BRITISH STANDARD

BS EN
1452-2:2000

Incorporating
Corrigenda
Nos. 1 and 2

Plastics piping systems for water supply — Unplasticized poly (vinyl chloride) (PVC-U) —

Part 2: Pipes

The European Standard EN 1452-2:1999 has the status of a British Standard

ICS 23.040.20; 91.140.60

National foreword

This British Standard is the official English language version of EN 1452-2:1999. Collectively, Parts 1, 2, 3, 4 and 5 of BS EN 1452 supersede BS 3505:1986, BS 4346-1:1969 and BS 4346-2:1970. Since those British Standards are the basis of piping systems with a design life of at least 50 years, it is intended that they will be declared obsolescent, by 26 June 2001. Collectively, Parts 1 to 5 of BS EN 1452 also partially supersede BS 4346-3:1982, which will be withdrawn or amended by 26 June 2001 to exclude requirements for joints for pressure pipes for water supply.

NOTE 1 The UK Water Industry has indicated that this British Standard is to be regarded as superseding the following Water Industry Specifications:
WIS 4-31-06, Issue 2: March 1994 *Blue unplasticised PVC pressure pipes, integral joints and post-formed bends for cold potable water (underground use)*
WIS 4-31-07, Issue 2: March 1994 *Unplasticised PVC pressure fittings and assemblies for cold potable water (underground use)*

The UK participation in its preparation was entrusted by Technical Committee PRI/61, Plastics piping systems and components, to Subcommittee PRI/61/2, Thermoplastics piping sytems and components for pressure applications, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

This British Standard, having been prepared under the direction of the Sector Committee for Materials and Chemicals, was published under the authority of the Standards Committee and comes into effect on 15 May 2000

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Amendments issued since publication

Amd. No.	Date	Comments
10999 Corrigendum No. 1	July 2000	Indicated by a sideline
12005 Corrigendum No. 2	October 2000	Correction to National foreword supersession details

The responsible UK committee gives the following advice concerning the selection and installation of piping systems and components conforming to this British Standard.

a) Water supply companies and other entities are obliged to use Parts 1 to 5 of this suite of European Standards, produced under EC/U mandate, if they wish to purchase PVC-U pipe systems or components within its scope.

NOTE 2 Parts 6 and 7 have each been prepared as an ENV (pre-standard), to allow further development, and their use is voluntary unless invoked contractually.

b) Sub-clause **5.2** enables the selection of pipe colours from grey, blue and cream. It has been the practice of UK water companies to use blue, metric PVC-U pipes (conforming to WIS 4-31-06), to facilitate identification of potable water pipelines. For buried applications in the United Kingdom, attention is drawn to the recommendations of the National Joint Utilities Group (NJUG) concerning the colour coding of pipelines and other services. For UK public water supply applications, the pipes should also be marked with the word "WATER".

Purchasers still requiring grey, Imperial (inch) -sized pipes should refer to normative annex B. The sizes equate to those of BS 3505:1986. Apart from the UK fracture toughness requirements, all other requirements are as in the main text of BS EN 1452-2:2000.

c) Table 2 covers a nominal outside diameter (d_n) of 12 to 1 000 and a nominal pressure PN range from 6 bar to 25 bar. In order not to use very thin wall PVC-U pipes and to benefit from rationalization, the UK water company range had been limited to PN 8 pipes in nominal outside diameters 90 mm to 630 mm, inclusive, and PN 12.5 pipes from 63 mm to 630 mm; the overall service (design) coefficient (*C)* was 2.0 for all sizes. In developing EN 1452-2, a compromise required the increase of *C* to 2.5 for nominal outside diameters up to and including d_n 90. For most PNs this has had the effect of increasing the maximum and minimum wall thickness values for d_n 90 pipe to 0.1 mm above those for d_n 110 pipe (in practice the wall thicknesses will probably be the same for these two diameters). Thus, if the same diameters and PNs are selected as previously, no pipe will have a wall thickness less than 3.5 mm.

d) In **6.6.2**, the requirements allow the wall thickness of the ring seal groove to be less than the minimum wall thickness of the pipe by up to 20 %. The UK Technical Committee recommends that the minimum wall thickness of the sealing ring groove is not less than the nominal (minimum) wall thickness for the pipe. This may be achieved by e.g. local thickening of the socket wall or by using an external sleeve.

e) In Table 5, the depths of engagement given for sockets are minimum depths. It has been UK practice to use depths larger than the minimum (thus still permitted).

f) For the purposes of **8.1**, no purchaser selection decisions are required to be made with respect to the 0 °C impact test; PN 8 pipes are required to conform to level H requirements and PN 12.5 pipes to the level M requirements given in Table 6.

g) In **8.2**, for testing of pipes, the second paragraph allows either of two types of end caps to be used without identifying which of these alternatives is to be the reference condition in case of dispute. Since use of these two types of end caps is not expected to always give identical results, users of this standard should agree which type of end cap shall comprise the reference method in case of dispute. This comment also applies to the fourth paragraph, for the testing of integral sockets.

h) In Table 9, attention is drawn to the normative note 2) and hence to annex C and to note 2 to Table 11 of ENV 1452-7, which permits fracture toughness test requirements to be specified for UK applications as an alternative to the gelation test requirements specified in Table 9. It is strongly recommended that purchasers for UK applications adopt this option on a contractual basis.

i) In the case of pipes which also conform to other standards, attention is drawn to **14.3.1** concerning marking.

j) In Table B.4 *Dimensions of sockets for solvent cementing*, the committee considers that a typographical error has been carried over for nominal size 8 (in), in that the value for the minimum mean inside diameter of socket at midpoint of the socket length, $d_{\mathrm{im,min.}}$ should be 219,0 not 218,0. (The value of 219,4 for $d_{\mathrm{im,max}}$ is correct.)

k) For the purposes of **B.5** and annex C to provide for UK needs for fracture toughness requirements, the UK has been made aware of a mismatch or error in the references to symbols for use of annex C in conjunction with the currently available (1999) ISO/DIS 11673. To avoid an erroneous double application of a correction factor and for consistency with the current and intended details of the test method, the values specified in Table C.1 of EN 1452-2 should be regarded as minimum values for K_{c} and not for K_{ic}.

l) In annex C, the significance of "alternative test" is unclear. See UK comments on Table 9, note 2). Bearing in mind the status of ENV 1452-7, users of this standard should declare or agree which test method and requirements apply in case of dispute.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

WARNING This British Standard, which is identical with EN 1452-2:1999, does not necessarily detail all the precautions necessary to meet the requirements of the Health and Safety at work etc. Act 1974. Attention should be paid to any appropriate safety precautions and the test methods should be performed only by trained personnel.

Regulation 25 of the Water Supply (Water Quality) Regulations 1989 specified the circumstances in which water undertakers may use products in contact with public water supplies in England and Wales. All pipes used to convey public water supplies must be approved under the provisions of regulation 25(1)(a) in order to ensure that use will not cause adverse effect on water quality or risk to health of consumers. Similar provisions apply in Scotland and Northern Ireland.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1452-2

June 1999

ICS 23.040.20

English version

Plastics piping systems for water supply – Unplasticized poly(vinyl chloride) (PVC-U) – Part 2: Pipes

Systèmes de canalisations en plastique pour alimentation en eau – Poly(chlorure de vinyle) non plastifié (PVC-U) – Partie 2: Tubes

Kunststoff-Rohrleitungssysteme für die Wasserversorgung – Weichmacherfreies Polyvinylchlorid (PVC-U) – Teil 2: Rohre

This European Standard was approved by CEN on 2 July 1998.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. EN 1452-2:1999 E

Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 155, Plastics piping systems and ducting systems, the Secretariat of which is held by NNI. It has been prepared with the cooperation of Eureau and in liaison with CEN/TC 164, Water supply.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by december 1999, and conflicting national standards shall be withdrawn at the latest by June 2001.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This standard forms part of a System Standard for plastics piping systems of a particular material for a specified application. There are a number of such System Standards.

System Standards are based on the results of the work undertaken in ISO/TC 138, Plastics pipes, fittings and valves for the transport of fluids, which is a Technical Committee of the International Organization for Standardization (ISO).

They are supported by separate standards on test methods to which references are made throughout the System Standard.

The System Standards are consistent with general standards on functional requirements and on recommended practice for installation.

EN 1452 consists of the following Parts, under the general title, *Plastics piping systems for water supply — Unplasticized poly(vinyl chloride) (PVC-U)*:

- *Part 1: General;*
- *Part 2: Pipes* (this standard);
- *Part 3: Fittings;*
- *Part 4: Valves and ancillary equipment;*
- *Part 5: Fitness for purpose of the system;*
- *Part 6: Guidance for installation (ENV);*
- *Part 7: Guidance for assessment of conformity (ENV).*

This part of EN 1452 includes the following annexes:

- Annex A (normative): Allowable operating pressures;
- Annex B (normative): Imperial(inch)-sized pipes;
- Annex C (normative): Requirements for fracture toughness test;
- Annex D (informative): Bibliography.

At the date of publication of this standard, System Standards for piping systems of other plastics materials used for the same application are the following:

NOTE All listed System Standards are in preparation.

prEN 1796, *Plastics piping systems for water supply with or without pressure — Glass-reinforced thermosetting plastics (GRP) based on polyester resin (UP);*

prEN 12201, *Plastics piping systems for water supply — Polyethylene (PE).*

Introduction

The System Standard, of which this is Part 2, specifies the requirements for a piping system and its components made from unplasticized poly(vinyl chloride) (PVC-U). The piping system is intended to be used for water supply.

In respect of potential adverse effects on the quality of water intended for human consumption, caused by the products covered by this standard:

1) this standard provides no information as to whether the product may be used without restriction in any of the Member States of the EU or EFTA;

2) it should be noted that, while awaiting the adoption of verifiable European criteria, existing national regulations concerning the use and/or the characteristics of this product remain in force.

For material and components, other than pipes, requirements and test methods are specified in Parts 1, 3 and 4 of EN 1452. Characteristics for fitness for purpose (mainly for joints) are covered in Part 5. Guidance for installation is given in ENV 1452-6. ENV 1452-7 is a guidance for the assessment of conformity.

This part of EN 1452 covers the characteristics of pipes.

1 Scope

This part of EN 1452 specifies the characteristics of pipes made from unplasticized poly(vinyl chloride) (PVC-U) for piping systems in the field of water supply.

It also specifies the test parameters for the test methods referred to in this standard.

In conjunction with Parts 1 to 5 of EN 1452 and ENV 1452-7, it is applicable to extruded PVC-U pipes without a socket and pipes with a socket (integral or not), intended to be used for the following:

a) water mains and services buried in ground;

b) conveyance of water above ground for both outside and inside buildings;

for the supply of water under pressure at approximately 20 °C (cold water) intended for human consumption and for general purposes.

This standard is also applicable to pipes for the conveyance of water up to and including 45 °C. For temperatures between 25 °C and 45 °C Figure A.1 in annex A applies.

This standard covers a range of pipe sizes and pressure classes and gives requirements concerning colours.

NOTE It is the responsibility of the purchaser or specifier to make the appropriate selections from these aspects, taking into account their particular requirements and any relevant national regulations and installation practices or codes.

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 publications are listed hereafter. 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.

prEN 496, *Plastics piping and ducting systems — Plastics pipes and fittings — Measurement of dimensions and visual inspection of surfaces*

EN 578, *Plastics piping systems — Plastics pipes and fittings — Determination of the opacity*

EN 580, *Plastics piping systems — Unplasticized poly(vinyl chloride) (PVC-U) pipes — Test method for the resistance to dichloromethane at a specified temperature (DCMT)*

EN 681-1, *Elastomeric seals — Material requirements for pipe joint seals used in water and drainage applications — Part 1: Vulcanized rubber*

EN 727, *Plastics piping and ducting systems — Thermoplastics pipes and fittings — Determination of Vicat softening temperature (VST)*

EN 743, *Plastics piping and ducting systems — Thermoplastics pipes — Determination of the longitudinal reversion*

EN 744:1995, *Plastics piping and ducting systems — Thermoplastics pipes — Test method for resistance to external blows by the round-the-clock method*

EN 921:1995, *Plastics piping systems — Thermoplastics pipes — Determination of resistance to internal pressure at constant temperature*

EN 1452-1, *Plastics piping systems for water supply — Unplasticized poly(vinyl chloride) (PVC-U) — Part 1: General*

EN 1452-5, *Plastics piping systems for water supply — Unplasticized poly(vinyl chloride) (PVC-U) — Part 5: Fitness for purpose of the system*

ENV 1452-7:1999, *Plastics piping systems for water supply — Unplasticized poly(vinyl chloride) (PVC-U) — Part 7: Guidance for the assessment of conformity*

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

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

ISO 6401:1985, *Plastics — Homopolymer and copolymer resins of vinyl chloride — Determination of residual vinyl chloride monomer — Gas chromatographic method*

ISO 7387-1:1983, *Adhesives with solvents for assembly of PVC-U pipe elements — Characterization — Part 1: Basic test methods*

ISO/TR 9080:1992, *Thermoplastics pipes for the transport of fluids — Methods of extrapolation of hydrostatic stress rupture data to determine the long-term hydrostatic strength of thermoplastics pipe materials*

3 Definitions, symbols and abbreviations

For the purposes of this standard, the definitions, symbols and abbreviations given in EN 1452-1 apply together with the following:

L : length of socket

m : depth of engagement

4 Material

4.1 Pipe material

The material to be used shall conform to EN 1452-1 and to the requirements given in 4.2 and 4.3.

4.2 Density

The density, ρ, at 23 °C of the pipe, when measured in accordance with ISO 1183, shall be between the following limits:

$1350\ kg/m^3 \leq \rho \leq 1460\ kg/m^3$

4.3 MRS-value

The pipe material shall have a minimum required strength, MRS, as defined in EN 1452-1, of at least 25 MPa.

The pipe material shall be evaluated according to ISO/TR 9080 method II [1)], where an internal pressure test is performed in accordance with EN 921:1995, to find the LCL. This evaluation shall be made with an end cap type a) or b) in accordance with EN 921:1995 and using a pipe series $S \leq 12,5$. The MRS-value shall be derived from the LCL and the pipe material shall be classified by the compound manufacturer in accordance with EN ISO 12162.

Where there is available long-term experience with the effect of a change in material/compound, it is not necessary to re-evaluate the MRS. In this case the values determined with 5 test pieces at 20 °C and 60 °C during 1000 h to 5000 h shall be located on or above the 97,5 % LCL long-term characteristic curve established prior to the material/compound change.

1) In ISO/TC 138/SC5 a new extrapolation method is under development, which is intended to replace ISO/TR 9080.

5 General characteristics

5.1 Appearance

When viewed without magnification the internal and external surfaces of pipes shall be smooth, clean and free from scoring, cavities and other surface defects to an extent that would prevent conformity to this standard. The material shall not contain any impurities visible without magnification. The ends of the pipe shall be cut cleanly and square to the axis of the pipe.

5.2 Colour

The colour of the pipes shall be either grey, blue or cream. The colour of the pipes shall be uniform throughout. For above ground application, cream pipes shall not be used.

5.3 Opacity

The wall of the pipe shall be opaque and shall not transmit more than 0,2 % of visible light when measured in accordance with EN 578. This requirement does not apply to cream pipes (see 5.2).

6 Geometrical characteristics

6.1 Measurement of dimensions

Dimensions shall be measured in accordance with prEN 496.

6.2 Nominal outside diameters

The nominal outside diameter, d_n, of a pipe shall conform to.

6.3 Mean outside diameters and their tolerances

The mean outside diameter, d_{em}, of a pipe shall conform to the applicable nominal outside diameter, d_n, within the tolerance given in table 1.

The tolerance for out-of-roundness shall conform to table 1.

Table 1 — Nominal outside diameters and tolerances

Dimensions in millimetres

Nominal outside diameter	Tolerance for mean outside diameter d_{em} [1]	Tolerance for out-of-roundness [2]	
d_n	x	S 20 to S 16 [3]	S 12,5 to S 5 [4]
12	0,2	––	0,5
16	0,2	––	0,5
20	0,2	––	0,5
25	0,2	––	0,5
32	0,2	––	0,5
40	0,2	1,4	0,5
50	0,2	1,4	0,6
63	0,3	1,5	0,8
75	0,3	1,6	0,9
90	0,3	1,8	1,1
110	0,4	2,2	1,4
125	0,4	2,5	1,5
140	0,5	2,8	1,7
160	0,5	3,2	2,0
180	0,6	3,6	2,2
200	0,6	4,0	2,4
225	0,7	4,5	2,7
250	0,8	5,0	3,0
280	0,9	6,8	3,4
315	1,0	7,6	3,8
355	1,1	8,6	4,3
400	1,2	9,6	4,8
450	1,4	10,8	5,4
500	1,5	12,0	6,0
560	1,7	13,5	6,8
630	1,9	15,2	7,6
710	2,0	17,1	8,6
800	2,0	19,2	9,6
900	2,0	21,6	––
1000	2,0	24,0	––

[1] The tolerance conforms to grade D of ISO 11922-1:1997 for $d_n \leq 50$ and to grade C for $d_n > 50$. The tolerance is expressed in the form $^{+x}_{0}$ mm, where x is the value of the tolerance.

[2] The tolerance is expressed as the difference between the largest and the smallest outside diameter in a cross-section of the pipe (i.e. $d_{e,max} - d_{e,min}$).

[3] For $d_n \leq 250$, the tolerance conforms to grade N of ISO 11922-1:1997.
For $d_n > 250$, the tolerance conforms to grade M of ISO 11922-1:1997. The requirement for out-of-roundness is only applicable prior to storage.

[4] For a d_n of 12 to 1000, the tolerance conforms to 0,5 grade M of ISO 11922-1:1997. The requirement for out-of-roundness is only applicable prior to the pipe leaving the manufacturer's premises.

6.4 Wall thicknesses and their tolerances

The nominal wall thickness, e_n, is classified with the pipe series S. The nominal wall thickness corresponds to the minimum allowable wall thickness.

The nominal wall thickness shall conform to table 2, as appropriate to the pipe series.

The tolerance for mean wall thickness, e_m, shall conform to table 3.

Table 2 — Nominal (minimum) wall thicknesses

Dimensions in millimetres

Nominal outside diameter	Nominal (minimum) wall thickness							
	Pipe series S							
	S 20 (SDR 41)	(S 16,7) (SDR 34,4)	S 16 (SDR 33)	S 12,5 (SDR 26)	S 10 (SDR 21)	S 8 (SDR 17)	S 6,3 (SDR 13,6)	S 5 (SDR 11)
	Nominal pressure PN based on service (design) coefficient C = 2,5							
d_n		PN 6	PN 6	PN 8	PN 10	PN 12,5	PN 16	PN 20
12		—	—	—	—	—	—	1,5
16		—	—	—	—	—	—	1,5
20		—	—	—	—	—	1,5	1,9
25		—	—	—	—	1,5	1,9	2,3
32		—	—	1,5	1,6	1,9	2,4	2,9
40		—	1,5	1,6	1,9	2,4	3,0	3,7
50		1,5	1,6	2,0	2,4	3,0	3,7	4,6
63		1,9	2,0	2,5	3,0	3,8	4,7	5,8
75		2,2	2,3	2,9	3,6	4,5	5,6	6,8
90		2,7	2,8	3,5	4,3	5,4	6,7	8,2
	Nominal pressure PN based on service (design) coefficient C = 2,0							
	PN 6	PN 7,5	PN 8	PN 10	PN 12,5	PN 16	PN 20	PN 25
110	2,7	3,2	3,4	4,2	5,3	6,6	8,1	10,0
125	3,1	3,7	3,9	4,8	6,0	7,4	9,2	11,4
140	3,5	4,1	4,3	5,4	6,7	8,3	10,3	12,7
160	4,0	4,7	4,9	6,2	7,7	9,5	11,8	14,6
180	4,4	5,3	5,5	6,9	8,6	10,7	13,3	16,4
200	4,9	5,9	6,2	7,7	9,6	11,9	14,7	18,2
225	5,5	6,6	6,9	8,6	10,8	13,4	16,6	—
250	6,2	7,3	7,7	9,6	11,9	14,8	18,4	—
280	6,9	8,2	8,6	10,7	13,4	16,6	20,6	—
315	7,7	9,2	9,7	12,1	15,0	18,7	23,2	—
355	8,7	10,4	10,9	13,6	16,9	21,1	26,1	—
400	9,8	11,7	12,3	15,3	19,1	23,7	29,4	—
450	11,0	13,2	13,8	17,2	21,5	26,7	33,1	—
500	12,3	14,6	15,3	19,1	23,9	29,7	36,8	—
560	13,7	16,4	17,2	21,4	26,7	—	—	—
630	15,4	18,4	19,3	24,1	30,0	—	—	—
710	17,4	20,7	21,8	27,2	—	—	—	—
800	19,6	23,3	24,5	30,6	—	—	—	—
900	22,0	26,3	27,6	—	—	—	—	—
1000	24,5	29,2	30,6	—	—	—	—	—

NOTE 1: The nominal wall thicknesses conform to ISO 4065:1996.
NOTE 2: To apply an overall service (design) coefficient of 2,5 (instead of 2,0) for pipes with nominal diameters above 90 mm, the next higher pressure rating, PN, shall be chosen.
NOTE 3: The PN 6 values for S 20 and S 16 are calculated with the preferred number 6,3.
NOTE 4: The pipe series S 16,7 in brackets is intended to be phased out by the end of the year 1999.

Table 3 — Tolerance on wall thicknesses

Dimensions in millimetres

Nominal (minimum) wall thickness e_n		Tolerance for mean wall thickness x	Nominal (minimum) wall thickness e_n		Tolerance for mean wall thickness x
>	≤		>	≤	
1,0	2,0	0,4	21,0	22,0	2,4
2,0	3,0	0,5	22,0	23,0	2,5
3,0	4,0	0,6	23,0	24,0	2,6
4,0	5,0	0,7	24,0	25,0	2,7
5,0	6,0	0,8	25,0	26,0	2,8
6,0	7,0	0,9	26,0	27,0	2,9
7,0	8,0	1,0	27,0	28,0	3,0
8,0	9,0	1,1	28,0	29,0	3,1
9,0	10,0	1,2	29,0	30,0	3,2
10,0	11,0	1,3	30,0	31,0	3,3
11,0	12,0	1,4	31,0	32,0	3,4
12,0	13,0	1,5	32,0	33,0	3,5
13,0	14,0	1,6	33,0	34,0	3,6
14,0	15,0	1,7	34,0	35,0	3,7
15,0	16,0	1,8	35,0	36,0	3,8
16,0	17,0	1,9	36,0	37,0	3,9
17,0	18,0	2,0	37,0	38,0	4,0
18,0	19,0	2,1			
19,0	20,0	2,2			
20,0	21,0	2,3			

NOTE 1: The tolerance applies to the nominal (minimum) wall thickness and is expressed in the form $^{+x}_{0}$ mm, where x is the value of tolerance for the mean wall thickness, e_m.
NOTE 2: The tolerance for mean wall thickness, e_m, conforms to grade W of ISO 11922-1:1997.

6.5 Length of pipe

The nominal pipe length shall be a minimum length which does not include the depth of the socketed portions, as shown in figure 1.

NOTE The preferred nominal length of pipe is 6 m. Other lengths are subject to agreement between manufacturer and purchaser.

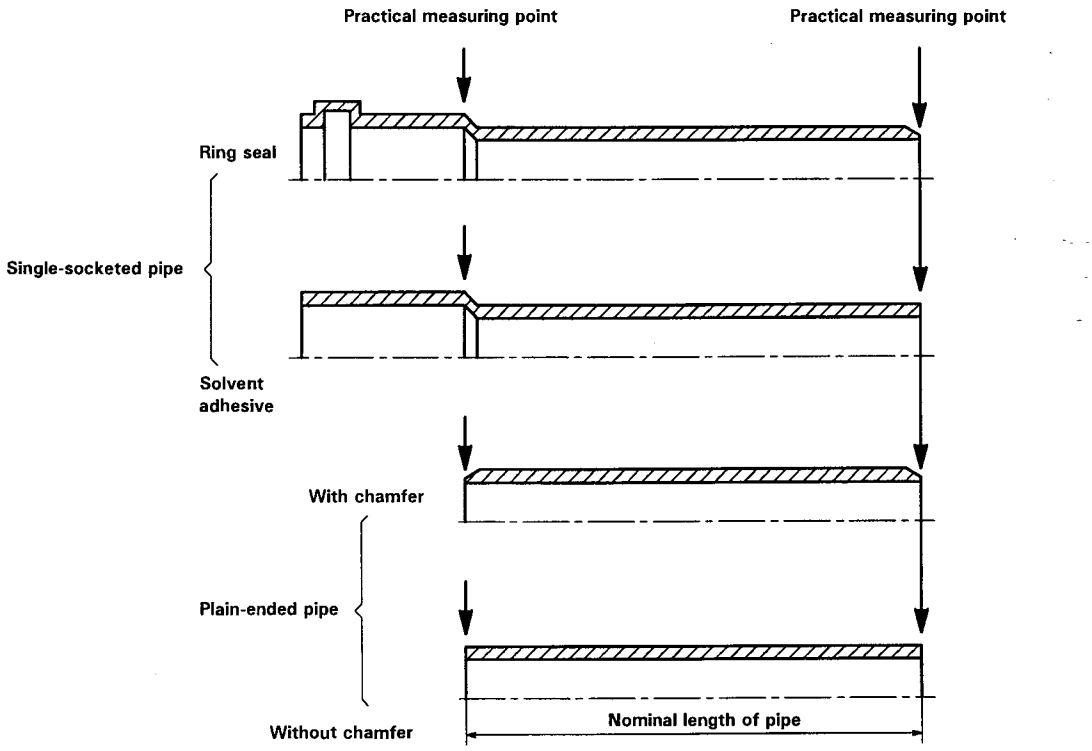

Figure 1 — Points of measurement for nominal pipe lengths

6.6 Pipes with sockets

6.6.1 Sockets for solvent cementing

The dimensions of sockets for solvent cementing are shown in figure 2. They shall conform to table 4.

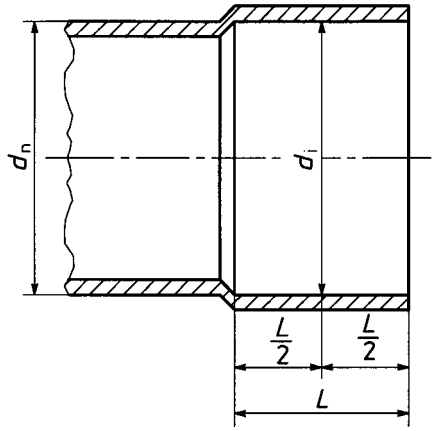

Figure 2 — Socket for solvent cementing

The nominal inside diameter of a socket shall be equal to the nominal outside diameter d_n of the pipe.

The maximum included internal angle of the socketed portion shall not exceed 0°30' (30 minutes).

The requirements for mean inside diameters, d_{im}, of sockets shall apply at the midpoint of the socket length.

Table 4 — Dimensions of sockets for solvent cementing

Dimensions in millimeters

Nominal inside diameter of socket	Mean inside diameter of socket		Maximum out-of-roundness for d_i	Minimum socket length
d_n	$d_{im,min}$	$d_{im,max}$	[1]	L_{min} [2]
12	12,1	12,3	0,25	12,0
16	16,1	16,3	0,25	14,0
20	20,1	20,3	0,25	16,0
25	25,1	25,3	0,25	18,5
32	32,1	32,3	0,25	22,0
40	40,1	40,3	0,25	26,0
50	50,1	50,3	0,3	31,0
63	63,1	63,3	0,4	37,5
75	75,1	75,3	0,5	43,5
90	90,1	90,3	0,6	51,0
110	110,1	110,4	0,7	61,0
125	125,1	125,4	0,8	68,5
140	140,2	140,5	0,9	76,0
160	160,2	160,5	1,0	86,0
180	180,2	180,6	1,1	96,0
200	200,2	200,6	1,2	106,0
225	225,3	225,7	1,4	118,5
250	250,3	250,8	1,5	131,0
280	280,3	280,9	1,7	146,0
315	315,4	316,0	1,9	163,5

[1] The out-of-roundness tolerances are rounded values of 0,25 grade M to ISO 11922-1:1997.

[2] The minimum socket lengths are equal to ($0{,}5d_n$ + 6 mm) or 12 mm if ($0{,}5d_n$ + 6 mm) ≤ 12 mm.

6.6.2 Sockets for elastomeric ring seal type joints

The minimum depth of engagement, m_{min}, of single sockets with elastomeric ring seal joints (see figure 3) is based on pipe lengths up to 12 m and shall conform to table 5.

The wall thickness of the sockets at any point, except the sealing ring groove, shall not be less than the minimum wall thickness of the connecting pipe. The wall thickness of the sealing ring groove shall not be less than 0,8 times the minimum wall thickness of the connecting pipe.

The requirements for mean inside diameters, d_{im}, of sockets shall apply at the midpoint of the depth of engagement *m.*

Figure 3 shows the engagement if the spigot end is pushed to the socket bottom. For assembly instructions see ENV 1452-6.

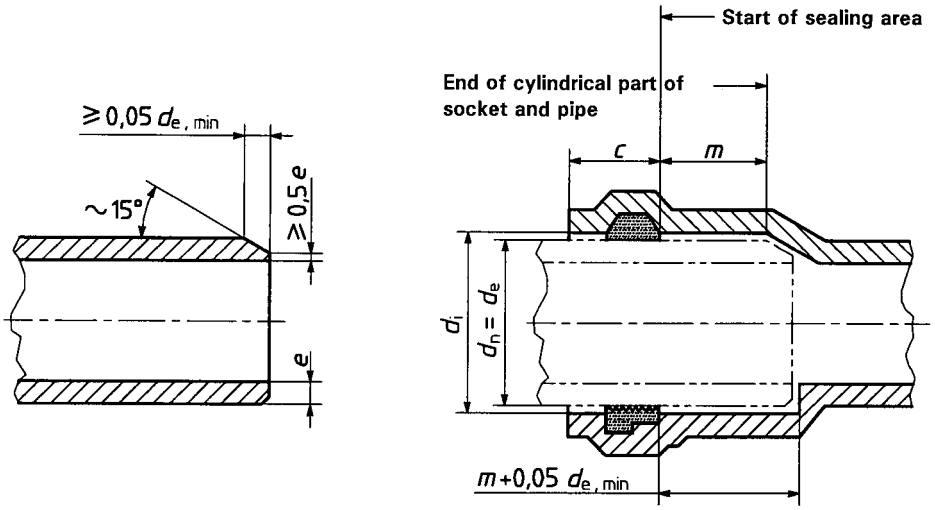

Figure 3 — Socket and spigot end for pipes with elastomeric sealing ring

Table 5 — Dimensions of sockets for elastomeric ring seal joints

Dimensions in millimetres

Nominal inside diameter of socket	Minimum mean inside diameter of socket	Maximum permissible out-of-roundness for d_i [2]		Minimum depth of engagement	Length of socket entrance and sealing area
d_n	$d_{im,min}$ [1]	S 20 to S 16	S 12,5 to S 5	m_{min} [3]	c [4]
32	32,3	0,6	0,3	55	27
40	40,3	0,8	0,4	55	28
50	50,3	0,9	0,5	56	30
63	63,4	1,2	0,6	58	32
75	75,4	1,2	0,7	60	34
90	90,4	1,4	0,9	61	36
110	110,5	1,7	1,1	64	40
125	125,5	1,9	1,2	66	42
140	140,6	2,1	1,3	68	44
160	160,6	2,4	1,5	71	48
180	180,7	2,7	1,7	73	51
200	200,7	3,0	1,8	75	54
225	225,8	3,4	2,1	78	58
250	250,9	3,8	2,3	81	62
280	281,0	5,1	2,6	85	67
315	316,1	5,7	2,9	88	72
355	356,2	6,5	3,3	90	79
400	401,3	7,2	3,6	92	86
450	451,5	8,1	4,1	95	94
500	501,6	9,0	4,5	97	102
560	561,8	10,2	5,1	101	112
630	632,0	11,4	5,7	105	123
710	712,3	12,9	6,5	109	136

[1] $d_{im,min}$ is measured in the middle of the engagement, m, and is calculated using the applicable equation as follows:

$d_{im,min} = d_n + 0,3$ mm, when $d_n \leq 50$;
$d_{im,min} = d_n + 0,4$ mm, when $63 \leq d_n \leq 90$;
$d_{im,min} = 1,003 d_n + 0,1$ mm, when $d_n \geq 110$.

The values obtained shall be rounded to the next greater 0,1 mm.

[2] The out-of-roundness tolerances are rounded values of 0,75 grades to ISO 11922-1:1997 for S 20 to S 16 as follows:

0,75 grade M for $32 \leq d_n \leq 50$;
0,75 grade N for $63 \leq d_n \leq 250$;
0,75 grade M for $280 \leq d_n \leq 710$.

For pipe series S 12,5 to S 5: 0,375 grade M, except 0,3 grade M for $d_n = 32$.

[3] The value of m_{min} is calculated from the applicable equation as follows:

$m_{min} = 50$ mm $+ 0,22 d_n - 2e$ (S 10), when $d_n \leq 280$;
$m_{min} = 70$ mm $+ 0,15 d_n - 2e$ (S 10), when $d_n > 280$.

The values obtained shall be rounded to the next greater 1,0 mm.

[4] The value of c is calculated using the following equation: $c = 22 + 0,16 d_n$ and c is given only for guidance in calculating minimum spigot lengths. The manufacturers shall state the c-values in their catalogues.

6.7 Pipe ends for ring seal or solvent cement joints

Pipes with plain ends intended to be used with elastomeric ring seal sockets or integral solvent cement sockets shall be chamfered as shown in figure 3. Pipes with plain ends intended to be used for other solvent cement joints shall have all sharp edges removed.

7 Classification and selection of pipes

7.1 Classification

Pipes shall be classified according to their nominal pressure PN and the pipe series S.

7.2 Selection of the nominal pressure PN and of the pipe series S for water up to approximately 20 °C

The nominal pressure PN, the pipe series S and the design stress, σ_s, are connected by the following relationship:

$$[PN] \triangleq \frac{10\sigma_s}{[S]}$$

For PVC-U pipes σ_s results from an MRS $\geq$ 25 MPa divided by the overall service (design) coefficient *C*. This coefficient shall be 2,5 for nominal outside diameters up to and including 90 mm and 2,0 for nominal outside diameters greater than 90 mm.

Therefore the design stress σ_s shall be 10,0 MPa for nominal outside diameters up to and including 90 mm and 12,5 MPa for nominal outside diameters greater than 90 mm.

The applicable pipe series shall be taken from table 2.

7.3 Determination of the allowable operating pressure PFA for water up to 45 °C

The allowable operating pressure, PFA, for temperatures up to 25 °C shall be equal to the nominal pressure, PN.

To determine the allowable operating pressure, PFA, for temperatures between 25 °C and 45 °C a supplementary derating factor, f_T, shall be applied to the nominal pressure, PN, as follows:

$$[PFA] = f_T \times [PN]$$

This factor is given in Figure A.1 of annex A.

8 Mechanical characteristics

8.1 Impact strength

Pipes with a nominal wall thickness of 14,9 mm or less, when tested for resistance to external blows at 0 °C in accordance with EN 744:1995 shall have a true impact rate (TIR) of not more than 10 % when tested at the levels given in table 6.

Pipes in the series S 5 to S 10 shall be tested at the medium level M and pipes in the series S 12,5 to S 20 shall be tested at the high level H.

The type of the striker shall be as given in table 2 of EN 744:1995 depending on the mass of the falling weight.

The sampling procedure shall conform to ENV 1452-7.

NOTE For practical reasons this test is not relevant for pipes with $d_n < 20$ mm.

Table 6 — Requirements for the falling weight impact test

Nominal outside diameter d_n	Medium level M			High level H		
	Mass of falling weight	Fall height	Impact energy [1) 2)]	Mass of falling weight	Fall height	Impact energy [1) 2)]
mm	kg	m	Nm	kg	m	Nm
20	0,5	0,4	2	0,5	0,4	2
25	0,5	0,5	2,5	0,5	0,5	2,5
32	0,5	0,6	3	0,5	0,6	3
40	0,5	0,8	4	0,5	0,8	4
50	0,5	1,0	5	0,5	1,0	5
63	0,8	1,0	8	0,8	1,0	8
75	0,8	1,0	8	0,8	1,2	9,5
90	0,8	1,2	9,5	1,0	2,0	20
110	1,0	1,6	16	1,6	2,0	31
125	1,25	2,0	25	2,5	2,0	49
140	1,6	1,8	28	3,2	1,8	57
160	1,6	2,0	31	3,2	2,0	63
180	2,0	1,8	35	4,0	1,8	71
200	2,0	2,0	39	4,0	2,0	78
225	2,5	1,8	44	5,0	1,8	88
250	2,5	2,0	49	5,0	2,0	98
280	3,2	1,8	57	6,3	1,8	111
≥ 315	3,2	2,0	63	6,3	2,0	124

1) Based on g = 9,81 m/s^2.
2) For less than 10, rounded off to 0,5; for greater than 10, rounded off to integers.

8.2 Resistance to internal pressure

Pipes shall withstand without bursting or leakage the hydrostatic stress induced by internal hydrostatic pressure when tested in accordance with EN 921:1995 using the test conditions specified in table 7.

For this test end caps type a) or b) in accordance with EN 921:1995 may be used.

The sampling procedure shall conform to ENV 1452-7.

Table 7 — Pressure test requirements for pipes

Characteristic	Requirement	Test parameters				Test method
		Temp. °C	Circumferential stress MPa	Time h	Type of test	
Short- and long-term strength	No failure during the test	20 20 60	42,0 35,0 12,5	1 100 1000	Water -in- water	EN 921:1995

Integral sockets shall be tested in accordance with EN 921:1995 using the test parameters given in table 8. For this test end caps type a) or b) in accordance with EN 921:1995 may be used and the socket entrance may be externally reinforced to prevent a displacement of the sealing ring. The sampling procedure shall conform to ENV 1452-7.

Table 8 — Pressure test requirements for all types of integral sockets on pipes

Characteristic	Requirement	Test parameters					Test method
		Nominal diameter d_n	Temp. °C	Pressure bar	Time h	Type of test	
Short-term strength	No failure during the test	≤ 90 mm	20	4,2 × [PN]	1	Water-in-water	EN 921:1995
		> 90 mm	20	3,36 × [PN]	1		

9 Physical characteristics

When tested in accordance with the test methods as specified in table 9 using the indicated parameters, the pipe shall have physical characteristics conforming to the requirements given in table 9.

The sampling procedure shall conform to ENV 1452-7.

Table 9 — Physical characteristics

Characteristic	Requirement	Test parameters		Test method
Vicat softening temperature (VST)	≥ 80 °C	Shall conform to EN 727		EN 727
Longitudinal reversion	Maximum 5 %	Test temperature: Test period for $e \leq 8$ mm $e > 8$ mm	(150 ± 2) °C 30 min 15 min	EN 743, Method A (liquid) [1]
		or [1]		
		Test temperature: Test period for $e \leq 8$ mm 8 mm < $e \leq 16$ mm $e > 16$ mm	(150 ± 2) °C 60 min 120 min 240 min	EN 743, Method B (air)
Resistance to dichloro-methane at elevated temperatures [2] (Degree of gelation)	No attack at any part of the surface of the test piece	Temperature of bath: Immersion time: Min. wall thickness	(15 ± 1) °C 30 min: 1,5 mm	EN 580

[1] In case of dispute method B shall be used.
[2] For requirements for fracture toughness see annex C and note 2) to table 11 of ENV 1452-7.

10 Chemical characteristics

The PVC-U pipe shall not contain vinyl chloride monomer (VCM) exceeding 1 ppm when determined by means of gas-phase chromatography using the 'headspace' method according to ISO 6401. The sampling procedure shall conform to ENV 1452-7.

11 Sealing rings

The material of the elastomeric sealing ring used in joint assemblies for pipes shall be chosen from EN 681-1 and shall conform to the appropriate class.

The sealing ring shall have no detrimental effect on the properties of the pipe and shall not cause the test assembly to fail the functional requirements of EN 1452-5.

12 Adhesives

The adhesive(s) shall have no detrimental effects on the pipe and shall not cause the test assembly to fail to conform to EN 1452-5.

The adhesives shall be identified according to ISO 7387-1 and their properties shall conform to the appropriate standards.

NOTE A standard on a test method for the determination of the film properties is under preparation (see prEN ISO 9311-1).

13 Performance requirements

When pipes conforming to this standard are jointed to each other or to components conforming to other Parts of EN 1452, the pipes and the joints shall conform to EN 1452-5.

14 Marking

14.1 General

14.1.1 The marking elements shall be printed or formed directly on the pipe with a maximum interval of 1 m in such a way that after storage, weathering, handling and installation (e.g. in accordance with ENV 1452-6), legibility is maintained during the use of the products.

NOTE The manufacturer is not responsible for marking being illegible due to actions caused by installation and use such as painting, scratching, covering of the pipes or by use of detergents on the pipe.

14.1.2 Marking shall not initiate cracks or other types of defects which would impair conformity to the requirements of this standard.

14.1.3 If printing is used, the colouring of the printed information shall differ from the basic colouring of the pipe.

14.1.4 The size of the marking shall be such that the marking is legible without magnification.

14.2 Minimum required marking

The minimum required marking on pipes shall conform to table 10.

Table 10 — Minimum required marking on pipes

Aspects	Mark or symbol
– Number of the System Standard	EN 1452
– Manufacturer's name and/or trade mark	xyz
– Material	PVC-U
– Nominal outside diameter d_n × wall thickness e_n	e.g. 110 x 6,6
– Nominal pressure PN [1)]	e.g. PN 16
– Manufacturer's information [2)]	e.g. 90.06.14
– Number of the extrusion line [3)]	e.g. N^o 12

1) The marking of the pipe series S may be included, e.g. PN 16/S 8.

2) For providing traceability the following details shall be given:

a) the production period, year, in figures or in code;
b) a name or code for the production site if the manufacturer is producing in different sites, nationally and/or internationally.

3) If not included in manufacturer's information.

14.3 Additional marking

14.3.1 Pipes which conform to this standard, and also conform to other standard(s) may be marked additionally with the number(s) of the other standard(s), together with the minimum required marking in accordance with the other standard(s).

14.3.2 It is recommended that those pipes which are purchased specifically for public water supply applications are marked additionally with the word WATER.

14.3.3 Pipes which conform to this standard and which are third party certified may be marked accordingly.

NOTE Attention is drawn to the possible need to include CE marking when required for legislative purposes.

Annex A
(normative)

Allowable operating pressures

A.1 Nominal pressures PN of pipes

The nominal pressure, PN, of a pipe shall be designated in accordance with Table A.1, depending upon the diameter of the pipe and the pipe series S.

Table A.1— Nominal pressures of pipes

Nominal diameter	Nominal pressures							
	Pipe series							
	S 20	S 16,7 [1)]	S 16	S 12,5	S 10	S 8	S 6,3	S 5
d_n	(SDR 41)	(SDR 34,4)	(SDR 33)	(SDR 26)	(SDR 21)	(SDR 17)	(SDR 13,6)	(SDR 11)
≤ 90	—	(PN 6)	PN 6	PN 8	PN 10	PN 12,5	PN 16	PN 20
> 90	PN 6	(PN 7,5)	PN 8	PN 10	PN 12,5	PN 16	PN 20	PN 25

1) The nominal pressures for the pipe series S 16,7 are intended to be phased out by the end of the year 1999.

A.2 Nominal pressures PN of the system

All system components conforming to this standard shall be classified and marked with PN and optionally with the pipe series S. Every component can be used at a temperature up to 25 °C for an operating pressure in bar equal to or less than the marked PN.

This means that fittings and valves may be used in combination with pipes marked with the same or with a lower PN.

The whole system allows the operating pressure to be equal to or less than that of the component having the lowest pressure rating.

A.3 Derating factor for service temperatures between 25 °C and 45 °C

The derating factor f_T for service temperatures up to 45 °C shall be taken from Figure A.1. The derating factor is based on long-term experience and test results.

EXAMPLE: Consider a pipe with PN 12,5 to be applied for water at 40 °C.

From Figure A.1 the derating factor at 40 °C is 0,71. Therefore the maximum allowable operating pressure at 40 °C in continuous use is: 0,71 × 12,5 bar = 8,88 bar.

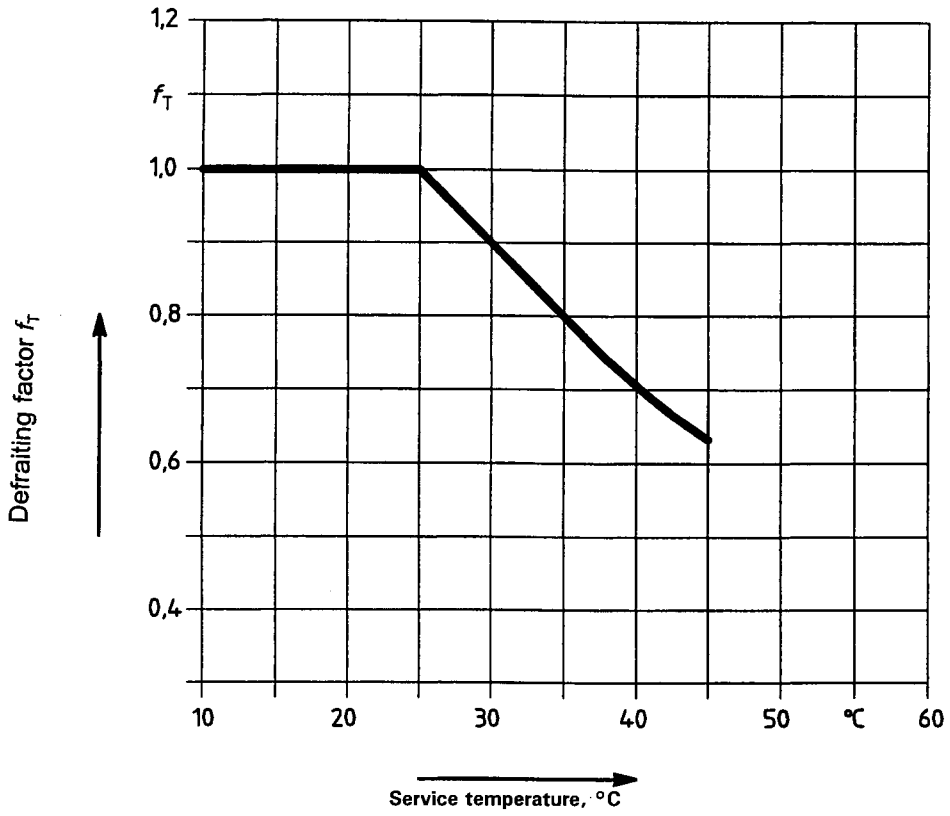

Figure A.1 — Derating factor f_T for service temperatures up to 45 °C

A.4 Derating (or uprating) factor related to application of the system

For applications which need additional derating (or uprating) factors, e.g. more safety than included in the overall service (design) coefficient of 2,0 or 2,5, an additional factor f_A shall be chosen at the design stage.

The allowable operating pressure in continuous use shall be then calculated by:

$$[PFA] = f_T \times f_A \times [PN]$$

where:

[PFA] is the allowable operating pressure;

f_T is the derating factor for service temperatures between 25 °C and 45 °C;

f_A is the derating (or uprating) factor related to the application;

[PN] is the nominal pressure.

NOTE [PFA] and [PN] are expressed in the same unit of pressure, preferably in bars.

Annex B
(normative)

Imperial(inch)-sized pipes

B.1 General

All clauses contained within the main text of this standard shall apply, together with the following clauses. Only those clauses for which the contents differ from the main text are described hereafter.

B.2 Normative references

In addition to the normative references given in clause 2 of this standard, the following normative reference applies.

ISO/DIS 11673:1993, *Determination of the fracture toughness of unplasticized poly(vinyl chloride) (PVC-U) pipes.*

B.3 Geometrical characteristics

B.3.1 Mean outside diameters and their tolerances

For the purposes of 6.3, table B.1 shall apply in place of table 1.

Table B.1 — Mean outside diameters and tolerances

Dimensions in millimetres

Nominal size	Mean outside diameter		Tolerance for out-of-roundness
(in)	$d_{em,min}$	$d_{em,max}$	
⅜	17,0	17,3	0,3
½	21,2	21,5	0,3
¾	26,6	26,9	0,3
1	33,4	33,7	0,5
1¼	42,1	42,4	0,5
1½	48,1	48,4	0,5
2	60,2	60,5	0,7
3	88,7	89,1	1,0
4	114,1	114,5	1,2
6	168,0	168,5	1,7
8	218,8	219,4	2,2
10	272,6	273,4	2,8
12	323,4	324,3	3,3
16	405,9	406,9	4,2
18	456,7	457,7	4,6
20	507,5	508,5	5,2
24	609,1	610,1	6,2

B.3.2 Wall thicknesses and their tolerances

For the purposes of 6.4, the following shall apply.

The nominal wall thicknesses, e_n, shall be classified according to the PN rating of the pipe, as given in table B.2.

The tolerances on the nominal (minimum) wall thickness at any point shall conform to table B.3.

Table B.2 — Nominal wall thicknesses

Dimensions in millimetres

Nominal size	Nominal wall thickness e_n		
(in)	PN 9	PN 12	PN 15
⅜	––	––	1,5
½	––	––	1,7
¾	––	––	1,9
1	––	––	2,2
1¼	––	2,2	2,7
1½	––	2,5	3,1
2	2,5	3,1	3,9
3	3,5	4,6	5,7
4	4,5	6,0	7,3
6	6,6	8,8	10,8
8	7,8	10,3	12,6
10	9,7	12,8	15,7
12	11,5	15,2	18,7
16	14,5	19,0	23,4
18	16,3	21,4	––
20	18,1	––	––
24	21,7	––	––

Table B.3 — Tolerance on wall thickness at any point

Dimensions in millimetres

Nominal size (in)	Tolerance *x* on nominal wall thickness [1]		
	PN 9	PN 12	PN 15
3/8	—	—	0,4
½	—	—	0,4
¾	—	—	0,6
1	—	—	0,6
1¼	—	0,5	0,6
1½	—	0,5	0,6
2	0,5	0,6	0,6
3	0,6	0,7	0,9
4	0,7	0,9	1,1
6	1,0	1,4	1,7
8	1,2	1,6	1,9
10	1,5	2,0	2,4
12	1,8	2,3	2,9
16	2,2	2,9	3,6
18	2,5	3,3	—
20	2,8	—	—
24	3,3	—	—

[1] The tolerance is expressed in the form of $^{+X}_{0}$ mm, where *x* is the value of the tolerance on the minimum wall thickness.

B.3.3 Pipes with sockets

B.3.3.1 Sockets for solvent cementing

For the purposes of 6.6.1, the following shall apply.

The dimensions of sockets for solvent cementing are shown in figure B.1. They shall conform to the values given in table B.4.

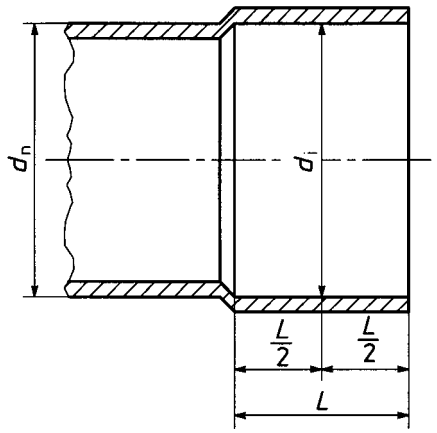

Figure B. 1 — Socket on pipe end for solvent cementing

At no point shall the inside diameter of the socket be greater than the mouth inside diameter of the associated socket. The mean inside diameter of the socket may decrease from mouth to root by the following maximum total included angle of taper:

⅜" to 2" nominal size: 0°40';

3" nominal size and greater: 0°30'.

An out-of-roundness tolerance of ± 0,2 % is allowed on the mean inside diameter of socket.

Table B.4 — Dimensions of sockets for solvent cementing

Dimensions in millimeters

Nominal size	Socket length	Mean inside diameter of socket at midpoint of socket length	
(in)	L_{min}	$d_{im,min}$	$d_{im,max}$
⅜	14,5	17,1	17,3
½	16,5	21,3	21,5
¾	19,5	26,7	26,9
1	22,5	33,5	33,7
1¼	27,0	42,2	42,4
1½	30,0	48,2	48,4
2	36,0	60,3	60,5
3	50,5	88,8	89,1
4	63,0	114,2	114,5
6	90,0	168,2	168,5
8	115,5	218,0	219,4
10	142,5	272,8	273,4
12	168,0	323,7	324,3

NOTE The minimum socket lengths, L_{min}, have been calculated using the following equation: $L_{min} = 0{,}5d_{em,min} + 6$ mm

where $d_{em,min}$ is the minimum mean outside diameter of the corresponding pipe (see EN 1452-1).

B.3.3.2 Sockets for elastomeric ring seal joints

For the purposes of 6.6.2 the following shall apply.

The depth of engagement, *m*, of single sockets with elastomeric sealing ring type joints are shown in figure B.2. The minimum value for *m* shall conform to the applicable value given in table B.5.

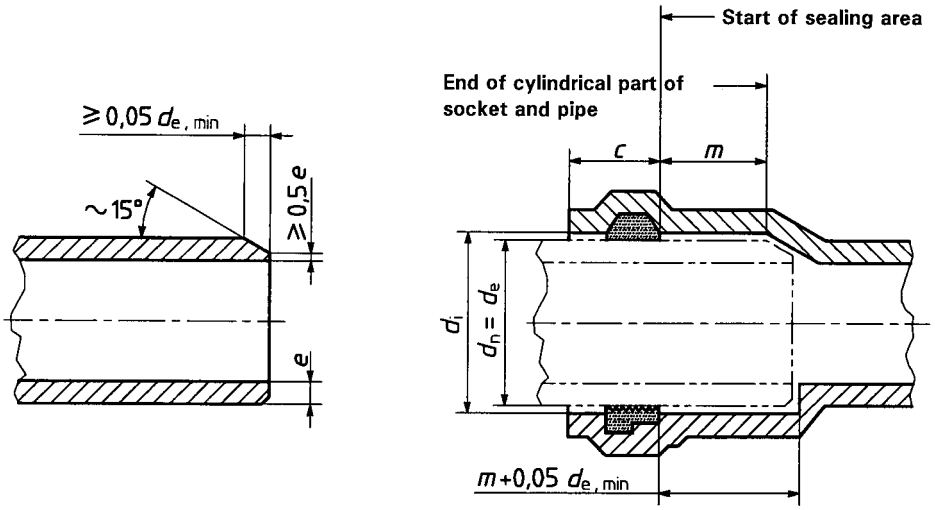

Figure B.2 — Socket and spigot end for pipes with elastomeric sealing ring

Figure B.2, shows the engagement if the spigot end is pushed to the socket bottom. For assembly instructions see ENV 1452-6.

Table B.5 — Dimensions of sockets for elastomeric ring seal joints

Dimensions in millimetres

Nominal size	Minimum depth of engagement m_{min}	
(in)	Single socket	Double socket
2	67	39
3	70	43
4	75	47
6	87	55
8	98	63
10	110	71
12	121	78
16	139	91
18	150	98
20	171	106
24	183	121

B.4 Classification and choice of pipes

Clause 7.1 and 7.2 shall not apply to imperial(inch)-sized pipes.

B.5 Physical characteristics

The characteristics given in table 9 shall be applied to imperial-sized pipes.

In addition, pipes of size 3 inch and larger shall be tested in accordance with ISO/DIS 11673 and with the requirements specified in annex C of this standard.

These pipes shall withstand the applicable test force, for not less than 15 min without breaking or cracking at the notch.

Annex C
(normative)

Requirements for fracture toughness test

Requirements for fracture toughness test conforming to ISO/DIS 11673 have been added to EN 1452-2 on request of the United Kingdom, where such test is traditionally used. It may be used in the United Kingdom as an alternative to the gelation test specified in EN 580.

The values for the fracture-toughness test shall conform to table C.1 for the applicable wall thickness range.

Table C.1 — Fracture toughness values required for specific wall thickness ranges

Pipe wall thickness e_n mm	**Fracture toughness** $K_{ic,min}$ $MNm^{-3/2}$
$4,0 \leq e_n < 6,2$	3,25
$6,2 \leq e_n < 11,9$	3,75
$11,9 \leq e_n < 21,5$	4,50
$21,5 \leq e_n < 33,95$	5,0

Annex D
(informative)

Bibliography

ENV 1452-6, *Plastics piping systems for water supply — Unplasticized poly(vinyl chloride) (PVC-U) — Part 6: Guidance for installation*

prEN ISO 9311-1, *Adhesives for thermoplastics piping systems — Part 1: Test methods for spreadability and film properties of adhesives*

ISO 161-2:1996, *Thermoplastic pipes for the transport of fluids — Nominal outside diameters and nominal pressures — Part 2: Inch series*

ISO 4065:1996, *Thermoplastics pipes — Universal wall thickness table*

ISO 11922-1:1997, *Thermoplastics pipes for the transport of fluids — Dimensions and tolerances — Part 1: Metric series*

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