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PAKISTAN STANDARD SPECIFICATION FOR

STEEL INGOTS AND BILLETS FOR THE PRODUCTION OF BARS (PLAIN AND DEFORMED) FOR CONCRETE REINFORCEMENT

PSQCA Complex, Standardization Wing I & II, 1st Floor, Plot-ST-7/A, Block-3, Scheme No.36, Gulistan-e-Jauher, Karachi

PAKISTAN STANDARDS & QUALITY CONTROL AUTHORITY
STANDARDS DEVELOPMENT CENTRE
MECHANICAL DIVISION
COMMITTEE FOR METAL ALLOYS AND TESTING

CHAIRMAN:

1. Capt. Habib-ur-Rehman	Director: Directorate of Ships Maintenance & Repairs, Technical Services Branch, Naval Head Quarters, Islamabad.

PARTICIPANTS:

2. Mr. Muhammad Ali Danishh	Assistant Manager Amreli Steel (Pv.) Ltd., D/89, Shershah Road, S.I.T.E Karachi. 75730 **Email: ali.danish@amrelisteels.com** **Cell # 0322-02937891**
3. Mr. Wajid Bux Siddiqui	Manager Production Control & Logistic Indus Motor Company Limited Karachi. Cell # 0333-3800846 Email: wajid.siddiqy@toyota.indus.cm
4. Mr. Zoeb Salem	Director Amreli Steel (Pv.) Ltd., D/89, Shershah Road, S.I.T.EKarachi. 75730 Cell #0321-8256042 Email: zoeb.salemwala@amrelisteels.com z_salemwala@yahoo.com
5. Engr. Abbas Akber Ali	Chief Executive Officer M/s. Amreli Steels Limited 4/18, S.I.T.E., Karachi-75730 Tel: 32587232-9 UAN No. 111-Amreli(267354) E-mail: abbas.akberali@amrelisteels.com.

6. Engr. Khalid Khan	Chief Executive Officer Abbas Steel Group 123-Old Clifton, Karachi. Ph: 021-35870171 Fax No. 021-35870708 Email: k.khan@asgpk.com,Cell#0300-8226913
7. Mr. Irshad Mowjee	M/s. Razzaque Steel)Pvt.) Ltd., B-30 (B) Estate Avenue, Shershah SITE – Karachi. Ph: 021-32561106-09 Fax No. 021-32563594 Email: irshad-mowjee@razaquesteels.com
8. Mr. Tayyib Aftab	Corporate Affairs Assistant Manager Atlas Honda Limited F-36 Estate Avenue S.I.T.E Karachi-75730 Cell # 0300-8255626 Email: tayyib.atlashonda@com.pk
9. Mr. Ghulam Raza	Manager M/s. Peoples Steel Mills Ltd., Jawedan Nagar Manghopir Road Karachi. Email: graza@psmltd.com Cell # 0333-2325357
10. Mr. Kamran Bhatti	Assistant Manager M/s. Peoples Steel Mills Ltd., Jawedan Nagar Manghopir Road Karachi. Email: kamran.bhatti@psmltd.com
11.Mr. Syed Zahid Ali,	Deputy Manager, EDB, Regional Office, PIDC House, Karachi. Cell # 0333-2325783 Email: sza50140@hotmail.com
12.Mr. Syed Ali Raza Rizvi	Assistant Director QCC-PSQCA Email: s_aliraza786@yahoo.com

13. Engr. Ali Bux	Director (WTO) PSQCA Karachi. Email: soomroali@yahoo.com
14. Engr. Shabbir Ahmed Qureshi	Director (C.A. South) PSQCA Email: shabbier.petarian@yahoo.com
15. Mr. Abdur-Rasheed	DGM (Plant) SUPARCO Hub – Karachi.
EX-OFFICIO	
16. Engr. Kamaluddin Mangnejo	Director Standardization Wing-I SDC-PSQCA Karachi.
SECRETARY	
17. Mr. Syed Kaleem Ahmed Dibaji	Assistant Director (Mechanical) / Secretary of the NSC SDC-PSQCA Karachi. Email: kaleemdibaji@yahoo.com

PAKISTAN STANDARD SPECIFICATION
FOR
STEEL INGOTS AND BILLETS FOR THE PRODUCTION OF BARS (PLAIN AND DEFORMED) FOR CONCRETE REINFORCEMENT.

0. FOREWORD

0.1 This Pakistan Standard was adopted by the authority of the General Council for Pakistan Standards Institution, after the draft prepared by the Sectional Committee for 'Metal Alloys and Testing' had been duly approved and endorsed by the Mechanical Engg, Divisional Council in 1989.

0.2 The Pakistan standard (PS-2337/1989) has been revised by the Sub-committee formed by the National Standards Committee (NSC) on 19th May 2015 and endorsed by the NSC on _____.

0.3 This Pakistan Standard has been prepared after taking into consideration the views and suggestions put forwarded by the representative sections of manufacturers, technologists and utilizing agencies, well inline with the World Trade Organizations/Technical Barriers to Trade Agreement (WTO/TBT).

0.4 In the preparation of this Pakistan Standard, assistance has been derived from the following documents which are acknowledged with thanks.

(i)	ISO 6929:2013	Steel Products – Vocabulary
(ii)	JIS G0321:2010	Product Analysis and its Tolerances for Wrought Steel
(iii)	ISO 4948-1:1982	Classification of steels into unalloyed and alloy steels based on chemical composition
(iv)	ASTM E381-01	Standard Method of Macro-etch Testing Steel bars, Billets, Blooms and Forgings
(v)	ASTM E45-02	Standard Test methods for Determining the Inclusion Content of Steel

0.4 This Pakistan Standard is subjected to periodical review in order to keep pace with development in technology. Any suggestion for improvement will be recorded and placed before the revising committee in due course.

0.5 This Second edition cancels and replaces the first edition (PS:2337/1989) which has been technically revised.

1. SCOPE:

1.1 This Pakistan Standard covers the requirements for ingots (including cast billet ingots) and billets (including continuous cast billets) for the production of bars (plain and deformed) for concrete reinforcement.

2. TERMINOLOGIES:

2.1 **Ingot:**

The product obtained by casting of a shape appropriate to the subsequent processing into semi-finish products, or flat or long products, generally by hot rolling or forging.

2.2 **Bloom:**

Semi-finish products obtained by casting or rolling/forging, generally described as bloom if sides are greater than 200mm or the cross-sectional area is greater than 40,000mm^2, provided that the width is up to the twice of thickness, in case of rectangular cross-section.

2.3 **Billet:**

Semi-finish products obtained by casting or rolling/forging, generally described as billet if sides are up to 200mm or the cross-sectional area is up to 40,000mm^2, provided that the width is up to the twice of thickness, in case of rectangular cross-section.

3. SUPPLY OF MATERIAL:

3.1 The general requirements relevant to the supply of steel shall conform to PS: 607 on "Steel and Steel Products-General Technical Delivery Requirements."

4. MANUFACTURE:

4.1 Steel shall be manufactured by open hearth, electric, duplex, basic oxygen or combination of these processes. In case any other process is employed by the manufacturer, prior approval of the purchaser should be obtained.

4.2 Steel shall be semi-killed or killed.

5. RAW MATERIAL FOR MELTING:

5.1 The material, which shall be used for melting, may be as follows:-

5.1.1 Steel scrap such as:-

(a) Carbon steel scrap;
(b) Low copper, carbon steel scrap (containing copper $\leq$ 0.20%; and
(c) Low phosphorus, low sulfur, low copper, carbon steel scrap (containing phosphorus or sulfur $\leq$ 0.025% or copper $\leq$ 0.15%).

5.1.2 Molten metal or scrap which can be transformed into any of the specified steel grade for the manufacture of reinforcement bars.

6. CHEMICAL COMPOSITION

6.1 The ladle analysis of the material, when analyzed in accordance with the appropriate Pakistan Standards on "Chemical Analysis of Steels" shall be of the composition below:

Elements	**Percent, max**
Carbon	0.40
Silicon	0.50
Manganese	1.65
Phosphorous	0.060
Sulfur	0.050

Note: - The carbon equivalent (CE) shall be subjected to the agreement between the purchaser and manufacturer. The formula for determination of CE is given below:

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

6.2 Permissible Variation in case of product analysis from the above specified limits shall be as follows:

Elements	**Variation, % max**
Carbon	+ 0.03
Silicon	+ 0.05
Manganese	+ 0.06
Phosphorous	+ 0.008
Sulfur	+ 0.008

Note: - When steel is killed with silicon, the permissible variation in Silicon content shall be 0.10%

6.2 The elements other than specified under 'Chemical Composition' shall be in the limits of unalloyed steels as specified in ISO 4948/1-1982, given below:

Elements	**Percent, max**
Aluminum(Al)	0.10
Boron(B)	0.0008
Bismuth(Bi)	0.10
Chromium(Cr)	0.30
Cobalt(Co)	0.10
Copper(Cu)	0.40
Molybdenum(Mo)	0.08
Nickel(Ni)	0.30
Niobium(Nb)	0.06
Lead(Pb)	0.40
Selenium(Se)	0.10
Tellurium(Te)	0.10
Titanium(Ti)	0.05
Tungsten(W)	0.10
Vanadium(V)	0.10
Zirconium(Zr)	0.05
Lanthanides (each)	0.05
Other specified elements (except C, Si, Mn, P, S and N)	0.05

7. MECHANICAL PROPERTIES:

Mechanical properties of the end product i.e. bar should qualify the relevant grade specification.

8. SAMPLING:

8.1 At least one ladle sample analysis shall be taken per cast.

8.2 If required, the samples for products analysis shall be prepared either by forging or rolling down to 30mm, round sections or to the size of plain and deformed bars to be rolled, whichever is lower.

8.2.1 Drilling shall be taken from the sample (see 8.2) representing two-third, half and one-third of height from bottom of the ingot separately.

8.2.2 In case of continuous cast billets and billets produced from ingots, the sample (see 8.2) may be taken from anywhere from the billet.

9. FREEDOM FROM DEFECTS:

9.1 The billets and continuous cast billets shall be sound and free from piping, blowholes, laminations, segregation, inclusions and cracks etc which are harmful for the purpose for which it is intended. Subject to the agreement between the purchaser and manufacturer, the billets and continuous cast billets may be supplied with suitable surface dressing.

9.2 The acceptance criteria shall be as follows:

(i) Surface defects should not be deeper than 1mm

(ii) Subsurface cracks with less than 5mm distance from surface and longer than 7mm are not acceptable.

(iii) Local grinding cavities, if any, should have max depth up to 5mm

(iv) Severe porosity, if concentrated in the rim area, is not acceptable

(v) Segregation, if any, should be in the acceptable range of the reference chart.

10. NON-METALLIC INCLUSIONS:

10.1 If agreed between the purchaser and the manufacturer, non-metallic inclusions content shall be determined in accordance with ASTM E45/02- Standard Test methods for Determining the Inclusion Content of Steel

11. DIMENSIONS:

11.1 The size of the ingot shall be such that the cross-sectional area of the ingot shall be four times or more, than the size of the billet to be produced from it by hot rolling or forging.

11.2 The preferred dimensions shall be:-

50 to 150 mm

11.3 The lengths of billets shall be up to 12 meters.

11.4 The size other than those specified may be supplied by agreement between the purchaser and the manufacturer.

12. TOLERANCES:

12.1 Cross Section:

±1.5mm for up to 75mm, and
±3.0mm for over 75mm

12.2 Length:

±150mm for all lengths

12.3 Rhomboidity:

3.0% max for all sections

Note: %Rhomboidity shall be calculated by $\frac{d2-d1}{d2-d1}\times 100$

(Where d2 is the large and d1 is the small diagonal)

13. MARKING:

13.1 Unless agreed otherwise, the material shall be marked as given in clause 13.2 and 13.3.

13.2 The ends of ingots and billets shall be painted with suitable color code.
Each ingot and billet shall be legibly stamped or painted with cast number and the name or trade-mark of the manufacturer.

13.3 The material shall also be marked with the PSQCA Standard Mark.

Note: - The use of the PSQCA Standard Mark is governed by the provision of the Pakistan Standards and Quality Control Authority Act-VI of 1996 and the rules and regulations made there under. Products bearing the PSQCA Stadard Mark are protected with the guarantee that they have been produced to comply with the requirements of the relevant standard under a well defined system of inspection, testing and quality control during production. Particular governing conditions, under which a licence for the use of the PSQCA Standard Mark may be granted to the manufacturer, which may be obtained from the Pakistan Standards and Quality Authority.