed the limits shown in table III when tested in accordance with 4.3.10.

TABLE III. Lengthwise shrinkage of sheet and film

Nominal thickness, mm (inch)	Type of sheet or film	Percent maximum, machine direction	Percent maximum, machine direction
0.01 and 0.02mm (0.0005 and 0.001 in.)	I, II, IV	± 5.0	± 5.0
0.05mm (0.002 in.)	I, II	± 3.0	± 3.0
0.07 to 1.52mm (0.003 to 0.060 in.)	I, II	± 2.0	± 2.0
0.12 to 2.41mm (0.005 to 0.095 in.)	III	± 2.0	± 2.0

3.4 Cementability of type II film. When tested in accordance with 4.3.11 the cemented film shall have the peel strength specified in table IV.

TABLE IV. Cementability of type II film

Nominal thickness, mm (inch)	Peel strength, grams per 25.4mm (1 inch), minimum
0.01 (0.0005)	170
0.02 (0.001)	300
0.05 (0.002)	750
0.07 (0.003)	800
0.12 (0.005)	2000

3.5 Sheet and film form and assembly. The sheet and film shall be furnished in the form of rolls, properly assembled (see 4.2.2.1).

3.6 Sheet and film dimensions excluding thickness. The sheet and film shall be furnished, as specified by the procuring agency, from the range of length, width, and core diameter normally available from the supplier (see 6.2). The maximum number of splices per roll and tolerances for length and core diameter shall be as specified by the procuring agency from the range normally available from the supplier. Tolerances for width of rolls (except type IV sheet or film) shall be ± 1.59mm (± 1/16 inch) in thickness up to and including 0.50mm (0.020 inch) and ± 3.18mm (± 1/8 inch) in thicknesses greater than 0.50mm (0.020 inch). Type IV film width tolerances shall be +6.36mm,-0 (+1/4 inch,-0).

3.7 Thickness of sheet or film. Sheet or film shall be furnished in the nominal thickness specified by the procuring agency. The nominal thickness and tolerance limits shall be within the range specified in table V, when tested in accordance with 4.3.12.

TABLE V. Thickness and tolerance limits[1/]

Nominal thickness, mm (inch)	Type of sheet or film
0.01 (0.0005)	I, II
0.02 (0.001)	I, II
0.05 (0.002)	I, II
0.07 (0.003)	I, II
0.12 (0.005)	I, II, III
0.25 (0.010)	I, III
0.35 (0.014)	I
0.5 (0.020)	I, III
0.7 (0.030)	I, III
1.5 (0.060)	I, III
2.4 (0.095)	III

1/Average thickness tolerance limits = ± 10% of nominal thickness

3.8 Color. The color shall be determined visually and shall be characteristic of unpigmented sheet or film which ranges from clear to translucent and is dependent upon the thickness.

3.9 Workmanship. The material shall be uniform in appearance and shall be sufficiently free from contamination, wrinkles, holes, scratches, and other imperfections so as to be functionally acceptable.

3.10 Recovered materials. The material offered shall contain not less than 0.1 percent of recovered materials. Recovered materials are defined as material which has been collected or recovered from solid waste.

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. Except as otherwise specified, in the contract or order, the contractor may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Sampling for inspection and acceptance. Sampling for inspection and acceptance shall be performed in accordance with the provisions set forth in MIL-STD-105, except where otherwise indicated. For purposes of sampling, an inspection lot or examination and tests shall consist of all material of the same type, class, and nominal thickness submitted for delivery at one time.

4.2.1 Inspection of materials and components. In accordance with 4.1, the supplier is responsible for insuring that materials and components used were manufactured, tested, and inspected in accordance with the requirements of this specification and, to the extent specified, of all referenced subsidiary specifications and standards. In the event of conflict, this specification shall govern. A supplier's certificate of compliance with 3.1 shall be furnished.

4.2.2 Inspection of sheet and film. Examination of sheet and film shall be made in accordance with the classification of defects, inspection levels and acceptable quality levels (AQLs) set forth below. The lot size, for purpose of determining the sample size in accordance with MIL-STD-105, shall be expressed in units of packages of plastic sheets, or film, for examination in 4.2.2.1, 4.2.2.2, 4.2.2.3 and in units of shipping containers for examination in 4.2.2.4.

4.2.2.1 Examination of the sheet and film for defects in form and assembly. The sample unit for the examination specified in table VI shall be one roll of sheet or film.

TABLE VI. Examination of sheet and film for defects in form and assembly.

Examine	Defect
Form	Not in rolls.
Assembly of roll	Not suitably restrained to prevent unwinding. Material not wound evenly and tightly on roll, causing uneven edges or telescoping of the roll. Rolls not wound on a substantial core. Core broken, collapsed, crushed, or mutilated.

4.2.2.2 Examination of the sheet and film for defects in length, width, core diameter, and number of splices. The sample unit for the examination specified in table VII shall be one roll of sheet or film.

TABLE VII. Examination of sheet and film for defects in length of roll, width of roll, core diameter and number of splices

Examine	Defect
Length of roll	Average length per roll less than specified.
Width of roll	Varies by more than ± 1.59 (± 1/16 inch) from width specified in thicknesses up to and including 0.5mm (0.020 inch) and ± 3.18mm (± 1/8 inch) in thicknesses greater than 0.5mm (0.020 inch)
Core diameter	Not as specified.
Number of splices	Exceeds allowable number of splices.

4.2.2.3 Examination of sheet and film for defects in color, appearance, and workmanship. The sample unit for the examination specified in table VIII shall be one linear yard full width or roll.

TABLE VIII. Examination of sheet and film for defects in color, appearance and workmanship

Examine	Defect
Color	Not characteristic of unpigmented sheet or film (see 3.8)
Appearance and Workmanship	Not clean, presence of excessive foreign matter such as imbedded particles, dirt, grit, or other foreign matter affecting serviceability Material not uniform in finish, or other appearance. Any cracks, scratches, bubbles, warpage, or other defects affecting serviceability. Any cut, puncture, sharp crease, hard permanently set wrinkle, tear, or hole. Edges not clean cut; ragged, crushed or uneven edges. NOTE: Slight discontinuities in the surface of the film. Gel particles and fine black specks inherent in polymer shall not be considered a defect.

4.2.2.4 Examination of packaging. An examination shall be made to determine compliance with the requirements of Section 5. The sample unit shall be one shipping container fully prepared for delivery. Sampling shall be in accordance with MIL-STD-105. The inspection level shall be S-2 with an AQL of 4.0 expressed in terms of percent defective.

4.2.2.5 Inspection levels and AQLs for examinations. The inspection levels for determining the sample size and the AQL, expressed as defects per 100 units, shall be as follows:

Examination paragraph	Inspection level	AQL
4.2.2.1	S-2	2.5
4.2.2.2	S-2	2.5
4.2.2.3	I	1.5
4.2.2.4	S-2	2.5

4.2.3 Testing. Sheet and film shall be tested for the applicable characteristics, in accordance with the test methods specified herein for each lot submitted for inspection. Sampling shall be in accordance with MIL-STD-105 and the lot size for the purpose of determining sample size for testing shall be expressed in units of 150 pounds of material. The inspection level shall be S-1. The sample size (number of units of product drawn from a lot) shall be in accordance with the single sampling plan for normal inspection and each unit shall consist of sufficient material to prepare all specimens required for testing. Each unit shall be tested and must meet all applicable requirements. Test results for each characteristic in each unit shall be the averaged results from the specimens tested for that characteristic.

4.2.3.1 Classification of tests. All tests shall be classified as follows:

a. Lot acceptance tests (see 4.2.3.2).
b. Periodic lot check tests (see 4.2.3.3).

4.2.3.2 Lot acceptance tests. Lot acceptance tests shall be made on each lot of sheet and film and shall be the basis for acceptance or rejection of the lot, except when periodic lot check tests are required. Lot acceptance tests shall consist of tests for tensile strength at $23^{\circ} + 2^{\circ}$ C ($73.4^{\circ} + 3.6^{\circ}$ F), tear strength lengthwise change in dimensions, cementability (for type II material), thickness, and dielectric strength (for types I and II material).

4.2.3.3 Periodic lot check tests. Periodic lot check tests shall be made on the first lot of material furnished under this specification and repeated at 6-month intervals on any subsequent lot specified by the procuring agency (see 6.2). Periodic lot check tests shall consist of tests for density, tensile strength, and elongation after conditioning at 175° ± 2° C (347° ± 3.6° F) for a minimum of 400 hours and dielectric constant, dissipation factor and volume resistivity at 23° ± 2° C (73.4° ± 3.6° F). When periodic lot check tests are made, they shall be included with lot acceptance tests in the basis for acceptance or rejection of the lot.

4.3 Test methods.

4.3.1 Preparation of specimens. Test specimens shall be taken across the width of film excluding areas of wrinkles, folds, gel, and other obvious visually determined imperfections.

4.3.2 Specimen conditioning and testing. Unless otherwise specified by the procuring activity, test specimens shall require no conditioning and shall be tested at ambient conditions of temperature and humidity.

4.3.3 Density. Three specimens shall be tested in accordance with ASTM D1505.

4.3.4 4.3.4 Tensile strength and elongation at 23° C (73.4° F). Five specimens shall be tested. Film 0.12mm (5 mils) or less in thickness shall be tested in accordance with ASTM D882, method A. Film or sheet over 0.12mm (5 mils) thick shall be tested in accordance with ASTM D1708. For all film thickness, the speed of testing shall be 50.8mm (2 inches) per minute.

4.3.5 Tensile strength and elongation after 400 hours at 175° C (347° F). Five specimens shall be conditioned in an oven for a minimum of 400 hours at 175° ± 2° C (347° ± 3.6° F) and then cooled to 23° ± 2° C (73.4° ± 3.6° F) in an atmosphere of 50 ± 5 percent relative humidity. After conditioning, the five specimens shall be tested in accordance with 4.3.4.

4.3.6 Tear strength. Three specimens shall be tested in accordance with ASTM D1922.

4.3.7 Dielectric strength. Five specimens shall be tested in accordance with ASTM D149, using the "short-time test" and a 6.35mm (1/4 inch) brass electrode with a 0.8mm (1/32 inch) edge radius. Specimens shall be of the thickness supplied.

4.3.8 Dielectric constant and dissipation factor. Three specimens shall be tested in accordance with ASTM D150, using vacuum plated metal or sprayed silver paint electrodes. Specimen dimensions shall be 102mm (4 inches) in diameter with thickness as supplied. Testing shall be at 1 kilohertz and 1 megahertz.

4.3.9 Volume resistivity. Three specimens shall be tested in accordance with ASTM D257. Specimen thickness shall be as supplied, and other dimensions shall conform to figure 4 of ASTM D257 using silver paint, sprayed metal, or evaporated metal electrodes.

4.3.10 Lengthwise change in dimensions. Lengthwise change in dimensions shall be determined by taking and averaging five measurements on specimens immediately before oven heating. Each specimen shall measure 102 ± 1.59mm (14 ± 1/16 inch) by 102 ± 1.59mm (4 ± 1/16 inch) and shall be freely suspended in an oven controlled at 200° ± 2° C (392° ± 3.6° F) for a minimum of 30 minutes. After the heating period, the specimens shall be cooled to 23° ± 2° C (73.4° ± 3.6° F), conditioned in accordance with 4.3.2, and tested at 23° ± 2° C (73.4° ± 3.6° F).

4.3.11 Cementability of type II film. The cementability of type II sheet and film is determined as follows. The treated surface of the film is heat sealed by the application of controlled heat, pressure, and dwell time to an adhesive coated strip of aluminum sheet. The peel seal strength is measured in a tensile tester at a peel angle of 180°.

Apparatus

(1) Heat sealer, single heated jaw with silicone rubberppad, temperature range 149-247° C (300-525° F) pressure 138 kPa (20 psi), dwell time 10 seconds. Sentinel Model 12AS or 12-12AS (Packaging Industries, Inc., Hyannis, MA) or equivalent.

(2) Tensile tester, range 12,000 grams, Suter Model 272 tester (Alfred Suter Co., 200 Fifth Ave., New York, NY) or equivalent.

(3) No. 24 "Draw Down" rod (R&D Specialties, P. O. Box 397, Webster, NY) or equivalent means for coating aluminum evenly with adhesive.

Reagents and materials

(1) Methyl ethyl ketone (2-butanone).

(2) No. 6840 Adhesive (Fabrics & Finishes Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, DE) or equivalent.

(3) Anodized aluminum, 0.483mm (0.019 inch) thick, "Alidine" #1200 (Alsco Inc., 225 South Forge Street, Akron, OH) or equivalent. Other sheet aluminum, either plain or anodized, should be satisfactory if it can be shown that the peel failure of the seals is between the treated film surface and the No. 6840 Adhesive or equivalent and not between the adhesive and the aluminum.

Preparation of adhesive coated aluminum

(1) Conveniently sized sheets of aluminum 254 by 254mm (10 by 10 inches) are evenly coated with 6840 Adhesive or equivalent using a No. 24 "Draw Down" rod and allowed to dry in air for eight hours. Thickness of coating is not critical but it is important that the coating be smooth and bubble free. Methyl ethyl ketone is used for thinning the adhesive if necessary and for equipment clean-up.

(2) The coated sheets are then cut up into 38.1 by 127mm (1-1/2 by 5 inches) strips and stored in a desiccator.

(3) Do not prepare more than a two or three month's supply of coated aluminum at one time. The adhesive slowly crosslinks in time, and seal values are lowered.

Sample

Cut five 25.4 by 12mm (1 by 5 inches) sample strips equally spaced across the width of the film. The film must be free from fingerprints and contamination.

Procedure

(1) Place each sample on a 38.1 by 12mm (1-1/2 by 5 inches) strip of coated aluminum with the treated surface facing the adhesive.

(2) Seal the strips in the heat sealer with the aluminum strip facing the heated jaw and the film facing the silicone rubber pad.

(3) The sealer is set at 10 seconds dwell time and 138 kPa (20 psi) jaw pressure. Temperature is set according to the following table.

Film thickness, mm (inch)	Temperature, C (F)
0.01 (0.0005)	149 (300)
0.02 (0.001)	163 (325)
0.05 (0.002)	190 (375)
0.07 (0.003)	190 (375)
0.12 (0.005)	274 (525)
0.25 (0.010)	274 (525)
0.50 (0.020)	274 (525)

(4) After the samples have cooled to room temperature, the seals are pulled in a tensile tester. Peel angle is 180°.

Calculations

Average seal strength, grams/25.4mm (grams/inch) = $\frac{\text{sum of 5 seals}}{5}$

4.3.12 Thickness. The thickness of sheet or film shall be measured in accordance with ASTM D374 method C, except for modification as follows: The dead weight dial micrometer shall exert a force of 0.03 ± 0.001 MPa (5 ± 0.1 pounds per square inch), and measurements shall be made 2 ± 0.1 seconds after the pressure foot contacts the film. The average of 10 random measurements shall fall within the specified limits, and the area over which such measurements are made shall exceed 7724 square millimeters (12 square inches).

5. PREPARATION FOR DELIVERY

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

5.1.1 Level A. The sheet or film shall be furnished in roll form and shall be wound on a substantial core. The rolls shall not exceed 150 pounds in weight and shall be wrapped with at least one layer of polyethylene film and tightly sealed with waterproof tape.

5.1.2 Commercial. The sheet or film shall be preserved in accordance with normal commerical practice. The complete package shall be designed to protect the sheet or film against damage during shipment, handling and storage.

5.2 Packing. Packing shall be level A or commercial, as specified (see 6.3).

5.2.1 Level A. The rolls of sheet or film of like description, preserved as specified in 5.1.1 shall be packed in close-fitting boxes conforming to PPP-B-636, class weather resistant. The box shall be closed, waterproofed, and reinforced in accordance with the appendix of PPP-B-636. Alternatively, cleated-plywood, wire-bound or nailed wood 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. The rolls of sheet or film preserved as specified in 5.1.2, shall be packed in a manner that will insure 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.

6. NOTES

6.1 Intended use. FEP-fluorocarbon sheet or film covered by this specification will be used in applications requiring superior electrical properties, complete inertness to all commonly used corrosive chemicals, complete inertness to common solvents and liquid oxygen, continuous service temperatures of -255 C (-499 F) to +200 C (+392 F), heat sealability, heat bondability, heat formability, nonflammability, and inertness under outdoor exposure conditions.

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

a. Title, number, and date of this specification.
b. Type and class of material (see 1.2.1).
c. If procuring agency requires dielectric constant and dissipation factor to be tested at 10^6 Hz (see table II) as well as at 10^3 Hz.
d. Length, width, core diameter required, and maximum number of splices allowable (see 3.6).
e. Sheet or film thickness (see 3.7).
f. Periodic lot check tests, when required (see 4.2.3.3).
g. Selection of applicable degree of preservation and packing required (see 5.1 and 5.2).
h. Special marking, if required (see 5.3.2).

6.3 Environmental. Environmental pollution measures are contained in the packaging material specification references herein. Refer to material specification or preparing activity for recommended disposibility methods.

MILITARY CUSTODIANS:

Army - MR
Navy - AS
Air Force - 11

Review activities:

Army - ER, MI, MD, SM
Navy - AS
Air Force - 99
DLA - GS

User activities:

Navy - MC, SH

Preparing activity:

Army - MR

Civil Agency Coordinating Activity:

GSA-FSS

Project No. 9330-0832

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