SLOVENSKI STANDARD
SIST EN 642:1996

01-marec-1996

Prednapete betonske tlačne cevi s kovinskim plaščem ali brez njega, skupaj s stiki, fazonskimi deli, in posebne zahteve za jeklo za prednapenjanje za cevi

Prestressed concrete pressure pipes, cylinder and non-cylinder, including joints, fittings and specific requirements for prestressing steel for pipes

Spannbetondruckrohre, mit und ohne Blechmantel, einschließlich Rohrverbindungen, Formstücke und besondere Anforderungen an Spannstahl für Rohre

Tuyaux pression en béton précontraint, avec ou sans âme en tôle, y compris joints et pieces spéciales et prescriptions particulieres relatives au fil de précontrainte pour tuyaux

Ta slovenski standard je istoveten z: **EN 642:1994**

ICS:

23.040.50	Cevi in fitingi iz drugih materialov	Pipes and fittings of other materials

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English version

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This European Standard was approved by CEN on 1994-10-26. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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CEN

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Central Secretariat: rue de Stassart,36 B-1050 Brussels

CONTENTS LIST

Foreword

0 Introduction

1 Scope

2 Materials

3 Design and fabrication of pipe
3.1 General requirements
3.1.1 *General*
3.1.2 *Wall thickness*
3.2 Design of pipes
3.2.1 *General*
3.2.2 *Design requirements*
3.3 Reinforcement
3.4 Concrete and mortar
3.4.1 *Mix design*
3.4.2 *Concrete strength*
3.5 Prestressing
3.5.1 *Longitudinal prestressing*
3.5.2 *Circumferential prestressing*
3.5.3 *Multiple layers*
3.6 Curing

4 Factory testing
4.1 Concrete test
4.2 Hydrostatic test
4.2.1 *General*
4.2.2 *Cylinder pipe*
4.2.3 *Non-cylinder pipe*
4.2.4 *Test pressure*
4.3 Permeability test on coating
4.3.1 *Test frequency on products*
4.3.2 *Test purpose*
4.3.3 *Testing equipment*
4.3.4 *Test method*
4.3.5 *Test results*
4.3.6 *Test acceptance criteria*

Annexes :

- Annex A (normative) : Specific technical requirements for high tensile steel wire used for prestressing concrete pipe with or without steel cylinder.
- Annex B (informative) : Typical joints.
- Annex C (informative) : Design guidance for prestressed concrete cylinder pipes.
- Annex D (informative) : Design guidance for prestressed concrete non-cylinder pipes.

FOREWORD

This European Standard for concrete pipes is a standard which was prepared by WG 5 "Concrete pipes" of the Technical Committee CEN/TC 164 "Water Supply", Secretariat of which is held by AFNOR.

During preparation of this standard the provisional results already available of CEN/TC 164/WG 1 "General requirements for external systems and components" and of CEN/TC 164/165/JWG 1 "Structural design" were considered.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 1995, and conflicting national standards shall be withdrawn at the latest by April 1995.

In accordance with the CEN/CENELEC Internal Regulations, following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

0 INTRODUCTION

The product* in permanent or temporary contact with water, intended for human consumption, shall not adversly affect the quality of the drinking water and shall not contraveene the CE Directives and EFTA Regulations on the quality of drinking water.

This standard is to be used together with the Common Requirements Standard (EN 639).

When the relevant EN dealing with general requirements, such as "General requirements for external systems and components" (CEN/TC 164/WG 1), "Materials in contact with water" (CEN/TC 164/WG 3) and "Structural design" (CEN/TC 164/165/JWG1) are adopted, the current standards shall be revised, where appropriate, in order to ensure that these requirements comply with these relevant EN's.

To the present standard are attached :

- Annex A (normative) : Specific technical requirements for high tensile steel wire used for prestressing concrete pipe with or without steel cylinder ;
- Annex B (informative) : Typical joints ;
- Annex C (informative): Design guidance for prestressed concrete cylinder pipes ;
- Annex D (informative) : Design guidance for prestressed concrete non-cylinder pipes.

1 SCOPE

This standard covers the requirements and the manufacture of prestressed concrete cylinder and non-cylinder pressure pipes and fittings in sizes from DN/ID 500 to DN/ID 4000 inclusive. Larger sizes could be manufactured based on the concepts of this standard. These types of pipes are designed for the internal pressure, external loads and bedding conditions designated by the purchaser.

* Should be considered as any product used for the conveyance and distribution of water intended for human consumption.

2 MATERIALS

Materials are specified in clause 5 of EN 639 (Common Requirements). Additional requirement is specified as follows :

The maximum size of aggregate shall not exceed the least of the following :

- the concrete cover ;
- or 0,33 times the thickness of the non-cylinder core pipe wall ;
- or 0,33 times the concrete wall thickness on either side of the steel cylinder.

3 DESIGN AND FABRICATION OF PIPE

3.1 General requirements

3.1.1 *General*

Prestressed concrete cylinder pipe shall have the following principal features :

A welded steel cylinder with steel joint rings welded to its ends.

For lined-cylinder pipe, a core consisting of a lining of concrete within the steel cylinder, or for embedded-cylinder pipe, a core consisting of the steel cylinder encased in concrete.

Circumferential prestressing with high-tensile wire wound around the outside of the core in one or more layers at a predetermined stress and fastened securely at its ends.

A coating of dense mortar or concrete, covering and protecting the core and wire, except for the necessarily exposed surfaces of the joint rings.

A self-centring joint so designed that the joint shall be watertight under all conditions of service.

Prestressed concrete non-cylinder pipe shall have the following principal features :

A concrete core pipe either steel reinforced or longitudinally prestressed with pretensioned high tensile steel wire embedded in the concrete.

Circumferential prestressing with high-tensile wire wound around the outside of the core in one or more layers at a predetermined stress and fastened securely at its ends.

A coating of dense mortar or concrete, covering and protecting the wire.

A self-centring joint so designed that the joint shall be watertight under all conditions of service.

Or for monolithic type :

A concrete pipe longitudinally prestressed with pretensioned high tensile steel wire embedded in the pipe wall which is cast in one operation.

Circumferential prestressing by means of a reinforcement cage of high tensile steel wire also embedded in the pipe wall and prestressed to a predetermined stress by means of hydraulic expansion while the concrete is still fresh.

A self-centring joint so designed that the joint shall be watertight under all conditions of service.

3.1.2 *Wall thickness*

Table 1 shows the minimum design wall thickness for each type of pipe.

Table 1 : Minimum design wall thickness

Pipe DN/ID mm	Cylinder pipe	Non-cylinder pipe	
	t_1 min mm	t_2 min mm	t_3 min monolithic mm
500	50	40	45
600	50	40	45
700	50	40	50
800	50	45	55
900	55	45	60
1000	65	50	65
1100	70	50	70
1200	75	60	75
1250	75	60	80
1400	85	70	85
1500	90	70	90
1600	100	75	95
1800	115	75	105
2000	125	80	115
2200	135	90	125
2400	145	100	135
2500	150	100	140
2600	160	110	145
2800	170	120	155
3000	180	130	165
3200	190	140	-
3500	210	160	-
4000	240	180	-

Table 1 (concluded)

Pipe DN/ID mm	Cylinder pipe	Non-cylinder pipe	
	t_1 min mm	t_2 min mm	t_3 min monolithic mm

Notes :

t_1 min : minimum design thickness of the core wall including the thickness of the cylinder.

t_2 min : minimum design thickness of the core wall.

t_3 min : minimum design thickness of the pipe wall.

3.2 Design of pipes

3.2.1 *General*

The reinforcement of the cylinder pipe shall consist of a welded steel cylinder in the core and high-tensile wire helically wound around the core under measured and controlled tension after the concrete in the core has been placed and cured. The minimum design thickness of the cylinder shall be 1,5 millimetre for all diameters.

For both cylinder and non-cylinder pipe the size of the high-tensile wire and the spacing and tension under which it is wound shall be such that the requirements specified for the design conditions stated in clause 3.2.2 are met. The design shall fully recognise all losses due to elastic and inelastic deformations. The initial tension in the high-tensile wire shall not exceed 75 % of the characteristic strength of the wire.

The wire shall not be less than 4 millimetres in diameter. The minimum clear spacing between wires shall be the wire diameter up to a maximum of 6 millimetres in the same layer of reinforcement.

The maximum centreline spacing of the wire shall be 50 millimetres. For lined-cylinder pipe with wire 6 millimetres and larger, the maximum centreline spacing of the wire shall be 25 millimetres.

3.2.2 *Design requirements*

The pipes shall be designed to resist the flexural and hoop stresses resulting from each of the following conditions :

- design pressure + dead load :
  there shall be no tension in the core ;
- maximum design pressure + 100 kPa + dead load :
  tension in the core shall not exceed0,38 $\sqrt[3]{f_{ck}^2}$ for cylinder pipe or 0,13 $\sqrt[3]{f_{ck}^2}$ for non-cylinder pipe ;
- design pressure + dead load + live load :
  tension in the core shall not exceed 0,38 $\sqrt[3]{f_{ck}^2}$ for cylinder pipe or 0,13 $\sqrt[3]{f_{ck}^2}$ for non-cylinder pipe ;
- maximum design pressure :
  there shall be no tension in the core ;

where f_{ck} is the 28-day compressive strength of the concrete in MPa.

The total tensile stress in the core shall be considered as the sum of the hoop and flexural stresses without the application of any reduction factors.

When submitted to hydrostatic test (see 4.2) the mortar or concrete coated pipe shall not have cracks in the coating wider than 0,1 millimetre for 300 millimetres length as measured in accordance with 6.3.10 of EN 639 (Common Requirements).

3.3 Reinforcement

Non-tensioned reinforcement is permitted.

3.4 Concrete and mortar

3.4.1 *Mix design*

3.4.1.1 Core

The concrete shall contain a minimum cement content of 350 kilogrammes per cubic metre. The water cement ratio of the concrete shall be suitable for the method of placement and shall not exceed 0,45 after compaction. For steel cylinder cores of less than 1000 DN/ID a maximum water cement ratio of 0,5 is allowed provided that the minimum cement content is 385 kilogrammes per cubic metre of concrete.

3.4.1.2 Coating

After the core has been wrapped with prestressing wire, an external coating either of concrete or mortar shall be applied to provide the minimum cover as specified in 3.5.2. For multiple layers see 3.5.3. There shall be no rust scale or pitting on the prestressing wire at the time of coating.

3.4.1.3 Mortar coating

Mortar for coating shall consist of one part cement by weight to not more than three parts fine aggregate. The water/cement ratio shall not exceed 0,35. The mortar shall be compacted by impact using high velocity projection on to the core or on to a first mortar coating.

Concurrently with the mortar coating a cement slurry shall be projected on to the core at a rate of not less than 1 litre per 2 square metres just ahead of the mortar coating. The slurry shall consist of 1,2 kilogramme of cement to 1 litre of water.

3.4.1.4 Concrete coating

The concrete shall contain a minimum cement content of 400 kilogrammes per cubic metre. The proportions of cement, fine aggregate, coarse aggregate and water shall be determined and controlled as the work proceeds to obtain homogenous and workable concrete. The water/cement ratio shall not exceed 0,45. The concrete shall be deposited under high frequency vibration or by other approved method so that a dense, durable encasement is obtained.

3.4.2 *Concrete strength*

- At the time of applying the circumferential prestressing the concrete shall have a minimum compressive strength of 27 MPa.
- At 28 days the concrete shall have a minimum compressive strength of 35 MPa.

3.5 Prestressing

3.5.1 *Longitudinal prestressing*

For non-cylinder pipes the core or pipe shall be longitudinally prestressed throughout its length, including the socket, by means of high tensile wires which shall be indented or provided with permanent anchorages, embedded in the concrete within the joint portion of each end. The longitudinal prestress shall be sufficient to prevent excessive tensile stresses developing in the core due to the effects of the circumferential

prestressing and bending due to beam loading during transporting, lifting and handling. The longitudinal wires shall be stressed to design tension, taking into account all losse due to elastic and inelastic deformations

Alternatively, the core shall be suitably reinforced with non-tensioned steel in order to take into consideration excessive tensile stresses developing in the core due to the effects of the circumferential prestressing and bending due to beam loading during transporting, lifting and handling.

The minimum cover to steel embedded in the core shall be 15 millimetres except to end faces.

3.5.2 *Circumferential prestressing*

In addition to the requirements of 3.4.2 the compressive stress induced in the concrete core during prestressing shall not exceed 55 % of the compressive strength of the concrete in the pipe at that time. The method and equipment for applying the wire shall be such that the wire is wound around the core in a helical form at the predetermined design spacing and tension and capable of indicating, controlling and recording the tension.

The mean tension shall be at least the design tension. Normal fluctuations in tension shall not deviate from the mean by more than 10 % nor shall more than 5 % of the windings have instantaneous fluctuations exceeding the 10 % deviation.

Splicing shall be permitted and where splicing is carried out the splice shall develop the full strength of the wire.

For lined cylinder pipes circumferential prestressing wire shall be coated with a cement slurry. Immediately prior to placement of the cement slurry, all loose mill scale, excessive rust, oil, grease, and other foreign substances shall be removed from all surfaces to receive the slurry.

For monolithic pipes the circumferential cage shall be manufactured in helical form to the design spacing and placed in the pipe mould. The clear distance between successive turns of the wire shall be not less than 14 millimetres. The monolithic pipe wall in which the reinforcement in embedded shall be cast in one operation and prestressing shall be achieved through hydraulic expansion whilst the concrete is still fresh. The hydraulic prestressing pressure shall be controlled in order to achieve the correct tension in the wire. The hydraulic pressure shall not be released until the concrete has attained a minimum compressive strength of 32 MPa. The compressive stress induced in the concrete shall not exceed 55 % of the compressive strength of the concrete at that time.

The minimum thickness of the mortar or concrete cover over the circumferential prestressing wire shall either be 20 millimetres or alternatively 15 millimetres in which case a permeability test on the coating is required on one in every hundred pipes (see 4.3).

Circumferential cracks in the core, due to discontinuity of prestress at the spigot end are allowed provided they do not affect watertightness.

3.5.3 *Multiple layers*

If multiple layers of circumferential prestressing wire are used, each layer except the final layer shall be coated in accordance with 3.4.1 to provide a minimum cover over the reinforcement at least equal to the diameter of the wire and cured in accordance with 3.6 for a period of not less than eight hours. The first layer of reinforcement shall be wound on the surface of the core, and subsequent layers shall be wound over the previous layers of coating as specified in this section.

The final coating shall provide the minimum cover to the steel (see 3.5.2).

3.6 Curing

Accelerated curing shall be permitted and shall be in accordance with procedures fixed by the manufacturer on the ground of experience in relation to the temperature and the time of the curing and the chamber humidity.

4 FACTORY TESTING

4.1 Concrete test

A minimum quantity of two cylinders or cubes per day of manufacture and per mix type of core concrete shall be tested for the compressive strength.

4.2 Hydrostatic test

4.2.1 *General*

The hydrostatic test shall be applied to the whole prestressed core or pipe, including the portions of socket and spigot which are to be subjected to

pressure in the as-laid condition. Care shall be taken to remove all air from the pipe before the pressure is applied. Internal pressure shall be applied at a rate not exceeding 200 kPa in five seconds.

4.2.2 *Cylinder pipe*

One in 250 pipes shall be subjected to the hydrostatic test after coating. Full pressure shall be maintained for at least three minutes during which time there shall be no leakage or cracking (see 3.3.2).

Should a pipe fail the test then a further two pipes from the batch of 250 shall be tested. If both pipes pass then the batch shall be accepted. If one or both pipes fail then the batch shall be rejected or each pipe in the batch shall be tested for individual approval.

For hydrostatic testing of steel cylinders before circumferential prestressing see 6.3.7 of EN 639 (Common Requirements).

4.2.3 *Non-cylinder pipe*

All non-cylinder pipes shall be subjected to the hydrostatic test before or after coating. Full pressure shall be maintained for at least three minutes during which time there shall be no leakage or cracking (if tested after coating see 3.2.2). Moisture which may appear on the surface of the pipe without dripping shall not be considered as a leakage. Pipes that fail may be retested at the option of the manufacturer.

If each pipe has been subjected to the hydrostatic test before coating then one in 250 pipes shall be subjected to the test after coating. Should a pipe fail this test then a further two pipes from the batch of 250 shall be tested after coating. If both these pipes pass then the batch shall be accepted. If one or both pipes fail then the batch shall be rejected or each pipe in the batch shall be hydrostatically tested after coating for individual approval.

4.2.4 *Test pressure*

The hydrostatic test pressure to be applied shall stress the pipe wall to zero tension taking into consideration the losses in prestress at time of testing.

4.3 Permeability test on coating

4.3.1 *Test purpose*

The test is to determine the permeability of the concrete or mortar cover coat on the finished product by non-destructive means. It is based on using standard style of equipment designed to measure the quantity of water absorbed under a constant pressure.

4.3.2 *Test frequency on products*

The test shall be applied to one pipe in a batch of every 100 pipes.

Should the pipe fail the test then a further two pipes from the batch of 100 pipes shall be tested. If both pipes pass then the batch shall be accepted. If one or both pipes fail then the batch shall be rejected or each pipe in the batch shall be tested for individual approval.

4.3.3 *Testing equipment*

A sketch of the required equipment is shown in Figure1. The accuracy of the equipment shall be verified by certification.

The equipment shall consist of :

- A chamber with resilient seating to be clamped to the external surface of the pipe. This chamber shall have an orifice to create a known contact area immediately on the pipe surface ;
- A calibrated sight glass attached to the chamber and with a suitable pressure gauge at its upper end ;
- A source of compressed air to give a regulated constant pressure of 300 kPa (± 20 kPa) at the upper end of the sight glass ;
- A suitable quantity of water based dye at a colour density sufficient to ensure observation within the sight glass and on the free surface of the pipe ;
- A six hour at least stop watch calibrated in minutes.

4.3.4 *Test method*

The cover coat shall be fully saturated with water prior to testing.

The test shall be continuous for six hours.

The equipment shall be clamped to the pipe and the sight glass filled with dye. The compressed air source shall then be fitted and the whole assembly checked for leaks under the required pressure of 300 kPa (±20 kPa).

The quantity of dye in the sight glass shall then be recorded at 30 minute intervals for a period of at

least six hours under the sustained pressure of 300 kPa (± 20 kPa) and under conditions of full hydraulic continuity of the dye to the pipe surface.

4.3.5 *Test results*

- The test results shall be expressed as the quantity of dye expelled from the sight glass within the time interval relative to the area of the orifice of the chamber being the dye contact area to the pipe surface.

- Quantities in the sight glass shall be expressed in cubic centimetres and the area of the orifice in square centimetres. A measurement of the quantity of dye expelled from the sight glass (cm^3) per unit area of the chamber orifice at pipe surface (cm^2) is made every 30 minutes.

The slope of the relevant diagram (see Figure 2) is the following ratio :

$$\frac{\text{Qty of dye expelled from the sight glass } (cm^3) \text{ per hour}}{\text{Area of the chamber orifice at pipe surface } (cm^2)}$$

4.3.6 *Test acceptance criteria*

A successfull test shall satisfy the following :

The ratio given in 4.3.5 above shall not exceed 0,15 per hour for the period between 121 and 180 minutes into the test.

If this requirement has not been attained in this period, then the ratio shall be determined for the periods from 121 minutes to either 240, 300, 360, 420 or 480 minutes until the requirement is met. If the requirement has not been met at 480 minutes the pipe has failed the test.

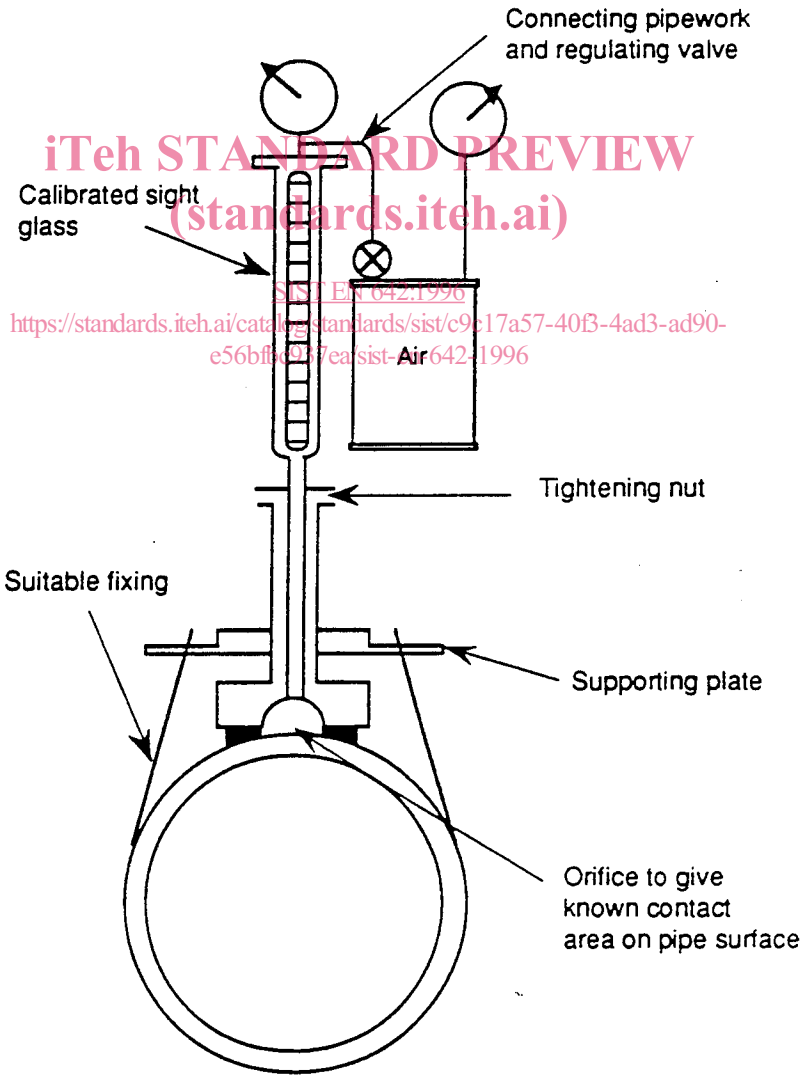

Figure 1 : Typical permeability test equipment