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SUPERSEDING  
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FEDERAL SPECIFICATION  
SYNTHETIC FILAMENTS FOR BRUSHES;  
GENERAL SPECIFICATION FOR

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 synthetic plastic filaments for filling brushes.

1.2 Classification.

1.2.1 Grade, classes, and types. The synthetic filaments shall be of one grade and of the following classes and types, as specified (see 6.2):

Class E - Polyester.  
Type I - Tapered.  
Type II - Level.  
Type III - Crimped.

Class N - Polyamide.  
Type I - Tapered.  
Type II - Level.  
Type III - Crimped.

Class P - Polypropylene.  
Type II - Level.  
Type III - Crimped.

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 Specifications:

TT-E-776 - Ethylene Glycol Monobutyl Ether (For Use in Organic Coatings).  
TT-M-261 - Methyleneethyl Ketone (For Use in Organic Coatings). Technical  
TT-T-291 - Thinner, Paint, Volatile Spirits, Petroleum Spirits  
PPP-B-636 - Boxes, Shipping, Fiberboard.  
PPP-F-320 - Fiberboard; Corrugated and Solid, Sheet Stock Container Grade), and Cut Shapes.

Federal Standard:

Fed. Std. No. 123 - Marking for Shipment (Civil Agencies).

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(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 Business Service Centers at the General Services Administration Regional Offices in Boston, New York, Washington, DC, Atlanta, Chicago, Kansas City, MO, Fort Worth, 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 Standards:

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.  
MIL-STD-129 - Marking for Shipment and Storage.

(Copies of Military Specifications and Standards required by suppliers 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.

National Motor Freight Traffic Association, Inc., Agent:

National Motor Freight Classification.

(Application for copies should be addressed to the American Trucking Associations, Inc., Tariff Order Section, 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.)

American Chemical Society (A.C.S.) Specifications: Reagent Chemicals (Fifth Edition)

Acetone.  
N-butanol (butyl alcohol).  
Ethyl Alcohol (Ethanol).  
Methanol (methyl alcohol)  
Toluene

(Application for copies should be addressed to the American Chemical Society, 1155 Sixteenth Street, NW, Washington, DC 20036.)

3. REQUIREMENTS

3.1 Materials. The plastic filament materials shall conform to the applicable physical characteristics in table I, when tested as specified in 4.2.4 and as indicated below:

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TABLE I. Physical characteristics

Characteristic	Class	Value
Melting point	E	210° - 230°C
	N	203° - 223°C
	P	164° - 170°C
Specific gravity	E	1.33 max.
	N	1.10 max.
	P	0.92 max.
Loss in weight	N	0.3 percent max.
	P	0.1 percent max.
Moisture absorption	E	1.0 percent max. at 100 percent relative humidity and 23°C (73.5°F) temperature.
	N	2.0 percent max. at 50 percent relative humidity and 23°C (73.5°F) temperature.
		4.0 percent max. at 100 percent relative humidity and 23°C (73.5°F) temperature.
	P	0.2 percent max. at 100 percent relative humidity and 23°C (73.5°F) temperature.
Solvent resistance	E, N, & P	Shall not dissolve or show visual swelling.
Modulus of elasticity (Type II only)	E	2.5 - 5.0 x 10 <sup>5</sup> p.s.i. min. after conditioning in 4.3.1.
	N	3.0 x 10 <sup>5</sup> p.s.i. min. after conditioning in 4.3.1.
		1.5 x 10 <sup>5</sup> p.s.i. min. after immersion in distilled water for 16 hours.
	P	2.5 x 10 <sup>5</sup> p.s.i. min. after conditioning in 4.3.1.
		2.5 x 10 <sup>5</sup> p.s.i. min after immersion in distilled water for 16 hours.
Shrinkage	P	1.0 percent max.
Resistance to N-butyl alcohol	N & P	Not dissolved or allacked after boiling for 3 minutes.
Recovery from flex.	P	100 max. angular degrees from original straight line or 180° form.

3.1.1 Class E. Class E filament material shall be composed principally of a highly polymerized ester of the poly (butylene - 1,4 terephthalate) type which has recurring ester groups as an integral part of the main polymer chain, the terephthalate being in greater amount than other dicarboxylates.

3.1.2 Class N. Class N filament materials shall be composed principally of a long-chain synthetic-polymeric amide which has recurring amide groups as an integral part of the main polymer chain.

3.1.3 Class P. Class P filament material shall be composed principally of a long chain hydrocarbon polymer which is predominately stereospecific in molecular character. The polymer shall be polypropylene.

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### 3.2 Design.

3.2.1 Type I. Type I tapered filaments shall uniformly decrease in diameter throughout their length and shall conform to the size designations in table II. The filaments shall be straight and have a smooth uniform surface. The ratio of bundle diameters, butt to tip, and bundle butt diameters shall be as shown in table II.

3.2.2 Type II. Type II level filaments shall be of uniform diameter throughout their length and shall conform to the size designation and variations in table III. Filaments shall be straight and have a smooth uniform surface.

3.2.3 Type III. Class P, type III crimped filaments shall be uniformly and consistently crimped in accordance with the values shown in table V when tested as specified in 4.2.4. Classes E and N, type III crimped filaments shall be uniformly and consistently crimped in accordance with the values shown in table V(a) when tested as specified in 4.2.4.

TABLE II. Dimensions of class E & N, type I filaments

Size designation	Length <sup>1</sup> Inches	Average tip diameter Inch	Average butt diameter Inch	Bundle, butt to tip ratio	Bundle butt diameter Inches
9-5	2-1/2 to 5-1/2	0.0050 + 0.0016 - 0.0004	0.0090 + 0.0008 - 0.0020	1.55 + .15	2 + 1/8
9-5	2 to 2-1/4	.0060 + .0008 - .0012	.0090 + .0008 - .0020	1.40 - .20	Do.
12-8	2-1/2 to 5-1/2	.0080 + .0008 - .0016	.0120 + .0014 - .0014	1.55 + .15	Do.
15-10	2-1/2 to 5-1/2	.0100 + .0010 - .0018	.0150 + .0017 - .0011	1.55 + .15	Do.

<sup>1</sup>/ Lengths supplied in 1/4-inch increments within the range as specified. (See 3.3.1 for length tolerance.)

### 3.3 Length.

3.3.1 Class E & N. Class E & N filaments shall be of the lengths shown in tables II and III for types I and II, respectively, as specified. The ends in each bundle shall be cut essentially square. A tolerance of plus 1/8 inch and no minus tolerance shall be permitted for type I filaments. A tolerance of + 1/16 inch shall be permitted for type II filaments.

3.3.2 Class P. Class P filaments shall have a length of from 1 inch to 49 inches, as specified. The filaments may be supplied in increments of 1/8 inch within this range. The ends of each bundle shall be cut square and there shall be no fusing together of individual filaments at the cut ends. A tolerance of + 1/16 inch will be permitted for types II and II filaments.

### 3.4 Sizes.

3.4.1 Class E and N. The diameter of class E and N filaments shall be as specified within the tolerances shown in tables II and III for types I and II filaments, respectively, when tested in accordance with 4.2.4. The bundle diameters shall be as shown in tables II and III when tested as specified in 4.2.4.

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TABLE III. Dimensions of class E and N, type II filaments

Size designations (caliper)	Variation in roundness (tolerances)		Lengths <sup>2</sup>	Inches 2 + 1/8" for all size designations
	Average all strands	In-dividual strands		
	Inch	Inch	Inches	Inches
0.0025-0.0060	+ 0.0005	+ 0.0005	1-9 inclusive + 1/6 <sup>3</sup>	2 + 1/8
.007-.014	+ .0005	+ .0010	Do.	Do.
.015-.022	+ .0005	+ .0015	Do.	Do.
.028-.032	+ .0010	+ .0020	Do.	Do.
.036-.040	+ .0015	+ .0023	Do.	Do.
.045-.050	+ .0020	+ .0025	Do.	Do.
.055-.060	+ .0020	+ .0030	Do.	Do.
	+ .0020	+ .0030	Do.	Do.

2/ Also supplied in hank lengths of 46 + 1/2 inch.

3/ Lengths supplied in any increments as specified within these ranges.

TABLE IV. Class P diameter sizes and tolerances

Specified diameter (min.) in inches	Tolerance of average small-diameter in inches	Maximum out of roundness ratio of average large diameter to average small diameter. (Measure perpendicular to each other.)
0.006 - 0.010	+ 0.0005	1.30
.011 - .018	+ .0010	1.40
.019 - .030	+ .0015	1.50
.031 - .039	+ .0020	1.60
.040 - up	+ .0030	1.60

3.4.2 Class P. Class P filaments shall have a (minor) diameter (when out of round) of 0.005 to 0.100 inch, inclusive, in increments of 0.001 inch, as specified, and shall be within the diameter and out-of-roundness tolerance shown in table A when tested as specified in 4.2.4. The bundle diameter for each size, as specified, shall be 2 inches or larger as agreed between the contracting officer and the supplier, with a plus or minus 1/4 inch tolerance for each bundle when tested in accordance with 4.2.4.

### 3.5 Color.

#### 3.5.1 Class E.

3.5.1.1 Types I, II and III. The color of types I, II and III filaments shall be sable brown.

#### 3.5.2 Classes N and P.

3.5.2.1 Type I. The color of type I filaments shall be black.

3.5.2.2 Types II and III. The color of types II and III filaments shall be black or natural as specified (see 6.2).

3.6 Workmanship. The filaments shall be clean, well finished, ends cut square, and free from dirt and grease. The filaments shall conform to the quality and grade of product established by this specification.

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TABLE V. Crimp amplitude<sup>4</sup> and frequency for class P, type III

Filament diameter, inch	No. 6 frequency crimp <sup>5</sup> Amplitude inch			No. 10 frequency crimp <sup>5</sup> Amplitude inch			No. 13 frequency crimp <sup>5</sup> Amplitude inch		
	Heavy	Medium	Light	Heavy	Medium	Light	Heavy	Medium	Light
0.006	-	-	0.014	-	-	0.012	-	0.018	0.012
.008	-	-	.018	-	-	.014	-	.020	.014
.010	-	0.024	.020	-	0.020	.016	-	.022	.016
.012	0.032	.026	.022	0.026	.022	.018	0.028	.024	.018
.014	.038	.032	.026	.032	.026	.020	.030	.026	.020
.016	.044	.036	.028	.038	.030	.024	.032	.028	.024
.018	.050	.040	.032	.042	.034	.026	.036	.030	.026
.020	.054	.044	.034	.046	.038	.030	.038	.032	.028
.022	.058	.046	.038	.052	.042	.032	.040	.034	.030
.024	.062	.048	.040	.058	.046	.036	.042	.036	.032
.026	.064	.050	.044	.062	.048	.038	-	-	-
.028	.064	.052	.046	.062	.050	.040	-	-	-
.030	.064	.054	.048	.062	.052	.042	-	-	-
.032	.064	.056	.050	.062	.054	.044	-	-	-
.034	.064	.058	.052	-	.056	.046	-	-	-
.036	-	.060	.054	-	-	.048	-	-	-
.038	-	-	.056	-	-	-	-	-	-
.040	-	-	.058	-	-	-	-	-	-

4/ Amplitudes shown are average amplitudes to  $\pm 0.005$  tolerance.5/ Frequencies shown are average frequency to  $\pm 15$  percent tolerance.

Amplitude = Total width of filament crimp.

Frequencies = Total half waves per inch.

TABLE V(a). Crimp amplitude and frequency for class E &amp; N, type III 6/ 7/

Nominal filament diameter (inch)	No. 10 crimp frequency Amplitude (inch)		No. 13 crimp frequency Amplitude (inch)		No. 15 crimp frequency Amplitude (inch)	
	HD (Deep)	HL (Light)	HD (Deep)	HL (Light)	HD (Deep)	HL (Light)
0.003	---	---	0.005	0.003	0.005	0.003
.004	---	---	.005	.003	.005	.003
.005	---	---	.005	.003	.005	.003
.006	---	---	.005	.003	.005	.003
.007	---	---	.005	.003	.005	.003
.008	---	---	.010	.005	.010	.005
.009	---	---	.010	.005	.010	.005
.010	---	---	.010	.005	.010	.005
.011	---	---	.010	.005	.010	.005
.012	---	---	.010	.005	.010	.005
.013	---	---	.012	.005	.012	.005
.014	---	---	.012	.005	.012	.005
.015	---	---	.012	.005	.012	.005
.016	---	---	.012	.005	.012	.005
.017	---	---	.012	.005	.012	.005
.018	---	---	.012	.005	.012	.005
.019	---	---	.012	.005	.012	.005
.020	---	---	.012	.005	.012	.005
.021	---	---	.012	.005	.012	.005
.022	---	---	.012	.005	.012	.005
.023	0.012	0.005	---	---	.012	.005
.025	.012	.005	---	---	.012	.005
.028	.012	.005	---	---	.012	.005
.032	.012	.005	---	---	.012	.005
.036	.012	.005	---	---	.012	.005

6/ Amplitudes shown are average amplitudes to  $\pm 0.002$  inch tolerance.7/ Frequencies shown are average frequencies to  $\pm 15$  percent tolerance and are based on the number of halfwaves per inch.

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#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by 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 Quality conformance inspections. Inspection shall be performed in accordance with the provisions set forth in MIL-STD-105 except where otherwise indicated. For purposes of sampling, a lot shall consist of all end items made of the same class, type, and color from the same production run and offered for inspection at one time.

4.2.1 Component and material inspection. In accordance with 4.1, 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.

4.2.2 Certificate of compliance. A certificate of compliance shall be furnished to the contracting officer for determination of requirements listed below.

Material	Characteristic	Requirement paragraph
Class E filament material	Material identification	3.1.1
Class N filament material	Material identification	3.1.2
Class P filament material	Material identification	3.1.3

4.2.3 Examination of the end item. The end item shall be examined for visual, dimensional, and preparation for delivery defects. For purposes of sampling, a lot shall consist of bundles of filaments of the same class and type for the examinations in 4.2.3.1 and 4.2.3.2 and of shipping containers in the end item inspection lot for the examination in 4.2.3.3. The inspection levels and acceptable quality levels (AQLs) for these examinations shall be as specified in 4.2.3.4.

4.2.3.1 Visual examination. The end item shall be examined for defects in workmanship and color. The sample unit shall be one bundle of filaments of the same class and type.

Examine	Defect
Workmanship	Not clean Ends not square cut. Fused cut ends of filaments. Rough finish.
Color	Contains dirt or grease. Not as specified.

4.2.3.2 Dimensional examination (length). An examination shall be made to determine that the length of the filaments conform to the dimensional requirements with allowable tolerances as specified. Any length that does not conform to requirements shall be a defect. The sample unit for this examination shall be one bundle of filaments of the same class and type.



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Examine	Defect
Dimensions	Filament length not within allowable tolerances.

4.2.3.3 Examination of preparation for delivery requirements. An examination shall be made to determine that packaging, packing, and marking requirements comply with section 5. Defects shall be scored in accordance with the list below. The sample unit shall be one shipping container fully prepared for delivery with the exception that it need not be sealed. Defects of closure listed below shall be examined on shipping containers fully prepared for delivery. The lot size shall be the number of shipping containers offered for delivery at one time.

Examine	Defect
Marking (exterior and interior)	Omitted, incorrect, illegible, of improper size, location, sequence, or method of application.
Materials	Any component missing. Any component damaged, affecting serviceability.
Workmanship	Inadequate application of components, such as: Incomplete closure of container. flaps, loose strapping, improper taping, or inadequate stapling. Bulging or distortion of containers.
Weight	Net weight exceeds requirement.

4.2.3.4 Inspection levels and AQLs for examination. The inspection levels for determining the sample size, and the AQLs, expressed in defects per 100 units shall be as follows:

Examination paragraph	Inspection levels	AQL
4.2.3.1	S-4	2.5
4.2.3.2	S-4	2.5
4.2.3.3	S-2	2.5

4.2.4 Testing of the end item. Testing of the filaments shall be performed in accordance with table VI for the characteristics shown therein. The sample unit shall be two bundles of filaments of each class and type. The lot size shall be expressed in units of bundles of filaments of the same class and type. The sample size for the designated lot size shall be as shown below. There shall be no evidence of failure of any sample unit to meet the requirements as specified. All test reports shall contain the individual values utilized in expressing the final result.

Lot size	Sample size
800 or less	2
801, up to and including 22,000	3
22,001 and over	5

4.3 Test procedures. Samples selected in accordance with 4.2 shall be subjected to the following test. Alternate test techniques and equipment may be used by the Government, but in case of dispute, the methods specified herein shall prevail. Unless otherwise specified, standard test conditions are a temperature of  $23 \pm 2^{\circ}\text{C}$  ( $73.4 \pm 3.6^{\circ}\text{F}$ ) and a relative humidity of  $50 \pm 5$  percent. Failure to pass any test or noncompliance to the requirement shall be cause for rejection of the lot. All tests shall be evaluated for conformance with the requirements specified in section 3.



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4.3.1 Conditioning. The filaments shall be conditioned for not less than 48 hours at standard laboratory conditions before conducting the tests for size and modulus of elasticity. The specimens shall be tested in the same atmosphere.

#### 4.3.2 Sizes.

4.3.2.1 Specimen. The specimen shall consist of thirty filaments, individually taken at random from any bundle of each class, type, and size, conditioned as specified in 4.3.1.

TABLE VI. Instructions for testing

Characteristic	Requirement paragraph	Test method	No. determinations per sample unit	Results reported as	
				Pass or fail	Numerically to nearest
Sizes	3.4	4.3.2	Average of 30	-	0.0002 inch
Bundles diameter	3.4	4.3.3	1	-	1/16 inch
Melting point	3.1	4.3.4	1	-	1°C
Specific gravity	3.1	4.3.5	1	-	0.01
Loss in weight	3.1	4.3.6	Average of 2	-	0.1 percent
Moisture absorption	3.1	4.3.7	Average of 2	-	0.1 percent
Solvent resistance	3.1	4.3.8	1	X	-
Modulus of elasticity	3.1	4.3.9	Average of 3	--	0.1 x 10 <sup>5</sup> p.s.i.
Shrinkage	3.1	4.3.10	Average of 5	-	0.1 percent for class P
Resistance to N-butyl alcohol	3.1	4.3.11	1	X	-
Crimp	3.2.3	4.3.12	5	-	0.002 inch crimp ampl.
Recovery from flex	3.1	4.3.13	Average of 5	-	1° of angle

#### 4.3.2.2 Apparatus.

4.3.2.2.1 Types I and II. The apparatus shall consist of a common micrometer caliper with the usual flat anvils which will give accurate readings to 0.0002 inch.

4.3.2.2.2 Type III. The apparatus shall consist of a micrometer caliper with triangular or wedge shaped anvils, the included angle of which shall not exceed 60° and which are so positioned as to make the specimen measurements between the points of the wedge.

#### 4.3.2.3 Procedure.

4.3.2.3.1 Type I. The diameter of each filament in the specimen of type I filament shall be measured at the butt end to the nearest 0.0002 inch and the value recorded.

4.3.2.3.2 Types II and III. The diameter of each filament in the specimen of types II and III shall be measured across both the minor diameter and the major diameter (perpendicular to the minor diameter) at the same spot on the filament to the nearest 0.0002 inch and the values recorded.

#### 4.3.2.4 Results.

4.3.2.4.1 Type I. The average of the results obtained from the thirty filaments measured shall be the diameter of the filament and shall be reported to the nearest 0.0002 inch.

4.3.2.4.2 Types II and III. The average of the minor diameter of the thirty filaments shall be the diameter of the filament and shall be reported to the nearest 0.0002 inch. The average of the measurements of the major diameter of the thirty filaments shall be divided by the average minor diameter (above) and the resulting out-of-roundness ratio reported for class P filaments only.

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4.3.3 Bundle diameter.

4.3.3.1 Specimen. The specimen shall consist of a bundle of synthetic filaments taken from each class, type, and size.

4.3.3.2 Apparatus. The apparatus shall consist of a narrow tape which will give accurate measurements to 1/16 inch.

4.3.3.3 Procedure. The circumference of the bundle shall be measured at both butt and tip ends.

4.3.3.4 Results. The diameters shall be measured to the nearest 1/16 inch and the ratio calculated. Both the diameters and ratio shall be recorded.

4.3.4 Melting point.4.3.4.1 Classes E, N and P filaments.

4.3.4.2 Specimen. The specimen shall consist of a piece of filament approximately 1/3 inch in length.

4.3.4.3 Apparatus. The apparatus shall be a Fisher-Johns melting point apparatus.

4.3.4.4 Procedure for determining the melting point for classes E, N and P filaments. Use procedure as furnished with apparatus.

4.3.4.2.4.3.4.5 Results. The melting point of the specimen shall be the melting point of the sample and shall be recorded to the nearest 1°C.

4.3.5 Specific gravity.

4.3.5.1 Specimen. The specimen shall consist of 0.5 to 1.0 gram of synthetic filaments.

4.3.5.2 Apparatus. The apparatus shall consist of the following:

- a. A 10-milliliter-capacity pycnometer.
- b. Analytical balance.
- c. Analytical weights.

4.3.5.3 Procedure. The specimen shall be weighed at standard laboratory conditions. The pycnometer shall be weighed empty, filled with 95 percent ethanol for all classes of filaments and weighed again. The specimen shall be inserted into the pycnometer again, filled with the specified liquid and again weighed. The specific gravity of the specimen shall be calculated as follows:

$$\text{Specific gravity, } 23^{\circ}\text{C}/23^{\circ}\text{C} = 0.9975 \times \frac{W_1}{W_1 - (W_3 - W_2)} \times S$$

where:

- $W_1$  = weight of the specimen in air, grams.
- $W_2$  = weight of the pycnometer filled with alcohol, grams.
- $W_3$  = weight of the pycnometer with specimen and alcohol, grams.
- $S$  = specific gravity of the 95 percent ethanol at 23°C/23°C.

4.3.5.4 Results. The specific gravity of the sample shall be the specific gravity of the specimen and shall be recorded to the nearest 0.01.

4.3.6 Loss in weight.

4.3.6.1 Specimen. The specimen shall consist of approximately 5 grams of the synthetic filaments.

4.3.6.2 Apparatus. The apparatus shall consist of the following:

- a. Analytical balance.
- b. Analytical weights.
- c. Controlled temperature circulating-air oven.

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4.3.6.3 Procedure. The specimen shall be cut into lengths approximately 1 inch long. The specimen shall be placed in a weighing bottle and dried to constant weight in a circulating-air oven at a temperature of  $70^{\circ} + 1^{\circ}\text{C}$  ( $158^{\circ} + 2^{\circ}\text{F}$ ) for 15-18 hours. The dried specimen shall then be heated in a circulating-air oven at a temperature of  $100^{\circ} + 1^{\circ}\text{C}$  ( $212^{\circ} + 2^{\circ}\text{F}$ ) for 8 hours and again weighed. The loss in weight in percent shall be calculated as follows:

$$\frac{\text{Loss in weight}}{\text{Weight of specimen (constant weight at } 70^{\circ}\text{C)}} \times 100 = \text{Percent loss in weight at } 100^{\circ}\text{C}$$

4.3.6.4 Results. Two specimens shall be tested. The average of the results obtained from the two specimens tested shall be the loss in weight of the sample and shall be recorded to the nearest 0.1 percent.

#### 4.3.7 Moisture absorption.

4.3.7.1 Specimen. The specimen shall consist of approximately 5 grams of the synthetic filament.

4.3.7.2 Apparatus. The apparatus shall consist of the following:

- a. Analytical balance.
- b. Analytical weights.
- c. Controlled temperature circulating-air oven.

4.3.7.3 Procedure. The specimen shall be cut into lengths approximately 1 inch long. The specimen shall be placed in a weighing bottle and dried to constant weight in a circulating-air oven at a temperature of  $70^{\circ} + 1^{\circ}\text{C}$  ( $158^{\circ} + 2^{\circ}\text{F}$ ) for 15-18 hours. The weighing bottle, with the lid off, but containing the dried specimen, shall be exposed to standard laboratory conditions until it reaches constant weight (5-6 days). At the end of the exposure period, the specimen shall be weighed and the amount of the moisture absorbed in percent shall be calculated as follows:

$$\frac{\text{Increase in weight}}{\text{Dry weight}} \times 100 = \text{Percent increase in weight at standard laboratory conditions.}$$

The procedure described above shall be repeated except that the conditioning atmosphere in this case shall be 98 to 100 percent relative humidity. The moisture absorbed shall be calculated as follows:

$$\frac{\text{Increase in weight}}{\text{Dry weight}} \times 100 = \text{Percent increase in weight at standard laboratory conditions.}$$

4.3.7.4 Results. Two specimens shall be tested. The average of the results obtained from the two specimens tested shall be the moisture absorption of the sample and shall be recorded to the nearest 0.1 percent.

#### 4.3.8 Solvent resistance.

4.3.8.1 Specimen. The specimen shall consist of five equal length pieces of the filament. Each piece shall be taken from a different filament.

4.3.8.2 Apparatus. The apparatus shall consist of the following:

- (a) Test tubes.
- (b) Solvents, class E filament.
  - (1) Denatured ethyl alcohol (ACS reagent grade).
  - (2) Methanol (ACS reagent grade).
  - (3) Mineral spirits (in accordance with TT-T-291).
- (c) Solvents, classes N and P filaments.
  - (1) Acetone (ACS reagent grade).
  - (2) Denatured ethyl alcohol (ACS reagent grade).
  - (3) Methanol (ACS reagent grade).
  - (4) Mixture of equal parts of toluene and methanol, methylethylketone or ethylene dichloride and chloroform. Toluene, methanol, and chloroform, ACS reagent grade; methylethyl ketone, TT-M-261.

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4.3.8.3 Procedure. A quantity of each solvent shall be placed in separate test tubes to a depth of approximately one-half the length of the pieces of filament. One or two pieces of the filament shall be immersed to a depth of about one-half their length in each solvent for a period of 8 hours at standard laboratory conditions. At the end of the exposure period, each piece of filament shall be examined visually for swelling or dissolving of the filament. In the case of black filament, a very slight discoloration is not considered an indication of the filament having dissolved.

4.3.8.4 Results. Any visual change in size or shape of the pieces of filament shall be recorded.

#### 4.3.9 Modulus of elasticity.

4.3.9.1 Specimen. The specimen shall consist of a piece of synthetic filament 1-1/4 inches long. For type I filaments, the specimen shall be taken from the butt end.

4.3.9.2 Apparatus and equipment. The apparatus and equipment shall consist of the following: (See 6.3).

- a. Traveling microscope or cathetometer, range 50 mm.
- b. Micrometer dial gage, 1/8 inch range, graduated in 0.0001 inch.
- c. Filament support and small weights made from copper and iron wire. The weight should be capable of being balanced easily on the filament. The weight to be used for any particular caliber of filament should give a deflection between 1.0 and 1.5 mm.
- d. The micrometer slide has the accessory apparatus, illustrated by figure 1, attached to the base.
- e. A source of illumination to facilitate measurement with micrometer slide.
- f. A steel rule to check position of telescope, forceps, and stopwatch.

#### 4.3.9.3 Procedure.

4.3.9.3.1 Several filaments shall be conditioned in accordance with 4.3.1.

4.3.9.3.2 Several filaments shall be soaked 16 hours in distilled water at standard laboratory conditions.

4.3.9.3.2.1 A filament shall be removed from the conditioning medium and a specimen 1-1/4 inches in length immediately cut from the butt end and placed in the support.

4.3.9.3.2.2 The telescope shall be focused on the top of the filament and the proper weight carefully placed on the center of the span. After 30 seconds, the weight shall be removed and the telescope refocused. The weight, which is balanced on the long arm of the accessory apparatus, shall again be placed on the filament and deflection measurement made after 30 seconds. The weight shall be removed, the telescope refocused and the deflection again determined, thus, two deflection measurements are made on the same specimen. (The telescope should give an inverted image.)

4.3.9.3.2.3 It is preferable to caliper the filament after determining the deflection, as the filament should not be handled too much before testing. The specimens (4.3.9.1) shall be tested as quickly as possible after removing from the conditioning medium, to avoid changes due to drying.

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4.3.9.3.2.4 The stiffness of the filament shall be calculated from the average diameter determined as described in 4.3.2 except that three measurements shall be made of each specimen and the results averaged, and the deflection with a particular weight. The weight used should give a deflection between 1.0 and 1.5 mm. Actually, the deflection should be proportional to the weight over a wide range of weights.

4.3.9.3.2.5 The telescope shall be centered so that the crosshairs are focused on the center of the 1-inch span. A steel rule should be used to obtain a good focus.

#### 4.3.9.3.3 Calculation.

a. Classes E and N, types I and II. The modulus of elasticity (stiffness) shall be calculated as follows:

$$E = \frac{(0.0237) (P)}{(Y) (d^4)} \text{ (Mechanical design formula for simple round beam in flexure.)}$$

where:

E = The stiffness of the filament, generally called the modulus of elasticity; pounds per square inch.

P = Weight at center of beam; grams.

d = Average diameter of filament; inch.

Y = Deflection of beam; millimeters.

b. Class P, type II. The modulus of elasticity (stiffness shall be calculated as follows:

$$E = \frac{(0.0237) (P)}{(Y) (A) (B^3)} \text{ (Mechanical design formula for simple out-of-round beam in flexure.)}$$

where:

Symbols common to (a) above indicate the same measurements and

A = Average diameter perpendicular to deflection (usually larger diameter of elliptical filament).

B = Average diameter in same direction of deflection (usually smaller diameter of elliptical filament).

4.3.9.4 Results. Three specimens from each sample shall be tested under each set of conditions described in 4.3.9.3.1 and 4.3.9.3.2. The average of the results obtained from the specimens tested under each set of conditions shall be the modulus of elasticity (stiffness) of the sample under those conditions and shall be reported to the nearest  $0.1 \times 10^5$  pounds per square inch.

4.3.10 Shrinkage. A specimen of the filament, not less than 1 inch in length, shall be immersed in water at a temperature of  $180^\circ \pm 2^\circ\text{F}$  for a period of 10 minutes. At the end of the immersion period, the specimen shall be removed, the decrease in length measured to the nearest 0.02 inch, and the percent decrease calculated. Five specimens shall be tested. The average of the results obtained from the specimens tested shall be the shrinkage of the sample and shall be recorded to the nearest one percent for class S filaments and to the nearest 0.1 percent for class P filaments.

#### 4.3.11 Resistance to N-butyl alcohol.

4.3.11.1 Specimen. The specimen shall consist of five equal-length pieces of the filament. Each piece shall be taken from a different filament.

#### 4.3.11.2 N-butyl alcohol in accordance with ACS reagent grade.

4.3.11.3 Procedure. The N-butanol shall be brought to boiling and the specimens immersed in the boiling liquid for a period of 3 minutes. At the end of the exposure period, each piece of filament shall be examined visually for swelling or other evidence of change.

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4.3.11.4 Results. Any visual change in any of the pieces of filament shall be recorded.

4.3.12 Crimp--type III filament.

4.3.12.1 Specimen. The specimen shall consist of five pieces of filament approximately 2 inches long, each of which has been taken from a different filament.

4.3.12.2 Apparatus. The apparatus shall consist of:

- a. A self-illuminated magnifying projector or shadow graph of known magnification of greater than 20X at a fixed projection distance (see 6.4).
- b. A projected image screen on which has been printed a scale, as below, of the same enlargement as the magnification of the projector. The crimp amplitude scale will be series of horizontal lines starting at the base line in intervals of 0.002 inch. The crimp frequency scale shall consist of a vertical base line and a series of vertical lines at proper intervals and so designated for 14, 13, 12, 11, 10, 9, 7, 6, and 5 crimp frequencies (half wave cycle) per inch.

4.3.12.3 Procedure. Each of the five specimens shall be placed in the objective field of the magnifying projector and projected onto the screen. The projected image shall first be examined for a smooth, uniform, crimp waveform and the absence of jagged, sharp, or saw tooth crimp. The specimen shall then be aligned so that the lower crests of its image rest on the base line of the amplitude scale on the screen. The image shall be examined for crimp amplitude as indicated by the scale. The specimen shall be aligned so the crimp frequency scale base line passes perpendicularly through the center of the upper crest of a waveform. A determination shall be made of the nearest crimp frequency line on the scale to the center of the adjacent lower crest of the waveform.

4.3.12.4 Results. A report and record shall be made of:

- a. The nature of the crimp waveform.
- b. The crimp amplitude to the nearest 0.002 inch.
- c. The nearest crimp frequency.

4.3.13 Flex recovery--class P.

4.3.13.1 Specimen. The specimen shall consist of five full length filaments up to 6 inches long.

4.3.13.2 Apparatus. The apparatus shall consist of:

- a. Two points in a horizontal plane between which a filament may be suspended.
- b. A set of seven clamps capable of tightly clamping filament ends and supporting up to five pounds.
- c. A set of weights variable from 100 to 3000 grams in intervals of 10 grams (such as a suspendable container of lead shot).
- d. A timer or stopwatch of at least 30 minutes maximum time measurement.
- e. A protractor or polar coordinate graph paper measured in full degrees and of at least 180° full measurement capacity.

4.3.13.3 Procedure. A length of filament of the size to be tested shall be clamped securely at each end and suspended horizontally between two fixed points. Each specimen shall be looped or folded once, without creasing, over the horizontally suspended filament and its ends clamped together. To this clamp, there shall be added sufficient weight to give a total hanging load, in grams, of sixteen times the filament diameter in mils (0.001 inch). The specimen shall be hung for 30 minutes at standard laboratory conditions. The specimens shall be removed, unclamped, and allowed to recover from the flex on a horizontal, smooth, unobstructed surface for 5 minutes. The specimen shall then be placed on the protractor or polar coordinate graph paper with one leg of the unrecovered bend on the 180 index and the flex point on the circle center or intersection of the index radii. Observation shall be made of the remaining lack of full recovery to the original straightness or 180° angle to the nearest 1° of angle.



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4.3.13.4 Results. The average of the five specimens shall be recorded as the flex recovery for the filament.

## 5. PREPARATION FOR DELIVERY

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

5.1.1 Level A. Synthetic filaments of one class, type, size, length, and color only shall be bundled in cylindrical form in a bundle diameter as specified in the applicable table. Each bundle shall be secured by means of a kraft paper wrapping, tightly wound around the entire length of the bundle.

5.1.2 Level C. Synthetic filaments shall be packaged in accordance with the industry's practice.

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

5.2.1 Level A. Synthetic filaments of one class, type, size, length, and color only packaged as specified in 5.1, shall be packed in a snug-fitting fiberboard shipping container conforming to style RSC-L, V3c or V3s of PPP-B-636. The inside of each shipping container shall be fitted with a taped liner conforming to type CF, class domestic, variety SW, grade 275 of PPP-F-320. Each shipping container shall be closed, waterproofed, and reinforced with flat steel strapping or tape banding in accordance with the appendix of the container specification. The weight of the contents of each shipping container shall not exceed 65 pounds.

5.2.2 Level B. Synthetic filaments of one class, type, size, length, and color only, packaged as specified in 5.1, shall be packed in a snug-fitting fiberboard shipping container conforming to style RSC-L, type CF or SF, class domestic, variety SW, grade 275 of PPP-B-636. The inside of each shipping container shall be fitted with a taped liner conforming to type CF, class domestic, variety SW, grade 275 of PPP-F-320. Each shipping container shall be closed, method II, in accordance with the appendix of the container specification. The weight of the contents of each shipping container shall not exceed 65 pounds.

5.2.3 Level C. Synthetic filaments, packaged as specified in 5.1, shall be packed in a manner to insure carrier acceptance and safe delivery to destination at the lowest transportation rate for such supplies. Containers shall be in accordance with National Motor Freight Classification Rules or Uniform Freight Classification Rules, as applicable.

## 5.3 Marking.

5.3.1 Civil agencies. With interior packages and shipping containers shall be marked in accordance with Fed. Std. No. 123.

5.3.2 Military requirements. With interior packages and shipping containers shall be marked in accordance with MIL-STD-129.

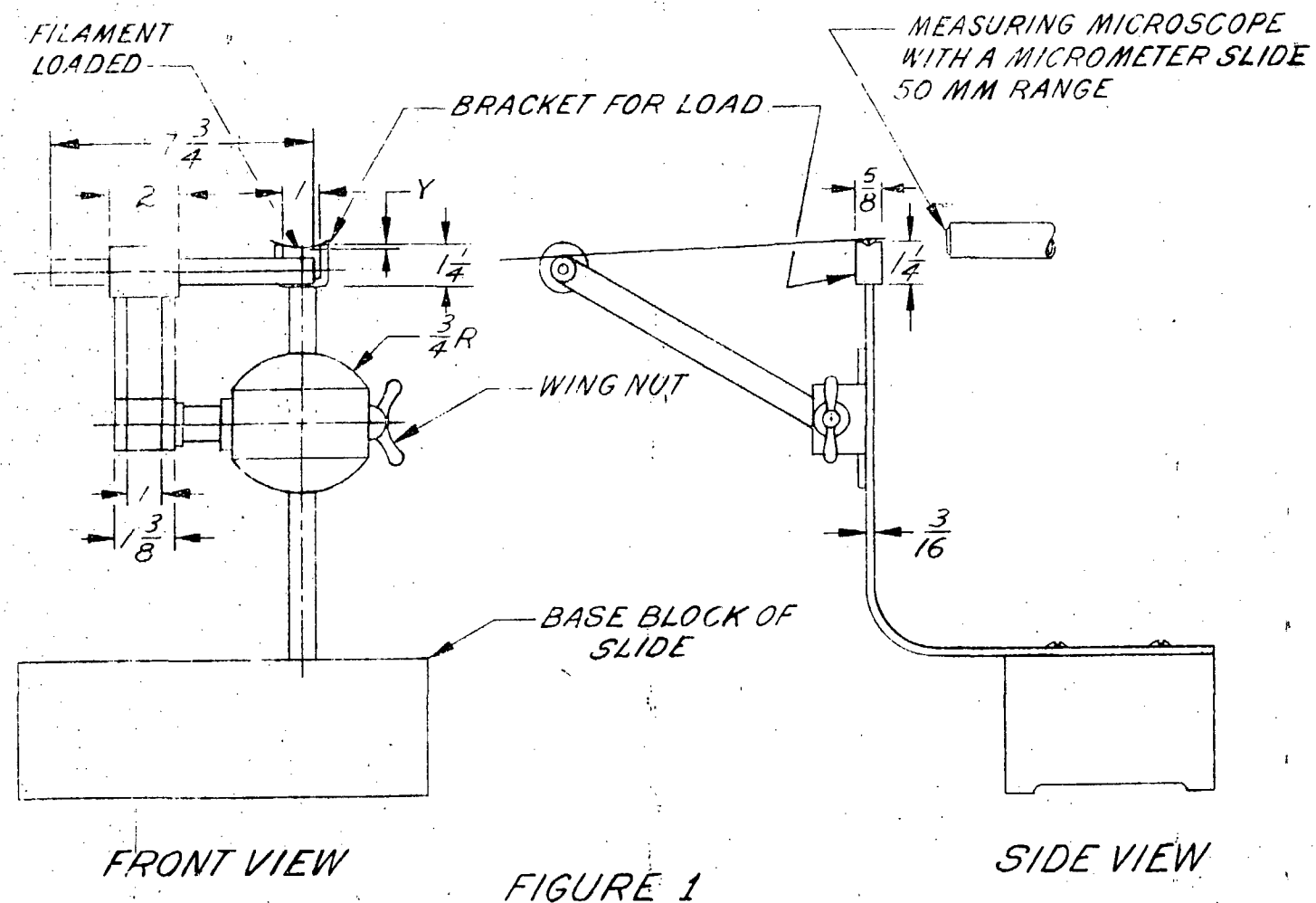
## 6. NOTES

6.1 Intended use. The synthetic filaments covered by this specification are intended for use in the manufacture of brushes.

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) Class and type of filament required (see 1.2.1).
- (c) Length and size of filament required (see 3.3 and 3.4).
- (d) Color of types II and III filaments required (see 3.5.2).
- (e) Selection of applicable levels of packaging and packing (see 5.1 and 5.2).





ACCESSORY APPARATUS FOR MICROMETER SLIDE

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6.3 A measuring microscope or cathetometer Gaertner 50 mm range-Cenco No. 72905 or equal shall be used (see 4.3.9.2).

6.4 A self-illuminated magnifying projector. Bausch and Lomb Tri-Simplex Micro Projector No. 42-63-59, or equal, shall be used (see 4.3.13.2).

6.5 Class S - styrene plastic. Class S has been deleted from the specification.

PREPARING ACTIVITY: GSA - FSS

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