



Standard Specification for Liquid Crystal Polymers¹

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1. Scope *

1.1 This specification covers liquid crystal polymeric materials suitable for injection molding and extrusion. This specification allows the use of recycled, reconstituted, recycled-regrind, recovered, or reprocessed liquid crystal polymer, or combination thereof, provided that the requirements as stated in this specification are met. It is the responsibility of the supplier and the buyer of recycled, reconstituted, recycled-regrind, recovered, or reprocessed liquid crystal polymer, or combination thereof, to ensure compliance.

1.2 The properties included in this specification are those required to identify the compositions covered. There may be other requirements necessary to identify particular characteristics important to specialized applications. These shall be agreed upon between the user and the supplier, by using suffixes as given in Section 5.

1.3 This specification is intended to be a means of calling out plastic materials used in the fabrication of end-use items or parts. It is not intended for the selection of materials. Material selection should be made by those having expertise in the plastics field after careful consideration of the design and the performance required of the part, the environment to which it will be exposed, the fabrication process to be employed, the costs involved, and the inherent properties of the material other than those covered by this specification.

1.4 The values stated in SI units are to be regarded as the standard.

1.5 The following precautionary caveat pertains only to the test method portion, Section 11, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There are no ISO standards covering the primary subject matter of this specification.

¹ This specification is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials.

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2. Referenced Documents

2.1 ASTM Standards:

- D 256 Test Method for Determining the Pendulum Impact Resistance of Notched Specimens of Plastics²
 - D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing²
 - D 638 Test Method for Tensile Properties of Plastic²
 - D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load²
 - D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials²
 - D 883 Terminology Relating to Plastics²
 - D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer²
 - D 1600 Terminology for Abbreviated Terms Relating to Plastics²
 - D 1898 Practice for Sampling of Plastics²
 - D 3418 Test Method for Transition Temperatures of Polymers by Thermal Analysis³
 - D 3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials³
 - D 3835 Test Method for Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer³
 - D 3892 Practice for Packaging/Packing of Plastics³
 - D 4000 Classification System for Specifying Plastic Materials³
 - D 5033 Guide for the Development of Standards Relating to the Proper Use of Recycled Plastics⁴
 - D 5630 Test Method for Ash Content in Thermoplastics⁴
 - E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁵
- ### 2.2 IEC and ISO Standards:⁶
- IEC 112 Recommended Method for Determining the Comparative Tracking Index of Solid Insulation Materials

² Annual Book of ASTM Standards, Vol 08.01.

³ Annual Book of ASTM Standards, Vol 08.02.

⁴ Annual Book of ASTM Standards, Vol 08.03.

⁵ Annual Book of ASTM Standards, Vol 14.02.

⁶ Available from the American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

*A Summary of Changes section appears at the end of this standard.

TABLE LCP Liquid Crystal Polymers—Classification

Group	Description	Class	Description	Grade ^A	Description
01	unsubstituted or methyl substituted, wholly aromatic copolyester, polyether, or polyester amide	1	high temperature DTUL ^B >260°C	0	
		2	medium temperature DTUL = 220–260°C	0	
		3	general purpose DTUL <220°C	0	
02	mixed aromatic/aliphatic copolyesters, polyethers, or polyester amides	1	high temperature DTUL >260°C	0	
		2	medium temperature DTUL = 220–260°C	0	
		3	general purpose DTUL <220°C	0	
03	aromatic copolyesters, polyethers, or polyesteramides with aliphatic sidechain	1	high temperature DTUL >260°C	0	
		2	medium temperature DTUL = 220–260°C	0	
		3	general purpose DTUL <220°C	0	
04	blends	1	high temperature DTUL >260°C	0	
		2	medium temperature DTUL = 220–260°C	0	
		3	general purpose DTUL <220°C	0	
00	other	0	other	0	

^A Description unspecified.

^B DTUL is deflection temperature under load measured at 1.8 MPa and is determined in accordance with Table A or Table B.

IEC 243 Recommended Methods of Test for Electrical Strength of Solid Insulating Materials at Power Frequencies

ISO 62 Plastics—Determination of Water Absorption

ISO 75-1 Determination of Temperature of Deflection Under Load—General Test Method

ISO 75-2 Determination of Temperature of Deflection Under Load—Plastics and Ebonite

ISO 178 Plastics—Determination of Flexural Properties of Rigid Materials

ISO 180/1A Plastics—Determination of Izod Impact Strength of Rigid Materials

ISO 294-1 General Principles for Injection Molding

ISO 527-1 Plastics—Determination of Tensile Properties—Test Conditions for Moulding and Extrusion of Plastics

ISO 527-2 Plastics—Determination of Tensile Properties—Test Conditions for Moulding and Extrusion of Plastics

ISO 604 Plastics—Determination of Compressive Properties

ISO 3146 Plastics—Determination of Melting Behaviour (Melting Temperature or Melting Range) of Semi-Crystalline Polymers

ISO 3167 Plastics—Multipurpose Test Specimens

2.3 *Military Standard*:⁷

M24519 Molding Plastics—Electrical Thermoplastics

2.4 *Underwriters Laboratories (UL)*:⁸

UL 94 Test for Flammability of Plastic Materials for Parts in Devices and Appliances

2.5 *National Technical Information Service (NTIS)*:⁹
AD297457 Procedure and Analytical Method for Determining Toxic Gases Produced by Synthetic Compounds

3. Terminology

3.1 *Definitions*—For definitions of technical terms pertaining to plastics used in this specification, see Terminologies D 883 and D 1600.

3.2 *Definition of Term Specific to This Standard*:

3.2.1 *liquid crystal polymer (LCP)*—A family of thermoplastic polymers which upon heating to the processing temperature, exhibit ordered structure and under shear, highly aligned chains that are retained in the solid state. Liquid crystal polymers are polymers that in the molten state exhibit birefringence in polarized light.

4. Classification

4.1 The LCP materials are classified into groups according to their chemical composition. These groups are subdivided, whether reinforced or not, into classes based on thermal performance as shown in Table LCP.

NOTE 2—An example of this classification is as follows: The designation LCP0120 would indicate liquid crystal polymer as found in Terminology D 1600:

01 (group)—Unsubstituted, or methyl substituted, wholly aromatic copolyester, polyether, or polyester amide.

2 (Class)—Medium temperature, DTUL = 220–260°C.

0 (Grade—Other)

4.1.1 To facilitate the incorporation of future or special materials, the “other” category for Group (00), Class (0), and Grade (0) is shown in Table LCP.

⁷ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

⁸ Available from Underwriters Laboratories, 333 Pfingsten Rd., Northbrook, IL 60062–2096.

⁹ Available from NTIS, 5285 Port Royal Rd., Springfield, VA 22161.

4.2 The LCP materials are also classified according to mechanical properties as shown in Table A, after specifying any addition of fillers, reinforcements, or lubricants at the nominal level indicated (see 4.2.1).

NOTE 3—Test specimens shall be prepared in accordance to ISO 3167, with Specimen A.

NOTE 4—A similar callout can be developed using Table B.

4.2.1 Reinforcements and additive materials shall use a symbol (single-letter) that shows the major reinforcement or combination, or both, along with two digits that indicate the percentage of addition by mass with the tolerances as tabulated as follows:

Symbol	Material	Tolerance (Based on Total Mass)
C	carbon and graphite fiber	±2 %
G	glass	±2 %
L	lubricants (for example PTFE, graphite, silicone, and molybdenum disulfide)	depends upon material and process to be specified
M	mineral	±2 %
R	combinations of reinforcements or fillers, or both	±3 % for the total

NOTE 5—This part of the system uses percent reinforcements or additives, or both, in the control of the modified basic material. The types and percentages of reinforcements and additives should be shown on the suppliers' technical data sheet unless they are proprietary in nature. If necessary, additional control of these reinforcements and additives can be established by the use of the suffix part of the system, Section 5.

4.2.2 Specific requirements shall be shown by a six-character designation. The designation will consist of the letter A and the five digits comprising the cell numbers for the property requirements in the order as they appear in Table A.

4.2.2.1 Although the values listed in Table A include the range of properties available in existing materials, users should not infer that every possible combination of properties exists or can be obtained.

4.2.3 When the grade or class of the basic material is not known or is not important, the "0" classification will be used.

NOTE 6—An example of this classification for a reinforced LCP is as follows: The designation LCP0120G30A22450 would indicate:

LCP 0120—Unsubstituted or methyl substituted, wholly aromatic copolyester, polyether, or polyester amide, medium temperature from Table LCP

G30—Glass reinforced at 30 % nominal level

- A —Table A property requirements
- 2 —Tensile strength, min, 100 MPa
- 2 —Flexural modulus, min, 8 GPa
- 4 —Notched izod impact, min, 15 kJ/m
- 5 —Deflection temperature under load, min, 260°C at 1.8 MPa,
- 0 —Unspecified

If no properties are specified, the designation would be LCP0120G30A00000.

5. Suffixes

5.1 When requirements are needed that supersede or supplement the requirements in Table LCP and A (or B), they shall be specified through the use of suffixes. In general, the first suffix letter indicates the special requirements needed and the second letter indicates the conditions or test method, or both, with a three-digit number indicating the specific requirement. The suffixes that may be used are listed in Table 3 of Classification System D 4000.

5.1.1 Additional suffixes will be added to this specification as test methods and requirements are developed or requested, or both.

6. General Requirements

6.1 The composition of the specified material shall be uniform and shall conform to the requirements specified herein.

6.2 The basic material requirements from Tables LCP and A (or B), as they apply, are always in effect unless these requirements are superseded by specific suffix requirements which always take precedence.

7. Detail Requirements

7.1 The material shall conform to the requirements prescribed in Tables LCP and A (or B), and the suffix requirements as they apply.

7.2 For the purposes of determining conformance with this specification, all specified limits in this specification are absolute limits, as defined in Practice E 29.

7.3 With the absolute method, an observed value or a calculated value is not rounded, but is to be compared directly with the specified limiting value. Conformance or nonconformance with this specification is based on this comparison.

TABLE A Property Requirements for Liquid Crystal Polymer Based on ISO Test Methods

			0	1	2	3	4	5	6	7	8	9
1	Tensile strength, min, MPa	ISO 527	unspecified	70	100	120	140	160	180	200	220	specify value
2	Flexural modulus, min, GPa	ISO 178	unspecified	4	8	12	16	20	24	28	32	specify value
3	Notched izod impact, min, kJ/m ²	ISO 180/1A	unspecified	5	9	12	15	18	25	37	50	specify value
4	DTUL ^A at 1.8 MPa, min, °C	ISO 75/A	unspecified	140	180	220	240	260	300	340	380	specify value
5	To be determined		unspecified									specify value

^A DTUL = Deflection temperature under load tested flatwise on 80 by 10 by 4-mm specimen.

TABLE B (Formerly Table A in D 5138 – 90) Property Requirements for LCP Based on ASTM Test Methods

	0	1	2	3	4	5	6	7	8	9
Tensile strength, MPa, min, ^A (D 638)	unspecified	70	100	120	140	160	180	200	220	specify value
Flex modulus, GPa, min, ^B (D 790)	unspecified	4	8	12	16	20	24	28	32	specify value
Notched Izod impact, min, J/m, (D 256) ^C	unspecified	40	75	100	125	150	200	300	400	specify value
Deflection temperature, min, °C at 1.8 MPa, (D 648)	unspecified	140	180	220	240	260	300	340	380	specify value
To be determined	unspecified									specify value

^A Type 1 tensile bar, 3.2 mm thick tested at 5 mm/min \pm 25 % (minimum length 200 mm).

^B 127 by 12.7 by 3.2-mm bar tested at 1.3 mm/min.

^C Bar thickness 3.2 mm.

8. Sampling

8.1 Sampling shall be statistically adequate to satisfy the requirements of 12.4.

8.2 A batch or lot shall be constituted as a unit of manufacture as prepared for shipment, and may consist of a blend of two or more production runs.

9. Specimen Preparation

9.1 The moisture content of the molding material for the preparation of test specimens shall not exceed 0.01 %. Material having a moisture content above these limits shall be dried in accordance with the instructions of the manufacturer.

9.2 The test specimens shall be prepared by an injection molding process as specified in ISO 294-1 for Table A or Practice D 3641 for Table B. The processing conditions specified in Table 4 are guidelines only. Since mechanical properties can vary depending on the molding conditions, for specification purposes contact the manufacturer of the grade for appropriate molding conditions.

9.3 Because of the shear sensitivity of LCP materials, occasionally a gate smaller than the gate specified in Practice D 3641 may be required to adequately fill the part. When reporting data in accordance with Specification D 5138, the gate design should be specified.

10. Conditioning

10.1 Test specimens shall be conditioned in the standard laboratory atmosphere for a minimum of 12 h (condition 12/23/50 of Practice D 618).

11. Test Methods

11.1 Determine the properties by means of the appropriate test methods in Table LCP and in Table A (or B) as they apply, unless otherwise stated herein.

TABLE 4 Processing Guidelines for Liquid Crystal Polymers for Preparation of Test Specimens^A

Material	Melt Temperature, °C	Cycle Time, s	Average Injection Velocity, mm/s	Mold Temperature, °C
Liquid crystal polymer	^B	30 \pm 5	150–600	90 \pm 5

^A Contact the manufacturer of the grade for more specific molding conditions when conducting tests for comparison with the requirements of this specification.

^B Target melt temperature shall be \pm 20°C around the melt point. Actual melt temperature shall be held at \pm 3°C of the target. The melt point is defined as the nominal melt transition temperature as measured by differential scanning calorimetry.

11.2 The glass content of glass-reinforced materials shall be in accordance with Test Method D 5630.

11.3 Conditions for running melt viscosity testing in accordance with Test Method D 3835 in a capillary rheometer are as follows:

11.3.1 *Drying*—Minimum 1½ h (maximum 72 h) at 150 \pm 10°C in a vacuum oven (minimum 0.05 MPa) under N₂ bleed.

11.3.2 *Temperature*—0–20°C above the nominal melt transition peak as defined by differential scanning calorimetry.

11.3.3 *Capillary Die*—1-mm diameter, 20:1 L/D or 30:1 L/D, 180° full entrance angle. An alternate capillary die has a diameter of 0.02 mm, 40:1 L/D, 120° full entrance angle.

11.3.4 *Shear Rates*—Scan of shear rates from 100 s⁻¹ to 2000 s⁻¹, reported at 1000 s⁻¹.

NOTE 7—The test method for flow rates of thermoplastic materials by extrusion plastometer (Test Method D 1238) is not recommended as a test method for describing liquid crystal polymers because of the morphological nature of the material. The LCPs maintain a crystalline structure even at their processing temperatures. They are highly shear sensitive, and are difficult to process under the low shear rate of the flow rate test. Repeatability of flow rate value is poor. Viscosity versus shear rate data should be used to describe the flow properties of these materials.

12. Certification and Inspection

12.1 Certification and inspection of the material supplied under this specification shall be for conformance to the requirements specified herein.

12.2 Lot-acceptance inspection shall be the basis on which acceptance or rejection of the lot is made. The lot-acceptance inspection shall consist of those tests listed as they apply: melt viscosity and filler or reinforcement content (if any).

12.3 Periodic check inspection shall consist of the tests specified for all requirements of the material under this specification. Inspection frequency shall be adequate to ensure the material is certifiable in accordance with 12.4.

12.4 Certification shall be that the material was manufactured by a process in statistical control in combination with a regimen of periodic inspecting, sampling, and testing the production runs to ensure both uniformity and conformance with this specification and that the average test values for the lot meet all the line call out requirements of this specification.

12.5 A report of the test results shall be furnished when requested. The report shall consist of the results of the lot-acceptance inspections for the shipment and the results and

dates of periodic check inspections. For viscosity measurements include a description of the capillary die (diameter and L/D) used to make the measurements.

13. Packaging and Package Marking

13.1 For packing, packaging, and package marking, the provisions of Practice D 3892 apply.

14. Keywords

14.1 aromatic polyester (ARP); extrusion materials; injection molding materials; line call out specification; liquid crystal polymers (LCP); recycled plastics

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the inquiry, contract, or order for agencies of the U.S. Government.

S1. Special End Uses

S1.1 Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all testing and inspections. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government may reserve the right to perform any of the testing or inspections set forth in the specification requirements. This testing ensures qualification on a one-time basis unless the manufacturer makes a significant change in formulation, raw material, or process.

S2. Physical Requirements

S2.1 The physical and electrical property requirements for initial material qualification are given in Table S2.1 and the test methods in Table S3.1. Unless otherwise stated, the values are minimum requirements.

TABLE S2.1 Property Values for Initial Physical and Electrical Qualification Testing

Property	Units	Value Required for Each Type of Compound	
		Type GLCP-30F	Type GLCP-50F
Flammability	—	V-0	V-0
Water absorption	%, max	0.08	0.08
Compressive strength	MPa	75	75
Dielectric strength			
Short-Time Test 1	kV/mm	18.8	18.8
Short-Time Test 2	kV/mm	18.8	18.8
Tracking index	V	120	140

S3. Quality Assurance

S3.1 *Acceptance Criteria*—Failure to conform to requirements in Table S2.1 shall result in rejection of the material.

S3.2 *Sample Size*—The minimum number of test specimens to be tested shall be as specified in Table S3.1.

S3.3 *Test Method*—Testing shall be in accordance with the methods specified in Table S3.1.

S3.4 *Conditioning*—Standard test specimens shall be conditioned before testing as specified in Table S3.1 and as described in Section 4.

TABLE S3.1 Sampling and Conditioning for Initial Qualification Testing

Property to Be Tested	Test Method	Test Method Modified per	Specimens	Number Tested	Conditioning	Units
Flammability	UL 94		125 × 13 mm × thickness	10	per UL 94	per UL 94
Compressive strength	ISO 604		25 × 10 × 4 mm	5	E-48/50+C-96/23/50	MPa (minimum average)
Water absorption	ISO 62		50-mm disk, 3 mm thick	3	E-24/100+des+D-48/50	Percent (maximum average)
Dielectric Strength:	IEC 243	S5.1	60 × 60 × 2-mm plaque	3	E-48/50+C-96/23/50	kV/mm (minimum average)
Short-time test				3	E-48/50+D-48/50	
Short-time test				3	E-48/50+D-48/50	
Tracking index	IEC 112		80 × 10 × 4 mm	4	A	V

S4. Conditioning

S4.1 Nomenclature:

S4.1.1 *Condition A*—As received.

S4.1.2 *Condition C*—Humidity conditioning.

S4.1.3 *Condition D*—Immersion conditioning in distilled water.

S4.1.4 *Condition E*—Temperature conditioning.

S4.1.5 *Condition des*—Dessication condition, cooling over silica gel or calcium chloride in a desiccator at 23°C for 16 to 20 h after temperature conditioning.

S4.2 *Designation*—Conditioning procedures shall be designated as follows:

S4.2.1 A capital letter indicating the general conditioning.

S4.2.2 A number indicating, in hours, the duration of conditioning.

S4.2.3 A number indicating, in °C, the conditioning temperature.

S4.2.4 A number indicating the relative humidity when it is controlled.

S4.3 Tolerances:

S4.3.1 *Relative Humidity*—Standard tolerance shall be $\pm 5\%$.

S4.3.2 *Temperature*—Standard tolerance shall be $\pm 2^\circ\text{C}$. For water immersion the standard tolerance shall be $\pm 1^\circ\text{C}$.

NOTE S4.1—The numbers shall be separated from each other by slant (/) marks, and from the capital letter by a dash (-). A sequence of

conditions shall be denoted by use of a plus (+) sign between successive conditions.

Examples: C-96/23/50 — Humidity condition; 96 h at 23°C and 50 % R.H.
 D-48/50 — Immersion condition; 48 h at 50°C.
 E-48/50 — Temperature condition; 48 h at 50°C.

S5. Test Method Modification

S5.1 Dielectric Strength:

S5.1.1 The test shall be performed under oil at a frequency not exceeding 100 Hz at the temperature of the final conditioning.

S5.1.2 *Short-Time Test*—The voltage shall be increased uniformly at the rate of 500 V/s.

S6. Toxicity Requirements

S6.1 Thermoplastic molding compounds shall be tested for toxicity in accordance with NTIS AD297457. Specimens shall meet the requirements in Table S6.1, expressed as the maximum level permissible.

TABLE S6.1 Toxicity When Heated

Compounds	Units	GLCP-30F	GLCP-50F
Carbon dioxide	ppm	15 000	15 000
Carbon monoxide	ppm	1 000	1 000
Ammonia	ppm	500	500
Aldehydes as HCHO	ppm	50	50
Cyanide as HCN	ppm	50	50
Oxides of nitrogen as NO ₂	ppm	100	100
Hydrogen chloride	ppm	50	50

APPENDIXES

(Nonmandatory Information)

X1. MELT VISCOSITY STABILITY TESTING, TEST METHOD D 3835

X1.1 Alternatively, a thermal residence time viscosity test may be run at the following conditions:

X1.1.1 *Drying*—Minimum 1½ h at 150 \pm 10°C in a vacuum oven (minimum 0.05 MPa) under N₂ bleed.

X1.1.2 *Temperature*—0–20°C above the nominal melt transition peak as defined by differential scanning calorimetry.

X1.1.3 *Capillary Die*—1-mm diameter, 20:1 L/D or 30:1 L/D, 180° full entrance angle. An alternative capillary die has a diameter of 0.02 mm, 40:1 L/D, 120° full entrance angle.

X1.1.4 *Shear Rates*—Run at constant shear rate of 400 s⁻¹ for 15 min. Interpolate and report viscosities at 5 and 10-min residence time.

X2. MILITARY SPECIFICATION M24519

X2.1 The following Specification D 5138 call outs describe the LCP materials referenced in Military Specification M-24519 under the appropriate MIL SPEC callout:

Specification D 5138

MIL M-24519

LCP0120G30A43430
 EA300ED035EE200EF140
 LCP0120G50A44230
 EA300ED042EE200EF180

GLCP-30F

GLCP-50F

SUMMARY OF CHANGES

This section identifies the location of selected changes to this specification. Committee D-20 has highlighted those changes that may impact the use of this specification. This section may also include descriptions of the changes or reasons for the changes, or both.

D 5138 – 97:

- (1) Added statement regarding the use of recycle.
- (2) Added ISO equivalency statement.
- (3) Changed property table to use of ISO test methods.
- (4) Changed classification table to include chemical description and thermal performance only.
- (5) Added table of processing conditions.
- (6) Defined lot inspection and certification to include melt

viscosity and filler or reinforcement content (if any) only.

- (7) Included an appendix with Mil Spec M24519 equivalency.

D 5138 – 99:

- (1) Added Supplementary Requirements section.
- (2) Deleted D 4000 suffixes from cross-reference in Appendix X2.

D 5138 – 99a:

- (1) Added S4.3 through S4.3.2.

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