SRI LANKA STANDARD 452: 2019

UDC 621.643.2.666.972

SPECIFICATION FOR CONCRETE NON-PRESSURE PIPES (First Revision)

SRI LANKA STANDARDS INSTITUTION

Sri Lanka Standard

SPECIFICATION FOR CONCRETE NON-PRESSURE PIPES

(First Revision)

SLS 452: 2019

Gr. 13

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SRI LANKA

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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SRI LANKA STANDARD
SPECIFICATION FOR CONCRETE NON PRESSURE PIPES
(First Revision)

FOREWORD

This standard was approved by the Sectoral Committee on Building and Construction Materials and was authorized for adoption and publication as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on 2019-08-07.

This standard was first published in 1979 and this is the first revision of the standard. This revision is in-line with the internationally followed practices in production and testing of concrete non-pressure pipes. Unreinforced concrete pipes of class NP1 in the previous standard has been excluded in this revision. Remaining NP2 and NP3 classes have been renamed as NP-RL and NP-RH respectively.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated value, 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 the assistance derived from the publications of the European Committee for Standardization and British Standards Institute are gratefully acknowledged.

1 SCOPE

This standard specifies performance requirements and describes test methods for reinforced precast concrete pipes and fittings, for use in pipelines with flexible joints (with seals either integrated in the units or supplied separately) and nominal sizes upto DN 1800 for units with a circular bore, for which the main intended use is the conveyance of sewage, rainwater and surface water under gravity or occasionally at low head of pressure, in pipelines that are generally buried.
The scope includes pipes (collectively referred to as ‘jacking pipes’) intended to be installed by pipe jacking, micro tunneling or other trenchless technology.
For the purpose of this standard, concrete non-pressure pipes shall be classified as follows:

TABLE 1 - Classification of pipes

Type	Description	Main use
NP-RL	Reinforced concrete light duty pipes	For culverts carrying light traffic, irrigation and drainage
NP-RH	Reinforced concrete heavy duty pipes	For culverts carrying heavy traffic, irrigation and drainage

2 REFERENCES

BS 8500	Concrete. Complementary British Standard to **BS EN 206**
BS EN 206	Concrete - Specification, performance, production and conformity
EN 681-1	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications – Part 1: Vulcanized rubber
EN 1916	Concrete pipes and fittings, unreinforced, steel fibre and reinforced
ISO 1920-4	Testing of concrete – Part 4: strength of hardened concrete
SLS 107	Ordinary Portland cement
SLS 1247	Blended hydraulic cement
SLS 1253	Portland limestone cement

3 DEFINITIONS

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

3.1 **adaptor:** Fitting that provides for connections to structures, to pipes of other materials, or to valves**.**

3.2 **bend:** Fitting that provides for a change of alignment within a pipeline.

3.3 **cementitious content:** Amount of cement plus any pozzolanic or latent hydraulic addition in the concrete mix.

3.4 **characteristic value:** That value of a characteristic beyond which, with a 75% confidence level, 5% of the population of all possible measurements of the specified material may fall.

3.5 **circular pipe:** Pipe whose barrel cross section in a plane perpendicular to its longitudinal axis is described by two concentric circles.

3.6 **circular pipe with base:** Circular pipe strengthened on the outside at the base.

3.7 **circular unit:** Circular pipe (including a jacking pipe) or fitting for use with such a pipe.

3.8 **concrete cover:** Actual thickness of concrete over any reinforcement.

3.9 **connecting pipe:** Short pipe with plain, spigot or socket ends.

3.10 **continuous inspection:** Routine inspection according to a sampling plan which indicates the number of units from a specific process evaluated to have attained, and continue to be in, a state of control, and the associated acceptance criteria.

3.11 **design chemical class (DC-class):** (As defined in **BS 8500-1**) Designation used to describe a concrete quality capable of resisting the selected aggressive chemical environment for the concrete, provided that any specified additional protective measures (APMs) are correctly applied to the structure.

3.12 **fitting:** Adaptor, bend, connecting pipe, junction, pipe with inlet or taper(reducer).

3.13 **group:** Clearly identifiable collection of units, manufactured using the same process; units of different nominal sizes may be grouped together, provided that the ratio of largest to smallest nominal size is not greater than 2.

3.14 **inspection:** Process of measuring, examining, testing, gauging or otherwise comparing a unit with the applicable requirements.

3.15 **integrated seal:** Seal incorporated in to a unit during manufacture.

3.16 **internal barrel length:** Length between the base of the socket and the end of the spigot of a unit as shown in Figure **1**.

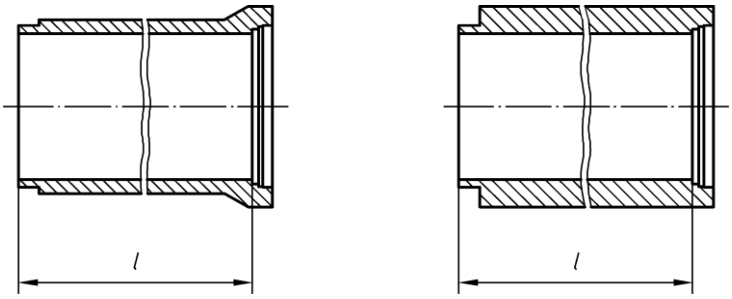
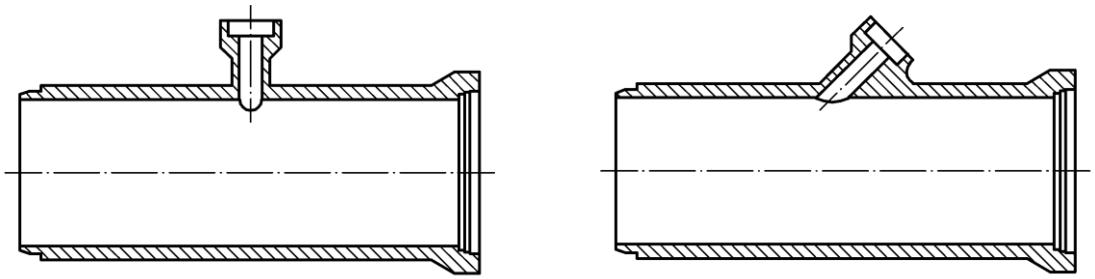


FIGURE 1: Internal barrel length

3.17 **jacking pipe:** Reinforced concrete pipe, incorporating a flexible joint within the wall thickness, rebated or butt-ended with collar and which is intended for jacking.

3.18 **junction:** Unit as shown typically in Figure **2a** and **2b**.



a) Typical junction with right- angled inlet b) Typical junction with angled inlet

FIGURE 2: Junctions with inlet

3.19 **lot:** All the units belonging to one batch of manufacture or supply, in any consignment or part of a consignment.

3.20 **manufacturing diameter:** Diameter of a circular unit that a manufacturer seeks to achieve.

3.21 **minimum crushing load:** Load that a unit is required to withstand.

3.22 **nominal size:** Numerical designation of the size of a unit, which is a convenient integer approximately equal to the manufacturing dimensions in millimeters; for a circular unit, it is the internal diameter, (DN)

3.23 **pipe:** Hollow precast concrete unit of uniform bore throughout its internal barrel length, except in the vicinity of the joint profile, manufactured with or without base. Joints of units are performed as spigot and socket and incorporate one or more joint seals.

3.24 **pipe with inlet:** Pipe as shown typically in Figure **3**, with one or more inlet-holes provided during or after manufacture.

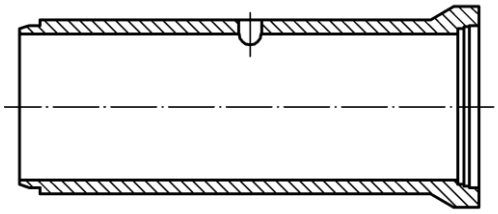


FIGURE 3: Typical pipe with inlet

3.25 **proof load:** Load that a reinforced concrete unit is required to withstand with a defined limit on cracking.

3.26 **reinforced concrete pipe:** Pipe that is structurally reinforced with one or more steel cages, suitably positioned to resist tensile stresses in the pipe wall.

3.27 **reinforced plastics:** A composite material reinforced with high modulus fibres to overcome low modulus and temperature limitations of plastic.

3.28 **routine inspection:** Inspection by sampling at prescribed intervals in order to determine the acceptability of the items represented by the samples.

3.29 **sample:** One or more units selected at random without regard to their quality.

3.30 **specific process:** Manufacture of units of the same nominal size, strength class and type, essentially under the same conditions over any period of time.

3.31 **strength class:** Minimum crushing load in kilonewtons per metre, divided by one thousandth of a unit's nominal size (DN).

3.32 **taper (reducer):** Fitting whose bore is reduced along its internal barrel length.

3.33 **type:** Units of the same manufacturing process, cross-section and reinforced concrete material.

3.34 **ultimate(collapse) load:** Maximum load reached by the testing machine during a crushing test (i.e. when the load-recording facility does not show any further increase).

3.35 **unit:** Pipe or fitting

4 GENERAL REQUIREMENTS

4.1 Materials

Materials under the scope of this standard shall be as listed in Table **2**.

TABLE 2 - Materials under the scope of this standard

Material	Supplementary requirements to the reference specification
Additions	Additions, when used, shall not contain harmful constituents in such quantities as may be detrimental to the setting, hardening, strength, watertightness or durability of the concrete, nor cause corrosion of any steel
Admixtures	Admixtures, when used, shall not impair the durability of the concrete, nor cause corrosion of any steel.
Aggregates	Aggregates shall not contain harmful constituents in such quantities as may be detrimental to the setting, hardening, strength, watertightness or durability of the concrete, nor cause corrosion of any steel. It is permissible for the manufacturer to modify standard grading to suit the manufacturing process.
Cements	None
Jacking pipe collars (including welding, if ferrous)	*See* **5.2.1.2**
Joint Seals	Joint seals shall conform to **EN 681-1** and to the durability requirements in **4.3.4** of **EN 1916**. They shall be supplied by the pipe manufacturer either integrated in the unit or supplied separately.
Mixing Water	Mixing water shall not contain harmful constituents in such quantities as may be detrimental to the setting, hardening, strength, watertightness or durability of the concrete, nor cause corrosion of any steel.
Reinforcing steel	Reinforcing steel shall be weldable where welding is to be carried out. It is permissible for reinforcing steel to be plain, intended, profiled or ribbed. The same materials shall be used in the manufacture of any welded fabric.

4.2 Concrete

4.2.1 *Concrete materials*

Only materials as described in Table **2** shall be used.

4.2.2 *Concrete quality*

The concrete in any unit shall be dense, homogeneous and conform to the requirements of **4.2.3**, **4.2.4, 4.2.5** and **4.2.6**.

4.2.3 *Water content of concrete*

4.2.3.1 General

Concrete shall have such a composition that the ratio of water to cement plus any pozzolanic or latent hydraulic addition in the fully compacted state is consistent with the serviceability conditions in **4.3.8**.

4.2.3.2 Requirement for water/cement ratio

The ratio of water to cement plus any pozzolanic or latent hydraulic addition in the fully compacted state shall not be greater than the values specified in Table **3**.

4.2.4 *Cement content of concrete*

4.2.4.1 General

Concrete shall have such a composition that the minimum content of cement plus any pozzolanic or latent hydraulic addition in the fully compacted state is consistent with the serviceability conditions in **4.3.8**.

4.2.4.2 Types of cement

The cement used shall conform to Table **3**.

4.2.4.3 Cementitious content

The fully compacted concrete shall have a minimum cementitious content of not less than the relevant amount shown in Table **3**. The composition/ specification of cement groups shall be as shown in Table **4**.

TABLE 3 - Limiting values of composition and properties for concrete where DC-class is specified

DC-class (design chemical class)	Maximum water cement ratio	Minimum cement or combination content in kg/m^3 for maximum aggregate sizes (mm) of:				Cement and combination types
		≥ 40	20	14	10	
DC-1*	-	-	-	-	-	All in Table **4**
DC-2	0.55	300	320	340	360	PFC/B-V-SR
	0.50	320	340	360	380	OPC, PSC/A-S, PSC/B-S, PFC/A-V, PFC/B-V
	0.45	340	360	380	380	PLC
	0.40	360	380	380	380	PLC
DC-2z	0.55	300	320	340	360	All in Table **4**
DC-3	0.40	360	380	380	380	PFC/B-V-SR
DC-3z	0.50	320	340	360	380	All in Table **4**
DC-4	0.35	380	380	380	380	PFC/B-V-SR
DC-4z	0.45	340	360	380	380	All in Table **4**
* If the concrete is reinforced or contains embedded metal, the minimum concrete quality for 20 mm maximum aggregate size is C25/30, 0.65, 260.						

TABLE 4 - General purpose cements

Type	Notation	Sri Lanka Standard
Ordinary Portland cement	OPC	**SLS 107**
Portland fly ash cement	PFC/A-V PFC/B-V PFC/A-W PFC/B-W	**SLS 1247**
Portland limestone cement	PLC	**SLS 1253**
Portland slag cement	PSC/A-S PSC/B-S	**SLS 1247**
Sulphate resisting Portland fly ash cement	PFC/B-V-SR	**SLS 1247**

4.2.5 *Chloride content of concrete*

4.2.5.1 General

The maximum amount of chloride ion in the concrete shall be evaluated by calculation.

4.2.5.2 Requirement for chloride content

The calculated chloride ion content of the reinforced concrete shall not exceed 0.4 % by mass of cement.

4.2.6 *Water absorption of concrete*

4.2.6.1 General

The water absorption of the concrete shall be tested in accordance with **6.7**.

4.2.6.2 Absorption requirement

The water absorption of the concrete shall not exceed 6 % by mass.

4.3 Units

4.3.1 *General*

Units shall conform to the following requirements at the time of delivery.

4.3.2 *Finish*

4.3.2.1 General

Functional surfaces of joint profiles shall be free from irregularities that would preclude a durable watertight assembly.

4.3.2.2 Surface evenness

When tested in accordance with **A.1,** the internal surface of a unit shall not have irregularities that cause the central portion of the gauge to touch the unit.

NOTE: *For units of the smaller nominal sizes, it may prove impracticable to test the central portion of the unit.*

4.3.3 *Geometrical characteristics*

4.3.3.1 Nominal sizes

The nominal sizes of circular units and circular units with base, for use in trench construction, shall be those given in Table **5**.

The nominal sizes of jacking pipes shall be either:

a) those given in Table **6**; or
b) other nominal sizes halfway between the sizes given in Table **6** with the proviso that the limits on internal manufacturing diameter shall be those for the next higher nominal size given in Table **6**.

TABLE 5 - Nominal sizes and tolerances of units with a circular bore, for use in a trench

Nominal size, DN mm	**Tolerance on actual diameter from nominal size** mm
80	±3
100	±3
150	±3
250	±3
300	±5
350	±5
400	±5
450	±5
500	±6
600	±6
700	±7
800	±7
900	±8
1000	±8
1100	±8
1200	±9
1400	±10
1500	±11
1600	±11
1800	±12

TABLE 6 - Nominal sizes, internal manufacturing diameter & tolerances of jacking pipes

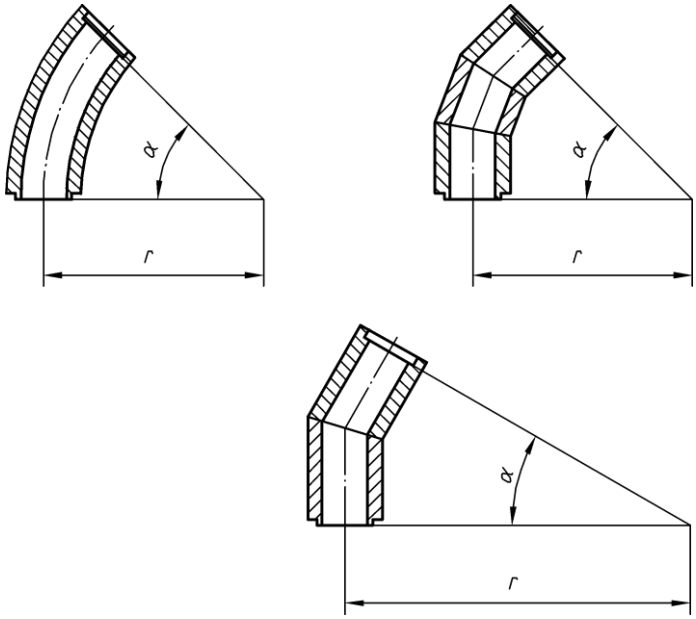
Nominal size, DN mm	**Limits of internal manufacturing diameter** mm		**Tolerances on actual diameter from manufacturer's stated diameter** [a] mm	
	minimum	maximum	internal	external
450	440	460	±5	±4
500	490	525	±6	±4
600	580	610	±6	±4
700	675	720	±7	±4
800	770	825	±7	±4
900	875	950	±8	±4
1000	980	1070	±8	±5
1200	1180	1220	±9	±5
1400	1350	1420	±10	±5
1500	1470	1530	±11	±5
1600	1580	1675	±11	±6
1800	1780	1830	±12	±6
2000	1950	2135	±13	±6
2200	2170	2250	±14	±7
2500	2375	2550	±15	±7
2800	2680	2850	±15	±7
3000	2965	3050	±15	±7
NOTE: *The values of certain limits of internal manufacturing diameter (See **3.20**) have been chosen to allow for utilization of existing manufacturing equipment during transition to a rationalized metric range of nominal sizes and also to suit the installation equipment, which controls the external diameter of jacking pipes*.				
[a]: S*ee* **3.20**				

4.3.3.2 Internal barrel length

The internal barrel length of a pipe shall either be declared by the manufacturer or manufacturer's specifications.
The internal barrel length of circular pipes greater than and including DN 250 shall not exceed six times their external diameter, unless conforming to the requirements of **4.3.6**.

4.3.3.3 Bends

Bends shall be manufactured as shown typically in Figure **4,** either cast as one piece or fabricated from cut lengths of pipe conforming to this standard that have been bonded together with concrete or special mortar.



α : angle subtended by a bend, degrees
r : radius of bend, mm

FIGURE 4: Typical bends

4.3.3.4 Squareness of ends

Units shall be capable of being jointed with their axes coincident within the deflection limit specified in **E.5.2** of **EN 1916** for circular units this requirement shall apply in any orientation.
NOTE: *Squareness of ends of trench units is significant only to the extent that it relates to the performance of the joint assembly.*
When evaluated in accordance with **B.5.1** and **B.5.2** the ends of a jacking pipe shall conform to the requirements of Table **7** for squareness across a diameter and wall thickness.

TABLE 7- Tolerances on the squareness of ends of jacking pipes

Nominal size, DN mm	**Maximum deviation across a diameter** mm	**Maximum deviation across wall thickness** mm
DN ≤ 900	3	2
900< DN≤ 1500	3.5	3
1500< DN≤ 2100	5	4
2100< DN≤ 3000	6	5

4.3.3.5 Deviation from straightness

When measured in accordance with **B.5** for the internal straightness of a straight unit (and for jacking pipes, the external straightness) both ends of the gauge shall not make contact with the surface of the unit when using Edge X and the two studs shall be in contact simultaneously when using Edge Y.
NOTE: *See Figure **B.1***

4.3.3.6 Tolerances on the internal diameter of units with a circular bore, for use in a trench.

The tolerance on the internal manufactured diameter of units with a circular bore, for use in a trench, shall be ±5 mm for nominal sizes greater than and including DN 300 and ± (3 + 0.005DN) mm for larger nominal sizes (rounded to the nearest millimetre), limited to ±15 mm (*See* Table **5**). No individual measurement, measured in accordance with **B.2**, shall be outside the specified limits.

4.3.3.7 Tolerances on the internal diameter of jacking pipes.

The tolerances on the internal manufactured diameter of jacking pipes shall be ± (3 + 0.005DN) mm (rounded to the nearest millimetre), limited to ±15 mm (*See* Table **6**). No individual measurement, measured in accordance with **B.2**, shall be outside the specified limits.

4.3.3.8 Tolerances on the external diameter of jacking pipes.

The tolerances on the external manufactured diameter of the barrel of a jacking pipe shall be as given in Table **6**. No individual measurement, measured in accordance with **B.3**, shall be outside the specified limits.

4.3.3.9 Tolerance on the wall thickness

Any value of wall thickness measured in accordance with **B.4** shall be not less than the value stated in the manufacturer's specifications.

4.3.3.10 Tolerance on the internal barrel length of jacking pipes.

When evaluated in accordance with **B.5.1** the tolerance on the mean internal barrel length of jacking pipes up to a nominal size of DN 800 shall be ±10 mm. For pipes with a larger nominal size, the tolerances on the internal barrel length shall be $^{+25}_{-10}$ mm. Where pipes are designed for use with a method of installation that requires tighter manufacturing tolerances, these shall be stated in the manufacturer's specifications and inspection procedures shall provide for the selection and marking of groups of pipes for delivery to a specific contract.

4.3.3.11 Tolerance on joint assemblies

The profile of a joint shall conform to the corresponding design dimensions and tolerances stated in the manufacturer's specifications.

The tolerances stated for each joint profile and the maximum permissible tolerances on the seal(s) (which shall not be greater than that specified in **EN 681-1**) as stated in the manufacturer's specifications shall be taken in to account when calculating the relative deformation of the seal(s) in accordance with **4.3.4**. The effect of any other dimensional tolerances that affect the functioning of the joint shall be taken into account, as appropriate.

4.3.4 *Joints and joint seals*

Joints and joint seals shall conform to **4.3.4** of **EN 1916**.

4.3.5 *Crushing strength*

4.3.5.1 General

A pipe shall withstand the minimum crushing load F_n and proof load, F_c (*See* **5.1.3**) corresponding to its nominal size and type when tested in accordance with **6.4**. For reinforced concrete pipes *See* **5.1.3.**

4.3.5.2 Minimum crushing loads of units for trench use

Units with a circular bore for trench use shall be of type NP-RL and NP-RH corresponding to minimum crushing loads in accordance with Table **8.**

TABLE 8 - Minimum crushing loads for units with a circular bore for use in a trench

Nominal size DN	**Minimum crushing load, F_n** kN/m	
	NP-RL	NP-RH
100	15.60	12
150	15.60	18
250	17.10	30
300	18.00	36
350	18.90	42
400	20.40	48
450	22.20	54
500	24.90	60
600	28.50	72
700	31.50	84
800	34.50	96
900	37.50	108
1000	40.20	120
1100	41.70	132
1200	43.20	144
1400	44.70	168
1500	44.70	180
1600	44.70	192
1800	44.70	216

4.3.6 *Longitudinal bending moment resistance*

4.3.6.1 General

The longitudinal bending moment resistance of a circular pipe greater than and including DN 250 and having an internal barrel length greater than six times its external diameter shall be tested in accordance with **6.5**.

4.3.6.2 Evaluation

The longitudinal bending moment resistance of a pipe shall be not less than that given by the following formula when tested as required by **4.3.6.1**.

$$M = C \times DN \times l^2$$

Where

M is the longitudinal bending moment resistance in kilonewtons metre;
C is a constant equal to 0.013 kilonewtons per metre;
DN is the nominal size;
l is the internal barrel length in metres

NOTE: *where the intended place of installation of a pipeline requires additional beam strength (e.g a pipeline on piles), a specific structural design should be carried out.*

4.3.7 *Watertightness*

When tested in accordance with **6.6** each unit or joint assembly shall not show any leakage or other visible defects during the test period; moisture adhering to the surface shall not constitute leakage. Units having a design wall thickness greater than 125 mm shall not be subjected to the hydrostatic test.
Where the same design of joint is used on pipes and fittings, at the manufacturer's discretion it is permissible to perform the tests for angular deflection and shear load (separately or combined) solely on pipes.

4.3.8 *Serviceability*

Units conforming to this standard are at least suitable for use in humid conditions and a slightly aggressive chemical environment (i.e normal conditions for domestic sewage and treated industrial effluent, and for most soils and groundwaters). Special attention needs to be paid if more severe conditions are expected, primarily to the cement plus any pozzolanic or latent hydraulic addition in the concrete.

4.3.9 *Durability*

The durability of installed units and their joints is specifically ensured by the following requirements:

- A maximum water/cement ratio of the concrete (*See* **4.2.3**)
- A maximum chloride content of the concrete (*See* **4.2.5**)
- A maximum water absorption of the concrete (*See* **4.2.6**)
- Conformity to the criteria in one of four methods for demonstrating the durability of joints (*See* **4.3.4.2** of **EN 1916**)
- A minimum concrete cover in reinforced units (*See* **5.1.2**)
- Special requirements for jacking pipes (*See* **5.2.1.2** and **5.2.3**)

5 SPECIAL REQUIREMENTS

Units shall conform to the following special requirements at the time of delivery.

5.1 Reinforced concrete units

5.1.1 *Reinforcement*

The reinforcement shall conform to Table **2** and the manufacturer's specifications.

The reinforced concrete of pipes shall relate to the appropriate minimum crushing strength according to their nominal size and strength class. The minimum percentage of reinforcement, relative to the longitudinal cross-sectional area of the barrel, shall be 0.4 % for plain steel and 0.25 % for indented, profiled or ribbed steel.

It is permissible for one or more cages of reinforcement to be used, either helically wound or as concentric hoops, or fabricated from steel fabric, securely connected.

Elliptical or other non-circular reinforcement cages are permissible. In this case a durable indication on the crown of the unit and incorporating means of locating the reinforcement shall be provided, at least inside the unit.

Circumferential and longitudinal (if any) steel bars shall be assembled by welding or splicing in order to control spacing and the shape of the reinforcement cage(s). The circumferential reinforcement shall be spaced at regular distances throughout the length of the unit. The reinforcement cage(s) shall be maintained in the designed shape.

5.1.2 *Concrete cover*

The minimum concrete cover shall be consistent with the serviceability conditions described in **4.3.8**.
The minimum concrete cover shall be 15 mm, or the relevant nominal maximum size of aggregate stated in the manufacturer's specifications, whichever is the larger.

NOTES:
1. Given the inspection procedures specified in this standard and the maximum permitted stabilized surface crack width specified in **5.1.3***., the value of minimum concrete cover is consistent with the serviceability conditions specified in* **4.3.8**.
2. Units conveying sea water, industrial waste, etc. and those to be installed in more aggressive serviceability conditions than those specified in **4.3.8** *may need additional concrete cover.*
3. See **5.2.3** *regarding the increased minimum concrete cover on external surfaces of jacking pipes to be in permanent contact with the ground.*
4. With respect to durability requirements, refer **BS 8500** *and* **BS EN 206**.

5.1.3 *Crushing strength*

In addition to the requirement in **4.3.5**, a reinforced concrete pipe shall also withstand a proof (crack) load F_c of 0.67 F_n when tested in accordance with **6.4**, with any stabilized surface crack

in the tensile zones of the concrete being not greater than 0.3 mm over a continuous length of 300 mm or more.

5.1.4 *Conformity of proof (crack) load tested pipes*

Reinforced concrete pipes that have been tested only to proof (crack) load in accordance with **6.4** and meeting the requirements of **5.1.3** conform to this standard.
NOTE: *Taking the necessary installation conditions into consideration, the constructor could decide to use a reinforced concrete jacking pipe (See* **5.2***) subjected successfully to the proof (crack) load crushing test to complete a jacked pipeline.*

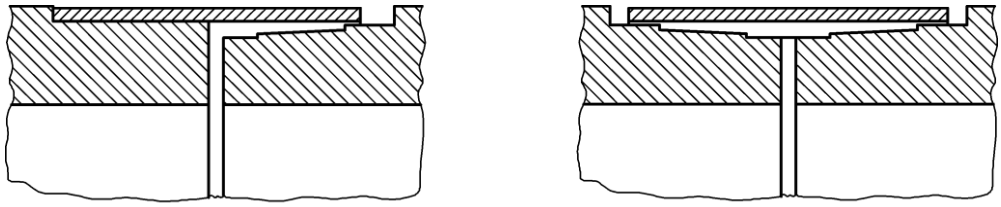
5.2 Jacking pipes

5.2.1 *Joints*

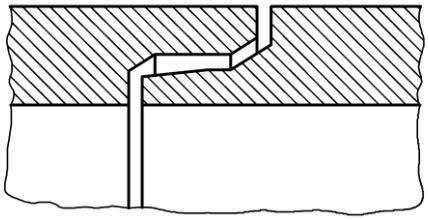
5.2.1.1 General

Joints of jacking pipes shall be in-wall flexible joints of either the collar or rebated type as shown typically in Figure **5**. They shall be designed to include one or more joint seals. All joint surfaces which will transmit load during installation shall be plane and free from irregularities that could cause high local concentrations of stress.

NOTE: *The angle calculated from angular deflection (See* **E.5.2** of **EN 1916***) is not necessarily that which can be accommodated during jacking operations. Consultation between constructor and manufacturer is recommended.*



b) Fixed collar a) Loose collar



c) Rebated

NOTE: *The joint seals have been omitted for clarity.*

FIGURE 5: Typical in-wall joints

5.2.1.2 Collars

Collars shall be manufactured from weldable structural steel plate, stainless steel plate or reinforced plastics.

NOTE: *Weldable structural steel plate collars can be susceptible to corrosion from the ground, groundwater or the effluent carried. If corrosion is expected by the specifier, the design of a joint incorporating this type of collar should provide for a secondary sealing gasket to be applied on site by the constructor, for example by means of an appropriate sealant.*

5.2.2 *Concrete strength*

5.2.2.1 General

The characteristic compressive strength of the concrete f_{ck} in jacking pipes shall be verified on the basis of testing in accordance with **6.8**. The verified value of this strength shall be not less than the manufacturer's declared design characteristic strength as stated in the manufacturer's specifications.

5.2.2.2 Strength requirement

The design characteristic strength declared by the manufacturer in the manufacturer's specifications shall be not less than 40 MPa (N/mm^2).

5.2.3 *Concrete cover*

For reinforced concrete jacking pipes, the minimum concrete cover required by **5.1.2** shall be increased by 5 mm on external surfaces to be in permanent contact with the ground.

There shall be no steel within the concrete cover on joint surfaces which will transmit the load during installation.

5.2.4 *Jacking load*

The manufacturer shall make available a statement of the jacking load for which each jacking pipe was designed (design jacking load F_j). This load shall be not greater than the maximum design load as determined by structural calculation in accordance with Annexe **B** of **EN 1916.** The maximum stress resulting from the manufacturer's assumed installation parameters shall not exceed 60 % of his declared characteristic strength of the concrete. (*See* Annexe **B** of **EN 1916**)

NOTE: *The design jacking load as declared by the manufacturer or calculated in accordance with Annexe* **B** *of* **EN 1916** *does not include any safety factor used by the constructor, having regard to the jacking method and subsequent deflection of the pipes, the nature of the ground and unforeseen conditions, or for the stress ratio across the jacking face (See Figure* **B.1** *of* **EN 1916***)*

5.3 Pipes with inlet

The design of the joint for a connection to a pipe with inlet shall ensure that conformity to **4.3.7** can be achieved. The bore of the inlet shall be free from burrs.

6 TEST METHODS FOR FINISHED PRODUCTS

6.1 General

6.2 to **6.8** inclusive shall apply to all units, unless stated otherwise in Table **9** for conformity evaluation.

TABLE 9 - Summary of test requirements

Clause	Requirement where specified	Pipes		Fittings				
		Pipe	Jacking pipe	Connecting pipe	Pipe with inlet	Junction	Taper (reducer) adaptor	Bend
4.2.6.1	Water absorption	T/R	T/R	T/R[a]	T/R[a]	T/R[a]	T/R[a]	T/R[a]
4.3.2	Visual inspection of finish	T/R	T/R	T/R	T/R	T/R	T/R	T/R
4.3.3	Geometrical characteristics - Units - Joint profiles	 T/R T/R	 T/R T/R	 T/R[a] T/R[a]	 T/R[a] T/R[a]	 T/R[a] T/R[a]	 T/R[a] T/R[a]	 T/R[a] T/R[a]
4.3.4	Joints and joint seals [b]	T	T	T[c]	T[c]	T[c]	T[c]	T[c]
4.3.5	Crushing strength	T/R	T/R	T/R[a]	T/R	-	-	-
4.3.6.1	Longitudinal bending moment resistance	T[d]	T[d]	-	T[d]	-	-	-
4.3.7	Watertightness - Hydrostatic - Joint assembly	T/R[e] T/R	T/R[e] T/R	T/R[e] T/R[g]	T/R[f] T/R[h]	T/R[f] T/R[h]	T/R T/R[h]	T/R[g] T/R[h]
5.1.1, 5.1.2 and 5.2.3	Reinforcement and concrete cover	T/R	T/R	T/R[a]	T/R[a]	T/R[a]	T/R[a]	T/R[a]
5.2.2.1	Drilled core strength	-	T/R	-	-	-	-	-

T : initial type test
R : routine inspection test
T/R : both initial type test and routine inspection test

[a] : not applicable to fittings fabricated from pipes or parts of pipes that conform to this standard;
[b] : Annex **A** of **EN 1916** is not applicable where Method 3 in **4.3.4.2**. of **EN 1916** is adopted;
[c] : not applicable to fittings having the same design of joints as pipes;
[d] : not applicable to pipes > DN 250, nor to pipes ≤ DN 250 whose internal barrel length does not exceed six times their external diameter;

[e] : not applicable to units with a design wall thickness > 125 mm;
[f] : not applicable to units with main pipes > DN 800 or inlets > DN 300, for safety reasons;
[g] : not applicable to bends > DN 300, for safety reasons;
[h] : not applicable to fittings having the same design of joint as pipes, at the manufacturer's discretion.

6.2 Joint profiles

The critical dimensions of joint profiles and their respective tolerances shall be evaluated for conformity to the manufacturer's specifications.

6.3 Reinforcement

A section shall be cut from an undamaged part of a reinforced concrete pipe that has been tested to collapse as required under a routine or initial type test, to enable both circumferential and any longitudinal reinforcement to be examined and the concrete cover evaluated for conformity to **5.1.1**, **5.1.2** or **5.2.3**, as appropriate.

6.3.1 *Placing and content of reinforcement*

The spacing and content of circumferential bars shall be measured over a length of at least 1 metre and evaluated for conformity to the manufacturer's specifications and **5.1.1**. The distance of the circumferential reinforcement from the end of the spigot and of the socket shall also be evaluated for conformity to **5.1.1**.

Longitudinal reinforcement (if any) shall be evaluated for conformity to the manufacturer's specifications.

6.3.2 *Concrete cover*

The reinforcement shall be exposed, the concrete cover measured, and the minimum recorded to the nearest millimeter. The cover shall then be evaluated for conformity to **5.1.2** or **5.2.3**, as appropriate.

6.4 Crushing strength(s)

Crushing strength(s) shall be determined in accordance with the relevant method(s) specified in Annexe **C** of **EN 1916**.

6.5 Longitudinal bending moment resistance

Longitudinal bending moment resistance shall be determined in accordance with one of the methods specified in Annexe **D** of **EN 1916**, the choice of method being at the manufacturer's discretion.

6.6 Watertightness

Watertightness of units, and of joint assemblies, shall be determined in accordance with the methods specified in Annexe **E** of **EN 1916**.

6.7 Water absorption

Water absorption shall be determined in accordance with the method specified in Annexe **F** of **EN 1916**.

6.8 Concrete strength in jacking pipes

Compressive strength of the concrete in jacking pipes shall be determined in accordance with **ISO 1920-4** and the test carried out by drilling a sample at each third-point along the internal barrel length, then calculating the mean value of the two results.

The drilled cores shall have a height equal to their diameter ± 10 mm:

when 100 mm ± 1 mm diameter cores are used, the result shall be applied without any conversion factor;

when 50 mm ± 1 mm diameter cores are used, a conversion factor of 1.07 shall be applied to the results.

Linear interpolation for intermediate diameters of core is permissible.

7 MARKING

Each unit of concrete non-pressure pipes manufactured in compliance with this standard shall be marked legibly and indelibly, with the particulars as given in (a) to (d).

(a) The manufactures name, trade mark or identification mark;
(b) The date of manufacture;
(c) Type; and
(d) Design chemical (DC) class.

NOTE: *Attention is drawn to the product certification marking facilities offered by the Sri Lanka Standards Institution. See the inside back cover of this standard.*

8 SAMPLING

8.1 Scale of sampling

8.1.1 The conformity of a lot to the requirements of this specification shall be ascertained on the basis of tests on pipes selected from it.

8.1.2 The number of pipes to be selected from the lot shall be in accordance with Columns **1** and **2** of Table **10**.

8.1.3 These pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every r^{th} pipe shall

be selected till the requisite number is obtained, *r* being the integral part of *N/n* where *N* is the lot size and *n* is the sample-size.

8.2 Number of tests

8.2.1 All the pipes selected as in **8.1.2** shall be inspected for dimensional requirements finish and deviation from straightness.

8.2.2 The number of pipes to be selected for tests under **8.2** shall be in accordance with Column **4** of Table **10**. These pipes shall be selected from pipes that have satisfied the requirements mentioned in **8.2.1**.

9 CRITERIA FOR CONFORMITY EVALUATION

9.1.1 A lot shall be considered as conforming to the requirements of this specification if the conditions mentioned in **9.1.2** and **9.1.3** are satisfied otherwise it shall be considered as not conforming to the requirements of this specification.

9.1.2 The number of defective pipes (those not satisfying one or more of the requirements for dimensions, finish and deviation from straightness) shall not be more than the permissible number given in Column **3** of Table **10**.

9.1.3 In case the number of pipes not satisfying the requirements of any one or more tests given under **6.3, 6.4, 6.5, 6.6** and **6.8** is less than or equal to the corresponding value given in Column **5** of Table **10** the lot shall be considered as conforming to these requirements. If this number is greater than or equal to the corresponding value given in Column **6** of Table **10** the lot shall be considered as not conforming to the requirements given in **6.3, 6.4, 6.5, 6.6** and **6.8**.

In case this number lies between the corresponding values given in column **5** and **6** of Table **10** a further sample of same size shall be selected and subjected to test (s) in which failure has occurred. If the number of pipes not satisfying the requirements of these tests in the two samples combined is less than the corresponding value given in Column **6** of Table **10**, the lot shall be considered as conforming to the requirements of these tests; otherwise not.

TABLE 10 - Sample size and criterion for conformity

Lot size	**For requirements under 6.2 and 6.7**		**For tests under 6.3, 6.4, 6.5, 6.6 and 6.8**		
	Sample size	**Permissible Number**	**Sample Size**	**Acceptance Number**	**Rejection Number**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Up to 50	10	1	2	0	1
51 to 100	15	1	3	0	2
101 to 200	20	2	4	0	2
201 to 300	30	3	5	0	3
301 to 500	40	4	7	1	4
501 and above	55	5	10	1	5

ANNEXE A
(NORMATIVE)
SURFACE FINISH TESTS

A.1 Surface evenness test

A.1.1 *Principle*

The purpose of this test is to evaluate whether the internal surface of a unit conforms to the limiting requirement in **4.3.2.2** for evenness.

A.1.2 *Apparatus*

Gauge, as described in Figure **A.1**. Dimensions are in mm.

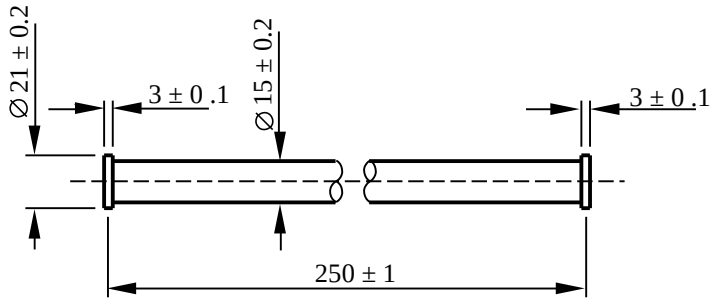


FIGURE A.1: Gauge for assessing surface evenness.

A.1.3 *Procedure*

Place the gauge in the unit so that its axis is in the same plane as the unit's longitudinal axis Roll the gauge around the inside of the unit, taking care to ensure that its axis remains in the same plane as the unit's longitudinal axis at all times.

A.1.4 *Expression of result*

Record whether the gauge rolled over any part of the internal surface without the central portion of the gauge contacting the unit.

ANNEXE B
(NORMATIVE)
DIMENSIONAL TESTS

NOTE: *At the manufacturer's discretion it is permissible to use purpose-made "go/no-go" gauges for dimensional measurements in lieu of the apparatus specified for the tests in this Annexe.*

B.1 Internal dimensions test

B.1.1 *Principle*

The purpose of this test is to evaluate whether the internal diameter of circular units and circular units with base for trench use and the internal diameter of jacking pipes conform to **4.3.3.6** and **4.3.3.7** respectively.

B.1.2 *Apparatus*

Steel measuring tape or retractable pocket rule, with metric graduation and figuring conforming to **BS 4484-1**.

B.1.3 *Procedure*

For units with a circular bore, make three measurements of the internal diameter at each end at approximately 60° to each other. For all units take the measurements at approximately 50 mm from the ends of the internal barrel and record the measurement.

B.1.4 *Expression of results*

Record whether each measured value of the internal diameter conforms to **4.3.3.6** and **4.3.3.7** as appropriate.

B.2 External diameter test for jacking pipes

B.2.1 *Principle*

The purpose of this test is to evaluate whether the external barrel of a jacking pipe conforms to **4.3.3.8**.

B.2.2 *Apparatus*

Steel measuring tape, steel band or retractable pocket rule, with metric graduation and figuring conforming to **BS 4484-1**.

B.2.3 *Procedure*

Measure the external circumference of the pipe at approximately 50 mm from the ends of the barrel and record this measurement.
Calculate the external diameter of the barrel from the measured circumference.

B.2.4 *Expression of results*

Record whether each measured value of the external diameter conforms to **4.3.3.8**.

B.3 Wall thickness test

B.3.1 *Principle*

The purpose of this test is to evaluate whether the wall thickness of a unit conforms to **4.3.3.9**.

B.3.2 *Apparatus*

B.3.2.1 Outside spring caliper, conforming to **BS 3123**.

B.3.2.2 Steel measuring tape or retractable pocket rule, with metric graduation and figuring conforming to **BS 4484-1**.

B.3.3 *Procedure*

For circular units, measure the wall thickness at approximately 50 mm from the end of the external barrel at the spigot end, at three positions equidistant around the circumference of the unit. For circular units with base, measure the wall thickness at approximately 50 mm from the end of the external barrel at the crown, springing points and invert.

B.3.4 *Expression of results*

Record whether each measured value of the wall thickness conforms to **4.3.3.9**.

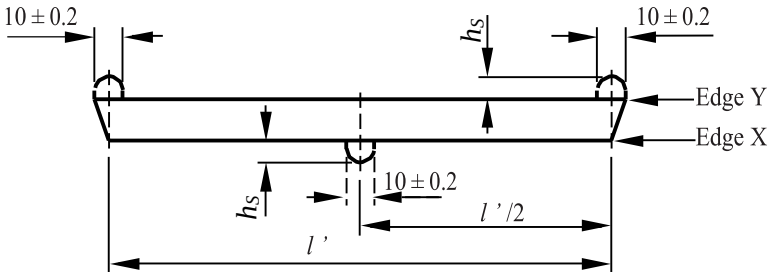
B.4 Straightness test

B.4.1 *Principle*

The purpose of this test is to evaluate whether the internal straightness, and for jacking pipes the external straightness, of a unit conforms to **4.3.3.5**.

B.4.2 *Apparatus*

Rigid straightedge, made into a gauge of the form and dimensions shown in Figure **B.1**.



$h_S = (3.5\ l' \pm 5\%)$

where,

h_S : Height of studs on straightness gauge in mm

l' : Internal barrel length minus 0.1 m

NOTE: *The studs should be detachable from the basic straightedge to facilitate checking and replacement.*

FIGURE B.1 : Gauge for measuring deviation from straightness

B.4.3 *Procedure*

Place the straightedge in the bore of the unit with Edge X (*See* Figure **B.1**) in contact with the unit and on a line parallel to its longitudinal axis. Hold the plane of the gauge in a radial plane and record whether both ends of the gauge, wherever so placed, were in contact with the internal surface of the unit.

If both ends of the gauge were not in contact with the internal surface of the unit at both ends, reverse the gauge so that Edge Y, placed as above (*See* Figure **B.1**), is adjacent to the internal surface of the unit.

For jacking pipes, repeat the procedure with the straightedge placed along the external surface of the pipe and on a line parallel to its longitudinal axis.

B.4.4 *Expression of result*

Record whether both ends of the gauge were in contact with the surface of the unit when using Edge X, and whether the two studs (*See* Figure **B.1**) touched the surface simultaneously when using Edge Y.

B.5 Internal barrel length and squareness of ends tests for jacking pipes

B.5.1 *Internal barrel length and squareness across a diameter test*

B.5.1.1 Principle

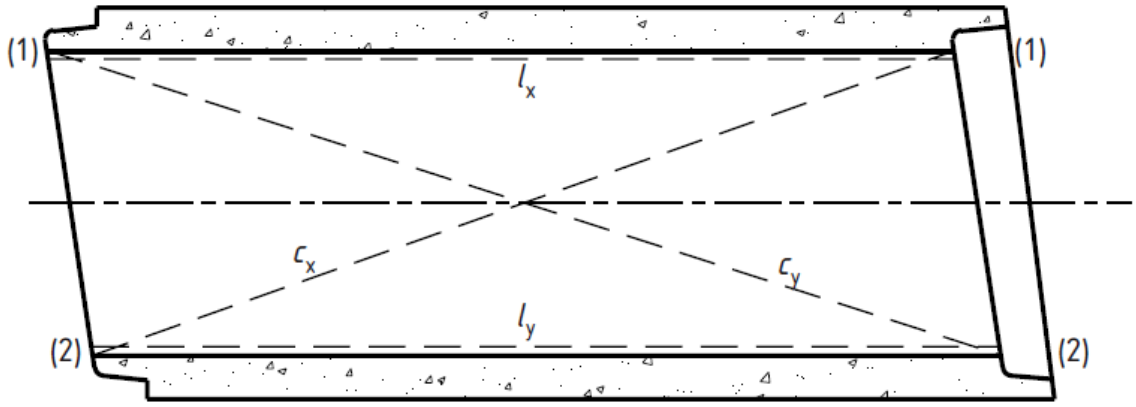
The purpose of this test is to evaluate whether the squareness of ends across a diameter and internal barrel length of a jacking pipe conform to **4.3.3.4** and **4.3.3.10** respectively.

B.5.1.2 Apparatus

Steel measuring tape or retractable pocket rule, with metric graduation and figuring conforming to **BS 4484-1**.

B.5.1.3 Procedure

Mark the opposite ends of an internal diameter at one end of the bore and measure the internal barrel length (l_x and l_y) by "swinging" the tape or rule from each mark. Measure the minimum internal diagonals (c_x and c_y), as shown in Figure **B.2**.



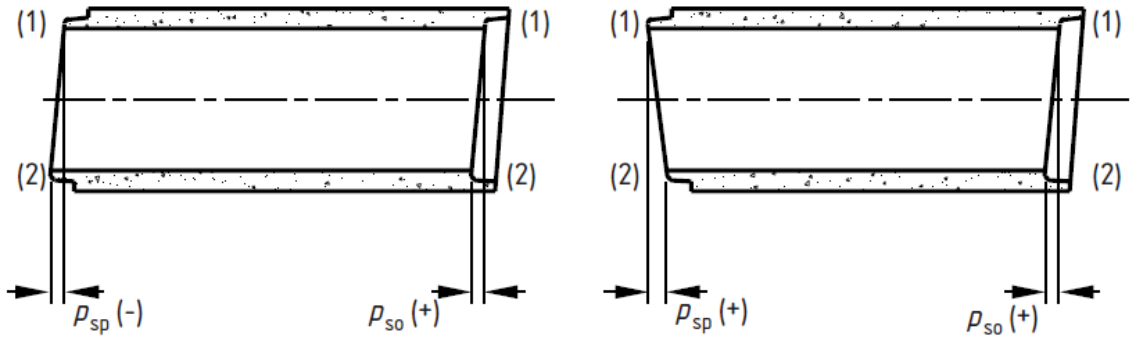
c_x , c_y: Opposite measured internal diagonals in mm
l_x , l_y : Opposite measured internal barrel lengths in mm

FIGURE B.2 : Measurement of internal lengths and diagonals of a jacking pipe

Using the following formulae, calculate the respective deviations from squareness of the spigot end (p_{sp}) and socket end (p_{so}) of the pipe. (*See* Figure **B.3**):

$$p_{sp} = (l_x^2 + c_x^2 - l_y^2 - c_y^2) / 2\,(l_x + l_y)$$
$$p_{so} = (l_x^2 - c_x^2 - l_y^2 + c_y^2) / 2\,(l_x + l_y)$$

The orientation in relation to the points of measurements x and y is indicated by the algebraic sign of p_{sp} and p_{so}. (*See* Figure **B.2** and Figure **B.3**).
Repeat the procedure using marks made at approximately 90° to the original ones and calculate the mean of the four measurements of internal barrel lengths shall then be calculated.



p_{sp} : Deviation of spigot end in mm
p_{so} : Deviation of socket end in mm

FIGURE B.3 : Squareness of ends across a diameter of a jacking pipe

B.5.1.4 Expression of result

Record whether the mean value of the four measurements of internal barrel length and each of the deviations from squareness across the diameter of the jacking pipe conformed to **4.3.3.10**.

B.5.2 *Squareness across the wall thickness test*

B.5.2.1 Principle

The purpose of this test is to evaluate whether the squareness across the wall thickness at the end of a jacking pipe conforms to **4.3.3.4**.

B.5.2.2 Apparatus

B.5.2.2.1 Cast iron or steel straightedge, conforming to **BS 5204-1** or **BS 5204-2**.
B.5.2.2.2 Steel measuring tape or retractable pocket rule, with metric graduation and figuring conforming to **BS 4484-1**.

B.5.2.3 Procedure

Place the straightedge diametrically across the end of the jacking pipe in three positions, approximately equidistant around its circumference. Measure and record any out-of-squareness across the wall thickness at each end of the three diameters.

B.5.2.4 Expression of result

Record whether the squareness across the wall thickness of the jacking pipe conforms to **4.3.3.4**.

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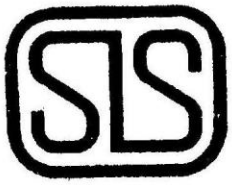

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