

ROLE OF INDIAN STANDARDS IN TAILORING THE PROPERTIES OF WROUGHT STEELS

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1. INTRODUCTION

Standards are documents established by consensus and approved by a recognised body that provide for common and repeated use, rules, guidelines or characteristics for activities or their results. They are aimed at the achievement of the optimum degree of order in a given context and are the outcome of the process of standardization. The standards are essential for:

Promoting better understanding between the producers and the consumers.

Aiding mass production of goods.

- Facilitating interchangeability of products and components.
- Rationalisation (variety, reduction) of types and sizes of products.
- Stipulation of optimum quality of products.
- Guarding against factors affecting health and safety.
- Conservation and optimum utilisation of materials.

We are aware that steel is a material vital to the economic development of any country and is the most consumed material the world over because of its multifaceted uses. Steel is basically an iron-

carbon alloy in which other alloying elements like Ni, Cr, W etc or microalloying elements like Nb, V, Ti etc are added to confer specific properties. Wrought steel owes its versatility to the fact that a variety of properties can be attained on subjecting them to mechanical processing, heat-treatment, thermomechanical treatment etc. This has given steel the pride of place it occupies amongst the various metals and alloys of industrial importance. Due to its variety of composition, properties and the method of production, it has become necessary to bring it in the ambit of standardization to benefit manufacturers, consumers, testers and others. Annexure-I provides various types of steel and the operational control measures.

After independence, in our country, it was felt necessary to develop various National Standards for steels for both development in industries and import of technology. Steels are necessary for construction, railways and communication, machine tools, defence production and others. It was, therefore, required to produce steels in large quantities with a variety of mechanical properties for specific uses to support the developmental process in the country. In alloy and special steel category, there was need for rationalising the variety. There were multiple and repetitive varieties in use due to foreign collaborators, who insisted on standards of their country. It was also necessary to conserve the scarcely available metals and so to specify alternate steels of equivalent properties. Bureau of Indian Standards, then known as Indian Standards Institution and which started functioning since the year of Independence, was entrusted with the drawing of Standards to achieve the above objectives.

2. SCHEDULES FOR **WOURT** STEELS

An important step in this context was to prepare Steel Schedule for Wrought Steels for General Engineering purposes. IS:1570 was evolved for this in 1961, which was later on published in various parts as enlisted in Annexure-II. Seven broad categories of steels

were incorporated and they were suitably designated for quick identification of the main elements present in each grade. A code of designation was also formulated as IS:1762. This schedule formed the base for Wrought Steel Standards and it was decided that relevant Technical Committee and other organisations preparing the standards will incorporate the grades as are in the schedules, except the steels for specialised applications. It was, however, felt necessary and proposed to BIS that there should be some standards to facilitate the selection of steels for various applications from IS:1570. Another Specification IS:1871 as Commentary on Indian Standards for Wrought Steels, was published in 1965 and later in 1987, it was made into equal number of parts as of 1570 (Annexure-III provides brief contents).

Steel-Schedules broadly provide compositions and tensile properties of various grades. However, a number of other informations are required in respect of the quality of the steels, the limits of carbon content (wherever weldability was involved), type of steel based on the extent of deoxidation, **other** physical test requirements etc. This needed individual **specifications** to be formulated depending upon the use and applications of the steels. Annexure-IV gives the specific requirements of steels covered in product standards.

3. UTILITY OF PRODUCT STANDARDS

In order to elucidate the point regarding the details of the product standards, which have bearing on the tailoring of the properties, example of IS:2062 can be taken up. The specification for Structural Steels, for instance, gives the details such as deoxidation mode, sulphur, phosphorus content and conditions of supplies (as rolled or normalised) for different grades, sections etc. These are not there in the equivalent grade specified in the schedule. Similarly, IS:1875, the specification for forging quality steel, IS:1079, the specification for Hot Rolled Steels etc give the specific

details for attaining the properties. Some standards have been included for elucidation in Annexures-V and VI, which highlight the importance of such standards in tailoring the properties of the steels.

4. STAWARDS **FOR CODE OF PRACTICE**

Apart from product standards, there are standards of Code of Practices. These standards recommend the **various** operational activities and precautions to be taken during the operation. They specify the standards for the materials such **as** composition of coating material, pickling acids, fluxes etc as are required for providing protective coating on steels or some **general** requirement of steels for drop, upset and press forgings etc. Specifications such as IS:3479, IS:134-17, IS:8508, IS:2629 come in this category, which have **their own role to play in** providing the requisite properties in the steel for specific applications. The specifications formulated for testing both chemical and physical properties contribute in controlling the quality. These aid while in process and also in other quality assurance activities. A few such standards are IS:228, IS:1608, IS:1590, IS:1599 etc.

5. **STAMARDS ON DiliENSIONS**

Standards and dimensional tolerances are of paramount importance **in forgings** and railings of alloy and tool steels to place orders for materials to suit specific applications. Standards like IS:1852, 3739, 3469, 9684 etc are available for this purpose. There are also many product standards in which tolerances are incorporated. Annexure-VII has been given to highlight the important control parameters of one such specifications IS:8508 - Code of practice for **Hot Dip Aluminising**. **To highlight** the details of tolerance **standards**, an example of the tolerance limits of HR Strip are given in IS:1852 in the same annexure.

6. VERSATILITY OF STANDARDS

It may be mentioned that the standards discussed above and many others applicable to both in semi-finished and finished conditions form the basis of controlling the properties in the processed steels. However, the manufacturers and the purchasers can always select compositions closer to those given and make their own process schedules to produce the material with the requisite properties as specified or to closer values as they may deem suitable. Manufacturers can work out the schedules depending upon the facilities available with them and the consumers may also insist upon certain manufacturing process control for which agreement between both the parties may be required. There are provisions in the standards, which call for such agreements. Specifications also do not restrict the design aspect and these are also subjected to mutual agreement. In Annexure-VIII, the scope of Indian Standards in this context has been highlighted. As an example of use of standards in tailoring the properties, a case study as reported by Mandal and Chakravorty on low carbon steel rods (at the bar and rod mill can be cited. Customer requirements were -- wire rod 5.5 mm to 10 mm dia having easy drawability with small number of breakages during drawing and low tensile strength with high reduction in area [UTS 430 N/mm² (max)]. In order to achieve these properties, steps taken were (i selecting steel composition with C 0.06/0.10%, Mn 0.35/0.60%, S&P 0.035 max, Si 0.08/0.15%, to SAE(C) 1008, (ii) restricting the carbon equivalent to 0.151 (avg), (iii) keeping nitrogen content to 80 ppm max, (iv) maintaining conveyor speed 0.3 m/s, (v) laying head temperature to 900°C + 10°C.

In their article 'Wire Rod Rolling Practice and Control', Mandal and Chakravarty report production of M.S wire rods and re-bars of identical diameters in the Wire Rod Mill to IS:7887, IS:2062, IS:1786 etc using their own control parameters. It is obvious that process control measures are to be adjusted according to the available technology and controls in the complex. Operational parameters and

controls of old mills are likely to be different from the modern mills and it is likely that surface quality, mechanical properties and dimensional variations may be different for the products of identical size, shape and grades as produced in the respective mills. In Indian context, this aspect takes an important dimension as we have both old and new technologies in vogue in steel production. Indian Standard being consensus one, specifies the optimum properties and come to the aid of the manufacturers and users both to produce and order the material within the specified requirements of the standards. The specifications provide lot of flexibility for entering into agreement between manufacturer and purchaser on various aspects of controls as also production to closer compositions and tolerances. There are examples, about production of sheet and strip of steels with the old as well as new technology as per IS:10787, IS:10748 and IS:1079. Standardization is a dynamic process and as the technology improves the quality parameters keep on changing.

7. a)Nausionts

With the present liberalisation in the economy, steel exports have increased and are likely to increase further. Indian Standards will be required to be identified with those of International Standards and, therefore, standards are being given special emphasis now. Indian Standards are being harmonised with the equivalent ISO standards. It is expected that such standards would play important role and would suit to the requirements of foreign buyers. Earlier a standard IS:1870 giving Comparison of Indian with overseas standards for wrought steels for general engine ring purposes, was published as a step towards finding the equivalent Indian Standards to corresponding foreign standards. As a closer step in harmonisation now-a-days, publication of dual specifications incorporating the provisions of overseas standards particularly ISO standards are being practised e.g.

IS:1403(Pt-I)/ISO 7790, Mechanical Testing of Metals, Reverse Bend Test, Sheet and Strip; IS:1993/ISO 1111-1-1983, Single Cold Reduced Tinplate and Black Plate, Electrolytic and Hot Dip Tinplate Sheets etc. Lastly, it may be stated that various steel plants, mini-steel plants, re-rollers and other engineering units are using various Indian Standards on wrought steel and steel products in their production and in accordance with the provisions to maintain the quality of the product. This is indicative of the importance of standards in contributing towards satisfying the national needs of suitable steels.

BIBLIOGRAPHY

SEI Mbnograph on Standardization.

S.K.Mandal and A.Chakraborty, Modified Standards Stelmor Practice as a Substitute for Retarted Stelmor for Mild Steel Wire Rod Rolling. National Seminar on Wire Rods and Wire Products (1992, Jamshedpur).

S.Mandel and S.Chakraborty, Wire Rod Rolling Practice and Control. National Seminar on Wire Rods and Wire Products (1992, Jamshedpur).

IS:2062	Steel for general structural purposes.
IS:2629	Recommended practice for hot dip galvanising.
IS:228	Method of chemical analysis of steels.
(various parts)	
IS:1608	Method of tensile testing of steel products.
IS:1598	Method for Izod Impact Test of metals.
IS:1599	Method of bend test.
IS:9684	Technical condition for supply of HR billets blooms etc for close die forging.
IS:7887	M.S wire rods for general engineering purposes.
IS:10787	Microalloyed steel sheet and strip for LPG cylinders.
IS:10748	HR steel skelp and strips for welded tubes and pipes.
IS:7291	High speed tool steel.

Annexure I

SALIENT FEATURES OF OPERATIONAL CONTROLS AFFECTING PROPERTIES IN WROUGHT STEELS

Common Features

Composition, grain size and structure impurities, inclusions their shape, size and distribution. The type and extent of mechanical working.

Specific Features

Type of wrought steels		Features
1. (a) Carbon steels	(i) structural steel (ii) sheet and wire drawing quality	(a) Degree of deoxidation K, SK, Rimming (b) .N content (c) S&P content
	(b) Forging quality slab	(a) Observance of minimum reduction (b) Direction of grain flow
2.	Steels for hardening and tempering and case carbonising steel	(a) Combination of alloying elements (b) Hardening and tempering cycle/temperatures quenching medium (c) Case carburising medium and temperature
3.	Microalloyed steels	(a) N.A elements (b) Controlled rolling and cooling
4.	Stainless steels	(a) Combination of alloying elements (b) Heat-treatment
5.	Tool steels	(a) Combination of alloying elements (b) Extent of reduction
6.	Steels for magnetic and electrical application	(a) Si-content (b) Grain orientation

COMMENTARY ON INDIAN STANDARD WROUGHT
STEELS FOR GENERAL ENGINEERING PURPOSES

Sl. No.	Grade	Indian standards	Typical uses
1.	Fe 410	IS:2062 IS:1079 IS:2830 IS:6915	Structural steel for bridges and building construction, railway rolling stock, oil well casting etc
2.	C05, (5C4) C07, C10, C14 (14C6) etc	IS:2879 IS:4432 etc	In rimming quality used as sheet strip, rod and wire, automobile body. Cold heading wire and revets killed steel used for forging case hardening steels used for crank shafts, oil pans, light duty gears etc
	C45 (45C8)	IS:1875 IS:2004	Used for machine tools, bigger gears bolts, shafts etc
3.	13S25	IS:4431	Used for lightly stressed components not subjected to shock (nuts, studs)
4.	40Cr1 50C1 20Mn5Cr5	IS:5517 IS:5518 IS:4432 etc	For making gears, connecting rods Concrete handling equipment etc spring steel For medium size gear wheels and shafts of vehicles
5.	04Cr19Ni19	IS:6603 etc	Chemical handling equipment, kitchen ware, textile dyeing equipment etc
6.	T70W18 Cr4V	IS:7291 IS:3748	Milling cutters, deep hole drills slitting saws, and other highspeed cutting tools

Annexure IV

SPECIFIC REQUIREMENT AS ARE COVERED IN INDIVIDUAL STANDARDS

Apart from compositions and tensile properties as covered in the schedules the standards will incorporate the following:

Degree and method of deoxidations i.e conditions as killed, semi-killed or rimming quality. Steel quality such as freedom from internal and external defects, internal homogeneity etc degree of purity i.e maximum limits of S & P wherever required conditions for guaranteed weldability, resistance to brittleness, conditions of formability, properties and stipulations for elevated temperature and cryogenic services. Surface finishes and treatments etc.

Beside the above they will contain:

Cu content for corrosion resistance

Pb content where increased machinability is required

Method of physical tests like bend, rebend, impact tests and their limits

Use of Schedules in Preparation of Standards

In preparation of Steel Standards or in revision thereof steels as listed in the Schedules are to be referred to except in those cases where special service condition makes it necessary to select slabs different from those specified. Wherever possible incorporation alternate compositions to save scarce elements like Ni and Mn to be encouraged.

Users may order steels as per Schedules with other details to serve their end-use.

Annexure V

CONTROLLING FACTORS FOR THE
SPECIFIED PROPERTIES TO IS:2062

Grade	Deoxidation mode	CE	Condition of supply	S % 1 (max)	P % 1 (max)
Gr 'A'	SK or K	0.42	As rolled	0.05	0.05
Gr 'B'	-do-	0.41	Plates above 12 mm may be normalised, if agreed to between the manufacturer and purchaser	0.045	0.045
Gr 'C'	Killed	0.39	Plates above 12 mm shall be normalised	0.040	0.040

Min. Si content for killed steel 0.10% Use of billets/slabs to IS:2830-91

M.A. if added to be 0.20% (max)
N content 0.012% (max)

SALIENT FEATURES OF CARBON STEEL SLABS
AND BARS FOR FORGING -- IS:1875-92

Manufacturing controls

(a) Sufficient discard to eliminate piping, (b) Ingot having atleast four times cross sectional area of the finished product, (c) For blooms 300 x 300 mm and larger size minimum reduction ratio to be 2.5:1 or prior permission of purchaser, if it is less, (d) conditioning of foreging stock for removal of surface defects depth of conditioning shall not exceed 1 mm for every 15 mm of the dimension concerned, subject to max depth of 20 mm 9 grades based on increasing C content S & P - 04/max (minimum carbon 0.10% and max 0.70%).

Al % 0.02 to 0.05 for Al killed steel size tolerances as per IS:9684 and IS:3739 for forgings and IS:1852 for rolling, various mechanical and NDT tests including blue fracture for the soundness and grain size specified.

SALIENT FEATLRE FOR IS :1079--88 AND IS:513, THE HOT ROLLED
AND COLD ROLLED CARBON STEEL SHEETS AND STRIPS RESPECTIVELY

S & P content for DD and EDD grades. 0.035% and 0.0307 max respectively and for 0 grade - 0.055 max. N content - 0.0127 max, Al% min 0.02 for Al killed.

For thickness 0.71 mm and less and for pack rolled sheets of grade '0', the P content related to 0.12%.

In case of cold rolled sheets, tempers to be controlled by Heavy Cold Rolling (Hard', Cold Rolling + Annealing (Half Hard), Skin passed etc.

Salient features for Case
Hardening Steel to IS:4432-88

Steel' fully killed, C.0 steels and reduction ratio between cast and final product as per agreement between the manufacturer and purchasers. The steel required to be free from surface and internal defects. The methods and the extent of the agreement between manufacturers and purchasers.

S & P content - Limit 1 : 0.045% max
Limit 2 : 0.02-0.035
Limits for residual elements specified

Temperature fc: hot working and heat treatment, quenching medium recommended. Grai7. size of the finished product provided inclusion rating, hardenabili:y and mechanical properties specified/recommended.

SCOPE OF INDIAN STANDARDS IN PROCESS
CONTROL MEASURES FOR WROUGHT STEELS

- (a) Steel Manufacture: Methods to be adopted provided viz IS:1875 use of OH, EF basic oxygen and combination.
IS:7291 (H.S steel): Use of EF only specified. In certain cases some processes are banned viz in IS:2062 bessemer process. In some cases like IS:9516 (H .R steel), it is left on the discretion of manufacturer.
- (b) (i) Operational controls in the mechanical processing, however, is kept open to the manufacturer to suit their mills, some general controls are specified namely as in IS:11169 (Pt.?). Minimum cross section of ingots to be used specified as 200 x 200 mm, for CC billets, minimum reduction ratio 20:1 to the finished product stipulated

(ii) In some standards like IS:1786-85, option of producing bars by hot rolling/thermomechanical treatment or cold working provided.

(iii) Design aspects are also left open and at times subject to the agreement between manufacturer and purchasers stipulation, however, provided in respect to certain properties on which the design would have bearing namely in case of IS :1786, the deformation pattern are required to be such that they provide a minimum projected area (Ar) so that the bond strength is 40% more than the plain bars of **equivalent** diameter, atleast.

(iv) In case of heat treatable steel and highly alloyed steels, hot working heat treatment, temperatures, rate of heating and or cooling, quenching medium, tempering temperature etc have been recommended, for example, as in IS:1875, IS:4432, IS:5517, IS:7291 etc.
- (c) Size tolerances of the material to be finished **in all the cases** stipulated.
- (d) Manufacturers normally are required to work out the respective process control schedules subject to the condition as specified and **in** some cases, there are provision that they are to keep purchasers informed about them.

Some of the other features regarding quality of the steel have **already been mentioned** in Annexures-V and VI.

CODE OF PRACTICE FOR HOT DIP ALUMINIZING
OF IRON AND STEEL -- IS:8508-77

Salient feature of the standard for a sound coating for protection from atmospheric corrosion

Rinsing	: Hot water - 60°C
Pickling	: HCl CrH ₂ SO ₄ solution (105 g/l) 60-80°C. Use of inhibitor Rhodine (0.27 m/v)
Rinsing	: Running water
Preflexing	: Potassium fluoride solution (10% m/v)
Aluminising	: Immediate after fluxing. Purity of Al% 99 as per IS:2590. Bath temp. specified

Precautions namely: Settling of dross, rate of immersion method of withdrawal, cooling, centrifuging etc specified.

There is an appendix giving the details of defects, causes and recommended actions.

An example of dimensional tolerance for strips as IS:1852.

Width		Tolerance	Total margin
Over (mm)	Up to and including (mm)	(mm)	(mm)
160		+ 1.25	2.5
1250		+ 8.0	8.0

Trimmed edges: THICKNESS - The tolerance on thickness for strip up to and including 500 mm width:

Width		Tolerance on thickness
Over (mm)	Up to and including (mm)	(mm)
200		+ 0.20
400	500	= 0.30