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Steel mesh reinforced polyethylene (PE) pipes for water supply

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Table of changes

Change No.	Date	Scope

Abstract

Specifies the required properties of steel mesh reinforced polyethylene (PE) pipes made by combining mesh-shaped steel reinforcement with polyethylene through extrusion technology. Also specifies the requirements for raw materials, marking, packing, storage and handling of the pipes.

Applies to steel mesh reinforced polyethylene (PE) pipes intended to be used for the conveyance of water under pressure for general purposes, as well as for the supply of drinking water with temperatures not exceeding 80 °C. The pipelines may be buried, above ground, or outside buildings.

Keywords

extrusion, pipes, plastics, polyethylene (PE), reinforced, specifications, steel mesh reinforced, water supply, water supply engineering.

Foreword

This South African standard was approved by National Committee StanSA SC 5140.14A, *Plastics pipes and fittings – Polyethylene*, in accordance with procedures of Standards South Africa, in compliance with annex 3 of the WTO/TBT agreement.

Annex A forms an integral part of this standard. Annex B is for information only.

The requirements in 11 (a) constitute, in terms of section 21(2) of the Standards Act 1993, (Act No. 29 of 1993), a self-declaration of conformity by the manufacturer, notwithstanding the implications of any third-party certification mark that might also be displayed.

Contents

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Steel mesh reinforced polyethylene (PE) pipes for water supply

1 Scope

This standard specifies the required properties of steel mesh reinforced polyethylene (PE) pipes made by combining mesh-shaped steel reinforcement with polyethylene through extrusion technology. The requirements for raw materials, marking, packing, storage and handling of the pipes are also specified. The steel mesh is made by continuously winding and welding transverse wires spirally to the longitudinal wires.

This standard applies to steel mesh reinforced polyethylene (PE) pipes intended to be used for the conveyance of water under pressure for general purposes, as well as for the supply of drinking water with temperatures not exceeding 80 °C. The pipelines may be buried, above ground, or outside buildings.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. All standards are subject to revision and, since any reference to a standard is deemed to be a reference to the latest edition of that standard, parties to agreements based on this standard are encouraged to take steps to ensure the use of the most recent editions of the standards indicated below. Information on currently valid national and international standards can be obtained from Standards South Africa.

2.1 Standards

ASTM A 641, *Standard specification for zinc-coated (galvanized) carbon steel wire.*

ASTM D 1598, *Standard test method for time-to-failure of plastic pipes under constant internal pressure.*

ASTM D 2837, *Standard test method for obtaining hydrostatic design basis for thermoplastic pipe materials or pressure design basis for thermoplastic pipe products.*

ISO 161-1, *Thermoplastics pipes for the conveyance of fluids – Nominal outside diameters and nominal pressures – Part 1: Metric series.*

ISO 6964, *Polyolefin pipes and fittings – Determination of carbon black content by calcination and pyrolysis – Test method and basic specification.*

ISO/TR 10837, *Determination of the thermal stability of polyethylene (PE) for use in gas pipes and fittings.*

ISO 12162, *Thermoplastics materials for pipes and fittings for pressure applications – Classification and designation – Overall service (design) coefficient.*

ISO 18553, *Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds.*

SANS 130/ISO 1167 (SABS ISO 1167), *Thermoplastics pipes for the conveyance of fluids – Resistance to internal pressure – Test method.*

SANS 241 (SABS 241), *Drinking water*.

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

SANS 2505-1/ISO 2505-1 (SABS ISO 2505-1), *Thermoplastics pipes – Longitudinal reversion – Part 1: Determination methods.*

SANS 2505-2/ISO 2505-2 (SABS ISO 2505-2), *Thermoplastics pipes – Longitudinal reversion – Part 2: Determination parameters.*

SANS 3126/ISO 3126 (SABS ISO 3126), *Plastics pipes – Measurement of dimensions.*

SANS 9080/ISO 9080, *Plastics piping and ducting systems – Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation.*

SANS 11922-1/ISO 11922-1 (SABS ISO 11922-1), *Thermoplastics pipes for the conveyance of fluids – Dimensions and tolerances – Part 1: Metric series.*

2.2 Other publications

EC Council Directive 98/83/EC of 3rd November 1988 on the *quality of water intended for human consumption*, Official journal of the European Community, L229, pp.11 to 29.

WHO *Guidelines for drinking water quality, third edition – Volume 1: Recommendations*.

3 Definitions and abbreviations

3.1 Definitions

For purposes of this standard, the following definitions apply:

3.1.1
nominal inside diameter
d_n
size designation based on the internal diameter of a pipe common to all components, other than flanges (see table 1)

NOTE The size designation is given as a convenient round number in millimetres.

3.1.2
nominal wall thickness
e_n
specified wall thickness, in millimetres, identical with the minimum wall thickness at any point ($e_{y, min}$) (see table 1)

3.1.3
minimum wall thickness
$e_{y, min}$
specified minimum wall thickness at any point around the circumference of the pipe, in millimetres

3.1.4
ovality
difference between the measured maximum outside diameter and the measured minimum outside diameter in the same cross-section of the pipe (see 5.3)

3.1.5
pipe length
overall length between the two flanged or coned pipe ends (see 5.5)

3.1.6
steel mesh
reinforcement of the pipe specified in this standard, which is made by winding and welding transverse wires spirally to longitudinal wires to form a continuous tube-like mesh (see 4.2.4)

3.1.7
flanged pipe end
pipe end for loose flange connection, which is injection moulded onto the pipe body (see 5.4.2)

3.1.8
coned pipe end
pipe end for electrofusion connection, which is cone-shaped and injection moulded onto the pipe body (see 5.4.3)

3.1.9
nominal pressure
PN
specified maximum allowable operating pressure of the pipe at 20 °C, in bars (see table 1)

NOTE 1 bar = 1 × 10^5 Pa = 0,1 MPa.

3.1.10
pressure reduction factors
factors of value smaller than 1, applied to obtain the maximum allowable operating pressure for elevated temperature operation of the pipe (see table 5)

3.2 Abbreviations

For the purposes of this standard, the following abbreviations apply:

PDB Pressure design basis

MOP Maximum operating pressure

4 Requirements for materials

4.1 Requirements for PE compounds

4.1.1 General

4.1.1.1 The compound from which the pipes are manufactured shall consist of PE base polymer and only those additives necessary for the manufacture and end use of the pipes, including weldability when possible.

All additives shall be uniformly dispersed.

4.1.1.2 The material for the stripes shall be of the same type of resin as used in the base compound for the pipe.

4.1.1.3 PE 63 and PE 80 resin that are classified in accordance with SANS 9080 and ISO 12162 are recommended for the manufacture of pipes.

4.1.2 Black pipes

4.1.2.1 Content of carbon black

When determined in accordance with ISO 6964, the carbon black content in the compound for black pipes shall be 2,25 % ± 0,25 % by mass.

4.1.2.2 Dispersion of carbon black

When determined in accordance with ISO 18553, the dispersion of the carbon black shall be equal to or less than grade 3.

4.1.3 Dispersion of blue pigments

When determined in accordance with ISO 18553, the dispersion of the blue pigments shall be equal to or less than grade 3.

4.1.4 Thermal stability

When determined in accordance with ISO/TR 10837, the induction time for materials PE 63 and PE 80 shall be either at least 20 min when tested at 200 °C, or an equivalent period when tested at 210 °C, respectively.

NOTE In case of dispute, the test temperature of 200 °C will be used.

4.1.5 Use of reprocessable and recycable material

Clean reprocessable material generated from a manufacturer's own production may be used if it is derived from the same compound as used for the relevant production, but the amount shall not exceed 5 % by mass. Reprocessable material obtained from external sources and recyclable material shall not be used.

4.1.6 Effect of materials on water quality

When used under conditions for which they are designed, material in contact with or likely to come into contact with drinking water shall not constitute a toxic hazard, shall not support microbial growth and shall not give rise to unpleasant taste or odour, cloudiness or discoloration of the water.

The concentrates of substances, chemicals and biological agents leached from materials in contact with drinking water, and measurements of the relevant organoleptic/physical parameters, shall not exceed the maximum values recommended by the World Health Organization in its publication, *Guidelines for drinking water quality, third edition,* Volume 1: *Recommendations*, or as required by the EC Council Directive 98/93/EC of 3 November 1998 on the quality of water intended for human consumption, whichever is the more stringent in each case. SANS 241 may apply as alternative, if users prefer to.

4.1.7 Melt flow rate and density

When determined in accordance with SANS 1133, the melt flow rate (MFR) shall comply with the following conditions:

a) the melt flow rate of the compound shall not deviate by more than ± 30 % from the value specified by the manufacturer of the raw material; and

b) the change in MFR caused by processing, i.e. the difference between the measured value for material from the pipe and the measured value for the compound, shall not be more than 25 %.

4.2 Requirements for steel wire

4.2.1 Mechanical characteristics

The mechanical characteristics of steel wire shall be in accordance with ASTM A 641. A proposed method to determine the strength of steel wire is given in annex A.

4.2.2 Coating

Steel wire shall be coated with metallic material with excellent corrosion resistance and good weldability. Coating shall be uniform throughout the wire, and free from scaling. It shall be ensured that no hazardous gas is generated during welding process. Coating surface shall be clean, smooth and free from dust and grease.

4.2.3 Straightness, diameter and tolerance on diameter

Steel wire shall be straight. There shall be no curve with radius less than 30 mm for steel wire with diameter not exceeding 3,0 mm. There shall be no curve with radius less than 50 mm for steel wire with diameter greater than 3,0 mm.

The diameters and tolerances on diameters shall be in accordance with ASTM A 641.

4.2.4 Steel mesh

The structural parameters of the steel mesh shall be determined by the manfacturer in accordance with annex A. The parameters of the steel mesh shall ensure that the geometrical and mechanical characteristics of the pipes meet the requirements of table 1 and table 6. The absolute distance between two adjacent transverse wires shall not be less than 3 mm.

5 Requirements for geometrical characteristics

5.1 Dimensions and nominal pressures of pipes

5.1.1 The dimensions of pipes shall be measured in accordance with SANS 3126.

5.1.2 The nominal diameters and wall thicknesses of pipes are given in table 1.

Table 1 — Nominal diameters, nominal pressures and wall thicknesses

1	2	3	4	5
Nominal diameter d_n mm	**Nominal pressure, *PN*** bar			
	PN 10	**PN 16**	**PN 20**	**PN 25**
	Nominal wall thickness, e_n mm			
50			9	9
65			9	9
80			9	9
100		9	10	10
125		10	12	12
150	12,0	12	12,5	
200	12,5	12,5	12,5	
250	12,5	13	14	
300	12,5	13	14	
350	15	16		
400	15	16		
450	16	18		
500	16	18		

NOTE 1 Theoretical analysis and test results show that when the pipe is working under nominal pressure, the stress sustained by PE is very small, normally less than 1 MPa. The pipe strength mainly depends on the strength, diameter and spacing of the steel wire. The structural parameters of the pipe are determined in accordance with annex A.

NOTE 2 The technology for manufacturing these pipes is different from that for manufacturing normal plastics pipes, but similar to that for manufacturing glass-fibre-reinforced thermoplastics pipes, in that the pipes are internally sized by a mandrel.

5.1.3 The nominal pressure series of the pipes shall be in accordance with ISO 161-1, see table 1.

5.1.4 The tolerances on the nominal diameters of the pipes shall be in accordance with the requirements of table 2.

Table 2 — Tolerances on internal diameters

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Internal diameter d_n (mm)	50	65	80	100	125	150	200	250	300	350	400	450	500
Tolerances (mm)	± 0,4	± 0,4	± 0,6	± 0,6	± 0,6	± 0,8	± 1,0	± 1,2	± 1,2	± 1,6	± 1,6	± 1,8	± 2,0

5.1.5 The minimum wall thickness, $e_{y,\,min}$, of the pipe shall be same as the nominal wall thickness, e_n, of the pipe. The tolerance on the wall thickness at any point shall comply with the relevant requirements of SANS 11922-1, grade T.

5.2 Eccentricity of the steel mesh

The distance L_{min} (see figure 1) between any longitudinal wire of the steel mesh and the inner wall surface of the pipe shall comply with the requirements as follows:

$L_{min} \geq$ 1,8 mm for $d_n \leq$ 125 mm.

$L_{min} \geq$ 2,5 mm for 150 mm $\leq d_n \leq$ 300 mm.

$L_{min} \geq$ 3,0 mm for 350 mm $\leq d_n \leq$ 500 mm.

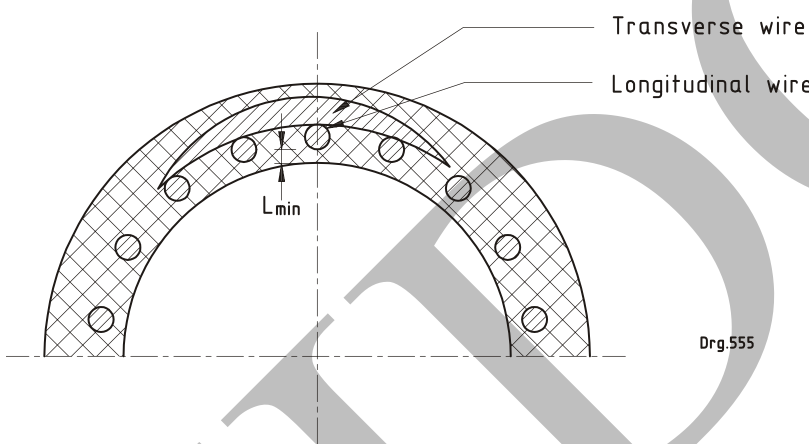

Figure 1 — Eccentricity of steel mesh

5.3 Ovality

The maximum and minimum outside diameter of the pipes shall be measured in accordance with SANS 3126. The ovality of the pipes shall comply with the relevant requirements of SANS 11922-1, as follows:

grade M for $d_n \leq$ 200 mm;

grade L for $d_n \geq$ 250 mm.

5.4 Types of pipe end

5.4.1 General

Two methods are used for joining of the pipes, flange connection and electrofusion connection.

5.4.2 Flanged pipe end

The geometrical characteristics of the flanged pipe ends are given in table 3. The "O" ring or gasket is used for sealing. When gasket is used, there shall be no sealing grooves on pipe end (see figure 2). Other types of sealing rings can also be used when agreed upon between the manufacturer and the purchaser.

Table 3 — Geometrical characteristics of flanged pipe ends

Dimensions in millimetres

1	2	3	4	5	6	7	8	9	10	11
Nominal diameter d_n	d_1	d_2	d_3	d_4	d_5	l, min	l_1	l_2	h	b
50	91±0,175	$75,6^{+0,19}_{0}$	97	75	$91^{+0,35}_{0}$	35	30	29	4,15±0,1	7,1±0,15
65	107±0,175	$90,6^{+0,22}_{0}$	113	90	$107^{+0,35}_{0}$	35	30	29	4,15±0,1	7,1±0,15
80	122±0,2	$105,6^{+0,22}_{0}$	128	105	$122^{+0,4}_{0}$	35	30	29	4,15±0,1	7,1±0,15
100	146±0,2	$125,6^{+0,25}_{0}$	152	127	$146^{+0,4}_{0}$	35	30	29	4,15±0,1	7,1±0,15
125	173±0,2	$150,6^{+0,25}_{0}$	179	156	$173^{+0,4}_{0}$	35	30	29	4,15±0,1	7,1±0,15
150	201±0,23	$175,6^{+0,25}_{0}$	207	182	$201^{+0,46}_{0}$	35	30	29	4,15±0,1	7,1±0,15
200	254±0,28	$232^{+0,29}_{0}$	260	233	$254^{+0,52}_{0}$	41	36	35	5.45±0,1	9,40±0,20
250	307±0,28	$279^{+0,32}_{0}$	313	286	$307^{+0,52}_{0}$	41	36	35	5,45±0,1	9,40±0,20
300	357±0,285	$329^{+0,36}_{0}$	363	336	$357^{+0,57}_{0}$	45	40	39	5.45±0,1	9,40±0,20
350	414±0,315	$389^{+0,36}_{0}$	422	390	$414^{+0,63}_{0}$	50	45	44	5,45±0,1	9,40±0,20
400	464±0,315	$439^{+0,4}_{0}$	472	440	$464^{+0,63}_{0}$	55	50	49	5,45±0,1	9,40±0,20
450	520±0,35	$489^{+0,4}_{0}$	528	495	$520^{+0,7}_{0}$	60	55	54	5,45±0,1	9,40±0,20
500	572±0,35	$544^{+0,44}_{0}$	580	545	$572^{+0,7}_{0}$	65	60	59	5,45±0,1	9,40±0,20

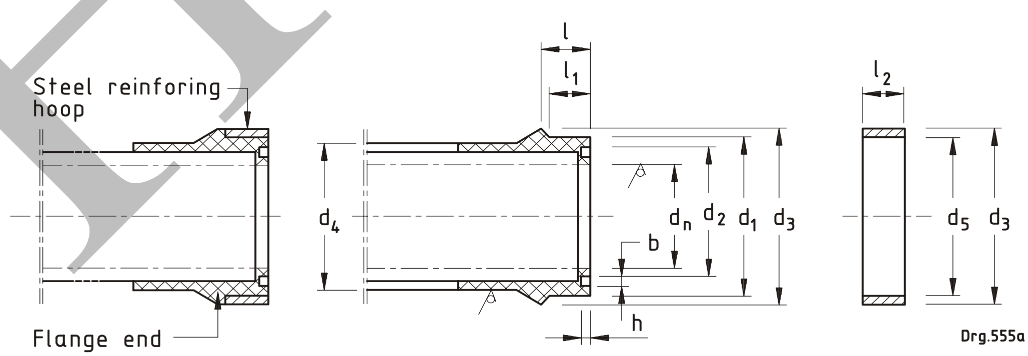

Figure 2 — Flanged pipe end and reinforcing hoop

5.4.3 Coned pipe end

The pipe end for electrofusion connection is cone-shaped (see figure 3), and the geometrical characteristics of coned pipe ends are given in table 4.

Table 4 — Geometrical characteristics of coned pipe ends

1	2	3	4
Nominal diameter d_n mm	**Outside diameter of smaller end of the cone and tolerances** D mm	**Length of the cone** L mm	α
50	$75^{\ 0}_{-1,1}$	100	30'
65	$90^{\ 0}_{-1,2}$	100	30'
80	$105^{\ 0}_{-1,3}$	100	30'
100	$128^{\ 0}_{-1,4}$	100	30'
125	$156^{\ 0}_{-1,6}$	100	30'
150	$182^{\ 0}_{-1,6}$	110	30'
200	$234^{\ 0}_{-1,6}$	120	30'
250	$287^{\ 0}_{-1,6}$	130	30'
300	$337^{\ 0}_{-1,6}$	150	30'
350	$390^{\ 0}_{-1,6}$	160	1°
400	$440^{\ 0}_{-1,6}$	170	1°
450	$495^{\ 0}_{-1,6}$	180	1°
500	$545^{\ 0}_{-1,6}$	190	1°

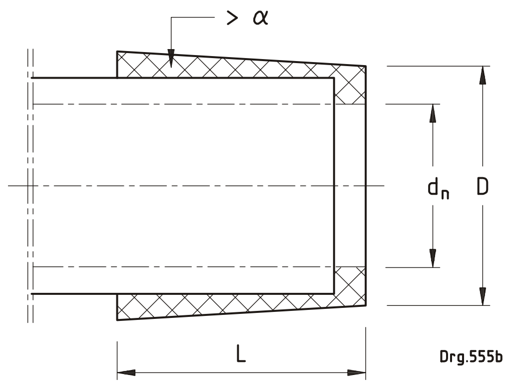

Figure 3 — Coned pipe end

5.5 Length of pipe

The nominal length of pipes shall be 6 m, 8 m, 10 m or 12 m, and the deviation shall be ± 20 mm maximum (see figure 4). The pipe length may also be agreed between the manufacturer and the purchaser.

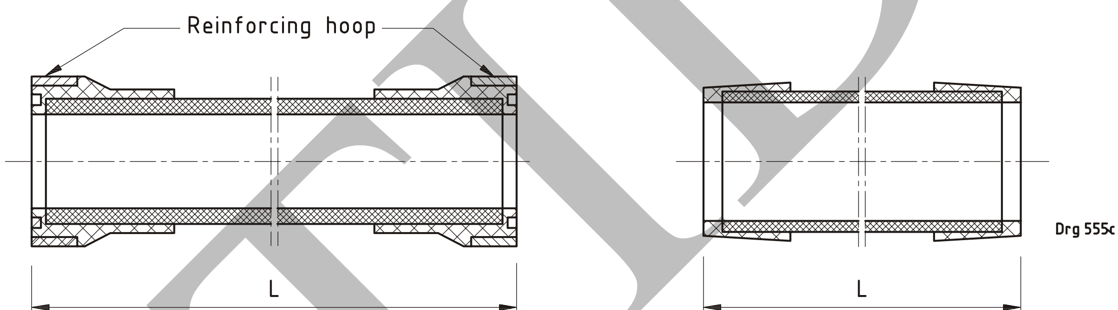

Figure 4 — Pipe length

6 Requirements for the appearance of pipes

6.1 Colour of pipes

The pipes shall be black or blue, or black with blue stripes. The pipe shall be uniform in colour throughout.

NOTE For above ground installations, all blue components and components with non-black layers should be protected from direct UV light.

6.2 Requirements for workmanship

6.2.1 When viewed without magnification, the internal surface shall be smooth, clean and free from scoring, discoloration, line and steel wire exposure. The external surface may take on a natural spiral contracting appearance, and minor surface unevenness caused by natural contracting of plastics shall be allowed. The external surface shall be free from defects such as scoring, blistering and impurities. The pipe ends shall be cut cleanly and square to the axis of the pipes.

6.2.2 The pipe end surface of the flanged end pipes and the cone surface of the coned end pipe shall be smooth, clean and free from defects like cavities, scoring and burs. The injection moulded part shall be fused well with the basic pipe body. Slight shrinkage in the PE part of the coned pipe end is allowed.

7 Requirements for pressure reduction factors

The pressure reduction factors given in table 5 shall apply to pipes that are used at temperatures above 20 °C for the conveyance of water which do not have adverse effects on the performance of the pipe. The working pressure at elevated temperature shall be obtained by multiplying the nominal pressure given in table 1, with the pressure reduction factors given in table 5.

Table 5 — Pressure reduction factors

1	2	3	4	5	6	7	8
Operating temperature °C	$0 < t \leq 20$	$20 < t \leq 30$	$30 < t \leq 40$	$40 < t \leq 50$	$50 < t \leq 60$	$60 < t \leq 70$	$70 < t \leq 80$
Pressure reduction factors[a]	1	0,95	0,89	0,83	0,77	0,72	0,67

[a] The values were obtained by analysing the test data of long term hydrostatic tests at different temperatures as per ASTM D 2837 and ASTM D 1598.

8 Mechanical characteristics

8.1 Hydrostatic strength

When tested in accordance with SANS 130, the pipes shall comply with to the requirements in table 6.

Table 6 — Hydrostatic strength of pipes

1	2	3
Test	**Test pressure** bar	**Requirements**
Hydrostatic strength at 20° (100 h)	PN × 1,6	No failure, no leakage
Hydrostatic strength at 80 ° (165 h)	PN × 1,6 × 0,67	No failure, no leakage
Burst test	Instantly increase test pressure to burst pressure	Burst pressure $\geq$ PN × 3

8.2 Resistance to cracking under compression

The pipe shall have no cracks on the internal or external surfaces of the pipe during testing. Cut a 100 mm long test piece from the pipe and place it between the two parallel flat plates of the compressive-testing machine. Gradually compress the pipe vertically to an extent of 50 % of the diameter of the pipe within 10 s to 15 s.

9 Physical requirements

9.1 Thermal stability of pipes manufactured from PE 63 and PE 80

When determined in accordance with ISO/TR 10837, the induction time for test specimens taken from pipes manufactured from PE 63 and PE 80 shall be either at least 20 min when tested at 200 °C, or an equivalent period when tested at 210 °C, provided the equivalence is supported by a clear correlation between results obtained at 200 °C or 210 °C, respectively. The test specimens shall be taken from the inside surface of the pipe.

9.2 Longitudinal reversion

When tested in accordance with ISO 2505-1, the value of the longitudinal reversion of pipes shall be not greater than 3 %. The test temperature shall be 110 °C ± 2 °C for PE 63 and PE 80, and the test time shall comply with to ISO 2505-2.

9.3 Weathering of non-black pipes

9.3.1 General

The effect of weathering shall be determined in accordance with the procedure given in 9.3.2, when the pipes are manufactured using non-black compound. After exposure to a total solar energy of at least 3,5 GJ/m^2, the pipe shall comply with to the following requirements:

a) the mechanical characteristics shall meet the requirements given in table 6; and

b) when measured in accordance with ISO/TR 10837, the induction time shall be at least 10 min at 200 °C.

9.3.2 Procedure for exposure to outdoor weathering

9.3.2.1 Exposure aspects and site

Test racks and specimen fixtures shall be made from inert materials which will not affect the test results. Wood, non-corrosive aluminium alloys, stainless steel or ceramics have been found suitable. Brass, steel or copper shall not be used. The test site shall be equipped with instruments to record the solar energy received and the ambient temperature.

The equipment shall be capable of supporting specimens of pipe such that the exposed surface of the specimens is at 45° to the horizontal, facing towards the equator. Normally, the exposure site shall be on open ground well away from trees and buildings. For exposure in the northern hemisphere, no obstruction, including adjacent racks, in an easterly, southerly or westerly direction, shall subtend a vertical angle greater than 20°, or in a northerly direction greater than 45°. For exposure in the southern hemisphere, corresponding provisions apply.

9.3.2.2 Test specimens

The width of the test specimens shall be approximately three times the diameter of the pipe, but at least 1 m long. Specimens shall be selected from any thickness-wall pipes and a random range of diameters. The batch of pipes from which the specimens are selected shall comply with to all the requirements of this standard.

9.3.2.3 Procedure

9.3.2.3.1 Mark each pipe specimen to identify it, and record the mounting position of each.

9.3.2.3.2 Expose the specimens to a total solar energy of at least 3,5 GJ/m^2.

9.3.2.3.3 Remove the specimens and test in accordance with the clause 9.3.1. Where the specimen to be tested includes only part of the pipe cross-section, e.g. a tensile dumb-bell or part of the surface layer, it shall be taken from the weathered crown of the exposed specimen.

10 Packing, transportation and storage

10.1 Packing

The pipes shall be packed as agreed upon between the manufacturer and the purchaser.

Adequate packing measures shall be taken to protect the pipe ends from being damaged during transportation and handling.

10.2 Transportation

Scratching, dropping pipes onto hard surfaces, dragging the pipes along the ground and severe impact on or between the pipes shall be avoided during transportation and handling of the pipes. Care shall be taken to prevent oil, grease or chemicals from contaminating the pipes. Direct contact with metal slings, hooks or chains shall not be allowed.

10.3 Storage

The pipes shall be stored away from heat sources. Care shall be taken to prevent oil, grease or chemicals from contaminating the pipes. The pipes shall be stacked properly, parallel to the ground. The stack bed shall be clean and flat, and the stack height shall not exceed 1,6 m. When stored outdoors, the pipes shall be covered properly.

11 Marking

The marking shall be maintained for the life of the pipe, and shall be so applied as not to adversely affect the pipe strength. If printing is used, the colouring of the pipe and the printed information shall differ. The size of the marking shall be such that it is legible without magnification. The information given below shall appear in legible and durable marking on each pipe, at intervals of length not exceeding 2 m:

a) the standard number SANS 370 (see foreword);

b) the manufacturer's trade name or trademark (or both);

c) nominal internal diameter;

d) nominal pressure;

e) PE designation;and

f) production date.

Annex A
(normative)

Pressure and structural design of the pipes

A.1 Load (hoop stress) sharing in the pipe

When a pipe works under allowable working pressure, it should be within elastic limits. In the pipe, the steel wires and plastic deform as a single unit, and therefore, experience equal strains. Thus the following expression can be obtained:

$$\varepsilon_s = \frac{\sigma_s}{E_s} \; \varepsilon_p = \frac{\sigma_p}{E_p} \qquad (1) \qquad\qquad \frac{\sigma_p}{\sigma_s} = \frac{E_p}{E_s} = K \qquad (2)$$

where

ε_s is the average strain of steel mesh;

ε_p is the average strain of PE;

σ_s is the average stress of steel wires, in megapascals;

σ_p is the average stress of PE, in megapascals;

E_s is the elastic modulus of steel mesh, in megapascals;

E_p is the elastic modulus of PE, in megapascals;

K is a constant.

The above expression shows that within the elastic limit there is a fixed relationship between the load sustained by the plastics and that of steel, i.e. the elastic modulus ratio between the plastics and the steel. The elastic modulus of steel is more than 200 times that of plastic, thus when the pipe is subject to nominal pressure, the plastics only sustains a minor percent of the total stress, which is far below its allowable stress.

A.2 Formula for calculating maximum operating pressure (MOP) of the pipe

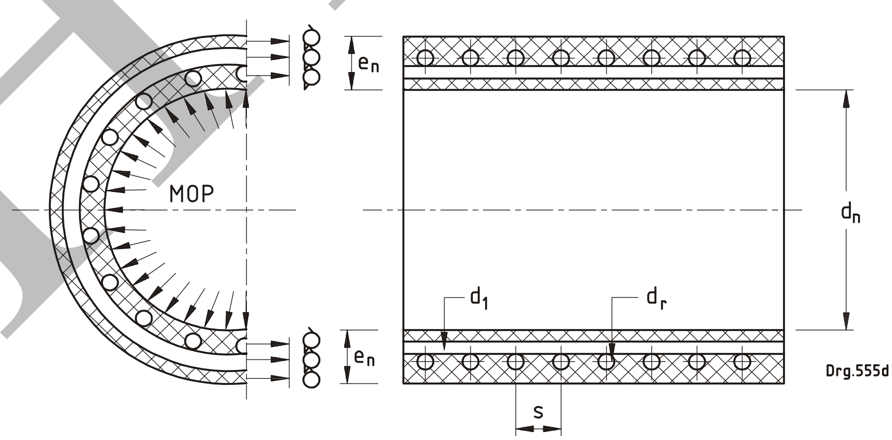

Figure A.1 — Cross-section in maximum hoop stress direction

According to figure A.1, the following equation can be obtained:

$$MOP \times d_n \times s = 2\,[\frac{\pi d_r^2}{4}\,\sigma_s + \sigma_p\,(s \cdot e_n - s \cdot d_l - \frac{\pi d_r^2}{4})] \quad (3)$$

By combining formula (2) and (3), the following formula is achieved:

$$MOP = \frac{\sigma_s\,[(1-K)\pi d_r^2 + 4Ks\,(e_n - d_l)]}{2d_n s} \geq PN^{1)} \quad (4)$$

where

- PN is the nominal pressure of the pipe, in megapascals;
- MOP is the maximum operating pressure of the pipe, in megapascals;
- d_n is the nominal diameter of the pipe (internal diameter), in millimetres;
- e_n is the nominal wall thickness of the pipe, in millimetres;
- s is the distance between two adjacent transverse wires, in millimetres;
- d_r is the diameter of transverse wires, in millimetres[2)];
- d_l is the diameter of longitudinal wires, in millimetres;
- σ_s is the average stress of steel wires;
- σ_p is the average stress of PE;
- K is a constant.

Uniform stress distribution is assumed in the cross-section of the pipe shown in figure A.1, for both PE and steel wires.

A.3 Formula for calculation of burst pressure of the pipe

The elongation of PE is much greater than that of steel wire, so when the pipe bursts, the plastics is still within yielding state. Introducing the values of tensile strength of steel wire and yield strength of PE to formula (3), we can obtain the formula (5) for calculating the burst pressure of the pipe:

$$P_b = \frac{\pi d_r \varphi \sigma_{sb} + \sigma_{ps}\,(4se_n - 4sd_l - \pi d_r^2)}{2d_n s} \quad (5)$$

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1) MOP $\geq$ PN. PN of the pipe is pre-determined according to the market analysis and demands. The structural parameters of the pipe is then designed. When the designed structural parameters of the pipe and the mechanical properties of the material can guarantee that the PN of the pipes meet the requirements of MOP $\geq$ PN, then the design is deemed to be correct. If not, then repeat the design process.

2) The welding factor (φ) applies only to the transverse wires. In the pipe, only transverse wires contribute to the hoop strength of the pipe, while longitudinal wires only serve as structural auxiliary elements, and do not contribute anything to the pipe hoop strength.

where

P_b is the burst pressure of the pipe, in megapascals;

σ_{sb} is the tensile strength of transverse wires, in megapascals;

σ_{ps} is the yield strength of PE, in megapascals;

φ is the welding factor of steel wires (normally 0,85 is adopted).

A number of burst tests have been conducted, and the proven results does not exceed 8 % in the calculation error of formula (5).

A.4 Pressure and structural design of the pipe

The procedure for pressure and structural design of the pipe is given in figure A.2. When referring to verification of the calculated results with actual burst test data, the criterion can be $P_b/PN \geq 3$.[3)]

A.5 Validation of the pipe design method

PDB tests and analysis on the test data have been carried out on d_n 50 mm, d_n 100 mm, d_n 150 mm, and d_n 500 mm pipes as per ASTM D 2837 and ASTM D 1598, which demonstrate that this method is reasonable and the nominal pressure of pipes obtained by using this method is reliable.

3) $P_b/PN \geq 3$ is used to further verify the correctness of the calculation results and the safety degree. $MOP = P_b$ is not mentioned.

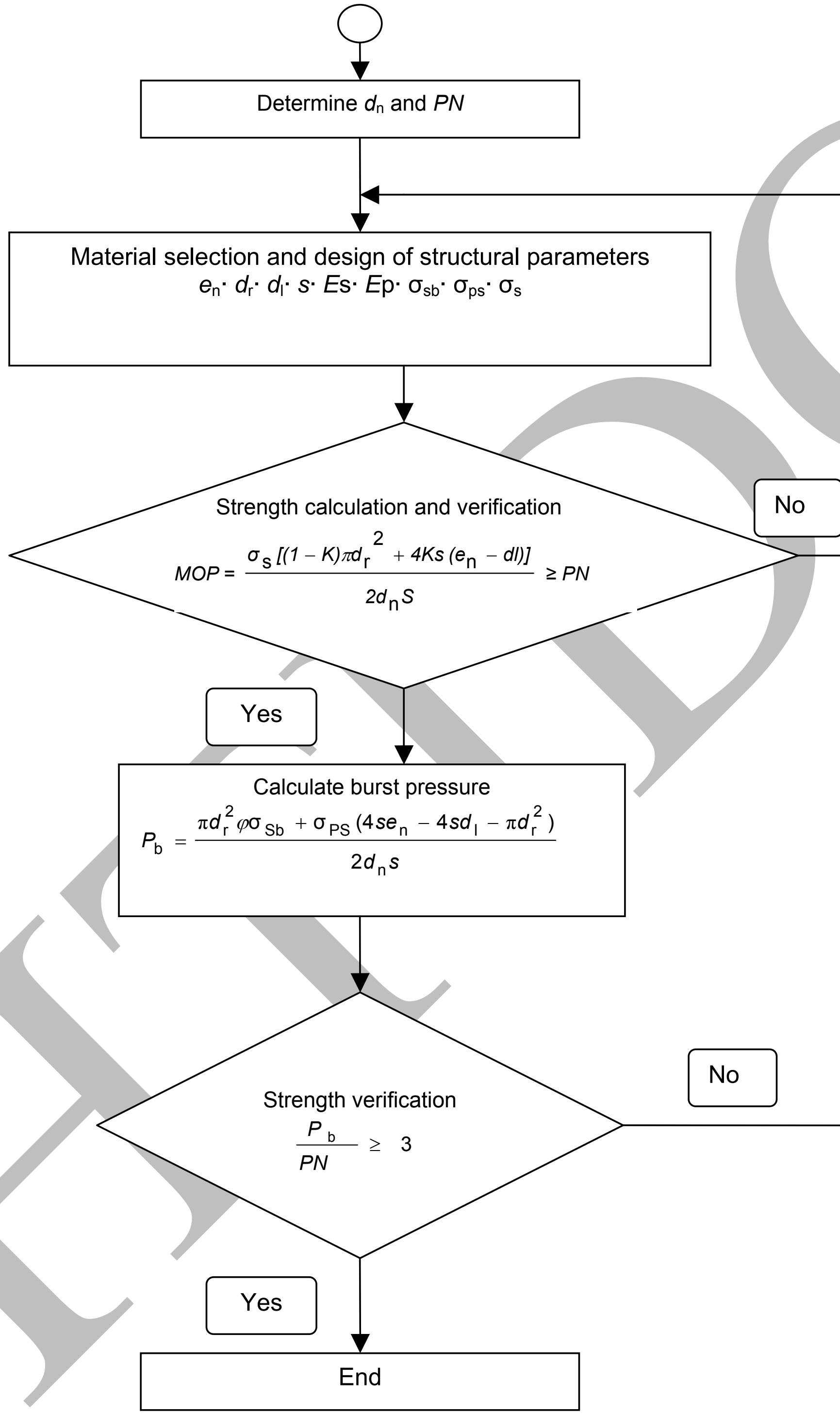

Figure A.2 — Procedure for pressure design of the pipe

Annex B
(informative)

Quality verification of steel mesh reinforced PE pipes for water supply

When a purchaser requires ongoing verification of the quality of steel mesh reinforced PE pipes for water supply, it is suggested that, instead of concentrating solely on evaluating of the final product, he also directs his attention to the manufacturer's quality system. In this connection it should be noted that SANS 9001 covers the provision of an integrated quality system.

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