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DRAFT EAST AFRICAN STANDARD

High-Strength Low-Alloy Steel (HSLA) for hot rolled sheet and cold rolled sheet — Specification

EAST AFRICAN COMMUNITY

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Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in the East African Community. It is envisaged that through harmonized standardization, trade barriers that are encountered when goods and services are exchanged within the Community will be removed.

In order to achieve this objective, the Community established an East African Standards Committee mandated to develop and issue East African Standards.

The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the procedures of the Community.

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

EAS 196 was prepared by Technical Committee EASC/TC 035, *TC Steel and Steel Products*.

This third edition cancels and replaces the second edition (EAS 196:2014).

High-strength low-alloy Steel (HSLA) for hot rolled sheet and cold rolled sheet — Specification

1 Scope

1.1 This East African Standard specifies the requirements for steel sheet in coils and cut lengths for high-strength low-alloy steel (HSLA) supplied as hot-rolled sheet and cold-rolled sheet.

1.2 For the purposes of determining conformance with this specification and the various material specifications, values shall be rounded to the nearest unit in the right-hand place of figures used in expressing the limiting values.

1.3 For the purposes of determining conformance with this product specification, measured values, calculated values, or observed values shall be rounded to the nearest unit in the right hand place of figures used in expressing the limiting values.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 437, *Steel and cast iron — Determination of total carbon content — Combustion gravimetric method*

ISO 439, *Steel and iron — Determination of total silicon content — Gravimetric method*

ISO 629, *Steel and cast iron — Determination of manganese content — Spectrophotometric method*

ISO 671, *Steel and cast iron — Determination of sulphur content — Combustion titrimetric method ISO 4829-1 Steel and cast iron — Determination of total silicon content — Reduced molybdosilicate spectrophotometric method — Part 1: Silicon contents between 0.05 and 1.0 %*

ISO 4829-1, *Steel and cast iron — Determination of total silicon content — Reduced molybdosilicate spectrophotometric method — Part 1: Silicon contents between 0.05 and 1.0 %*

ISO 4829-2, *Steel and iron — Determination of total silicon content — Reduced molybdosilicate spectrophotometric method — Part 2: Silicon contents between 0.01 and 0.05 %*

ISO 4943, *Steel and cast iron — Determination of copper content — Flame atomic absorption spectrometric method*

ISO 10714, *Steel and iron — Determination of phosphorus content — Phosphovanadomolybdate spectrophotometric method*

ISO 14284; *Steel and iron — sampling and preparation of samples for the determination of chemical composition*

3 Terminology

3.1 High-strength low-alloy steel

The specific group of steels in which higher strength, and in some cases additional resistance to atmospheric corrosion or improved formability, are obtained by moderate amounts of one or more alloying elements.

3.2 Hot-rolled sheet

Sheet manufactured by hot rolling slabs in a continuous mill to the required thickness and shall be supplied in coils or cut lengths as specified.

Table 1 (a) Hot-rolled high-strength low-alloy steel (HSLA) sheet in coils and cut lengths

Dimensions in millimetres

Width, w	Thickness, x
All widths[A]	0.8 to 6.0, excl
[A] Hot-rolled sheet in coils and cut lengths less than 300 mm in width must have cut edges. Hot-rolled material with mill edges 300 mm and less in width is considered hot-rolled strip.	

3.3 Cold-rolled sheet

Sheet manufactured from hot-rolled descaled coils by cold reducing to the desired thickness, generally followed by annealing to recrystallize the grain structure. If the sheet is not annealed after cold reduction it is known as full hard with a hardness of 84 HRB minimum and shall be used for certain applications where ductility and flatness are not required.

Cold-rolled high-strength, low-alloy sheet is commonly classified by size as follows:

Table 1 (b) Cold-rolled high strength, low-alloy carbon sheet

Dimensions in millimetres

Width, mm	Thickness, mm
To 300, incl[A]	0.5 to 2.0, incl
Over 300[B]	0.5 and Over
[A] Cold-rolled sheet coils and cut lengths, slit from wider coils with cut edge (only) and in thicknesses 0.4826 mm. [0.5 mm] through 0.082 mm. [2.0 mm] carbon 0.25 % maximum by cast analysis.	
[B] When no special edge or finish (other than matte, commercial bright, or luster finish) or single strand rolling of widths, or both under 24 mm. [600 mm] is not specified or required.	

3.4 Retests

An additional test, or tests, made from the original material when the original test did not meet the appropriate acceptance criteria required by a product specification and the failure was mechanical in nature.

3.5 Resample

An additional test or tests made when the test on the original sample did not meet the appropriate acceptance criteria required by the product specification, but possibly requiring that the material in question have an appropriate amount discarded prior to securing the new sample or samples.

3.6 Steel manufacturer

The organization that directly controls or is responsible for the melting and refining of steel and the conversion of that steel into semi-finished steel products known as slabs either through continuous casting, conventionalor compact methods, or ingot casting and subsequent conversion of the ingots to slabs, and for one or more additional operations such as testing, marking, loading for shipment, and certification.

3.7 Coil processor
the organization that directly controls or is responsible for operations involved in processing the coil such as leveling, cutting to length, testing, inspection, blanking, slitting, pickling, cold rolling (cold reduction), heat treating, temper rolling, coating, packaging, marking, loading for shipment, and certification.

3.8 Hot roll manufacturer
the organization that directly controls or is responsible for the conversion of steel slabs, by hot-rolling into coils, and for one or more additional operations such as leveling, cutting to length, testing, inspection, blanking, slitting, pickling, cold rolling, heat treating, coating, packaging, marking, loading for shipment, and certification.

3.9 Cold roll manufacturer
the organization that directly controls or is responsible for the conversion of hot roll coils into cold roll coils, and for one or more additional operations such as pickling, annealing, temper rolling, slitting, cutting to length, testing, inspection, blanking, coating, packaging, marking, loading for shipment, and certification.

4. Materials and Manufacture

4.1 Unless otherwise specified, hot-rolled material shall be furnished hot-rolled, not annealed, not pickled.

4.2 Coil breaks, stretcher strains, and fluting can occur during the user's processing of hot-rolled or hot-rolled pickled sheet. When any of these features are detrimental to the application, the manufacturer shall be notified at time of ordering in order to properly process the sheet.

4.3 Unless specified as a full-hard product, cold-rolled sheet is annealed after being cold reduced to thickness. The annealed, cold-rolled sheet can be used as annealed last (dead soft) for unexposed end-use applications. When cold-rolled sheet is used for unexposed applications and coil breaks are a hazard in uncoiling, it may be necessary to further process the material. In this case the manufacturer should be consulted. After annealing, cold-rolled sheet is generally given a light skin pass to impart shape or may be given a heavier skin pass or temper pass to prevent the phenomenon known as stretcher straining or fluting, when formed. Temper passing also provides a required surface texture.

4.4Temper Rolling:
4.4.1 Unless otherwise specified, cold-rolled sheet for exposed applications shall be temper rolled and is usually specified and furnished in the strain free condition as shipped.
4.4.2 Cold-rolled sheet for unexposed applications may be specified and furnished "annealed last" or "temper rolled." "Annealed last" is normally produced without temper rolling but may be lightly temper rolled during oiling or rewinding. Unexposed temper-rolled material may be specified strain-free or nonfluting. Where specific hardness range or limit or a specified surface texture is required, the application is considered as exposed.

5. Chemical Composition

5.1 Limits

5.1.1 Where the material is used for fabrication by welding, care must be exercised in selection of chemical composition or mechanical properties to assure compatibility with the welding process and its effect on altering the properties.

5.2 Cast or Heat Analysis:

5.2.1 An analysis of each cast or heat of steel shall be made by the steel manufacturer to determine the percentage of elements specified or restricted by the applicable specification.

5.2.2 When requested, cast or heat analysis for elements listed or required shall be reported to the purchaser or to his representative. The steel manufacturer, or the hot roll manufacturer, cold roll manufacturer, or processor, if different from the steel manufacturer, is responsible for providing this information to the purchaser or his representative as requested.

5.3 Product, Check, or Verification Analysis

5.3.1 Non-killed steels such as capped or rimmed steels are not technologically suited to product analysis due to the non-uniform character of their chemical composition; therefore, the tolerances in Table 2 do not apply. Product analysis is appropriate on these types of steel only when misapplication is apparent or for copper when copper steel is specified.

5.3.2 For steels other than non-killed (capped or rimmed), product analysis may be made by the purchaser. The chemical analysis shall not vary from the limits specified by more than the amounts in Table 2. The several determinations of any element in a cast shall not vary both above and below the specified range.

Table 2 - HSLA Steel Grade Composition

Grade	% Carbon (max)	% Manganese (max)	% Phosphorus (max)	% Sulfur (max)	% Silicon (max)	Notes
942X	0.21	1.35	0.04	0.05	0.90	Niobium or vanadium treated
945A	0.15	1.00	0.04	0.05	0.90	
945C	0.23	1.40	0.04	0.05	0.90	
945X	0.22	1.35	0.04	0.05	0.90	Niobium or vanadium treated
950A	0.15	1.30	0.04	0.05	0.90	
950B	0.22	1.30	0.04	0.05	0.90	
950C	0.25	1.60	0.04	0.05	0.90	
950D	0.15	1.00	0.15	0.05	0.90	
950X	0.23	1.35	0.04	0.05	0.90	Niobium or vanadium treated
955X	0.25	1.35	0.04	0.05	0.90	Niobium, vanadium, or nitrogen treated
960X	0.26	1.45	0.04	0.05	0.90	Niobium, vanadium, or nitrogen treated
965X	0.26	1.45	0.04	0.05	0.90	Niobium, vanadium, or nitrogen treated
970X	0.26	1.65	0.04	0.05	0.90	Niobium, vanadium, or nitrogen treated
980X	0.26	1.65	0.04	0.05	0.90	Niobium, vanadium, or nitrogen treated

5.4 Sampling for Product Analysis

5.4.1 To indicate adequately the representative composition of a cast by product analysis, it is general practice to select samples to represent the steel, as fairly as possible, from a minimum number of pieces as follows: 3 pieces for lots up to 15 tons and 6 pieces for lots over 15 tons.

5.4.2 When the steel is subject to tension test requirements, samples for product analysis may be taken either by drilling entirely through the used tension test specimens themselves, or as covered in 5.4.3.

5.4.3 When the steel is not subject to tension test requirements, the samples for analysis must be taken by

milling or drilling entirely through the sheet in a sufficient number of places so that the samples are representative of the entire sheet or strip. The sampling may be facilitated by folding the sheet both ways, so that several samples may be taken at one drilling. Steel subjected to certain heating operations by the purchaser may not give chemical analysis results that properly represent its original composition. Therefore, users must analyze chips taken from the steel in the condition in which it is received from the steel manufacturer.

5.5 Specimen Preparation

Drillings or chips must be taken without the application of water, oil, or other lubricant, and must be free of scale, grease, dirt, or other foreign substances. They must not be overheated during cutting to the extent of causing decarburization. Chips must be well mixed and those too coarse to pass a No. 10 sieve or too fine to remain on a No. 30 sieve are not suitable for proper analysis.

5.6 Test Methods
Chemical analysis must be in accordance with any Standard Test Methods.

6. Mechanical Properties

6.1 The mechanical property requirements shall be in accordance with Table 3.

6.2 Unless otherwise specified in the applicable product specification, test specimens must be prepared in accordance with any Standard Test Methods and Definitions. Also the number of specimens, test locations, and specimen orientation shall be in accordance with the applicable product specification.

6.3 Mechanical tests shall be conducted in accordance with any Standard Test Methods.

6.4 Bend tests where required shall be conducted in compliance with any Standard Test Methods

6.5 To determine conformance with the product specification, a calculated value should be rounded to the nearest 6.9 MPa tensile strength and yield point or yield strength, and to the nearest unit in the right-hand place of figures used in expressing the limiting value for other values.

6.6 Structural sheet steels are commonly fabricated by cold bending. There are many interrelated factors that affect the ability of given steel to cold form over a given radius under shop conditions. These factors include thickness, strength level, and degree of restraint, relationship to rolling direction, chemistry, and microstructure. These radii should be used as minima for 90° bends. They presuppose “hard way” bending (bend axis parallel to rolling direction) and reasonably good shop forming practices. Where possible, the uses of larger radii or “easy way” bends are recommended for improved performance.

6.7 Fabricators should be aware that cracks may initiate upon bending a sheared or burned edge. This is not considered to be a fault of the steel but is rather a function of the induced cold-work or heat-affected zone.

Table 3 - Mechanical Properties for HSLA Steel Grades

Grade	Form	Yield strength (min) [MPa]	Ultimate tensile strength (min) [MPa]
942X	Plates, shapes & bars up to 101.6 mm.	290	414
945A, C	Sheet & strip	310	414
	Plates, shapes & bars:		
	0 – 12.7 mm.	310	448
	12.7 – 38.1 mm.	290	427
	38.1 – 76.2 mm.	276	427
945X	Sheet, strip, plates, shapes & bars up to 38.1 mm.	310	414
950A, B, C, D	Sheet & strip	345	483
	Plates, shapes & bars:		
	0 – 12.7 mm.	345	483
	12.7 – 38.1 mm.	310	462
	38.1 – 76.2 mm.	290	434
950X	Sheet, strip, plates, shapes & bars up to 38.1 mm.	345	448
955X	Sheet, strip, plates, shapes & bars up to 38.1 mm.	379	483
960X	Sheet, strip, plates, shapes & bars up to 38.1 mm.	414	517
965X	Sheet, strip, plates, shapes & bars up to 19.05 mm.	448	552
970X	Sheet, strip, plates, shapes & bars up to 19.05 mm.	483	586
980X	Sheet, strip & plates up to 9.525 mm.	552	655

7. General Requirements for Delivery

7.1 The products covered by this specification are produced to inch-pound or metric decimal thickness only and the appropriate thickness tolerances apply.

7.2 Steel may be produced as ingot-cast or strand-cast. When different grades of strand-cast steel are sequentially cast, identification and separation of the transition material is required.

8. Dimensions, Tolerances, and Allowances

8.1 Dimensions, tolerances, and allowances applicable to products covered by this specification are contained in Tables 4-20. The appropriate tolerance tables shall be identified in each individual specification.

TABLE 4 - List of Tables for Dimensions, Tolerances, and Allowances

High-Strength Low-Alloy Steel				
Dimensions	**Table No.**			
	Hot-Rolled Sheet		**Cold-Rolled Sheet**	
	SI Units	**SI Units**	**SI Units**	**SI Units**
Camber tolerances	10	A1.7	10, 19	A1.7, A1.16
Diameter tolerances of sheared circles	9	A1.6	9	A1.6
Flatness tolerances	13, 14	A1.10, A1.11	20	A1.17
Length tolerances	8	A1.5	16, 17	A1.13, A1.14
Out-of-square tolerances	11	A1.8	11	A1.8
Restricted squareness tolerances	12	A1.9	12	A1.9
Thickness tolerances	5, S1.2	A1.2, S1.5	15, S1.3	A1.12, S1.6
Width tolerances of cut edge	7	A1.4	7, 18	A1.4, A1.15
Width tolerances of mill edge	6	A1.3	. . .	. . .

TABLE 5 Thickness Tolerances for Hot-Rolled Sheet (High-Strength, Low-Alloy Steel) — 15.875 mm. (Cut Edge) and 25.4 mm. (Mill Edge) Minimum Edge Distance
(Coils and Cut Lengths, Including Pickled)

Specified Width, mm.	**Specified Ordered Thickness, mm.[A]**						
	0.7874 <X≤1.2954,	**1.2954 <X≤1.4986,**	**1.4986 <X≤1.778**	**1.778 <X≤2.0828**	**2.0828 <X≤2.4892**	**2.4892 <X≤4.572,**	**4.572 <X≤5.842**
	Thickness Tolerances All Over, mm., No Tolerance Under[B]						
≤ 381	0.2032	0.2286	0.2286	0.2286	0.2286	0.254	0.254
381 <X≤ 508	0.2032	0.228	0.254	0.254	0.254	0.3048	0.3048
508 <X≤ 812.8	0.228	0.228	0.254	0.254	0.254	0.3048	0.3556
812.8 <X≤ 1016	0.228	0.228	0.254	0.254	0.3048	0.3048	0.3556
1016<X≤1219.2	0.228	0.254	0.254	0.254	0.3048	0.381	0.381
1219.2<X≤1524	. . .[C]	0.254	0.254	0.254	0.3048	0.381	0.381
1524<X≤1828.8	. . .[C]	. . .[C]	0.3048	0.3048	0.3556	0.4064	0.4064
1828.8<X≤2032	. . .[C]	. . .[C]	. . .[C]	0.3048	0.3556	0.4572	0.4572
> 2032	. . .[C]	. . .[C]	. . .[C]	. . .[C]	0.381	0.4572	0.4572[C]

[A] The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.
[B] The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance is divided equally over and under.
[C] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

TABLE 6 Width Tolerances[A] of Hot-Rolled Mill Edge Sheet (All Designations)
(Coils and Cut Lengths, Including Pickled)

High-Strength Low-Alloy	
Specified Width, mm.	**Tolerances Over Specified Width, mm. No Tolerance Under**
304.8 <X≤ 355.6	11.1125
355.6 <X≤ 431.8	12.7
431.8 <X≤ 482.6	14.2875
482.6 <X≤ 533.4	15.875
533.4 <X≤ 609.6	17.4625
609.6 <X≤ 660.4	20.6375
660.4 <X≤ 711.2	23.8125
711.2 <X≤ 889	28.575
889 <X≤ 1270	31.75
1270 <X≤ 1524	38.1
1524 <X≤ 1651	41.275
1651 <X≤ 1778	44.45
1778 <X≤ 2032	47.625
> 2032	50.8
[A] The above tolerances do not apply to the uncropped ends of mill edge coils (10.1.1.1).	

TABLE 7 Width Tolerances of Hot-Rolled Cut Edge Sheet (All Widths) and Cold-Rolled Sheet (Widths Over 304.8 mm. Only)—(All Designations)[A]
(Coils and Cut Lengths, Including Pickled)

Specified Width, mm.	**Tolerances Over Specified Width, mm. No Tolerance Under**
≤ 762 incl[A]	3.175
762 <X≤ 1219.2	4.7625
1219.2 <X≤ 1524	6.35
1524 <X≤ 2032	7.9375
> 2032	9.525
[A] Cold Rolled widths 304.8 mm. and less refer to Table 18.	

TABLE 8 Length Tolerances of Hot-Rolled Sheet (All Designations)
(Cut Lengths, Including Pickled)

Specified Length, mm.	Tolerances Over Specified Length, mm. No Tolerance Under
≤ 381	3.175
381 <X≤ 762	6.35
762 <X≤ 1524	12.7
1524 <X≤ 3048	19.05
3048 <X≤ 3962.4	25.4
3962.4 <X≤ 4876.8	31.75
4876.8 <X≤ 6096	38.1
> 6096	44.45

TABLE 9 Diameter Tolerances of Circles Sheared from Hot-Rolled (Including Pickled) and Cold-Rolled Sheet (Over 304.8 mm. Width) (All Designations)

Specified Thickness, [A] mm.	Tolerances Over Specified Diameter, mm. (No Tolerances Under)		
	≤ 762	762 <X≤ 1219.2	> 1219.2
1.1176 <X≤ 1.4478	1.5875	3.175	4.7625
1.4478 <X≤ 2.4892	2.38125	3.96875	5.55625
> 2.4892	3.175	4.7625	6.35
[A] 1.8034 mm. minimum thickness for hot-rolled high-strength low-alloy steel sheet.			

8.2 The appropriate thickness tolerance tables for measurements taken 10 mm from the edge are found in Section S1 of the Supplementary Requirements in this specification. See the appropriate product specification for instructions on how to specify.

8.3 When thickness is measured using hand held micrometers make sure all standard procedures for taking measurement are adhered to including instrument checking for zero error and other defaults, holding position etc. Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 480 mm. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 2.55 mm. Micrometers with pointed tips are not suitable for thickness measurements.

8.4 Flatness Tolerances
8.4.1 Standard flatness tolerances are contained in Tables 13 and 14 for hot-rolled sheet and Table 20 for cold-rolled sheet.
8.4.2 Measurement techniques for flatness characteristics are described in Annex B.
8.4.3 Two alternative methods for flatness determination are the use of I-units and percent steepness. A description of these two alternative methods is contained in Annex B.
8.4.3.1 The use of I-units or percent steepness as a flatness standard is subject to negotiation between the purchaser and the producer.
8.4.3.2 Measurement techniques for I-units, percent steepness, and rejection limits are subject to negotiation between the purchaser and the producer.

9 Finish and Condition

9.1 Hot-rolled sheet has a surface with an oxide or scale resulting from the hot-rolling operation. The oxide or scale can be removed by pickling or blast cleaning when required for press-work operations or welding. Hot-rolled and hot-rolled descaled sheet is not generally used for exposed parts where surface is of prime importance.
9.1.1 Hot-rolled sheet can be supplied with mill edges or cut edges as specified. Mill edges are the natural edges resulting from the hot-rolling operation. They do not conform to any particular contour. They may also contain some edge imperfections, the more common types of which are cracked edges, thin edges (feather), and damaged edges due to handling or processing and which should not extend in beyond the ordered width. These edge conditions are detrimental where joining of the mill edges by welding is practiced. When the purchaser intends to shear or to blank, a sufficient width allowance should be made when purchasing to ensure obtaining the desired contour and size of the pattern sheet. The manufacturer may be consulted for guidance. Cut edges are the normal edges which result from the shearing, slitting, or trimming of mill-edge sheet.
9.1.1.1 The ends of plain hot-rolled mill-edge coils are irregular in shape and are referred to as uncropped ends. Where such ends are not acceptable, the purchaser's order should so specify. Processed coils such as pickled or blast cleaned are supplied with square-cut ends.

9.2 Cold-rolled carbon sheet (exposed) is intended for those applications where surface appearance is of primary importance. This class will meet requirements for controlled surface texture, surface quality, and flatness. It is normally processed by the manufacturer to be free of stretcher strain and fluting.
Subsequent user roller leveling immediately before fabrication will minimize strain resulting from aging.
9.2.1 Cold-rolled carbon sheet, when ordered for exposed applications, can be supplied in the following finishes:
9.2.1.1 Matte finish is a dull finish, without luster, produced by rolling on rolls that have been roughened by mechanical or chemical means to various degrees of surface texture depending upon application. With some surface preparation matte finish is suitable for decorative painting. It is not generally recommended for bright plating.

9.2.1.2 Commercial bright finish is a relatively bright finish having a surface texture intermediate between that of matte and luster finish. With some surface preparation commercial bright finish is suitable for decorative painting or certain plating applications. If sheet is deformed in fabrication the surface may roughen to some degree and areas so affected will require surface preparation to restore surface texture to that of the undeformed areas.

9.2.1.3 Luster finish is a smooth bright finish produced by rolling on ground rolls and is suitable for decorative painting or plating with additional special surface preparation by the user. The luster may not be retained after fabrication; therefore, the formed parts will require surface preparation to make them suitable for bright plating.

TABLE 10 - Camber Tolerances[A] for Hot-Rolled (Including Pickled) and Cold-Rolled Sheet (All Designations) (Cut Lengths)

NOTE 1—Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straightedge.

Cut Length, mm	Camber Tolerances, mm.
≤ 1219.2	3.175
1219.2 <X≤ 1828.8	4.7625
1828.8 <X≤ 2438.4	6.35
2438.4 <X≤ 3048	7.9375
3048 <X≤ 3657.6	9.525
3657.6 <X≤ 4267.2	12.7
4267.2 <X≤ 4876.8	0.625
4876.8 <X≤ 5486.4	19.05
5486.4 <X≤ 6096	0.875
6096 <X≤ 9144	31.75
9144 <X≤ 12192	38.1
[A] The camber tolerance for coils is 25.4 mm. in any 6096 mm.	

TABLE 11 Out-of-Square Tolerances of Hot-Rolled Cut-Edge (Including Pickled) and Cold-Rolled Sheet (All Designations) (Cut Lengths)

Out-of-square is the greatest deviation of an end edge from a straight line at right angle to a side and touching one corner. It is also obtained by measuring the difference between the diagonals of the cut length. The out-of-square deviation is one half of that difference. The tolerance for all thicknesses and all sizes is 1.5875mm./ 152.4 mm. of width or fraction thereof.

TABLE 12 Restricted Squareness Tolerances of Hot-Rolled (Including Pickled) and Cold-Rolled Sheet (All Designations) (Cut Lengths)

When cut lengths are specified restricted squareness, the width and the length are not less than the dimensions specified. The individual tolerance for over-width, over-length, camber, or out-of-square should not exceed 1.5875 mm. up to and including 1219.2 mm. in width and up to and including 3048 mm. in length. For cut lengths wider or longer, the applicable tolerance is 3.175 mm.

9.4 Cold-rolled high-strength low-alloy sheet is supplied with a matte finish, unless otherwise specified.

9.5 The cold-rolled products covered by this specification are furnished with cut edges and square cut ends, unless otherwise specified.
9.5.1 The term cut edge refers to the edge resulting from trimming the hot-rolled mill edge that is formed during the hot-rolling process. At the producer's option, the edge shall be trimmed at any process step after the hot-rolling process step to the final process step.
9.5.1.1 The term slit last edge is a cut edge that was edge-trimmed at the final process step.
(1) If the purchaser requires the edge to be trimmed at the final process step, the term slit last edge shall be shown on the purchase order.

(2) If the producer decides to trim the edge at the final process step, without being required by the purchaser, the term slit last edge is not required, since this condition falls under the term cut edge as described in 9.5.1.

TABLE 13 Flatness Tolerances[A] of Temper Rolled or Pickled Hot-Rolled Sheet Cut Lengths[B] (All Designations)

Specified Minimum Thickness, mm.	Specified Width, mm.	Flatness Tolerances, C mm.			
		Specified Yield Strength, min, MPa			
		< 310	310 <X≤ 380[D]	380 <X≤ 550[D]	550 <X≤ 690[D]
0.6858 <X≤ 1.4478	≤ 914.4	12.7	19.0	25.4	31.75
	914.4 <X≤ 1524	19.0	28.575	38.1	44.45
	> 1524	25.4	. . .	44.45	50.8
1.4478 <X< 4.572	≤ 1524	12.7	19.0	25.4	31.75
	1524<X≤ 1828.8	19.0	28.575	38.1	44.45
	> 1828.8	25.4	38.1	44.45	50.8
4.572 <X< 5.842	≤ 1524	12.7	19.0	25.4	31.75
	1524<X≤ 1828.8	19.0	28.575	38.1	44.45
	> 1828.8	25.4	38.1	44.45	50.8

[A] The above table also applies to lengths cut from coils by the consumer when adequate flattening operations are performed.
[B] Application of this table to product in coil form is not appropriate unless the coil has been rolled out and adequately flattened with all coil set removed.
[C] Maximum deviation from a horizontal flat surface.
[D] 0.071 minimum thickness of HSLA.
[E] The term Levelled also includes but is not limited to Tension Levelled, Stretcher Levelled, Roller Levelled, & Z-Mill

TABLE 14 Flatness Tolerances[A] of Non-Processed Hot-rolled Sheet Cut Lengths[B] (All Designations)

Specified Minimum Thickness, mm.	Specified Width, mm.	Flatness Tolerances, C mm.			
		Specified Yield Strength, min, MPa			
		< 310	310 <X≤ 380[D]	380 <X≤550[D]	550 <X≤ 690[D]
0.6858< X ≤ 1.4478	304.8 <X≤ 914.4	38.1	57.15	63.5	69.85
	914.4 <X≤ 1524	57.15	85.725	88.9	95.25
	> 1524	76.2	. . .	120.65	127
1.4478 < X < 4.572	304.8 <X≤ 1524	38.1	57.15	63.5	69.85
	1524 <X≤ 1828.8	57.15	85.725	88.9	95.25
	> 1828.8	76.2	114.3	120.65	127
4.572 < X < 5.842	304.8 <X≤ 1524	38.1	57.15	63.5	69.85
	1524 <X≤ 1828.8	57.15	85.725	88.9	95.25
	> 1828.8	76.2	114.3	120.65	127

[A] The above table also applies to lengths cut from coils by the consumer when adequate flattening operations are performed.
[B] Application of this table to product in coil form is not appropriate unless the coil has been rolled out and adequately flattened with all coil set removed.
[C] Maximum deviation from a horizontal flat surface.
[D] 0.071 minimum thickness of HSLA.

9.6 Oiling
9.6.1 Plain hot-rolled sheet is customarily furnished not oiled. Oiling must be specified, when required.
9.6.2 Hot-rolled pickled or descaled sheet is customarily furnished oiled. If the product is not to be oiled, it must be so specified since the cleaned surface is prone to rusting.
9.6.3 Cold-rolled products covered by this specification can be furnished oiled or not oiled as specified.

9.7 Sheet steel in coils or cut lengths may contain surface imperfections that can be removed with a reasonable amount of metal finishing by the purchaser.

10. Workmanship

10.1 Cut lengths shall have a workmanlike appearance and shall not have imperfections of a nature or degree for the product, the grade, class, and the quality ordered that will be detrimental to the fabrication of the finished part.
10.2 Coils may contain some abnormal imperfections that render a portion of the coil unusable since the inspection of coils does not afford the producer the same opportunity to remove portions containing imperfections, as in the case with cut lengths.

10.3 Surface Conditions:
10.3.1 Exposed cold-rolled sheet is intended for applications where surface appearance is of primary importance, that is, exposed applications. Unexposed or annealed cold-rolled sheet is intended for applications where surface appearance is not of primary importance, that is, unexposed applications.
10.3.2 Cut lengths for exposed applications shall not include individual sheets having major surface imperfections (holes, loose slivers, and pipe) and repetitive minor surface imperfections. Cut lengths may contain random minor surface imperfections that can be removed with a reasonable amount of
metal finishing by the purchaser. These imperfections shall be acceptable to the purchaser within the manufacturer's published standards.
10.3.3 For coils for exposed applications, it is not possible to remove the surface imperfections listed in 10.3.2. Coils will contain such imperfections which shall be acceptable to the purchaser within the manufacturer's

published standards. Coils contain more surface imperfections than cut lengths because the producer does not have the same opportunity to sort portions containing such imperfections, as is possible with cut lengths.
10.3.4 Cut lengths for unexposed applications shall not include individual sheets having major surface imperfections such as holes, loose slivers, and pipe. In addition, unexposed cut lengths can be expected to contain more minor imperfections such as pits, scratches, sticker breaks, edge breaks, pinchers, cross breaks, roll marks, and other surface imperfections than exposed. These imperfections shall be acceptable to the purchaser without limitation.
10.3.5 For coils for unexposed applications, it is not possible to remove the surface imperfections listed in 10.3.4. Coils will contain surface imperfections that are normally not repairable. Minor imperfections shall be acceptable to the purchaser within the manufacturer's published standards. Unexposed coils contain more surface imperfections than exposed coils.

TABLE 15 Thickness Tolerances for Cold-Rolled Sheet (All Designations)[A] —25.4-mm. Minimum Edge Distance (Coils and Cut Lengths)
NOTE 1—Thickness is measured at any point across the width not less than 25.4 mm. from a side edge.

NOTE 2—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of mm. 4.80 mm. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of mm. 2.55 mm. Micrometers with pointed tips are not sui for thickness measurements.

NOTE 3—The thickness of material <50.8 mm. wide shall be measured at mid-width.

Specified Width, mm.	**Specified Ordered Thickness, mm.[B]**						
	< 0.3556	**0.3556 <X≤ 0.4826**	**0.4826[A] <X≤ 0.9906**	**0.9906 < X≤ 1.4478**	**1.4478 <X≤ 1.8034**	**1.8034 <X≤ 2.4892**	**2.4892 <X≤ 3.6068**
	Thickness Tolerances, Over, mm., No Tolerance Under[C]						
≤ 381	0.0254	0.0508	0.0762	0.1016	0.127	0.127	0.127
381<X≤1828.8	0.0254	0.0508	0.0762	0.1016	0.127	0.127	0.1524
> 1828.8	. . .[D]	. . .[D]	0.0762	0.1016	0.127	0.1524	0.1778

[A] Minimum Thickness, 0.5334 mm. for high-strength, low-alloy.
[B] The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.
[C] The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance is divided equally over and under.
[D] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

TABLE 16 Length Tolerances of Cold-Rolled Sheet (All Designations) (Cut Lengths Over 304.8 mm. in Width)

Specified Length, mm.	**Tolerances Over Specified Length, mm. No Tolerances Under**
304.8 <X≤ 762	3.175
762 <X≤ 1524	6.35
1524 <X≤ 2438.4	12.7
2438.4 <X≤ 3048	19.0
3048 <X≤ 3962.4	25.4
3962.4 <X≤ 4876.8	31.75
4876.8 <X≤ 6096	38.1
> 6096	44.45

TABLE 17 Length Tolerances of Cold-Rolled Sheet (All Designations)
(Cut Length Sheets, to 304.8 mm. in Width)

NOTE 1—This table applies to widths produced by slitting from wider sheet.

Specified Length, mm.	Tolerances Over Specified Length, mm. No Tolerance Under
609.6 <X≤ 1524	12.7
1524 <X≤ 3048	19.0
3048 <X≤ 6096	25.4

TABLE 18 Width Tolerances for Cold-Rolled Sheet (All Designations)[A]
(Coils and Cut Lengths to 304.8 mm. Width)

Specified Width, mm.	Width Tolerance, Plus and Minus, mm.
≤ 152.4	0.3048
152.4 <X≤ 228.6	0.4064
228.6 <X≤ 304.8	0.8128
[A] 0.508 mm. minimum thickness for high-strength low-alloy.	

TABLE 19 Camber Tolerances of Cold-Rolled Sheet in Coils (All Designations)[A]
(Coils to 304.8 mm. in Width)

NOTE 1—Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straightedge.
NOTE 2—This table applies to widths produced by slitting from wider sheet.

Width, mm.	Camber Tolerance
≤ 304.8	6.35 mm. in any 2438.4 mm
[A] 0.508 mm. minimum thickness for high-strength low-alloy.	

TABLE 20 Flatness Tolerances of Cold-Rolled Sheet Cut Length (All Designations)

NOTE 1—This table does not apply when product is ordered full hard, to a hardness range, or "annealed last" (dead soft).
NOTE 2—This table also applies to lengths cut from coils, when adequate flattening measures are performed to remove all undesirable flatness conditions, including, but not limited to, coil set.

Specified Thickness, mm.	Specified Width, mm.	Flatness Tolerance,[A] mm.	
		Specified Yield Point, min, MPa	
		< 310	310 <X≤ 380[D]
≤ 1.1176	≤ 914.4	9.525	19.0
	914.4 <X≤ 1524	15.875	28.575
	> 1524	22.225	38.1
> 1.1176	≤ 914.4	6.35	19.0
	914.4 <X≤ 1524	9.525	19.0
	1524 <X≤ 1828.8	15.875	28.575
	> 1828.8	22.225	38.1

[A] Maximum deviation from a horizontal flat surface.
[B] Tolerances for high-strength, low-alloy steel with specified minimum yield point in excess of 380 MPa are subject to negotiation.

11. Retests and Disposition of Non-Conforming Material

11.1 Retests

11.1.1 Unless otherwise prohibited by the product specification, retests are permitted under the following circumstances:
11.1.1.1 If any tension test specimen shows defective machining or develops flaws, it must be discarded and another specimen substituted.

11.1.1.2 If the percent elongation of any tension test specimen is less than that specified and any part of the fracture is more than 20 mm from the center of the gauge length of a 50 mm specimen, or is outside the middle half of the gauge length of a 200 mm specimen, as indicated by scribe scratches marked on the specimen before testing, a retest is allowed.

11.1.1.3 If the test result of any tension test specimen fails to meet the specification requirements and the failure is the result of improper adherence to tension test procedures, a retest is permitted.

11.1.1.4 If the test result of an original tension test specimen fails to meet the specification requirements and the failure is not related to the conditions described in 11.1.1.1 – 11.1.1.3, but the results are within 14 MPa of the required yield strength, within 14 MPa of the required tensile strength, or within 2 percentage points of the required elongation, one retest shall be permitted to replace the failing test.

11.1.2 The retest specimen shall be taken either adjacent to the first failed specimen or selected at random from the material to be certified to the specification.

11.1.3 If the results of a retest satisfy the specified tension test requirements and all other requirements of the applicable specification are satisfied, the material shall be accepted.

11.2 Disposition of Non-Conforming Material

11.2.1 In those cases where the lot is found to be nonconforming, and resampling of non-conforming material is not prohibited by the specification, resampling is permitted under the following circumstances and using the following practices:
11.2.1.1 If the results of an original tension test or retest specimen fail to satisfy the specification requirements, and the failed test results are not related to the conditions described in 11.1, the lot shall be quarantined and resampled for certification of the non-conforming material to the specification requirements.

11.2.1.2 Resampling for certification of the non-conforming material shall include the discarding of out-of-specification material and the resampling of the lot. The resampling shall be appropriate to the specific out-of-specification condition and the processing history of the lot.

11.2.1.3 A maximum of two resampling efforts shall be permitted. If after conducting two resampling efforts, the material does not satisfy the specification requirements, the lot shall be rejected.

12. Inspection

12.1 When purchaser's order stipulates that inspection and tests (except product analyses) for acceptance on the steel be made prior to shipment from the mill, the manufacturer shall afford the purchaser's inspector all reasonable facilities to satisfy him that the steel is being produced and furnished in accordance with the specification. Mill inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operation.

13. Rejection and Rehearing

13.1 Unless otherwise specified, any rejection shall be reported to the manufacturer within a reasonable time after receipt of material by the purchaser.
13.2 Material that is reported to be defective subsequent to the acceptance at the purchaser's works shall be set aside, adequately protected, and correctly identified. The manufacturer shall be notified as soon as possible so that an investigation may be initiated.

13.3 Samples that are representative of the rejected material shall be made available to the manufacturer. In the event that the manufacturer is dissatisfied with the rejection, he may request a rehearing.

14. Test Reports and Certification

14.1 When test reports are required by the purchase order or the material specification, the supplier shall report the results of all test required by the material specification and the order.

14.2 The manufacturer or processor shall issue a test report or optional certificate of compliance, or both, when required by the purchase order or the specification.

14.3 The test report shall show the heat analysis and the results of all tests required by the purchase order and seller and by the specification.

14.4 The certificate of compliance shall include a statement that the product was manufactured and tested in accordance with the requirements of the specification and that the test results conform to the requirements of the specification.

NOTE 4—The heat analysis, results of all tests, and the certificate of compliance may be reported separately on in a combined report.

14.5 Steel processors shall pass transfer data supplied by the steel manufacturer provided the processing has not altered the attributes represented. In cases where the steel is retested the processor is responsible for the accuracy of the data and shall maintain traceability back to its source. Retesting for heat analysis shall be

done in accordance with the any Standard Test Methods. The report shall clearly identify the physical product it represents.

14.6 Test reports and certificates of compliance shall provide information necessary to identify the product represented; for example the manufacturer's name or brand, the processor's name or brand or the seller's name or brand, EAS specification number and year date, product designation, type or class, as applicable, and all other information necessary to completely identify the material.

14.7 A signature is not required on test reports or certifications. However, the document shall clearly identify the organization submitting the document. Notwithstanding the absence of a signature, the organization submitting the document is responsible for the content of the document.

14.8 When required, copies of the original material manufacturer's test report shall be included with any subsequent test report.

14.9 A Material Test Report, Certificate of Inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document must meet the requirements of the invoked ASTM standard(s) and conform to any existing EDI agreement between the purchaser and the supplier. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.
14.9.1 The content of the EDI document shall meet all the requirements of 14.3 through 14.6.

NOTE 5—The industry definition as invoked here is: EDI is the computer to computer exchange of business information in an agreed upon standard format.

15. Product Marking

15.1 As a minimum requirement, the material shall be identified by having the manufacturer's name, designation, weight, purchaser's order number, and material identification legibly stenciled on top of each lift or shown on a tag attached to each coil or shipping unit.

15.2 Bar coding is acceptable as a supplementary identification method.

16. Packing and Package Marking

16.1 Unless otherwise specified, the sheet shall be packaged and loaded in accordance with any Standard Practices.

16.2 When coils are ordered, it is customary to specify a minimum or range of inside diameter, maximum outside diameter, and a maximum coil weight, if required. The ability of manufacturers to meet the maximum coil weights depends upon individual mill equipment. When required, minimum coil weights are subject to negotiation.

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the purchase order or contract.

S1. Thickness Tolerances
S1.1 See Tables S1.2-S1.6.

TABLE S1.2 Thickness Tolerances for Hot-Rolled Sheet (High-Strength, Low-Alloy Steel)— 9.525-mm. (Cut Edge) and 19.0-mm. (Mill Edge) Minimum Edge Distance (Coils and Cut Lengths, Including Pickled)

NOTE 1—Thickness is measured at any point across the width not less than 9.525 mm. from a cut edge and not less than 19.0 mm. from a mill edge. This table does not apply to the uncropped ends of mill edge coils.

NOTE 2—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of mm. 4.80 mm. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of mm. 2.55 mm. Micrometers with pointed tips are not suitable for thickness measurements.

NOTE 3—This table was used to construct Table 5 by multiplying the values in this table by 0.75 and rounding to 3 decimal places using standard practice.

NOTE 4—The thickness of material <25.4 mm. wide shall be measured at mid-width.

Specified Width, mm.	**Specified Ordered Thickness, mm.[A]**						
	0.7874 <X≤ 1.2954, incl	**1.2954 <X≤ 1.4986, incl**	**Over 1.4986 <X≤ 1.778, incl**	**Over 1.778 <X≤ 2.0828, incl**	**Over 2.0828 <X≤ 2.4892, incl**	**Over 2.4892 <X≤ 4.572, excl**	**4.572 <X≤ 5.842, excl**
	Thickness Tolerances Over, mm., No Tolerance Under[B]						
≤ 381	0.254	0.254	0.3048	0.3048	0.3556	0.3556	0.3556
381<X≤ 508	0.254	0.254	0.3048	0.3556	0.3556	0.4064	0.4064
508<X≤812.8	0.3048	0.3048	0.3556	0.3556	0.3556	0.4064	0.4572
812.8<X≤1016	0.3048	0.3048	0.3556	0.3556	0.4064	0.4064	0.4572
1016<X≤1219.2	0.3048	0.3556	0.3556	0.3556	0.4064	0.508	0.508
1219.2<X≤1524	. . .[C]	0.3556	0.3556	0.3556	0.4064	0.508	0.508
1524<X≤1828.8	. . .[C]	. . .[C]	0.4064	0.4064	0.4572	0.5588	0.5588
1828.8<X≤2032	. . .[C]	. . .[C]	. . .[C]	0.4064	0.4572	0.6096	0.6096
> 2032	. . .[C]	. . .[C]	. . .[C]	. . .[C]	0.508	0.6096	0.6096[C]

[A] The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.
[B] The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance is divided equally over and under.
[C] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

TABLE S1.3 Thickness Tolerances for Cold-Rolled Sheet (All Designations)[A] —9.525-mm. Minimum Edge Distance (Coils and Cut Lengths)

NOTE 1—Thickness is measured at any point across the width not less than 9.525 mm. from a side edge.

NOTE 2—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 4.80 mm. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 2.55 mm. Micrometers with pointed tips are not suitable for thickness measurements.

NOTE 3—This table was used to construct Table 15 by multiplying the values in this table by 0.50 and rounding to 3 decimal places using standard practice.

NOTE 4—The thickness of material <25.4 mm. wide shall be measured at mid-width.

Specified Width, mm.	Specified Ordered Thickness, mm.[B]						
	< 0.3556,	**0.3556** <X≤ **0.4826**	**0.4826**[A] <X≤ **0.9906**	**0.9906** <X≤ **1.4478**	**1.4478** <X≤ **1.8034,**	**1.8034** <X≤ **2.4892**	**2.4892** <X≤ **3.6068**
	Thickness Tolerances, Over, mm., No Tolerance Under[C]						
≤ 381	0.0508	0.1016	0.1524	0.2032	0.254	0.254	0.254
381 <X≤ 1828.8	0.0508	0.1016	0.1524	0.2032	0.254	0.254	0.3048
> 1828.8	. . .[D]	. . .[D]	0.1524	0.2032	0.254	0.3048	0.3556

[A] Minimum Thickness, 0.5334 mm. for high-strength, low-alloy.
[B] The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.
[C] The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance is divided equally over and under.
[D] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

TABLE S1.5 Thickness Tolerances [Metric] for Hot-Rolled Sheet (High-Strength, Low-Alloy Steel)—10-mm (Cut Edge) and 20-mm (Mill Edge) Minimum Edge Distance (Coils and Cut Lengths, Including Pickled)

NOTE 1—Thickness is measured at any point across the width not less than 10 mm from a cut edge and not less than 20 mm from a mill edge. This table does not apply to the uncropped ends of mill edge coils.

NOTE 2—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 4.80 mm. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 2.55 mm. Micrometers with pointed tips are not suitable for thickness measurements.

NOTE 3—The thickness of material <25 mm wide shall be measured at mid-width.

Specified Width, mm	Specified Ordered Thickness, mm[A]			
	Through 2.0	**2.0 <X≤ 2.5**	**2.5 <X≤ 4.5**	**4.5 <X≤ 6.0**
	Thickness Tolerances Over, mm, No Tolerance Under[B]			
≤ 600	0.30	0.35	0.40	0.40
600 <X≤ 1200	0.35	0.40	0.45	0.50
1200 <X≤ 1500	0.35	0.40	0.50	0.50
1500 <X≤ 1800	0.40	0.45	0.55	0.56
1800 <X≤ 2000	0.40	0.45	0.60	0.60
> 2000	. . .[C]	0.50	0.60	0.60[C]

[A] The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.
[B] The tolerances provided in the table are based on minimum thickness (tolerance over, not tolerance under). For nominal thickness, the tolerance is divided equally over and under.
[C] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

TABLE S1.6 Thickness Tolerances [Metric] for Cold-Rolled Sheet (All Designations)[A] —10-mm Minimum Edge Distance

NOTE 1—Thickness is measured at any point across the width not less than 10 mm from a side edge.

NOTE 2—Widths up to and including 300 mm in this table apply to widths produced by slitting from wider sheet.

NOTE 3—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of mm. 4.80 mm. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 2.55 mm. Micrometers with pointed tips are not suitable for thickness measurements.

NOTE 4—This table was used to construct Table A1.12 by multiplying the values in this table by 0.50 and rounding to 2 decimal places using standard practice.

NOTE 5—The thickness of material <25-mm wide shall be measured at mid-width.

Specified Width, mm		Specified Ordered Thickness, mm[B]				
Over	Through	Through 0.4	0.4 <X≤ 1.0	1.0 <X≤ 1.2	1.2 <X≤ 2.5	2.5 <X≤ 4.0
		Thickness Tolerances Over, mm, No Tolerance Under[C]				
...	1800	0.10	0.15	0.20	0.25	0.30
1800	2000	. . .D	0.15	0.20	0.30	0.35
2000	. . .D	. . .D	0.30	0.30	0.35	0.40

[A] 0.55-mm minimum thickness for high-strength low-alloy.
[B] The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.
[C] The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance is divided equally over and under.
[D] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

ANNEX A

(Normative)

A1. PERMISSIBLE VARIATIONS IN DIMENSIONS AND MASS IN SI UNITS

A1.2 Listed in A1.17 are permissible variations in dimensions and mass expressed in the International System of Units (SI) terminology.

TABLE A1.2 Thickness Tolerances of Hot-Rolled Sheet (High-Strength, Low-Alloy Steel)—15-mm (Cut Edge) and 25-mm (Mill Edge) Minimum Edge Distance

(Coils and Cut Lengths, Including Pickled)

NOTE 1—Thickness is measured at any point across the width not less than 15 mm from a cut edge and not less than 25 mm from a mill edge. This table does not apply to the uncropped ends of mill edge coils.

NOTE 2—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 0.188 mm. [4.80 mm]. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 0.10 mm. [2.55 mm]. Micrometers with pointed tips are not suitable for thickness measurements.

NOTE 3—This table was constructed by multiplying the values in the standard table by 0.75 and rounding to 2 decimal places using standard practice.

NOTE 4—The thickness of material <50 mm wide shall be measured at mid-width.

Specified Width, mm	Specified Ordered Thickness, mm[A]			
	Through 2.0	2.0 <X≤ 2.5	2.5 <X< 4.5	4.5 <X< 6.0
	Thickness Tolerances Over, mm, No Tolerance Under[B]			
≤ 600	0.22	0.26	0.30	0.30
600 <X≤ 1200	0.26	0.30	0.34	0.38
1200 <X≤ 1500	0.26	0.30	0.38	0.38
1500 <X≤ 1800	0.30	0.34	0.41	0.42
1800 <X≤ 2000	0.30	0.34	0.45	0.45
> 2000	. . .[C]	0.38	0.45	0.45[C]

[A] The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.
[B] The tolerances provided in the table are based on minimum thickness (tolerance over, not tolerance under). For nominal thickness, the tolerance is divided equally over and under.
[C] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

TABLE A1.3 Width Tolerances[A] of Hot-Rolled Mill Edge Sheet (All Designations)

(Coils and Cut Lengths, Including Pickled)

Specified Width, mm		Width Tolerance, Over Only, mm	
Over	Through	Carbon	HSLA
300	600	16	16
600	1200	26	28
1200	1500	32	38
1500	1800	35	45
1800	. . .	48	50

[A] The above tolerances do not apply to the uncropped ends of mill edge coils (9.1.1.1).

TABLE A1.4 Width Tolerances of Hot-Rolled Cut Edge Sheet (All Widths) and Cold-Rolled Sheet (Widths Over 300 mm)—(All Designations)[A]

(Coils and Cut Lengths, Including Pickled)

Specified Width, mm		Width Tolerance, Over Only, mm
Over	Through	
. . .	600[A]	3
600	1200	5
1200	1500	6
1500	1800	8
1800	. . .	10
[A] Cold rolled widths 300 mm and less, refer to Table A1.15.		

TABLE A1.5 Length Tolerances of Hot-Rolled Sheet (All Designations)

(Cut Lengths, Including Pickled)

Specified Length, mm		Length Tolerance, Over Only, mm
Over	Through	
300	600	6
600	900	8
900	1500	12
1500	3000	20
3000	4000	25
4000	5000	35
5000	6000	40
6000	. . .	45

TABLE A1.6 Diameter Tolerances of Circles from Hot-Rolled (Including Pickled) and Cold-Rolled Sheet (Over 300 mm Width) (All Designations)

Specified Thickness[A] , mm		Tolerances Over Specified Diameter, mm (No Tolerances Under)		
Over	Through	Diameters, mm		
		≤ 600	600 <X≤ 1200	> 1200
. . .	1.5	1.5	3.0	5.0
1.5	2.5	2.5	4.0	5.5
2.5	. . .	3.0	5.0	6.5
[A] 1.8 mm minimum thickness for hot-rolled high-strength low-alloy steel sheet.				

TABLE A1.7 Camber Tolerances[A] for Hot-Rolled (Including Pickled) and Cold-Rolled Sheet (All Designations) (Cut Lengths)

NOTE 1—Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straightedge.

Cut Length, mm		Camber Tolerances[A] , mm
Over	Through	
. . .	1200	4
1200	1800	5
1800	2400	6
2400	3000	8
3000	3700	10
3700	4300	13
4300	4900	16
4900	5500	19
5500	6000	22
6000	9000	32
9000	12 200	38
[A] The camber tolerance for coils is 25.0 mm in any 6000 mm.		

TABLE A1.8 Out-of-Square Tolerances of Hot-Rolled Cut-Edge (Including Pickled) and Cold-Rolled Sheet (All Designations) (Cut Lengths)

Out-of-square is the greatest deviation of an end edge from a straight line at right angle to a side and touching one corner. It is also obtained by measuring the difference between the diagonals of the cut length. The out-of-square deviation is one half of that difference. The tolerance for all thicknesses and all sizes is 1.0 mm/100 mm of width or fraction thereof.

TABLE A1.9 Restricted Squareness Tolerances of Hot-Rolled (Including Pickled) and Cold-Rolled Sheet (All Designations) (Cut Lengths)

When cut lengths are specified restricted squareness, the width and the length are not less than the dimensions specified. The individual tolerance for overwidth, over-length, camber, or out-of-square should not exceed 1.6 mm up to and including 1200 mm in width and up to and including 3000 mm in length. For cut lengths wider or longer, the applicable tolerance is 3.2 mm.

TABLE A1.10 Flatness Tolerances[A] of Temper Rolled or Pickled Hot-Rolled Sheet Cut Lengths[B] (All Designations)

Specified Thickness, mm		Specified Width, mm	Flatness Tolerance[C] , mm Specified Yield Strength, min, MPa[D]			
Over	Through		≤ 310	310 <X≤ 380	380 <X≤ 550	550 <X≤ 690
1.2	1.5	≤ 900	15	20	25	30
		900 <X≤ 1500	20	30	40	45
		over 1500	25	. . .	45	50
1.5	4.5	≤ 1500	15	20	25	30
		1500 <X≤ 1800	20	30	40	45
		> 1800	25	40	45	50
4.5	6.0 excl	≤ 1500	15	20	25	30
		1500 <X≤ 1800	20	30	40	45
		> 1800	25	40	45	50

[A] The above table also applies to lengths cut from coils by the consumer when adequate flattening operations are performed.

[B] Application of this table to product in coil form is not appropriate unless the coil has been rolled out and adequately flattened with all coil set removed.

[C] Maximum deviation from a horizontal flat surface.

[D] The term Levelled also includes but is not limited to Tension Levelled, Stretcher Levelled, Roller Levelled, & Z-Mill.

TABLE A1.11 Flatness Tolerances[A] of Non-Processed Hot-Rolled Sheet Cut Lengths[B]

(All Designations)

Specified Thickness, mm		Specified Width, mm	Flatness Tolerance[C] , mm Specified Yield Strength, min, MPa[D]			
Over	Through		≤ 310	310 <X≤ 340	380 <X≤ 550	550 <X≤ 690
1.2	1.5	≤ 900	45	60	70	80
		900 <X≤ 1500	60	90	100	110
		> 1500	75	. . .	130	140
1.5	4.5	≤ 1500	45	60	70	80
		1500 <X≤ 1800	60	90	100	110
		> 1800	75	120	130	140
4.5	6.0 excl	≤ 1500	45	60	70	80
		1500 <X≤ 1800	60	90	100	110
		> 1800	75	120	130	140

[A] The above table also applies to lengths cut from coils by the consumer when adequate flattening operations are performed.

[B] Application of this table to product in coil form is not appropriate unless the coil has been rolled out and adequately flattened with all coil set removed.

[C] Maximum deviation from a horizontal flat surface.

TABLE A1.12 Thickness Tolerances of Cold-Rolled Sheet (All Designations)[A] —25-mm Minimum Edge Distance

NOTE 1—Thickness is measured at any point across the width not less than 25 mm from a side edge.

NOTE 2—Widths up to and including 300 mm in this table apply to widths produced by slitting from wider sheet.

NOTE 3—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 4.80 mm. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 2.55 mm. Micrometers with pointed tips are not suitable for thickness measurements.

NOTE 4—This table was constructed by multiplying the values in the standard table by 0.50 and rounding to 2 decimal places using standard practice.

NOTE 5—The thickness of material <50 mm wide shall be measured at mid-width.

Specified Width, mm		Specified Ordered Thickness, mm[B]				
Over	Through	Through 0.4	0.4 <X≤ 1.0	1.0 <X≤ 1.2	1.2 <X≤ 2.5	2.5 <X≤ 4.0
		Thickness Tolerances Over, mm, No Tolerance Under[C]				
...	1800	0.05	0.08	0.10	0.12	0.15
1800	2000	. . .[D]	0.08	0.10	0.15	0.18
2000	. . .[D]	. . .[D]	0.15	0.15	0.18	0.20

[A] 0.55 mm minimum thickness for high-strength low-alloy.

[B] The specified thickness range captions apply independent of whether the ordered thickness is stated as a nominal or minimum.

[C] The tolerances provided in the table are based on minimum thickness (tolerance over, no tolerance under). For nominal thickness, the tolerance is divided equally over and under.

[D] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

TABLE A1.13 Length Tolerances of Cold-Rolled Sheet (All Designations)

(Cut Lengths Over 300 mm in Width)

Specified Length, mm		Tolerance Over Specified Length (No Tolerance Under), mm
Over	Through	
300	1500	6
1500	3000	20
3000	6000	35
6000	. . .	45

TABLE A1.14 Length Tolerances of Cold-Rolled Sheet (All Designations)

(Cut Length Sheets, to 300 mm in Width)

NOTE 1—This table applies to widths produced by slitting from wider sheet.

Specified Length, mm		Tolerances Over Specified Length (No Tolerance Under), mm
Over	Through	
600	1500	15
1500	3000	20
3000	6000	25

TABLE A1.15 Width Tolerances for Cold-Rolled Sheet (All Designations)[A]

(Coils and Cut Lengths to 300 mm in Width)

NOTE 1—This table applies to widths produced by slitting from wider sheet.

Specified Width, mm		Width Tolerance, Over and Under, mm
Over	Through	
50	100	0.3
100	200	0.4
200	300	0.8
[A] 0.50 mm thickness for high-strength low-alloy.		

TABLE A1.16 Camber Tolerances of Cold-Rolled Sheet in Coils (All Designations)[A]

(Coils to 300 mm in Width)

NOTE 1—Camber is the greatest deviation of a side edge from a straight line, the measurements being taken on the concave side with a straightedge.

NOTE 2—This table applies to widths produced by slitting from wider sheet.

Width, mm	Camber Tolerances
Through 300, incl	5.0 mm in any 2000 mm
[A] 0.50 mm minimum thickness for high-strength low-alloy.	

TABLE A1.17 Flatness Tolerances of Cold-Rolled Sheet Cut Length (All Designations)[A]

NOTE 1—This table does not apply when product is ordered full hard, to a hardness range or “annealed last” (dead soft).

NOTE 2—This table applies to lengths cut from coils, when adequate flattening measures are performed to remove all undesirable flatness conditions, including, but not limited to, coil set.

Specified Thickness, mm	Specified Width, mm		Flatness Tolerance, mm Specified Yield Point, min, MPa	
	Over	Through	Under 310 MPa	310 to 340MPa[B]
≤ 1.0	. . .	900	10	20
	900	1500	15	30
	1500		20	40
> 1.0	. . .	900	8	20
	900	1500	10	20
	1500	1800	15	30
	1800	. . .	20	40

[A] Maximum deviation from a horizontal flat surface.

[B] Tolerances for high-strength, low-alloy steel with specified minimum yield point in excess of 340 MPa are subject to negotiation.

ANNEX B

(Informative)

B1. ALTERNATIVE METHODS FOR EXPRESSING FLATNESS

B1.1 Introduction and Definitions

B1.1.1 In addition to the conventional expression of flatness, the "maximum deviation from a horizontal flat surface," at least two other flatness parameters have been developed and are in use for characterizing sheet with longitudinal waves or buckles. These are steepness index and flatness index (or "I-unit"), that are illustrated using the example in Fig. B1.1.

B1.1.2 *Steepness Index*—Fig. B1.1 (*a*) shows a representation of a sheet sample exhibiting edge waves of height, *H*, and interval, *L*. The steepness index value for this sample is defined as:

$$steepness\ index = H / L$$

Often, the steepness value is expressed as a percentage:

$$\%\ steepness = S = (H / L) \times 100$$

B1.1.3 *I-Units*—Making a series of lengthwise cuts to the sample in Fig. B1.1 (*a*) relaxes elastic stresses present in the sheet and results in narrow strips of differing lengths, as shown in Fig. B1.1 (*b*). Using the length of one of these strips as a reference (L_{ref}), the I-unit value (*I*) for an individual strip is defined as:

$$I = (\Delta L / L_{ref}) \times 10^5$$

where:

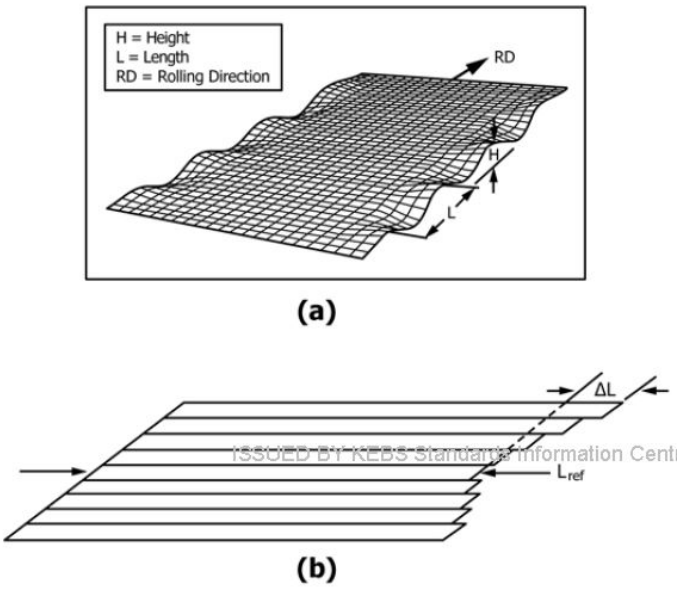

FIG. B1.1 Representation of Sheet Sample With Edge Waves (a) and Strips of Differing Length That Result from Making Longitudinal Cuts Along Sample (b)

ΔL is the difference between the length of a given strip and the reference strip.
B1.1.4 For the special case of waves/buckles that are perfectly sinusoidal in character, the following relationship applies:

$$I = [(\pi/2)\,(H/L)]^2 \times 10^5$$

or:

$$I = 24.7S^2$$

Table B1.1 provides I-unit values based on the sinusoidal approximation for wave heights up to 12.7-mm. (increments of 0.79375 mm.) and intervals between 254 and 1016 mm. (increments of 1 mm.). Mathematical relationships between the three representations of flatness described here are given in Table B1.2; these relationships can be used to convert between I-unit, % steepness, and wave height values (see examples in Table B1.2).

B1.2 Flatness Evaluation Example and Determination of I-Unit or % Steepness Value
B1.2.1 While the strip is on an inspection table, find the locations on the strip that are not lying flat on the table. If no flatness deviation can be found, that portion of the coil (head/middle/tail) can be described as flat (that is, zero I-unit or zero % steepness).

B1.2.2 If the coil is not totally flat, the height of the deviation must be determined and recorded. If the coil has edge waves, a step gauge (incremented in intervals of 1.5875 or 0.79375 mm.) can be inserted under a wave to determine the height. If the coil exhibits flatness deviation in the center of the strip, a lightweight straight edge can be placed on the highest portion of the buckle and on the highest portion of the next repeating buckle. The height can then be determined by inserting a step gauge between the straight edge and the strip.

B1.2.3 Along with the height, the wave period or wave interval must also be determined. The wave interval can be obtained by using a standard tape measure or straight edge to measure the distance between the highest point of one flatness deviation to the highest point of the next repeating flatness deviation.

B1.2.4 After determining height and wave interval, either the I-unit or % steepness value can be obtained. To determine the I-unit flatness, locate the appropriate height and wave interval in Table B1.1 and read the I-unit value at the intersection of the two measurements. To determine % steepness, divide the height by the wave interval and multiply the result by 100.

TABLE B1.1 I-Unit Conversion Chart

	Wavelength (in.)																													
Wave Height (in.)	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1/32	2	2	2	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/16	10	8	7	6	5	4	4	3	3	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3/32	22	18	15	13	11	10	8	8	7	6	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1
1/8	39	32	27	23	20	17	15	13	12	11	10	9	8	7	7	6	6	5	5	5	4	4	4	4	3	3	3	3	3	3	2
5/32	60	50	42	36	31	27	24	21	19	17	15	14	12	11	10	10	9	8	8	7	7	6	6	6	5	5	5	4	4	4	4
3/16	87	72	60	51	44	39	34	30	27	24	22	20	18	16	15	14	13	12	11	10	10	9	8	8	8	7	7	6	6	6	5
7/32	118	98	82	70	60	53	46	41	36	33	30	27	24	22	21	19	17	16	15	14	13	12	12	11	10	10	9	9	8	8	7
1/4	154	128	107	91	79	69	60	53	48	43	39	35	32	29	27	25	23	21	20	18	17	16	15	14	13	13	12	11	11	10	10
9/32	195	161	136	116	100	87	76	68	60	54	49	44	40	37	34	31	29	27	25	23	22	20	19	18	17	16	15	14	14	13	12
5/16	241	199	168	143	123	107	94	83	74	67	60	55	50	46	42	39	36	33	31	29	27	25	24	22	21	20	19	18	17	16	15
11/32	292	241	203	173	149	130	114	101	90	81	73	66	60	55	51	47	43	40	37	35	32	30	29	27	25	24	23	21	20	19	18
3/8	347	287	241	206	177	154	136	120	107	96	87	79	72	66	60	56	51	48	44	41	39	36	34	32	30	28	27	25	24	23	22
13/32	408	337	283	241	208	181	159	141	126	113	102	92	84	77	71	65	60	56	52	48	45	42	40	37	35	33	31	30	28	27	25
7/16	473	391	328	280	241	210	185	164	146	131	118	107	98	89	82	76	70	65	60	56	53	49	46	43	41	39	36	35	33	31	30
15/32	543	449	377	321	277	241	212	188	168	150	136	123	112	103	94	87	80	74	69	65	60	56	53	50	47	44	42	40	38	36	34
1/2	618	510	429	365	315	274	241	214	191	171	154	140	128	117	107	99	91	85	79	73	69	64	60	57	53	50	48	45	43	41	39
	Wavelength (mm)																													
Wave Height (mm)	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	825	850	875	900	925	950	975	1000
0.5	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	4	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1.5	9	7	6	5	5	4	3	3	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2.0	16	13	11	9	8	7	6	5	5	4	4	4	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
2.5	25	20	17	15	13	11	10	9	8	7	6	6	5	5	4	4	4	3	3	3	3	2	2	2	2	2	2	2	2	2	2
3.0	36	29	25	21	18	16	14	12	11	10	9	8	7	7	6	6	5	5	5	4	4	4	3	3	3	3	3	3	2	2	2
3.5	48	40	34	29	25	22	19	17	15	13	12	11	10	9	8	8	7	7	6	6	5	5	5	4	4	4	4	4	3	3	3
4.0	63	52	44	37	32	28	25	22	20	18	16	14	13	12	11	10	9	9	8	8	7	7	6	6	5	5	5	5	4	4	4
4.5	80	66	56	47	41	36	31	28	25	22	20	18	17	15	14	13	12	11	10	10	9	8	8	7	7	7	6	6	6	5	5
5.0	99	82	69	58	50	44	39	34	30	27	25	22	20	19	17	16	15	14	13	12	11	10	10	9	9	8	8	7	7	6	6
5.5	120	99	83	71	61	53	47	41	37	33	30	27	25	23	21	19	18	16	15	14	13	12	12	11	10	10	9	9	8	8	7
6.0	142	118	99	84	73	63	56	49	44	39	36	32	29	27	25	23	21	20	18	17	16	15	14	13	12	12	11	10	10	9	9
6.5	167	138	116	99	85	74	65	58	52	46	42	38	34	32	29	27	25	23	21	20	19	17	16	15	14	14	13	12	12	11	10
7.0	194	160	134	115	99	86	76	67	60	54	48	44	40	37	34	31	29	27	25	23	22	20	19	18	17	16	15	14	13	13	12
7.5	222	184	154	132	113	99	87	77	69	62	56	50	46	42	39	36	33	30	28	26	25	23	22	20	19	18	17	16	15	15	14
8.0	253	209	176	150	129	112	99	88	78	70	63	57	52	48	44	40	37	35	32	30	28	26	25	23	22	21	20	18	18	17	16
8.5	286	236	198	169	146	127	112	99	88	79	71	65	59	54	50	46	42	39	36	34	32	30	28	26	25	23	22	21	20	19	18
9.0	320	265	222	189	163	142	125	111	99	89	80	73	66	61	56	51	47	44	41	38	36	33	31	29	28	26	25	23	22	21	20
9.5	357	295	248	211	182	159	139	123	110	99	89	81	74	67	62	57	53	49	45	42	40	37	35	33	31	29	28	26	25	23	22
10.0	395	327	274	234	202	176	154	137	122	109	99	90	82	75	69	63	58	54	50	47	44	41	39	36	34	32	30	29	27	26	25

TABLE B1.2 Flatness Conversion Factors[A]

NOTE 1— "L" is the wave interval as defined in Fig. B1.1 (a).

	I Unit	Height	% Steepness
I Unit (I)	1	$2L/\pi \sqrt{/10^{-5}}$	$2/\pi \sqrt{/10-1}$
Height (H) (peak to peak)	$(H\pi/2L)^2 \times 10^5$	1	$\frac{100H}{L}$
% Steepness (S)	$2.5(\pi S)^2$	$\frac{LS}{100}$	1

[A] Examples—(1) Assume % steepness is given as 1.5 and the corresponding I-unit value is desired. From Table B1.2, $I = 2.5(\pi S)^2 = 2.5[(3.14)(1.5)]^2 = 55.5$.
(2) Assume an I-unit value of 25 is given and the corresponding % steepness is desired. From Table B1.2, $S = 2/\pi (I \times 10^{-1})^{1/2} = 2/3.14\ (25 \times 10^{-1})^{1/2} = 1.0$.

Bibliography

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