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SPECIFICATION FOR PLAIN STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

(*Second Revision*)

SRI LANKA STANDARDS INSTITUTION

Sri Lanka Standard

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SLS 26: 2020

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Sri Lanka Standard

SPECIFICATION FOR PLAIN STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

(Second Revision)

FOREWORD

This standard was approved by the Sectoral committee on Materials, Mechanical Systems and manufacturing engineering and was authorized for adoption and publication as a Sri Lanka standard by the council of the Sri Lanka Standards Institution on 2020-05-27.

This is the second revision of SLS 26 and in this revision 10 grades of steel have been introduced instead of 2 steel grades in previous version.

Guideline for the determination of compliance of a lot with the requirements of this standard based on statistical sampling and inspection are given in Appendix A.

The formulation of SLS 874 on Steel Products, (part 1 Classification and definitions, and part 2 Identification markings) made it necessary to revise all the existing steel standards to bring them in line with the new classification, definitions and international standards published by the International Organization for standardization.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value observed or calculated expressing the result of a test or an analysis shall be rounded off in accordance with SLS 102. The number of significant places 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 following publications is gratefully acknowledged.

ISO 6935: 2007 - Steel for the reinforcement of concrete - **Part 1**: Plain bars.

1 SCOPE

This standard specifies the technical requirements for plain steel bars intended for use as reinforcement in ordinary concrete structures and as non - prestressed reinforcement in prestressed concrete structures.

This standard covers nine steel grades not intended for welding which are B240A-P, B240B- P, B240C-P, B240D-P, B300A-P, B300B-P, B300C-P, B300D-P and B420D-P, and one steel grade intended for welding which is B420DWP. The production process is at the discretion of the manufacturer. The requirements of this standard apply to straightened product. It also applies to plain bars supplied in coil form. The steel grades are designated with steel names allocated in accordance with ISO/TS 4949.

NOTE: The first “B” stands for steel for reinforcing concrete. The next 3 digits represent the specified characteristic value of upper yield strength. The fifth letter stands for ductility class (3.4). The next symbol relates to welding; “ –“ means not intended for welding and

"W" means intended for welding. The last "P" stands for plain bar.

Plain bars produced from finished products, such as plate and railway rails, are excluded.

2 REFERENCES

SLS 978	Metallic Materials - Tensile testing at ambient temperature.
ISO 6892-1	Metallic materials – Tensile testing – Part 1 Method of test at room temperature.
ISO 15630 -1	Steel for the reinforcement & pre-stressing of Concrete -Test method Part 1: Reinforcing bars, wire rod and wire.
ISO 7438	Metallic materials –Bend test.
ISO 7500 -1	Metallic materials – Verification of static uniaxial testing machines – Part 1: Tension/Compression testing machines – Verification and calibration of the force measuring system.
ISO 9513	Metallic materials – Calibration of extensometers used in uniaxial testing
SLS 102	Presentation of numerical values.
SLS 874	Steel products Part 1 Classification and definitions. Part 2 Identification markings.
SLS 428	Random sampling method

3 DEFINITIONS

For the purpose of this standard the following definitions apply:

3.1 cast analysis: chemical analysis representative of the cast determined by the steelmaker in accordance with his own procedures [ISO 16020:2005]

3.2 product analysis: chemical analysis carried out on the product
[ISO 16020:2005]

3.3 characteristic value: value having a prescribed probability of not being attained in a hypothetical unlimited test series
[ISO 16020:2005]

NOTE 1: *Equivalent to fractile, which is defined in ISO 3534-1.*

NOTE 2: *A nominal value is used as the characteristic value in some circumstances.*

3.4 ductility class: classification of the ductility properties of reinforcing steels based on the value of the ratio of tensile strength to yield strength, as well as the elongation measured either as A or as $A_{gt.}$

NOTE *See Table 5.*

4 SYMBOLS

The symbols used in this standard shall have the meanings assigned to them as given Table 1.

TABLE 1 - Symbols

Symbol	Unit	Description	Reference
A	%	Percentage elongation after fracture	6.5.2
A_{gt}	%	Percentage total elongation at maximum force	6.5.2
A_n	mm^2	Nominal cross-sectional area	6.4.2
d	mm	Nominal diameters of the bar	6.4.1
R_{eH}	N/mm^2	Upper yield strength	6.5.2
R_m	N/mm^2	Tensile strength	6.5.2
F_m	N	Maximum force in the tensile test	Appendix B
$R_{p\ 0.2}$	N/mm^2	0.2 % proof strength, non-proportional extension	6.5.2

5 DESIGNATIONS

Plain bars according to this standard shall be designated in the following order,

- Nominal diameter, in millimetres
- a reference to the note in the scope of the SLS 26
-

Example : 10 B 240A – P

6 REQUIREMENTS

6.1 Material

6.1.1 Chemical composition

6.1.1.1 Cast analysis

The chemical composition of the steel, as determined by cast analysis, shall conform to Table 2.

**TABLE 2 - Chemical composition based on cast analysis –
Maximum values of mass fractions, in percentage**

Steel Grade	C	Si	Mn	P	S	N	CEV [a]
B240A-P B240B-P B240C-P B300A-P B300B-P B300C-P	-	-	-	0.060	0.060	-	-
B240D-P B300D-P	-	-	-	0.050	0.050	-	-
B420D-P B420DWP[b]	0.30	0.55	1.50	0.040	0.040	0.02	0.56

The Carbon equivalent value, CEV is calculated according to the following formulae,

$$CEV = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

Where, C, Mn, Cr, V, Mo, Cu & Ni are the mass fractions, expressed as percentages, of respective chemical elements of the steel.

a - Other CEV formulae and values may be used by agreement between the manufacture and purchaser.

b - Alloy elements, such as Cu, Ni, Cr, Mo,V, Nb, Ti, Zr and B may be added. Limits of alloying elements shall be agreed between the manufacturer and purchaser.

6.1.1.2.1 Product analysis

The chemical composition of the steel, based on product analysis, shall be in accordance with Table 3.

**TABLE 3 - Chemical Composition based on product analysis-
Permissible deviation of the product analysis in percentage by mass**

Elements	Specified maximum value in cast analysis in Table 2 %	Permissible deviation in product analysis from the specified limits of the cast analysis in Table 2 %
C	>0.25	+0.030
Si	≤ 0.60	+0.050
Mn	≤ 1.65	+0.060
P	≤ 0.05 >0.05	+0.008 +0.010
S	≤0.05 >0.05	+0.008 +0.010

In general, the chemical composition is determined by dry analysis (Spectrometric methods) or wet analysis.

In case of dispute about the analytical method, the chemical composition shall be determined by an appropriate reference method specified in one of the international standards listed in ISO /TR 9769.

6.2 Manufacture

Unless otherwise agreed at the time of ordering, the method of manufacture shall be left to the manufacturer. However, the user shall have the right to be informed of the method on request at the time of delivery.

6.3 Finish

All bars shall be well and cleanly rolled and shall be sound and free from harmful surface defects such as cracks, surface flaws and lamination.

6.4 Dimensions, mass per meter and permissible deviations

6.4.1 The range of nominal diameters of bars shall be as given in Table 4.

6.4.2 The values of nominal cross sectional areas and mass per meter of nominal diameters shall be as given in Table 4.

6.4.3 Tolerance on area of cross-section

The deviation of any cross-sectional dimension, from its nominal size, shall not exceed ± 8 per cent.

6.4.4 Tolerance on mass per meter

The tolerance on mass per meter shall be as given in column 4 of Table 4.

TABLE 4 – Nominal diameter, cross sectional area and mass per meter

Nominal diameter of the bar (d) mm	Nominal cross sectional area[a] mm^2 A_n	Mass per meter, kg/m	
		Requirement[b] kg/m	Permissible deviation percent[c] %
(1)	(2)	(3)	(4)
6	28.3	0.222	±8
8	50.3	0.395	±8
10	78.5	0.617	±5
12	113	0.888	±5
16	201	1.58	±5
20	314	2.47	±5
25	491	3.85	±4.5

a $A_n = 0.785\ 4 \times d^2$
b mass per unit length = $7.85 \times 10^{-3} \times A_n$
c Permissible deviation refers to a single bar.

6.4.5 Tolerance on length

The preferred delivery length of straight bars is 6 m or 12 m. Delivery length should be agreed between the manufacturer and purchaser.

Each bar shall be cut to a ± 25 mm of the length specified by the purchaser.

Where a minimum length is requested it shall be subject to a tolerance of + 50mm -0 mm.

Where a maximum length is requested it shall be subject to a tolerance of + 0mm -50mm.

6.5 Mechanical Properties

6.5.1 General

The characteristic value is (unless otherwise indicated) the lower or upper limit of the statistical tolerance interval at which there is a 90% probability ($1 - \alpha = 0.90$) that 95% ($p = 0.95$) or 90% ($p = 0.90$) of the values are at or above the lower limit, or at or below upper limit, respectively. This definition refers to the long-term quality level of production.

6.5.2 Tensile properties

The specimen shall conform to the requirements for tensile properties specified in Table **5.**

Tensile test shall be carried out in accordance with Appendix B.

By agreement between manufacturer and purchaser, the values shown in Table 5 may be used as specified minimum and / or maximum values.

For steels that have no significant yield stress, the proof stress $R_{p.0.2}$ shall be used to define the yield stress.

TABLE 5 - Values for upper yield strength, tensile strength and percentage elongation

Ductility class	Steel grade	Specified characteristic value of upper yield strength, R_{eH} N/mm^2		Specified characteristic value of Tensile strength, R_m N/mm^2	Ductility property		
					Specified characteristic value of R_{eH} / R_m	Specified characteristic value of elongation[a] %	
(l)	(2)	(3)		(4)	(5)	(6)	
		Minimum	Maximum	Maximum	Minimum	A Minimum	A_{gt} Minimum
A	B240A-P	240	-	-	1.02	20	2.0
	B300A-P	300	-			16	
B	B240B-P	240	-	-	1.08	20	5.0
	B300B-P	300	-			16	
C	B240C-P	240	-	-	1.15	20	7.0
	B300C-P	300	-			16	
D	B240D-P	240	-	520	1.25	22	8.0
	B300D-P	300	-	600		19	
	B420D-P	420	540	-		16	
	B420DWP						

[a] By agreement between the manufacturer and the purchaser, the type of elongation shall be selected between A and A_{gt} If the type of elongation is not specified by agreement, A_{gt} should be used.

6.5.3 Bending properties

The bend test shall be carried out in accordance with Appendix C. The test specimen shall show no sign of fracture or cracks on visual examination with normal or corrected vision.

6.5.4 Preparation of test pieces

The tensile and bend tests shall be carried out by the as rolled condition without machining. Test pieces from mild steel bars shall not be annealed or otherwise subjected to heat treatment. Any straightening which may be required shall be done in cold form.

6.5.5 Sampling

Sampling shall be carried out as given in Appendix A.

7 MARKINGS

The product features shall be legibly marked on the tag or painting etc as follows:

a) Manufactured name or trade mark and country of origin.
b) Steel grade
c) Heat number /Batch no.
d) Form of product (Coil or straight)
e) Nominal diameter
f) Manufacturing process (hot or cold etc)
g) Weight of bundle/coil

NOTES

1. *Method and position of marking will depend on the type of product (see SLS 874 Part 2 Identification markings).*
2. *Attentions is drawn to certification facilities offered by SLSI. See the inside back cover of this standard*

8 RETESTS

Should any sample fail any of the tests, where possible, two additional test samples shall be taken from the same batch and subjected to the test or tests in which the original sample failed. Should with additional test samples pass the test or tests, the material from which they were taken complies with this standard. Should either of them fail, the material in the batch shall be deemed not to comply with this standard.

9 CERTIFICATE OF COMPLIANCE

If requested, the manufacturer shall supply the purchaser with a certificate stating the process of manufacture and a test sheet signed by the manufacturer giving the results of each of the mechanical tests applicable, and if so required, the chemical analysis shall also be provided.

APPENDIX A

A.1 LOT INSPECTION

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

A1.1 Lot

Any quantity of plain steel bars /coils of same designation, length and belonging to one batch of manufacturer shall constitute a lot.

A.2 SCALE OF SAMPLING

A.2.1 The number of bars/coils to be selected from a lot for testing for dimensions, mass per meter, chemical properties, mechanical properties and marking shall be in accordance with Table 6. Only one bar shall be selected per bundle.

If the number of bundles is less than the number of bars to be selected, approximately equal number of bars shall be selected from each bundle.

TABLE 6 – Scale of sampling

Number of bars in the lot (1)	Number of bars to be selected (2)	Sub samples to be selected (3)	Value of k (4)
Up to 500	5	2	1.53
500-1200	7	3	1.62
1201-3200	10	5	1.72
3201 and above	15	7	1.78

A2.2 The bars to be tested shall be selected at random. To ensure randomness, the bars shall be drawn from bundles in accordance with **SLS 428**.

A.3 NUMBER OF TESTS

A 3.1 Each bundle/coil of a lot shall be inspected for and marking requirements **(7).**

A3.2 Each bar selected in accordance with column 2 of Table **6** shall be inspected for finish (**6.3**).

A3.3 Each bar selected in accordance with column 2 of Table **6** shall be inspected for Dimensions, mass per meter and permissible deviations (**6.4**).

A3.4 Each bar selected in accordance with column 2 of Table **6** shall be tested for mechanical properties specified in **6.5.2** and **6.5.3**.

A.3.5 Each bar selected in accordance with column 3 of Table **6** shall be tested for Chemical properties specified in **6.1.1.2**.

A.4 CRITERIA FOR CONFORMITY

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

A.4.1 Each bundle inspected as in **A.3.1** satisfy the marking requirements.

A.4.2 Each bar inspected as in **A.3.2** satisfy the finish requirements.

A.4.3 Each bar inspected as in **A.3.3** satisfy the specified requirements for dimensions, length and mass per meter.

A.4.4 Each bar inspected as in **A.3.5** satisfy the chemical requirements.

A.4.5 Mechanical Properties

Each bar inspected as in A.3.4 satisfy the requirement in **A.4.5.1** and **A.4.5.2.**

A.4.5.1 Tensile properties

Each bar tested shall satisfy the stress ratio (Specified characteristic value of R_{eH} / R_m) requirements in Table **5**.
In respect of other properties in Table **5**, the value of the expressions ($\bar{x}$– ks) calculated using test results of yield strength and elongation are complied with relevant property requirement in Table **5.**

$\bar{x}$ - Mean of the test results
The value for 'k' shall be taken from column 4 of Table **6**.
s – standard deviation of the test results

A.4.5.2 Bending properties.

In respect of bending properties, each bar tested shall satisfy the requirements in **6.5.3.**

NOTE : *In process inspections*
When compliance with this standard is to be assured at the manufacturing stage based on manufacturer's control systems and testing procedures, appropriate schemes of sampling and inspections should be adopted.

APPENDIX B
DETERMINATION OF TENSILE STRENGTH OF THE PLAIN BARS

B.1 Conditions of testing

Unless otherwise agreed, the test piece shall be taken from the bar, in the as delivered condition.

In the case of a test piece taken from coil the test pieces shall be straightened prior to any tests by a simple bend operation with a minimum amount of plastic deformation.

For the determination of the mechanical properties in the tensile test and the bend test, the test piece may be artificially aged (after straightening if applicable) depending on the requirements of Table **7**.

TABLE 7 - Conditions of testing the mechanical properties

Manufacturing and delivery condition	Condition of testing
Produced in straight lengths by hot rolling Produced in straight lengths by cold working Produced as coil and delivered decoiled Produced and delivered as coil	As delivered[a] or aged[b] As delivered[a] or aged[b] Aged[b] Aged[b]
[a]Aged in case of dispute [b]Ageing method : heat the test piece to 100°C maintain at this temperature (±10°C) for a period of 60^{+15}_{-0} min; and then cool in still air to room temperature. The method of heating is left to the discretion of the manufacturer.	

When an ageing treatment is applied to the test piece, the conditions of the ageing treatment shall be stated in the test report.

B.2 Test piece

In addition to the general provisions given above, the free length of the test piece shall be sufficient for the determination for the percentage elongations in accordance with **B.4**.
Original gauge length shall be 5 times the nominal diameter.

When percentage total elongation at maximum force (A_{gt}) is determined by the manual method, equidistant marks shall be made on the free length of the test piece. The distance between the marks shall be 20 mm, 10 mm or 5 mm, depending on bar diameter.

When percentage elongation after fracture (A) is determined, the test piece shall be marked according to **8** of **SLS 978.**

B.3 Test *equipment*

The testing machine shall be verified and calibrated in accordance with **ISO 7500-1** and shall be at least of class 1.

When an extensometer is used, it shall be of class 1 (see **ISO 9513**) for the determination of R_{eH} or $R_{pO.2}$; for the determination of A_{gt}, a class 2 extensometer (see **ISO 9513**) can be used.
The extensometer which may be used to determine the percentage total elongation at maximum force (A_{gt}) shall have a gauge length of at least 100 mm. The gauge length shall be indicated in the test report.

B.4 Test procedure

The tensile strength, yield stress and percentage elongation shall be determined in accordance with the procedure given in **SLS 978**.

For the determination of tensile properties, the effective cross sectional area of the bar shall be used.

Cross sectional area is substantially uniform along the length of the bar, the effective cross sectional area A shall be the area in millimetre squared determined by weighing and measuring to a precision of ±0.5 per cent, a length of not less than 0.5 m and calculating as follows,

$$A = \frac{M}{0.00785\ L}$$

Where,
M is the mass of the bar (kg)
L is the length of the bar (m)
For the determination of $R_{pO.2,}$ if the straight portion of the force-extension diagram is limited or not clearly defined, one of the following methods shall be applied.

- the procedure recommended in **13** of **SLS 978**.
- The straight portion of the force-extension diagram shall be considered as the line joining the points corresponding to 0.1 F_m and 0.3 F_m.

In case of dispute the second procedure shall be applied.

NOTE : *The test should be considered invalid when the slope of this line differs by more than 10 percent from the theoretical value of the modulus of elasticity.*

Where fracture occurs in the grips or at a distance from the grips less than 20 mm or d (whichever is the greater), the test may be considered as invalid.

For the determination of the percentage total elongation at maximum force (A_{gt}),

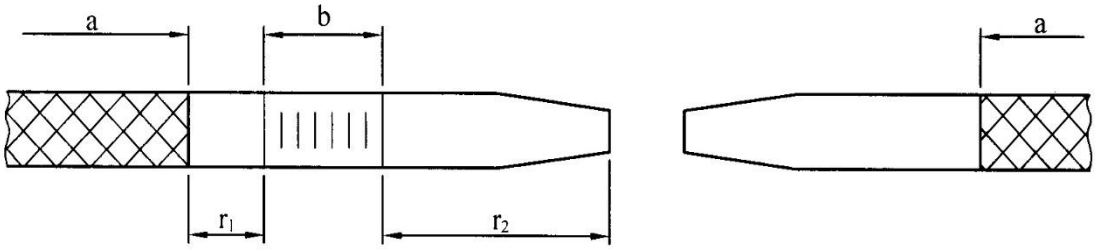
SLS 978 shall be applied with the following modifications or complements:

- If A_{gt} is measured by using an extensometer, A_{gt} shall be recorded before the force has dropped more than 0.5 per cent from its maximum value;
- If A_{gt} is determined by the manual method after fracture, A_{gt} shall be calculated from the following formula:

$A_{gt} = A_g + R_m/ 2000$

Where A_g is the percentage non-proportional elongation at maximum force. The measurement of A_g made on a gauge length of 100 mm a distance, r_2, of at least 50 mm or 2d (whichever is the greater) away from the fracture. This measurement may be considered as invalid if the distance r_1, between the grips and the gauge length is less than 20 mm or d (whichever is the grater) See Figure **1**.

- in case of dispute, the manual method shall apply.



a Grip length
b Gauge length 100 mm

FIGURE 1 – Measurement of A_{gt} by the manual method

APPENDIX C
DETERMINATION OF BEND TEST FOR THE ROUND BARS

C.1 Conditions of testing

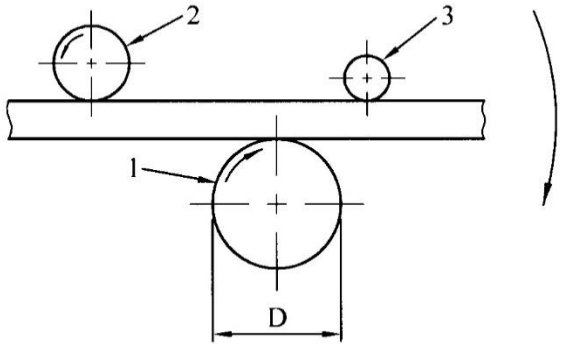
The conditions of testing given in **B.1** of Appendix **B** shall be applied.

C.2 Test equipment

A bending device, the principle of which is shown in Figure **2**, shall be used.

NOTE: Figure ***2*** *shows a configuration where the mandrel and support rotate and the carrier is locked. It is possible that the carrier rotates and the support or mandrel is locked.*

The bend test may also be carried out by using a device with supports and a mandrel (e.g see **4.1** of **ISO 7438**).



Key
1 Mandrel
2 Support
3 Carrier

FIGURE 2 : Principle of a bending device

C.3 Test procedure

The bend test shall be carried out in accordance with the procedure given in clause 6 of ISO 15630-1.

The bend test shall be carried out at a temperature between 10 ºC and 35 ºC . The test piece shall be bent over a mandrel.

NOTE : *The maximum bending rate shall be 3 radians per minute.*

The test piece shall be bent an angle between 160^0 and 180^0 over a mandrel of the diameter specified in Table **8**.

TABLE 8 - Mandrel diameter to be used for the bend test

Nominal diameter **d**	Mandrel diameter (max.)[a,b]
≤ 16	3d. [a, b]
16 < d ≤ 25	6d
[a] By agreement between the manufacturer and purchaser, larger mandrel diameters may be used. [b] For nominal diameters larger than 25 mm, the mandrel diameters in bend tests shall be agreed between the manufacturer and purchaser.	

C.4 Interpretation of test results

The interpretation of the bend test shall be carried out according to the requirements of **6.5.3.**

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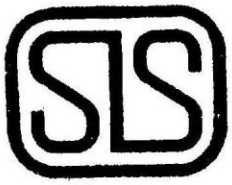

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