

L-P-410a

March 16, 1966

SUPERSEDING

Int. Fed. Spec. L-P-00410 (GSA-FSS)

January 25, 1965

(See 6.6.)

FEDERAL SPECIFICATION**PLASTIC, POLYAMIDE (NYLON), RIGID: RODS,
TUBES, FLATS, MOLDED AND CAST PARTS**

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 the requirements of rigid plastic polyamide (nylon) molded and cast parts, rods, tubing, bushing stock, tubular bar, and flats for mechanical and electrical applications.

1.2 Classification. The polyamide rods, tubes, flats, molded and cast parts covered by this specification shall be furnished in the following composition as specified (see 6.2).

Polyhexamethylene adipamide, (nylon 6/6).

Polycaprolactam, (nylon 6).

Monomer cast, (nylon 6).

Polyhexamethylene sebacamide, (nylon 6/10), low moisture absorption polyamide.

1.2.1 Electrical grade. Polyhexamethylene sebacamide, (nylon 6/10) shall also be classified as electrical grade when control of its electrical properties is required (see 3.5.1 and 6.2).

1.2.2 The polyamide specified in 1.2 shall be furnished filled or unfilled as follows and as specified by the procuring activity (see 6.2).

Natural, with or without fillers.

Weather resistant.

Wear resistant.

Heat stabilized.

2. APPLICABLE DOCUMENTS

2.1 Specifications and standards. The following specifications and standards, 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:

QQ-A-250/4—Aluminum Alloy 2024, Plate and Sheet.

QQ-C-576—Copper Flat Products with Slit, Slit and Edge-Rolled, Sheared, Sawed, or Machined Edges, (Plate, Bar, Sheet, and Strip).

PPP-B-576—Box, Wood, Cleated, Veneer, Paper Overlaid.

PPP-B-585—Boxes, Wood, Wirebound.

PPP-B-591—Boxes, Fiberboard, Wood-Cleated.

PPP-B-601—Boxes, Wood, Cleated-Plywood.

PPP-B-621—Boxes, Wood, Nailed and Lock-Corner.

PPP-B-636—Box, Fiberboard.

Federal Standards:

Fed. Std. No. 102—Preservation, Packaging, and Packing Levels.

Fed. Std. No. 123—Marking for Domestic Shipment (Civilian Agencies).

Fed. Test Method Std. No. 406—Plastics: Methods of Testing.

(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, D. C. 20402.

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(Single copies of this specification and other product specifications required by activities outside the Federal Government for bidding purposes are available without charge at the General Services Administration Regional Offices in Boston, New York, Washington, D. C., Atlanta, Chicago, Kansas City, Mo., Dallas, Denver, San Francisco, Los Angeles, and Seattle, Wash.

(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 Specifications:

- MIL-P-116—Preservation, Methods of.
- MIL-L-10547—Liners, Case, and Sheet, Overwrap, Water-Vaporproof or Waterproof, Flexible.
- MIL-S-18729—Steel Plate, Sheet, and Strip, Alloy, 4130, Aircraft Quality.
- MIL-S-81087—Silicone Fluid, Chlorinated Phenyl Methyl Polysiloxane.

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 contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publication. The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials (ASTM) Standard:

- D 789-62T-Nylon Injection Molding and Extrusion Materials (Tentative).

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

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. REQUIREMENTS

3.1 Material. The products furnished under this specification shall consist of polyamide (see 1.2) with or without fillers (see 1.2.2), colorants, additives or stabilizers, as required. No reworked material, other than clean polyamide that has been generated from the manufacturer's own production, conforming to the requirements specified for the virgin material and yielding a product equal to one made from virgin material, shall be used to make the products.

3.2 Method of fabrication. Standard shapes (rods, tubes and flats) of polyhexamethylene adipamide (nylon 6/6), polycaprolactam (nylon 6), and polyhexamethylene sebacamide (nylon 6/10) shall be extruded. However, thick flats and large diameter rods may be compression molded. Extruded flats may be press-polished and extruded rounds may be centerless ground. Molded parts shall be injection or compression molded. Cast parts shall be made from monomer cast (nylon 6).

3.3 Form and dimensional tolerances. Unless otherwise specified in the contract or order, standard shapes furnished under this specification shall comply with the requirements of 3.12.2 thru 3.12.6. Molded and cast parts shall have the dimensions and tolerances specified in the contract or purchase order (see 6.2).

3.4 Color. Unless otherwise specified by the procuring activity, the color of unfilled nylon 6/6, 6, and 6/10 shall be light cream (natural). Colors other than light cream (natural) for any nylon product furnished under this specification shall be as specified by the procuring activity unless they are standard commercial colors used for identification purposes (see 6.2).

3.5 Physical property requirements. The values obtained from each set of samples or specimens for each polyamide specified shall meet the applicable requirement values of tables I and II when tested as specified in 4.4. Specimens prepared from weather re-

TABLE I. *Physical property requirements*

Property	Polyhexa- methylene adipamide (nylon 6/6)	Polycapro- lactam (nylon 6)	Monomer cast (nylon 6)	Polyhexa- methylene sebacamide (nylon 6/10)	Test method
Specific gravity 23°/23°C.:					
Minimum	1.13	1.12	1.13	1.07	Table XI
Maximum	1.15	1.15	1.17	1.12	
Melting point, °C.:					
Minimum	250	212	212	208	4.4.3
Maximum	260	225	230	220	
Relative viscosity, minimum	90 ¹	33	²	28	4.4.4
Tensile strength, pounds per square inch (p.s.i.), minimum					4.4.5
Rods: 1 inch and under	13,000	10,000	NA ³	7,000	
over 1 inch	12,000	11,000	11,000	6,000	
Flats: 1/8 inch and under	9,000	7,000	11,000 ⁵	7,000	
over 1/8 to 3/8 inch	12,000	9,000	11,000 ⁵	7,000	
over 3/8 inch	13,000	10,000	11,000 ⁵	6,000	
Tubing: 3/8 inch and under	9,000	8,000	NA ³	7,000	
over 3/8 inch	11,000	10,000	11,000	7,000	
Molded and cast parts (other than rods, flats, and tubing) ⁴					—
Elongation, percent, minimum					4.4.5
Rods: 3/16 inch and under	100	100	NA ³	12	
over 3/16 inch	20	25	20	8	
Flats: 1/8 inch and under	50	60	15	20	
over 1/8 inch	20	25	20	10	
Tubing: 3/8 inch outside diameter and under	120	120	NA ³	100	
over 3/8 inch outside diameter	20	20	20	8	
Molded and cast parts (other than rods, flats, and tubing) ⁴					—

¹ For extruded shapes less than 0.031 inch thick, this value shall be 50. For molded standard shapes (rods, tubes, and flats), the minimum value shall be 42.

² Not applicable.

³ Value not available.

⁴ Tensile and elongation requirements for molded and cast parts (other than rods, flats, and tubing) shall be as specified in table II.

⁵ Values based on 1/8-inch thick specimen machined from 1/2-inch flat.

stant, wear resistant or heat stabilized polyamides shall conform to the applicable requirement values of tables I and II and to the additional requirements or modification of table III as applicable.

3.5.1 Electrical grade. Electrical grade polyamide shall meet the applicable requirements of nylon 6/10 as specified in tables I and II, and all the requirements of table IV (see 1.2.1 and 6.2).

3.6 Flammability. When specified by the procuring activity (see 6.2), the flammability of the polyamide shall be "self-extinguishing" when tested as specified in table XIV.

3.7 Dimensional stability. (Applicable only for rods, tubes, and flats.) The dimensional stability for rods, tubes, and flats shall conform to the requirements of table V when tested as specified in 4.4.10.

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TABLE II. *Raw material property requirements for unfilled and unpigmented test specimens*

Property	Polyhexamethylene adipamide (nylon 6/6)	Polycaprolactam (nylon 6)	Monomer cast (nylon 6) ¹	Polyhexamethylene sebacamide (nylon 6/10)	Test method
Rockwell, R scale hardness, minimum ..	118	105	115	111	Table XIV
Impact strength at 23° C., foot-pounds per inch of notch, minimum (use 1/8 inch thick specimen)	0.9	1.0	0.4	0.9	Table XIV
Deflection temperature under load, °C., minimum:					Table XIV
At 66 p.s.i. fiber stress	182	160	200	149	
At 264 p.s.i. fiber stress	66	60	100	52	
Deformation under load at 2000 p.s.i. percent maximum	1.4	3.0	1.2	4.0	Table XIV
Tensile strength, p.s.i., minimum ²	11,000	10,000	11,000	7,000	4.4.5
Elongation, percent minimum ²	50	50	15	50	4.4.5
Water absorption, maximum, percent:					4.4.6
After 24 hours immersion	1.5	2.5	1.0	0.5	
At saturation	9.0	10.0	7.0	4.0	

¹ Values based on 1/2-inch plate produced by direct chemical reaction.² Applicable only for parts other than rods, flats and tubing.TABLE III. *Additional or modification of material property requirements of filled and pigmented test specimens*

Property	Limits—all polyamides			Test method
	Weather resistant	Wear resistant	Heat stabilized	
Elongation, percent, minimum	5	5	1	4.4.5
Carbon content, range, percent	1.90 to 2.25	1	1	4.4.7
Absorbance, percent, minimum	0.18	1	1	4.4.8
Molybdenum disulfide content, percent	1	0.5 to 6.5	1	4.4.9
Specific gravity 23°/23°C.	1.13—1.17	1.15 min.	2	Table XIV
Heat resistance, original tensile strength retention, percent	1	1	75	Table XIV

¹ Not applicable.² Specific gravity values shall be in accordance with table I requirements as applicable.TABLE IV. *Property values for electrical grade polyamide (see 3.5.1 and table XI)*

Property	Requirement
Dielectric strength, step-by-step, volts per mil, minimum	375
Dielectric constant 10 ⁶ cycles, maximum	4.0
Dissipation factor, 10 ⁶ cycles, maximum	0.11
Insulation resistance, megohms, minimum	5x10 ⁶

TABLE V. *Dimensional stability*

Group	Size	Change in dimension permitted, percent maximum
Rods	Under 1/2 inch, outside diameter	Not applicable
Rods	1/2 inch and over, outside diameter	0.4 (Outside diameter and length of specimen)
Tubes	Under 1/2 inch outside diameter and wall thickness under 1/8-inch	Not applicable

TABLE V. *Dimensional stability (cont'd)*

Group	Size	Change in dimension permitted, percent maximum
Tubes	1/2 inch and over, outside diameter wall thickness 1/8-inch and over	0.4 (Outside diameter and length of specimen)
Flats	Under 3/16-inch thickness	Not applicable
Flats	3/16-inch thickness and over	0.7 (Thickness and diameter of specimen)

3.8 X-ray requirements. When specified by the procuring activity (see 6.2), the nylon products shall be x-ray examined for hidden defects.

3.9 Product information sheet. When specified (see 6.2), one or more copies of a product information sheet shall be furnished by the supplier with each shipment, describing any characteristics or limitations of the product which should be known in order that the product may be suitably handled, stored, finished, or fabricated (see 6.3), to prevent the development of surface or internal defects.

3.10 Corrosivity. (Applicable only to wear resistant polyamide.) Wear resistant polyamide shall not cause pitting or corrosion of copper, steel, or aluminum when tested as specified in 4.4.11. Corrosion inhibitors when used, shall not alter the physical or chemical properties specified herein.

3.11 Distortion. The warp or twist of flats, and the warp of rods and tubes shall conform to the requirements of table VI when tested as specified in 4.4.12.

TABLE VI. *Distortion requirements*¹

Outside diameter (rods and tubes) or thickness (flats), inch	Rods and tubes	Flats
	Permissible warp, percent, maximum	Permissible warp or twist, percent, maximum
Over 3/16 to 1/4 inclusive	1.0	2.00
Over 1/4 to 3/4 inclusive	1.0	1.00
Over 3/4	0.50	0.50

¹ Values based on 36-inch dimension.

3.12 Dimensions and tolerances.

3.12.1 Measurement temperature. Measurements shall be made at $23^{\circ} \pm 1^{\circ}\text{C}$. ($73.4^{\circ} \pm 1.8^{\circ}\text{F}$). When measurements are made at temperatures sufficiently different from $23^{\circ} \pm 1^{\circ}\text{C}$. to appreciably affect the results, suitable correction factors shall be applied, and the pertinent information, including the measurement temperature, shall be reported to the procuring activity.

3.12.2 Flats. Length, width, and thickness dimensions shall be as specified by the procuring activity (see 6.2). However, when not specified in the contract or order, tolerances for thickness dimensions at any point shall be within the applicable limits of table VII.

TABLE VII. *Nominal dimensions and tolerances of flats*

Nominal thickness, inch	Tolerances, inch		
	Thickness	Width	Length
Up to 0.060	± 0.003	± 0.032	± 0.5
0.061 to 0.094 inclusive	± 0.005	± 0.062	± 0.5
0.095 to 0.125	± 0.010	± 0.062	± 0.5
Over 0.125	+ 0.025, - 0.000	± 0.250	± 0.5

3.12.3 Rods. Length and diameter shall be as specified by the procuring activity (see 6.2). Rods only up to 3/16 inch diameter may be furnished in coils. The average length per coil shall be not less than that specified or marked. When furnished in cut lengths, the length tolerance shall be plus 1 inch, minus 0, unless otherwise specified or unless ordered to random lengths (see 6.2). Tolerances on rod diameter shall be within the applicable limits of table VIII. Unless otherwise specified, random lengths with a minimum of 75 percent of nominal length, may be supplied up to 10 percent of the order.

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TABLE VIII. *Dimensions and tolerances of rods*

Nominal rod diameter, inches	Tolerances, inch
Up to 3/16 inclusive	± 0.001
Over 3/16 to 1	± 0.002
Over 1 to 2	+ 0.008 - 0.000
Over 2 to 3	+ 0.025 - 0.000
Over 3 to 4	+ 0.060 - 0.000
Over 4	+ 0.125 - 0.000

3.12.4 Tubing (see 6.1). The length and diameter (inside or outside), plus the wall thickness shall be as specified by the procuring activity (see 6.2). Unless otherwise stated, the term diameter shall be considered to mean inside diameter. Tolerances for the cross-sectional dimensions shall be as shown in table IX. The length tolerance shall be the same as for rods.

3.12.5 Bushing stock. Bushing stock shall have the inside and outside diameters specified in the contract or purchase order (see 6.2), and shall be capable of being machine finished to the inside diameter so specified, and shall have a minimum wall thickness at

any point around the circumference as follows:

Nominal outside diameter — Nominal inside diameter
2

The length shall be as specified and, unless otherwise specified or specified to random lengths, the length tolerances shall be plus 1 inch, minus 0. Unless otherwise specified, random lengths with a minimum of 75 percent of nominal length, may be supplied up to 10 percent of the order. Tolerances for bushing stock shall be the same as specified for rods in table VI.

3.12.6 Tubular bar. Tubular bar shall have the outside diameter and inside diameter specified in the contract or purchase order, within the tolerances specified in table X. The minimum wall thickness at any point around the circumference shall be as stated above for bushing stock (see 3.12.5). The length tolerances shall be the same as for bushing stock.

TABLE X. *Nominal dimensions and tolerances of tubular bar*

Outside diameter or inside diameter, inches	Tolerance, inch	
	Outside diameter	Inside diameter
All sizes	+ 0.625 - 0.000	Undersized for finishing to machined dimensions

TABLE IX. *Dimensions and tolerances of tubing*¹

Nominal outside diameter (OD) or inside diameter (ID), inches	Outside diameter or inside diameter tolerance, inch plus or minus	Nominal wall thickness inch	Wall tolerance, inch plus or minus
0.034 to 0.055 incl.	0.004	0.012 to 0.020	0.003
0.056 to 0.148	.005	.012 to .020	.003
0.149 to 0.219	.007	.020 to .062	.004
0.220 to 0.295	.010	.020 to .062	.004
0.296 to 0.325	.012	.020 to .062	.004
0.326 to 0.500	.015	.020 to .062	.005
0.501 to 0.750	.015	.031 to .125	.010
0.751 to 1.250	.020	.031 to .125	.010
1.251 to 1.500	.025	.031 to .250	.015

¹ When checking outside diameter of 0.050 inch wall tubing and under, use inside diameter plug to support.

3.13 Workmanship. The polyamide items furnished under this specification shall be free from blisters, cracks, checks, foreign inclusions, scratches, voids, or any other surface or internal defect which may detrimentally affect serviceability or appearance. Similarly shaped items shall be uniform in color and finish.

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, the supplier 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. Sampling for inspection shall be performed in accordance with the provisions set forth in MIL-STD-105, except where otherwise indicated.

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

4.3 Inspection of the end item.

4.3.1 Examination of the end item. Examination of the end item 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 rods, tubing, flats, molded or cast parts, each unit being of the same composition for examination in 4.3.1.1, 4.3.1.2, and in units of shipping containers in 4.3.1.3.

4.3.1.1 Examination of the end item for defects in appearance and workmanship. The sample unit for the examination specified in table XI shall be one sheet, one length or a minimum of six feet of rod, tubing or flat, or one molded or cast part as applicable.

TABLE XI. *Examination of the end item for defects in appearance and workmanship*

Examine	Defect
Appearance and workmanship: All forms	Polyamide, filler, or form not as specified. Color not as specified. Not uniform in color, finish, or texture. Presence of dirt, foreign material, or imbedded particles. Any blisters, cracks, scratches, holes, gouges, wrinkles, chipped edges or surfaces, dents, or heat marks. Edges not straight, smooth or square. X-ray examination for defects not conducted when specified (see 3.8 and 6.2).
Rods and flats	Ends not square cut.
Tubes	Hole not concentric. Ends not square cut.
Molded or cast parts	Not shape specified. For standard shapes, the flash thickness shall not exceed 0.005 inch.

4.3.1.2 Examination of the end item for dimensional defects. The sample unit for the examination specified in table XII shall be one flat, rod, tube, bushing stock, tubular bar, molded or cast part as applicable.

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TABLE XII. Examination of the end item for dimensional defects

Examine	Defect										
Flats	Length, width, or thickness varies by more than the applicable tolerance indicated in 3.12.2 or table VII.										
Rods	Length or diameter varies by more than the applicable tolerances indicated in 3.12.3 or table VIII.										
Tubing	Varies by more than the applicable tolerances indicated in 3.12.4 or table IX.										
Bushing stock	Varies by more than the applicable tolerances indicated in 3.12.5.										
Tubular bar	Varies by more than the applicable tolerances indicated in 3.12.6 and table X.										
Molded parts	Varies by more than the tolerances specified or indicated. When tolerances are not specified, the following shall apply: <table border="1" style="margin-left: 40px;"> <thead> <tr> <th>Range (inches)</th> <th>± Tolerances</th> </tr> </thead> <tbody> <tr> <td>Up to 0.5 inch</td> <td>0.0045</td> </tr> <tr> <td>Over 0.5 to 1.0</td> <td>0.0055</td> </tr> <tr> <td>Over 1.0 to 2.0</td> <td>0.007</td> </tr> <tr> <td>Over 2.00</td> <td>0.010</td> </tr> </tbody> </table>	Range (inches)	± Tolerances	Up to 0.5 inch	0.0045	Over 0.5 to 1.0	0.0055	Over 1.0 to 2.0	0.007	Over 2.00	0.010
Range (inches)	± Tolerances										
Up to 0.5 inch	0.0045										
Over 0.5 to 1.0	0.0055										
Over 1.0 to 2.0	0.007										
Over 2.00	0.010										
Cast parts	Varies by more than the tolerances specified by the procuring activity (see 6.2).										

4.3.1.3 Examination of preparation for delivery. An examination in accordance with table XIII shall be made to determine that packaging, packing, and marking shall comply with the requirements set forth in section 5. The sample unit for this examination shall be one shipping container, fully packed, selected just prior to the closing operation. Shipping containers, fully packed for shipment shall be examined for closure defects.

TABLE XIII. Examination of preparation for delivery

Examine	Defect
Packaging	Not level specified. Not individually packaged, multiple packaged, or intermediate packaged as specified. Packaging material not as specified; closure not accomplished by specified or required methods or materials; component missing. Weight of intermediate packages exceeds specified requirements.

Examine	Defect
Packing	Not level specified. Containers not as specified, closures not accomplished by specified or required methods or materials. Any nonconforming component, component missing, damaged, or otherwise defective, affecting serviceability.
Count	Less than specified or indicated quantity.
Weight	Gross weight exceeds specified requirements.
Markings	Interior or exterior markings (as applicable) omitted, illegible, incorrect, incomplete, or not in accordance with contract requirements.

4.3.1.4 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 level	AQL
4.3.1.1	I	2.5
4.3.1.2	S-2	4.0
4.3.1.3	S-2	2.5

4.3.2 Sampling for tests. A sample of sufficient size of the specified polyamide to conduct the melting point, relative viscosity, carbon content, absorbance, and molybdenum disulfide tests and those of table IV, as applicable, shall be selected at random from the sample specified in 4.3.1 or from the lot of material from which the shapes were made.

4.3.3 Lot acceptance tests. Lot acceptance tests shall be made on each lot of material furnished and shall be the basis for acceptance or rejection of the lot. Lot acceptance tests shall consist of all the test requirements of tables I and II for the same polyamide composition and the applicable requirements of table III. Electrical grade material shall conform to all the tests listed in table IV, in addition to the applicable requirements of nylon 6/10 in tables I and II. If the average value obtained for any test fails to meet the requirements of this specification, the lot represented by the test specimens shall be rejected.

4.4 Test methods. Unless otherwise specified herein, all specimens shall be tested in accordance with the applicable test methods of Fed. Test Method Std. No. 406. The reported results shall be the average of the values obtained for that particular test. Individual test values shall not deviate by more than ± 15 percent of the average value, except for elongation values which shall not deviate by more than minus 15 percent.

4.4.1 Preparation of test specimens. The number of samples required for the raw material tests shall be selected either from the powder or pellets and tested in that form or molded into test specimens, as applicable, or shall be selected from the sample units of 4.3.1 and used either as drillings, millings, or shavings or machined into test specimens as applicable. For cast nylon 6, specimens shall be prepared from a standard slab by direct chemical reaction. For the other tests, the specimens shall be prepared from the sample units of 4.3.1 in the manner described in the particular test method. When more than one specimen is required for any test, the specimens shall be taken from different sample units of 4.3.1 except that when more than three specimens are required, at least three sample units shall be used and not more than two specimens for a particular test shall be taken from each.

4.4.1.1 Conditioning. Test specimens for melting point and specific gravity shall be tested as received without conditioning. Test specimens for relative viscosity, tensile strength and elongation of tables I, II, and III and all the test specimens for requirements of table II shall be dried under vacuum as specified in 4.4.5. Unless otherwise specified, all other test specimens shall be conditioned in accordance with section IV of Fed. Test Method Std. No. 406.

4.4.2 The following tests shall be made in accordance with the applicable methods specified in table XIV, and 4.4.3 through 4.4.12.

TABLE XIV. *Test methods*

Test	Fed. Std. 406	Number determinations per sample unit
Specific gravity	5011	Avg. of 3
Rockwell hardness (R scale)	1081	Avg. of 3
Impact strength	1071	Avg. of 3
Deflection temperature under load	2011	Avg. of 3
Deformation under load .	1101	Avg. of 3
Heat resistance ¹ , 100 hours minimum at 150° $\pm 2^{\circ}\text{C}$. (302° $\pm 3.6^{\circ}\text{F}$.)	1011	Avg. of 3
Dielectric strength (step-by-step) ²	4031	Avg. of 4
Dielectric constant and dissipation factor (10 ⁶ cycles) ²	4021	Avg. of 2
Insulation resistance ³ ...	4041 or 4052 as applicable	Avg. of 3
Flammability	2021	Determined on 10 specimens

¹ Applicable only to heat stabilized polyamide. Specimens shall consist of 1/8 inch thick tensile bars.

² Applicable only to electrical grade polyamide. Specimens shall have a thickness of 1/8 inch.

³ Applicable only to electrical grade polyamide.

4.4.3 Melting point. The melting point shall be determined in accordance with paragraph 6 (e) of ASTM D 789-62T. The test shall be performed in duplicate.

4.4.4 Relative viscosity. The relative viscosity shall be determined in accordance with paragraph 6 (d) of ASTM D 789-62T. The specimens shall be conditioned as described in 4.4.5 and the test shall be performed in duplicate.

4.4.5 Tensile strength and elongation. Five specimens, each 1/8 inch in thickness shall be tested. For specimens selected from finished products in accordance with 4.3.2, the tensile strength and elongation shall be determined in accordance with method 1011 of Fed. Test Method Std. No. 406 with the following exception: Five specimens shall be

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machined from the sample selected using a coolant and taking light cuts. After machining, the specimens shall be dried at 66°C. (150°F.) under a vacuum of 28 inches of mercury minimum, to constant weight and cooled to 23° ± 1°C. (73.4° ± 1.8°F.) over a desiccant and kept in a desiccator until immediately before testing (see 6.4).

4.4.6 Water absorption.

4.4.6.1 Water absorption after 24 hours immersion. Three disc specimens, each 1/8 inch thick by 2 inches diameter, shall be thoroughly cleaned with a suitable solvent such as trichloroethylene. Testing shall be conducted in accordance with method A of method 7031 of Fed. Test Method Std. No. 406.

4.4.6.2 Water absorption at saturation. The three discs used for 4.4.6.1 shall be boiled in water for 48 hours. The percent increase in weight shall be calculated in accordance with method A of method 7031 of Fed. Test Method Std. No. 406.

4.4.7 Carbon content. (Applicable to weather resistant polyamide only.) This method of test is based on the hydrolysis of nylon to soluble products with hydrochloric acid and the subsequent separation of the carbon residue by filtration. Formic acid is employed to dissolve traces of unhydrolyzed nylon or similar insolubles, if present.

4.4.7.1 Apparatus. The apparatus shall be as follows:

- (a) Drying oven at 100° ± 5°C.
- (b) Crucibles, Gooch, or equivalent, 30 milliliter (ml.).
- (c) Staticmaster Utility Unit, Emil Greiner Company, or equivalent.

4.4.7.2 Reagents (reagent grade). The reagents shall be as follows:

- (a) Hydrochloric acid, 1:1 (about 6 N).
- (b) Hydrochloric acid, 1:3 (about 3 N).
- (c) Methanol.

- (d) Asbestos, long fiber, acid washed, A. H. Thomas Company "Pov-minco" grade A, or equivalent. Digest the asbestos for at least 2 hours, using hot 6 N hydrochloric acid. Wash with water on a filter, using suction.
- (e) Formic acid, 90 percent.

4.4.7.3 Procedure. The procedure shall be as follows:

- (a) Weigh 1 ± 0.1 gram (g.) to the nearest 0.1 milligram (mg.) of sample which has been cut into about 1/8-inch cubes and transfer to a 400 ml. Pyrex beaker.
- (b) Add 200 ml. of about 6 N hydrochloric acid and cover the beaker with a watchglass.
- (c) Heat the contents of the beaker just to boiling on a hotplate and then continue the digestion for 1 hour + 5 minutes, with occasional stirring. If necessary, replace any loss in volume during the digestion with 6 N hydrochloric acid.
- (d) While digesting the sample, prepare crucibles as follows:
 1. Cover the bottom with a bed of purified asbestos. Wash several times successively with hot 3 N hydrochloric acid; 90 percent formic acid at 80° to 90° C., inclusive; hot water; and methanol.
 2. Dry the crucible to constant weight in a 100° ± 5°C. oven. Before each weighing, cool the crucible in a desiccator for 15 to 20 minutes.
 3. Place the crucible on the pan of an analytical balance and remove any static charge by passing the "Staticmaster" over it.
 4. Tare the crucible to the nearest 0.1 mg.

- (e) Dilute the solution with hot water so that the beaker is almost full, and heat just to boiling. Digest hot for 15 minutes, with occasional stirring.
- (f) Remove the beaker from the hot-plate and allow the carbon to settle for 15 to 20 minutes. (A dark layer of carbon will be evident at the bottom of the beaker, although some will be suspended in the liquid. The settling step allows the bulk of the separation to be accomplished by decantation and greatly reduces filtration time.)
- (g) Filter the warm solution through the weighed crucible, decanting at first and then transferring the bulk of the residue. Remove any adhering residue from the sides of the beaker with a glass rod tipped with a rubber policeman and wash the residue from the beaker with hot 3 N hydrochloric acid.
- (h) Wash the residue on the crucible with 100 ml. of 90 percent formic acid at 80° to 90°C., inclusive, passing the acid slowly through the bed, using suction.
- (i) Wash with hot distilled water and methanol; dry and weigh the crucible as in step (d).

4.4.7.4 Calculation.

$$\text{Percent carbon black} = \frac{\text{Wt. of residue (including crucible)} - \text{Wt. of crucible}}{\text{Wt. of sample}} \times 100$$

4.4.8 Absorbance. (Applicable to weather resistant polyamide only). A dispersion of carbon black in phenol shall be obtained by dissolving carbon-filled nylon in 85 ± 3 percent phenol, reagent grade. The amount of light scattered by the carbon-black dispersion shall be measured in a 1 centimeter (cm.) Pyrex absorption cell at 578 millimicrons ($m\mu$), using a Beckman model DU

spectrophotometer, or equivalent, in the following manner.

4.4.8.1 Procedure. Add 1.000 ± 0.005 g. of molding compound to a 100-ml. volumetric flask. Add 50 ml. of 85 percent phenol. Stopper the flask securely and shake for 4 hours on any standard shaking machine or until all of the nylon is in solution. Solution time can be shortened by heating for 1 hour under infrared lamps at 50°C. Remove flask from shaker, shake vigorously by hand, and immediately pipet 1 ml. of the solution into a 50-ml. volumetric flask, allowing proper time for drainage. Dilute to volume with 85 percent phenol and shake vigorously by hand. Balance the spectrophotometer at zero absorbance at 578 $m\mu$ by filling two 1 cm. absorption cells with 85 percent phenol and placing them in the cell compartment of the instrument. Refill one of the absorption cells with the final diluted sample and measure the absorbance at 578 $m\mu$, using the other cell containing 85 percent phenol as reference.

4.4.9 Molybdenum disulfide. (Applicable to wear resistant polyamide only.) The molybdenum disulfide content shall be determined in accordance with the test method for carbon content (see 4.4.7).

4.4.10 Dimensional stability (applicable only for rods, tubes, bushing stock, tubular bar, and flats).

4.4.10.1 Specimens.

4.4.10.1.1 Rods, tubing, bushing stock, and tubular bar. Each specimen shall be prepared by cutting a 1-1/2 inch long slice from the shape to be tested. The slice shall then be machined, using a coolant and light cut to a length of 1.000 ± 0.005 inch. Each end of the specimen shall have a machined surface.

4.4.10.1.2 Flats. Each specimen shall consist of a 2-inch-diameter disc machined from the flat. The same care shall be used in the machining as described above. The thickness of the specimen shall be that of the original flat from which it was cut, no ma-

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chining being done on the top or bottom faces.

4.4.10.2 Procedure. For nylon 6/6 shapes, a bath consisting of type I silicone fluid conforming to MIL-S-81087 shall be heated to $218^{\circ} \pm 3^{\circ}\text{C}$. ($425^{\circ} \pm 5.4^{\circ}\text{F}$). For nylon 6 and 6/10 shapes, the oil bath shall be heated to $177^{\circ} \pm 2^{\circ}\text{C}$. ($350^{\circ} \pm 3.6^{\circ}\text{F}$). The outside diameter and thickness or length of the specimen as applicable shall be measured, at $23^{\circ} \pm 1^{\circ}\text{C}$. ($73.4^{\circ} \pm 1.8^{\circ}\text{F}$) to the nearest 0.0001 inch. The specimen shall be placed in the oil bath at the applicable temperature. After six hours, the specimen shall be allowed to slowly cool to room temperature in the oil at a rate not to exceed 22°C . (40°F) per hour. The specimen shall then be measured at $23^{\circ} \pm 1^{\circ}\text{C}$. ($73.4^{\circ} \pm 1.8^{\circ}\text{F}$) and the percent change in each dimension calculated.

4.4.11 Corrosivity. Two flat specimens of wear resistant polyamide, each having at least one square inch of contact area on each parallel surface, shall be conditioned for a minimum of 72 hours in a desiccator or similar humidity chamber maintained at 90 to 95 percent relative humidity and $24^{\circ} \pm 3^{\circ}\text{C}$. ($75^{\circ} \pm 5^{\circ}\text{F}$). One specimen shall then be clamped between two metal plates which have been polished with either grade FF or FFF powdered pumice. One plate shall be copper conforming to QQ-C-576 and the other shall be aluminum alloy conforming to QQ-A-250/4, temper T4. The other polyamide specimen shall be clamped between two steel plates, conforming to condition N of MIL-S-18729 which have been polished with the above pumice. The plates shall be clamped sufficiently tight to flatten the specimens and insure intimate contact. The assemblies shall be conditioned for one hour at 150°C . in a circulating air oven, removed from the oven and maintained at standard conditions for 2 hours, and again conditioned in the humidity chamber for 7 days. After the exposure period, the metal plates shall be washed with acetone and examined for signs of pitting or corrosion. A

slight discoloration of the metals shall not be cause for rejection.

4.4.12 Distortion.

4.4.12.1 Flats. The warp and twist of flats shall be determined in accordance with method 6051 of Fed. Test Method Std. No. 406. Percentage of warp shall be in terms of the lateral dimensions (length and width) of the flat. Percentage twist shall be in terms of dimensions from one corner to the opposite corner.

4.4.12.2 Rods and tubes.

4.4.12.2.1 Apparatus. A horizontal flat surface and a rigid bar with a vertically plane surface firmly fixed at right angles to the flat surface, both at least as long as the specimen, shall be used. The height of the bar shall exceed half the outside diameter of the tube or rod. Feeler gages of suitable thicknesses will also be required.

4.4.12.2.2 Procedure. The specimen shall be placed on the horizontal flat surface and rotated against the vertically plane surface of the rigid bar. The bar shall be firmly fastened to the horizontal flat surface. With the aid of feeler gages, the maximum distance between the tube or rod and the vertically plane surface shall be measured to the nearest 0.001 inch.

4.4.12.2.3 Report and calculation. Warp or lack of straightness shall be reported as the maximum distance of any part of the tube or rod from a straight edge which connects the ends of the specimen. The minimum length tested for warpage shall be 24 inches. The warpage shall then be calculated as follows:

where:

$$W_{36} = \frac{36 D \times 100}{L^2}$$

W_{36} = Percentage of warp, calculated to a 36-inch length.

D = Maximum deviation of tube or rod from straight edge in inches.

L = Length of tube or rod in inches.

5. PREPARATION FOR DELIVERY

For civil agency procurement, the definitions and applications of the levels of pack-

aging and packing shall be in accordance with Fed. Std. No. 102.

5.1 Preservation and packaging. Preservation and packaging shall be level A or C as specified (see 6.2).

5.1.1 Level A.

5.1.1.1 Unit packaging. Unless otherwise specified in the contract or purchase order (see 6.2), flats, rods, tubes, molded, and cast parts shall be packaged in quantities specified by the procuring activity in accordance with method III of MIL-P-116. Shapes of only one set of nominal dimensions shall be placed in one package.

5.1.1.2 Intermediate packaging. When required, specified quantities of unit packages shall be intermediately packaged as specified in the contract or purchase order (see 6.2).

5.1.2 Level C. Rods, tubes, flats, molded and cast parts shall be packaged in accordance with supplier's commercial practices. Protection shall be such as to prevent deterioration during shipment and ensure safe delivery at destination.

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

5.2.1 Level A. Items packaged as specified in 5.1.1 shall be separated by form, size, and thickness of diameter, and shall be packed in containers conforming to the following specifications as specified (see 6.2):

Specification	Class or style
PPP-B-576	Class 2
PPP-B-585	Class 2 or 3
PPP-B-591	Style A or B
PPP-B-601	Style A or B
PPP-B-621	Class 2
PPP-B-636	Class weather-resistant

Box closures and strapping shall be as specified in the applicable box specification or appendix thereto. Unless otherwise specified, the above containers except those complying with PPP-B-636, shall be provided with a case liner conforming to MIL-L-10547. The gross weight of wood boxes shall not ex-

ceed 200 pounds; contents of fiberboard boxes shall not exceed the limitations of the applicable box specification.

5.2.2 Level B. The item shall be packed in accordance with 5.2.1 except that the containers shall be constructed for domestic requirements. Fiberboard boxes shall be banded as prescribed in the appendix of the box specification. Box closures shall be as specified in the applicable box specification or appendix thereto.

5.2.3 Level C. The packaged item shall be packed in containers of the type, size, and kind commonly used for the purpose, in a manner that will insure acceptance by common carrier and safe delivery at destination. Shipping containers shall comply with the carrier rules and regulations applicable to the mode of transportation.

5.2.4 General. Exterior containers shall be uniform in shape and size, be of minimum cube, and tare consistent with the protection required, and shall contain identical quantities of identical items.

5.3 Marking.

5.3.1 Civil agencies. In addition to any special marking required by the contract or order, unit packages, intermediate packages, and exterior shipping containers shall be marked in accordance with Fed. Std. No. 123.

5.3.2 Military agencies. In addition to any special marking required by the contract or order, unit packages, intermediate packages, and exterior shipping containers shall be marked in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. The polyamides specified herein show a unique combination of general properties including strength, stiffness, toughness, resilience, abrasion and wear resistance, low surface friction, a non-abrasive surface, plus high heat resistance, good chemical resistance, and excellent dielectric properties. For critical applications, only the specific nylon which is known to

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meet the requirements of the intended application should be specified. The low moisture absorption material, nylon 6/10, shall be considered when the moisture resistance of the other nylons is inadequate.

6.2 Ordering data. Purchasers should exercise any desired options offered herein and procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Specific polyamide required (see 1.2).
- (c) Electrical grade, if required (see 1.2.1).
- (d) Weather resistant, wear resistant, or heat stabilized if required (see 1.2.2).
- (e) Applicable drawings, or stock dimensions and tolerances for molded or cast parts (see 3.3).
- (f) Color required (see 3.4).
- (g) Flammability test, if required (see 3.6).
- (h) X-ray examinations, if required (see 3.8).
- (i) If product information sheet is required, and if required, specify information and number of copies (see 3.9 and 6.3).
- (j) Length¹, width, and thickness of flats (see 3.12.2).
- (k) Length¹, and diameter of rods (see 3.12.3).
- (l) Length¹, inside or outside diameter and wall thickness of tubing (3.12.4).
- (m) Nominal inside and outside diameters and length of bushing stock or tubular bar (see 3.12.5 and 3.12.6).
- (n) Tolerances for molded and cast parts (see 4.3.1.2).
- (o) Applicable level of packaging and packing (see 5.1 and 5.2).
- (p) Special marking, if required (see 5.3).

¹ Specify straight lengths or in coils. When length is unimportant, random lengths should be specified.

6.3 Data in product information sheet. The information sheets should include all necessary precautions to be observed in handling, storing, shipping, or in machining, forming, bending, bonding, abrading, polishing, or any other fabricating or finished operations.

6.4 Tensile specimen conditioning (see 4.4.5) should be carried out under vacuum in order to prevent oxidation and consequent degradation of the material.

6.5 Chemical resistance. Polyamide plastic is not resistant to formic acid, phenol or strong mineral acids and oxidizing agents. Precautions should therefore be exercised to avoid contact with these chemicals.

6.6 Supersession data. This specification supersedes MIL-P-17091B, Polyamide (Nylon) Plastic, Rigid: Molded Parts, Rods and Flats dated November 4, 1954, MIL-P-46060(MR), Plastic, Polyamide (Nylon), Rigid: Rods, Tubes and Flats dated June 7, 1963; and those parts of MIL-M-19098 (Ships), Molding Plastic, Polyamide (Nylon); and Molded and Extruded Polyamide Plastic Parts—Weather Resistant, concerned with the characteristics of the molded and extruded polyamide plastic parts.

6.7 Transportation descriptions. Transportation descriptions and minimum weights applicable to this commodity are:

Rail:

Rods, sheets, tubes or unfinished shapes, plastic. (Specify weight per cu. ft.)
Carload minimum weights 10,000, 20,000 and 30,000 pounds, subject to Rule 34, Uniform Freight Classification.

Motor:

Rods, sheets, tubes, or shapes, not otherwise indexed, plastic.
Truckload minimum weights 10,000, 16,000, 21,000 and 30,000 pounds, subject to Rule 115, National Motor Freight Classification.

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MILITARY INTERESTS:

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Air Force—11

Review activities:

Army—EL, MI, MR, MU, WC
Navy—WP, SH
Air Force—11, 69

User activities:

Army—MO
Navy—MC

Preparing activity:

Navy—WP

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