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## Thermoplastic polymers for plain bearings — Classification and designation

*Polymères thermoplastiques pour paliers lisses — Classification et  
désignation*

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## Contents

Page

|  |    |
|--|----|
| Foreword.....  | iv |
| 1 <b>Scope</b> .....   | 1  |
| 2 <b>Normative references</b> .....  | 1  |
| 3 <b>Classification and designation system</b> .....   | 2  |
| 4 <b>Designation examples</b> .....  | 9  |
| 5 <b>Ordering information</b> .....  | 10 |
| <b>Annex A</b> (informative) <b>Properties and applications of the most common unfilled thermoplastic polymers</b> ..... | 11 |
| <b>Annex B</b> (informative) <b>Fundamental application procedures</b> .....   | 17 |
| <b>Bibliography</b> .....  | 23 |

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 6691 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 2, *Materials and lubricants, their properties, characteristics, test methods and testing conditions*.

This second edition cancels and replaces the first edition (ISO 6691:1989), of which has been technically revised.

Annexes A and B of this International Standard are for information only.

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# Thermoplastic polymers for plain bearings — Classification and designation

## 1 Scope

This International Standard specifies a classification and designation system for a selection of the most common unfilled thermoplastic polymers for plain bearings.

The unfilled thermoplastic polymers are classified on the basis of appropriate levels of distinctive properties, additives and information about their application for plain bearings. The designation system does not include all properties; thermoplastic polymers having the same designation cannot therefore be interchanged in all cases.

It also provides an outline of the properties and applications of the most common unfilled thermoplastic polymers as well as listing some of the fundamental parameters that influence the selection of thermoplastic polymers for use for plain bearings.

NOTE In the further course of the work it is intended to prepare standards on "thermosetting polymers" and "mixed polymers" for plain bearings.

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## 2 Normative references

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The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 307, *Plastics — Polyamides — Determination of viscosity number.*

ISO 527-1, *Plastics — Determination of tensile properties — Part 1: General principles.*

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

ISO 527-3, *Plastics — Determination of tensile properties — Part 3: Test conditions for films and sheets.*

ISO 527-4, *Plastics — Determination of tensile properties — Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites.*

ISO 527-5, *Plastics — Determination of tensile properties — Part 5: Test conditions for unidirectional fibre-reinforced plastic composites.*

ISO 1133, *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics.*

ISO 1183, *Plastics — Methods for determining the density and relative density of non-cellular plastics.*

ISO 1628-5, *Plastics — Determination of the viscosity of polymers in dilute solution using capillary viscometers — Part 5: Thermoplastic polyester (TP) homopolymers and copolymers.*

ISO 1872-2, *Plastics — Polyethylene (PE) moulding and extrusion materials — Part 2: Preparation of test specimens and determination of properties.*

ISO 1874-2, *Plastics — Polyamide (PA) moulding and extrusion materials — Part 2: Preparation of test specimens and determination of properties.*

ISO 7148-2, *Plain bearings — Testing of the tribological behaviour of bearing materials — Part 2: Testing of polymer-based bearing materials.*

### 3 Classification and designation system

#### 3.1 General

The classification and designation are based on a block system consisting of a "description block" and "identity block". The "identity block" comprises an "International Standard number block" and an "individual item block". For unambiguous coding of all thermoplastic polymers, the "individual item block" is subdivided into five data blocks.

| Designation       |                                     |                       |              |              |              |              |
|-------------------|-------------------------------------|-----------------------|--------------|--------------|--------------|--------------|
| Description block | Identity block                      |                       |              |              |              |              |
|                   | International Standard number block | Individual item block |              |              |              |              |
|                   |                                     | Data block 1          | Data block 2 | Data block 3 | Data block 4 | Data block 5 |

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The "individual item block" starts with a dash. The data blocks are separated by commas.

Data blocks 1 to 5 include the following information:

data block 1: material symbol (see 3.2)

data block 2: intended application or method of processing (see 3.3)

data block 3: distinctive properties (see 3.4)

data block 4: type and content of fillers or reinforcing materials (see 3.5)

data block 5: information about tribological properties for plain bearings (see 3.6)

The meaning of the letters and digits is different for each data block (see 3.2 to 3.6).

Data block 2 comprises up to 4 positions. If at least one of positions 2 to 4 is used, but no information is given in position 1, then the letter "X" shall be placed in position 1. The letters in positions 2 to 4 shall be arranged in alphabetical order.

If a data block is not used, this shall be indicated by consecutive data block separators, i.e. two commas (,,).

Designation examples are given in clause 4.

### 3.2 Data block 1

The chemical nature of the thermoplastic polymer is designated by its symbol in accordance with ISO 1043-1.

**Table 1 — Symbols for the chemical structure of the materials**

| Thermoplastic polymers    |            | Name and chemical structure  |
|---------------------------|------------|--|
| Group/Name                | Symbol     |  |
| Polyamide                 | PA 6       | Polyamide 6; homopolymer based on $\epsilon$ -caprolactam  |
|                           | PA 6 cast  | Polyamide 6, cast; homopolymer based on $\epsilon$ -caprolactam  |
|                           | PA 66      | Polyamide 66; homopolycondensate based on hexamethylenediamine and adipic acid   |
|                           | PA 12      | Polyamide 12; homopolymer based on $\omega$ -laurinlactam or $\omega$ -aminododecanoic acid  |
|                           | PA 12 cast | Polyamide 12, cast; homopolymer based on $\omega$ -laurinlactam or $\omega$ -aminododecanoic acid  |
|                           | PA 46      | Polyamide 46; a co-condensate based on 1,4-diaminobutane and adipic acid   |
| Polyoxymethylene          | POM        | Polyacetal (homopolymer)<br>Polyacetal (copolymer)   |
| Polyalkyleneterephthalate | PET        | Polyethylene terephthalate   |
|                           | PBT        | Polybutylene terephthalate   |
| Polyethylene              | PE-UHMW    | Polyethylene with ultra high molecular weight  |
|                           | PE-HD      | High density polyethylene  |
| Polyfluorocarbon          | PTFE       | Polytetrafluoroethylene  |
| Polyimide                 | PI         | Polyimides from polyaddition reactions are available as thermosetting plastics. Polyimides from polycondensation reactions are available as thermoplastics and thermosetting plastics, as well as copolymers of the imide group. Some thermoplastic polyimides are "apparent thermosetting plastics" because their thermoplastic range lies above the decomposition temperature. Because of their intermediate position, polyimides and imide copolymers are only treated marginally in this International Standard. |
| Polyetheretherketone      | PEEK       | Polyaryletherketone  |
| Polyvinylidene fluoride   | PVDF       | Homopolymer based on difluorodichloroethane  |
| Polyphenylene sulfide     | PPS        | Polyphenylene sulfide, linearly structured phenyl ring and sulfur atoms (tribologically modified material)   |
| Poly(amide-imide)         | PAI        | Poly(amide-imide) reacted by polycondensation is a hard/tough, amorphous thermoplastic. After postcuring the PAI parts cannot be used for re-processing ("pseudo-thermoset plastics").   |

### 3.3 Data block 2

Position 1 gives the code for the intended application (see Table 2).

**Table 2 — Data block 2 — Position 1**

| Code | Intended application |
|------|----------------------|
| E    | Extrusion            |
| G    | General use          |
| M    | Injection moulding   |
| Q    | Compression moulding |
| R    | Rotational moulding  |
| X    | No indication        |

Up to three important properties and/or additives can be indicated in positions 2 to 4 (see Table 3).

**Table 3 — Data block 2 — Positions 2 to 4**

| Code | Intended application            |
|------|---------------------------------|
| A    | Processing stabilized           |
| F    | Special burning characteristics |
| H    | Heat ageing stabilized          |
| L    | Light and weather stabilized    |
| R    | Release agent                   |
| S    | Slip agent, lubricated          |

### 3.4 Data block 3

#### 3.4.1 General

The levels of distinctive properties are coded by letters and numbers.

The properties used for the designation are different for every thermoplastic polymer.

Owing to manufacturing tolerances, single property values can lie on, or to either side of, two intervals. It is up to the manufacturer to state which interval will designate the thermoplastic polymer.

#### 3.4.2 Polyamides

Polyamides are designated in data block 3 by their viscosity number, represented by two digits (see Table 4) in accordance with ISO 1874-1 and, separated by a dash, their modulus of elasticity represented by three digits (see Table 5).

In the last position, rapid-setting products may be indicated with the letter N.

The viscosity number shall be determined in accordance with ISO 307 using the solvents given in Table 4. The modulus of elasticity shall be determined in the dry state in accordance with ISO 527-1, ISO 527-2, ISO 527-3, ISO 527-4 and ISO 527-5, under the conditions specified in ISO 1874-2.



Table 4 — Viscosity number for polyamides

| Polyamide                  | Code | Viscosity number, ml/g   |     |         |     |
|----------------------------|------|--------------------------|-----|---------|-----|
|                            |      | Sulfuric acid 96 % (m/m) |     | Solvent |     |
|                            |      | >                        | ≤   | >       | ≤   |
| PA 6<br>PA 6 cast<br>PA 66 | 09   | —                        | 90  | —       |     |
|                            | 10   | 90                       | 110 |         |     |
|                            | 12   | 110                      | 130 |         |     |
|                            | 14   | 130                      | 160 |         |     |
|                            | 18   | 160                      | 200 |         |     |
|                            | 22   | 200                      | 240 |         |     |
|                            | 27   | 240                      | 290 |         |     |
|                            | 32   | 290                      | 340 |         |     |
|                            | 34   | 340                      | —   |         |     |
| PA 12<br>PA 12 cast        | 11   | —                        |     | —       | 110 |
|                            | 12   |                          |     | 110     | 130 |
|                            | 14   |                          |     | 130     | 150 |
|                            | 16   |                          |     | 150     | 170 |
|                            | 18   |                          |     | 170     | 200 |
|                            | 22   |                          |     | 200     | 240 |
|                            | 24   |                          |     | 240     | —   |

Table 5 — Modulus of elasticity

| Code | Modulus of elasticity<br>N/mm <sup>2</sup> |        |
|------|--|--------|
|      | >  | ≤      |
| 001  | 50   | 150    |
| 002  | 150  | 250    |
| 003  | 250  | 350    |
| 004  | 350  | 450    |
| 005  | 450  | 600    |
| 007  | 600  | 800    |
| 010  | 800  | 1 500  |
| 020  | 1 500                                      | 2 500  |
| 030  | 2 500                                      | 3 500  |
| 040  | 3 500                                      | 4 500  |
| 050  | 4 500                                      | 5 500  |
| 060  | 5 500                                      | 6 500  |
| 070  | 6 500                                      | 7 500  |
| 080  | 7 500                                      | 8 500  |
| 090  | 8 500                                      | 9 500  |
| 100  | 9 500                                      | 10 500 |
| 110  | 10 500                                     | 11 500 |
| 120  | 11 500                                     | 13 000 |
| 140  | 13 000                                     | 15 000 |
| 160  | 15 000                                     | 17 000 |
| 190  | 17 000                                     | 20 000 |
| 220  | 20 000                                     | 23 000 |
| 250  | 23 000                                     | —      |

### 3.4.3 Polyethylenes

Polyethylenes are designated by their density represented by two digits (see Table 6) in accordance with ISO 1872-1 and, separated by a dash, their melt flow rate (MFR) represented by one letter and three digits (see Table 7).

The density of the base material shall be determined in accordance with ISO 1183 under the conditions specified in ISO 1872-2.

The melt flow rate shall be determined in accordance with ISO 1133 at 190 °C with a load of 2,16 kg (symbol D). For thermoplastic polymers with a melt flow rate < 0,1 g/10 min, a test under a load of 5 kg (symbol T) is recommended. If the melt flow rate is still < 0,1 g/10 min, the test should then be carried out under a load of 21,6 kg (symbol G).

The symbols D, T and G shall precede the code for melt flow rate given in Table 7.

**Table 6 — Density**

| Code | Density <sup>a</sup><br>g/cm <sup>3</sup> |       |
|------|---|-------|
|      | >   | ≤     |
| 15   | —   | 0,917 |
| 20   | 0,917                                     | 0,922 |
| 25   | 0,922                                     | 0,927 |
| 30   | 0,927                                     | 0,932 |
| 35   | 0,932                                     | 0,937 |
| 40   | 0,937                                     | 0,942 |
| 45   | 0,942                                     | 0,947 |
| 50   | 0,947                                     | 0,952 |
| 55   | 0,952                                     | 0,957 |
| 60   | 0,957                                     | 0,962 |
| 65   | 0,962                                     | —     |

<sup>a</sup> Density ranges for uncoloured and unfilled polyethylene materials.

**Table 7 — Melt flow rate (MFR)**

| Code | Melt flow rate<br>g/10 min |     |
|------|----------------------------|-----|
|      | >                          | ≤   |
| 000  | —                          | 0,1 |
| 001  | 0,1                        | 0,2 |
| 003  | 0,2                        | 0,4 |
| 006  | 0,4                        | 0,8 |
| 012  | 0,8                        | 1,5 |
| 022  | 1,5                        | 3   |
| 045  | 3                          | 6   |
| 090  | 6                          | 12  |
| 200  | 12                         | 25  |
| 400  | 25                         | 50  |
| 700  | 50                         | 100 |

### 3.4.4 Polyalkyleneterephthalates

The distinctive property of polyalkyleneterephthalates is the viscosity number according to ISO 7792-1, determined in accordance with ISO 1628-5, and designated by two digits (see Table 8).

Table 8 — Viscosity number for polyalkyleneterephthalate

| Polyalkylene-<br>terephthalate | Code | Viscosity number, ml/g |     |
|--------------------------------|------|------------------------|-----|
|                                |      | >                      | ≤   |
| PET                            | 06   | —                      | 60  |
|                                | 07   | 60                     | 70  |
|                                | 08   | 70                     | 80  |
|                                | 09   | 80                     | 90  |
|                                | 10   | 90                     | 100 |
|                                | 11   | 100                    | 120 |
|                                | 13   | 120                    | 140 |
|                                | 15   | 140                    | —   |
| PBT                            | 08   | —                      | 90  |
|                                | 10   | 90                     | 110 |
|                                | 12   | 110                    | 130 |
|                                | 14   | 130                    | 150 |
|                                | 16   | 150                    | 170 |
|                                | 18   | 170                    | —   |

### 3.4.5 Other polymers

The coding for the distinctive properties of polyoxymethylene, polytetrafluoroethylene, poly(amide-imide) and polyimide will be included in a future edition of this International Standard.

### 3.5 Data block 4

The fillers and reinforcing materials, as well as additives specific for the application in plain bearings, are coded as follows:

position 1: types of fillers and reinforcing materials, coded by a letter (see Table 9)

position 2: physical forms of fillers and reinforcing materials, coded by a letter (see Table 10)

positions 3 and 4: mass content of fillers and reinforcing materials, coded by two digits (see Table 11)

positions 5 and 6: fillers in position 1, coded by two letters (see Table 12)

Table 9 — Types of fillers and reinforcing materials (position 1)

| Code | Type                       |
|------|----------------------------|
| C    | Carbon                     |
| G    | Glass                      |
| K    | Chalk                      |
| S    | Synthetic organic material |
| T    | Talcum                     |
| X    | No indication              |

Table 10 — Physical forms of fillers and reinforcing materials (position 2)

| Code | Morphology    |
|------|---------------|
| D    | Powder        |
| F    | Fibre         |
| S    | Spheres       |
| X    | No indication |

Table 11 — Mass content (positions 3 and 4)

| Code | Mass percentage |      |
|------|-----------------|------|
|      | >               | ≤    |
| 0X   | No indication   |      |
| 01   | 0,1 (inclusive) | 1,5  |
| 02   | 1,5             | 3    |
| 05   | 3               | 7,5  |
| 10   | 7,5             | 12,5 |
| 15   | 12,5            | 17,5 |
| 20   | 17,5            | 22,5 |
| 25   | 22,5            | 27,5 |
| 30   | 27,5            | 32,5 |
| 35   | 32,5            | 37,5 |
| 40   | 37,5            | 42,5 |
| 45   | 42,5            | 47,5 |
| 50   | 47,5            | 55   |
| 60   | 55              | 65   |
| 70   | 65              | 75   |
| 80   | 75              | 85   |
| 90   | 85              | —    |

Table 12 — Fillers (positions 5 and 6)

| Code | Type                                    |
|------|---|
| GR   | Graphite                                |
| MO   | MoS <sub>2</sub> (Molybdenum disulfide) |
| OL   | Mineral oil                             |
| PE   | Polyethylene                            |
| TF   | PTFE (Polytetrafluoroethylene)          |

### 3.6 Data block 5

For the testing of tribological properties, see ISO 7148-2.