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Specifications for use of poly(lactic acid) based filament in additive manufacturing applications

Spécifications pour l'utilisation de filaments à base de poly(acide lactique) dans les applications de fabrication additive

Reference number
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Foreword

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This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 14, *Environmental aspects.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Poly(lactic acid) (PLA) is a thermoplastic polymer material that is commonly used in additive manufacturing/3D Printing. This document specifically addresses the following:

a) specify various parameters such as the appearance, dimensions, chemical and physical properties;

b) this document is expected to improve the quality management of PLA based filament for additive manufacturing applications;

c) provide information on end-of-life management, use of renewable biobased carbon feedstocks vs. fossil based feedstocks, Carbon and Environmental Footprint, and methodology of a circular economy.

The document is expected to provide benefits to both consumers and industry. Consumers may profit from this document by relying on standardized specification. This document is also important for the development and growth of a new environmentally responsible polymer material industry based on PLA.

Specifications for use of poly(lactic acid) based filament in additive manufacturing applications

1 Scope

This document specifies the technical requirements, test methods, detection rules, marking/labelling, packaging, transportation and storage of poly(lactic acid) (PLA) based filament for use in specific additive manufacturing technology, such as materials extrusion (MEX).

The document applies to PLA based filament for MEX additive manufacturing applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 1133-1:2022, *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics — Part 1: Standard method*

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 8124-3, *Safety of toys — Part 3: Migration of certain elements*

ISO 12219-2, *Interior air of road vehicles — Part 2: Screening method for the determination of the emissions of volatile organic compounds from vehicle interior parts and materials — Bag method*

ISO 15512:2019, *Plastics — Determination of water content*

ISO 16620 (all parts), *Plastics — Biobased content*

ISO 22526 (all parts), *Plastics — Carbon and environmental footprint of biobased plastics*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
additive manufacturing
AM
process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies

Note 1 to entry: This is also commonly referred to as 3D-printing.

[SOURCE: ISO/ASTM 52900:2021, 3.1.2, modified — Note 1 to entry replaced and Note 2 to entry removed.]

3.2
material extrusion
MEX
additive manufacturing (3.1) process, where an object is built by selectively depositing melted material in a pre-determined path layer-by-layer

Note 1 to entry: More specifically, MEX, refers to a process in which a filament material (i.e. PLA) is heated to melt in a printer and extruded through a nozzle (with certain bore diameter), that moves following a preset computer slice model to continuously deposit a layer on, and bond to a previous layer after solidification to form the final product.

3.3
melt mass-flow rate
MFR
rate of extrusion of a molten resin through a die of specified length and diameter under prescribed conditions of temperature, load and piston position in the cylinder of an extrusion plastometer

Note 1 to entry: The rate is determined as the mass extruded over a specified time.

Note 2 to entry: MFR can be expressed in milligrams per second (mg/s) or grams per 10 min (g/10 min).

3.4
total volatile organic compounds
TVOC
group of compounds that are present in emissions or ambient air, which include benzene, toluene, butyl acetate, ethylbenzene, *p*-(*m*-)xylene, styrene, *o*-xylene, undecane, etc.

Note 1 to entry: Indoor building and decoration materials are the main sources of TVOC in the air.

3.5
3D printing
3DP
type of rapid prototyping and digital model file-based technology using powdered metal or plastic and other adhesive materials to construct object layer-by-layer

4 Labelling

The product shall be labelled with the specifications: barcode, country of production, build temperature, name of material, 3D filament, colour and net mass as shown in Figure 1.

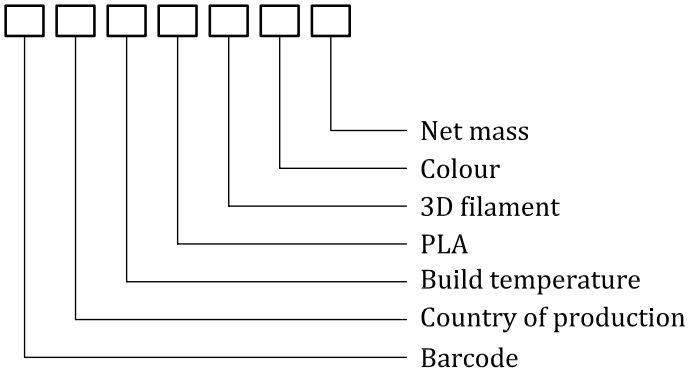

Figure 1 — Labelling of product

EXAMPLE A blue PLA filament material having diameter of 1,75 mm, with net mass of 1 kg shall be designated as 1,75 mm PLA 3D filament blue: 1 kg as shown in Figure 2.

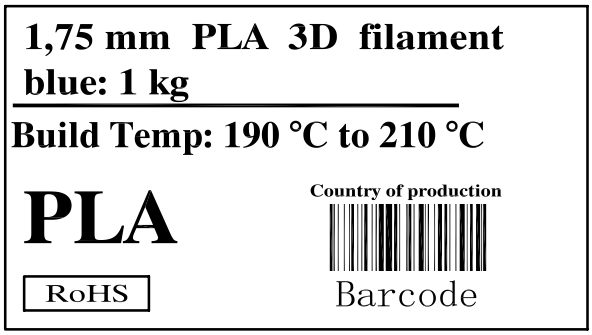

Figure 2 — Label example

5 Requirements

5.1 Appearance

In general, the filament material shall be of uniform colour consistency, without burrs, protuberances, visible crease, scratches, or bubbles. However, filaments can also be multicolour or contain foreign matter such as foaming agents, fillers, metals powders and cellulose particles. The filament material shall be of uniform colour consistency if marked as a single colour filament. In the case of multicolour filament, two or three basic colours should be mentioned.

Appearance requirements shall be assessed in accordance with 6.2.

5.2 Specification

5.2.1 Diameter and ovality tolerance

Filament diameters of 1,75 mm and 2,85 mm are the most common (80 % to 90 %) of filament produced. Other diameter sizes can also occur. Filament diameter and filament ovality shall meet the requirements of Table 1, when measured according to 6.3.

Table 1 — Diameter and roundness

Nominal diameter (ND)	Tolerance		Ovality
	Premium product	Qualified product	
2,85 mm	±0,03 mm	±0,05 mm	≤0,07 mm
1,75 mm	±0,03 mm	±0,03 mm	≤0,05 mm
Other values	±1,7 %ND	±1,1 %ND	≤±2,6 %ND

NOTE Filament products are classified into premium products and qualified products based on nominal diameter tolerance and ovality tolerance.

5.2.2 Net mass and tolerance

The net mass of filament shall be 0,5 kg or 1,0 kg with tolerance of +3 % when measured according to 6.4. Spools can range from 0,75 kg to 6 kg.

5.2.3 Volatile matter limit

Follow the reporting requirements in ISO 12219-2.

5.2.4 Biobased (carbon) content

Follow the reporting requirements in the ISO 16620 series.

5.2.5 Carbon and environmental footprint

Follow the reporting requirements in the ISO 22526 series.

5.3 Property requirements

Filament shall meet the property requirements in Table 2.

Table 2 — Properties of filament

Item		Requirements	Test method
Build temperature		(200 ± 20) °C	Device settings
Moisture content		≤0,5 %	6.6
Line tensile load	1,75 mm	≥125 N	6.7
	2,85 mm	≥340 N	6.7
	Other value	Negotiated by manufacture and user	
Line elongation at break	1,75 mm	≥10 %	6.7
	2,85 mm	≥6 %	6.7
	Other value	Negotiated by manufacture and user	

5.4 Limit quantity of substances and impurities

Appropriate limitations should be met according to, for example, ISO 8124, ISO 17088, etc.

6 Test methods

6.1 Conditioning

Conditioning of filament samples on the spool shall be done according to ISO 291 under condition of 23 °C ± 2 °C. The time of conditioning shall be at least 48 h, but no longer than 96 h.

6.2 Appearance of filament material

Take a whole roll of the sample, under the condition of sufficient light with the help of a magnifying glass, the eyes are (30~50) cm away from the sample to directly observe the colour difference, burr, protrusion, creases, foreign bodies, scratches, bubbles, etc. of the sample, and the observation time is (2 s~3 s). A colour chart shall be used.

6.3 Diameter and ovality of filament material

Use a micrometer or other non-contact detection tool such as an infrared calliper or a laser calliper with an error limit of 0,001 mm.

The filament diameter shall be measured by at least three different directions, at least 50° apart. All values shall attend the diameter tolerance.

The ovality is measured by measuring diameters of at least three different directions, at least 50° apart, and by subtracting the minimum value from the maximum value.

The ovality result is used to determine whether the filament is cylindrical, and the basis for the determination shall meet the ovality requirements in Table 1.

6.4 Net mass and tolerance of filament material

This shall be measured by using a calibrated balance with maximum error limit no larger than 0,001 kg.

6.5 Melt mass-flow rate

Measure melt mass-flow rate method A of ISO 1133-1 under test condition D [temperature (190 ± 1) °C, load (2,16 ± 0,01) kg].

6.6 Moisture content

6.6.1 General

Moisture content shall be measured using one of the following methods given in 6.6.2 to 6.6.4.

6.6.2 Method A

Measure moisture in accordance with ISO 15512:2019, method B.

6.6.3 Method B

Take (10,0 ± 0,5) g of sample and spread it on the bottom of the weighing pan and place it in a halogen fast moisture meter whose temperature is raised to (105 ± 1) °C. Press the "Display" key to allow an 80 s of judgment before the moisture measurement is completed, when the instrument will automatically stop heating, and an alarm will sound to record the display data in the form of a % sign. Each sample was tested at least three times and the average value taken.

6.6.4 Method C

Take 1,0 g of sample (tolerance of ±0,1 g), put it in weighing bottle (w_2) that was dried to constant mass at (110 ± 1) °C and heat the bottle at (70 ± 1) °C for 4 h in a dryer before cooling to room temperature and weigh it (w_1). Moisture content shall be calculated using Formula (1).

$$\Delta w = \frac{w-(w_1-w_2)}{w}\times 100\,\% \tag{1}$$

where

Δw is the moisture content, expressed as a percentage (%);

w is the measured mass of sample, in gram (g);

w_1 is the mass of sample and weighing bottle after cooling to room temperature, in gram (g);

w_2 is the mass of weighing bottle, in gram (g).

In an arbitration experiment, the moisture test shall be carried out according to Method C.

6.7 Tensile load and elongation at break of filament

Take filament test sample directly with fixture spacing of (350 ± 5) mm for testing in accordance with ISO 527-2 at a tensile speed of (50 ± 2) mm/min. Five test samples shall be tested and the average is reported as result. The numerical deviation of the 5 samples should be no more than 20 % from the mean value.