INTERNATIONAL STANDARD

ISO 6691

First edition
1989-12-01

Thermoplastics for plain bearings — Classification and designation

Matières thermoplastiques pour paliers lisses — Classification et désignation

Reference number
ISO 6691 : 1989 (E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 6691 was prepared jointly by Technical Committee ISO/TC 123, *Plain bearings* and ISO/TC 61, *Plastics.*

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

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Thermoplastics for plain bearings — Classification and designation

1 Scope

This International Standard specifies a system for designating the most common thermoplastics for plain bearings.

The thermoplastic materials are differentiated from each other by a classification system based on appropriate levels of designatory properties, additives and information about their application for plain bearings. The designation system does not include all properties; materials having the same designation cannot therefore be interchanged in all cases.

This International Standard does not specify performance data which may be required for particular applications.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 307 : 1984, *Plastics — Polyamides — Determination of viscosity number.*

ISO/R 527 : 1966, *Plastics — Determination of tensile properties.*

ISO 1043-1 : 1987, *Plastics — Symbols — Part 1: Basic polymers and their special characteristics.*

ISO 1133 : 1981, *Plastics — Determination of the melt flow rate of thermoplastics.*

ISO 1183 : 1987, *Plastics — Methods for determining the density and relative density of non-cellular plastics.*

ISO 1628-5 : 1986, *Plastics — Determination of viscosity number and limiting viscosity number — Part 5: Poly(alkylene terephthalates).*

ISO 1872-1 : 1986, *Plastics — Polyethylene (PE) and ethylene copolymer thermoplastics — Part 1: Designation.*

ISO 1872-2 : 1989, *Plastics — Polyethylene (PE) and ethylene copolymer thermoplastics — Part 2: Preparation of test specimens and determination of properties.*

ISO 1874-1 : 1985, *Plastics — Polyamide (PA) homopolymers for moulding and extrusion — Part 1: Designation.*

ISO 1874-2 : 1987, *Plastics — Polyamide (PA) homopolymers for moulding and extrusion — Part 2: Preparation of test specimens and determination of properties.*

ISO 7792-1 : 1985, *Plastics — Polyalkylene terephthalates — Part 1: Designation.*

3 Designation system

The classification and designation are based on a block system consisting of a Description Block and an Identity Block. The Identity Block comprises an International Standard Number Block and an Individual Item Block. For unambiguous coding of all thermoplastics, 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

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: Symbol of material and, if applicable, symbol of the plasticizer separated by a dash (see 3.1).

Data Block 2: Intended application or method of processing (see 3.2).

Positions 2 to 4: Important properties and/or additives (see 3.2).

Data Block 3: Designatory properties (see 3.3).

Data Block 4: Type and content of filler or reinforcing materials (see 3.4).

Data Block 5: Information about tribological properties for plain bearings (see 3.5).

The meaning of the letters and digits is different for each data block (see 3.1 to 3.5).

Data block 2 comprises up to 4 positions. If at least one of Positions 2 to 4 is taken, and no information is given in Position 1, then the letter X shall figure 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 two commas (,,).

Designation examples are given in clause 4.

3.1 Data Block 1

The chemical nature of the plastic is designated by its symbol in accordance with ISO 1043-1 and — separated by a hyphen — plasticized materials are indicated by a P (see table 1).

Table 1 — Symbols for the chemical structure of the materials

Thermoplastics		Name and chemical structure
Group/name	Symbol	
Polyamide	PA 6	Polyamide 6; homopolymer based on ε-caprolactam
	PA 6G[1]	Polyamide 6, cast; homopolymer based on ε-caprolactam
	PA 66	Polyamide 66; homopolycondensate based on hexamethylenediamine and adipic acid
	PA 610	Polyamide 610; homopolycondensate based on hexamethylenediamine and sebacic acid
	PA 612	Polyamide 612; homopolycondensate based on hexamethylenediamine and dodecanedioic acid[2]
	PA 11	Polyamide 11; homopolymer based on 11-aminoundecanoic acid
	PA 12	Polyamide 12; homopolymer based on ω-laurinlactam or ω-aminododecanoic acid
	PA 12G[1]	Polyamide 12, cast; homopolymer based on ω-laurinlactam or ω-aminododecanoic acid
Polyoxymethylene	POM	Polyacetal (homopolymer) Polyacetal (copolymer)
Polyalkylene-terephthalate	PET	Poly(ethylene terephthalate)
	PBT	Poly(butylene terephthalate)
Polyethylene	PE-UHMW	Polyethylene with ultra high molecular weight
	PE-HD	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.
Plasticizer	P	—

1) Symbol not standardized in ISO 1043-1 : 1987.

2) Dodecanedioic acid is a synonym for decanedicarboxylic acid 1,10.

3.2 Data Block 2

Position 1 gives the code for the intended use (see table 2).

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

Table 2 — Data Block 2 — Position 1

Code	Use
E	Extrusion
G	General use
M	Injection moulding
Q	Compression moulding
R	Rotational moulding
X	No indication

Table 3 — Data Block 2 — Positions 2 to 4

Code	Property or additive
A	Processing stabilized
F	Special burning characteristics
H	Heat ageing stabilized
L	Light and weather stabilized
R	Release agent
S	Slip agent, lubricated

3.3 Data Block 3

The levels of designatory properties are coded by letters and figures.

The properties appropriate for the designation are different for every thermoplastic material.

Due to manufacturing tolerances, single property values can lie on, or to either side of, the cell limit. It is up to the manufacturer to state which cell will designate the material.

3.3.1 Polyamides

The viscosity number of polyamides designated in accordance with ISO 1874-1 by two digits (see table 4) and, separated by a dash, the modulus of elasticity by three digits (see table 5).

In the last position, rapid-setting products can 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 under the conditions specified in ISO 1874-2.

Table 4 — Viscosity number for polyamides

Material	Code	Viscosity number, ml/g			
		Solvent			
		Sulfuric acid 96 % (*m*/*m*)		*m*-cresol	
		above	up to	above	up to
PA 6 PA 6G PA 66 PA 610 PA 612	**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 11 PA 12 PA 12G	**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 N/mm²	
	above	up to
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	–

3.3.2 Polyethylenes

The density of polyethylenes is designated in accordance with ISO 1872-1 by two digits (see table 6) and, separated by a dash, the melt flow rate (MFR) 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 materials with a melt flow rate $< 0,1$, a test under a load of 5 kg (symbol T) is recommended. If the melt flow rate is still $< 0,1$, the test should then be carried out under a load of 21,6 kg (symbol G).

The symbols D, T and G shall be given in front of the code for melt flow rate.

Table 6 — Density

Code	Density [1] g/cm³	
	above	up to
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	–

1) Density ranges for uncoloured and unfilled polyethylene materials.

Table 7 — Melt flow rate

Code	Melt flow rate (MFR) g/10 min	
	above	up to
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

3.3.3 Polyalkyleneterephthalates

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

Table 8 — Viscosity number for polyalkyleneterephthalate

Material	Code	Viscosity number, ml/g	
		above	up to
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	—

3.3.4 Others

The coding for the properties of polyxymethylene, polytetrafluoroethylene and polyimide will be included in future editions of this International Standard.

3.4 Data Block 4

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

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
B	Boron
C	Carbon
G	Glass
K	Chalk
M	Minerals [1], metal [1]
S	Synthetic organic material
T	Talcum
X	No indication
Y	Others [1]

1) More detailed information on the fillers shall be given in Positions 5 and 6 (see table 12).

Table 10 — Physical form of fillers and reinforcing materials (Position 2)

Code	Morphology
D	Powder
F	Fibre
H	Whisker
S	Spheres
X	No indication

Table 11 — Mass content (Positions 3 and 4)

Code	Weight percentage	
	above	up to
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
CU	Bronze
GR	Graphite
MO	MoS_2 (Molybdenumdisulfide)
OL	Mineral oil
PE	Polyethylene
SI	Silicone
TF	PTFE (Polytetrafluoroethylene)
WS	Tungsten-sulfide or -disulfide, tungsten-selenide

3.5 Data Block 5

Tribological properties (corresponding International Standards are in preparation).

4 Designation examples

A summary of the designation system is given in table 13.

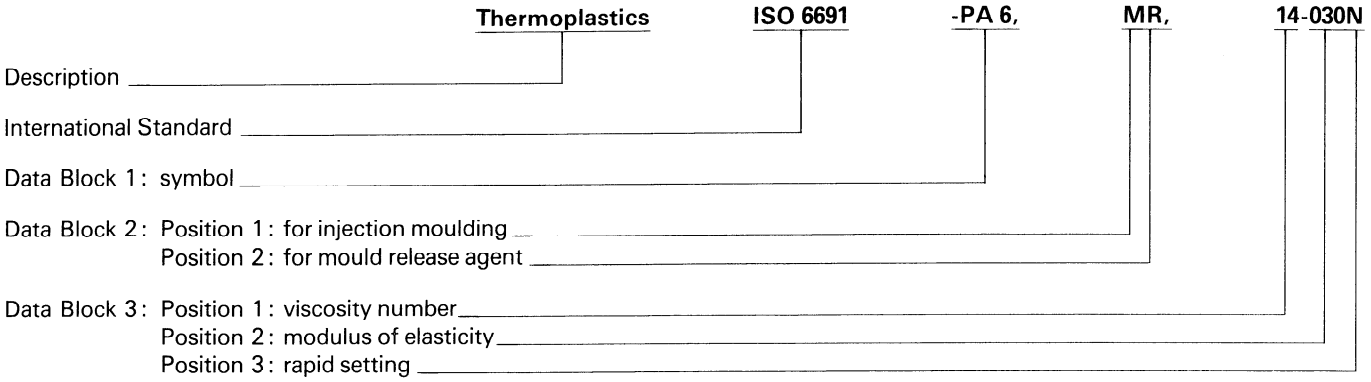
Table 13 — Summary of the designation system

Description Block			Thermoplastics		
International Standard Number Block			ISO 6691		
Individual Item Block	Data Block	Position	Contents	Reference	
				Subclause	Table
	1	—	Symbol of material and, if applicable, symbol of the plasticizer separated by a dash	3.1	1
	2	1	Intended application or method of processing	3.2	2
		2 to 4	Important properties and/or additives	3.2	3
	3	—	Designatory properties	3.3	4 to 8
	4	1	Types of fillers and reinforcing materials	3.4	9
		2	Physical forms of fillers and reinforcing materials	3.4	10
		3 and 4	Mass content of fillers and reinforcing materials	3.4	11
		5 and 6	Additional information	3.4	12
	5[1]	—	Tribological properties for plain bearings	3.5	—

1) See 3.5.

EXAMPLE 1

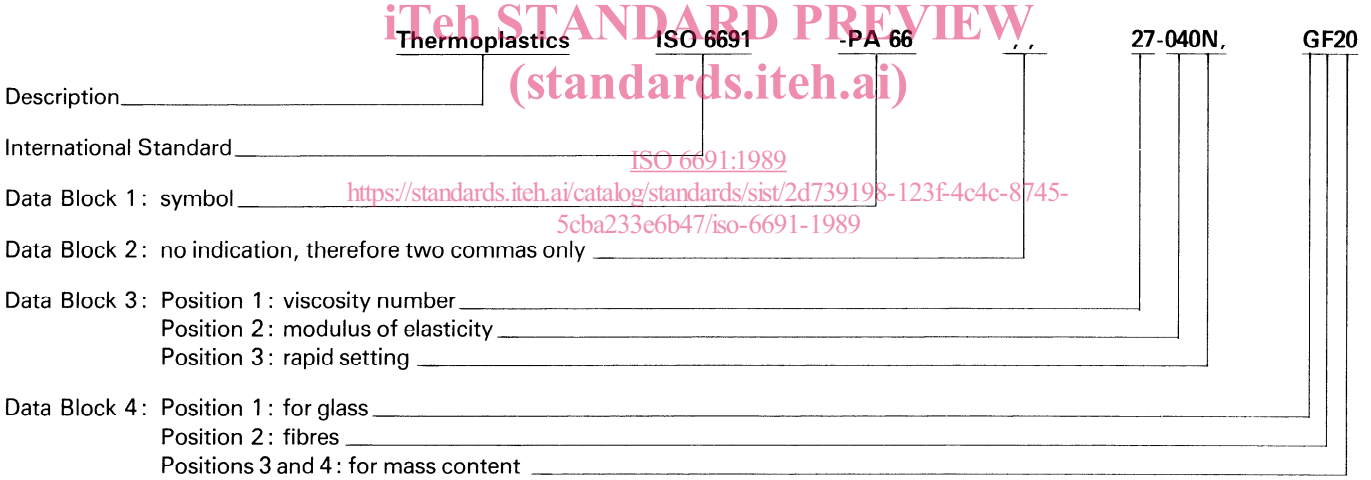
A polyamide 6 (PA 6), for injection moulding (M) with mould release agent (R), having a viscosity number of 140 ml/g (14), a modulus of elasticity of 2 600 N/mm² (030) and rapid setting (N) would be designated:



Designation: ISO 6691-PA 6,MR,14-030N

EXAMPLE 2

A polyamide 66 (PA 66), without indications as to use and additives in Data Block 2, having a viscosity number of 280 ml/g (27), a modulus of elasticity of 4 000 N/mm² (040), rapid setting (N) and 20 % glass fibre (GF20) would be designated:



Designation: ISO 6691-PA 66,,27-040N,GF20

5 Ordering information

Purchaser and supplier shall agree if and which tests are to be carried out.

If mechanical and/or tribological properties are to be tested, it shall be agreed whether such tests be carried out on

a) unmodified parts of the delivered goods;

b) test bars, manufactured from the same batch;

c) test bars taken from a finished part to be supplied, and whether the test shall be carried out parallel or perpendicular to the flow direction and/or machining direction.

Annex A
(informative)

Characteristics and properties of the most common thermoplastics (unfilled)

A.1 Properties and applications of unfilled thermoplastics

Table A.1 gives an outline of the properties and applications of unfilled thermoplastics most commonly used for plain bearings.

Table A.1

Group of thermoplastics (symbol)	General description	Chemical properties	Examples of application
Polyamide (PA)	Impact-resistant material, extraordinarily shock- and wear-resistant, good damping properties. High sliding resistance in dry running. Relatively high moisture absorption.	Resistant to fuels, oils, and greases and to most common solvents. Sensitive to mineral acid even in dilute solution, but not attacked even by strong alkalis. The use of PA 6 and PA 66 in hot water requires formulations that are stabilized against hydrolysis. PA 11 and PA 12 are widely resistant to hydrolysis.	Bearings subjected to shock and vibration. Guide blocks in steel mill couplings. Bushes for brake rods in wagon construction. Bearings for agricultural machinery. Spring eye bushes.
Polyoxymethylene (POM)	Hard material; therefore higher resistance to pressure than polyamide, but more sensitive to shock. Less wear resistant but smaller coefficient of friction than polyamide. Very low moisture absorption.	Resistant to numerous chemicals, above all to organic liquids. Only a few solvents can dissolve POM. Even at high temperatures POM-copolymer withstands strong alkaline solutions such as 50 % NaOH. Chemicals having an oxidizing effect and strong acids (pH < 4) attack POM.	Plain bearings having more severe requirements concerning dimensional stability and coefficient of friction. Good for dry running or deficient lubrication. Plain bearings for fine mechanics, electromechanics and household appliances.
Polyethyleneterephthalate (PET) Polybutyleneterephthalate (PBT)	Hardness similar to that of POM; however, decreases considerably above 70 °C. Up to 70 °C, wear and coefficient of friction very low. Low moisture absorption.	Good weather resistance and high resistance to numerous solvents, oils, greases, and salt solutions. Sufficiently resistant to many acids and alkalis in aqueous solution. Attacked by concentrated inorganic acids and alkalis. Halogenated hydrocarbons such as methylene chloride and chloroform lead to high swelling. Sensitive to hydrolysis at higher temperatures.	Application for plain bearings similar to POM. Mostly for plain bearings at temperatures below 70 °C. Good for dry running and deficient lubrication. Plain bearings for fine mechanics and submerged installations, guide bushes for rods. Plain bearings for oscillating movements.
Polyethylene with ultra high molecular weight (PE-UHMW) High-density polyethylene (PE-HD)	PE-UHMW has high shock resistance. PE-HD has low resistance to permanent pressure. However, it is resistant to shock. About twice the thermal expansion of PA and POM. Excellent wear resistance against abrasive stresses. Good sliding and bedding characteristics. No moisture absorption. Resistant to low temperatures.	At room temperature, PE is inert to water, alkaline solutions, salt solutions, and inorganic acids (except strongly oxidizing acids). At room temperature, polar liquids such as alcohols, organic acids, esters, ketones, and the like only result in slight swelling. Aliphatic and aromatic hydrocarbons and their halogen derivates are absorbed more strongly, resulting in a decrease in strength. After the diffusion of these media, polyethylene can regain its original properties. Non-volatile liquids such as greases, oils, waxes, etc. are less active.	Plain bearings for installation in waters carrying sand. Road and agricultural machinery construction. Bearings for low temperatures. Plain bearings in chemical installations.