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SPECIFICATION FOR UNPLASTICIZED POLY (VINYL CHLORIDE) PIPES FOR WATER SUPPLY AND FOR BURIED AND ABOVE GROUND DRAINAGE AND SEWERAGE UNDER PRESSURE

(Third Revision)

SRI LANKA STANDARDS INSTITUTION

Sri Lanka Standard

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(Corrigendum 1 Attached)

Gr.11

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Sri Lanka Standards are subject to periodical revision in order to accommodate the progress made by industry. Suggestions for improvement will be recorded and brought to the notice of the Committees to which the revisions are entrusted.

This standard does not purport to include all the necessary provisions of a contract.

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FOREWORD

This standard was approved by the Sectoral Committee on Materials, Mechanical Systems and Manufacturing Engineering and authorized for adoption and publication as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on 2013.06.04.

This Sri Lanka standard is the third revision of **SLS 147** Rigid Unplasticized Polyvinyl Chloride Pipes for Potable Cold water Supplies, first published in 1972 and then revised in 1983 and 1993. In this revision the title, scope, requirements for materials and dimensions of pipes have been revised.

All values given in this specification are in SI units as **ISO 1000**.

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 an analysis, shall be rounded off in accordance with **SLS 102**. The number of significant figures to be retained in the rounded off value shall be the same as that of the specified value in this standard.

In the preparation of this standard, valuable assistance derived from the following publications of International Organization for Standardization is gratefully acknowledged.

ISO 1452 Plastics piping systems for water supply and for buried and above ground drainage and sewerage under pressure-Unplasticized poly (vinyl chloride) PVC-U
Part 1: General
Part 2: Pipes

1 SCOPE

This standard specifies the characteristics of solid-wall pipes made from unplasticized polyvinyl chlorides (PVC-U) for piping systems, intended for water supply for human consumption and for general purposes as well as for sewerage under pressure.

This standard specifies a range of pipe sizes and pressure classes and specifies requirements concerning colour and methods of test. This is applicable to extruded pipes with or without a socket (integral or not) intended to be used for conveyance of water and waste water up to and including 45 ^{0}C for the following:

a) water mains and services buried in the ground;
b) conveyance of water above ground for both outside and inside buildings; and
c) buried and above-ground drainage and sewerage under pressure.

2 NORMATIVE REFERENCES

ISO 3	Preferred numbers - Series of preferred numbers
ISO 497	Guide to the choice of series of preferred numbers and series containing more rounded values of preferred numbers
ISO 1000	SI units and recommendation for use of their multiples and of certain other units
ISO 4065	Thermoplastics pipes - Universal wall thickness table
ISO 6401	Plastics - Poly (vinyl chloride) - Determination of residual vinyl chloride monomer - Gas chromatographic method
EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber
EN 744	Plastics piping and ducting systems - Thermoplastics pipes - test method for resistance to external blows by the round the clock method
SLS ISO 1167-1	Thermoplastics pipes, fittings and assemblies for the conveyance of fluids - Determination of the resistance to internal pressure Part 1: General method
SLS ISO 1167-2	Thermoplastics pipes, fittings and assemblies for the conveyance of fluids - Determination of the resistance to internal pressure Part 2: Preparation of pipe test pieces
SLS ISO 1183-1	Plastics - Methods of determining the density of non-cellular plastics Part 1: Immersion method, liquid pyknometer method and titration method
SLS ISO 2505	Thermoplastics pipes and fittings - Longitudinal reversion - Test method and parameters
SLS ISO 2507-1	Thermoplastics pipes and fittings - Vicat softening temperature Part 1: General test method
SLS ISO 3114	Unplasticized polyvinyl chloride (PVC) pipes for potable water supply - Extractability of lead and tin - Test method
SLS ISO 3126	Plastics piping systems - Plastic components - Determination of dimensions
SLS ISO 6259-1	Thermoplastics pipes - Determination of tensile properties - Part 1: General test method
SLS ISO 6259-2	Thermoplastics pipes - Determination of tensile properties - Part 2: Pipes made of unplasticized poly(vinyl chloride), chlorinated poly(vinyl chloride) and high - impact poly(vinyl chloride)
SLS ISO 7686	Plastics pipes and fittings - Determination of opacity
SLS ISO 9852	Unplasticized poly (vinyl chloride) pipes - Dichloromethane resistance at specified temperature (DCMT) - Test method
SLS ISO 18373-1	Rigid PVC pipes - Differential Scanning Calorimetry (DSC) method
SLS 102	Presentation of numerical values
SLS 428	Random sampling methods
SLS 935	Solvent cement for polyvinyl chloride (PVC) pipes and fittings

3 TERMS AND DEFINITIONS

For the purpose of this standard the following definitions shall apply:

3.1 Geometrical definition

3.1.1 mean inside diameter of socket (d_{im}) : Arithmetical mean of two measured inside diameters perpendicular to each other at the midpoint of the socket length.

3.1.2 mean outside diameter (d_{em}) : Value of the measurement of the outer circumference of a pipe or spigot at any cross-section, divided by π (= 3.142), rounded up to the nearest 0.1 mm.

3.1.3 mean wall thickness (e_m) : Arithmetical mean of a number of measurements of the wall thickness, regularly spaced around the circumference and in the same cross-section of a pipe or socket, including the measured minimum and the measured maximum values of the wall thickness in that cross-section.

3.1.4 nominal diameter (d_n) : Specified diameter assigned to a nominal size.

NOTES :

1. *The nominal (outside) diameter of a thermoplastics pipe or spigot, is equal to its minimum mean outside diameter, $d_{em, min.}$*
2. *The nominal inside diameter of the socket of a pipe is equal to the nominal outside diameter of the connecting pipe for which they are designed.*

3.1.5 nominal size (DN) : Numerical designation of the size of a component, other than a component designated by thread size, which is a convenient round number approximately equal to the manufacturing dimension in millimeters.

3.1.6 nominal wall thickness (e_n) : Numerical designation of the wall thickness of a pipe which is identical to the minimum permissible wall thickness at any point.

3.1.7 outside diameter at any point (d_e) : Value of the measurement of the outside diameter through its cross-section at any point of a pipe or spigot, rounded up to the nearest 0.1 mm.

3.1.8 out-of roundness (ovality) : Difference between the measured maximum and the measured minimum outside diameter in the same cross-section of a pipe or spigot or the difference between the measured maximum and the measured minimum inside diameter in the same cross- section of a socket.

3.1.9 pipe series (S) : Dimensionless number for pipe designation.

NOTE : *The pipe series S is related to a given pipe geometry as given in following equation*,

$$S = \frac{d_n - e_n}{2e_n}$$

3.1.10 standard dimension ratio (SDR) : Numerical designation of a pipe series which is a convenient round number approximately equal to the dimension ratio of the nominal outside diameter, d_n , and the nominal wall thickness, e_n.

NOTE : *The standard ratio, SDR and the pipe series S are related as given in the following equation.*

$$SDR = 2\,S + 1$$

3.1.11 tolerance : Permitted variation of the specified value of a quantity, expressed as the difference between the permitted maximum and the permitted minimum value.

3.1.12 wall thickness at any point (e) : Value of the measurement of the wall thickness at any point around the circumference of a pipe, spigot or socket.

3.2 Material definitions

3.2.1 design coefficient (C) : Overall coefficient with a value greater than 1, which takes into consideration service conditions as well as properties of the components of a piping system other than those represented in the lower predictive limit.

3.2.2 design stress (σ_s) : Allowable stress for a given application at 20 ^{0}C.

NOTES :

1. *It is derived from the MRS by dividing it by the coefficient, C using the following equation*:

$$\sigma_s = \frac{MRS}{C}$$

2. *Design stress is expressed in MPa*.

3.2.3 lower prediction limit (σ_{LPL}) : Quantity which can be considered as a material property, representing the 97.5% lower confidence limit of the predicted long-term hydrostatic strength at 20 ^{0}C for 50 years with internal water pressure.

NOTE: *Lower prediction limit is expressed in MPa.*

3.2.4 minimum required strength (MRS) : Value of σ_{LPL} rounded to the next lower value of the R10 series when σ_{LPL} is below 10 MPa, or to the next lower value of the R20 series when σ_{LPL} is 10 MPa or greater.

NOTE : *The R10 and R20 series are the basic series of preferred numbers conforming to* ***ISO 3*** *and* ***ISO 497***.

3.2.5 external reprocessable material : material comprising either one of the following forms:

a) material from rejected unused pipes or trimmings, which will be reprocessed and which were originally processed by another manufacturer.
b) material from the production of used PVC-U products other than pipes, regardless of where they are manufactured.

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

3.2.7 recyclable material : Material comprising either one of the following forms:

a) material from used pipes, which have been cleaned and crushed or ground;
b) material from used PVC-U products other than pipes, which have been cleaned and crushed or ground.

3.2.8 virgin material : Material in the form of granules or powder that has not been subjected to use or processing other than that required for its manufacture and to which no reprocess able or recyclable material(s) has been added .

3.3 Definitions related to service conditions

3.3.1 allowable operating pressure (PFA) : Maximum hydrostatic pressure which a pipe is capable of withstanding continuously in services (excluding surge).

NOTE :

1. *For the temperatures up to and including 25 ^{0}C,*
   PFA = PN
2. *For water temperatures above 25 ^{0}C,*
   PFA = f_T x PN

Where,

f_T is the derating factor depending on water temperature
PN is the nominal pressure.

In case, where a further derating factor for application is required,
PFA = f_A x PN, where f_A is the factor depending on the application

3.3.2 hydrostatic stress (σ) : Stress induced in the wall of a pipe when a pressure is applied using water as a medium

NOTES :

1. *The hydrostatic stress is related o the applied pressure, p in bar, the wall thickness at any point, e and the mean outside diameter, d_{em} of a pipe and is calculated using the following approximation equation .*

$$\sigma = \frac{p\,(d_{em} - e)}{2e}$$

2. *Hydrostatic stress is expressed in MPa.*

3.3.4 nominal pressure (PN) : Numerical designation used for reference purpose related to the mechanical characteristics of a component of a piping system.

NOTE : *For plastics pipes, it corresponds to the allowable operating pressure, (in bar) conveying water at 20 ^{0}C during 50 years, as given in the following equation:*

$$PN = \frac{20\ MRS}{C\ x\ (SDR-1)}$$

3.3.5 true impact rate (TIR) : Total number of failures divided by the total number of blows, in per cent, as if the whole batch had been tested.

NOTE : *In practice, test pieces are drawn at random from the batch and the result is only an estimate of the TIR for that batch.*

3.4 Symbols

C	Design coefficient
d_e	Outside diameter at any point
d_{em}	Mean outside diameter
d_i	Inside diameter at any point
d_n	Nominal outside or inside diameter
e	Wall thickness at any point
e_m	Mean wall thickness
e_n	Nominal wall thickness
f_A	De-rating factor for application
f_T	De-rating factor for water temperatures
σ	Hydrostatic stress
σ_s	Design stress

4 CLASSIFICATION OF PIPES

4.1 Classification

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

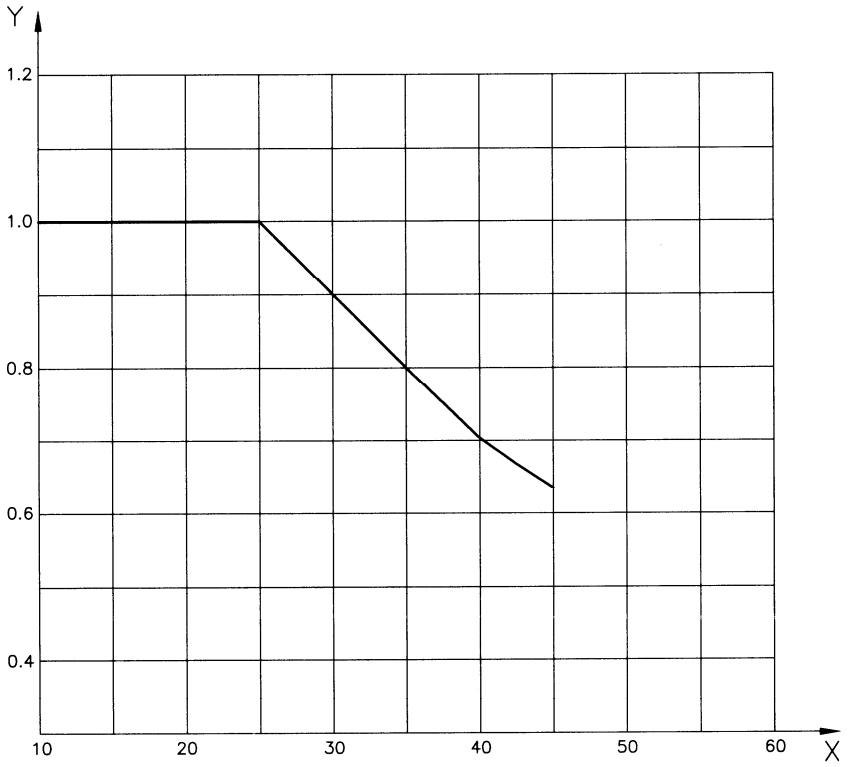
The allowable operating pressure PFA, for temperatures up to and including 25^0 C shall be equal to the nominal pressure, PN.

To determine the allowable operating pressure (PFA) for temperatures between 25 ^{0}C and 45 ^{0}C, a supplementary de-rating factor, f_T, shall be applied to the nominal pressure, PN as given as follows:

$$PFA = f_T \times PN$$

This factor is given in Figure **1**.

In this standard, maximum allowable operating pressure at 30 ^{0}C is calculated using a de-rating factor and expressed as PN_T. For other service temperatures, the de-rating factor f_T shall be taken from Figure 1.



Key
X Service temperature, in degree Celsius
Y Derating factor, f_T

FIGURE 1- De-rating factor f_T, for service temperatures up to 45 ^{0}C

5 REQUIREMENTS

5.1 Material

5.1.1 *General requirements for compounds or formulations*

The material from which the pipes are made shall be an unplasticized poly (vinyl chloride) compound or formulation. This compound or formulation shall consist of PVC-U resin/powder, to which shall be added those additives which are needed to facilitate the manufacture of pipes conforming to this standard.

None of these additives shall be used separately or together in quantities sufficient to constitute a toxic, organoleptic or microbiological hazard or to impair the fabrication or solvent-cementing properties of the product or to impair the chemical and physical or mechanical properties (in particular long-term mechanical strength and impact strength) as specified in this standard.

The vinyl chloride monomer (VCM) in the resin used in PVC-U compound/formulation shall be less than ± 0.0001 % volume fraction (this is the equivalent of 1 ppm, which is a deprecated unit), if determined by means of gas-phase chromatography using the "headspace" method in accordance with **ISO 6401**.

5.1.2 *Use of reprocessable and recyclable material*

The use of the manufacturer's own reprocessable material obtained during the production and testing of product conforming to this standard is permitted, in addition to the use of virgin material. Reprocessable material obtained from external sources and recyclable material shall not be used.

5.1.3 *Density*

The density, ρ, of the pipe, at 23 ^{0}C when measured in accordance with **7.1**, shall be within the following limits:

$$1\ 350\ kg/m^3 \leq \rho \leq 1\ 460\ kg/m^3$$

5.1.4 *MRS-value*

The pipe material shall have a minimum required strength, MRS of at least 25 MPa.

NOTE: *The manufacturer of the compound or formulation shall confirm the MRS value by testing in accordance with* ***ISO 1452-1***.

5.1.5 Effect of materials on water quality

Material shall not adversely affect the quality of the drinking water and when tested in accordance with **7.2**, the extracted quantities of lead, tin, cadmium and mercury levels as metals shall not exceed the levels specified in Table **1**.

TABLE 1 – Limits of the toxic substance

Toxic substance	Levels of toxic substance (third extraction), mg/l
Lead	0.01
Dialkyl tin as tin(C_4 and above)	0.02
Cadmium	0.003
Mercury	0.001

5.2 General characteristics

5.2.1 *Appearance*

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

5.2.2 *Colour*

The colour of the pipes shall be grey or blue for water supply, and grey or brown for drainage and sewerage under pressure. The colour of the pipes shall be uniform throughout the wall.

5.2.3 *Opacity of pipes intended for the above-ground conveyance of water*

The wall of the pipe shall be opaque and shall not transmit more than 0.2% of visible light when measured in accordance with **7.3**.

5.3 Geometrical characteristics

Dimensions shall be measured in accordance with **7.4**.

5.3.1 *Pipes*

5.3.1.1 Nominal outside diameters

The nominal outside diameter, $d_{n,}$ of a pipe shall conform to Table **2**.

5.3.1.2 Mean outside diameters and their tolerances

The mean outside diameter, $d_{em,}$ of a pipe shall conform to the applicable nominal outside diameter, $d_{n,}$ with the tolerance given Table **2**. The tolerance for out-of-roundness shall conform to Table **2**.

TABLE 2 - Nominal outside diameters and tolerances

Dimensions in millimeters

Nominal outside diameter, d_n (1)	Tolerance for mean outside diameter d_{em} [a], x (2)	Tolerance for out -of-roundness [b]	
		S 12.5 to S 5[c] (3)	S 16 [d] (4)
20	0.2	0.5	-
25	0.2	0.5	-
32	0.2	0.5	-
40	0.2	0.5	1.4
50	0.2	0.6	1.4
63	0.3	0.8	1.5
75	0.3	0.8	1.5
90	0.3	1.1	1.8
110	0.4	1.4	2.2
125	0.4	1.5	2.5
140	0.5	1.7	2.8
160	0.5	2.0	3.2
180	0.6	2.2	3.6
200	0.6	2.4	4.0
225	0.7	2.7	4.5
250	0.8	5.0	5.0
280	0.9	3.4	6.8
315	1.0	3.8	7.6
355	1.1	4.3	8.6
400	1.2	4.8	9.6
500	1.5	6.0	12.0

a - The tolerance is expressed in the form $^{+\ x}_{-\ 0}$, where x is the value of the tolerance.

b - The tolerance is expressed as the difference between the largest and the smallest outside diameter in a cross-section of the pipe.

c - The requirements for out of roundness is only applicable prior to the pipe leaving the manufacturer's premises.

d - The requirements for out of roundness is only applicable prior to storage.

5.3.1.3 Wall thickness and their tolerances

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

The nominal wall thickness shall conform to Table **3**, as appropriate to the pipe series. The tolerance for wall thickness e, shall conform to the Table **4**.

TABLE 3 - Nominal wall thickness

Dimensions in millimeters

Nominal Outside Diameter, d_n	Pipe series S											
	Nominal wall thickness											
	S 16 (SDR 33)		S 12.5 (SDR 26)		S 10 (SDR 21)		S 8 (SDR 17)		S 6.3 (SDR 13.6)		S 5 (SDR 11)	
	Nominal pressure PN based on design coefficient C = 2.5											
	-		PN 8	PN_T 7	PN 10	PN_T 9	PN 12.5	PN_T 11	PN 16	PN_T 14	PN 20	PN_T 18
20	-		-		-		-		1.5		1.9	
25	-		-		-		1.5		1.9		2.3	
32	-		1.5		1.6		1.9		2.4		2.9	
40	-		1.6		1.9		2.4		3.0		3.7	
50	-		2.0		2.4		3.0		3.7		4.6	
63	-		2.5		3.0		3.8		4.7		5.8	
75	-		2.9		3.6		4.5		5.6		6.8	
90	-		3.5		4.3		5.4		6.7		8.2	
Nominal pressure PN based on design coefficient C = 2.0[a]												
	PN 8	PN_T 7	PN 10	PN_T 9	PN 12.5	PN_T 11	PN 16	PN_T 14	PN 20	PN_T 18	PN 25	PN_T 22.5
110	3.4		4.2		5.3		6.6		8.1		10.0	
125	3.9		4.8		6.0		7.4		9.2		11.4	
140	4.3		5.4		6.7		8.3		10.3		12.7	
160	4.9		6.2		7.7		9.5		11.8		14.6	
180	5.5		6.9		8.6		10.7		13.3		16.4	
200	6.2		7.7		9.6		11.9		14.7		18.2	
225	6.9		8.6		10.8		13.4		16.6		-	
250	7.7		9.6		11.9		14.8		18.4		-	
280	8.6		10.7		13.4		16.6		20.6		-	
315	9.7		12.1		15.0		18.7		23.2		-	
355	10.9		13.6		16.9		21.1		26.1		-	
400	12.3		15.3		19.1		23.7		29.4		-	
450	13.8		17.2		21.5		26.7		33.1		-	
500	15.3		19.1		23.9		29.7		36.8		-	

a - To apply a design coefficient of 2.5 (instead of 2.0) for pipes with nominal diameters above 90 mm the next higher pressure rating, PN shall be chosen.

NOTES:

1. *The nominal wall thickness confirm to **ISO 4065**.*
2. *PN_T is calculated by using the de-rating factor at 30 ^{0}C.*

TABLE 4 – Tolerance on wall thicknesses at any point

Dimensions in millimeters

Nominal (minimum) wall thickness, e_n (1)	Tolerance for wall thickness, x (2)	Nominal (minimum) wall thickness, e_n (3)	Tolerance for wall thickness, x (4)
$1.0 < e_n \leq 2.0$	0.4	$20.0 < e_n \leq 21.0$	2.3
$2.0 < e_n \leq 3.0$	0.5	$21.0 < e_n \leq 22.0$	2.4
$3.0 < e_n \leq 4.0$	0.6	$22.0 < e_n \leq 23.0$	2.5
$4.0 < e_n \leq 5.0$	0.7	$23.0 < e_n \leq 24.0$	2.6
$5.0 < e_n \leq 6.0$	0.8	$24.0 < e_n \leq 25.0$	2.7
$6.0 < e_n \leq 7.0$	0.9	$25.0 < e_n \leq 26.0$	2.8
$7.0 < e_n \leq 8.0$	1.0	$26.0 < e_n \leq 27.0$	2.9
$8.0 < e_n \leq 9.0$	1.1	$27.0 < e_n \leq 28.0$	3.0
$9.0 < e_n \leq 10.0$	1.2	$28.0 < e_n \leq 29.0$	3.1
$10.0 < e_n \leq 11.0$	1.3	$29.0 < e_n \leq 30.0$	3.2
$11.0 < e_n \leq 12.0$	1.4	$30.0 < e_n \leq 31.0$	3.3
$12.0 < e_n \leq 13.0$	1.5	$31.0 < e_n \leq 32.0$	3.4
$13.0 < e_n \leq 14.0$	1.6	$32.0 < e_n \leq 33.0$	3.5
$14.0 < e_n \leq 15.0$	1.7	$33.0 < e_n \leq 34.0$	3.6
$15.0 < e_n \leq 16.0$	1.8	$34.0 < e_n \leq 35.0$	3.7
$16.0 < e_n \leq 17.0$	1.9	$35.0 < e_n \leq 36.0$	3.8
$17.0 < e_n \leq 18.0$	2.0	$36.0 < e_n \leq 37.0$	3.9
$18.0 < e_n \leq 19.0$	2.1		
$19.0 < e_n \leq 20.0$	2.2		

NOTE : *The tolerance applies to the nominal (minimum) wall thickness and is expressed in the form* $^{+\ x}_{-\ 0}$ *m, where x is the value of tolerance for the mean wall thickness* e_m.

5.3.1.4 *Length of pipe*

The nominal pipe length, *l* shall be a minimum length which does not include the depth of the socketed portions, as shown in Figure **2**.

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

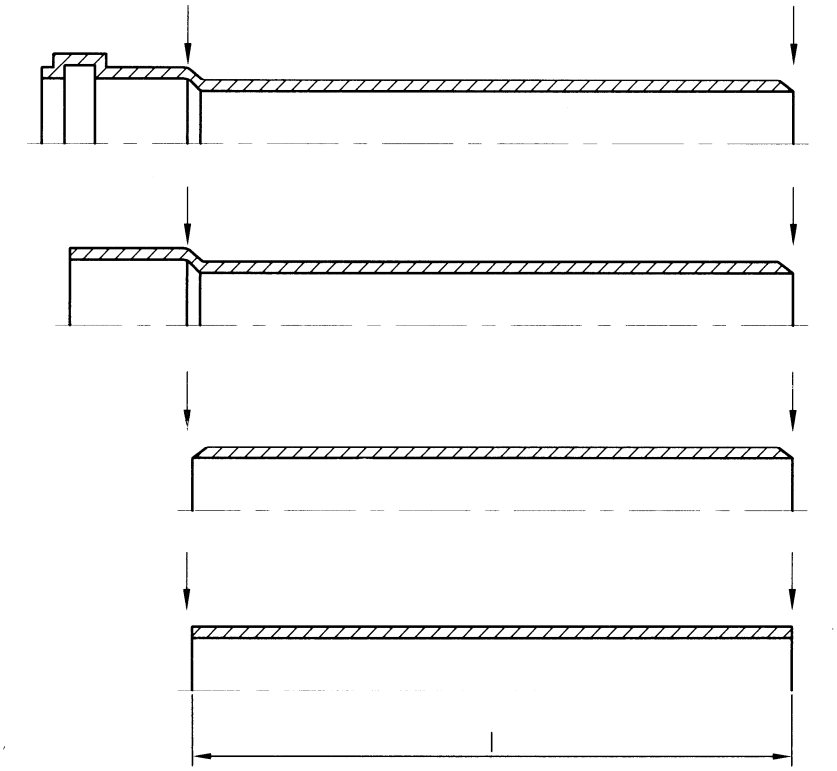


FIGURE 2 – Points of measurement for nominal pipe lengths

5.3.2 *Pipes with sockets*

5.3.2.1 Sockets for solvent cementing

The dimensions of sockets for solvent cementing are given in Figure **3**. They shall conform to Table **5**.

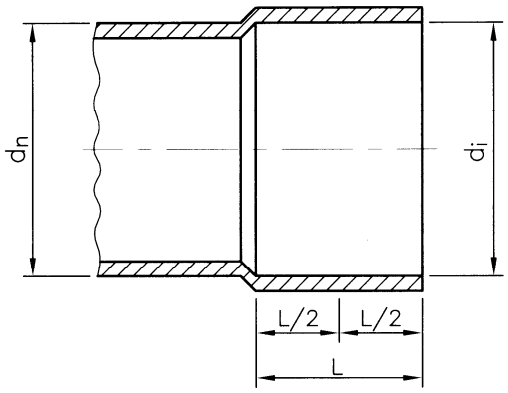


FIGURE 3 – Socket for solvent cementing

The nominal inside diameter of a socket shall be equal to the normal outside diameter, $d_{n,}$ of the pipe. The maximum included internal angle of the socketed portion shall not exceed 0^0 30' (30 min). The requirements for mean inside diameter d_{im} of sockets shall apply at the midpoint of the socket length.

TABLE 5 – Dimensions of sockets for solvent cementing

Dimensions in millimeters

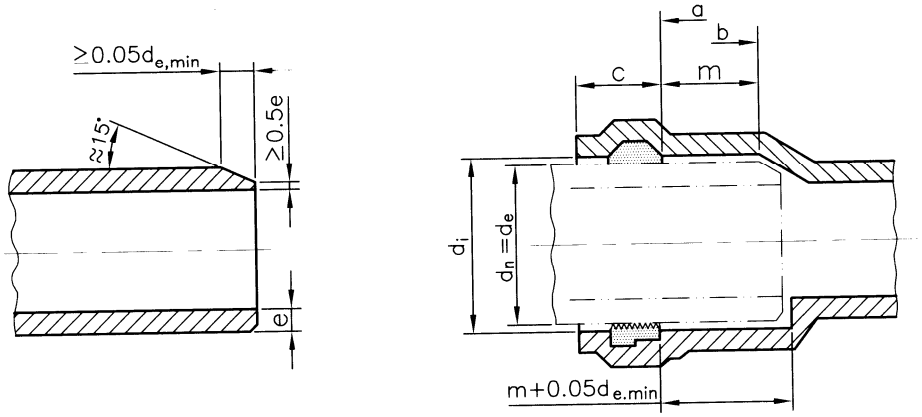
Nominal inside diameter of socket, d_n (1)	Mean inside diameter of socket		Maximum out-of roundness for d_i (4)	Minimum socket length L_{min} [a] (5)
	$d_{im, min}$ (2)	$d_{im, max}$ (3)		
20	20.1	20.3	0.25	16.0
25	25.1	25.3	0.25	18.5
32	32.1	32.3	0.25	22.0
40	40.1	40.3	0.25	26.0
50	50.1	50.3	0.3	31.0
63	63.1	63.3	0.4	37.5
75	75.1	75.3	0.5	43.5
90	90.1	90.3	0.6	51.0
110	110.1	110.4	0.7	61.0
125	125.1	125.4	0.8	68.5
140	140.2	140.5	0.9	76.0
160	160.2	160.5	1.0	86.0
180	180.2	180.6	1.1	96.0
200	200.2	200.6	1.2	106.0
225	225.3	225.7	1.4	118.5
250	250.3	250.8	1.5	131.0
280	280.3	280.9	1.7	146.0
315	315.4	316.0	1.9	163.5
355	355.4	356.1	2.0	183.5
400	400.4	401.2	2.0	206.0

a The minimum socket lengths are equal to ($0.5d_n$ + 6 mm) or 12 mm if ($0.5d_n$ + 6 mm) ≤ 12 mm.

5.3.2.2 Sockets for elastomeric ring seal type joints

The minimum depth of engagement, m_{min} of single sockets with elastomeric ring seal joints (see Figure **4**) is based on pipe lengths up to 12 m and shall conform to Table **6**.

The wall thickness of the sockets at any point, except the sealing ring groove, shall not be less than the minimum wall thickness of the connecting pipe. The wall thickness of the sealing ring groove shall not be less than 0.8 times the minimum wall thickness of the connecting pipe.
The requirements for mean inside diameters, $d_{im,}$ of sockets shall apply at the midpoint of the depth of engagement, m.



Key
a Start of sealing area
b End of cylindrical part of socket and pipe.

FIGURE 4 - Socket and spigot end for pipes with elastomeric sealing

Figure **4** shows the engagement if the spigot end is pushed to the socket bottom.

TABLE 6 – Dimensions of sockets for elastomeric ring seal joints

Dimensions in millimeters

Nominal inside diameter of socket, d_n	Minimum mean inside diameter of socket $d_{im,min}$ [a]	Maximum permissible out-of roundness for d [b]		Minimum depth of engagement m_{min} [c]	Length of socket entrance and sealing area, c [d]
		S 16	S 12.5 to S 5		
(1)	(2)	(3)	(4)	(5)	(6)
20	20.3	-	0.3	55	27
25	25.3	-	0.3	55	27
32	32.3	0.6	0.3	55	27
40	40.3	0.8	0.4	55	28
50	50.3	0.9	0.5	56	30
63	63.4	1.2	0.6	58	32
75	75.4	1.2	0.7	60	34
90	90.4	1.4	0.9	61	36
110	110.5	1.7	1.1	64	40
125	125.5	1.9	1.2	66	42
140	140.6	2.1	1.3	68	44
160	160.6	2.4	1.5	71	48
180	180.7	2.7	1.7	73	51
200	200.7	3.0	1.8	75	54
225	225.8	3.4	2.1	78	58
250	250.9	3.8	2.3	81	62
280	281.0	5.1	2.6	85	67
315	316.1	5.7	2.9	88	72
355	356.2	6.5	3.3	90	79
400	401.3	7.2	3.6	92	86
450	451.5	8.1	4.1	95	94
500	501.6	9.0	4.5	97	102

a $d_{im,\ min}$ is measured in the middle of the engagement, *m,* and is calculated using the applicable Equation (1), (2) or (3).

When $d_n \leq 50$, $d_{im,min} = d_n + 0.3$ mm (1)

When $63 \leq d_n \leq 90$, $d_{im,min} = d_n + 0.4$ mm (2)

When $d_n \geq 110$, $d_{im,min} = 1.003\ d_n + 0.1$ mm (3)

The values obtained shall be rounded to the next greater 0.1 mm.

b The out of roundness tolerances are rounded values of 0.75 grades to **ISO 11922-1** for S 16 as follows:

0.75 grade M for $32 \leq d_n \leq 50$;

0.75 grade N for $63 \leq d_n \leq 250$;

0.75 grade M for $280 \leq d_n \leq 500$.

For pipe series S 12.5 to S 5: 0.375 grade M, except 0.3 grade M for $d_n \leq 32$.

c The value of $m_{min.}$ is calculated from the applicable Equation (4) or (5):

When $d_n \leq 280$; $m_{min} = 50$ mm $+ 0.22\ d_n - 2e$ (S 10) (4)

When $d_n > 280$; $m_{min} = 70$ mm $+ 0.15\ d_n - 2\ e$ (S 10) (5)

The values obtained shall be rounded to the next greater 1.0 mm.

d The value of c is calculated using the following equation: $c = 22 + 0.66\ d_n$ and c is given only for guidance in calculating minimum spigot lengths. The manufacturer shall state the c-values in his catalogue.

5.3.3 *Pipe ends for ring seal or solvent cement joints*

Pipes with plain ends intended to be used with elastomeric ring seal sockets shall be chamfered as shown in Figure **4**. Pipes with plain ends intended to be used for solvent cement joints shall have all the sharp edges removed.

5.4 Physical and chemical properties

5.4.1 *Vicat softening temperature*

When tested in accordance with **7.5**, the minimum vicat oftening temperature of pipe shall be 80 ^{0}C.

5.4.2 *Longitudinal reversion*

When tested in accordance with **7.6**, a length of pipe of approximately 200 mm shall not alter in length by more than 5 per cent.

NOTE: *In case of dispute, liquid bath method shall be used*.

5.4.3 *Resistance to dichloromethane*

When tested in accordance with **7.7**, there shall be no attack at any part of the surface of the test piece of pipe.

5.4.4 *Processing temperature - Differential scanning calorimetry (DSC)*

When tested in accordance with **7.8**, the minimum B onset temperature resistance of pipe shall be 185 ^{0}C.

NOTE : *Alternative test method to resistance dichloromethane*.

5.4.5 *Resistance to acetone*

When tested in accordance with **7.9**, pipe shall show no delamination or disintegration. Flattening and/or swelling of the pipe shall not be deemed to contribute failure.

NOTE : *Alternative test method to resistance dichloromethane*.

5.4.6 *Tensile properties*

When tested in accordance with **7.10**, the pipes shall have the following tensile properties.

a) Minimum ultimate tensile stress 45 Mpa
b) Minimum elongation at break 80 per cent

5.5 Mechanical properties

5.5.1 *Impact strength*

Pipes with a nominal wall thickness of 14.9 mm or less, if tested for resistance to external blows at 0 ^{0}C in accordance with **7.11**, shall have a true impact rate (TIR) of not more than 10%.

5.5.2 *Resistance to internal pressure*

5.5.2.1 When tested in accordance with **7.12**, using the test conditions specified in Table **7**, the pipes shall withstand, without bursting or leakage, the hydrostatic stress induced by internal hydrostatic pressure in less than the time given there in.

TABLE 7 – Pressure test requirements for pipes

Test **(1)**	**Test temperature** **^{0}C** **(2)**	**Circumferential stress (Hoop stress), MPa** **(3)**	**Test time** **h** **(4)**
Test I	20	42.0	1
Test II	60	12.5[a]	1000
a - If tested with the circumferential stress of 12.5 MPa, due to statistical spread of the test results, test times less than 1000 h can be achieved. In this case, a retest procedure with a circumferential stress of 12.5 MPa or 10.0 MPa shall be performed with pipes of the same production batch and double sampling. If the test results are positive, the requirement of the minimum reference curve for PVC-U 250, given in **4.4.2** of ISO **1452-1**, is deemed to be verified.			

5.5.2.2 When tested in accordance with **7.12**, using the test parameters given in Table **8**, the integral sockets formed on pipes shall not fail in less than the time given there in.

TABLE 8 - Resistance of integral sockets to internal pressure at 20 ^{0}C

Nominal diameter **d_n, mm** **(1)**	**Test pressure** **bar** **(2)**	**Test time** **h** **(3)**
$d_n \leq 90$	4.2 X PN	1
$d_n > 90$	3.36 X PN	1

5.6.1 Sealing rings

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

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

5.6.2 Adhesives

The adhesive(s) shall have no detrimental effects on the pipe and shall not cause the test assembly to fail to conform to **ISO 1452-5**. The adhesive shall be identified in accordance with **ISO 7387-1** and their properties shall conform to **SLS 935**.

6 MARKING

All the pipes shall be legibly and indelibly marked at intervals not more than 1m with the following:

a) Manufacturer's name or registered trade-mark;
b) Material (eg: PVC-U);
c) Nominal outside diameter, d_n x wall thickness (eg: 110 x 7.3);
d) Maximum allowable pressure at 30 ^{0}C, PN_T (eg: PN_T 14);
e) Batch number; and
f) Intended use (eg: W/P).

7 METHODS OF TEST

7.1 Determination of material density

The density of the pipe material shall be determined in accordance with **SLS ISO 1183-1**.
The test results shall be reported for each test specimen to the nearest 1 kgm^{-3}.

7.2 Determination of effect of materials on water quality

The quantities of lead and dialkyl tin in the extracts shall be determined after the third extractions in accordance with **SLS ISO 3114** and shall be reported separately for each test specimen to the nearest 0.01 mg/l.

The quantities of cadmium and mercury in the extracts shall also be determined after the third extractions and reported separately for each test specimen to the nearest 0.001 mg/l.

7.3 Determination of opacity

The opacity of the pipe shall be determined in accordance with **SLS ISO 7686**.

7.4 Determination of dimensions

Dimensions shall be measured in accordance with **SLS ISO 3126**.

All the dimensions shall be measured at the room temperature.

7.5 Determination of vicat softening temperature

The vicat softening temperature shall be determined for 3 test pieces in accordance with **SLS ISO 2507-1**. The test results shall be reported for each test specimen.

7.6 Determination of longitudinal reversion

The longitudinal reversion of the pipe shall be determined in accordance with **SLS ISO 2505**.

For thickness grater than 16 mm, the duration of exposure in air oven shall be 240 min and conditioning period at 23 ± 2 ^{0}C shall be minimum of 10 h.

7.7 Determination of resistance to dichloromethane

The resistance to dichloromethane of the pipe shall be determined in accordance with **SLS ISO 9852**.

The temperature of the test shall be at 15 ^{0}C.

7.8 Determination of processing temperature - Differential Scanning Calorimetry (DSC)

DSC of the pipe shall be determined in accordance with **SLS ISO 18373-1**.

7.9 Determination of resistance to acetone

A short length of pipe shall be immersed vertically to a depth of at least 25 mm in analytical reagent at room temperature. The effect of acetone on the pipe surface shall be observed after two hours.

7.10 Determination of tensile properties

The tensile test shall be determined in accordance with **SLS ISO 6259-1** and **SLS ISO 6259-2**.

The testing speed shall be 5 ± 1 mm/min and test temperature shall be 23 ± 2 ^{0}C.

7.11 Determination of resistance to external blow

Resistance to external blow shall be determined in accordance with **EN 744**.

Pipes in the series S 5 to S 10 shall be tested at the medium level M and pipes in the series S 12.5 to S 16 shall be tested at the high level H as given in Table **9** for impact strength. The striker shall be as Table **1** and Table **2** of **EN 744**, depending on the mass of the falling weight.

TABLE 9 – Requirements for the falling weight impact test

Nominal outside diameter d_n mm (1)	Medium level M			High level H		
	Mass of falling weight kg (2)	Fall height m (3)	Impact energy [ab] Nm (4)	Mass of falling weight kg (5)	Fall height m (6)	Impact energy [ab] Nm (7)
20	0.5	0.4	2	0.5	0.4	2
25	0.5	0.5	2.5	0.5	0.5	2.5
32	0.5	0.6	3	0.5	0.6	3
40	0.5	0.8	4	0.5	0.8	4
50	0.5	1.0	5	0.5	1.0	5
63	0.8	1.0	8	0.8	1.0	8
75	0.8	1.0	8	0.8	1.2	9.5
90	0.8	1.2	9.5	1.0	2.0	20
110	1.0	1.6	16	1.6	2.0	31
125	1.25	2.0	25	2.5	2.0	49
140	1.6	1.8	28	3.2	1.8	57
160	1.6	2.0	31	3.2	2.0	63
180	2.0	1.8	35	4.0	1.8	71
200	2.0	2.0	39	4.0	2.0	78
225	2.5	1.8	44	5.0	1.8	88
250	2.5	2.0	49	5.0	2.0	98
280	3.2	1.8	57	6.3	1.8	111
≥ 315	3.2	2.0	63	6.3	2.0	124

a Based on g = 9.81 m/s^2
b For less than 10, round off to 0.5; for greater than 10, rounded off to integers.

7.12 Hydrostatic pressure test

The hydrostatic pressure of the pipe shall be determined for 3 test pieces, water in water, in accordance with **SLS ISO 1167-1** and **SLS ISO 1167-2**. For this test, end caps type A or B in accordance with **SLS ISO 1167-1** may be used. In case of dispute, end caps type A shall be used.

The hydrostatic pressure of integral sockets shall be determined for 3 test pieces, water in water, in accordance with **SLS ISO 1167-1** and **SLS ISO 1167-2**. For this test, end caps type B in accordance with **SLS ISO 1167-1** may be used and the socket entrance may be externally reinforced to prevent a displacement of the sealing ring.

APPENDIX A
COMPLIANCE OF A LOT

The sampling scheme given in his Appendix should be applied where compliance of a lot to the requirements of this standard is to be assessed based on statistical sampling and inspection.

Where compliance with this standard is to be assured based on manufacturer's control systems coupled with type testing and check tests or any other procedure, appropriate schemes of sampling and inspection should be adopted.

A.1 SAMPLING

A.1.1 *Lot*

All PVC pipes in a single consignment of he same type and size manufactured under essentially similar conditions shall constitute a lot.

A.1.2 *Scale of sampling*

A.1.2.1 Sample shall be tested from each lot separately for ascertaining conformity of the lot to the requirements of this standard.

A.1.2.2 The number of PVC pipes to be taken from the lot shall depend on the size of he lot and outside diameter of PVC pipes and shall be in accordance with Table **10**.

TABLE 10 – Scale of sampling

Number of PVC pipes in the lot	Out side diameter up to and including 110 mm		Outside diameter above 110 mm		Size of sub sample
	Sample size	Acceptance number	Sample size	Acceptance number	
(1)	(2)	(3)	(4)	(5)	(6)
Up to 1000	20	1	8	0	3
1001-3000	32	1	13	0	3
3001-10000	50	2	20	1	5
10001 and above	80	3	32	1	5

A.1.2.3 PVC pipes shall be selected at random. In order to ensure randomness of selection, random number tables as given in **SLS 428** shall be used.

A.1.3 *Number of tests*

A.1.3.1 Each pipe selected as in **A.1.2.2** shall be examined for the requirements given in **5.2.2** and **6**.

A.1.3.2 Each pipe or pipe with socket selected as in **A.1.2.2** shall be examined for requirements given in **5.3** and **5.2.1** of this specification.

A.1.3.3 If the lot has been found satisfactory in respect of visual and dimensional requirements, a sub-sample of size as given in Column **6** of Table **10** shall be drawn at random from the sample obtain as in **A.1.2.2** and shall be subjected to the given requirements given in **5.1.3**, **5.1.5** (for water pipes), **5.4.1**, **5.4.2**, **5.4.3 (**or **5.4.4** or **5.4.5)**, **5.4.6**, **5.5.1** and **5.5.2**.**1**(Test I), **5.5.2.2** (for pipes with sockets).

The required test pieces for each requirement shall be cut (one piece from one PVC pipe) from the PVC pipes of the sub-sample.

A.1.3.4 Adequate number of test pieces shall be cut from the remaining part of the pipes in the sub sample and shall be tested for **5.5.1**.

A.1.4 *Conformity to standard*

A.1.4.1 The lot shall be declared as conforming to the requirements of this standard if the following conditions are satisfied;

A.1.4.1 a) Each pipe satisfies the requirements given in **5.2.2** and **6** when examined as given in **A.1.3.1**.

A.1.4.1.b) The number of PVC pipes, not conforming to one or more requirements given in **5.2.1** and **5.3**, when examined as in **A.1.3.2** is less than or equal to the corresponding acceptance number given in Column **3** or Column **5** of the Table **10** as applicable.

A.1.4.1.c) Each test piece tested as in **A.1.3.3** satisfies the relevant requirements.

A.1.4.1.d) The test pieces tested as in **A.1.3.4** satisfied the relevant requirements.

A.1.5 *Optional tests*

Tests for requirements given in **5.2.3** and **5.5.2.1** (Test II) shall be carried out as and when agreed between supplier and purchaser. Five samples of pipes shall be subjected to these requirements. The lot shall be declared as conforming to the requirements if all the pipes in the sample pass the test. The frequency of sampling shall be as agreed to between supplier and purchaser.

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CORRIGENDUM 1 (2013)
To SLS 147:2013

Sri Lanka Standard Specification for Unplasticized poly(vinyl chloride) pipes for water supply and for buried and above ground drainage and sewerage under pressure

FOREWORD
Delete the third paragraph.

NORMATIVE REFERENCES
Delete the following;

"ISO 1000	SI units and recommendation for use of their multiples and of certain other units"

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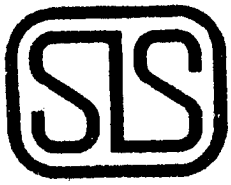

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