



Standard Practice for Measuring Flatness Characteristics of Steel Sheet Products¹

This standard is issued under the fixed designation A1030/A1030M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 Flatness is a significant quality characteristic of steel sheet products. Sheet flatness is affected by mill process factors plus the grade, thickness and width of the material supplied. It is the purpose of this practice to define the different flatness characteristics and to describe the method(s) most commonly used to measure particular characteristics. The methods described are designed and intended to be used in mill situations and environments.

1.2 The substrate shall conform to all the requirements of the appropriate specifications as follows: Specifications **A568/A568M** or **A924/A924M**.

1.3 Quantitative limits are not addressed and are established in the general requirements, or individual product specifications, or both; or when applicable, as agreed to between supplier and user.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

A568/A568M Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for

A924/A924M Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

3. Significance and Use

3.1 The definitions and procedures for measuring flatness characteristics of steel sheet products are provided so that purchasers and suppliers have common definitions and measuring procedures for flatness characteristics. The intention of these definitions and measuring methods is not to provide a dimensional specification for flatness characteristics, but rather common procedure(s) for quantifying flatness anomalies. For determining compliance with flatness specifications, references are provided to appropriate ASTM standards.

4. Interferences

4.1 Measurement of flatness often has been subjective, at best. Successful measurement of various flatness anomalies on quantitative terms requires recognition of several factors that can interfere with accurate measurements.

4.1.1 Flat surfaces are required. Measurement of several anomalies requires laying of the sample, or a coil area, on a recognized flat surface. In most cases, laying the sample, or a coil area, on a floor will produce satisfactory results, as long as the floor is recognized as being flat. The flatness of coil areas is also measured on the flat tables of coil processing lines, with the strip tension released. If the measuring surface is not recognized as being flat, a machined flat surface is recommended.

4.1.2 Stepblock gauges or tapered gauges should be checked regularly with a calibrated hand micrometer. Wear or dirt build up will affect accuracy.

4.1.3 The flat tables of shape gauges capable of measuring flatness characteristics must be clean and the sensors must be in good condition.

4.1.4 The sheet sample must be damage free.

5. Apparatus

5.1 Appropriate tools to measure flatness anomalies are described along with drawings as indicated.

5.1.1 *Flat Surfaces*—Accurate measurements of flatness anomalies require a flat surface, machined flat preferred.

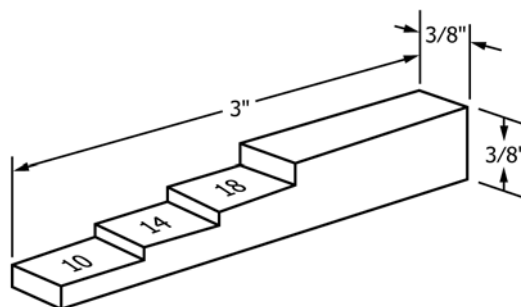
5.1.2 *Machined Stepblock Gauge*—See Fig. 1. Typically steps are in $\frac{1}{16}$ in. [1 mm] increments.

5.1.3 *Tapered Gauge*—See Fig. 2.

¹ This practice is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.07 on Methods of Testing.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.



NOTE 1—Stepblock gauge for all thicknesses and sizes of cut sheets.

NOTE 2—Dimensions given are approximate overall dimensions.

FIG. 1 Flatness Stepblock Gauge



NOTE 1—Tapered gauge for all thicknesses and sizes of cut sheets.

FIG. 2 Flatness Tapered Gauge

5.1.4 Standard Ruler or Tape Measure.

5.1.5 Hand Micrometer.

5.1.6 *Lightweight Straightedge*—Rigid, but light enough not to affect the test result.

6. Procedure

6.1 Wavy Edge (see Fig. 3):

6.1.1 *Definition*—A series of rolling direction edge deviations or undulations of the sheet from a recognized flat surface, having a height (H) and a measurable cycle length (L).

6.1.2 Measuring Methods:

6.1.2.1 With a sheet sample, or coil area, of at least 4 ft [1.2 m] in length by coil width on a recognized flat surface, measure the height (H) at the peak point of each wave from the recognized flat surface with a ruler, tape measure, tapered gauge, or stepblock gauge. Also measure the cycle length (L) from peak to peak of each wave with a ruler or tape measure.

6.1.3 Permissible Variations

6.1.3.1 The height (H) of the highest peak measured in accordance with 6.1.2.1 shall comply with applicable limits, such as found in the tables on flatness tolerances of Specifications A568/A568M or A924/A924M. Note that the referenced tables apply to cut sheet that has received adequate flattening. While the wavy edge height result from a coil area still attached to a coil is a reasonable indication of flatness, it is not bound by the limits of the referenced tables.

6.1.3.2 As stated in the section on flatness tolerances of Specifications A568/A568M or A924/A924M, I-Unit and % Steepness rejection limits are subject to agreement between producer and purchaser. Using the procedures of Appendix X1, and the readings from 6.1.2.1, determine the I-Unit and % Steepness values, first using the distance between the two highest peaks, and second using the distance between two adjacent peaks. The highest I-Unit and % Steepness values obtained from these two situations shall be used to determine if the specification has been met.

6.1.3.3 If the I-Unit and % Steepness values are supplied directly using a shape gauge; determine if the results are within the maximum specified values.

6.2 Ridge Buckle, Quarter Buckle, Center Buckle (see Fig. 4):

6.2.1 *Definition*—Buckles are continuous deviations from a recognized flat surface, having a height (H) and a measurable cycle (L), and usually occur in narrow width areas parallel to the rolling direction other than at the sheet edges.

6.2.2 Measuring Methods:

6.2.2.1 With a sheet sample, or coil area, of at least 4 ft [1.2 m] by coil width resting on a recognized flat surface, place a lightweight straightedge on the highest portion of a buckle and on the highest portion of the next repeating buckle. Measure the height (H) between the straightedge and a strip using a ruler, tape measure, tapered gauge, or stepblock gauge. Measure the cycle length (L) from peak to peak of each buckle with a ruler or tape measure.

6.2.2.2 In the case of a sheet sample, it is permissible to shear through the centerline of the flatness anomaly and measure as an edge wave (see 6.1.2.1) using a ruler, tape measure, tapered gauge, or stepblock gauge.

6.2.3 Permissible Variations

6.2.3.1 The height (H) of the highest peak measured in accordance with 6.2.2.1 or 6.2.2.2 shall comply with applicable limits, such as found in the tables on flatness tolerances of Specifications A568/A568M or A924/A924M. Note that the referenced tables apply to cut sheet that has received adequate flattening. While the buckle height result from a coil area still attached to a coil is a reasonable indication of flatness, it is not bound by the limits of the referenced tables.

6.2.3.2 As stated in the section on flatness tolerances of Specifications A568/A568M or A924/A924M, I-Unit and % Steepness rejection limits are subject to agreement between producer and purchaser. Using the procedures of Appendix X1,

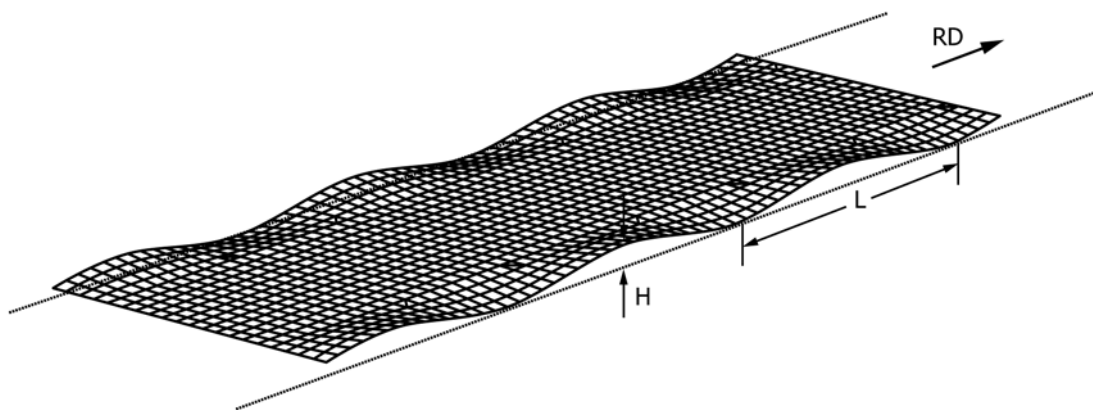


FIG. 3 Wavy Edge

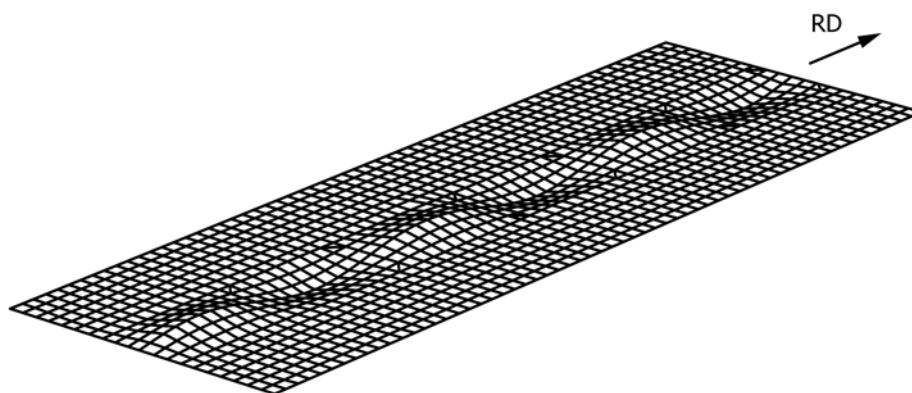


FIG. 4 Ridge Buckle, Quarter Buckle, Center Buckle

and the readings from 6.2.2.1 or 6.2.2.2, determine the I-Unit and % Steepness values, first using the distance between the two highest peaks, and second using the distance between two adjacent peaks. The highest I-Unit and % Steepness values obtained from these two situations shall be used to determine if the specification has been met.

6.2.3.3 If the I-Unit and % Steepness values are supplied directly using a shape gauge; determine if the results are within the maximum specified values.

6.3 Full Center (see Fig. 5):

6.3.1 *Definition*—Any overall deviation of a sheet from a recognized flat surface, having a height (H) and a measurable cycle (L), and occurring over a major portion of the sheet width parallel to the rolling direction other than at the sheet edges.

6.3.2 Measuring Methods:

6.3.2.1 With a sheet sample, or a coil area, of at least 4 ft [1.2 m] by coil width resting on a recognized flat surface, place a lightweight straightedge on the highest portion of a full center region and on the highest portion of the next repeating region of full center. Measure the height (H) between the straightedge and the strip using a ruler, tape measure, tapered gauge, or stepblock gauge. Measure the cycle length (L) from peak to peak of a full center region with a ruler or tape measure.

6.3.2.2 In the case of a sheet sample, it is permissible to shear through the centerline of the flatness anomaly and measure as an edge wave (see 6.1.2.1) using a ruler, tape measure, tapered gauge, or stepblock gauge.

6.3.3 Permissible Variations

6.3.3.1 The height (H) of the highest peak measured in accordance with 6.3.2.1 or 6.3.2.2 shall comply with applicable limits, such as found in the tables on flatness tolerances of Specifications A568/A568M and A924/A924M. Note that the referenced tables apply to cut sheet that has received adequate flattening. While the buckle height result from a coil area still attached to a coil is a reasonable indication of flatness, it is not bound by the limits of the referenced tables.

6.3.3.2 As stated in the section on flatness tolerances of Specifications A568/A568M or A924/A924M, I-Unit and % Steepness rejection limits are subject to agreement between producer and purchaser. Using the procedures of Appendix X1, and the readings from 6.3.2.1 or 6.3.2.2, determine the I-Unit and % Steepness values, first using the distance between the two highest peaks, and second using the distance between two adjacent peaks. The highest I-Unit and % Steepness values obtained from these two situations shall be used to determine if the specification has been met.

6.3.3.3 If the I-Unit and % Steepness values are supplied directly using a shape gauge; determine if the results are within the maximum specified values.

6.4 Coil Set and Reverse Coil Set (see Fig. 6):

6.4.1 *Definition*—A bow condition in the sheet, parallel with the rolling direction, as measured from a recognized flat surface. Coil set (also known as positive coil set) curves downward in the same direction as the upper outside lap of an

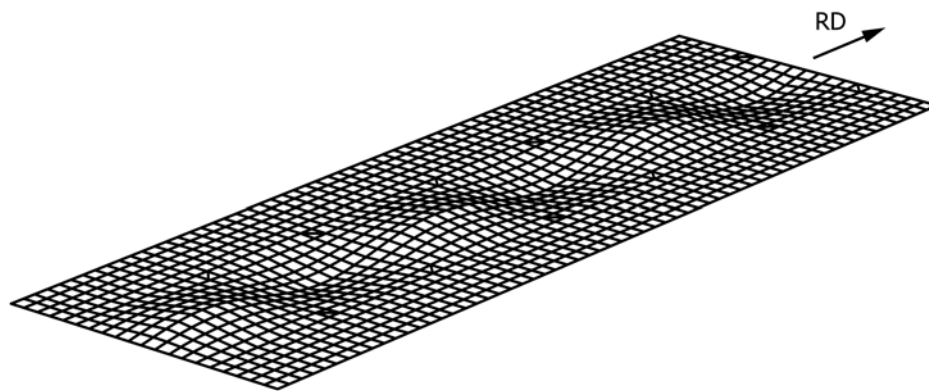


FIG. 5 Full Center

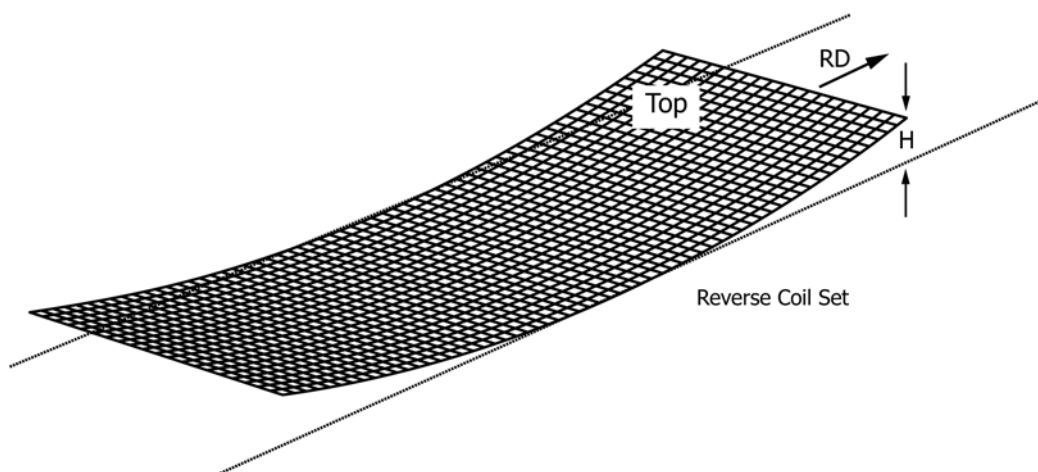
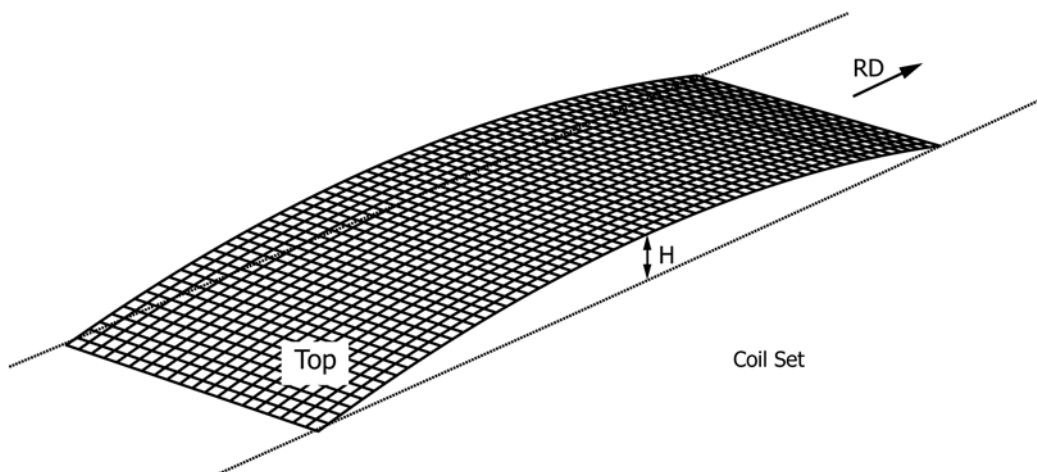


FIG. 6 Coil Set and Reverse Coil Set

overwound coil. Reverse coil set (also known as negative coil set) curves upward, opposite to the curvature of the upper outside lap of an overwound coil.

6.4.2 Measuring Methods:

6.4.2.1 For coil set, place a sheet sample of approximately 4 ft [1.2 m] by coil width on a recognized flat surface. Measure the highest rise (H) of the sheet edges from the flat surface. Use a ruler accurate to $\frac{1}{16}$ in. [1 mm].

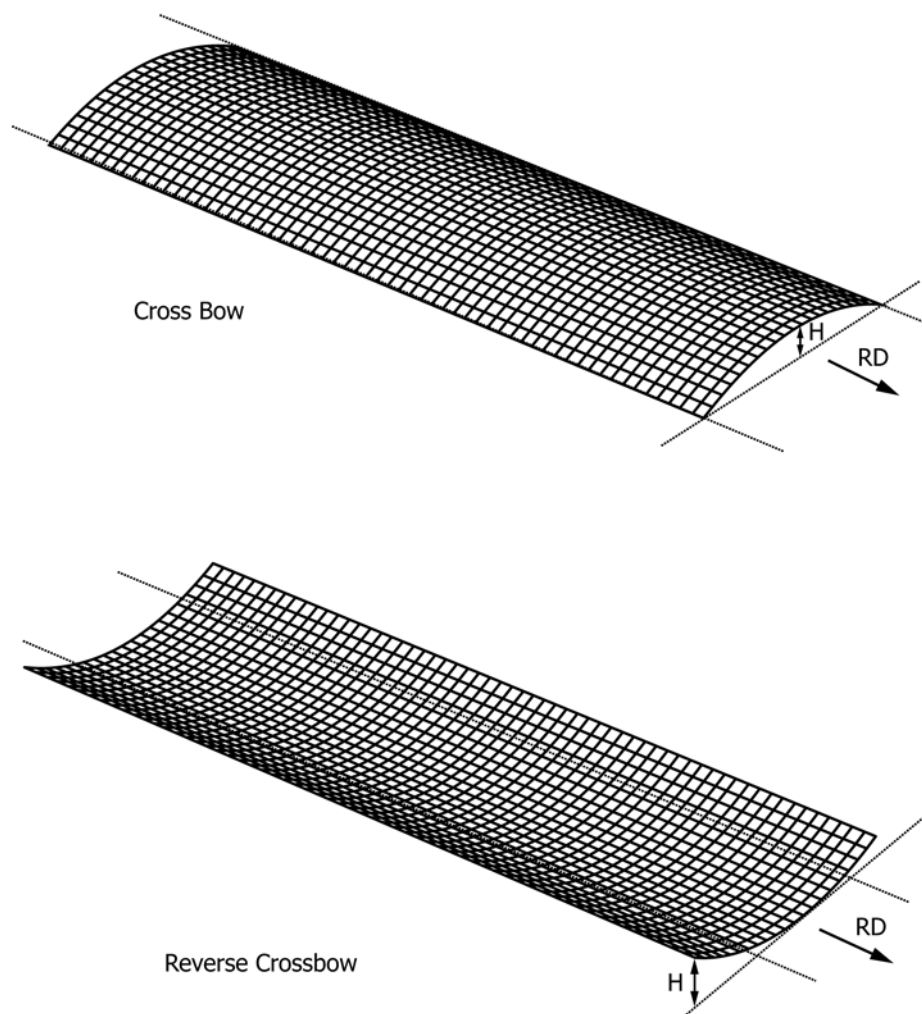


FIG. 7 Crossbow and Reverse Crossbow

6.4.2.2 For reverse coil set, place an adequately leveled sheet sample of approximately 4 ft [1.2 m] by coil width on a recognized flat surface. Measure the highest rise (H) of the cut end(s) of the sheet from the flat surface. Use a ruler accurate to $\frac{1}{16}$ in. [1 mm].

6.4.3 Permissible Variations

6.4.3.1 The height (H) of the highest deviation measured in accordance with 6.4.2.1 or 6.4.2.2 shall comply with applicable limits, such as found in the tables on flatness tolerances of Specifications A568/A568M or A924/A924M, or a value agreed upon between the producer and purchaser.

6.5 Crossbow and Reverse Crossbow (see Fig. 7):

6.5.1 *Definition*—A bow condition in the sheet, perpendicular to the rolling direction as measured from a recognized flat surface. Crossbow (also known as positive crossbow) curves downward, with the center portion of the sheet raised a measurable amount (H) above the sheet edges. Reverse crossbow (also known as negative crossbow) curves upward, with the edges of the sheet raised a measurable amount (H) above the center portion of the sheet. The degree of cross bow is determined in a horizontal position on a recognized flat surface.

6.5.2 Measuring Methods:

6.5.2.1 For crossbow, place a sheet sample, or coil area, of approximately 4 ft [1.2 m] by coil width on a recognized flat surface. Measure the highest rise (H) of the center of the sheet from the flat surface. Use a ruler accurate to $\frac{1}{16}$ in. [1 mm].

6.5.2.2 For reverse crossbow, place an adequately leveled sheet sample, or coil area, of approximately 4 ft [1.2 m] by coil width on a recognized flat surface. Measure the highest rise (H) of the edges of the sheet from the flat surface. Use a ruler accurate to $\frac{1}{16}$ in. [1 mm] or a lightweight straightedge as required.

6.5.3 Permissible Variations

6.5.3.1 The height (H) of the highest deviation measured in accordance with 6.5.2.1 or 6.5.2.2 shall comply with applicable limits, such as found in the tables on flatness tolerances of Specifications A568/A568M or A924/A924M, or a value agreed upon between the producer and purchaser.

6.6 Camber (see Fig. 8):

6.6.1 *Definition*—The greatest deviation of a coil edge from a straight line. The measurement is taken on the concave side and is the perpendicular distance from a straight line to the point of maximum deviation (A).

6.6.2 Measuring Methods:

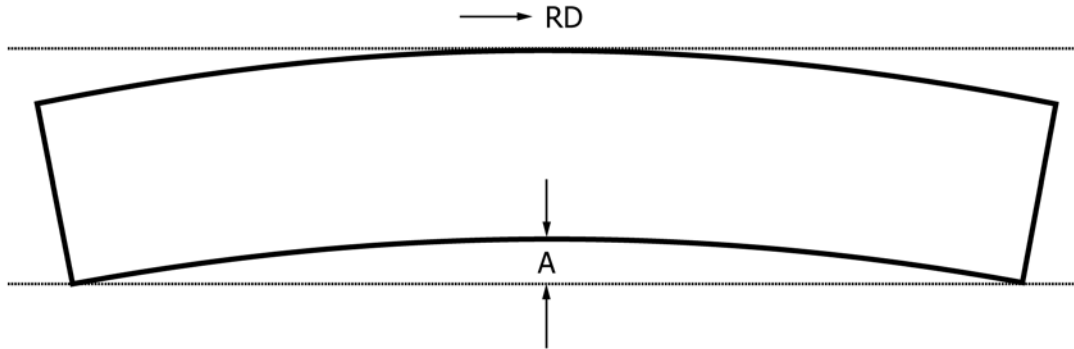


FIG. 8 Camber

6.6.2.1 Lay a sample of at least 20 ft [6 m] next to recognized straightedge. The perpendicular distance (A) is measured using a ruler accurate to $\frac{1}{16}$ in. [1 mm].

6.6.2.2 Cut two 20 ft [6 m] consecutive sections from the master coil. Butt together the sections lengthwise with the same edges together. At a 10 ft [3 m] distance from the end, measure the distance between the two edges. Divide this measurement in half to determine the actual camber (A).

6.6.3 Permissible Variations

6.6.3.1 The maximum deviation (A) measured in accordance with 6.6.2.1 or 6.6.2.2 shall comply with applicable limits of the table on camber tolerances of Specifications A568/A568M or A924/A924M, or a value agreed upon between the producer and purchaser.

7. I-Unit Calculation

7.1 This calculation assumes that flatness irregularities most closely conform to sinusoidal waveforms and uses the flatness

wavelength and height for the calculation. An alternate approach is to use I-Unit or % Steepness as a measure of the severity of flatness anomalies. Refer to Appendix X1 for a complete discussion of I-Units.

7.2 Steel sheet processing units such as temper mills are sometimes equipped with sensor rolls and detection systems that directly measure flatness in terms of I-Units. These devices are an acceptable method of measuring flatness. While the operation of such devices is beyond the scope of this practice, the information they supply can be compared with the results obtained using this practice. I-Unit values obtained from such in-line measuring devices will not necessarily agree with those obtained using this practice.

8. Keywords

8.1 flatness; steel sheet; steel sheet—metallic-coated

APPENDIX

(Nonmandatory Information)

X1. ALTERNATIVE METHODS FOR EXPRESSING FLATNESS

X1.1 Introduction and Definitions :

X1.1.1 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), which are illustrated using the example in Fig. X1.1.

X1.1.2 *Steepness Index*—Fig. X1.1 (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 follows:

$$\text{steepness index} = \frac{H}{L} \quad (\text{X1.1})$$

$$\% \text{ steepness} = S = \left(\frac{H}{L} \right) \times 100 \quad (\text{X1.2})$$

X1.1.3 *I-Units*—Making a series of lengthwise cuts to the sample in Fig. X1.1 (a) relaxes elastic stresses present in the sheet and results in narrow strips of differing lengths, as shown in Fig. X1.1 (b). Using the length of the shortest strip as a reference (L_{ref}), the I-unit value (I) for an individual strip is defined as follows:

$$I = \left(\frac{\Delta L}{L_{\text{ref}}} \right) \times 10^5 \quad (\text{X1.3})$$

where

ΔL = difference between the length of a given strip and the reference strip.

X1.1.4 For the special case of waves/buckles that are perfectly sinusoidal in character, the following relationship applies:

$$I \left[\left(\frac{\pi}{2} \right) \left(\frac{H}{L} \right) \right]^2 \times 10^5 \quad (\text{X1.4})$$

or

$$I = 24.7S^2 \quad (\text{X1.5})$$

X1.1.4.1 **Fig. X1.2** provides I-unit values based on the sinusoidal approximation for wave heights up to 1/2 in. [10 mm] (increments of 1/32 in. [0.5 mm]) and intervals between 10 and 40 in. [250 and 1000 mm] (increments of 1 in. [25 mm]). Mathematical relationships between the three representations of flatness described here are given in **Table X1.1**; these relationships can be used to convert between I-unit, % steepness, and wave height values (see examples in **Table X1.1**).

X1.2 Flatness Evaluation Example and Determination of I-Unit or % Steepness Value:

X1.2.1 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).

X1.2.2 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 1/16 or 1/32 in. [1 or 0.5 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 straightedge 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 straightedge and the strip.

X1.2.3 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 straightedge to measure the distance between the highest point of one flatness deviation to the highest point of the next repeating flatness deviation.

X1.2.4 After determining the 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 **Fig. X1.2** 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.

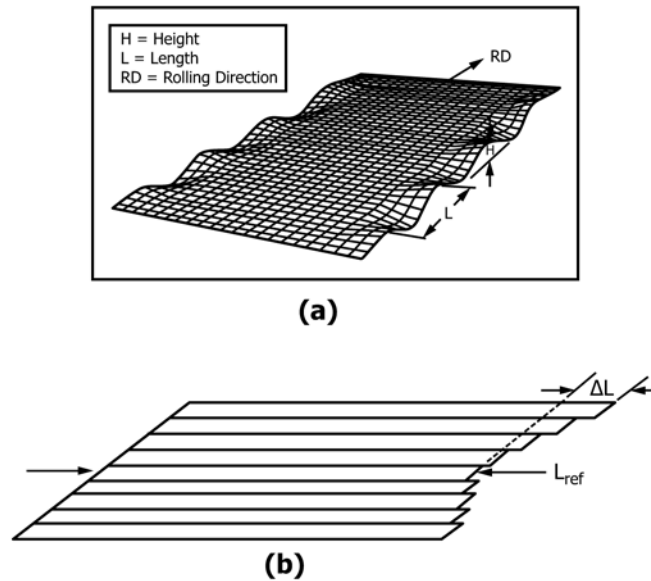


FIG. X1.1 Representation of Sheet Sample with Edge Waves (a) and Strips of Differing Length Which Result from Making Longitudinal Cuts Along the Sample (b)



|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|

FIG. X1.2 Unit Conversion Chart

TABLE X1.1 Flatness Conversion Factors^{A,B}

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

^AL = wave interval as defined in Fig. X1.1 (a).^BExamples:(1) Assume % steepness is given as 1.5 and the corresponding I-unit value is desired. From Table X1.1, $I = 2.5(\pi S)^2 = 2.5[(3.14)(1.5)]^2 = 55.5$.(2) Assume an I-unit value of 25 is given and the corresponding % steepness is desired. From Table X1.1, $S = 2/\pi (I \times 10^{-1})^{1/2} = 2/3.14(25 \times 10^{-1})^{1/2} = 1.0$.



SUMMARY OF CHANGES

Committee A05 has identified the location of selected changes to this standard since the last issue, A1030/A1030M - 05, that may impact the use of this standard. (May 1, 2011)

(1) Deleted subsection 5.1.7 and Appendix X2 on Automated Shape Gauges.

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