UDC 621.643.2-034.14 : 620.197.6-036.742
: 628.1/.3 : 662.76

DEUTSCHE NORM

October 199

Polypropylene coatings for steel pipes

DIN 30678

Umhüllung von Stahlrohren mit Polypropylen

[redacted]-CONTROLLED

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.

This standard has been jointly prepared by *DIN Deutsches Institut für Normung e. V.* and *DVGW Deutscher Verein des Gas- und Wasserfaches e. V.* (German Gas and Water Engineers' Association) and has been adopted into the DVGW Codes of practice on gas and water.

Dimensions in mm

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1 Scope and field of application

This standard specifies requirements for and methods of testing extruded polypropylene coatings applied at the works to DIN 2448 or DIN 2458 steel pipes that will be in contact with soil or water. The pipes thus coated may be exposed to direct sunlight for a period of up to one year, with no additional protection being necessary.

This standard is intended to be used for quality assurance purposes.

The service life of the coatings as covered here is a function of the operating temperatures to which they are exposed (cf. table 1).

Table 1: Service life of coatings

Operating temperature, in °C	Minimum expected service life, in years
23	50
60	50
80	30
90	15
100	8
Where coatings are used at alternating temperatures, their expected service life shall be extrapolated from the values given above.	

2 Concepts

Relevant concepts are specified in DIN 30670 and DIN 53383 Part 1.

3 Designation

A polypropylene (PP) coating in compliance with this standard shall be designated:

Coating DIN 30678 – PP

4 Requirements

4.1 Requirements for substrate

4.1.1 Immediately prior to application of the coating, the surface of the steel pipe (substrate) shall be clean (i.e. free from dirt, oil, grease, welding beads, moisture) and blasted to comply with standard preparation grade Sa 2½ as defined in DIN 55928 Part 4.

4.2 Requirements for coating

4.2.1 Minimum thickness

The minimum coating thickness shall be as specified in table 2 (cf. subclause 5.3.1).

Continued on pages 2 to 6

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Sales No. 010

Table 2: Minimum coating thickness

Nominal size (DN)	Minimum coating thickness, in mm
Up to 100	1,[redacted]
125 to 250	2,0
300 to 500	2,2
600 or more	2,5

Along any 1 m length of pipe, the coating thickness may be up to 10% less than the minimum required, provided the thinner area does not cover more than 5 cm^2.

The ends of pipes less than DN 500 in size shall be free from adhesive over a length of 50 mm, those of at least DN 500 in size, over a length of 100 mm, unless otherwise specified by the purchaser.

The length of uncoated pipe ends shall not exceed 150 mm, unless otherwise specified by the purchaser.

4.2.2 Continuity

The coating shall be continuous (i.e. free from pinholes). This requirement shall be deemed satisfied if no breakdown in the coating occurs during spark testing (cf. subclause 5.3.2).

★ #### 4.2.3 Bond strength

When the coating is tested as specified in subclause 5.3.3, not more than 24 hours after application, the mean force required to lift it off shall

a) at a test temperature of (50 ± 5) °C, be at least 100 N per cm of test piece width,

b) at a test temperature of (90 ± 5) °C, be at least 80 N per cm of test piece width.

4.2.4 Impact strength

When tested in accordance with subclause 5.3.4, the coating shall withstand 30 impacts without any electrical breakdown occurring.

★ #### 4.2.5 Indentation hardness

When tested in accordance with subclause 5.3.5, the indentation depth shall not exceed 0,3 mm at a temperature of (90 ± 5) °C.

★ #### 4.2.6 Percentage elongation at failure

When tested in accordance with subclause 5.3.6, the percentage elongation at failure shall be at least 300% at a temperature of (23 ± 2) °C.

4.2.7 Coating resistivity

When tested in accordance with subclause 5.3.7, the coating resistivity, determined after conditioning the test piece in the test medium for 100 days, shall be not less than 10^{10} Ω m².

The ratio of resistivity after 100 days to that after 70 days shall be not less than 0,8, provided the resistivity after 70 days is only one power of 10 above that specified for 100 days of conditioning.

4.2.8 Heat ageing resistance

When tested in accordance with subclause 5.3.8, the coating shall not have become brittle.

5 Testing

5.1 General

Testing may be carried out by the manufacturer or by a recognized test house.

The manufacturer shall be responsible for ensuring compliance with the requirements specified in subclauses 4.1.1, 4.1.2 and 4.2.1 to 4.2.3.

For each coating material and application process, the manufacturer shall provide proof of compliance with the requirements specified in subclauses 4.2.4 to 4.2.8 at intervals of at least three years.

5.2 Inspection documents

Issuing a DIN 50 049 inspection document shall be the subject of agreement.

5.3 Procedure

5.3.1 Coating thickness

The coating thickness shall be measured at points uniformly distributed along the length and about the circumference of the pipe, using a non-destructive (e.g. magnetic) method which permits measurements to be made to an accuracy of 10%.

5.3.2 Continuity

The coating shall be tested for continuity by means of spark testing, using commercially available high voltage equipment complying with DIN VDE 0433 Part 2, the voltage of which is discharged via a sphere spark gap. The test voltage shall be 25 kV. The electrode (e.g. metal brush) shall be in contact with the coating surface, since any air gap would falsify results.

When a fault is present, a spark will be seen, or the test equipment will emit a signal.

Note. Spark testing is intended to reveal any discontinuities in the coating, not to test the breakdown resistance of a continuous coating.

5.3.3 Bond strength

The bond strength of the coating shall be determined by means of testing using one of the test assemblies illustrated in figures 1 and 2 or equivalent equipment. The coating shall be peeled off at right angles to the pipe surface at a rate of 10 mm/min. Three samples each shall be tested at a temperature of (50 ± 5) °C. If one of the samples fails to meet the requirements, the test shall be repeated on five further samples, none of which shall fail.

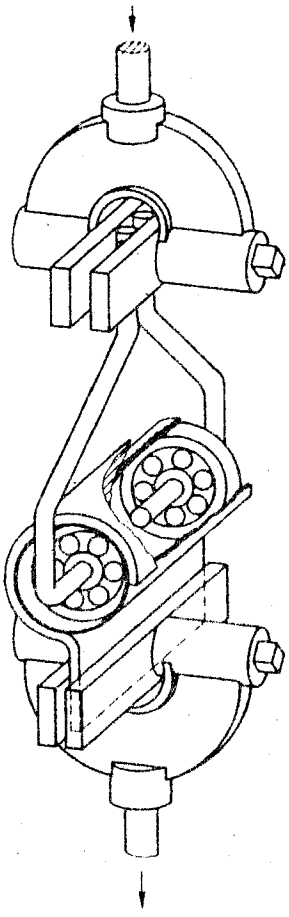
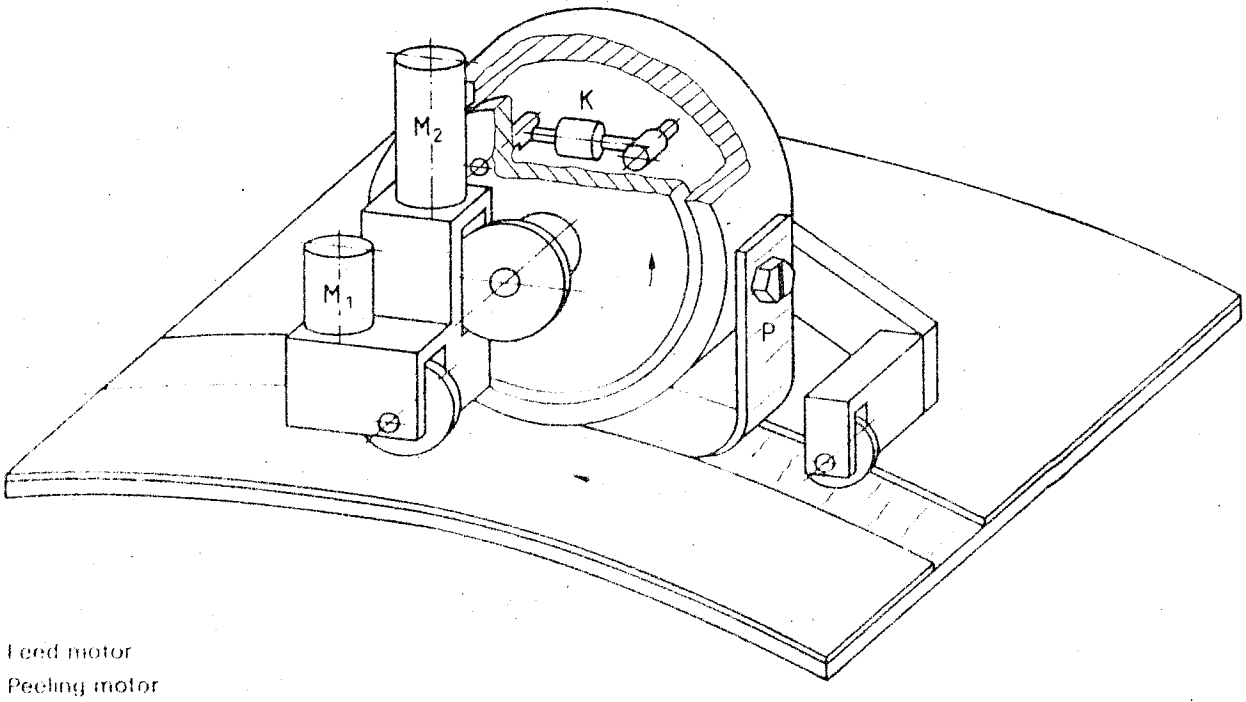


Figure 1: Type 1 test assembly for determining bond strength (taken from the April 1991 edition of DIN 30 670)



M_1 Feed motor
M_2 Peeling motor
K Dynamometer
P Test strip

Figure 2: Type 2 test assembly for determining bond strength (taken from DIN 30 670)

Using a twin motor saw, an incision shall be made in the coating, at least 20 mm but not more than 50 mm wide, in the direction of the pipe circumference, down to the substrate, and another incision made at right angles to the cuts just made. The test piece so obtained shall be gripped, and a length of about 20 mm lifted from the pipe surface. Disregarding the first and last 20 mm of test strip, the force used to lift off the strip shall be continuously recorded using, for example, a dynamometer. The mean result obtained shall be expressed in N. Any test strip section (defined as being 25 mm in length) for which the mean force applied (in the peeling mode) is more than 25 % lower than the value specified in subclause 4.2.3 shall not be included in the evaluation.

For testing at (50 ± 5) °C (and (90 ± 5) °C), the sample shall be incised as described above and heated to about 60 °C (or 100 °C). The temperature of the external surface of the test piece shall be continuously monitored using, for example, a fast-response contact thermometer. Measurements shall start being recorded as soon as the temperature has dropped to 55 °C (or 95 °C), and the test completed before it reaches 45 °C (or 85 °C).

3.4 Impact strength

In the impact test, a sphere with a diameter of 25 mm shall be dropped onto the sample, which shall be supported so that it does not yield under the impact of the falling weight.

The test temperature shall be (0 ± 2) °C, and the drop height approximately 1 m. The impact energy, E, shall be equal to (5φ) J per mm of coating thickness, with a tolerance of 5 %. The factor φ (cf. table 2) accounts for the curvature of the pipe, it being permissible to reduce the impact energy by this amount by reducing the mass of the falling weight or the drop height.

Table 3: Factor φ

Nominal size (DN)	φ
Up to 65	0,7
80 to 150	0,85
200 or more	1,0

The falling weight shall be guided so as to minimize friction and so that the direction of fall is normal to the pipe surface.

The pipe shall be subjected to impact 30 times, the distance between two points of impact being at least 30 mm. Following that, a test voltage of 25 kV shall be applied, and it shall be checked whether breakdown occurs.

5.3.5 Indentation hardness

Indentation hardness testing shall be carried out on three test pieces, taken from coating not more than 2 mm thick, which has been removed from the pipe and freed of adhesive. (It may be necessary to abrade the reverse side of the test piece to obtain the required thickness.) If one of the test pieces fails to meet the requirements, the test shall be repeated on five further test pieces, none of which shall fail.

The indentor shall be a 250 g metal rod to which an additional weight can be attached. A metal pin with a flat face, 1,8 mm in diameter (or 2,5 mm² in area), shall be fitted centrally at the lower end of the rod. The total mass of the assembly shall be 2,5 kg (corresponding to a surface pressure of 10 N/mm²).

For measurement of indentation depth, a penetrometer with dial gauge, which permits measurements to be made to an accuracy of 0,1 mm, is required.

Testing shall be carried out at a temperature of (90 ± 3) °C, using a temperature-controlled water bath, if necessary.

After conditioning the test piece for one hour at the test temperature, the indentor (without the additional weight) shall be slowly and carefully lowered on the test piece, and the zero value set at the penetrometer within five seconds. Following this, the additional weight shall be attached to the indentor and, after 24 hours, the depth of penetration read from the penetrometer.

5.3.6 Percentage elongation at failure

The coating of three pipes shall be tested for elongation at failure, from which five test pieces each shall be taken. The test pieces shall have the form of specimen no. 3 (if necessary, half that size) or no. 4, as specified in DIN 53 455. One test piece per pipe shall be permitted to fail.

Test pieces shall be taken after the pipe has been heated to a maximum of 100 °C to 110 °C.

Testing shall be performed as described in DIN 53 455, at a temperature of (23 ± 2) °C and a rate of 50 mm/min (or 25 mm/min in the case of half-size test pieces).

5.3.7 Coating resistivity

Three test pieces having a minimum test area of 0,03 m² shall be tested, none of which shall fail.

A sodium chloride solution with a concentration of 0,1 mol/l shall be used as the test medium. The test equipment shall be made up of a counterelectrode with a surface area of not less than 10 cm², a d.c. source with an output voltage of not less than 50 V, an ammeter and a voltmeter.

The test pieces shall be exposed to the test medium for 100 days at a temperature of (23 ± 2) °C, in one of the ways described below.

a) The pipe shall be placed horizontally in a plastic container with lateral openings of suitable size. The space between container walls and test piece shall be sealed with a non-conductive material. The test medium shall be poured in, covering the pipe to a depth of at least 10 mm.

b) Plastic pipe sections shall be bonded to the surface of the sample (pipe or pipe section) using a non-conductive adhesive. The former shall then be filled with the test medium.

c) One end of a pipe shall be sealed with a non-conductive material so that the steel surface is not in contact with the test medium. The pipe shall then be placed vertically in a vessel containing the test medium. The pipe may be removed from the medium and wetted with an electrolyte solution to measure resistivity.

The coating shall be tested for continuity (cf. subclause 5.3.2) before being tested for resistivity.

For the purposes of measurement, the positive pole of the d.c. source shall be connected to the steel pipe, and the negative pole to the counterelectrode, which shall then be immersed in the test medium. The coating resistivity, r_u, in $\Omega\,m^2$, shall be calculated from the following equation:

$$r_u/\Omega\,m^2 = \frac{(U/V)\,(S/m^2)}{(I/A)}$$

where

U is the voltage between counterelectrode and steel pipe, in V;

S is the test area, in m²;

I is the intensity of current flowing through the coating, in A.

The current flowing through the d.c. source is equal to that flowing through the coating if there are only negligible leakage currents along the surface between the test area and the steel at the pipe ends. Leakage current earthing complying with DIN VDE 0303 Part 3 shall be provided.

where the intensity of measuring current, I, is high. The results of measurement are only correct if the leakage current intensity is substantially lower than I.

5.3.8 Heat ageing resistance

Five test pieces shall be subjected to the test for heat ageing resistance as specified in DIN 53383 Part 1. After an exposure time of 100 days, the test pieces shall be removed from the oven and observed for brittleness.

6 Marking

Steel pipes as covered in this standard shall be clearly and durably marked with at least the manufacturer's mark or registered trade mark and the DIN number.

Example:

(Mark) – Coating DIN 30 678 – PP

Standards referred to

DIN 2448	Seamless steel pipes and tubes; dimensions and mass per unit length
DIN 2458	Welded steel pipes and tubes; dimensions and mass per unit length
DIN 30670	Polyethylene coatings for steel pipes and fittings; requirements and testing
DIN 50049	Inspection documents for the delivery of metallic products
DIN 53383 Part 1	Testing of plastics; testing polypropylene for resistance to oxidation
DIN 53455	Tensile testing of plastics
DIN 55928 Part 4	Corrosion protection of steel structures by the application of organic or metallic coatings; preparation and testing of surfaces
DIN VDE 0303 Part 3	Testing of electrical insulating materials; measurement of electrical resistance of non-metallic materials
DIN VDE 0433 Part 2	High-voltage generation and measurement; voltage measurement using sphere gaps (one sphere method)

Explanatory notes

This standard has been prepared by Technical Committee AA 5.2 of the *Normenausschuß Gastechnik* (Gas Technology Standards Committee), the aim being to ensure that polyethylene pipe coatings provide adequate protection against the mechanical, thermal and chemical stresses occurring in service, transit and storage, and during installation.

★ Polypropylene coatings are significantly different from DIN 30670 polyethylene coatings, which necessitated their being covered in a separate standard. For example, it is only possible to apply polypropylene coatings by means of extrusion, i.e. subsequent coating and repair work cannot be carried out using the materials specified in DIN 30672 Part 1 when the service temperature exceeds 50 °C. (A standard in this regard is currently in preparation.)

★ Experience has shown that the resistance of polypropylene to oxidation also differs from that of polyethylene, in that it tends to become brittle when exposed to high temperatures. For this reason, the expected service life of polypropylene as a function of service temperature has been specified in clause 1.

★ It should be noted that polypropylene that is coloured with carbon black will not satisfy the requirements specified in DIN 53383 Part 1.

It was decided not to include a test for resistance to light ageing (i.e. behaviour on exposure to filtered xenon arc radiation), but rather to specify material characteristics that are suitable for use at high service temperatures. It can be deduced from the information given in clause 1 that polypropylene coatings can be exposed to direct sunlight for long periods only when other protection (e.g. a covering) is provided, and therefore, that the use of unprotected polypropylene coatings outdoors is not within the scope of this standard.

The values specified for minimum coating thickness are based on those specified in DIN 30670, since both polypropylene and polyethylene coatings are used as a physical barrier against corrosion, and since permeation testing of both types gave comparable results. Likewise, the mechanical stability of both types is similar, even when the bond strength is reduced after long periods of use.

Similar requirements have also been specified for percentage elongation after failure, continuity and coating resistivity. Only those parameters which can be reliably determined and which are relevant for the expected stresses in service have been specified, i.e. the properties of both polyethylene and polypropylene may be much better under different conditions.

★ Different tests and requirements have been specified for bond strength, impact strength and indentation hardness. For example, since polypropylene tends to become brittle at low temperatures, a test temperature of (0 ± 2) °C has been specified for the test of impact strength.

Determination of resistance to blistering is irrelevant because such does not occur in the coating materials covered here. Similarly, determination of cathodic disbonding is not included, since this test does not provide relevant information with regard to the quality of polypropylene coatings and their long-term corrosion protection.

Bond strength is not a significant factor with regard to the protection the coating provides against corrosion (e.g. underrusting), as long as the thickness and quality of the coating meet the requirements specified here.

The responsible technical committee agreed that it would be useful to determine the tear resistance of polypropylene coatings, but it was not possible to develop a reproducible test method. Polypropylene coatings are, however, more resistant to detergents than polyethylene coatings, i.e. it can be stated with relative certainty that the former are more resistant to tearing than the latter.

International Patent Classification

B 29 C 47/02
F 16 L 9/14
F 16 L 58/10
G 01 L 1/00
G 01 N 33/44