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BUREAU OF INDIAN STANDARDS

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STRUCTURED - WALL PLASTICS PIPING SYSTEMS FOR NON- PRESSURE DRAINAGE AND SEWERAGE – SPECIFICATION

PART 2: PIPES AND FITTINGS WITH NON-SMOOTH EXTERNAL SURFACE, TYPE B

ICS 23.040.20;23.040.45;91.140.80;93.030

Plastic Piping Systems Sectional Committee, CED 50	**Last Date of Comments is 12 April 2012s**

FOREWORD

(Formal clauses will be added later)

The Standard on structured wall plastic piping systems for non pressure underground drainage and sewerage has been published in following two parts:

Part 1: Pipes and fittings with smooth external surface, Type A
Part 2: Pipes and fittings with non smooth external surface, Type B

In the formulation of this standard considerable assistance has been derived from ISO 21138: Part 1 and Part 3: 2007 Plastic piping systems for non pressure underground drainage and sewerage - structured wall piping systems of unplasticized polyvinyl chloride (PVC-U), polypropylene (PP) and polyethylene (PE): Part 1 Material Specifications and performance criteria for pipes, fittings and system and Part 3 Pipe and Fittings with non-smooth external surface, Type B. However only corrugated wall construction pipes and fittings of polyethylene and polypropylene have been included as other type of pipes are not being manufactured in India at present. The test for low temperature installation performance - Impact resistance (staircase Method) at –10° C has not been included due to the Indian climatic conditions. Provisions for adding calcium carbonate ($CaCo_3$) or talc to the virgin PE or PP material has not been considered as this practice is not prevailing in India. Sizes being widely used in India have also been included.

General guidance regarding laying and jointing including storage and handling for polyethylene pipes has been provided in IS 7634 (Part 2):1975 Code of practice for plastic pipe work for potable water supplies: Part 2 Laying and jointing of polyethylene pipes. However, some additional requirements for these pipes have been given at Annex E. There is no Indian Standard for the laying and jointing of PP pipes at present.PE and PP pipes belong to the same polyolefin's family as such IS 7634(Part 2) 1975 may be used for PP pipes also. However, some additional requirements for Transportation, Handling, Installation and Jointing of these pipes have been given at Annex E .

Piping systems conforming to this part of standard 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 system conforming to this part are to be used for chemically contaminated waste waters, such as industrial discharges, chemical and temperature resistance must be taken in to account. Guidance on the chemical resistance of PVC-U and PE materials is given in IS/ISO/TR 10358 (under preparation).

Guidelines on Structural design of thermoplastics pipelines have been provided in Annex F of the standard for information.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis , shall be rounded off in accordance with IS 2 :1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1 SCOPE

This Standard specifies requirements for pipes and fittings with non-smooth external and smooth internal surface based on PE or PP structured wall piping system for non pressure underground drainage and sewerage.

It is applicable to PE or PP structured wall pipes and fittings with or without Integral sockets and with elastomeric sealing ring joints as well as welded or fused joints. This standard covers the pipes and fittings sizes from 75mm to 1200 mm nominal inside diameter, pipe construction, nominal ring stiffness, test methods and test parameters.

Notes –

1. These pipes, fittings and the system can be used for highway drainage and surface water.
2. Other thermoplastic materials can be added via an addendum.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No	*Title*
4905:1968	Methods for random sampling
5382:1985	Specification for rubber sealing rings for gas mains, water mains and sewers (first revision)
2530: 1963	Methods of test for polyethylene molding materials and Polyethylene compounds.
7328:1992	High Density polyethylene materials for molding and extrusion – specification (first revision)
14885: 2001	Polyethylene Pipes for the Supply of Gaseous Fuels - Specification

14333: 1996	High Density Polyethylene Pipes for Sewerage – Specification
12235: 2004	Thermoplastic Pipes and Fittings – Methods of Test
(Part 1):2004	Measurement of dimensions
(Part 8):2004	Resistance to Internal hydrostatic pressure
(Part 9):2004	Resistance to external blows at 0 ℃
(Part 18):2004	Determination of ring stiffness

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Nominal Size (DN) – The numerical designation for the size of a pipe, other than a pipe designated by thread size, which is a convenient round number approximately equal to the manufacturing dimension in millimeters.

3.2 Nominal Outside Diameter (d_n) – The specified outside diameter in millimeters assigned to the nominal size.

3.3 Outside Diameter at any point (d_e) – The value of the measurement of the outside diameter of a pipe through its cross-section at any point of the pipe, rounded off to the next higher 0.1mm

3.4 Mean Outside Diameter (d_{em}) – The quotient of the outer circumference of a pipe and 3.142(π) in any cross-section, rounded off to the next higher 0.1mm.

3.5 Minimum Mean Outside Diameter ($d_{em,}$min) – The minimum value of the mean outside diameter as specified for a given nominal size.

3.6 Maximum Mean Outside Diameter (d_{em},max) – The maximum value of the mean outside diameter as specified for a given nominal size.

3.7 Inside Diameter of a socket (d_s) – The value of the measurement of the inside diameter of the socket at any point in any cross-section of the socket.

3.8 Mean inside Diameter of a Socket (d_{sm}) – The arithmetical mean of four measurements, taken at 45° to each other, of the inside diameter of the socket in the same cross-section of the socket.

3.9 Out-of-Roundness (Ovality) – The difference between the measured maximum and the measured minimum outside diameter in the same cross-section of the pipe.

3.10 Nominal Wall Thickness (e_a) – A numerical designation of the wall thickness of a component which is a convenient round number, approximately equal to the manufacturing dimension in millimeters.

3.11 Wall Thickness at any Point (e) – The value of the measurement of wall thickness at any point around the circumference of a pipe, rounded off to the next higher 0.1mm.

3.12 Minimum Wall thickness at any Point (e_{min}) – The minimum value for the wall thickness at any point around the circumference of a pipe, rounded off to the next higher 0.1mm.

3.13 Maximum Wall thickness at any Point (e_{max}) – The maximum value for the wall thickness at any point round the circumference of a pipe, rounded off to the next higher 0.1mm.

3.14 Mean Wall Thickness (e_m) – The arithmetic mean of at least four measurements regularly spaced around the circumference and in the same cross-section of a pipe, including the measured minimum and measured maximum values of the wall thickness in that cross-section, rounded off to the next higher 0.1mm.

3.15 Maximum Mean Wall thickness ($e_{m,}$max) – The maximum value for the mean wall thickness around the circumference of a component, as specified.

3.16 Construction height (e_c) – Radial distance between the top of ribs or corrugation or, in the case of Type A and Type B pipes and fittings, between the outside surface of wall and inside surface of wall.

3.17 Minimum Length of a Spigot (l_1,min) – Minimum permitted value for the length of a spigot of a pipe or fitting.

3.17 Tolerance – The permitted variation of the specified value of a quantity, expressed as the difference between the permitted maximum and the permitted minimum value.

3.18 Standard Dimension Ratio (SDR) – A numerical designation of a pipe series, which is a convenient round number approximately equal to the ratio of the minimum mean outside diameter, $d_{em,min}$ and the minimum wall thickness at any point, e_{min}

$$SDR = \frac{d_{em,min}}{e_{min}}$$

3.19 Nominal Ring Stiffness (SN) – A numerical designation, which is a convenient round number, of the ring stiffness in kilo-Newton per square meter ($kN.m^2$), indicating the minimum required ring stiffness of a pipe or fitting.

3.20 Structured Wall Pipes – Pipes which have an optimized design with regard to material usage to achieve the physical, mechanical and performance requirements of this standard.

3.21 Ring flexibility – Ability of a pipe to resist diametric deflection without loss of structural integrity.

3.22 Virgin Material – Material in such form as granules or powder that 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.

3.23 Double Wall Corrugated (DWC) – Structured wall pipes with hollow annular profiled outer surface and a smooth inner surface.

3.24 Tests

3.24.1 Type Tests – Tests carried out whenever a change is made in the composition or in the size/ series in order to establish the suitability and the performance capability of the pipes and fittings.

3.24.2 Acceptance Tests – Tests are carried out on samples taken from a lot for the purpose of acceptance of the lot.

3 SYMBOLS

A : length of engagement, or maximum pull-out whilst maintaining tightness
D_i : socket inside diameter
$D_{im,min}$: minimum mean inside diameter of a socket
d_e : outside diameter
d_{em} : mean outside diameter
d_i : inside diameter
d_{im} : mean inside diameter
e : wall thickness (at any point)
e_c : construction height
e_2 : wall thickness of the socket
e_3 : wall thickness of the groove
e_4 : wall thickness of the inside layer (waterway wall thickness)
F : distance from the spigot end to the effective sealing point
l : effective length of a pipe
$L_{1,min}$: minimum length of a spigot
Z1 : Design length of a fitting
Z2 : Design length of a fitting
Z3 : Design length of a fitting
α : nominal angle of a fitting
l_1 : Length of spigot

4 COMPOSITION OF THE MATERIAL

5.1 The material from which the pipe is produced shall consist substantially of polyethylene (PE) or polypropylene (PP) to which may be added those additives that are needed to facilitate the manufacture of these pipes and fittings conforming to requirements of this standard as per Table 1A ,1B, 1C and 1D.

Table 1A Material Characteristics for PE Material in Granules Form
(*Clause* **5.1**)

Characteristics	**Requirements**	**Test Parameters**		**Test Method**
Base Density	0.930 gm/cc and greater	In accordance with IS 7328		As per IS 7328
Melt Flow Rate (MFR) [a]	≤ 1.6g/10 min	Temperature	190^0 C	As per IS 2530
		Loading Mass	5 Kg	
Thermal stability(OIT)[b]	≥ 20 minutes	Temperature	200^0 C	As per Annex D of IS 14885

a. For PE Rotational Moulded fittings MFR values should be between 3g/10mins and 16g/10mins.
b. This requirement is only valid for pipes and fittings intended to be jointed in field by fusing or welding

Table 1B Material Characteristics for PE Material in Pipe Form
(*Clause* **5.1**)

Characteristics	**Requirements**	**Test Parameters**		**Test method**
Resistance to internal pressure 165 hrs [a]	No failure during the test period	Test Temperature Orientation Number of test pieces Circumferential stress Conditioning period Type of test Test period	80℃ Free 3 4,0 MPa As per IS 12235 (Part 8/Sec 1) Water-in-water 165 h	As per IS 12235 (Part 8/Sec 1)
Resistance to internal pressure 1000 hrs [a]	No failure during the test period	Test Temperature Orientation Number of test pieces Circumferential stress Conditioning period Type of test Test period	80℃ Free 3 2.8 MPa As per IS 12235 (Part 8/Sec 1) Water-in-water 1 000 h	As per IS 12235 (Part 8/Sec 1)

a. For the above PE Compound, this test shall be carried out in the form of a solid wall pipe made from the relevant grade of material.

‘

Table1C Material Characteristics for PP Material in Granules form (Clause 5.1)

Characteristics	Requirements	Test Parameters		Test method
Melt Flow Rate (MFR)	≤ 1.5g/10 min	Temperature	230^{0} C	As per IS 2530
		Loading Mass	2.16 Kg	
Thermal stability(OIT) [a]	≥ 8minutes	Temperature	200^{0} C	As per Annex D of IS 14885

a. This requirement is only valid for pipes and fittings intended to be jointed in field by fusing or welding

Table1D Material Characteristics for PP Material in Pipe form (Clause 5.1)

Characteristics	Requirements	Test Parameters		Test method
Resistance to internal pressure 140 hrs [a]	No failure during the test period	Test Temperature Orientation Number of test pieces Circumferential stress Conditioning period Type of test Test period	80℃ Free 3 4.2 MPa 27 ±2℃ water-in-water 140h	As per IS 12235 (Part 8/Sec1)
Resistance to internal pressure 1000 hrs [a]	No failure during the test period	Test Temperature Orientation Number of test pieces Circumferential stress Conditioning period Type of test Test period	95℃ Free 3 2.5 MPa 27 ±2℃ water-in-water 1 000 h	As per IS 12235 (Part 8/Sec1)

a. For the above PP Compound, this test shall be carried out in the form of a solid wall pipe made from the relevant grade of material.

5.2 Rework Material

Clean, reprocessable material generated from a manufacturer's own production according to this standard may be used if it is derived from the same raw material as used for the relevant production. Reprocessable material obtained from external sources and recyclable material shall not be used.

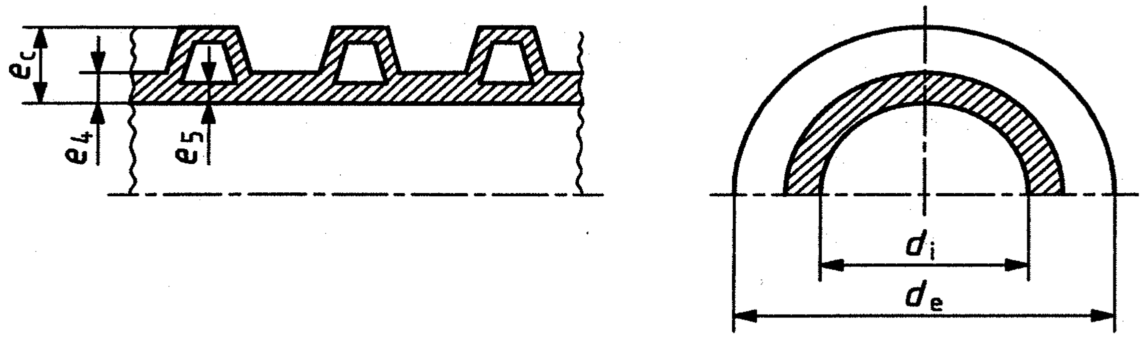
6 DESIGNATION OF WALL CONSTRUCTIONS AND EXAMPLES OF TYPICAL JOINING METHODS

6.1 Wall Construction Designated as Type B

6.1.1 *Outside Profiled and Inside Smooth Profile Section*

A pipe or fitting with a smooth internal and profiled external surface forming a finished double walled profile shall come under this standard.

Typical example of corrugated wall construction is shown in Fig. 1.



NOTE - The Figs are schematic sketches only to indicate the relevant dimensions. They do not necessarily represent the manufactured components.

Fig. 1 – Typical Examples of Non-Smooth External Profiled (Corrugated Wall) Construction

6.2 Designation

Pipes and fittings will be designated on the basis of its material / structure wall construction / nominal ID (DN/ID) / nominal ring stiffness such as: PE or PP/ DWC/ ID/ SN.

6.3 Dimension of Pipes and Fittings

6.3.1 *Diameter of Pipe*

The Internal Diameter (DN/ID) shall be as per Table 2.

Other nominal sizes, falling within the range of Table 2 are permitted.

For DN/IDs not specified in Table 2, the minimum inside diameter, $d_{im,min}$, shall be linearly interpolated between the adjacent values specified in the Table 5.

Table 2 Nominal Sizes, Minimum Mean Inside Diameters, Thickness of Inside Layers and Socket Length
(*Clause* **6.3.1**)
Dimensions in millimetres

DN/ID Series		Minimum Wall Thickness		Socket [a] Length
DN/ID	$d_{im,min}$	$e_{4,min}$	$e_{5,min}$	A_{min}
75	71	1.0	0.85	27
100	95	1.0	1.0	32
125	120	1.2	1.0	38
135	130	1.2	1.0	39
150	145	1.3	1.0	43
170	165	1.4	1.0	48
200	195	1.5	1.1	54
225	220	1.7	1.4	55
250	245	1.8	1.5	59
300	294	2.0	1.7	64
400	392	2.5	2.3	74
500	490	3.0	3.0	85
600	588	3.5	3.5	96
800	785	4.5	4.5	118
1 000	985	5.0	5.0	140
1 200	1 185	5.0	5.0	162

a. For selection of A_{min} requirements for socket, refer to the pipe material and construction. For pipes longer than 6 m it is recommended that one produce a larger A_{min} than is specified in this table.

6.3.2 *Lengths of Pipe*

The effective length of pipe '*l*' shall be not less than that specified by the manufacturer when measured as shown in Fig. 2.

6.3.3 *Diameters of Pipes and Spigots of Pipes or Fittings*

The nominal sizes and minimum mean inside diameter for DN-ID series are specified in Table 2. The ODs of the DN-ID series pipes and spigots intended to have jointing dimensions as pipes and/or fittings according to this standard shall comply with the outside diameters and tolerances as specified by the manufacturer. However, the guidelines for pipes, spigots and fittings not intended to have jointing dimensions as pipes and/or fittings according to this standard, the tolerance of the outside diameter of pipes and spigots, fittings shall be:

$D_{em,min} \geq 0.994 \times d_e$
$D_{em,max} \leq 1.003 \times d_e$

Where

d_e is the nominal size of outside diameter as specified by the manufacturer of a DN-ID designated pipe. The results are to be rounded to the next higher 0.1 mm.

6.3.4 *Diameters and Jointing Dimensions of Sockets and Spigots*

6.3.4.1 *Joints with the elastomeric sealing ring positioned in the socket of pipes or fittings*

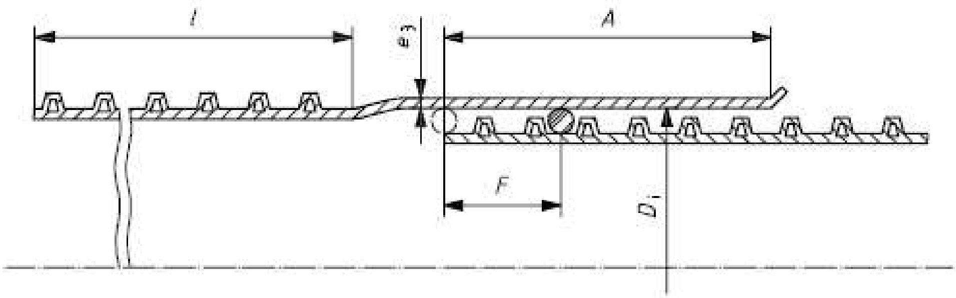


Fig. 2 Typical Assembly of Piping System with elastomeric sealing Ring on Spigot

For these pipes, the requirement regarding the socket and spigot dimension, A_{min} specified in Table 2 applies.

In the case where other nominal sizes other than those specified in Table 2 are selected, the requirements regarding the socket dimension A_{min} shall be linearly interpolated between the adjacent values specified in Table 2.

$D_{i,min}$ shall be equal to $d_{e,max}$.

6.3.5 *Wall Thickness*

6.3.5.1 *Wall Thickness of sockets and joint design requirements*

6.3.5.1.1 *General*

In addition to the minimum required wall thickness of sockets and spigots as specified below, their ring stiffness, when determined in accordance with Table 5 shall conform to the following equation:

$S_{socket} + S_{spigot} \geq SN_{pipes}$

For the test it is permitted to use cut-off straight socket and spigot parts even if they do not conform to the length requirements specified in Annex A of Part 1 of this standard.

6.3.5.1.2 *Spigot*

When the spigot has the same design as the pipe, the wall thickness requirements for the corresponding pipe dimension and construction apply.

In the case of a solid plain spigot design, the wall thickness, e, shall conform to values given below:

$d_e \leq 500$	d_e/ 33 but not less than 4.2 mm
$d_e > 500$	15.2 mm

Note – The values shall be calculated to the 2nd decimal place and rounded to the next higher 0.1mm.

6.3.5.1.3 *Sockets heat formed on the pipes*

When a socket is heat formed on a pipe segment the following is permitted:
-For joints with the sealing ring positioned on the pipe: a reduction of the wall thickness e_4 and e_5, as applicable, to 75%. The manufacturer specifies the reference value for the wall thickness.

6.3.5.1.4 *Structured Wall designed Sockets with stiffness ≥ 4 kN/m²*

For structured-wall designed sockets the wall thickness e_4 and e_5 as applicable, shall comply with the requirements given in Table 2.

6.3.5.1.5 *Other sockets with stiffness < 4 kN/m²*

The thickness of the inner wall of the socket shall be at least 1.5 x e_4 as specified in Table 2.

6.3.5.1.6 *Injection moulded fittings*

The minimum wall thickness in the body of injection moulded fittings construction, e_{4min}, for DN/ID ≤ 300mm shall be 2.0 mm. For larger sizes, it shall conform to the requirements for e_{4min} as specified in Table 2.

The construction height of the body wall, e_c for Injection moulded fittings up to 200 mm actual outside diameter of pipes in the DN-ID series shall be at least as specified for e_{min} as below:

All dimensions are in millimeters

Nominal size DN/ID	e_{min}
75	4.0
100	4.8
125	5.8
135	6.2
150	7.0
170	7.7

In the case of ID series fittings, the calculations shall be based on the actual diameter of the corresponding pipes.

The joining design including socket and spigot dimensions conform to **6.3.5.1**.

6.3.5.3 *Fabricated Fittings*

The wall thickness of the body of fittings fabricated from pipes shall conform to the requirements of the corresponding pipes. Wall thickness reduction due to the process is permitted provided the requirements in Table 7 are satisfied. The jointing design including socket and spigot dimensions shall conform to 6.3.5.1.

6.3.5.4 *Rotational moulded fittings*

The minimum wall thickness in the body of rotational moulded fitting, e_{4min} shall be 1.25 x the values specified for the Injection moulded fittings, rounded to the next higher 0.1mm.

If a Rotational moulded fitting has a solid plain spigot and/or socket, the minimum required wall thickness e_1, e_2 and e_3 as applicable shall be 1.25 x the values derived from **6.3.5**.

The socket and spigot dimensions shall comply with **6.3.5.1**.

6.4 Types of Fittings

6.4.1 *General*

This part of the standard is applicable for the following types of fittings. Other designs of fittings, including all sockets and all spigots, are also permitted.

a) Bends, swept and unswept angle (*see* Figs. 3 and 4)

Note 1 - Preferred nominal angles, α, are: 15°, 22.5°, 30°, and 45°.

b) Couplers (*see* Fig. 5)

c) Reducers (*see* Fig. 6)

d) Branches and reducing branches, swept and unswept entry (*see* Fig. 7)

Note 2 - Preferred nominal angles, α, are 45° and between 87.5° and 90°

e) Plugs (*see* Fig. 8)

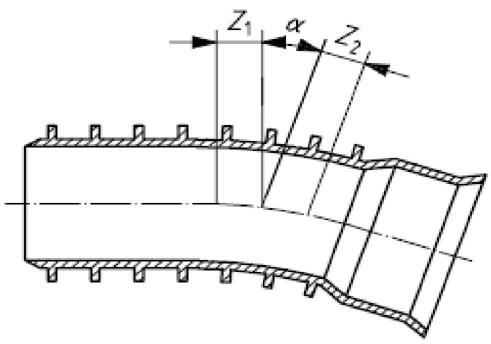


Fig. 3 Example of an Unswept Bend

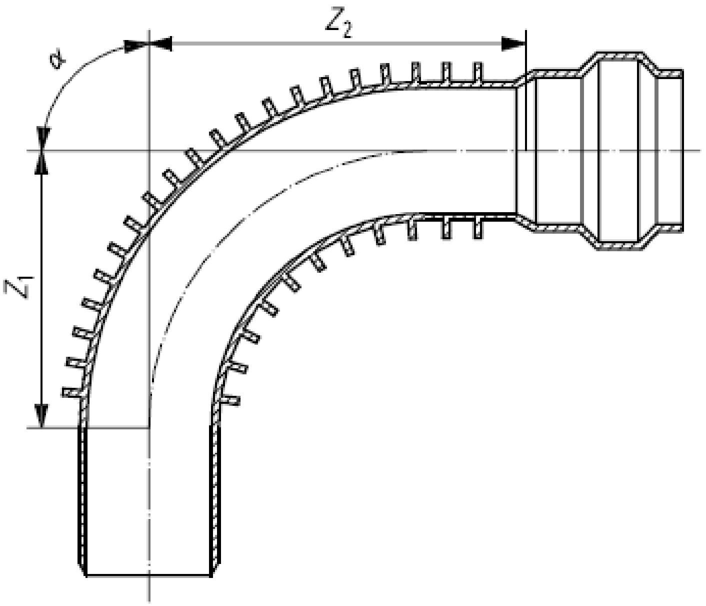
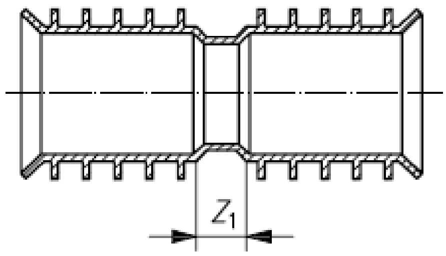


Fig. 4 Example of a Swept Bend



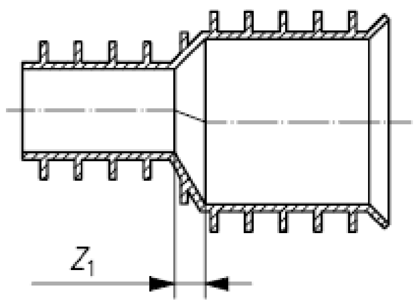


Fig. 5 Example of a Coupler

Fig. 6 Example of a Reducer

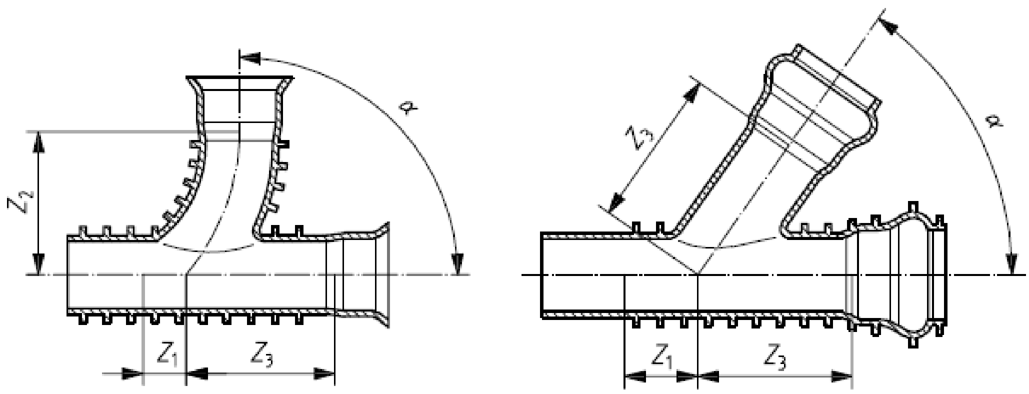


Fig. 7 Example of a Swept Entry and a Straight Branch

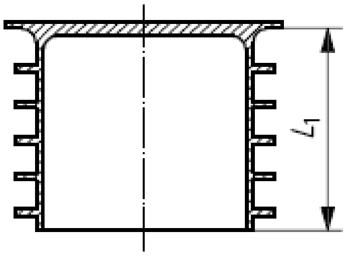


Fig. 8 Example of a Plug

Notes -

1. *Figs. 3-8* are for reference only and do not necessarily represent manufactured components.
2. The design lengths(s) (Z lengths) of the fittings shall be declared by manufacturer.
3. The minimum length, L_1 of the spigots shall be such that it passes the ring seal by at least 10 mm

7 PHYSICAL CHARACTERISTICS FOR PIPES

7.1 Appearance

The structured outer layer of finished pipes and fittings shall be uniformly corrugated. The inner layer shall be smooth and plain. Both layers shall be free from any visual defects such as cracks, blisters, foreign inclusions and any other visual irregularities which may cause harm to its construction integrities. The inner surface may reflect slight shallow undulations.

7.1.1 *Colour of Finished Pipes*

The inner and outer layer of pipes and fittings shall be colored throughout. The outside layer of pipes and fittings should preferably be black, orange brown or grey.

7.2 When tested in accordance with the test method specified in Table 3 using the indicated parameters, the pipes shall have physical characteristics conforming to the requirements given in the Table.

Table 3A Physical Characteristics of PE Pipes
(*Clause* **7.2**)

Characteristic	Requirements	Test Parameters		Test Method
Resistance to heating Oven test	The pipe shall show no delaminations, cracks or bubbles	Temperature Immersion time for.[a] *e*≤ 8 mm *e*> 8 mm	(110±2)℃ 30 min 60 min	As per IS 12235 (Part 6)
[a] For the wall thickness, e, the maximum measured wall thickness of the pipe excluding e_c shall be taken				

7.3 When tested in accordance with the test method specified in Table 4 using the indicated parameters, the fitting shall have physical characteristics conforming to the requirements as given in the Table.

Table 3B: Physical characteristics of PP pipes
(*Clause* **7.2**)

Characteristic	Requirements	Test parameters		Test method
Resistance to heating Oven test	The pipe shall show no delaminations, cracks or bubbles	Temperature Immersion time[a] for. *e*≤ 8 mm *e*> 8 mm	(150±2)℃ 30 min 60 min	As per IS 12235 (Part 6)
[a] For the wall thickness, e, the maximum measured wall thickness of the pipe excluding e_c shall be taken				

Table 4A Physical characteristics of PE Injection-Moulded Components
(*Clause* **7.3**)

Characteristic	Requirements	Test Parameters		Test Method
Effect of heating [a]	[b]	Test temperature Heat tube time [c] for *e*≤ 3 mm 3 mm< e≤ 10 mm 10 mm <e≤20 mm	(110±2)℃ 15 min 30 min 60 min	**Annex A**
[a] Only applicable to injection-moulded fittings and injection-moulded components for fabricated fittings. [b] The depth of cracks, delamination or blisters shall not be more than 20% of the wall thickness around the injection point(s). No part of the weld line shall open to a depth of more than 20% of the wall thickness. [c] For the wall thickness e the maximum measured wall thickness of the fitting excluding e_c shall be taken				

Table 4B: Physical characteristics of PP Injection-moulded Components

Characteristic	Requirements	Test Parameters		Test Method
Effect of heating[a]	[b]	Test temperature Heating time	(150±2)℃ As per table A.1 of Annex A	**Annex A**
[a] Only applicable to injection-moulded fittings and injection-moulded components for fabricated fittings. [b] The depth of cracks, delamination or blisters shall not be more than 20% of the wall thickness around the injection point(s). No part of the weld line shall open to a				

depth of more than 20% of the wall thickness.
[c] For the wall thickness e the maximum measured wall thickness of the fitting excluding e_c shall be taken

8 MECHANICAL CHARACTERISTICS

8.1 Mechanical Characteristics of Pipes

8.1.1 *General*

The pipes shall be designated in the following nominal ring stiffness classes (SN):

DN ≤ 500: SN 4, SN 8 or SN 16
DN > 500: SN 2, SN 4, SN 8 or SN 16

For DN ≥ 500: the manufacturer's guaranteed minimum stiffness, between the SN values, of a component may be used for calculation purposes only. Such pipes shall be classified and marked as the next lower stiffness class.

When tested accordance with the test method specified in Table 5 using the indicated parameters, the pipe shall have mechanical characteristics conforming to the requirements.

Table 5 Mechanical Characteristics of Pipes
(*Clause* **8.1.1**)

Characteristic	**Requirements**	**Test Parameters**		**Test Method**
Ring stiffness	≥ relevant SN	In accordance with Annex A of Part 1 of this standard		As per Annex A of Part 1 of this standard
Impact strength	TIR≤ 10%	Type of striker Mass of striker for: $d_{im,max}$≤100 mm 100 < $d_{im,max}$ ≤125 125 < $d_{im,max}$ ≤160 160 < $d_{im,max}$ ≤200 200 < $d_{im,max}$ ≤250 200< $d_{im,max}$ ≤315 $d_{im,max}$ > 315 Fall height of striker: $d_{im,max}$≤ 100 $d_{im,max}$ > 100	d90 0.5 kg 0.8 kg 1.0kg 1.6kg 2.0kg 2.5kg 3.2kg 1600 mm 2000 mm	As per IS 12235 (Part 9)
Ring flexibility	In accordance with 8.1.2 at	Deflection Position of test	30% Mould split line, when applicable, at 0°,	As per Annex B of Part 1 of this

	30% of d_{em}	piece	45º and 90º from the upper plate	standard
Creep ratio	≤ 4 at 2 year extrapolation	As per Annex C of Part 1 of this standard		As per Annex C of Part 1 of this standard

8.1.2 Ring Flexibility

When tested in accordance with the test method described in Table 5 using the indicated parameters, and visually inspected without magnification, a and b shall be satisfied during the test and *'c' to 'e'* shall be satisfied after the test.

a) There shall be no decrease of the measured force.
b) There shall be no cracking in any part of the wall structure.
c) There shall be no wall de-lamination except possible de-lamination between the outside and inside wall of double wall pipes occurring in reduced welding zone in the ends of test piece. Process aiding profile of material other than the pipe material (*see* Fig. 1) is not subject to this requirement.
d) There shall be no other types of rupture in the test piece.
e) Permanent buckling in any part of the structure of the pipe wall including depressions and craters shall not occur in any direction.

8.2 Mechanical Characteristics of Fittings

8.2.1 *General*

The fittings shall be designated in one of the following nominal stiffness classes (Sl No.):

- DN ≤ 500: SN 4, SN 8 or SN 16
- DN > 500: SN 2, SN 4 or SN 8 or SN 16

Note - For DN≥500, the manufacture's guaranteed minimum stiffness, between the SN nominal values of a component, can be used for calculation purpose.

When tested in accordance with test methods specified in Table 6 using the indicated parameters, the fitting shall have mechanical characteristics conforming to the requirement given in the Table.

Table 6 Mechanical Characteristics of Fittings
(*Clause* **8.2.1**)

Characteristic	**Requirements**	**Test Parameters**		**Test method**
Stiffness [a]	≥ relevant SN	In accordance with Annex A of Part 1 of this standard		Annex A of Part 1 of this standard
Impact test	No cracks through the wall ; jumped-off sealing elements shall be able to be restored in correct position manually	As per Clause 8.3.1		As per Clause 8.3.1
Mechanical strength or flexibility [b]	No signs of splitting cracking, separation and/or leakage	EITHER		
		Test period Minimum moment for: d_e ≤250mm d_e >250mm	15 min $0,15(DN)^3 \times 10^{-6}$ kNm 0,01(DN) kNm	Annex B
		OR		
		Minimum displacement	170 mm	

[a] When a fitting in accordance with this standard has the same wall construction as a corresponding pipe, the stiffness of the fitting, because of its geometry, is equal to or greater than that of the pipe. Such fittings can be classified with the same stiffness class as that pipe without testing the stiffness.

[b] Only for fabricated fittings made from more than one piece (a sealing ring retaining component is not considered as a piece) or when the minimum wall thickness in the body, $e_{4,\ min}$ is less than (0,9 x d_{em} */33)*

8.3.1 *Impact Strength of Injection-Moulded and Fabricated Fittings*

For this test, fittings shall be conditioned for 30 min at a temperature of 0℃ ± 1℃. Within 10 S after the conditioning treatment, five fittings of each diameter and type shall be dropped freely in various positions on to a flat concrete floor from a height of 1m ± 0.05m.

If one fitting is damaged the test shall be repeated with five other fittings. None of these last five fittings shall be damaged.

Note - In the context of this test, “damage” means any visible split or any complete breakage in the body of the fitting. Surface scratches, scuffing, or chipping of edge which may occur in the test does not constitute damage.

8.4 Joints

Elastomeric sealing rings shall be free from substances that can have a detrimental effect on the pipes or fittings, used in conjunction with pipes.

The design of the profile and dimensions of the sealing ring is left to the manufacturer, as long as the pipe with the sealing ring meets the requirements of this standard. Where the design of the socket is such that the ring is not firmly fixed in position, the housing for the ring shall be so designed as to minimize the possibility of the ring being dislodged during insertion of the pipe (or spigot or fitting) to complete the joint.

Elastomeric sealing rings shall be in accordance with one of the type (Type 1 to Type 6) of IS 5382. The manufacturer should specify the type of sealing ring (namely type 1, 2, 3, 4, 5 or 6) that is being offered.

NOTE – A test report or conformity certificate may be obtained from the manufacturer of the sealing ring for conformity to IS 5382.

9 Performance Requirements

When tested in accordance with the test methods specified in Table 7, using the indicated parameters, the joints and the system shall have characteristics conforming to the requirements given in the Table.

Table 7 Performance Requirements
(*Clause* **9**)

Characteristics	Requirements	Test Parameters		Test Method
Tightness of elastomeric ring seal joint	No leakage	Temperature Joint deflection for: $d_e \leq 315$ mm 315 mm < d_e ≤ 630 mm 630 mm < d_e Water Pressure	(27±2)℃ 2° 1.5°1° 5 kPa (0.05 bar)	As per IS 12235 (Part 8/ Sec 2 and Sec 3)
	No leakage	Water Pressure	50 kPa (0.5 bar)	
	≤ - 27 kPa (-0.27 bar)	Air Pressure	-30 kPa (-0.3 bar)	
Water-tightness [a]	No leakage	Water Pressure Duration	50 kPa(0.5 bar) 1 min	Annex C
Resistance to combined temperature cycling and external loading [b]	See footnote c	For dim ≤ 160mm: As per Method A of Annex D For dim > 160mm: As per Method B of Annex D		Annex D

a Only for fabricated fittings made from more than one piece. A sealing ring retaining component is not considered as a piece.
b Only for components with DN/ID ≤ 300mm.
c The following requirements apply:

- vertical deformation: ≤ 9 %
- deviation from surface evenness in bottom: ≤ 3 mm

- radius of bottom: ≥ 80 % of original
- opening of weld line: ≤ 20 % of wall thickness
- tightness at 35 kPa (0,35 bar)/15 min: no leakage allowed.

10 Sampling, Frequency of Tests and Criteria for Conformity

10.1 Acceptance Test

10.1.1 Acceptance tests are carried out on sample selected from a Lot (clause 10.3.1) for the purpose of acceptance of the lot. Samples for acceptance tests shall be prepared as per Table 8A (for pipes) and 8B (for fittings).

Table 8A Acceptance Tests for Pipes
(*Clause* **10.1.1**)

Sl. No	Description of Test	Requirement Clause	Sample Size
1	Visual appearance, finish and colour	7.0	Table 10
2	Dimensions	6.3	Table 10
3	Melt Flow Rate	5.1	Table 11
4	Density	5.1	Table 11
5	Ring Stiffness	8.1.1	Table 11
6	Ring Flexibility	8.1.2	Table 11
7	Impact Test	8.1.1	Table 11
8	Oven Test	7.2	Table 11

Table 8B Acceptance Tests for Fittings
(*Clause* **10.1.1**)

Sl. No	Description of Test	Requirement Clause	Sample Size
1	Visual appearance, finish and colour	7.0	Table 10
2	Dimensions	6.3	Table 10
3	Ring Stiffness	8.2.1	Table 11
4	Impact Test	8.3.1	Table 11
5	Effect of Heating	7.3	Table 11

10.2 Type Test

10.2.1 Type tests are intended to prove the suitability and performance of a new technique or a new size of a pipe, even if no change is envisaged, type testing shall be done to conform to Table 9A and 9B. All tests are required to be carried out either in an in-house laboratory or at an authorized third party laboratory.

Table 9A Type Test for Pipes
(*Clause* **10.2.1**)

Sl.No.	**Tests**	**Requirement Clause**	**Sample Size**
1	Resistance to internal hydrostatic pressure for 165 Hours 4 Mpa	5.1	Table 11
2	Resistance to internal hydrostatic pressure for 1000 Hours 2.8 Mpa	5.1	Table 11
3	Creep Ratio	8.1.1	Table 11
4	Oxidation Induction Test	5.1	Table 11
5	Water tightness test	9.0	Table 11
6	Tightness of elastomeric ring seal joint	9.0	Table 11
7	Resistance to combined temperature cycling and external loading	9.0	Table 11

Table 9B Type Test for Fittings
(*Clause* **10.2.1**)

Sl. No.	**Tests**	**Requirement Clause**	**Sample Size**
1	Oxidation Induction Test	5.1	Table 11
2	Water tightness test	9.0	Table 11
3	Ring Flexibility	8.2.1	Table 11

Table 9C Type Test for PP pipes
(Clause 10.2.1)

Sr. No.	**Tests**	**Requirement Clause**	**Sample Size**
1	Resistance to internal hydrostatic pressure for 165 Hours 4 .2 Mpa	5.1(Table 1D)	Table 11
2	Resistance to internal hydrostatic	5.1(Table	Table 11

	pressure for 1000 Hours 2.5 Mpa	1D)	
3	Creep Ratio	8.1.1	Table 11
4	Oxidation Induction Test [a]	5.1(Table 1 C)	Table 11
5	Water tightness test	9.0	Table 11
6	Tightness of elastomeric ring seal joint	9.0	Table 11
7	Resistance to combined temperature cycling and external loading	9.0	Table 11
a- This requirement is only valid for pipes and fittings intended to be jointed in field by fusing or welding			

Table 9D Type Test for PP Fittings
(Clause 10.2.1)

Sr. No.	**Tests**	**Requirement Clause**	**Sample Size**
1	Oxidation Induction Test[a]	5.1(Table 1D)	Table 11
2	Water Tightness Test	9.0	Table 11
3	Ring Flexibility	8.2.1	Table 11
a- This requirement is only valid for pipes and fittings intended to be jointed in field by fusing or welding			

10.3 Sampling

10.3.1 Lot

All pipes of the same size, same grade and manufactured essentially under similar conditions shall constitute a lot. These pipes shall be selected at random from the lot and in order to ensure the randomness of selection, a random number Table shall be used. For guidance and use of random number Tables, IS 4905 may be referred. In the absence of a random number Table the procedure given below may be adopted.

Table 10 Scale of Sampling for Dimensional and Visual Requirements
(*Clause* **10.3.1**)

No of Pipes In the Lot	**Sample No A**	**Sample Size**	**Cumulative Sample Size**	**Acceptance No**	**Rejection No**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Upto 1000	First	13	13	0	2
	Second	13	26	1	2
1001 to 3000	First	20	20	0	2
	Second	20	40	1	2
3001 to 10000	First	32	32	0	3
	Second	32	64	3	4
10001 and above	First	50	50	1	4
	Second	50	100	4	5

10.3.2 Starting from any pipe in the lot, count them as 1, 2, 3, 4, etc, up to r and so on where r is the integral part of N/n, N being the number of pipes in the lot and n is the number of pipes in the sample. Every r^{th} pipe so counted shall be drawn so as to constitute the required sample size.

The number of pipes given for the first sample in col 3 of Table 10 shall be examined for dimensional and visual requirements. A pipe failing to satisfy any of these requirements shall be considered as defective. The lot shall be deemed to have satisfied these requirements, if the number of detectives found in the first sample are less than or equal to the corresponding acceptance number given in col 5 of Table 10. The lot shall be deemed not to have met these requirements if the number of detectives found in the first sample is greater than or equal to the corresponding rejection numbers given in column 6 of Table 10.

If, however, the number of detectives found in the first sample lies between the corresponding acceptance and rejection numbers given in col 5 and 6 of Table 10, the second sample of the size given in col 3 of Table 10 shall be taken and examined for these requirements. The lot shall be considered to have satisfied these, requirements, if the number of detectives found in the cumulative sample is less than or equal to the corresponding acceptance number given in col 5 of Table 10; otherwise not.

10.4 Conformance

The lot having satisfied dimensional and visual requirements shall be tested for other requirements with the sample size selected as per Table 11 from the lot. If the first sample drawn fails the tests, re-sampling should be done from the lot which has satisfied the dimensional and visual requirements. The lot shall be considered to have met the requirements of these tests, if none of these samples tested fails.

Table 11 Scale of Sampling for Tests Other than Visual and Dimensional Requirements
(*Clause* **10.4**)

Sl. No	No. of Pipes in lot	Sample Size for Sizes Less than or Equal to 500mm ID	Sample Size for Sizes Greater than 500mm ID
1	Upto 1 000	2	1
2	1 001 – 3 000	3	2
3	3 001 and above	4	3

11 MARKING

11.1 General

Marking elements shall be labeled, printed or formed directly on the pipe or fitting, in such a way that after storage, weathering and handling legibility shall be maintained. Marking shall not initiate cracks or other types of defects which adversely influence the performance of the pipes or the fitting.

11.2 Minimum Required Marking

11.2.1 *Pipes*

Pipes shall be marked at intervals of maximum 3 m, at least once per pipe.

11.2.1.1 *Information*

The Marking on the Pipe shall carry the following minimum information:

a) Mark of this standard
b) Diameter series, Nominal size
c) Manufacturers Name/ Trade-mark
d) Stiffness class
e) Material
f) Lot number/Batch number containing information regarding period of manufacture.

11.2.2 *Fittings*

Fittings shall be marked once per fitting.

11.2.2.1 *Information*

The Marking on the Fittings shall carry the following minimum information:

a) Mark of this standard
b) Diameter series, Nominal size
c) Manufacturers Name/ Trade-mark

d) Nominal angle
e) Stiffness class
f) Material
g) Lot number/Batch number containing information regarding period of manufacture.

11.3 BIS Certification Marking

11.3.1 Each pipe or fittings may also be marked with the Standard Mark.

11.3.2 The provisions of the Bureau of Indian Standards Act, 1986 and the rules and regulations made thereunder govern the use of the Standard Mark. Details of conditions under which a license for the use of the Standard Mark may be granted to the manufacturers or the producers may be obtained from the Bureau of Indian Standards.

Annex A
(*Clause* **7.3**)

Methods for Visually Assessing the Effects of Heating

A-1 SCOPE

This Annex specifies two methods for assessing the effects of heating on injection - moulded thermoplastics pipe fittings – method A, using an air oven, and method B, using a liquid bath. In case of disagreement, method A is the reference method.

This Annex is applicable to cement-welded fittings as well as to flanged fittings and fittings incorporating elastomeric seals and to fittings consisting of the assembly of several moulded parts (e.g. union connectors). It is applicable to both pressure and non-pressure fittings.

A-2 PRINCIPLE

Complete mouldings are subjected to an elevated temperature in an air-circulating oven or a liquid bath for a given period of time, depending upon the wall thickness of the fitting and the material being moulded.

The surfaces of the moulding are examined before and after heating and any cracks, blisters, delaminations or opening of fusion lines are measured and expressed as a percentage of the wall thickness.

A-3 TEST PARAMETERS

The following test parameters are specified by the subclauses referenced as follows and in Table A-1 for the particular material used in the manufacture of the fitting, unless the referring standard (a standard making reference to this Annex in its own provisions) or regulations specify otherwise.

a) The test temperature, T (*see* **A-4.1.1** and **A-4.3**);
b) The number of test pieces (*see* **A-4.2.2**);
c) The heating time, t (*see* **A-4.3.3**);
d) The test method to be used and, for method B (liquid bath) only, the test liquid.
e) The acceptable limits for the occurrence or dimensions of any cracks or other features found (*see* **A-4.3.6**)

Unless otherwise specified in the referring standard or regulations the test parameters shall be in accordance with Table A-1.

Table A-1 Test Parameters
(*Clause* **A-3**)

Material	**Temperature (T)**	**Heating Time**	
		Mean Wall Thickness (mm)	**Duration** (t, min)
PE	110 ± 2 ℃	$e_m \le 3$	15
		$3 < e_m \le 10$	30
PP	150 ± 2 ℃	$10 < e_m \le 20$	60
		$20 < e_m \le 30$	140
		$30 < e_m \le 40$	220
		$40 < e_m$	240

A-4 METHOD A

A-4.1 Apparatus

A-4.1.1 Air-circulating oven, thermostatically controlled, equipped with a thermostat so that the temperature of the working zone can be maintained at the prescribe test temperature throughout the test and of sufficient heating capacity to enable the test temperature to be regained within 15 min of insertion of the test pieces.

A-4.1.2 Thermometer, graduated in 0.5℃ or a type "T" thermocouple wit h a resolution of 0.1℃ and an accuracy of at least ± 0.8℃.

A-4.2 Test Pieces

A- 4.2.1 *Preparation*

After removing any runners, take the complete molding as test pieces. If the fitting incorporates an elastomeric sealing ring, remove the ring before testing. In the case of fittings assembled from more than one element, separate the components and test then out of contact with each other.

A-4.2.2 *Number*

The number of test pieces shall be as specified in the product standard. In the absence of any information on the number of test pieces, use at least three pieces.

A-4.3 PROCEDURE

A-4.3.1 Set the oven temperature (**A-4.1.1**) at the test temperature (T ± 2) ℃ in accordance with Table A-1

A-4.3.2 Put the test pieces in the oven and arrange them so that they are standing on one side of their sockets wherever possible, avoiding contact with another test piece or the sides of the oven.

A-4.3.3 Leave the test pieces in the oven until the oven returns to the test temperature (T ± 2)℃ and for a further period, t, dependent on the mean wall thickness, e_m, of the thickest part of the test piece(s) in accordance with the product standard or Table A-1.

A-4.3.4 Remove the test pieces from the oven, taking care not to deform or damage them.

A-4.3.5 Cut the test pieces with a sharp knife or razor blade while they are still hot, to enable the dimensions of cracks, blisters, delaminations and weld-line openings, if any, to be measured as required. Allow the test pieces and/or parts to cool in air until they can be handled without deformation.

If not otherwise specified in the referring standard, the following number of cuts should be made:

- For cylindrical components of $d_n \leq 160$ mm, not less than two cuts equally spaced around the periphery of the mouth of each socket or spigot of the component.

- For cylindrical components of $d_n > 160$ mm, not less than four cuts equally spaced around the periphery of the mouth of each socket or spigot of the component.

For d_n, see Fig. A-1

A-4.3.6 Examine each test piece, for, and record, any surface changes, such as cracks, delaminations and weld-line openings as well as changes inside the wall, e.g. blisters, and in the gating area. Determine the extent of such defects in the gating area as a percentage of the wall thickness as follows.

a) For spruce-gated mouldings (*see* Fig. **A-1**) around the injection point(s) within a radius as specified in the referring standard. In the absence of any information in the referring standard use R = $0.3d_n$ with a maximum value of 50 mm.
b) For ring-or-diaphragm-gated mouldings (*see* Fig. **A-1**) within a length L, of the cylindrical portion of the gating area as specified in the referring standard or, in absence of any information within a length L = $0.3d_n$. In the case of cracks running through the whole wall thickness of the gating area, determine also the length of the crack.
c) For mouldings containing fusion lines, determine the widest and deepest part(s) of any open part of the fusion line.
d) For all other parts of the moulding beyond the gating area, examine the surface for any change such as cracks, blisters and determinations of the wall. If not specified in the referring standard Basic Specifications given at the end of this Annex should be used for the examination of a test piece.

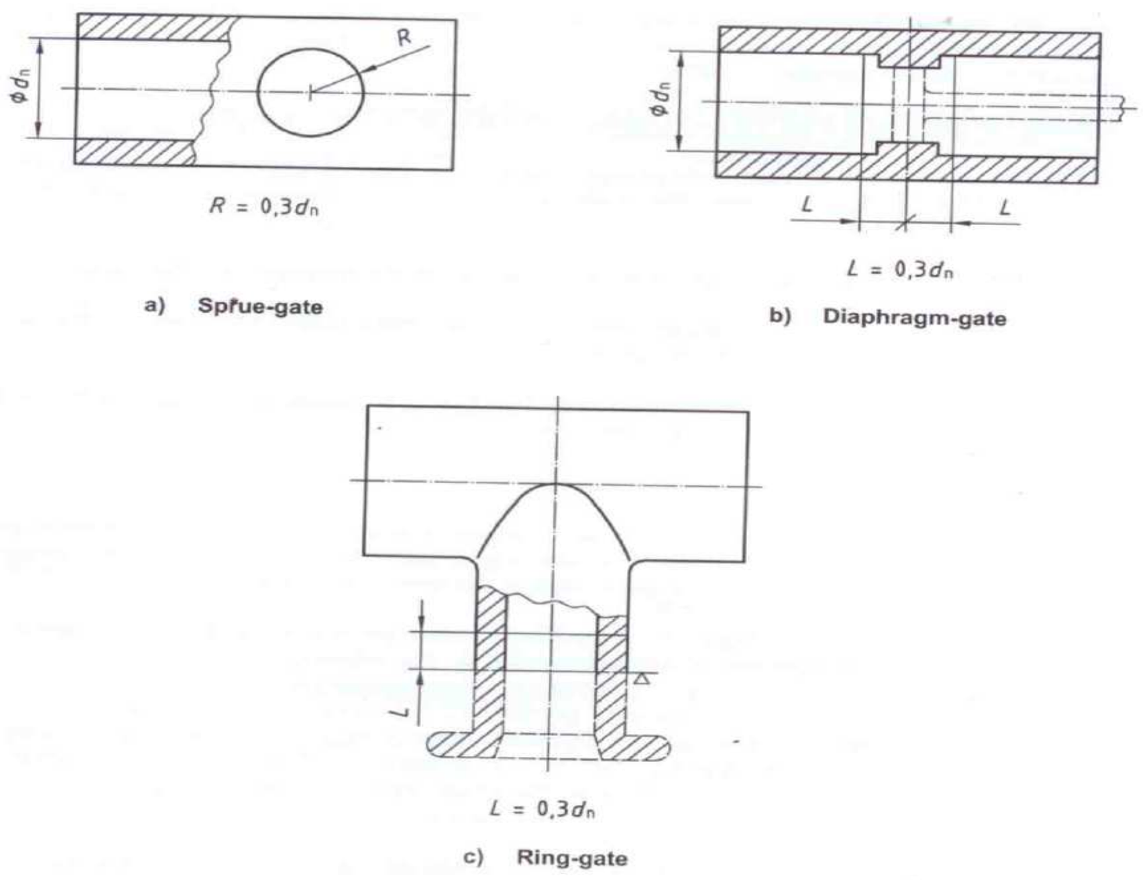


Fig. A-1 Injection Gating Areas

A-5 METHOD B

A-5.1 Apparatus

A-5.1.1 Heating bath, thermostatically controlled, at the prescribed test temperature, (T ± 2) ℃. The volume and agitation of the bath shall be such that the temperature remains within the specified temperature range when the test pieces are immersed.

The liquid chosen shall be stable at the specified temperature and shall not otherwise affect the test piece.

It shall be ensured that the liquid does not cause any safety or health risks.

Notes –

1. Glycerin, glycol, mineral oil free fro aromatic hydrocarbons, or a solution of calcium chloride may be suitable, depending upon which of the materials covered by this method is under test. For example, all these liquids are suitable for PVC-U, but the use of glycols is not appropriate for ABS fittings, for which the selection of an appropriate mineral oil is preferable.
2. Attention is drawn to my relevant legislation which requires that the use of the liquid chosen does not cause any safety or health risks.

A-5.1.2 **Holder,** to support the test piece(s) within the heating bath. The fittings shall be supported in such a way as to not cause additional distortion.

A-51.3 **Thermometer,** graduated in 0.5℃ or a type "T" thermocouple with a resolution of 0.1℃ and an accuracy of at least ± 0.8℃.

A-5.2 **Test Pieces** (*see* **A-4.2**)

A-5.3 **Procedure**

A-5.3.1 Set up the liquid bath (*see* **A-5.1.1**) to the prescribed test temperature ((T ± 2) ℃.

A-5.3.2 Put the test pieces in the liquid bath and arrange them so that they are not touching each other or the side of the bath.

A-5.3.3 Leave the test pieces in the bath for a test period, t, as specified in the referring standard for the mean wall thickness, e_m, of the thickest part of the test piece use a test period, t, in accordance with **Table A-1**.

A-5.3.4 Remove the test pieces from the bath, taking care not to deform or damage them.

A-5.3.5 Cut the test pieces in accordance with **A-4.3.5.**

A-5.3.6 Examine the test pieces in accordance with **A-4.3.6**

A-5.3.7 Record the composition of the liquid used in conjunction with the results obtained [*see* also Clause **A-6.c**].

Annex B
(*Clause* **8.2.1**)

Thermoplastics Fittings – Test Method for Mechanical Strength or Flexibility of Fabricated Fittings

B-1 SCOPE

This Annex specifies a method for testing the mechanical strength or flexibility of fabricated thermoplastics fitting intended to be used in non-pressure applications.

B-2 PRINCIPLE

An assembly of a fabricated fitting and the relevant number of adjacent pipe(s) and anchorages (*see* **Fig. B-1** and **B-2**) is subjected to a moment at the critical point. The critical point is where structural damage is most likely to start when increasing the moment. Either a specified moment, M, or a specified displacement, A, becomes the determining factor, whichever is reached first.

Note - It is assumed that the following test parameters are set by the standard making reference to this standard:

a) the sampling procedure and the number of test pieces (*see* **B-4.2**)
b) the conditioning temperature, if other than (27±5)℃ (*see* clause **B-5**)
c) the conditioning time, if other than 21 days (*see* clause **B- 5**)
d) if appropriate, the moment (M = F X L) or displacement to be applied (*see* clause **B- 6**)

B- 3 APPARATUS

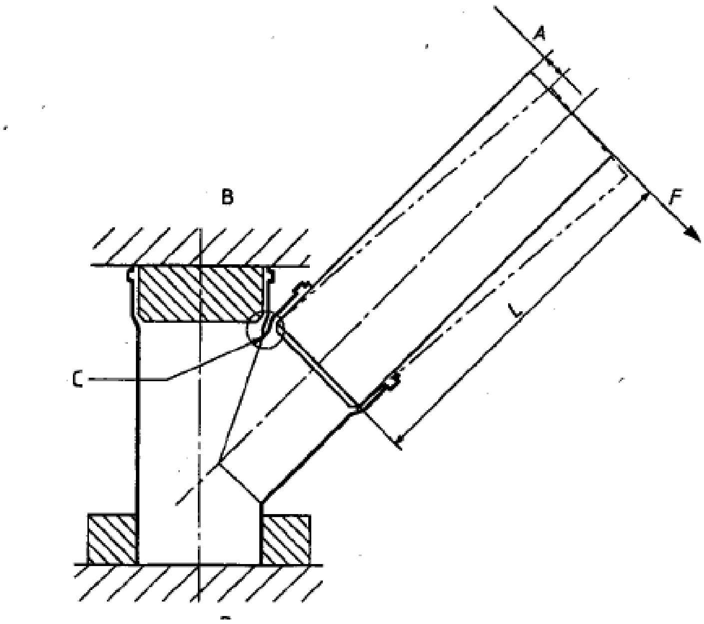
B- 3.1 Anchorages(s), capable of holding the body of the fabricated fitting rigid during the best. The anchorages shall not deform the fitting.

B- 3.1 Anchorages(s), capable of holding the body of the fabricated fitting rigid during the test. The anchorages shall not deform the fitting.

B- 3.2 Equipment capable of applying a force that will result in moment in the critical point (*see* clause **6)**. The direction of the force can be clockwise or anticlockwise, provided that tensile stresses are applied to the critical point.

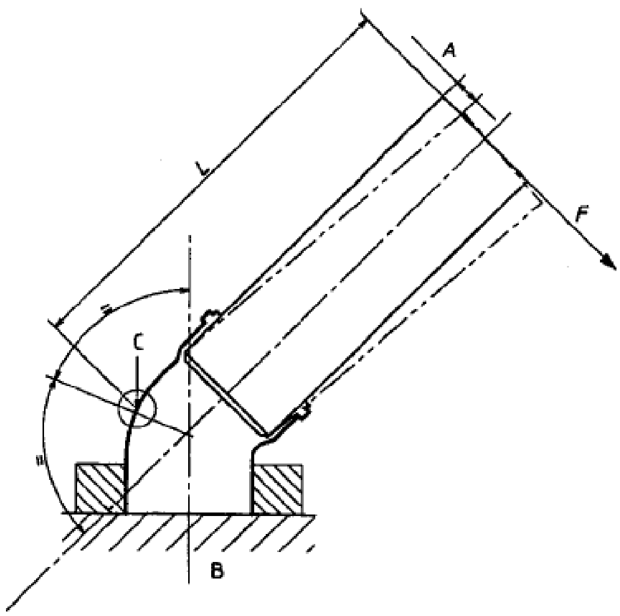
B-3.3 Equipment capable of determining the Length, L, of the arm to the critical point (*see* **Figs B-1** and **B-2**). When the displacement, A, is the determining factor, the arm, L, as shown in **Figs B-1** and **B-2**, shall be (1200±10) mm.

B- 3.4 Force and/or displacement measurement instruments, capable of determining the force applied and/or the displacement of the end of the arm to which the force is applied, as applicable (*see* clause **B-4** and **Table B-1**)



A Discharge
B Fixing
C Example of critical point (see clause 2)

Fig. B 1 Typical Test Assembly for a Branch with a Socket



A Discharge
B Fixing
C Example of critical point (see clause **2***)*

Fig. B 2 Typical Test Assembly for a Bend with a Socket

If a socket is designed to take up an angular deflection, β the total displacement shall be the sum of the displacement given by the design angles β as declared by the manufacturer, plus the specified displacement. In this case, however, a mechanical arrangement where the arm is fixed to the socket is preferred.

3.5 If necessary, additional means to ensure the tightness of the joint (*see* clause **B-4**)

B- 4 TEST PIECE

B- 4.1 Preparation

The test piece shall comprise an assembly of the fabricated fitting, with a pipe of the ring stiffness class for which the fitting is designed and fixing as appropriate.

In the case where a fitting is designed for both solid wall and structured-wall pipes, a solid wall pipe shall be used.

If the limiting factor is the moment, M, the pipe may be replaced by a mechanical arrangement that ensures that the required moment is applied.

If the limiting factor is the displacement, A the pipe may be replaced by a mechanical arrangement of longitudinal rigidity not less than that of the specified pipe. In case of dispute the specified pipe shall be used.

Where a joint between a pipe and a fabricated fitting is made, the manufacturer's instructions shall be followed except that additional means may be used to ensure the tightness of the joint during the test.

B- 4.2 Sampling Procedure and Number of Test Pieces

The sampling procedure and the number of test pieces shall be as specified in the referring standard.

B- 5 CONDITIONING

Samples shall be stored at room temperature of (27±2)℃ for at least 21 days before testing, unless otherwise specified in the referring standard

B- 6 PROCEDURE

B- 6.1 Non-Mechanical Joined Fabricated Fittings (Cemented or Fused) Carry Out the following Procedure at (27±2) ℃ .

Assemble the fitting with the pipe or mechanical arrangement (*see* **B-4.1**) and fix it e.g. as shown in Figs. **B-1** or **B-2**. If possible, fill the assembly with water or air pressure.

Apply the necessary force in 1 s to 20 s to obtain the specified moment at the critical point or the specified displacement as given in Table 1, unless otherwise specified in the referring standard.
Maintain the force or the displacement applied for 15 min while monitoring for and recording any signs of splitting, cracking, separation and/or leakage. The inspection may be performed after the relaxing of force or displacement, and if necessary also after removal from the anchorage, by applying water or air pressure or vacuum. Record any leakage at the fabricated joint as a failure.

B- 6.2 Mechanical Jointed Fabricated Fittings

Carry out the followings procedure at (27±2) ℃. As semble the fitting with the pipe or mechanical arrangement (*see* **B-4.1**) and fix it e.g. as shown in Fig. **B-1** or **B-2**.
Fill the assembly with water until the level is between 200 mm and 300 mm above the critical point. Apply the necessary force between 1 s and 20 s to obtain the specified moment at the

critical point or the specified displacement as given in Table B1 unless otherwise specified in the referring standard.

Maintain the force or the displacement applied for 15 min while monitoring for and recording any signs of splitting, cracking, separation and/or leakage.

Record any leakage at the fabricated joint as a failure.

Table B1 Moment/Displacement to be Applied
(*Clause* **B-3.4**)

Nominal Size (DN/ID)	**Minimum Moment** *kN-m*	**Minimum Displacement** *mm*
110	0.20	170
125	0.29	170
160	0.61	170
200	1.2	170
250	2.3	170
315	3.1	170
355	3.5	170
400	4.0	170
450	4.5	170
500	5.0	170
600	6.0	170
710	7.1	170
800	8.0	170
900	9.0	170
1000	10	170

NOTE- For DN/IDs up to and including 250, the Fig.s of the minimum moment approximate to the following equation:

$M = 0.15 \times [DN]^3 \times 10^{-6}$ kN-m

For DN/IDs greater than 250, the following equation is used:

$M = 0.010 \times [DN]$ kN-m

ANNEX C
(*Clause* **B-3.4**)
WATER TIGHTNESS AT JOINTS

C- 1 SCOPE

This annex specifies test method for water-tightness of:

a) Joints of Piping System for non-pressure applications;
b) Fabricated products made from more than one piece for non-pressure applications.

C- 2 PRINCIPLE

A test assembly comprising either a fabricated product or an assembly of pipes and or fittings is subjected to a given internal hydrostatic pressure for a given period during which the leak tightness of the fabricated product or the joint is verified by inspection.

NOTE- It is assumed that the following test parameters are set by the standard making reference to this standard

a) The sampling procedure (*see* **C- 4.1**)
b) The number of test pieces (*see* **C- 4.2**)

C- 3 APPARATUS

C-3.1 End-sealing devices, having a size and using a sealing method both appropriate to the type of joint under test. The devices shall be restrained in a manner that does not exert longitudinal forces on the joint assembly and that prevents the devices or the assembly under test from separating under pressure. The weight of the devices shall not be allowed to influence the angular deflection to be applied (*see* **C- 5.2**).

C-3.2 Hydrostatic pressure source connected to one end of at least one end-sealing device, capable of applying the required pressure gradually and evenly in accordance with **C-5.4** and then of keeping it constant to within $^{+2}_{-1}$ % for the duration of the test required (see clause **C-5**).

C- 3.3 *Bleed valve*, capable of venting air when hydrostatic pressure is applied to the test piece.

C- 3.4 Pressure Measuring Device, Capable of Checking Conformity to the required Test Pressure (*see* Clause **C-3.2**) and Clause **C-5**.

C- 4 TEST PIECES

C- 4.1 Preparation

The test piece shall comprise fabricated fitting or an assembly of (a) pipe section(s) (with or without socket) and/or fitting(s) including at least one joint of the type under test (*see* Fig. **C- 1**)

To assist air removal the test piece may be inclined by up to 12°.

The assembly of the joint(s) shall be carried out in accordance with the manufacturer's instructions.

The assembly shall comprise the combination of the smallest available spigot end and the largest available socket or socket groove diameter within the applicable tolerance(s) and obtained by sampling in accordance with the referring standard.

The relevant diameters of the selected spigot (s) and socket(s) shall be measured and recorded

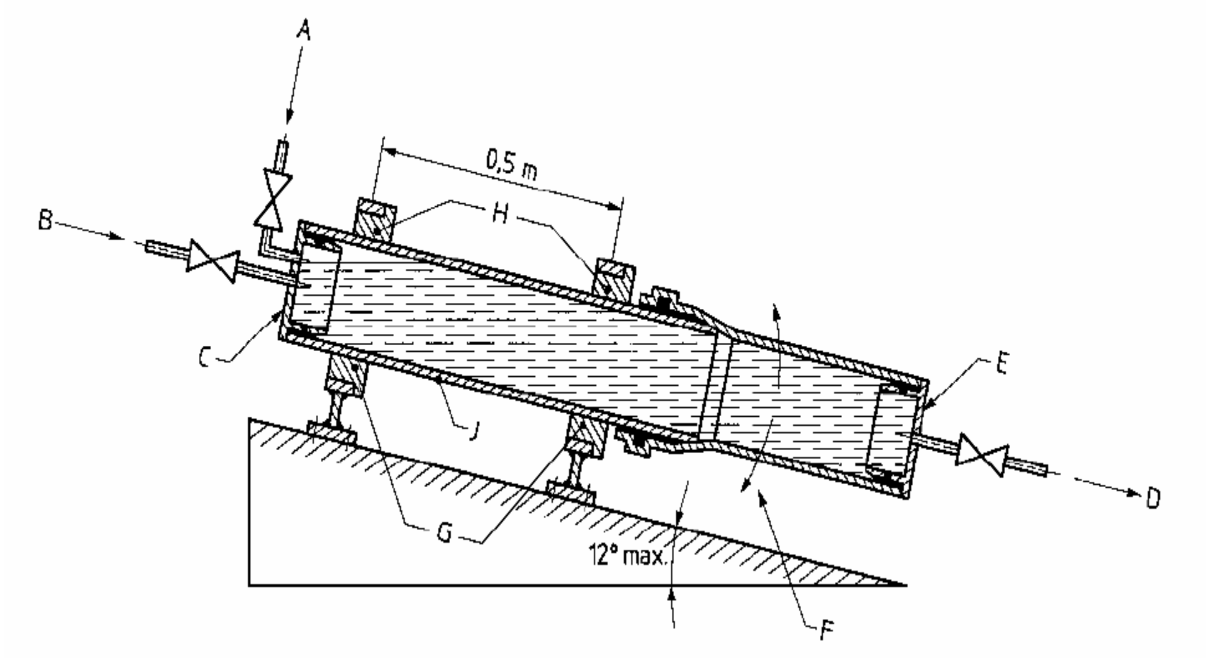


FIG. C1: Typical Arrangement

Dimensions in metres

A	Air outlet
B	Water inlet
C	Sealing plug with water inlet, air outlet and end restraint
D	Water Outlet
E	Sealing plug with water outlet and end restraint (*see* **C- 3.1**)
F	Direction of movement for angular deflection, if applicable (*see* **C- 5.2**)
G	Loose bushes to allow all sizes of pipes to be accommodated on the same test fixture
H	Fixed Points
J	Fixed component

C- 4.2 Number

The number of test pieces shall be as three

C- 5 PROCEDURE

C- 5.1 Carry out the following procedure at an ambient temperature of 27 ± 5) ℃ using cold tap water permitting any condensation on the surface of the test piece.

C- 5.2 Mount the test piece in the apparatus. If the joint to be tested permits angular deflection, arrange the test assembly so that the joint(s) under test is (are) subject to the (their) maximum angular deflection, as declared for the joint by manufacturer, for the axes of the components thus joined.

C- 5.3 When testing in accordance **C-5.4** and **C-5.5** monitor the test piece for and record any evidence of leakage.

C- 5.4 Introduce water into the test piece, while bleeding off all air, and apply the hydrostatic pressure as follows:

a) Accelerated procedure for fabricated products unless otherwise specified in the referring standard, apply in hydrostatic pressure of 0.5 bar (50kPa) and maintain if for at least 1 min.

b) Assemblies of pipes and / or fittings which are not fabricated: raise the hydrostatic pressure smoothly over a period of not greater than 15 min to 0.5 bar (50kPa) and maintain that pressure for at least 15 min.

C- 5.5 De-pressurize, drain and dismantle the test piece. Inspect for and record any changes in the appearance of the components tested.

Annex D
(*Clause* **9**)

Test Method for Resistance to Combined Temperature Cycling and External Loading

D-1 SCOPE

This Annex specifies two methods for testing pipes and fittings or joints for plastics piping systems intended for use in underground drainage and sewerage systems for their resistance to deformation and leakage when subjected to sustained external loading in conjunction with the passage of hot water.

Method A involves temperature cycling, by passing hot water and cold water alternately, and is applicable to pipes and associated fittings having a mean outside diameter $d_{em} \leq$ 190mm.

Method B involves passing hot water only, except at intervals specified for measurement of internal deflection, and is applicable to pipes and associated fittings having a mean outside diameter 190mm < $d_{em} \leq$ 510mm

D-2 PRINCIPLE

A test piece comprising a pipe or an assembly of pipe (s) and placed on a 100 mm gravel bed and covered with gravel to 600 mm above the crown of the pipe confined by a box of specified dimension. Depending on the nominal size of the largest pipe or joint under test, a constant vertical load is applied via the gravel and either a specified number of cycles of hot and cold water or just hot water is passed through the test piece. The deformation of the test piece as indicated by vertical deflection or internal diametric compression is measured.

For sizes having a mean outside diameter d_{em}< 190 mm, hot and cold water is passed though the test piece and air may be blown through the test piece during the interval between stages (Method A).

For pipes with a mean outside diameter 190<d_{em}<510mm a constant flow of hot water passed though the test piece (Method B).

Vertical deflection of the test piece is measured; the test piece is checked at the end of the test for cracking, for local deflection in the bottom of the main channel and for leakage at the joints.

NOTE - it is assumed that the following are set by the standard making reference to the standard:

a) if appropriate, the limits of the temperature of the water flowing out(*see* **D-6.2.2**);
b) if appropriate, the duration of the flow(*see* **D-6.2.2**):
c) The percentage x, of d_i for the diameter of the calculation of the diameter of the hard ball, in accordance with **D-6.3.3**.

D-3 APPARATUS

D-3.1 Gravel-filled box, to accommodate a test as shown in fig 1,2 and 3 with dimensions depending upon the size of the test piece as given in Table D-1 and with a horizontal base.

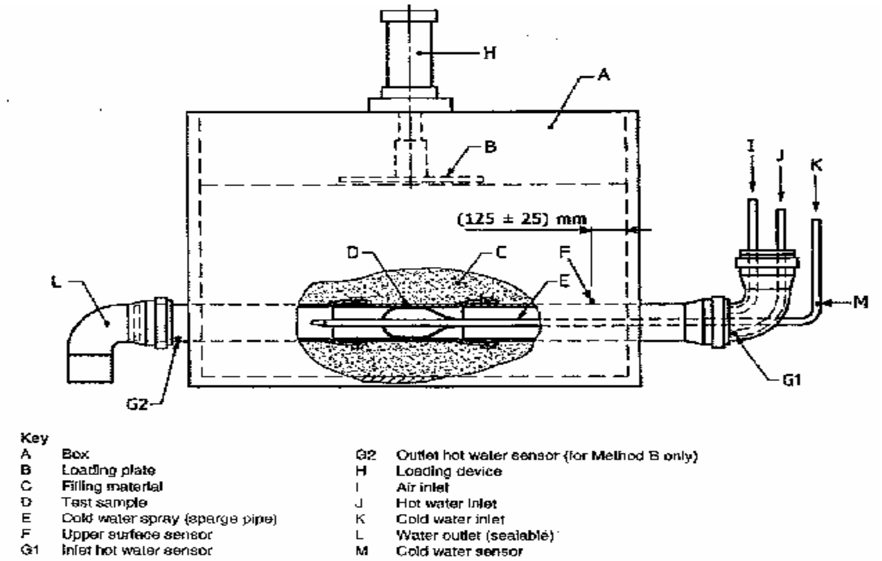


Figure 1 — Typical box loading test (BLT) apparatus

Table D1 Box Dimensions
(*Clause* **D-3.1)**

Mean Outside Diameter Pipe/Fitting d_{em}	**Inside Box Width** L1	**Minimum Length of Box** L2
Method A: <-190	700+-20	1200
Method B: 190<d_{em}<-205 205<d_{em}<-255 255<d_{em}<-320 320<d_{em}<-410 410<d_{em}<-510	 800+-20 900+-20 1 000+-20 1 300+-20 1 600+-20	 1 300 1 500 1 500 1 500 1 500

The inside walls of the box shall be vertical +/-3mm and shall have an inside smooth surface e.g. plywood or flat sheet.

The box shall be constructed and reinforced such that, when under load, I shall not deflect more than 3.0 mm at any point.

The pipeline shall pass through the walls of the box via holes sealed in such a way as to impose minimal restrain on the assembly (see clause D-5), e.g. by flexible closed cell sponge collars. The test assembly of the pipe or pipes and fittings shall be placed with a fall of between 1:100 and 1:75 to the horizontal base so that in the case of method A conditions alternate discharges of hot and cold water or in the case of method B, water at a constant temperature can be passed through the assembly while it is subject to a constant force acting through the gravel.

The box shall be constructed such that it can accommodate a total height of gravel of 600 mm above the crown of the pipe.

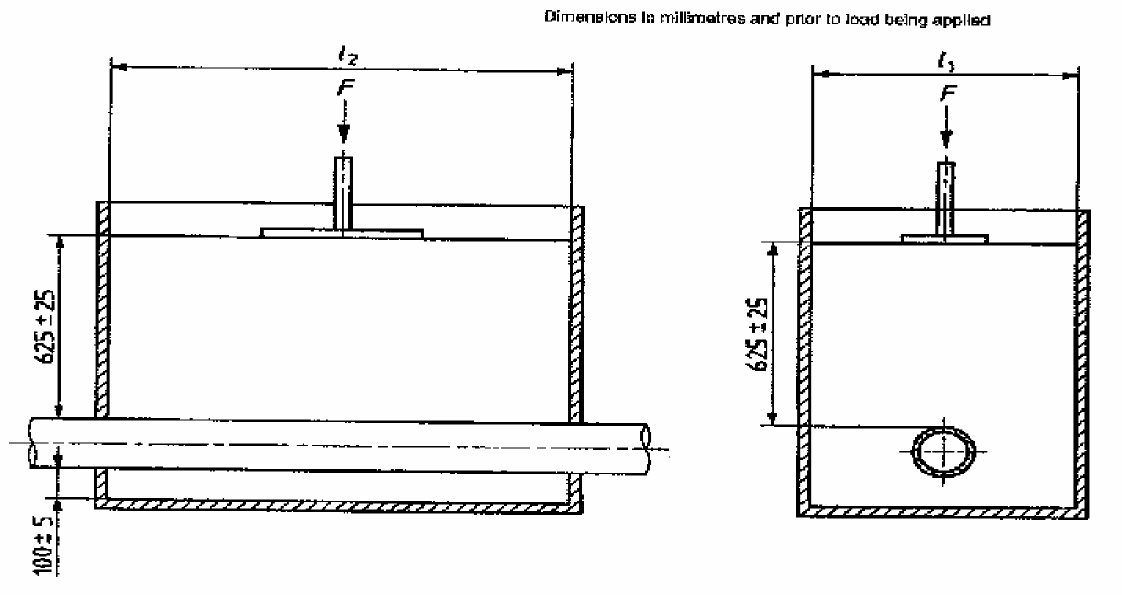
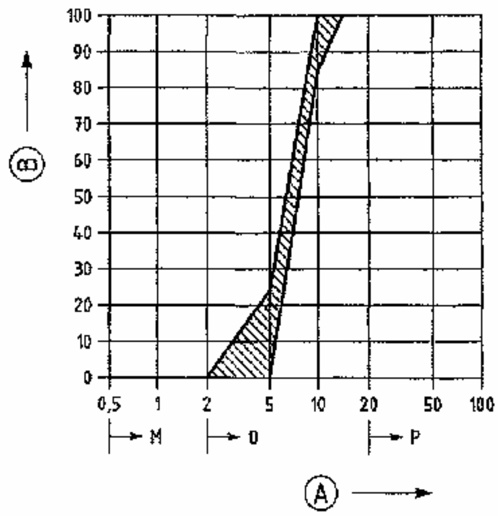


Figure 2 — Main dimensions of the box

The gravel shall be classified in accordance with Table **D-2**, shall have a surface texture in accordance with Table **D-3**, with granular composition within the range shown in Fig. 3 and shall conform to the requirements of Table **D-3**.



Key
A Particle size, in millimetres
B Cumulative percentage passing
M Sand
O Gravel
P Stone

Figure 3 — Gradation range of the gravel for box loading test

The gravel shall be washed natural material comprising hard, durable and clean particles. It shall be dry during the preparation and completion of the test.

Table D-2 Particle Shape
(*Clause* **D-3.1)**

Classification	**Description**
Rounded	Fully water worn or completely shaped by attrition
Irregular	Naturally irregular or partly shaped by attrition and having rounded edges
Angular	Possessing well defined edges formed at the intersection of roughly planar faces
Flaky	Material of which the thickness is small relative to the other two dimensions
Elongated	Material, usually angular, in which the is considerably larger than the other two dimension
Flaky and elongated	Material having the length considerably larger than the width considerably larger than the thickness

Table D-3 Surface Texture of Particles
(*Clause* **D-3.1)**

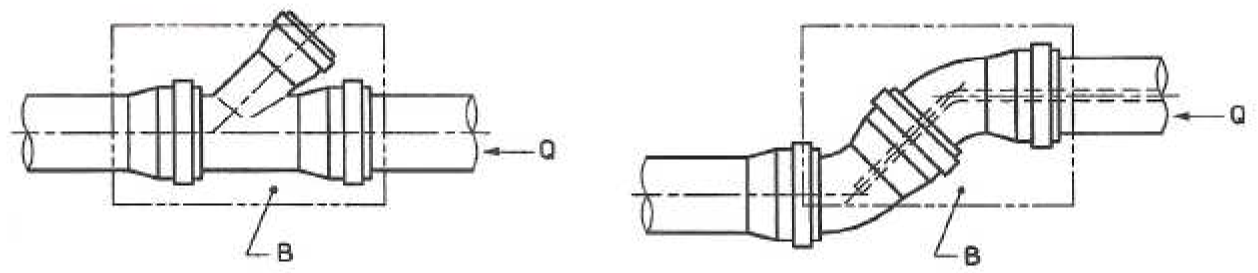
Surface Texture	**Characteristics**
Glossy	Conchoidal fracture
Smooth	Water worn or smooth due to fracture of laminated or fine grained rock
Granular	Fracture showing more or less uniform rounded grains
Rough	Rough fracture of fine or medium grained rock containing no easily visible crystalline constituents
Crystalline	Easily visible crystalline constituents

Table D-3 Shape of Particles
(*Clause* **D-3.1)**

Shape	**Surface**	**Content**
Rounded/irregular	Glassy/smooth	At least 85%
Upto 15% may fall within the other classes/textures given in Table 2 and 3 as applicable. The particle size distribution for all particles shall conform to Fig. 3.		

D-3.2 Compressive Loading Equipment, capable of applying the force, F, (*see* **D-6.1.7**) by means of hydraulic or pneumatic equipment acting through a (450+/-) mm * (300+-5) mm plate of steel at least 25 mm thick, or of another material of an equivalent stiffness, which shall be positioned horizontally. The 450 mm dimension shall be positioned parallel to the long wall of the box as shown in Fig. 1, 2 and 4. The force shall be applied such that the initial applicable load is applied during between 1 min and 2min and maintained to within +/-1kN.

Fixed points shall be established above each of the four corners of the loading plate to act as datum points to measure the sinking of the plate into the gravel after application of the final load (*see* **D-6.1.7**).



Q Flow
B Loading plate 300 mm × 450 mm

Fig. 4 Example of Positioning of a Test Piece Under the Loading Plate

D-3.3 Hot and cold water and air delivery systems, capable of providing the following:

a) hot water at the specified flow and temperature, T1, *see* **D-6.2.1** or **D-6.2.2** along the invert of the test assembly for the applicable period (*see* **D-6.2.1**or **D-6.2.2**);
b) cold water at the specified flow and temperature (see item c of **D-6.2.1.2**), which shall be sprayed on to the upper part of the inside surface of the test assembly throughout its entire length for the applicable periods (*see* **D-6.2.1**) the pipe shall be held off the surface of the test assembly;
c) if required, additional cold air can be passed through the test piece before , during or after circulation of cold water (*see* item D of **7.2.1**)

D-3.4 Temperature Measuring Device, having temperature sensors linked to an automatic continuous recording device and capable of measuring, to an accuracy of + 1ºC,
External surface temperatures and/or water temperature(s) as necessary in accordance with **D- 7.2** and positioned as shown in Fig. 1.

D-3.5 Bore Micrometer or Equivalent, capable of measuring changes in the vertical Inside diameter of the test piece to within + 0.1 mm.

D-3.6 A Gauge, capable of checking the bottom radius of the test piece for the purpose of item b) of **D-6.3.2**.

D-3.7 If applicable, **a hard ball** confirming to **D-6.3.3**.

D-3.8 A Straight edge of length > (1.5 X actual outside diameter ± 10) mm.

D-3.9 A Tamping tool, of overall mass (10±0.5) kg and having a (300±10)mm square food faced with rubber at least 5mm thick and nominally 60 IRHD when measured in accordance with ISO 48.

D- 4 TEST PIECE

The Test piece shall comprise an assembly of two connected together, or fitting(s), assembled with two or more pieces of pipe, of the size(s) and type(s) for which the fitting is designed, or a length of pipe having no joints. Any jointing shall be carried out in accordance with the manufacturer's instructions.

D- 5 CONDITIONING

Pipes and fittings shall not be tested within a period of 24h after their production.

D- 6 PROCEDURE

D- 6.1 Test Piece Embedment and Loading

D -6.1.1 Wherever this method call for compaction, the method shall be used as follows.

Apply 75 blows with the tamping tool evenly spaced over the surface of the gravel, For each blow, raise the tamping tool (450±50) mm above the surface of the gravel and allow it to fall under gravity.

D- 6.1.2 Using gravel conforming to Table 4, lay and level a compacted gravel bed (100±5) mm thick, so that a fall of between 1:100 and 1:75 is achieved in the direction of flow.

D- 6.1.3 Check that the test piece conforms to the dimensional requirements of the applicable standard and determine the minimum inside diameter (d_o) of the test piece. Place the test piece flat on the gravel bed under the loading plate generally as indicated in Fig. 4 and so that the weld line of fittings, if any, will be subjected to the flow of water, where this is possible.

For piece jointed directly, position the joint under the centre of the loading plate. In the case of a single branch fitting, install the side inlet of the fitting at a gradient of approximately 1:40.

When testing branch, locate the side limb in the horizontal position and seal any socket not being used with a short length of pipe having a sealed end or b means of a socket plug. If necessary, add gravel so that the test piece rests on an even base and/or remove gravel to just fit any socket.

D- 6.1.4 Attach a temperature sensor (F) to the crown of the test piece, where applicable in the valley between two stiffening ribs, inside the box adjacent to the water inlet, within 100 mm to 150 mm from the inside of the box.

For Method A, place a temperature sensor in the inlet of the hot water stream.

For Method B, place a temperature sensor in the outlet side of the hot water flow outside of the box structure.

D- 6.1.5 *Fill box in the following Stages:*

a) using gravel conforming to Table **D- 4**, fill the box to within 100mm to 150mm above the crown of the pipe, minimizing voids below the pipe ensuring that it is fully supported and compacted:

b) Thereafter fill the box with two approximately equal layers, each compacted in turn, to achieve a total depth of gravel cover of between 600mm and 650 mm over the crown of the assembly.

D- 6.1.6 Measure and record the vertical inside diameter, or a convenient vertical diameter reference d_1, of the test place at the centre of loading plate.

D- 6.1.7 Apply the load as follows.

a) Lower the rigid plate to the surface of the gravel and within two minutes apply an initial load of (5±0.5) kN. Note the level of the face of the load plate, by measurement using the four corners as datum points (*see* **D-3.2**).

b) Depending on the size of the test assembly, apply the test force (*see* Table **D-5**).

Table D-5 Test Loads
(*Clause* **D-6.1)**

Mean Outside Diameter D_{em} mm	**Load F** kN
$\leq$ 255	50±2
255<$d_{em}\leq$410	55±2
410<$d_{em}\leq$510	60±2

d) If the plate sinks more than 20mm at any datum point, remove the load plate. In case of dispute empty the box and refill it in accordance with **D- 6.1.5**, otherwise add to, level and re-compact the top layer of gravel to re-establish a total depth of gravel cover of between 600mm over the crown of the pipe, Restart the test by commencing at the procedure given in **D- 6.1.6**.

D- 6.2 Exposure to Hot Water

D- 6.2.1 Method A: Temperature cycling (for pipes/fittings with a mean outside diameter d_{em}< 190mm)

D- 6.2.1.1 *Procedure*

Subject the assembly to a minimum of 2500 cycles in accordance with **D-6.2.1.2**, provided that within the first 20 cycles and for all subsequent cycles, the temperature of the crown of the pipe recorded by the sensor F is above 30℃ on the hot cycle and is below 30℃ on the cold cycle. If necessary, this may be achieved by controlling the outlet ventilation.

If during the test the water temperature drops below 83℃ or the load drops below the minimum required for a number of cycles then an equal number of cycles shall be added to the test.

If during the test the water temperature increase above 87℃ or the load rises above that specified the test my be discontinued at the discretion of the manufacturer.

D- 6.2.1.2 *Cycle procedure*

Use the following cycle schedule, where cooling may be supplemented by an air flow or air blast at any time during the cycle so as to achieve the requirement of **D-6.2.1** for the temperatures measured by sensor F:

a) Pass (35±3) l of water at (85 ± 2) ℃ measure at the point of inlet to the assembly by the sensor G_1, over a period of 90 s to 95 s:
b) Rest and drain period of 60 s to 90 s.
c) pass at least 30 l of water of between 5 ℃ and 22 ℃ via a spurge pipe positioned within the bore of the assembly and having holes on its upper past to direct the flow over the pipe crown, The flow, together if necessary with an optical air flow or air blast through

the test assembly shall be sufficient to reduce the crown temperature to below 30 ℃ as recorded by sensor F. The cooling discharge shall be introduced through a pipe of suitably small diameter positioned in the bore within the assembly and having perforations along its upper part so that the water is direct over the upper 120℃ sector,

d) Drain the assembly for a period sufficient to allow the assembly to be emptied.
e) Return to a)

D- 6.2.2 Method B: Constant hot water (for pipes/ fittings with a mean outside diameter d_{em} >190mm). Pass water at a temperature, T_1, of (50 ± 2) ℃ constantly through the test piece. The temperature of the water, T_2, measured at the outlet sensor G_2, shall be (50±2) ℃, unless otherwise specified in the referring standard.

Note: Surface temperature is not measured.

Unless otherwise specified in the referring standard, maintain the flow for 192h.

The hot water temperature may be recorded at G_2, continuously during the test.

D- 6.3 Assessment

D- 6.3.1 *Assessment of Initial Deflection and Leak Tightness*

Before removing the force the loading plate and, unless **D-6.3.3** applies, proceed as follows.

a) Locate, measure and record the vertical inside diameter, d_2, or the, reference dimension at the position at which d_1, was measured.

b) Seal the pipe ends, fill the assembly with water at a temperature of (17 ± 5) ℃ and apply, after a conditioning period of 15 min apply a hydrostatic pressure of 0.35 bar, for a period of 15 min whilst monitoring the pressure and during which the pressure shall not fall below 0.3 bar.

The vertical deflection may be measured continually during the test.

D- 6.3.2 *Control of Deflection, Weld Line and Cracks*

After the leak-tightness test and within 24h after removal of the load and, unless **D- 6.3.3** applies, measure the local deflection in the test piece as follows:

a) Measure the evenness of the bottom of the test piece from the outside in the direction of the longitudinal axis, by placing the straight edge against the bottom of the test piece, without contacting any raised structural features of the test piece, and measuring the greatest gap between the straight edge and the bottom of the test piece:
b) Measure deviations in the bending radius of the test piece by using a gauge not less than 2mm thick in the shape of a cylinder with the axis of the gauge aligned with the longitudinal axis of thet test piece and the convex part of the gauge turned in the direction of the perimeter along the test piece which was subjected to water flow.

c) Drain, recover and dismantle the test piece and inspect the test piece components for any damage visible without magnification. In weld line zones, if any opening is visible, break it open and measure the greatest dept of the crack in the fracture surface induced by the exposure to hot water. Record the observations and the crack depth(s), as applicable.

D- 6.3.3 *Alternative Deflection Measurement*

Alternatively items **D-6.3.1 a)**, **D-6.3.2 a)** and **D-6.3.2.b)** may be replaced by the following procedure.

Determine whether the test piece assembly is capable of passing a hard ball having a diameter D_B in accordance with the following equation:

$D_B = (d_1 – x)$ …………………… (1)

Where

X is a percentage of d_1 as specified by the referring standard:
d_1 is the measured vertical inside diameter prior to loading and exposure to hot water (*see* **D- 6.1.4**) in millimeters.

D-7 CALCULATION AND EXPRESSION OF RESULTS

Calculate the deformation, λ, as the percentage change in inside diameter, using the following equation:

$$\lambda = \frac{d_1 - d_2}{d_1} \times 100 \quad \text{……………………. (2)}$$

Where

d_1 is the measured vertical inside diameter prior to loading and exposure to hot water (*see* **D- 6.1.4**)

d_2 is the measured vertical inside diameter after loading and exposure to hot water at the position at which d_1 was measured (*see* **D- 6.3.1**)

Annex E
(*Foreword*)

Transportation, Handling, Installation and Jointing

E- 1 TRANSPORTATION

The arrangement of loading the pipes in a telescopic manner is advised, i.e. smaller diameters inserted into the next higher sizes of pipes up to the height of 2.5 meters in a truck. While loading the pipes into the truck, care should be taken that the spigot/ coupler end should be arranged alternatively in the corresponding layer so as to avoid the damage to the coupling/ socket-end.

E- 2 HANDLING

Following Recommendations shall be followed while handling the pipes:

- Pipes shall be smoothly lowered to the ground.
- Pipes should not be dragged against the ground to avoid the damages to the coupler/pipes.
- 900 mm and larger diameter pipes are carried with Slings at two points spaced approximately at 3 Meters apart.
- For smaller diameters (450 mm – 900 mm both exclusive) one lift point shall be sufficient.
- For diameters smaller than or equal to 450 mm manual labour can be used.
- Do not use a loading Boom or Fork Lift directly on or inside pipe.

E- 3 PIPE STORAGE AT SITE

E- 3.1 Stockpiling shall be done temporarily on a Flat Clear Area as per Fig. **E-1**.

E- 3.2 For avoiding collapse of Stacks use Wooden Posts or Blocks

E- 3.3 Stacking shall not be higher than 2.5 Meters

E- 3.4 While stacking, alternate the socket/coupler ends at each row of stacked pipes as per Fig. **E-2**.

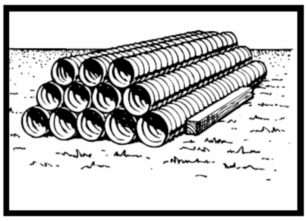


Fig E1

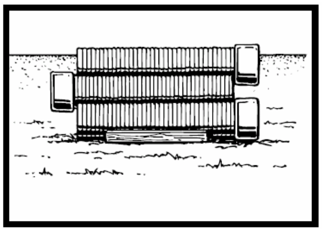


Fig E2

E- 4 CONSTRUCTION METHODS

E- 4.1 Trench Preparation

E- 4.1.1 *Dimensions*

The width of a Sewer Trench depends on the soil condition, type of side protection and the working space required at the bottom of Trench for smooth installations. Increase in width over required minimum would unduly increase the load on pipe and cost of road restoration. Considering all above factors, the Minimum Trench Width is specified as per Table **E-2**.

Table E- 2 Minimum Trench Widths
(*Clause* **E-4.1.1**)

Pipe Diameter (mm)	Trench Width (M)
75-200	0.6
250	0.7
300	0.8
400	0.9
600	1.2
800	1.3
900	1.6
1000	1.8
1200	2.0

E- 4.1.2 *Excavation*

Excavation of Sewer Trenches shall be in straight lines as much as possible and to the correct depths and gradients as specified in Drawings. However, because of inherent flexible property these pipes can also be laid at very wide and smooth curvatures without transitional manholes. Instead of conventional manholes, the specified fittings such as Tees and Bends etc. can be used at transitions.

Excavated spoils shall not be deposited in the near proximity to prevent the collapse of side of the trenches. The sides of the trench shall, however, be supported by shoring (where necessary) to ensure proper and speedy excavations and concurrently ensuring necessary protections to contiguous structures.

In the event, the presence of ground water is likely to cause instability in soil conditions, a well point system may be adopted for lowering of Ground Water Table below the requisite Trench bed level. If excavation is made deeper than necessary the same shall be filled and compacted.

E- 4.1.2.1 *Shoring / M.S. sheet piling*

The protective shoring works shall be strong enough to prevent caving in of Trench walls or subsidence of contagious areas adjacent to Trench.

For wider and deeper trenches, a system of Wall Plates (Wales) and struts of heavy timber section is commonly used as per the requisite Structural Design.

In non-cohesive soils with high Ground Water Table, continuous interlocking M S Sheet Piling may be necessary to prevent excessive soil movements due to Ground Water percolation. Such sheet piling shall extend 1.5 m below the Trench Bottom unless the lower soil strata are adequately cohesive.

E- 4.1.2.2.*Underground services*

The underground Public and Private Utility Services exposed due to the Excavation shall be effectively supported unde
r the guidance of the owners of such services

E- 4.1.2.3 *Dewatering*

Sewer Installation Trenches shall be adequately dewatered for the placement of pipe at proper gradient till the pipe is integrated through socket and Spigot Joint/coupler Assembly with the already laid segment. Precautions are to be taken to arrest floating of installed Sewer Segments against buoyant forces in case of sudden accumulation of water in the Trench. The Diameter wise 'Minimum Cover' necessary to counteract the buoyant forces are tabulated as per Table **E- 3**:

Table E-3 Required Minimum Cover to Prevent Floatation
(*Clause* **E-4.1.2.3**)

Nominal Diameter (mm)	**Minimum Cover** (mm)
75	65
100	77
150	102
200	127
250	178
300	368
400	505
600	711
900	1067
1050	1219
1200	1372

*Computation is based on the pipes being completely empty, water table at the ground surface, solid density of 2083 kg/m^3 and a soil friction angle appropriate for most sand/gravel mixtures. The average of the inside and outside diameters was used to determine solid and water displacement.

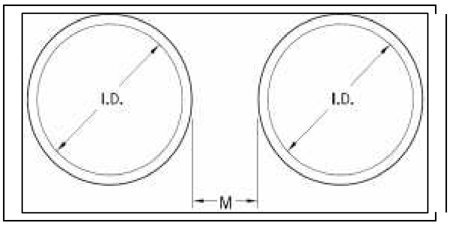
For exceptional cases of higher level of Ground Water, additional anchoring at equal intervals is proposed.

E- 4.1.2.4 *Bedding*

- Normally, even for the maximum combined loading (wheel load + backfill), any form of cement concrete structural bedding would not be necessary.
- For maintenance of sewer slopes the initial backfill envelop with sand or gravel (as computed through structural design of buried flexible conduit) over a single BFS would be sufficient.
- In the event, anchorage becomes imperative the transverse concrete anchorage blocks spaced at suitable interval shall also act as chairs for defining and maintaining the sewer slopes.

E- 4.1.2.5 *Parallel pipe installation*

For Cross Drainage under roads, often parallel pipe installations become necessary. In such cases allowance for adequate spaces between pipes are imperative. The proposed configuration of such system is depicted in Fig **E-3**.



UP TO 600MM I.D.: M=300 mm
MORE THAN 600MM I.D.: M=1/2 I.D of Larger Diameter pipe

Fig. E-3

E- 4.2 Laying and Jointing

E- 4.2.1 *Laying*

E- 4.2.1.1 *For shallow trenches*

Place the pipe manually on the initial backfill envelop directly.

E- 4.2.1.2 *Deep trenches with shoring/MS sheet piling*

- Make the trench reasonably free from ground water and other liquids.
- Place the pipe on the top level cross – struts of the timber shoring/MS sheet piling frame work
- Dismantle one/two cross struts and lower the pipe to the immediate lower layer of the cross-struts and re-fix the struts immediately
- In the same manner, reach up to the initial back filling and place the pipe at proper slope
- Ensure anchorage, if any, after laying

E- 4.2.2 *Jointing*

Various methods for jointing such as regular coupler made by online process, Spigot and sockets are used.

The moulded socket will have a suitable internal surface with profiles ribs for insertion of the next pipe into it. The socket end of the pipe to be inserted will have corrugated outer layer. On first valley segment of corrugator pipe (destined to be pushed into the coupler) one elastomeric rubber ring needs to be placed which is pushed into the coupler socket. This provides sufficient gripping lock and leak proof joint.

Similar system is also used for fabricated accessories or moulded fittings required such as Tee, Bends, Elbows, Reducer end caps for the purpose of installation of the system related to drainage/sewerage.

For quality connections following steps are to be ensured, failing which the performance aspects are to be severely compromised:

- The non-coupler end needs to be thoroughly cleared and shall be free from any foreign material
- Use a clean rag or brush to lubricate the non-coupler end with lubricant.
- Clean and lubricate the coupler end of the pipe to be laid in similar manner.
- Lubricate the exposed Gasket in the same manner with pipe lubricant
- Keep the lubricated non-coupler end free from dirt, backfill material, and foreign matter so that the joint integrity is not compromised.
- Push the coupler into non-coupler and align properly. Always push coupler end into non-coupler end.

For smaller diameter pipes simple manual insertion shall be sufficient. In every methodology, it should be ensured that the coupler end is adequately 'Homed' within non-coupler end to ensure installation and tight joining seal. Therefore prior to insertion always place a 'Homing Mark' on appropriate corrugation of the 'Non-Coupler End'.

E- 4.2.2.1 *Jointing different pipe types or sizes*

Sewerage/Drainage system often encounters connecting pipes of different materials/ sizes etc. The fittings or adapters specifically designed for the purpose are available.

A selection of fittings designed to make the transition from one material directly to another are also available. In few cases, fitting may need to be used in combination with separate manufacturer's gasket or coupler to give proper effect to the transition.

E- 4.2.3 *Manholes and Catch Pit Connections*

Brick Masonry Manholes can also be used at changes in pipe material, size, grade, direction and elevation. Manufacturer specified prefabricated appurtenant structures made of thermoplastic materials shall also be available for onsite user friendly installations. Similar methodology shall be followed for integration of catch pits.

E- 4.2.4 *Sewer Connections*

Other connecting lines shall be integrated with the already laid system in the same manner as of original sewer lines.

E- 4.2.5 *Construction of Backfill Envelope and Backfilling of the Trenches*

These pipes and well compacted backfill envelope work together to support soil and traffic load.

In General, material used for construction of back fill envelop around the pipe comprises the following:

- Initial backfill
- Side Fill
- Top back fill

The material for backfill envelop shall be as per the structural design of flexible buried conduit. It can be the same material that were removed in the course of excavation or it can be fine sand/course sand/gravel depending on the over burden and superimposed load, but it should be the concrete which invariably induces undesired rigidity in the system.

- The remaining portion of backfilling shall be the materials that were removed in the course of excavation. These materials shall consist of clean earth and shall be free from large clod or stone above 75 mm, ashes, refuse and other injurious materials.
- After completion of laying of pipes, etc, first the backfill envelope shall be constructed as per design around pipe. Voids must be eliminated by knifing under and around pipe or by some other technique and compacted with necessary watering, either by hand rammers or compactors to a possible maximum level of proctor density.
- Backfilling shall start only after ensuring the water tightness test of joints for the concerned sewer segments. However, partial filling may be done keeping the joints open.
- Precautions shall be taken against floatation as per the specified methodology and the minimum required cover.

Annex F
Structural Design

F.1 General

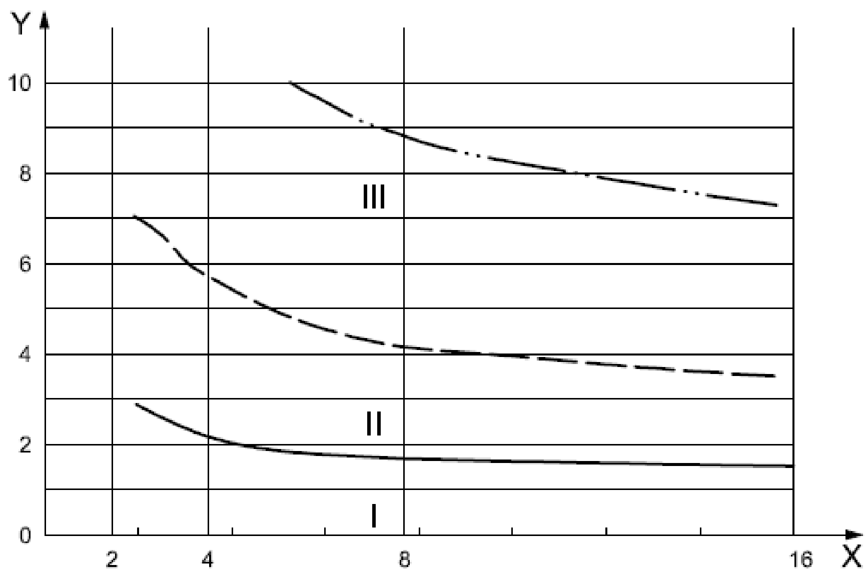
In general, structural design of a thermoplastics pipeline construction by applying analytical or numerical methods is not needed. Whether any calculated prediction of the pipe behaviour holds true in reality is strongly dependent on whether the installation conditions used for the calculation are the 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 Table F.1, is available and results in good prediction of the pipe performance.

Table F.1

Characteristic	**Test method**	**PP**	**PE**	**Unit**
Flexural modulus , $E_{(1\ min)}$	As per relevant IS Codes	1250 to 1900	1000 to 1200	MPa
Density		900	950	$kg.m^{-3}$
Co-efficient of linear thermal expansion		14 $x10^{-5}$	17 x 10^{-5}	$mm.mm^{-1}.K^{-1}$
Thermal conductivity		0.2	0.4 to 0.50	$W.K^{-1}.m^{-1}$
Poisson's Ratio		0.4	0.4	
Specific heat			2300 to 2900	$J.kg^{-1}K^{-1}$

F.2 Structural design based on a design graph

Designers first need to establish permitted deflections, average and maximum.An intensive study of the deflection history of pipes installed globally under different conditions for a period of 25 years has resulted in experience as presented in the design graph shown in Figure F1.For the deflection mentioned in the design graph, the strain will be far below the design limit, and therefore need not be taken into account in the design.



Key
X ring stiffness in kilopascals (kN/m^2)
Y pipe deflexion in percent

I "well" compaction
II "moderate" compaction
III "non-" compaction (not recommended)

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

Figure F.1 Design graph (long term pipe deflection (maximum values)

Table F.2 - Validity of the design graph

Pipe System	Fulfilling requirements in this IS code…, Parts 1 & 2
Installation depth	0.8 m to 6.0 m
Traffic loading	Included
Installation quality Installation categories “well”, “moderate” (and “non”) should reflect the workmanship on which the designer can rely.	**“Well” Compaction (I)** 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) 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%.
	Sheeting / Sheet piling given below the spring line of Sewer in accordance with the recommendations in Manual on Sewerage and Sewage Treatment, CPHEEO, MoUD, GoI. 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).

F.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 per established practices may be used. If input values for the pipes are required, the values given in Table F.1 are recommended.

It is recommended that, for reasons of serviceability, the calculated average deflection values do not exceed the values given in Table F.3

Table F.3

Recommended design deflection limits		
Stiffness class SN	**Average initial deflection**	**Average long term deflection**
SN 2	5%	8%
SN 4,8,16	8%	10%

F.4 Selection of fitting stiffness or class

Table F.4

Pipe stiffness class	Minimum fitting classes recommended for use with structured-wall thermoplastic Pipes
	As per this IS code
SN 2	SN 2
SN 4	SN 4
SN 8	SN 8
SN 16	SN 16