British Standard

BRITISH STANDARD

BS EN
523:1997

Steel strip sheaths for prestressing tendons — Terminology, requirements, quality control

The European Standard EN 523:1997 has the status of a British Standard

ICS 01.040.77; 01.040.91; 77.140.75; 91.080.40

National foreword

This British Standard is the English language version of EN 523:1997. The UK participation in its preparation was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/2, Structural use of concrete, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 10 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

This British Standard, having been prepared under the direction of the Sector Board for Materials and Chemicals, was published under the authority of the Standards Board and comes into effect on 15 November 1997

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Contents

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Descriptors: Prestressed concrete, cables, ropes, sheaths, protectors, strips, steels, plastics, classifications, specifications, quality control, marking

English version

Steel strip sheaths for prestressing tendons — Terminology, requirements, quality control

Gaines en feuillard d'acier pour câbles de précontrainte — Terminologie, prescriptions, contrôle de qualité

Hüllrohre aus Bandstahl für Spannglieder — Begriffe, Anforderungen, Güteüberwachung

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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

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 104, Concrete (performance, production, placing and compliance criteria), the Secretariat of which is held by DIN.

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 September 1997, and conflicting national standards shall be withdrawn at the latest by September 1997.

This European Standard applies together with the standards of the EN 524 series which comprises test methods for sheaths.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the 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 the United Kingdom.

Contents

1 Scope

This standard is applicable to uncoated cylindrical steel sheaths with a corrugated profile and with a nominal internal diameter of up to 130 mm[1)] and their connectors (couplers) which are assembled to form ducts for prestressing tendons in post-tensioned prestressed concrete elements. It is only applicable to sheaths and connectors made of interlocked or welded steel strip[2)3)].

The seals required between sheaths and couplers are not covered by this standard[4)].

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 524-1, *Steel strip sheaths for prestressing tendons — Methods of test — Part 1: Determination of shape and dimensions.*

EN 524-2, *Steel strip sheaths for prestressing tendons — Methods of test — Part 2: Determination of flexural behaviour.*

EN 524-3, *Steel strip sheaths for prestressing tendons — Methods of test — Part 3: To-and-fro bending test.*

EN 524-4, *Steel strip sheaths for prestressing tendons — Methods of test — Part 4: Determination of lateral load resistance.*

EN 524-5, *Steel strip sheaths for prestressing tendons — Methods of test — Part 5: Determination of tensile load resistance.*

EN 524-6, *Steel strip sheaths for prestressing tendons — Methods of test — Part 6: Determination of leaktightness (Determination of water loss).*

ISO 6932, *Cold-reduced carbon steel strip with a maximum carbon content of 0,25 %.*

3 Definitions

3.1
types of sheath

sheaths are designated by the manufacturer according to type, each type having certain features, e.g. production procedure (welded or interlocked), shape of profile, etc

3.2
connectors (couplers)

connectors are specific devices to join sheath sections. They are usually made from cut ends of sheaths with the same profile type but with larger diameter (see **5.2**)

3.3
stiffeners

stiffeners are additional components whose purpose is to increase the lateral load strength of the sheaths at supporting points, e.g. semi-circular sheathing sections placed between supports and tendons

4 Classification

Sheaths are classified by the requirements as given in Table 1.

Class 1 (normal sheaths)

Class 2 (rigid sheaths)

5 Requirements

5.1 Sheaths

5.1.1 *General requirements*

Sheaths shall have sufficient strength to ensure that they are able to withstand varying degrees and types of mechanical loading.

Sheaths shall have a corrugated profile to provide a sufficient mechanical bond with the concrete externally and the grout internally.

The inner and outer surfaces of the sheaths shall be free of any detrimental corrosion (see clause **7**). Sheaths shall be leaktight (see **5.1.9**). All joints between sheaths shall be sealed carefully (see Annex A). The sheaths and their connectors shall be designed in such a way to allow this proper sealing of the joints.

[1)] For diameters greater than 130 mm requirements should be drawn up on the basis of this standard and agreed upon by the parties involved.

[2)] In case of coated or galvanized steel additional provisions have to be considered, which are not covered by this standard.

[3)] For plastic sheaths, see Annex A.

[4)] The appropriate rules will be specified in a separate European Standard for concrete structures which is under preparation.

5.1.2 *Steel strip*

Sheaths shall be made from rolled steel strip conforming to ISO 6932 or specifies steel with similar properties. The nominal thickness of the steel strip shall be not less than the values given in Table 1, lines 1a and 1b.

5.1.3 *Tolerances (ovality)*

Deviations from the mean values of the internal diameter of any cross-section of the sheaths determined according to EN 524-1 shall not exceed ± 1 % or ± 0,5 mm, whichever is the greater.

5.1.4 *Relative volume of the profile*

The relative volume of the profile V_{rel} determined in accordance with EN 524-1 shall be not less than 0,08 cm^3/cm^2. For nominal internal diameters greater than 25 mm, the height of the profile shall be not less than 2,5 mm (see EN 524-1).

5.1.5 *Flexural behaviour*

The relative load $F_{rel} = F_{pl}/d_1$ in N/mm and the load F_{pl} at the beginning of plastic deformation shall be determined in accordance with EN 524-2.

The relative load F_{rel} for class 2 shall not be less than the given values in Table 1, line 2.

For class 1 there are no requirements but test results shall be given for information to the user in the relevant documents (see **6.2**).

5.1.6 *Flexibility*

When tested by means of the to-and-fro bending test described in EN 524-3, flexibility is sufficient if, after the bending test, no significant deformations of the corrugation appear so that the plunger can push in the specimen in whole length. A straightening of the specimen by means of the tensile load test (see EN 524-5) is permitted.

5.1.7 *Lateral load resistance*

The irreversible reduction of the internal diameter shall not exceed 10 % or 5 mm whichever is the smaller when the loads given in Table 1, lines 4a to 4c are applied according to EN 524-4. If any type of sheaths of class 1 withstands the load F_l = 1 500 N without a stiffener a test with lower forces accordance to Table 1, line 4a is not required.

5.1.8 *Tensile load resistance*

When loaded in accordance with EN 524-5, the tensile load strength is sufficient if the sleeve coupling (comprising sheaths and the corresponding coupler) does not fall by complete separation under the test loads specified in Table 1, line 5.

5.1.9 *Leaktightness*

When tested in accordance with EN 524-6, using a specimen tested earlier for flexibility, lateral load resistance and tensile load resistance, the water loss shall not exceed the values given in Table 1, line 6.

Table 1 — Minimum requirements

	1		2	3	4	5	6	7	8	9	10	11
	Characteristic		Class	Nominal internal diameter d_1 in mm								
				≤ 25	over 25 to 35	over 35 to 45	over 45 to 55	over 55 to 65	over 65 to 75	over 75 to 85	over 85 to 100	over 100 to 130
1a	Nominal thickness of steel strip in mm		1	0,20	0,25	0,25	0,30	0,30	0,35	0,35	0,40	≥ 0,40
1b			2	—	—	0,40	0,45	0,45	0,50	0,50	0,60	≥ 0,60
2	Relative load F_{pl}/d_1 in N/mm		2	3,0	3,5	4,0	4,0	4,5	5,0	5,5	6,0	6,5
3a	Radius r for the flexibility test, in mm (maximum values)		1	750	750	750	750	750	750	750	900	1 000
3b			2	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 800	1 800
4a	Lateral load F_l in N	without stiffeners	1	500	600	750	750	950	950	950	1 050	1 050
4b		with stiffeners	1	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500
4c		without stiffeners	2	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500
5	Tensile load F_2 in N		1 and 2	250	400	600	900	1 100	1 400	1 600	1 900	2 200
6	Tightness		1 and 2	Water loss ≤ 1,5 % by volume								

5.2 Connectors (couplers)

5.2.1 *General requirements*

Couplers made from corrugated metal strip sheaths shall fulfil the requirements given in **5.1.1**.

5.2.2 *Minimum length*

The length of the couplers shall be at least three times the nominal internal diameter of the sheaths, but not less than 150 mm.

5.2.3 *Nominal internal diameter and wall thickness of the couplers*

When measured in accordance with EN 524-1, the nominal internal diameter of the couplers $d_{1,c}$ shall not exceed a value of

$d_{1,c} = d_{1,s} + 8t_s + c$ (for interlocked sheaths)

$d_{1,c} = d_{1,s} + 3t_s + c$ (for welded sheaths)

where (see also Figure 1)

$d_{1,s}$ is the nominal internal diameter of the sheath (in mm)

t_s is the nominal wall thickness of the sheath (in mm)

c is the clearance between the outer surface of the sheath and the inner surface of the coupler, taking into account the increase due to folds or seams (in mm).

The clearance, c, shall not exceed 2,0 mm for sheaths with an internal diameter of up to 55 mm or 3,0 mm for larger diameters.

The steel strips from which couplers are made shall at least fulfil the minimum requirements concerning the wall thickness as the sheaths which are to be connected (see Table 1, lines 1a to 1b).

5.3 Stiffeners

It shall be possible to strengthen locally those sheaths which do not possess the increased lateral load resistance specified in Table 1, line 4b. The size of the stiffeners shall not exceed half the circumference of the sheath and shall be designed such that, after concreting, no cavities remain between the sheath and the stiffener which could have detrimental effects. This requirement can be met for instance by using the same profile and at least the same wall thickness for stiffener and sheath.

The length of the stiffeners shall not exceed 1,5 times the nominal internal diameter of the sheaths or 10 cm, whichever is the greater.

6 Marking, technical documents, delivery note

6.1 Marking

The producer's mark or trademark, the reference "EN 523", classification, nominal internal diameter and, where necessary, the type of sheath shall be displayed either on each packing unit or transport bundle or on the sheaths themselves.

6.2 Technical documents

Technical documents shall be prepared by the producer in which the following information shall be given for both sheaths and the corresponding couplers:

— marking;

— dimensions and tolerances;

— nominal thickness of the steel strip;

— sketch of the shape of the profile;

— relative volume of the profile;

— load F_{pl};

— nominal weight;

— chosen radius for the bending test;

— lateral load;

— type, shape and dimensions of stiffeners required for the sheaths to fulfil the requirements given in Table 1, line 4 (if relevant).

6.3 Delivery note

The following information shall be given on the delivery note and shall correspond to that given in the technical documents:

— name of producer;

— marking;

— number of this European Standard, EN 523;

— nominal internal diameter, classification, type;

— approved certification body (where appropriate).

In the case of couplers and stiffeners, reference shall be made to the sheaths with which they are to be used.

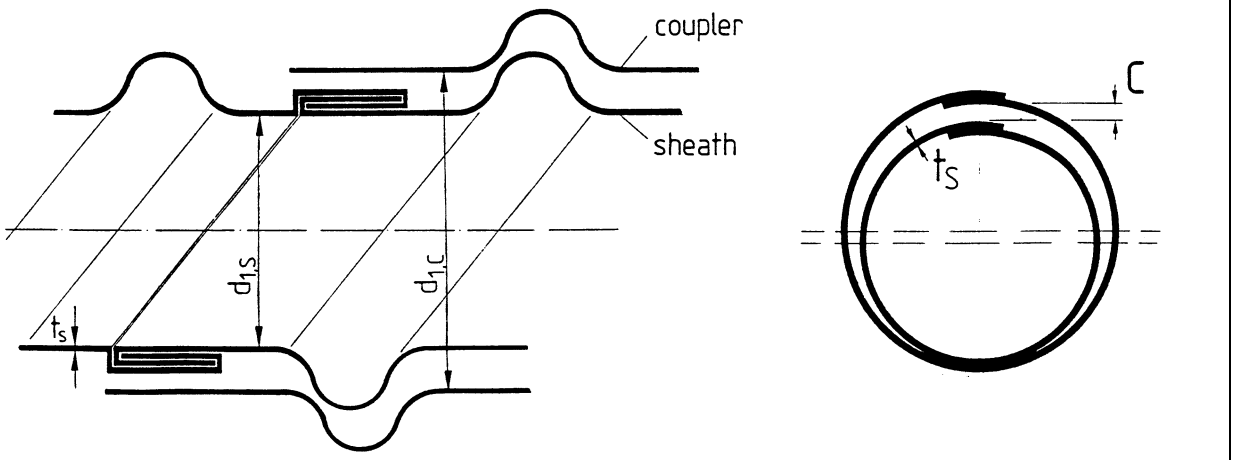

Figure 1 — Dimensions of couplers

7 Storage

Sheaths shall be stored in such a way that any damage or corrosion is avoided and no water or other substances harmful to the prestressing steel are able to penetrate into them.

8 Quality control procedures

8.1 General

The production of steel strip sheaths shall be subject to the following quality control procedures.

Quality control is defined as a combination of actions and decisions with the aim of ensuring that the sheaths comply with the requirements specified in clause **5**.

8.2 Factory production control

8.2.1 *General*

Factory production control comprises all measures necessary to obtain the quality of steel strip sheaths in conformity with the specified requirements. It includes checking and testing of production equipment, basic materials (steel) and the finished sheaths.

Factory production control shall be carried out by the manufacturer or his representative.

All relevant data from factory production control shall be recorded.

8.2.2 *Checking production equipment and manufacturing process*

The production equipment and manufacturing process shall be checked before starting production in order to ensure correct manufacturing of the sheaths.

8.2.3 *Checking the basic materials (steel strip)*

The delivery ticket of the incoming steel strip shall be checked to ensure that it is in compliance with the properties which are required for the intended production of sheaths. Checks and tests in accordance with Table 2, lines 1 and 2, shall be carried out by the manufacturer of the sheaths in order to verify that the incoming steel strip complies with the properties declared on the delivery ticket and which are relevant to the manufacturing process.

8.2.4 *Routine checks of running production*

Table 2, lines 3 to 7 specifies the kind and frequency of tests which have to be carried out by the manufacturer or his representative for routine checks of the running production. A record shall be kept of the checks and, where required, of the test results. Compliance with the requirements shall be confirmed in each case.

Table 2 specifies the minimum number of checks to be carried out.

For the determination of leaktightness other simplified tests may be carried out after the specimen has passed the flexibility test as described in EN 543-3. If factory production control is subject to the supervision of a approved certification body in the frame of attestation of conformity this has to be agreed in advance.

8.2.5 *Quality control of finished sheaths*

Fulfilment of the requirements given in clause **5** and compliance with the specifications given in clause **6** shall be checked by the manufacturer using random samples taken separately. These checks shall be performed independently of the routine production checks.

The number of sampling shall be related to types and nominal internal diameters of sheaths as follows:

— initial test for each type and nominal internal diameter;

— from a production of up to four different nominal internal diameters: two nominal internal diameters per type and year;

— from a production of more than four different nominal internal diameters: every fourth nominal internal diameter, however at least three nominal internal diameters per year.

The number of random samples tested shall be not less than one per month and machine.

Sheaths which are manufactured separately for use in the production of couplers shall be treated as having separate nominal internal widths.

Table 2 — Routine checks as specified in clause 8.2.3 and 8.2.4

	Check	Product to be tested	Inspection/tests		Requirements	Frequency
			Properties	Procedure		
	1	2	3	4	5	6
1	Inspection of incoming material	Strip steel	Tensile strength Elongation at rupture	Check works' certificate	See order documents	On delivery
2			Dimensions	Measuring		On delivery, however at least once per delivery lot
3	Production		Dimensions (and, where appropriate, the material)	Measuring (check marking)	See information given in the technical operating instructions	After each coil change and, where necessary, after each change of type of sheath or of nominal internal diameter
4		Sheaths	Dimensions (internal diameter, height, shape and thread of profile)	Measuring	See information given in the technical documents	After each change in the machine setting[a] and, where appropriate, after each coil change
5			Flexibility and leaktightness	**5.1.6**, **5.1.9**[b]	To be agreed with the third party inspection agency in accordance with clause **8.2.4**	
6	Final inspection before delivery to customer		Marking	Visual inspection	Clause **6**	Each delivery
7			Protection during transport, suitability of vehicles used for transport.		Clause **7**	

[a] At least once per shift and machine.

[b] Other, simpler tests may be applied (see EN 524-6).

Table 3 — Testing of characteristics as specified in clause 5

	Characteristic to be tested	Tests	Requirements
	1	2	3
1	Material, dimensions	Check works' certificate	Technical documents
2	Dimensions	EN 524-1	**5.1.2**, **5.1.3** or technical documents
3	Relative volume of profile	EN 524-1	**5.1.4** or technical documents
4	Flexural strength	EN 524-2	**5.1.5** or technical documents
5	Flexibility	EN 524-3	**5.1.6**
6	Lateral load resistance	EN 524-4	**5.1.7**
7	Tensile load strength	EN 524-5	**5.1.8**
8	Leaktightness	EN 524-6	**5.1.9**

Annex A (informative) Explanatory notes

A.1 Use with tendons in post-tensioning

Metal sheaths made of steel strips have been in use for many years and experience has shown that they have an important contribution to make to the long-term fitness for use of post-tensioned prestressed concrete structures. Knowledge regarding the required properties of such sheaths has been accumulated during this time and comprehensive and simple test methods for quality control at the factory as well as on the construction site have been developed. Thus it was possible to draft a European standard for sheaths based on existing national specifications for inclusion in the package of European Standards.

Sheaths for post-tensioning should permit elongation of the tendons during stressing with as little friction as possible. For this reason, sheaths may not display any unacceptable deflections, local bends or damages.

They should have ample load-bearing capacity during manufacture, transport, installation and concreting.

In particular, they should remain leaktight under these conditions in order to prevent moisture and cement slurry entering the sheaths during concreting as moisture in the sheaths can lead not only to corrosion of the prestressing steel but also to a very considerable increase in friction losses if there is a relatively long interval between concreting and post-tensioning.

A.2 Shape of sheaths

Furthermore, the sheaths should be designed in such a way that their shape permits the complete filling of the cavities between tendon and sheath with grout in order to ensure lasting protection of the prestressing steel against corrosion and the necessary bond for the load transfer from tendon to sheath and from sheath to the surrounding concrete structure.

The following effects may be obtained by special shaping of the profile:

— an adequate profile height ensures the necessary bond;

— a sufficiently large profile volume ensures that any air bubbles can collect and be kept away from the surface of the prestressing steel;

— an appropriate area supporting the prestressing steel along a curved sheath has a positive influence on the lateral pressure, thus reducing friction losses.

A.3 Application of classes

The criterion of distinction of the classes is marked by the thickness of the steel strip, forming the sheath.

Most of the post-tensioning systems recommend the use of sheath with normal thickness of strip. This class of sheath (class-1-sheath) is widely used all over the world.

In addition to this type of sheath a more robust sheath is applied in cases where a more stiff sheath is required. This class-2-sheath has been successfully used when empty sheaths have to be placed in the formwork, to reduce the influence of the unintentional angles of deviation (reduce the wobble effect). When no stiffening element is present before pouring the concrete, large deflections of the sheath on the occasion of placing the concrete are to be expected and therefore in such cases the use of class-1-sheaths is not recommended.

Class-2-sheaths, also called “rigid”, in general do not require high flexibility because they are not placed from rolls or drums. Rigid sheaths have in particular been used successfully in cases when stepping on the sheath during installation cannot be avoided.

A.4 Filling ratio

One general point should be mentioned here which has not been included in the specifications of this standard but which should nevertheless be borne in mind when selecting sheaths or during the manufacture of sheath sections: In the case of prestressing tendons made of groups of strands, the filling ratio — i.e. the ratio of the cross-sectional areas of the prestressing reinforcement to the cross-sectional area of the sheath should not exceed 0,5. This prevents an increased friction loss and allows the grout to be injected correctly.

A.5 Couplers

Sheath sections are generally connected by means of screwed couplers when they are joined to make sheaths of the required lengths. However, unless provided with additional protection, joints with screwed couplers are not watertight. They should therefore always be sealed very carefully, e.g. by wrapping strips of a suitable waterproofing material around them.

A.6 Plastics sheaths

Sheaths for tendons are, however, not only made of steel strips. The recent development of plastic sheaths should be noted. While their shapes, dimensions, possible applications and conditions for use correspond to those of the traditional metal sheathing, several technical differences (e.g. protection against corrosion, risk of fretting corrosion of the prestressing steel) should be mentioned. As neither adequate nor long-term experience is available at present, the standardization of plastic sheaths should be planned for the future.

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