INTERNATIONAL STANDARD

ISO 6993-1

First edition
2006-06-01

Buried, high-impact poly(vinyl chloride) (PVC-HI) piping systems for the supply of gaseous fuels —

Part 1: Pipes for a maximum operating pressure of 1 bar (100 kPa)

Systèmes de canalisations enterrées en poly(chlorure de vinyle) à résistance au choc améliorée (PVC-HI) pour réseaux de combustibles gazeux —

Partie 1: Tubes pour une pression maximale de service de 1 bar (100 kPa)

Reference number
ISO 6993-1:2006(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

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

ISO 6993-1 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 4, *Plastics pipes and fittings for the supply of gaseous fuels*.

This first edition of ISO 6993-1, together with ISO 6993-2, ISO 6993-3 and ISO 6993-4, cancels and replaces ISO 6993:2001, of which it constitutes a technical revision.

ISO 6993 consists of the following parts, under the general title *Buried, high-impact poly(vinyl chloride) (PVC-HI) piping systems for the supply of gaseous fuels*:

— *Part 1: Pipes for a maximum operating pressure of 1 bar (100 kPa)*

— *Part 2: Fittings for a maximum operating pressure of 200 mbar (20 kPa)*

— *Part 3: Fittings and saddles for a maximum operating pressure of 1 bar (100 kPa)*

— *Part 4: Code of practice for design, handling and installation*

Buried, high-impact poly(vinyl chloride) (PVC-HI) piping systems for the supply of gaseous fuels —

Part 1:
Pipes for a maximum operating pressure of 1 bar (100 kPa)

1 Scope

This part of ISO 6993 specifies the requirements for pipes made of high-impact poly(vinyl chloride) (PVC-HI) intended to be used for the supply of gaseous fuels through buried pipelines having an operating temperature range of 0 °C up to and including +30 °C and a maximum operating pressure of 1 bar (100 kPa) [1)].

It is applicable only to pipes manufactured from the high-impact PVC materials PVC-A, PVC-CPE and PVC-EPR. The pipes are suitable for those gases not containing potentially damaging components in such concentrations as to impair the properties of the pipe material.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1167-1:2006, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method*

ISO 2505:2005, *Thermoplastics pipes — Longitudinal reversion — Test method and parameters*

ISO 2507-1, *Thermoplastics pipes and fittings — Vicat softening temperature — Part 1: General test method*

ISO 2507-2, *Thermoplastics pipes and fittings — Vicat softening temperature — Part 2: Test conditions for unplasticized poly(vinyl chloride) (PVC-U) or chlorinated poly(vinyl chloride) (PVC-C) pipes and fittings and for high impact resistance poly(vinyl chloride) (PVC-HI) pipes*

ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

ISO 3127, *Thermoplastics pipes — Determination of resistance to external blows — Round-the-clock method*

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

ISO 9852, *Unplasticized poly(vinyl chloride) (PVC-U) pipes — Dichloromethane resistance at specified temperature (DCMT) — Test method*

ISO 9969, *Thermoplastics pipes — Determination of ring stiffness*

---

1) 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2

ISO 16871, *Plastics piping and ducting systems — Plastics pipes and fittings — Method for exposure to direct (natural) weathering*

EN 922:1994, *Plastics piping and ducting systems — Pipes and fittings of unplasticized poly(vinyl chloride) (PVC-U) — Specimen preparation for determination of the viscosity number and calculation of the K-value*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 Geometrical definitions

3.1.1
nominal outside diameter
d_n
numerical designation of size which is common to all components in a thermoplastics piping system other than flanges and components designated by thread size

NOTE 1 It is a convenient round number for reference purposes.

NOTE 2 For metric pipes conforming to ISO 161-1, the nominal outside diameter, expressed in millimetres, is the minimum mean outside diameter $d_{em,\,min}$.

3.1.2
mean outside diameter
d_{em}
measured length of the outer circumference of the pipe divided by π, rounded up to the nearest 0,1 mm

NOTE The value for π is taken to be 3,142.

3.1.3
minimum outside diameter
$d_{e,min}$
minimum value of the mean outside diameter

NOTE It is equal to the nominal outside diameter d_n, expressed in millimetres.

3.1.4
maximum outside diameter
$d_{e,max}$
maximum value of the mean outside diameter

3.1.5
outside diameter at any point
d_e
measured outside diameter through the cross-section at any point of the pipe, rounded up to the nearest 0,1 mm

3.1.6
out-of-roundness
difference between the measured maximum outside diameter and the measured minimum outside diameter in the same cross-sectional plane of the pipe

3.1.7
nominal wall thickness
e_n
wall thickness, in millimetres, tabulated in ISO 4065, corresponding to the minimum wall thickness, e_{min}, at any point

3.1.8
mean wall thickness
e_m
arithmetic mean of at least four measurements regularly spaced around the same cross-sectional plane of the pipe, including the measured minimum and maximum values obtained, rounded up to the nearest 0,1 mm

3.1.9
wall thickness at any point
e
measured wall thickness at any point around the circumference of the pipe, rounded up to the nearest 0,1 mm.

3.1.10
standard dimension ratio
SDR
numerical designation of a pipe series, which is approximately equal to the ratio of the nominal outside diameter d_n to the nominal wall thickness e_n:

$$\text{SDR} = \frac{d_n}{e_n}$$

NOTE It is a convenient round number for reference purposes.

3.2 Material definitions

3.2.1
high-impact poly(vinyl chloride)
PVC-HI
mixture of unplasticized PVC and an impact-resistance modifier

3.2.2
lower confidence limit of the predicted hydrostatic strength
σ_{LPL}
quantity with the dimensions of stress, which represents the 97,5 % lower confidence limit of the predicted hydrostatic strength for a single value at a temperature T and a time t

NOTE It is denoted as $\sigma_{LPL} = \sigma_{(T, t, 0,975)}$.

3.2.3
minimum required strength
MRS
value of σ_{LPL}, at a temperature of 20 °C and a time 50 years, $\sigma_{(20, 50\ years, 0,975)}$, rounded down to the next smaller value of the R 10 series or of the R 20 series conforming to ISO 3 and ISO 497, depending on the value of σ_{LPL}

3.2.4
overall service [design] coefficient
C
overall coefficient with a value greater than 1, which takes into consideration service conditions as well as properties of the components of a piping system other than those represented in the σ_{LPL}

3.3 Definitions related to service conditions

3.3.1
natural gas
gaseous fuel containing a mixture of hydrocarbons, primarily methane, but generally also including ethane, propane and higher hydrocarbons in much smaller amounts, as well as some inert gases such as nitrogen and carbon dioxide, plus minor amounts of trace constituents

NOTE Natural gas remains in the gaseous state under the temperature and pressure conditions normally found in service.

3.3.2
pressure
overpressure relative to atmospheric pressure

3.3.3
maximum operating pressure
MOP
maximum effective pressure of the gas in a piping system, expressed in bars, which is allowed in continuous use

NOTE 1 It takes into account the physical and the mechanical characteristics of the components of the piping system.

NOTE 2 MOP is given by the equation:

$$\mathrm{MOP} = \frac{20 \times \mathrm{MRS}}{C \times (\mathrm{SDR} - 1)}$$

4 Symbols and abbreviated terms

4.1 Symbols

C	overall service (design) coefficient
d_e	outside diameter at any point
$d_{e,max}$	maximum outside diameter
d_{em}	mean outside diameter
$d_{e,min}$	minimum outside diameter
d_n	nominal outside diameter
e_n	nominal wall thickness
e	wall thickness at any point
e_{max}	maximum wall thickness
e_m	mean wall thickness
e_{min}	minimum wall thickness
σ	hoop stress
σ_{LPL}	lower confidence limit

4.2 Abbreviated terms

PVC-A acrylate modified PVC

PVC-CPE chlorinated polyethylene modified PVC

PVC-EPR ethylene propylene rubber modified PVC

MOP maximum operating pressure

MRS minimum required strength

PVC-HI high-impact PVC

PVC-U unplasticized PVC

SDR standard dimension ratio

STIS specific tangential initial stiffness

THT tetrahydrothiophene

5 Material

5.1 Composition

The pipes shall be made of high-impact PVC, to which only such additives are added that are necessary to facilitate conformity of the components to this part of ISO 6993.

The impact-resistant modified PVC shall be one of the following compositions:

a) a mixture based on PVC;

b) a blend based on PVC;

c) a copolymer based on PVC;

d) a combination of these types.

The proportion of the impact modifier in the composition shall be at least 7 % by mass.

5.2 Long-term strength

The MRS value of the extrusion material shall be at least 18 MPa. Conformity to this requirement shall be proven using a long-term evaluation in accordance with ISO 9080. Testing shall be carried out at 20 °C, 40 °C and 60 °C, for periods up to 9 000 h. At 60 °C no knee shall occur before 5 000 h.

This test shall be carried out on test pieces in the form of a solid wall extruded pipe made from the relevant extrusion material.

NOTE The MRS evaluation is used for a material qualification and is not intended to be used for a pressure rating.

5.3 Vicat softening temperature

The Vicat softening temperature of the extrusion material shall be not less than 76 °C when determined in accordance with ISO 2507-1 and ISO 2507-2.

5.4 K-value

The K-value of the unplasticized polyvinyl chloride (PVC-U) resin in the extrusion material shall exceed 65, when measured in accordance with EN 922.

5.5 UV stability

Test samples of the extrusion material in the form of a pipe of d_n 63 shall be exposed to weathering in accordance with 11.1 and 11.3. After exposure, the impact resistance of the weathered side shall be determined in accordance with Annex B, using a falling weight of $(750\ ^{+5}_{-0})$ g and a drop height of $(2\ 000\ ^{+10}_{-0})$ mm at 0 °C.

5.6 Resistance to gas constituents

The resistance to gas constituents shall be determined in accordance with 11.1 and Annex A.

6 General characteristics

6.1 Contaminants

The material of the pipe shall not be shown to contain any contaminants, such as inorganic particles or agglomerations thereof, exceeding 50 µm in size, when measured in accordance with 11.1 and 11.2.

6.2 Appearance and finish

The appearance and finish of the pipes shall be examined visually without magnification.

Internal and external pipe surfaces shall be free from grooves, pits, blisters, indications of burning and other irregularities.

The pipe ends shall be cut cleanly and square to the axis of the pipe. The cut end shall not show any voids.

7 Geometrical characteristics

7.1 Measurements

All dimensions shall be measured in accordance with ISO 3126.

7.2 Nominal outside diameter

The nominal outside diameter, d_n, shall be selected from those given in Table 1.

7.3 Mean outside diameter

The mean outside diameter at any point, d_{em}, shall be in accordance with Table 1.

7.4 Out-of-roundness

The out-of-roundness at any cross-section, $(d_{e,max} - d_{e,min})$, shall be in accordance with Table 1.

7.5 Wall thickness

The wall thickness at any point, e, shall be in accordance with Table 1.

The measured e_m shall not be less than e_n.

NOTE In order to meet the requirements for handling and resistance to soil loads, a minimum wall thickness of 2,0 mm is specified for all SDR series.

Table 1 — Pipe dimensions and tolerances

Dimensions in millimetres

d_n	Mean outside diameter d_{em}		Out-of-roundness $d_{e,max} - d_{e,min}$	Wall thickness e			
				SDR 41 [c]		SDR 33 [c]	
	min.	max. [a]	max. [b]	min. [d]	max. [e]	min. [d]	max. [e]
50	50	50,2	1,2			2,0	2,4
63	63	63,2	1,6			2,0	2,4
75	75	75,3	1,8	2,0	2,4	2,3	2,8
90	90	90,3	2,2	2,2	2,7	2,8	3,3
110	110	110,4	2,7	2,7	3,2	3,4	3,9
125	125	125,4	3,0	3,1	3,6	3,8	4,4
140	140	140,5	3,4	3,5	4,0	4,3	4,9
160	160	160,5	3,9	3,9	4,6	4,9	5,6
180	180	180,6	4,4	4,4	5,1	5,5	6,3
200	200	200,6	4,8	4,9	5,6	6,1	6,9
225	225	225,7	5,4	5,5	6,3	6,9	7,8
250	250	250,8	6,0	6,1	7,0	7,6	8,6
280	280	280,9	6,8	6,9	7,6	8,6	9,6
315	315	316,0	7,6	7,7	8,7	9,6	10,8
355	355	356,0	8,6	8,7	9,6	10,8	12,1
400	400	401,0	9,6	9,8	11,0	12,2	13,6

a 0,003 d_{em} rounded up to the next 0,1 mm with a minimum of 0,2 mm and a maximum of 1 mm.

b 0,024 d_{em} rounded up to the next 0,1 mm.

c The SDR designation applies starting from the nominal diameter of 63 mm.

d $e_{min} = e_n$.

e 1,1 e_n + 0,2 mm, rounded up to the nearest 0,1 mm.