Polyamide tubing for use in motor vehicles

DIN 73 378

ICS 23.040.20; 43.040.00

Supersedes December 1990 edition.

Descriptors: Tubes, Motor vehicles, polyamide.

Rohre aus Polyamid für Kraftfahrzeuge

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

Foreword

This standard has been prepared by the *Normenausschuß Kraftfahrzeuge* (Road Vehicles Standards Committee), Technical Committee *Polyamidrohre*.

Amendments

The following amendments have been made to the December 1990 edition.

a) Types PA 6-HIHL, PA 6-HIPHL, PA 6-HIPH, PA 11-PHLY, PA 12-HIPHL, PA 12-HIPH, and PA 12-PHLY moulding materials have been introduced.

b) The use of additional stabilizers to prevent deterioration due to UV radiation has been specified.

c) Symbol HI has been used to indicate that the material contains an impact modifier.

d) The modulus of elasticity has been specified as a criterion of the flexural strength of the material.

e) Specifications for PA 66 type tubes have been dropped.

Previous editions

DIN 73 378: 1973-08, 1975-02, 1990-12.

1 Scope

This standard specifies requirements for and methods of testing polyamide tubing intended for the transport of fuel in motor vehicles. The specifications of this standard take into account the general operating conditions pertaining to motor vehicles. If there is any doubt regarding the suitability of a particular moulding material, this shall be subject to agreement.

Tubes are manufactured by extrusion and, given their single-layer construction, are chiefly used in the low and medium pressure ranges (cf. Explanatory notes).

2 Normative references

This standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the titles of the publications are listed below. For dated references, subsequent amendments to or revisions of any of these publications apply to this standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

DIN 16 773-1
Polyamide (PA) homopolymers for injection moulding and extrusion; classification and designation

DIN 16 773-2
Polyamide (PA) homopolymers for injection moulding and extrusion; preparation of specimens and determination of their properties

DIN 50 011-12
Artificial climates in technical applications; air temperature as a climatological quantity in controlled-atmosphere test installations

DIN 50 014
Artificial climates in technical applications; standard atmospheres

DIN 53 453
Impact testing of plastics by the torsion pendulum test

DIN 53 479
Determination of density of plastics and elastomers

DIN 53 736
Determination of the melting temperature of semicristalline plastics

DIN 53 738
Determination of heat-extractable matter content of plastics

DIN 53 758
Short-term internal hydrostatic pressure test on plastics hollow bodies

DIN 73 377
Fittings for polyamide tubing; insert profiles

DIN 74 323
Coiled tubing for air braking systems

ISO 179:1993
Plastics; determination of Charpy impact strength

Continued on pages 2 to 10.

ISO 1043:1987
Plastics; symbols; basic polymers and their special characteristics

ISO 1874-1:1992
Plastics; polyamide (PA) homopolymers and copolymers for moulding and extrusion; designation

ISO 3310-1:1990
Test sieves; technical requirements and testing; test sieves of metal wire cloth

3 Concepts

3.1 Stress utilization factor

The stress utilization factor is a measure of the utilization of the basic stress at a temperature of 23 °C.

NOTE: The stress utilization factors specified in table 6 refer to the actual basic stress.

3.2 Basic stress

The basic stress, σ_{vE}, in N/mm^2, is the stress sustained during continuous operation without failure of the tubing wall when exposed to a fluid under static stress. It is to be calculated using the following formula:

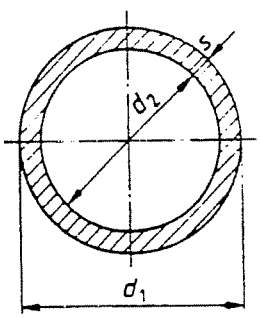

Figure 1

$$\sigma_{vE} = \frac{p_B \cdot d_m}{20s} \text{ in N/mm}^2 \qquad (1)$$

where

p_B is the bursting pressure, in bar;
d_m (= $d_1 - s_1$) is the mean tube diameter;
d_1 is the tubing outside diameter;
s is the tubing wall thickness.

3.3 Impact energy

The impact energy is the energy determined by means of an impact bending test. It is used for assessing the brittleness or toughness of the material.

4 Designation

Designation of tubing of nominal size 12,5 × 1,25, made from black (sw) polyamide moulding material of type PA 11-P, EHL, 22-004 (PA 11-PHL):

Tubing DIN 73 378–12,5 × 1,25–PA 11-PHL–sw

5 Requirements

5.1 Dimensions, mass and working pressures

See table 3.

5.2 Materials

5.2.1 Moulding materials

Tubing as specified in this standard shall be made from the moulding materials listed in table 1, the choice being based on the particular application.

5.2.1.1 Stabilization

Tubing may be stabilized against UV radiation by adding stabilizers or carbon black (designated by the letter L, as in DIN 16 773-1), the most effective method being the addition of carbon black.

Resistance to heat ageing shall be identified by the symbol H, as in DIN 16 773-1.

5.2.1.2 Colour

The standard colours of tubing are natural (nf) or black (sw), other colours being subject to agreement (bl = blue; gn = green; rt = red; ge = yellow).

5.2.2 Density

The density of PA moulding materials is given in table 7.

5.2.3 Melting temperature

The melting temperature of PA moulding materials is given in table 7.

5.2.4 Water content on delivery

PA 6 tubing shall, on delivery, have the water content specified in table 7, without any additives.

5.2.5 Extractable matter

Extractable matter may consist of monomers, oligomers, stabilizers, water and plasticizers, and shall be soluble when tested as described in subclause 6.4.4 (see table 7).

5.3 Workmanship

Tubing shall be free from defects, such as blisters, shrinkholes, voids, striated surfaces, inhomogeneities and impurities, which might impair its performance. The colour of the tubing shall be uniform throughout.

5.4 Properties

5.4.1 Pressure rating

Polyamide tubing is rated for the allowable working pressures specified in table 3. The values refer to tubing exposed to static and dynamic internal stress and assume tubing of nominal size and subjected to the basic stress, σ_v, specified in table 4. Unlike the $\sigma_{v\,min}$ values given in table 7, the σ_v values include a safety factor of 3.

5.4.2 Stress utilization factor

See table 6.

5.4.3 Basic stress

For values for basic stress, see table 7. When tested in accordance with subclause 6.4.5, the materials shall undergo no brittle fracture.

5.4.4 Impact strength

When tested in accordance with subclause 6.4.6, the impact energy shall comply with the values given in table 7. Tubing that has undergone testing without fracturing or incipient cracking shall be deemed to have passed the test, regardless of the actual impact energy measured.

5.4.5 Thermal stability

Tubing shall be thermally stable. This requirement shall be deemed satisfied if the requirements specified in subclause

Table 1: Polyamide moulding materials

Moulding material[1]) (as in DIN 16773-1)	Symbol	Description[2])
PA 6, E, 27-030	**PA 6**	Polymer of ε-caprolactam, expandable
PA 6-EH, 27-030	**PA 6-H**	Polymer of ε-caprolactam, expandable, heat-ageing stabilized
PA 6-HI, EHL, 18-020, N	**PA 6-HIHL**	Polymer of ε-caprolactam, expandable, heat-ageing stabilized, light stabilized, impact-modified, nucleated
PA 6-HIP, EHL, 32-005	**PA 6-HIPHL**	Polymer of ε-caprolactam, plasticized, expandable, impact-modified, heat-ageing and light stabilized
PA 6-HIP, EH, 32-005	**PA 6-HIPH**	Polymer of ε-caprolactam, plasticized, expandable, heat-ageing stabilized, impact-modified
PA 11-P, E, 22-004	**PA 11-P**	Polymer of 11-aminoundecanoic acid, plasticized, expandable
PA 11-P, EH, 22-004	**PA 11-PH**	Polymer of 11-aminoundecanoic acid, plasticized, expandable, heat-ageing stabilized
PA 11-P, EHL, 22-004	**PA 11-PHL**	Polymer of 11-aminoundecanoic acid, plasticized, expandable, heat-ageing and light stabilized
PA 11-P, EHL, 22-005	**PA 11-PHLY**	As for PA 11-PHL, but suitable for elevated pressures
PA 11, E, 22-010	**PA 11**	Polymer of 11-aminoundecanoic acid, unplasticized, expandable
PA 11, EH, 22-010	**PA 11-H**	Polymer of 11-aminoundecanoic acid, unplasticized, expandable, heat-ageing stabilized
PA 11, EHL, 22-010	**PA 11-HL**	Polymer of 11-aminoundecanoic acid, unplasticized, expandable, heat-ageing and light stabilized
PA 12-P, E, 22-004	**PA 12-P**	Polymer of Ω-dodecanolactam, plasticized, expandable
PA 12-P, EH, 22-004	**PA 12-PH**	Polymer of Ω-dodecanolactam, plasticized, expandable, heat-ageing stabilized
PA 12-P, EHL, 22-004	**PA 12-PHL**	Polymer of Ω-dodecanolactam, plasticized, expandable, heat-ageing and light stabilized
PA 12-P, EHL, 22-005	**PA 12-PHLY**	As for PA 12-PHL, but suitable for elevated pressures
PA 12-HIP, EHL, 22-004	**PA 12-HIPHL**	Polymer of Ω-dodecanolactam, plasticized, expandable, heat-ageing and light stabilized, impact-modified
PA 12-HIP, EH, 22-004	**PA 12-HIPH**	Polymer of Ω-dodecanolactam, plasticized, expandable, heat-ageing stabilized, impact-modified
PA 12, E, 22-010	**PA 12**	Polymer of Ω-dodecanolactam, unplasticized, expandable
PA 12-EH, 22-010	**PA 12-H**	Polymer of Ω-dodecanolactam, unplasticized, expandable, heat-ageing stabilized
PA 12-EHL, 22-010	**PA 12-HL**	Polymer of Ω-dodecanolactam, unplasticized, expandable, heat-ageing and light stabilized

[1]) The codes identifying the viscosity number ranges represent minimum requirements.
[2]) Cf. ISO 1043 and ISO 1874-1.

5.4.4 continue to be met following heat ageing in accordance with subclause 6.4.7.

5.4.6 Stiffness

The pipe stiffness shall be assessed by determining the modulus of elasticity, which shall be as specified in table 7.

Table 2: Test classes

Property (Requirement)	Test class	
	A	B
Density (cf. table 7)	×	–
Melting temperature (cf. table 7)	×	–
Workmanship (cf. subclause 5.3)	×	×
Water content (cf. table 7)	×	×
Extractable matter (cf. subclause 5.2.5 and table 7)	×	–
Basic stress (cf. table 7)	×	×
Impact strength (cf. table 7)	×	×
Thermal stability [1] (cf. subclause 5.4.5)	×	–
Modulus of elasticity (cf. table 7)	×	–
Dimensions (cf. table 3)	×	×
Marking (cf. clause 8)	×	×
[1] Applies only to thermally stabilized moulding materials.		

6 Testing

6.1 Test classes

Tubing is to be subjected to type testing (test class A) and/or to in-process testing as part of the quality control procedures (test class B), as specified in table 2.

6.2 Sampling and number of samples

Testing shall be performed either on the tubing itself or specimens taken from the tubing.

One specimen each shall be used for determining the properties specified in subclauses 5.2.2, 5.2.3, 5.2.4 and 5.2.5 and five specimens each for determining the properties specified in subclauses 5.4.2, 5.4.3 and 5.4.4.

6.3 Time of testing

Unless otherwise specified, testing shall be carried out in DIN 50 014 – 23/50-2 standard atmosphere, not earlier than 24 hours after manufacture. It shall be ensured that, on testing, the water content of the tubing material is that of the as-moulded state (as specified in table 7). To this effect, suitable packaging and storage conditions are to be agreed upon between supplier and customer.

6.4 Procedure

6.4.1 Density

The density shall be tested as specified in DIN 53 479, at a temperature of 23 °C.

6.4.2 Melting temperature

Testing of the melting temperature shall be carried out in accordance with method B1 as specified in DIN 53 736.

6.4.3 Water content

For unplasticized tubing, a section of tubing is to be dried at 105 °C in an oven as specified in DIN 50 011 – 12 for 48 hours. The resulting loss in mass shall be taken as being equivalent to the water content to within 0,2 % (absolute).

6.4.4 Extractable matter

Testing for extractable matter shall be carried out in accordance with DIN 53 738, method A, for a period of (18 ± 1) h.

The specimen material in its as-delivered condition shall be reduced in size by means of suitable tools such as scissors, a saw, a mill, or a pencil sharpener, the particle size used for extraction being not less than 500 µm and not exceeding 3,15 mm (to be determined using test sieves as specified in ISO 3310-1). Ethanol shall be used as the extraction liquid.

6.4.5 Basic stress

Testing shall be carried out as described in DIN 53 758, mineral oil, silicone oil, or water etc. being used as the stress transmission agent. The sample tubing, including any fittings and valves, shall be conditioned by immersing it in an inert fluid such as polyglycol (with a molar mass of 400 g/mol) or silicone oil brought to test temperature.

The stress shall be applied one hour after immersion.

Evaluation of the test results shall comply with the specifications of clause 6 of DIN 53 758.

The basic stress shall then be determined in accordance with subclause 3.2.

For each type of tubing and for each desired temperature, five σ_v values shall be determined and their mean plotted as a function of temperature. The curves thus obtained may be used for assessing the stress utilization factor at elevated temperatures as compared with that at 23 °C.

6.4.6 Impact strength

Testing shall be carried out as described in DIN 53 453 (cf. ISO 179), with the following deviations:

a) the velocity shall be 3,6 to 4 m/s (preferably, 3,8 m/s) and the energy 7,5 J (see Explanatory notes);

b) the specimens shall be flat sections of tubing, at least 50 mm long;

c) the test temperatures shall be (23 ± 2) °C and (−40 ± 3) °C.

For testing at −40 °C, the specimens shall be conditioned for at least one hour at that temperature and, within 5 s of being placed on the supports of the testing machine (with a spacing of 40 mm), subjected to impact testing. The energy absorbed by the specimen shall be recorded.

Tests in which the specimen does not fracture shall count as passed, regardless of the actual impact energy measured.

6.4.7 Thermal stability

The thermal stability shall be established by testing the impact strength in accordance with subclause 6.4.6 at (23 ± 2) °C, after the specimens have been conditioned for (70 ± 2) hours at a temperature of (150 ± 2) °C in an oven with forced circulation, followed by cooling in a desiccator to (23 ± 2) °C.

NOTE: The purpose of this test is to examine the material for the presence of any stabilizer.

Table 3: Dimensions (in mm) and guideline values for allowable working pressure

Nominal size	d_1 [1]		d_2 [1]		s [1]	Allowable working pressure at 23 °C, in bar												
						PA 6, PA 6-H	PA 6-HIHL	PA 6-HIPHL	PA 6-HIPH	PA 11-P, PA 11-PH, PA 11-PHL	PA 11-PHLY	PA 11, PA 11-H, PA 11-HL	PA 12-P, PA 12-PH, PA 12-PHL	PA 12-PHLY	PA 12-HIPH, PA 12-HIPHL			PA 12, PA 12-H, PA 12-HL
$d_1 \times s_{nom}$		Limit deviations		Limit deviations	min.										Type 1	Type 2	Type 3	
4 × 0,75	4	±0,1	2,5	±0,2	0,65	46	38	34	31	31	42	62	31	42	34	38	38	62
4 × 0,85	4	±0,1	2,3		0,75	54	–	–	–	36	49	72	36	49	40	45	45	72
4 × 1	4	±0,1	2,0		0,90	67	56	49	45	44	60	89	44	60	49	56	56	89
5 × 1	5	±0,1	3,0		0,90	50	42	37	34	33	45	67	33	45	37	42	42	67
6 × 1	6	±0,1	4,0		0,90	40	33	29	27	27	36	53	27	36	29	33	33	53
6 × 1,5	6	±0,1	3,0		1,35	–	56	49	45	44	60	89	44	60	49	56	56	89
6 × 2	6	±0,1	2,0		1,80	–	83	73	67	67	90	133	67	90	73	83	83	133
8 × 1	8	±0,1	6,0		0,90	29	24	21	19	19	26	38	19	26	21	24	24	38
8 × 1,25	8	±0,1	5,5		1,12	37	31	27	25	25	33	49	25	33	27	31	31	49
8 × 1,5	8	±0,1	5,0		1,35	46	38	34	31	31	42	62	31	42	34	38	38	62
8 × 2	8	±0,15	4,0		1,80	–	56	49	45	44	66	89	44	60	49	56	56	89
9 × 1,5	9	±0,15	6,0		1,35	–	33	29	27	27	36	53	27	36	29	33	33	53
10 × 1	10	±0,1	8,0		0,90	–	19	16	15	15	20	30	15	20	16	19	19	30
10 × 1,25	10	±0,12	7,5		1,12	–	–	–	–	19	26	38	19	26	21	24	24	38
10 × 2	10	±0,15	6,0	±0,3	1,80	–	42	37	34	33	45	67	33	45	37	42	42	67
11 × 1,5	11	±0,15	8,0		1,35	–	26	23	21	21	28	42	21	28	23	26	26	42
12 × 1,5	12	±0,15	9,0		1,35	29	24	21	19	19	26	38	19	26	21	24	24	38
12 × 2	12	±0,15	8,0		1,80	–	33	29	27	27	36	53	27	36	29	33	33	53
12,5 × 1,25	12,5	±0,15	10,0		1,12	–	19	16	15	15	20	30	15	20	16	19	19	30
14 × 2	14	±0,15	10,0		1,80	–	–	–	–	22	30	44	22	30	24	28	28	44
15 × 1	15	±0,15	13,0		0,90	–	12	11	10	10	13	19	10	13	10	12	12	19
15 × 1,5	15	±0,15	12,0		1,35	22	19	16	15	15	20	30	15	20	16	19	19	30
16 × 2	16	±0,15	12,0		1,80	29	–	–	–	19	26	38	19	26	21	24	24	38
18 × 2	18	±0,15	14,0		1,80	–	21	19	17	17	23	33	17	23	18	21	21	33
20 × 2	20	±0,15	16,0		1,80	–	19	16	15	15	20	30	15	20	16	19	19	30

s_{nom} is the nominal wall thickness.

[1]) Limit deviations specified for the outside diameter, inside diameter and wall thickness cannot all be met and coaxiality ensured at the same time.

Table 4: Basic stress

Material	PA 6 PA 6-H	PA 6-HIHL	PA 6-HIPHL	PA 6-HIPH	PA 11-P, PA 11-PH, PA 11-PHL	PA 11-PHLY
Basic stress*), σ_v, in N/mm^2	10	8,3	7,3	6,7	6,7	9,0

Material	PA 11, PA 11-H, PA 11-HL	PA 12-P, PA 12-PH, PA 12-PHL	PA 12-PHLY	PA 12-HIPH, PA 12-HIPHL			PA 12, PA 12-H, PA 12-HL
				Type 1	Type 2	Type 3	
Basic stress*), σ_v, in N/mm^2	13,3	6,7	9,0	7,3	8,3	8,3	13,3

*) The σ_v values given for the basic stress of PA 6 types are based on a water content as specified in table 7.

7 Form supplied

Tubing shall be supplied in rolls, bundles or fixed lengths. Other forms (e.g. hot-formed tubing or tubing with branches) shall be the subject of agreement.

8 Marking

Tubing in compliance with clause 5, irrespective of the form supplied, shall be provided with a label giving the following information: DIN symbol and DIN number, outside diameter and wall thickness, symbol as in table 1, code identifying the colour (cf. subclause 5.2.1.2), the length, in m, and the manufacturer's symbol.

Example:

DIN 73 378 – 12,5 × 1,25 – PA 11-PHL – sw – 5 m (manufacturer's symbol)

Furthermore, the tubing shall have a marking printed on it at intervals of 350 mm maximum. This marking shall have no detrimental effect on the mechanical properties and shall give the following information: DIN symbol and number, outside diameter, wall thickness, symbol as in table 1, and manufacturer's symbol.

Example:

DIN 73 378 – 12,5 × 1,25 – PA 11-PHL (manufacturer's symbol)

Table 5: Mass and density of tubing (guideline values) (mass given in kg/100 m and density in kg/dm³)

Nominal size	PA 6, PA 6-H[1]		PA 6-HIHL[1]		PA 6-HIPHL[1]		PA 6-HIPH[1]		PA 11-P, PA 11-PH, PA 11-PHL		PA 11-PHLY		PA 11, PA 11-H, PA 11-HL		PA 12-P, PA 12-PH, PA 12-PHL		PA 12-PHLY		PA 12-HIPH, PA 12-HIPHL		PA 12, PA 12-H, PA 12-HL	
$d_1 \times s_{nom}$	Mass[2]	Density	Mass[2]	Density	Mass[2]	Density	Mass[2]	Density	Mass	Density	Mass	Density	Mass	Density	Mass	Density	Mass	Density	Mass	Density	Mass	Density
4 × 0,75	0,87		0,82		0,82		0,86		0,80		0,80		0,79		0,79		0,78		0,79		0,77	
4 × 0,85	0,95		–		–		–		0,88		0,87		0,87		0,87		0,86		0,87		0,85	
4 × 1	1,07		1,00		1,01		1,06		0,99		0,98		0,97		0,97		0,96		0,97		0,95	
5 × 1	1,42		1,33		1,34		1,41		1,32		1,31		1,29		1,29		1,28		1,29		1,27	
6 × 1	1,78		1,67		1,69		1,76		1,65		1,63		1,62		1,62		1,60		1,62		1,59	
6 × 1,5	–		2,25		2,27		2,38		2,23		2,20		2,18		2,18		2,16		2,18		2,14	
6 × 2	–		2,66		2,69		2,81		2,64		2,61		2,59		2,59		2,56		2,59		2,54	
8 × 1	2,49		2,34		2,36		2,47		2,31		2,29		2,26		2,26		2,24		2,26		2,22	
8 × 1,25	3,00		2,81		2,84		2,97		2,78		2,76		2,73		2,73		2,70		2,73		2,68	
8 × 1,5	3,46		3,25		3,28		2,43		3,21		3,18		3,15		3,15		3,12		3,15		3,09	
8 × 2	–		4,00		4,03		4,22		3,96		3,92		3,88		3,88		3,84		3,88		3,81	
9 × 1,5	–		3,74		3,78		3,95		3,71		3,67		3,64		3,64		3,60		3,64		3,57	
10 × 1	–	1,13	3,00	1,06	3,03	1,07	3,17	1,12	2,97	1,05	2,94	1,04	2,91	1,03	2,91	1,03	2,88	1,02	2,91	1,01	2,85	1,01
10 × 1,25	–		–		–		–		3,61		3,57		3,54		3,54		3,50		3,54		3,47	
10 × 2	–		5,33		5,38		5,63		5,28		5,23		5,17		5,17		5,12		5,17		5,07	
11 × 1,5	–		4,75		4,79		5,01		4,70		4,65		4,61		4,61		4,56		4,61		4,52	
12 × 1,5	5,59		5,24		5,29		5,54		5,19		5,14		5,09		5,09		5,04		5,09		5,00	
12 × 2	–		6,66		6,72		7,04		6,59		6,53		6,47		6,47		6,41		6,47		6,34	
12,5 × 1,25	–		4,68		4,73		4,95		4,64		4,59		4,55		4,55		4,50		4,55		4,46	
14 × 2	–		–		–		–		7,91		7,84		7,76		7,76		7,69		7,76		7,61	
15 × 1	–		4,66		4,71		4,93		4,62		4,57		4,53		4,53		4,48		4,53		4,44	
15 × 1,5	7,19		6,74		6,81		7,13		6,68		6,61		6,55		6,55		6,49		6,55		6,42	
16 × 2	9,44		–		–		–		9,23		9,14		9,06		9,06		8,97		9,06		8,88	
18 × 2	–		10,66		10,76		11,26		10,55		10,45		10,35		10,35		10,25		10,35		10,15	
20 × 2	–		11,99		12,10		12,66		11,87		11,76		11,64		11,64		11,53		11,64		11,42	

[1]) Based on a water content of (2,5 ± 0,5) %.

[2]) Calculated for the nominal size and specified average density.

Table 6: Stress utilization factor (guideline values)

Temperature, in °C	Stress utilization factor, as a percentage							
	PA 6, PA 6-H	PA 6-HIHL, PA 6-HIPH, PA 6-HIPHL	PA 11, PA 11-H, PA 11-HL, PA 12, PA 12-H, PA 12-HL	PA 11-P, PA 11-PH, PA 11-PHL, PA 12-P, PA 12-PH, PA 12-PHL	PA 11-PHLY*), PA 12-PHLY	PA 12-HIPH, PA 12-HIPHL		
						Type 1	Type 2	Type 3
−60 to +23	100	100	100	100	100	100		
−60 to +30	83	80	81	87	85	83		
−60 to +40	71	62	61	74	73	71		
−60 to +50	58	55	50	64	65	62		
−60 to +60	54	49	44	57	59	55		
−60 to +70	51	46	39	52	54	49		
−60 to +80[1])	48	43	34	47	50	45		
−60 to +90	46	41	31	44	47	41		
−60 to +100	41	39	28	40	43	37		
−60 to +110	36	36	26	36	39	34		
−60 to +120	33	33	23	33	35	31		
−60 to +130	30	29	21	30	31	29		

[1]) For service temperatures above 80 °C, tubing should generally be made from heat-ageing stabilized moulding materials. Where tubing is intended to be exposed to direct solar radiation, the addition of carbon black to the moulding material is highly recommended.

*) For this material, the values are to be considered provisional. They will be reviewed once sufficient experience has been gained.

Table 7: Requirements for tubing

Property	PA 6, PA 6-H	PA 6-HIHL	PA 6-HIPHL	PA 6-HIPH	PA 11-P, PA 11-PH, PA 11-PHL	PA 11, PA 11-H, PA 11-HL	PA 11-PHLY	PA 12-P, PA 12-PH, PA 12-PHL	PA 12-PHLY	PA 12-HIPH, PA 12-HIPHL			PA 12, PA 12-H, PA 12-HL	Testing as in
										Type 1	Type 2	Type 3		
Density, in kg/dm^3	1,12 to 1,14	1,05 to 1,07	1,06 to 1,08	1,11 to 1,13	1,04 to 1,06	1,02 to 1,04	1,03 to 1,05	1,02 to 1,04	1,01 to 1,03	1,01 to 1,04	1,01 to 1,04	1,02 to 1,04	1,00 to 1,02	DIN 53 479
Melting temperature ($\pm$ 5 °C), in °C	220	220	214	214	182	186	184	172	174	172	172	185	176	DIN 53 736, method B1
Water content (as-moulded), as a percentage by mass	2,5 $\pm$ 0,5	2,0 $\pm$ 0,5	2,0 $\pm$ 0,5	2,5 $\pm$ 0,5	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	subclause 6.4.3
Extractable matter, as a percentage by mass	$\leq$ 5	$\leq$ 5	10 $\pm$ 2	17 $\pm$ 2	14 $\pm$ 2	$\leq$ 4	9 $\pm$ 2	14 $\pm$ 2	9 $\pm$ 2	12 $\pm$ 2	8 $\pm$ 2	8 $\pm$ 2	$\leq$ 4,0	subclause 6.4.4
Minimum basic stress, $\sigma_{v\,min}$, at 23 °C, in N/mm^2	30	25	22	20	20	40	27	20	27	22	25	25	40	subclause 6.4.5
Minimum impact energy, in J, at (23 $\pm$ 2) °C	No fracture													subclause 6.4.6
Minimum impact energy, in J, at ($-$40 $\pm$ 3) °C	1	No fracture	No fracture	No fracture	6	6	No fracture	6	No fracture	No fracture	No fracture	No fracture	6	
Modulus of elasticity of specimens in the as-moulded state (as in DIN 16 773-1), at 23 °C, in N/mm^2	> 2 500 $\leq$ 3 500	> 1 500 $\leq$ 2 500	> 450 $\leq$ 600	> 450 $\leq$ 600	> 350 $\leq$ 450	> 800 $\leq$ 1 500	> 450 $\leq$ 600	> 350 $\leq$ 450	> 450 $\leq$ 600	> 350 $\leq$ 450	> 400 $\leq$ 500	> 350 $\leq$ 450	> 800 $\leq$ 1 500	DIN 16 773-2

[1] Water content irrelevant.

Explanatory notes

Preparation of this standard was prompted by the way in which polyamide tubing has found widespread use in the last few years for fuel lines, lubricant pipes, piping for fluid power systems, compressed air pipes, etc. In the past, such tubing was made of metal or rubber.

Attention is drawn to the fact that tubing made from PA 6-type moulding materials has a moisture content in the as-delivered condition which may drop under the effect of elevated service temperatures and low humidity, reducing the tubing's toughness and possibly leading to impaired performance if the tubing is exposed to sudden, dynamic stress (such as may be the case with diesel engines). A similar situation may also arise at low temperatures.

Tubing made from PA 6-type moulding materials should not be used in conjunction with parts containing zinc which are likely to come into contact with de-icing salts or other substances releasing zinc ions.

Polyamide tubing should also be protected against battery acids.

Due consideration should be given to the risk of some paints, varnishes and solvents causing damage to the tubing.

Tubing of types PA 11 P, PA 11-PH, PA 11-PHL, PA 12-P, PA 12-PH, PA 12-PHL, PA 12-HIPHL, PA 12-HIPH, PA 6-HIHL, PA 6-HIPHL, and PA 6-HIPH of a smaller size can mostly be laid without pre-bending being required. In other cases, pre-bending at elevated temperatures using suitable tools may prove necessary.

For tubing subjected to stress, connectors as specified in DIN 73 377 have generally been found suitable.

The guideline values for working pressures and stress utilization factors given in tables 3 and 6 are based on experience. They may need to be substantiated as and when required.

Finally, it should be noted that the impact energy values specified in table 7 are based on testing using a pendulum working with an energy of 7,5 J. An agreement between manufacturer and user should be reached on this as and when required.

Other relevant standards

DIN 16 982 Dimensions of polyamide (PA) tubes