Designation: A 971/A 971M – 05

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

This standard is issued under the fixed designation A 971/A 971M; 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: A 677, A 683, A 726, A 840/A 840M, and A 876.

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

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 340 Terminology of Symbols and Definitions Relating to Magnetic Testing

A 677 Specification for Nonoriented Electrical Steel Fully Processed Types

A 683 Specification for Nonoriented Electrical Steel, Semiprocessed Types

A 726 Specification for Cold-Rolled Magnetic Lamination Quality Steel, Semiprocessed Types

A 840/A 840M Specification for Fully Processed Magnetic Lamination Steel

A 876 Specification for Flat-Rolled, Grain-Oriented, Silicon-Iron, 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 A 340.

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 slope (γ) is expressed in ten thousandths of an inch per inch (ten thousandths of a millimetre per millimetre).

3.1.1.1 *Discussion*—The variation of thickness from the edge to approximately 4 in. [100 mm] from the edge of the coil is called edge taper. The variation of thickness from the center to the edge is called crown.

3.1.1.2 *Discussion*—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).

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 master coil.

3.1.3 *master coils*—full-width coils as produced by cold-rolling mills. Slit coils are narrower width coils slit from a master coil. A coupon is a full-width piece of the master coil, usually manually cut off for test purposes. A sample strip 1 to 4 in. [25 to 102 mm] wide is sheared across the width of the coil from a coupon for the purpose of measuring edge taper and crown. This is called a gamma strip because gamma (γ) is the symbol used to quantify edge taper slope or rate of variation with distance. See Fig. 1.

4. Summary of Test Method

4.1 In determining the edge taper and crown, a sample 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 , 1⅜ , 2⅜ , and 4⅜ in. [10, 35, 60, 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

[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.

Current edition approved Dec. 15, 2005. Published January 2006. Originally approved in 1997. Last previous edition approved in 2000 as A 971 – 00.

[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.

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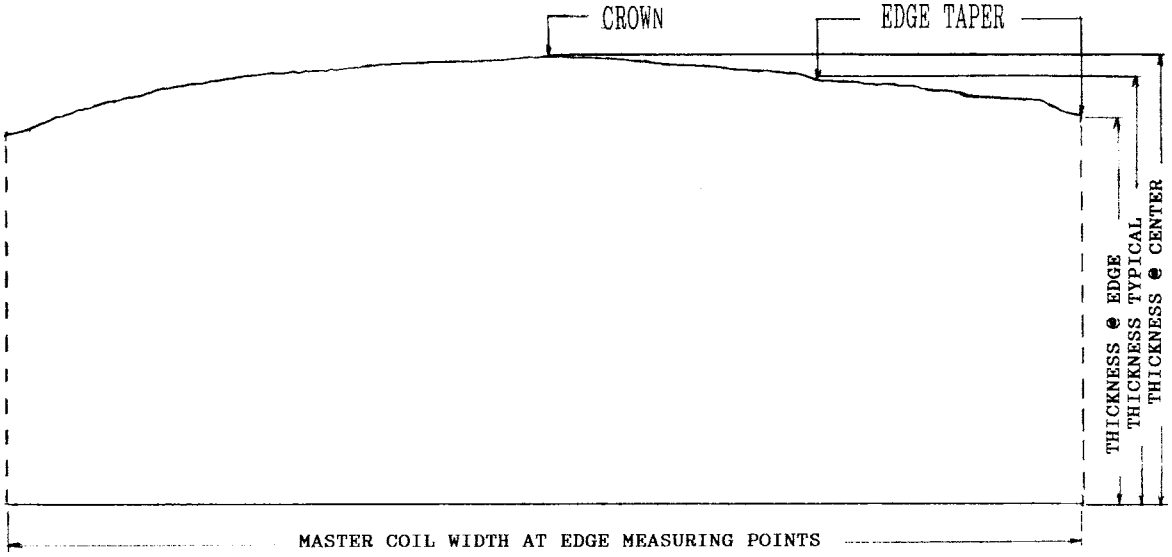

FIG. 1 Typical Steel Mill Coil Thickness Profile across Width of Coil

than specified, edge trimming can be performed to meet the limits agreed upon between the producer and the purchaser.

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. Uniform 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, exciting current, and 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 correct for the worst case

7. Description of Sample 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. In Fig. 3, CW is coil width, and CW/2 locates its center. 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 trace.

7.3 A micrometer or other thickness measuring device shall be provided. The micrometer shall have anvils that are convex 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, gaging devices, and data acquisition instruments. Thickness measurement device repeatability shall be 100 µin. [2.54 µm] (on precision gage 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.

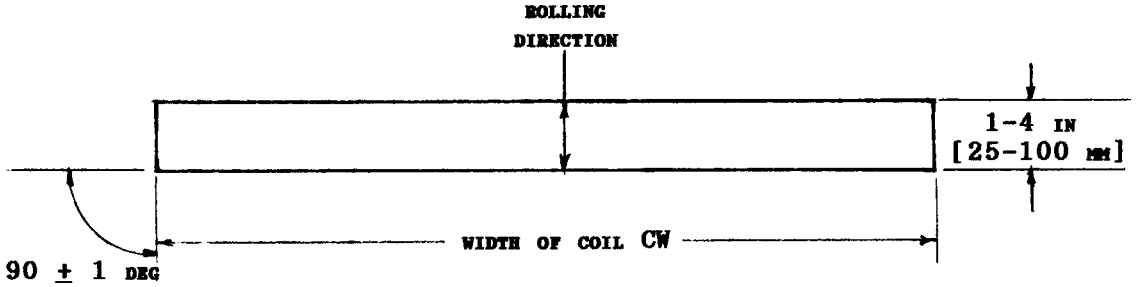

FIG. 2 Typical Gamma Strip

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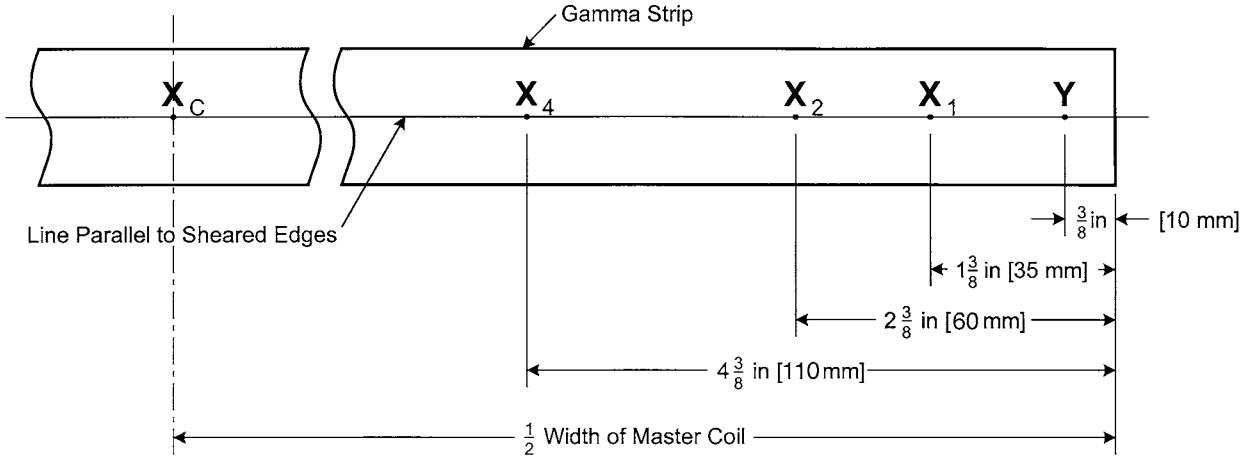

NOTE 1—Measurement points for opposite edge of gamma strip are the mirror image of the edge shown.

FIG. 3 Measurement Points Marked on Gamma Strip

8. Procedure

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

9. Calculation

9.1 Edge taper and crown are defined as the thickness variation perpendicular to the rolling direction of the steel coil or sheet. Edge taper gamma is in ten thousandths of an inch per inch [ten thousandths of a millimetre per millimetre] of width. See Fig. 4.

9.2 Calculate edge taper gamma as follows:

$$\gamma = \frac{(X_W - Y)\ 10^4}{W},\ 10^{-4}\ \text{in./in.} \quad (1)$$

$$\gamma = \frac{(X_W - Y)10^4}{W},\ 10^{-4}\ \text{mm/mm} \quad (2)$$

where:

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

Thickness is measured at width increments W of 1.00, 2.00, and 4.00 in. [25.4, 50.8, 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.

9.3 Calculate crown as follows:

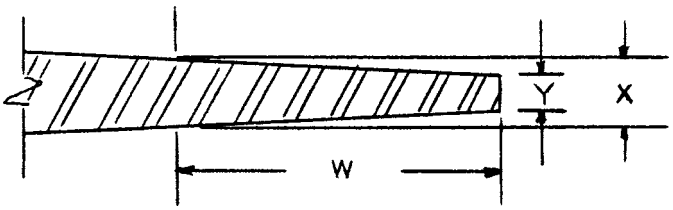

FIG. 4 Edge Taper/Crown Dimensions

$$\text{crown} = (X_C - Y)\ 10^4,\ 10^{-4}\text{in. } [10^{-4}\text{mm}] \quad (3)$$

where:

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

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

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 master coil into specification. Each edge of the master 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 several samples of steel coils. However, no statement of precision and bias is made at this time.

12. Keywords

12.1 coupon; crown; edge taper; edge trim; gamma strip; master coil; slit coil

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