INTERNATIONAL STANDARD

**ISO 21138-1**

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# Plastics piping systems for non-pressure underground drainage and sewerage — Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) —

## Part 1: Material specifications and performance criteria for pipes, fittings and system

*Systèmes de canalisations en plastique pour les branchements et les collecteurs d'assainissement sans pression enterrés — Systèmes de canalisations à parois structurées en poly(chlorure de vinyle) non plastifié (PVC-U), polypropylène (PP) et polyéthylène (PE) —*

*Partie 1: Spécifications des matières et critères de performance des tubes, raccords et système*

Reference number
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# 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 21138-1 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 1, *Plastics pipes and fittings for soil, waste and drainage (including land drainage)*.

ISO 21138 consists of the following parts, under the general title *Plastics piping systems for non-pressure underground drainage and sewerage — Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE)*:

— *Part 1: Material specifications and performance criteria for pipes, fittings and system*

— *Part 2: Pipes and fittings with smooth external surface, Type A*

— *Part 3: Pipes and fittings with non-smooth external surface, Type B*

# Introduction

ISO 21138 is the system standard covering the plastics piping systems for non-pressure underground drainage and sewerage, in particular thermoplastics structured-wall piping systems.

# Plastics piping systems for non-pressure underground drainage and sewerage — Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) —

## Part 1: Material specifications and performance criteria for pipes, fittings and system

## 1 Scope

This part of ISO 21138 specifies the definitions and requirements for pipes, fittings and the system based on unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) structured-wall piping systems in the field of non-pressure underground systems for underground drainage and sewerage.

NOTE 1 These pipes, fittings and the system can be used for highway drainage and surface water.

This part of ISO 21138 specifically refers to PVC, PP and PE materials.

NOTE 2 Other thermoplastic materials can be added via an addendum.

This part of ISO 21138 covers a range of pipe and fitting sizes, materials, pipe constructions, nominal ring stiffnesses, and gives recommendations concerning colours.

NOTE 3 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.

In conjunction with ISO 21138-2 and ISO 21138-3, it is applicable to PVC-U, PP and PE structured-wall pipes and fittings, to their joints and to joints with components of other plastics and non-plastics materials intended to be used for buried piping systems for the transport of drainage and sewerage.

It is applicable to PVC-U, PP and PE structured-wall pipes and fittings with or without an integral socket with elastomeric ring seal joints as well as welded and fused joints.

NOTE 4 Pipes, fittings and other components conforming to any plastics product standards referred to in Clause 2 can be used with pipes and fittings conforming to this part of ISO 21138 when they conform to the requirements for joint dimensions given in Parts 2 and 3 of ISO 21138 and to the performance requirements given in Clause 9.

NOTE 5 For dimensions larger than DN/OD 1200 or DN/ID 1200, this part of ISO 21138 can serve as a general guide regarding appearance, colour, physical and mechanical characteristics as well as performance requirements.

## 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 472, *Plastics — Vocabulary*

ISO 580:2005, *Plastics piping and ducting systems — Injection-moulded thermoplastics fittings — Methods for visually assessing the effects of heating*

ISO 1043-1:2001, *Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics*

ISO 1133:2005, *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics*

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

ISO 1167-2, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 2: Preparation of pipe test pieces*

ISO 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pyknometer method and titration method*

ISO 2505, *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 4435, *Plastics piping systems for non-pressure underground drainage and sewerage — Unplasticized poly(vinyl chloride) (PVC-U)*

ISO 8772, *Plastics piping systems for non-pressure underground drainage and sewerage — Polyethylene (PE)*

ISO 8773, *Plastics piping systems for non-pressure underground drainage and sewerage — Polypropylene (PP)*

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

ISO 9967, *Thermoplastics pipes — Determination of creep ratio*

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

ISO 11173, *Thermoplastics pipes — Determination of resistance to external blows — Staircase method*

ISO 11357-6, *Plastics — Differential scanning calorimetry (DSC) — Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)*

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

ISO 12091:1995, *Structured-wall thermoplastics pipes — Oven test*

ISO 13967, *Thermoplastics fittings — Determination of ring stiffness*

ISO 21138-2:2007, *Plastics piping systems for non-pressure underground drainage and sewerage — Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) — Part 2: Pipes and fittings with smooth external surface, Type A*

ISO 21138-3:2007, *Plastics piping systems for non-pressure underground drainage and sewerage — Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) — Part 3: Pipes and fittings with non-smooth external surface, Type B*

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

EN 681-2, *Elastomeric seals — Materials requirements for pipe joint seals used in water and drainage applications — Part 2: Thermoplastic elastomers*

EN 681-4, *Elastomeric seals — Materials requirements for pipe joint seals used in water and drainage applications — Part 4: Cast polyurethane sealing elements*

EN 1053, *Plastics piping systems — Thermoplastics piping systems for non-pressure applications — Test method for watertightness*

EN 1277, *Plastics piping systems — Thermoplastics piping systems for buried non-pressure applications — Test methods for leaktightness of elastomeric sealing ring type joints*

EN 1446, *Plastics piping and ducting systems — Thermoplastics pipes — Determination of ring flexibility*

EN 1979, *Plastics piping and ducting systems — Thermoplastics spirally-formed structured-wall pipes — Determination of the tensile strength of a seam*

EN 12061, *Plastics piping systems — Thermoplastics fittings — Test method for impact resistance*

EN 12256, *Plastics piping systems — Thermoplastics fittings — Test method for mechanical strength or flexibility of fabricated fittings*

EN 14741, *Thermoplastics piping and ducting systems — Joints for buried non-pressure applications — Test method for the long-term sealing performance of joints with elastomeric seals by estimating the sealing pressure*

## 3 Terms, definitions, symbols and abbreviated terms

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

### 3.1 Terms and definitions

In addition to the terms and definitions given below, the terms and definitions given in ISO 472, ISO 1043-1 and ISO 11922-1 apply.

#### 3.1.1 General terms

**3.1.1.1**
**structured-wall pipes and fittings**
products that have an optimized design with regard to material usage to achieve the physical, mechanical and performance requirements of this part of ISO 21138

NOTE For a description of the particular designs covered by this part of ISO 21138, see ISO 21138-2 for Type A and ISO 21138-3 for Type B. Type A pipes have an internal and external plain surface. Type B pipes have an internal plain surface and a hollow spiral or annular ribbed external surface.

**3.1.1.2**
**fabricated fitting**
fitting manufactured by heat forming and/or joining more than one piece of pipe and/or moulded component

NOTE Sealing rings retaining components are not considered as a piece.

### 3.1.2 Geometrical terms

**3.1.2.1**
**nominal size DN**
numerical designation of the size of a component, other than a component designated by thread size, which is approximately equal to the manufacturing dimension in millimetres

**3.1.2.2**
**nominal size DN/OD**
nominal size, related to the outside diameter

**3.1.2.3**
**nominal size DN/ID**
nominal size, related to the inside diameter

**3.1.2.4**
**nominal diameter**
$d_n$
specified diameter, in millimetres, assigned to a nominal size (DN/OD or DN/ID)

**3.1.2.5**
**outside diameter**
$d_e$
value of the measurement of the outside diameter through its cross-section at any point of a pipe or spigot, rounded to the next greater 0,1 mm

NOTE For Type B constructions, see ISO 21138-3.

**3.1.2.6**
**mean outside diameter**
$d_{em}$
value of the measurement of the outer circumference of a pipe or spigot in any cross-section divided by $\pi$ (= 3,142), rounded up to the nearest 0,1 mm

NOTE For Type B constructions, see ISO 21138-3.

**3.1.2.7**
**mean inside diameter**
$d_{im}$
average value of a number of equally spaced measurements of inside diameter in the same cross-section of a pipe or fitting

**3.1.2.8**
**minimum mean inside diameter of a socket**
$D_{im,min}$
average value of equally spaced measurements of inside diameter in the same cross-section of a socket

**3.1.2.9**
**wall thickness**
$e$
measured wall thickness at any point of the body of a component

**3.1.2.10**
**construction height**
$e_c$
radial distance between the top of ribs or corrugation or, in the case of Type A1 and Type A2 pipes and fittings, between the outside surface of the wall and the inside surface of the wall

**3.1.2.11**
**wall thickness of the inside layer**
**waterway wall thickness**
$e_4$
⟨Type A1⟩ thickness at any point of the inner layer of a pipe or fitting

See Figure 1 in ISO 21138-2:2007.

⟨Type B⟩ thickness at any point of the wall between the ribs or corrugations of the pipe or fitting

See Figure 4 in ISO 21138-3:2007.

**3.1.2.12**
**wall thickness of the inside layer under a hollow section**
$e_5$
thickness at any point of the inside wall between a hollow section and the inside surface of the Type A2 or Type B pipe or fitting

See Figure 2 in ISO 21138-2:2007 and Figure 4 in ISO 21138-3:2007.

**3.1.2.13**
**minimum length of a spigot**
$L_{1,min}$
minimum permitted value for the length of a spigot of a pipe or fitting

**3.1.2.14**
**nominal ring stiffness**
**SN**
numerical designation of the ring stiffness of the pipe or fitting, which is a convenient round number, indicating the minimum required ring stiffness of the pipe or stiffness of the fitting

**3.1.2.15**
**fitting stiffness**
mechanical characteristic of a fitting, which is a measure of the resistance to ring deflection under an external force as determined in accordance with ISO 13967

### 3.1.3 Material terms

**3.1.3.1**
**virgin material**
material in a form such as granules or powder, which has not been subjected to use or processing other than that required for its manufacture and to which no reprocessable or recyclable materials have been added

**3.1.3.2**
**own reprocessable material**
material prepared from rejected unused pipes or fittings, including trimmings from the production of pipes and fittings, which will be reprocessed in a manufacturer's plant after having been previously processed by the same manufacturer by a process such as moulding or extrusion and for which the complete formulation is known

**3.1.3.3**
**external reprocessable material**
material comprising either one of the following:

a) material from rejected unused pipes or fittings, or trimmings therefrom, that will be reprocessed and that were originally processed by another manufacturer;

b) material from the production of unused thermoplastics products other than pipes and fittings, regardless of where they are manufactured

**3.1.3.4**
**recyclable material**
material comprising either one of the following:

a) material from used pipes or fittings that have been cleaned and crushed or ground;

b) material from used thermoplastics products other than pipes or fittings which have been cleaned and crushed or ground

## 3.2 Symbols

| | |
|---|---|
| $a$ | circumferential cover by a saddle branch |
| $D_{im,min}$ | minimum mean inside diameter of a socket |
| $d_e$ | outside diameter |
| $d_{em}$ | mean outside diameter |
| $d_{im}$ | mean inside diameter |
| $d_n$ | nominal diameter |
| $d_{n1}$ | nominal diameter of the main of a branch/saddle branch |
| $d_{n2}$ | nominal diameter of the branch of a branch/saddle branch |
| $d_s$ | inside diameter of socket |
| $e$ | wall thickness (at any point) |
| $e_2$ | wall thickness of the socket |
| $e_3$ | wall thickness of the groove area |
| $e_4$ | wall thickness of the inside layer (waterway wall thickness) |
| $e_5$ | wall thickness of the inside layer under a hollow section |
| $e_c$ | construction height |
| $L$ | axial cover by a saddle branch |
| $L_{1,min}$ | minimum length of a spigot |
| $Z_1$ | design length of a fitting |
| $Z_2$ | design length of a fitting |
| $Z_3$ | design length of a fitting |
| $\alpha$ | nominal angle of a fitting |

### 3.3 Abbreviated terms

DN/ID nominal size related to inside diameter

DN/OD nominal size related to outside diameter

ID inside diameter

OD outside diameter

PE polyethylene

PP polypropylene

PVC-U unplasticized poly(vinyl chloride)

S pipes series S

SDR standard dimension ratio

SN nominal ring stiffness

## 4 Material

### 4.1 General

The material shall be one of those specified in the relevant Annexes of ISO 21138-2 and/or ISO 21138-3.

Information about general material characteristics is given in Annex A.

### 4.2 Sealing ring retaining components

It is permitted that sealing rings be retained using components made from polymers other than PVC-U, PP or PE.

### 4.3 Sealing rings

The sealing ring material shall conform to EN 681-1, EN 681-2 or EN 681-4, as applicable.

The sealing ring shall have no detrimental effects on the properties of the components.

### 4.4 Fused or welded joints

When fused or welded joints are used, the manufacturer's instructions for jointing shall be followed.

## 5 Designation of wall construction

Designations of wall constructions including schematic sketches and examples of typical jointing methods are given in ISO 21138-2 for Type A pipes (inside and outside smooth ) and in ISO 21138-3 for Type B pipes (inside smooth and outside structured).

## 6 Colour

The inner and outer layer of pipes and fittings shall be coloured throughout.

NOTE The outside layer of pipes and fittings should preferably be black, orange-brown (approximately RAL 8023, see [5]) or dusty grey (approximately RAL 7037, see [5]). Other colours may be used.

## 7 Geometrical characteristics

This part of ISO 21138 specifies the following nominal sizes. Other dimensions are permitted.

| Nominal sizes: DN/ID |
|---|
| 100, 125, 150, 200, 225, 250, 300, 400, 500, 600, 800, 1000, 1200 |

| Nominal sizes: DN/OD |
|---|
| 110, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000, 1200 |

## 8 Types of fitting

### 8.1 General

This part of ISO 21138 is applicable for the following types of fitting. Other designs of fitting, including all sockets and all spigots, are permitted.

a) Bends, swept and unswept angle (see Figure 1 and Figure 2).

NOTE 1 Preferred nominal angles, $\alpha$, are the following: 15°, 22,5°, 30°, 45° and between 87,5° and 90°.

b) Couplers and slip couplers (see Figure 3).

c) Reducers (see Figure 4).

d) Branches and reducing branches, swept and unswept entry (see Figure 5).

NOTE 2 Preferred nominal angles, $\alpha$, are 45° and between 87,5° and 90°.

e) Saddle branches for solvent cementing, fusion or welding (see Figure 6):

— the axial cover, $L$, in millimetres, shall conform to the following:

Dimensions in millimetres

| | $d_{n2} \leqslant 110$ | $110 < d_{n2} \leqslant 125$ | $125 < d_{n2} \leqslant 160$ | $160 < d_{n2} \leqslant 200$ |
|---|---|---|---|---|
| $L$ | $\geqslant 50$ | $\geqslant 60$ | $\geqslant 70$ | $\geqslant 80$ |

— for saddles having $d_{n1} < 315$ mm the cover shall be not less than half a circumference, see Figure 6[a];

— for saddles having $d_{n1} \geqslant 315$ mm the circumferential cover, $a$, shall not be less than 80 mm, see Figure 6[b].

NOTE 3 The preferred nominal angle, $\alpha$, for saddle branches is 45°. When $(d_{n2}/d_{n1}) \leqslant 2/3$, the nominal angle, $\alpha$, can be 90°.

f) Plugs (see Figure 7).

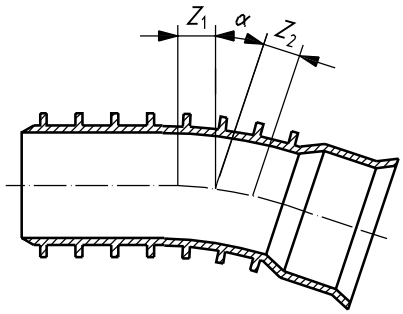



**Figure 1 — Example of an unswept bend**

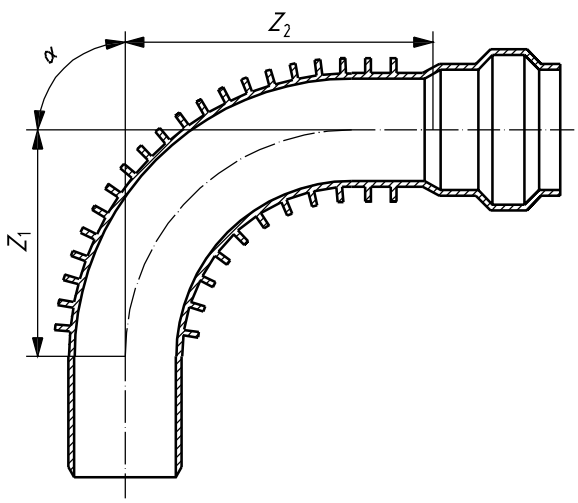



**Figure 2 — Example of a swept bend**

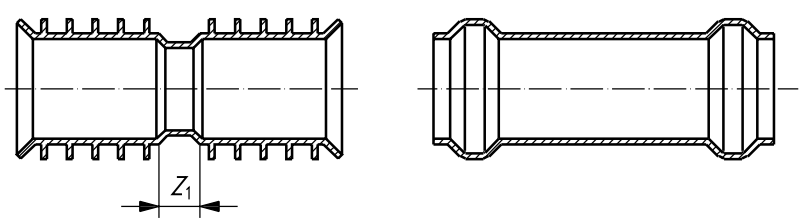



**Figure 3 — Example of a coupler and slip coupler**

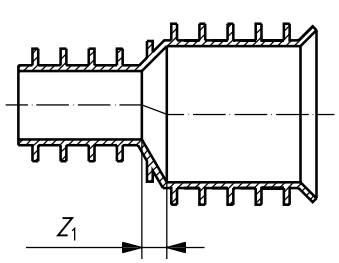



**Figure 4 — Example of a reducer**

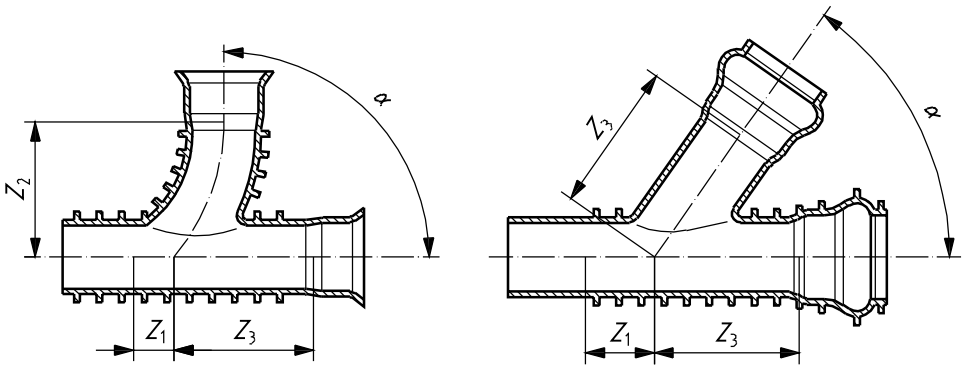
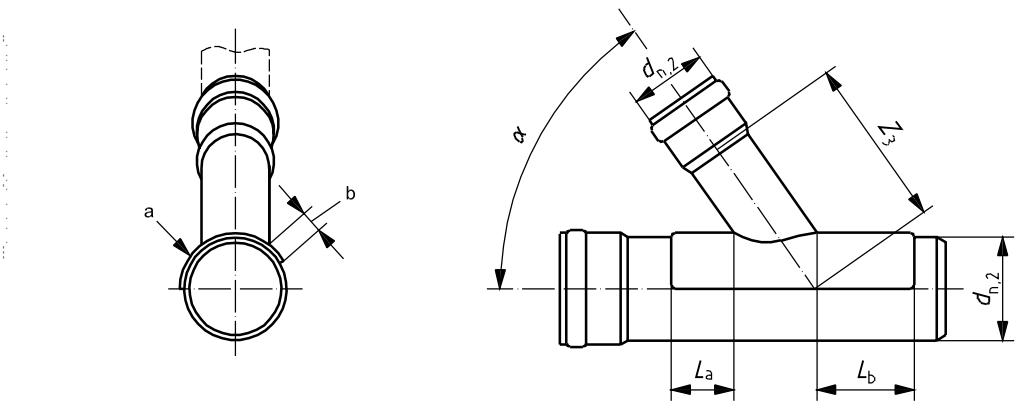



**Figure 5 — Example of a swept entry and a straight branch**




**Key**

a $d_{n1} < 315$ mm.

b $d_{n1} \geqslant 315$ mm.

**Figure 6 — Example of a non-mechanical saddle**

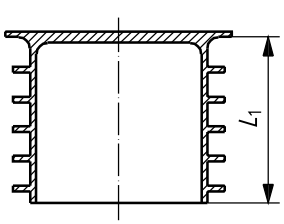



**Figure 7 — Example of a plug**

The minimum length, $L_1$ of the spigots shall be such that it passes the ring seal by at least 10 mm.

### 8.2 Design length of fittings

The design length(s) ($Z$-lengths) of the fittings (see Figures 1 to 6) shall be declared by the manufacturer.

NOTE The design lengths ($Z$-lengths) are intended to assist in the design of moulds and are not intended to be used for quality control purposes; ISO 265-1 can be used as a guide.

## 9 Functional characteristics

In order to ensure good system performance, i.e. safe installation and proper functioning of the installed piping system, the components shall meet the test requirements specified in ISO 21138-2 or ISO 21138-3 as relevant.

The relation between the system performance and the tested characteristics is explained in Table 1.

Information about other functional characteristics is given in Annex B.

## 10 Relation between ring stiffness, installation technique and resulting deflection

Flexible pipes installed in the ground deflect during installation due to the forces exerted on them, as well as after installation due to further settlement of the soil. The amount of deflection reached after installation depends, to a great extent, on the quality of workmanship and, to a lesser extent, on the pipe stiffness.

The choice of nominal ring stiffness (SN) can be made based on the following existing reference situations:

— the same class of pipe used under acceptable similar or more severe conditions;

— the design graph and the structural design (see Annex C).

**Table 1 — Relationship between system performance criteria and tested characteristics**

| System performance criterion | Tested characteristic | Test method/practice |
|---|---|---|
| System compatibility | Dimensions and tolerances | ISO 3126 |
| Resistance to soil load | Ring stiffness — pipe | ISO 9969 |
| | Ring stiffness — fitting | ISO 13967 (same nominal ring stiffness as pipe if same wall construction as pipe) |
| | Ring flexibility | EN 1446 |
| | Mechanical strength or flexibility of fabricated fitting | EN 12256 |
| | Tensile strength of seam | EN 1979 |
| Long term performance (durability) | Creep ratio | ISO 9967 |
| Handling/robustness | Impact strength — pipe | ISO 3127 |
| | Impact strength — fitting | EN 12061 |
| | Additional characteristics — cold climate | ISO 11173 |
| | UV resistance | According to national practice |
| | Tensile strength of seam | EN 1979 |
| Ability to hold fluid (leaktightness) | Dimensions and tolerances | ISO 3126 |
| | Tightness | EN 1277 |
| | Long term performance of TPE seals | EN 14741 |
| | Watertightness of fabricated fittings | EN 1053 |
| | Tensile test of welded and fused joints | EN 1979 |
| | Longitudinal reversion | ISO 2505 |
| | Tensile strength of seam | EN 1979 |
| Identification | Colour | National preference |
| Cleaning | Roding | According to national practice |
| | Flushing — high volume, low pressure | |
| | High pressure cleaning | |
| Durability | UV resistance | According to national practice |
| | Vicat softening temperature | ISO 2507-1 and ISO 2507-2 |
| | Resistance to dichloromethane | ISO 9852 |
| | Resistance to internal pressure | ISO 1167-1 and ISO 1167-2 |
| | Resistance to heating – oven test | ISO 12091 |
| | Effect of heating | ISO 580 |
| | Melt flow rate | ISO 1133 |
| | Thermal stability | ISO 11357-6 |
| | Density | ISO 1183-1 |

# Annex A
(informative)

# General material characteristics of PVC-U, PP and PE pipes and fittings

## A.1 Material characteristics

The materials of pipes and fittings conforming to this part of ISO 21183 generally have the following characteristics. See Table A.1.

NOTE The values in Table A.1, whilst approximate, commonly suffice for design purposes. In instances where more accurate values are required, reference should be made to the pipe or fitting manufacturer.

**Table A.1**

| Characteristic | Test method | PVC-U | PP | PE | Unit |
|---|---|---|---|---|---|
| Flexural modulus, $E_{(1\ min)}$ | ISO 178 | 3 100 to 3 500 | 1 250 to 1 900 | 1 000 to 1 200 | MPa |
| Density | ISO 1183-1 | 1 400 | 900 | 950 | $kg \cdot m^{-3}$ |
| Coefficient of linear thermal expansion | ISO 11359-2 | $8 \times 10^{-5}$ | $14 \times 10^{-5}$ | $17 \times 10^{-5}$ | $mm \cdot mm^{-1} \cdot K^{-1}$ |
| Thermal conductivity | | 0,16 | 0,2 | 0,4 to 0,50 | $W \cdot K^{-1}\ m^{-1}$ |
| Poisson's Ratio | | 0,37 | 0,4 | 0,4 | |
| Specific heat | | 1 000 | | 2 300 to 2 900 | $J \cdot kg^{-1}K^{-1}$ |

## A.2 Chemical resistance

Piping systems conforming to this part of ISO 21138 are resistant to corrosion by water with a wide range of pH-values such as domestic waste water, surface water and ground water. If piping systems conforming to this part of ISO 21138 are to be used for chemically contaminated waste waters, such as industrial discharges, chemical and temperature resistance must be taken into account.

Guidance on the chemical resistance of PVC-U, PP and PE materials is given in ISO/TR 10358 and of rubber materials in ISO/TR 7620.

# Annex B
(informative)

# General performance characteristics of PVC-U, PP and PE pipes and fittings

## B.1 Abrasion resistance

Pipes and fittings conforming to this part of ISO 21138 are resistant to abrasion. For special circumstances, the abrasion can be determined from the test method given in EN 295-3.

## B.2 Hydraulic roughness

The internal surfaces of pipes and fittings conforming to this part of ISO 21138 are hydraulically smooth. The design of joints and fittings ensures good hydraulic performances. For further information about hydraulic capacity of pipes and fittings conforming to this part of ISO 21138, refer to the manufacturer's instructions.

## B.3 Diametric deflection

In normal installation conditions (well or moderate compaction in Annex C), the expected average deflection of the inside diameters of the pipes will be less than 8 %.

# Annex C
(informative)

# Structural design

## C.1 General

In general, structural design of a thermoplastics pipeline construction by applying analytical or numerical methods is not needed. Whether any calculated prediction of the pipe behaviour holds true in reality is strongly dependent on whether the installation conditions used for the calculation are the same as those used for the installation. Therefore, it is important that effort be put into controlling the input values by extensive soil surveys and monitoring of the installation. In many cases, practical and/or reference information, e.g. as listed in Annex A, is available and results in good prediction of the pipe performance.

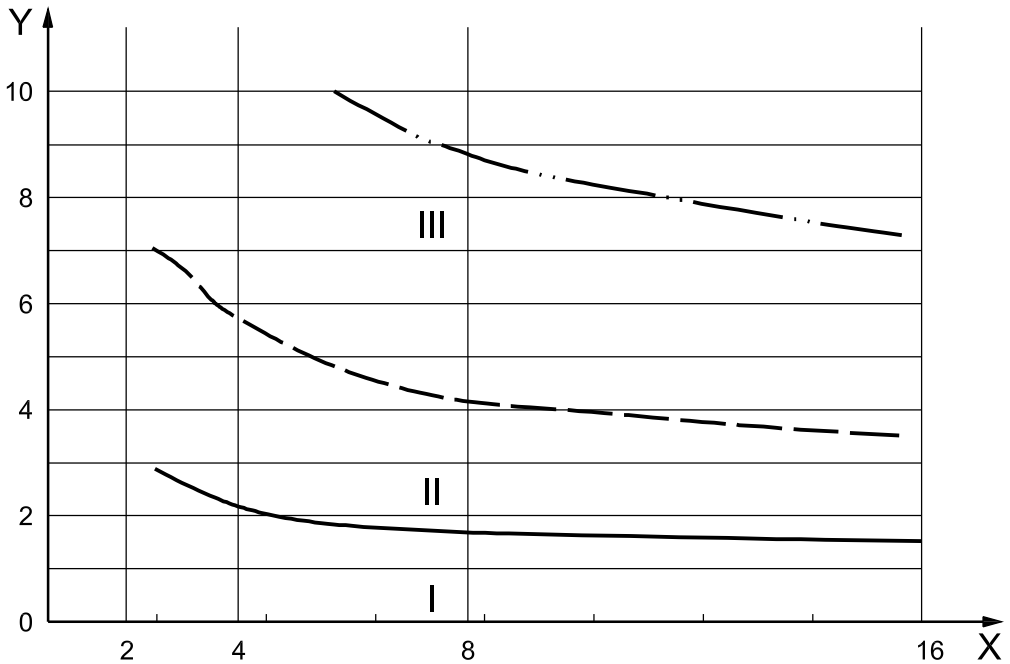
## C.2 Structural design based on a design graph

Designers first need to establish permitted deflections, average and maximum. (National requirements, product standards and this part of ISO 21138, etc. give guidance.)

Following the method described below fulfils the requirements of EN 1610:1997, 4.2.

An intensive study of the deflection history of pipes installed under different conditions up to 25 years ago has resulted in experience as presented in the design graph shown in Figure C.1.

For the deflection mentioned in the design graph, the strain will be far below the design limit, and does not need to be taken into account in the design.




**Key**

X ring stiffness in kilopascals

Y pipe deflexion in percent

I “well” compaction

II “moderate” compaction

III “non-” compaction (not recommended)

**Figure C.1 — Design graph (long term pipe deflection (maximum values)**

The design graph is valid under the conditions in Table C.1.

**Table C.1 — Validity of the design graph**

| | |
|---|---|
| Pipe system | Fulfilling requirements in ISO 8772, ISO 8773, ISO 4435, ISO 21138, Parts 1 to 3 as applicable |
| Installation depth | 0,8 m to 6,0 m |
| Traffic loading | Included |
| Installation quality<br>Installation categories "well", "moderate" (and "non-") should reflect the workmanship on which the designer can rely. | **"Well" compaction (I)**<br>The embedment soil of a granular type is placed carefully in the haunching zone and compacted, after which the soil is placed in shifts of maximum 30 cm, after which each layer is compacted carefully. The pipe shall at least be covered by a layer of 15 cm. The trench is further filled with soil of any type and compacted. Typical values for the proctor density are above 94 %. |
| | **"Moderate" compaction (II)**<br>The embedment soil of a granular type is placed in shifts of maximum 50 cm, after which each layer is compacted carefully. The pipe shall at least be covered by a layer of 15 cm. The trench is further filled with soil of any type and compacted. Typical values for the proctor density are in the range of 87 % to 94 %. |
| | Sheet piles should be removed before compaction, in accordance with the recommendations in EN 1610:1997. If, however, the sheet piles are removed after compaction one should realise that the "well" or "moderate" compaction level will be reduced to the "non-" compaction level (III). |
| Additional | National rules may apply. |

## C.3 Structural design based on design calculations

When structural design is required, e.g. in cases where no other information exists, then a method as defined in EN 1295-1 should be used. If input values for the pipes are required, the values given in Table A.1 are recommended.

Unless otherwise agreed between the specifier and the system owner it is recommended that, for reasons of serviceability, the calculated average deflection values do not exceed the values given in Table C.2.

**Table C.2 — Recommended design deflection limits**

| Stiffness class SN | Average initial deflection | Average long term deflection |
|---|---|---|
| SN 2 | 5 % | 8 % |
| SN 4, 8, 16 | 8 % | 10 % |

## C.4 Selection of fitting stiffness or class

**Table C.3 — Minimum fitting classes recommended for use with structured-wall pipes**

| Pipe stiffness class | Minimum wall-thickness class of fittings according to | | | |
|---|---|---|---|---|
| | ISO 21138-2 and ISO 21138-3 | ISO 8773 | ISO 4435 | SO 8772 |
| SN 2 | SN 2 | SDR 41 | SDR 51 | SDR 33 |
| SN 4 | SN 4 | SDR 41 | SDR 41 | SDR 33 |
| SN 8 | SN 8 | SDR 33 | SDR 34 | SDR 26 |
| SN 16 | SN 16 | SDR 23,4 | SDR 34 | SDR 21 |

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