Designation: A971/A971M – 17 (Reapproved 2022)

Standard Test Method for Measuring Edge Taper and Crown of Flat-Rolled Electrical Steel Coils[1]

This standard is issued under the fixed designation A971/A971M; 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 This test method provides a procedure for measuring edge taper and crown of flat-rolled electrical steel coils as produced at the steel mill.

1.2 The values and equations stated in customary (cgs-emu and inch-pound) units or SI units are to be regarded separately as standard. Within this standard, the SI units are shown in brackets. 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 nonconformance with this standard.

1.3 The following material specifications include requirements for edge taper or crown: A677, A683, A726, A876, and A1086. Specification A840 also includes requirements for edge taper or crown, but it has been withdrawn and reference to it is included for historical purposes.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

A677 Specification for Nonoriented Electrical Steel Fully Processed Types

A683 Specification for Nonoriented Electrical Steel, Semi-processed Types

A726 Specification for Cold-Rolled Magnetic Lamination Quality Steel, Semiprocessed Types

A840 Specification for Fully Processed Magnetic Lamination Steel (Withdrawn 2011)[3]

A876 Specification for Flat-Rolled, Grain-Oriented, Silicon-Iron, Electrical Steel, Fully Processed Types

A1086 Specification for Thin-Gauge Nonoriented Electrical Steel Fully Processed Types

3. Terminology

3.1 *Definitions:* Except as defined as follows, the symbols and terminology used in this test method are defined in Terminology A340.

3.1.1 *edge taper and crown*—the variations of thickness across the widths of cold-rolled steel coils, that is, perpendicular to the rolling direction. Edge taper and crown are not the same as thickness variation. Thickness variation is measured parallel to the rolling direction (although it is loosely defined as variation in any direction). See Fig. 1.

3.1.1.1 *crown*—the variation of thickness from the edge to the center, perpendicular to the rolling direction.

3.1.1.2 *edge taper*—the variation of thickness from the edge to approximately 4 in. [100 mm] from the edge of the coil.

3.1.1.3 *edge taper gamma (γ)*—the slope of the edge taper (a dimensionless number) expressed in ten thousandths of a unit per unit.

3.1.2 *edge trimming*—the slitting of a narrow strip from each edge of the master coil for discard. This reduces the edge taper gamma on the remainder of the coil.

3.1.3 *gamma strip*—a 1 in. to 4 in. [25 mm to 102 mm] strip cut across the full width of the master coil (or master coil coupon), for the purpose of measuring edge taper and crown.

3.1.4 *master coils*—full-width coils as produced by cold-rolling mills. Slit coils are narrower width coils slit from a

[1] This test method is under the jurisdiction of ASTM Committee A06 on Magnetic Properties and is the direct responsibility of Subcommittee A06.01 on Test Methods.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

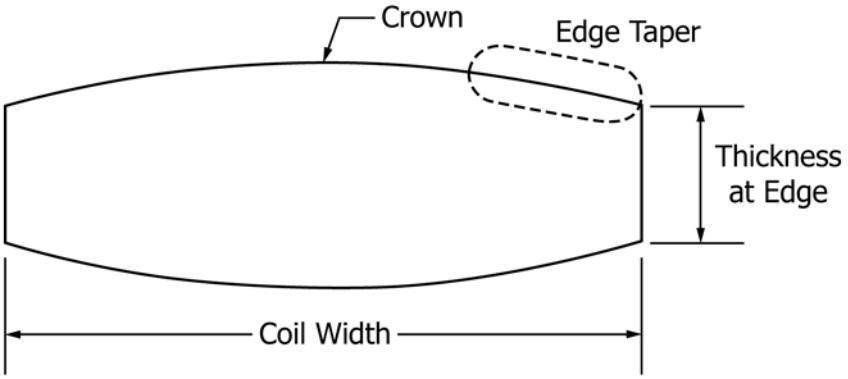


FIG. 1 Typical Steel Mill Coil Thickness Profile across Width of Coil

master coil. A master coil coupon is a full-width piece of the master coil, usually manually cut off for test purposes.

4. Summary of Test Method

4.1 In determining the edge taper and crown, a gamma strip is taken from the coil head and tail. Thickness readings are taken using a micrometer or other measuring device along a single line perpendicular to the rolling direction at points ⅜ in., 1⅜ in., 2⅜ in., and 4⅜ in. [10 mm, 35 mm, 60 mm, and 111 mm] from each edge to determine edge taper and in the center to determine crown. The readings are recorded, and variations between the readings calculated. If the edge taper is greater than specified, edge trimming can be performed to meet the limits agreed upon between the producer and the user.

5. Significance and Use

5.1 Flat-rolled electrical steel master coils are usually slit into narrower coils. Usually these slit coils are punched or sheared into laminations of various shapes. The laminations are then uniformly stacked to become the cores of magnetic devices such as motors and transformers. Stacking of many laminations exhibiting excessive taper causes assembly problems and poor appearance. Nonuniform stack lengths in motors cause imbalance and noise. When the laminations are interleaved in transformers, taper causes air spaces within the core resulting in increased noise, increased exciting current, and higher core loss.

6. Interference

6.1 This test method assumes that edge taper and crown are consistent through each individual coil. If different coils are welded together to make up a finished coil, this may not be the case. Nevertheless, edge trim can be used to correct for inconsistencies.

7. Description of Gamma Strip and Equipment Required

7.1 A coupon is cut from head and tail ends of the master coil. A shear in good working condition with sufficient capacity is used to cut a gamma strip from the coupon. The shear can be fitted with an edge guide or other means to establish a strip perpendicular to the coil edges. Perpendicularity shall be within 1°. See Fig. 2.

7.2 Means for locating and marking the gamma strip measurement points shall be provided. A template can be made that will quickly locate for marking the test points from each edge. The center point can be located with a scale. Points shall be located to within 0.032 in. [0.81 mm]. See Fig. 3. Alternatively, a machine may be constructed that automatically locates all nine points on the gamma strip, measures the points, and records/displays the data. If a continuous sequence of measurements are taken over the length of the strip (thickness profile), then the specified nine points shall be read from the recorded data.

7.3 A micrometer or other thickness measuring device shall be provided. The micrometer shall have anvils that are convex

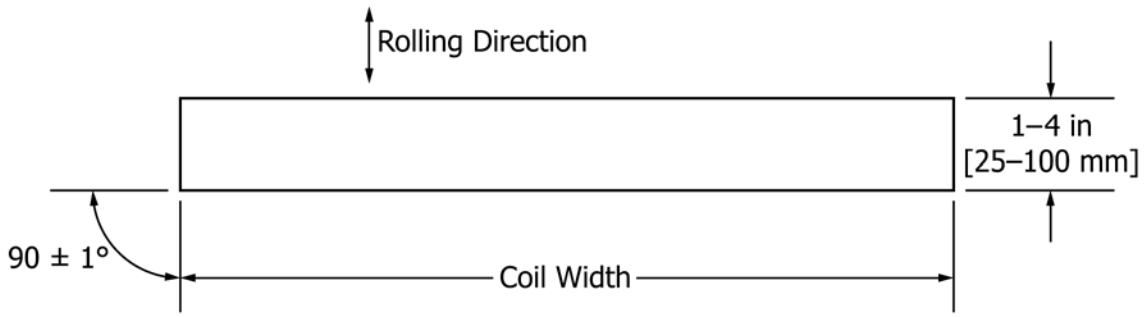
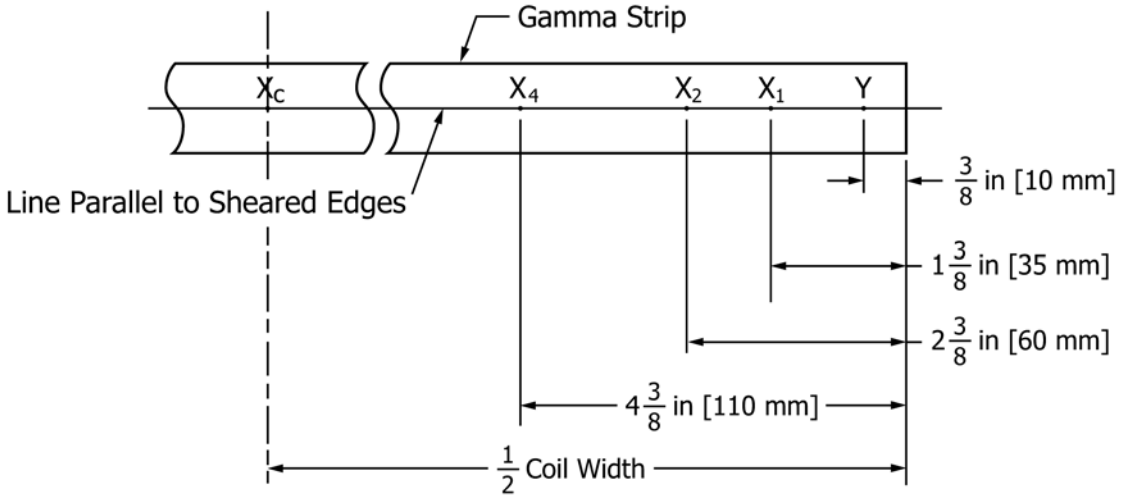


FIG. 2 Typical Gamma Strip



NOTE 1—Measurement points for opposite edge of gamma strip are the mirror image of the edge shown.

FIG. 3 Measurement Points Marked on Gamma Strip

with a radius no less than 0.062 in. [1.6 mm]. Operation may be manual or automatic as part of a system of fixtures, gauging devices, and data acquisition instruments. Thickness measurement device repeatability shall be 100 µin. [2.54 µm] (on precision gauge block).

NOTE 1—Roughness of the steel sheet surface can affect repeatability.

7.4 A data sheet or computer printout shall be provided for entry of thickness readings and computation of gamma for the gamma strip.

8. Procedure

8.1 Measure and record the data for all nine points previously specified.

9. Calculation

9.1 Calculate edge taper gamma as follows:

$$\gamma = \frac{(X_W - Y)}{W} 10^4 \quad (1)$$

where:

γ (gamma) = edge taper gamma,
X_w = thickness at distance W from Y, in in. [mm], and
Y = thickness at ⅜ in. [10 mm] from the edge, in in. [mm].

Thickness is measured at width increments W of 1.00 in., 2.00 in., and 4.00 in. [25.4 mm, 50.8 mm, and 102 mm] from a point, Y, ⅜ in. [10 mm] from the edge. These points are labeled X_1, X_2, and X_4, respectively.

9.2 Calculate crown as follows (see Fig. 4):

$$\text{crown} = X_C - Y \quad (2)$$

where:

Y = average of the thicknesses ⅜ in. [10 mm] from each edge, in in. [mm], and
X_c = thickness at center, in in. [mm].

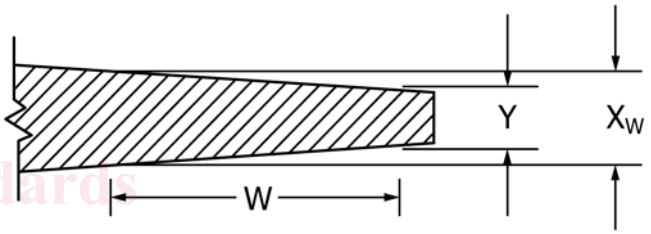


FIG. 4 Edge Taper/Crown Dimensions

The crown is measured at the center of the gamma strip and is substantially the thickest point across its width. Crown is measured the same way as edge taper except the distance W_c is between measurement points X_c and Y.

9.3 Calculate edge taper as follows (see Fig. 4):

$$\text{edge taper} = X_4 - Y \quad (3)$$

where:

X_4 = thickness at 4⅜ in. [110 mm] from the edge, in in. [mm], and
Y = thickness at ⅜ in. [10 mm] from the edge, in in. [mm].

10. Interpretation of Results

10.1 Edge taper gamma exceeding agreed upon limits can usually be corrected by edge trimming an amount sufficient to bring the coil into specification. Each edge of the coil shall be considered separately for the amount of trim. After trimming, this same method can again be followed.

11. Precision and Bias

11.1 This test method, although being followed by several steel mills and their customers, has not yet been the subject of a comparison of the same samples at several laboratories (round robin). However, a computerized instrument that adheres to this test method has been in use in at least three laboratories and supplier laboratories. At the time of preparation of this test method, correlation has been achieved between three such instruments to 0.0002-in. [5 µm] tolerance for