

(R) Surface Roughness and Peak Count Measurement of Cold-Rolled Steel Sheet

1. Scope

- 1.1** This SAE Recommended Practice describes a method for measuring Roughness Average (R_a) and Peak Count (PC) of the surface of cold-rolled steel sheet.
- 1.2** The method includes a system for equipment configuration, calibration, and procedures for determining average surface roughness, R_a (μm or μin), and average peak count, PC (peaks per cm or peaks per inch) on cold-rolled steel sheet surfaces.

2. References

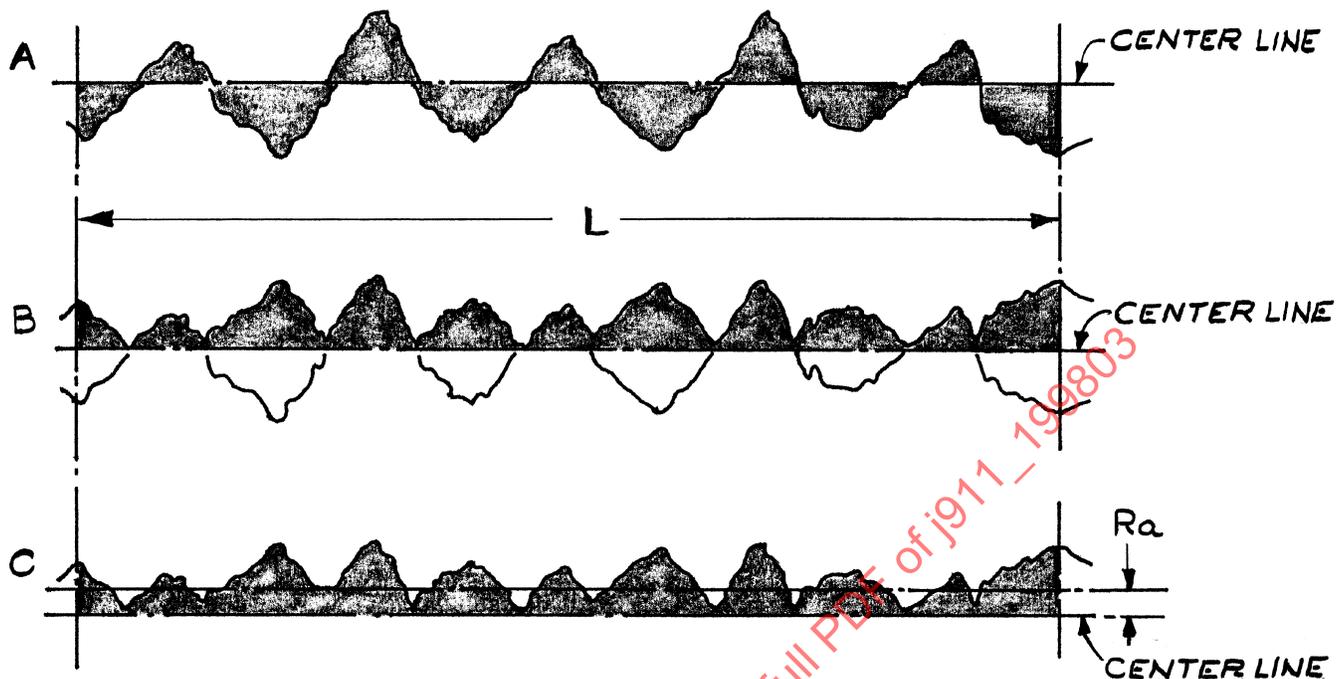
- 2.1 Applicable Publication**—The following publication forms a part of the specification to the extent specified herein.
- 2.1.1 ASME PUBLICATION**—Available from ASME, 345 East 47 Street, New York, NY 10017-2330.
- ASME B46.1-1995—Surface Texture

3. Definitions

- 3.1 Roughness Average**—The surface roughness average (R_a) shall be reported in micrometers (μm) as the arithmetical average of the absolute deviations from the median line, Figure 1, established within the limits of the filtered roughness profile.

Surface roughness consists of the finer irregularities in the surface texture which usually include those irregularities which result from the inherent action of the production process. These are considered to include texture characteristics transferred to the sheet surface from the roll surface during cold rolling, and which are within the limits of the roughness-width cutoff.

- 3.1.1 ROUGHNESS CUTOFF**—The roughness cutoff is the electrical response characteristic of the roughness filter of the measuring instrument. Selection of this cutoff limits the spacings of the surface irregularities to be included in the assessment of roughness average. The standard value of the roughness cutoff is 0.8 mm (nominally 0.03 in).



A = Profile with Centerline.
 B = Lower Portions of Profile Inverted.
 C = R_a is the Mean Height of the Profile.

FIGURE 1—REPRESENTATION OF AVERAGE ROUGHNESS (R_a)

- 3.1.2 **ROUGHNESS PROFILE**—The roughness profile is the basis for measurement of all roughness-related surface properties, irrespective of whether an actual graphical recording is made of it or not. The roughness profile is a plot of the amplitude of the roughness irregularities along the scan length, and is obtained from the raw (unfiltered) profile signal by means of instrument filtering.
- 3.2 **Peak**—A surface irregularity wherein the roughness profile intersects consecutively a lower and upper boundary line. The boundary lines are located parallel and equidistant from the roughness profile mean line. The vertical distance between these boundary lines is termed the peak count level.
- 3.2.1 **PEAK COUNT LEVEL**—The vertical distance in micrometers (or micro-inch) between the boundary lines described in the definition of "Peak", (see Figure 2). The standard value for the peak count level is $1.25 \mu\text{m}$ ($50 \mu\text{in}$).

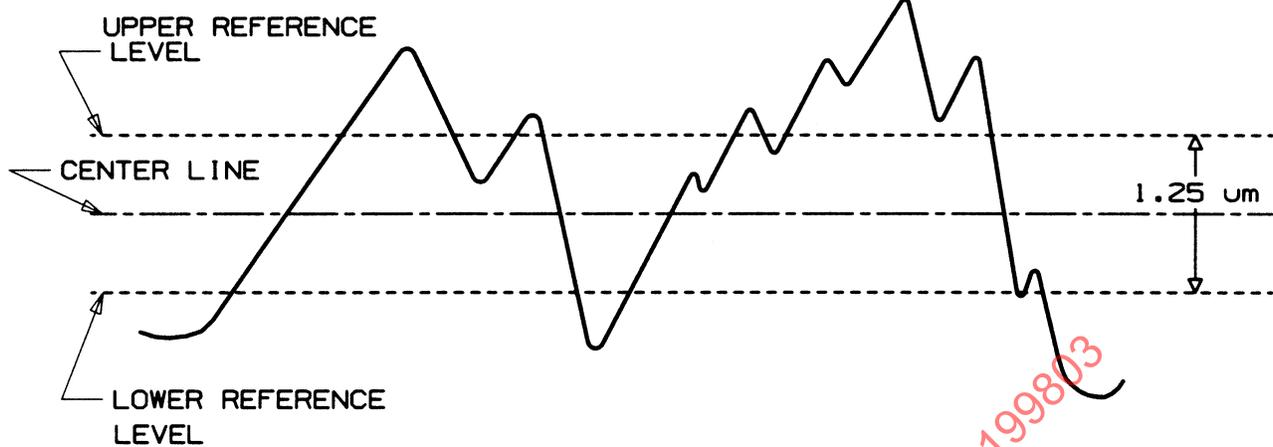


FIGURE 2—PEAK COUNTING

3.2.2 PEAK COUNT—The peak count (PC) is the number of peaks per unit length (peaks/cm or peaks/in).

4. Equipment, Test Conditions, and Materials

- 4.1 A stylus type surface roughness and peak counting instrument (profilometer) or equivalent.
- 4.2 The instrument shall comply with specifications for stylus type instruments as detailed in section 4.4 of the American National Standard: ASME B46.1-1995; namely:
- The nominal stylus radius shall be $10\ \mu\text{m}$ ($400\ \mu\text{in}$) or smaller.
 - The static stylus force (for a $10\ \mu\text{m}$ stylus) shall not exceed $0.016\ \text{N}$ at any point within the displacement range of the stylus, and the minimum stylus force shall be sufficient to maintain contact with the surface. (The maximum recommended stylus force will be lower for a smaller stylus radius; as tabulated in section 3.3.5.2 of ASME B46.1-1995).
 - The response of the filter used to process the profile signal (or the profile data) shall comply with the attenuation characteristics and limits stated in section 9.4 (of ASME B46.1-1995).
- 4.3 The instrument shall be calibrated in terms of average roughness (R_a) using a precision reference specimen having a nominal R_a value in the measurement range (typically 0.25 to $2.5\ \mu\text{m}$ or 10 to $100\ \mu\text{in}$, for cold-rolled steel surfaces).
- 4.4 The standard filter cutoff length for average roughness and peak count measurements on cold-rolled steel sheet surfaces shall be $0.8\ \text{mm}$ (nominally $0.03\ \text{in}$).
- 4.5 The standard value for the peak count level shall be $1.25\ \mu\text{m}$ ($50\ \mu\text{in}$).
- 4.6 The standard value for the traverse length (measurement length) shall be 7 times the filter cutoff length for "integrated roughness profilometers." Integrated roughness profilometers (recommended for use here) compute the roughness properties from a stored electrical waveform representing the profile upon completion of a surface scan over the traverse length. Most modern profilometers are of this type. Continuously averaging profilometers continuously compute, update, and display roughness properties as the stylus scans the traverse length. Use of these profilometers adds more constraints on the instrument's response time, speed, and indicated device characteristics (sections 4.4.3 and 4.4.4 of ASME B46.1-1995).

4.7 The instrument shall exclude from assessment, a short segment of the traverse length at either end to ensure that mechanical and electrical transients at the beginning and end of the profile are excluded from the measurement. The segment length shall be no longer than one cutoff length to ensure that at least five cutoff lengths are used for assessment.

4.8 Sample material selected for measurement shall be representative of the material as produced. The area tested should be at least 50 mm (2 in) from the coil edge. Samples for sheet examination shall be identified as to rolling direction, suitably flat, and the sample size large enough to run the tests. (A convenient size is 150mm (6 in) long, and 100 mm (4 in) wide, with the longer dimension parallel to the direction of rolling.)

5. Test Procedure

5.1 **Preparation**—The following items should be inspected to insure proper operation of the measuring equipment:

- a. Prepare the instrument for use according to the manufacturer's instructions.
- b. Set the traverse length to 5.6 mm (nominally 0.21 in) for an integrated roughness profilometer, or 28mm (nominally 1.05 in) for a continuously averaging profilometer. (Longer traversing lengths for either type of profilometers are permissible.)
- c. Set the cutoff length to 0.8 mm (nominally 0.03 in).
- d. Set the peak count level to 1.25 μm (50 μin).
- e. Check the suitability of location. The suitability of location can be checked by observing the roughness reading obtained on a smooth piece of flat glass. A reading of 0.05 μm (2 μin) or less indicates the location is suitably vibration free.
- f. Allow ample warm-up time after powering-up the instrument and before performing measurements.
- g. Inspect the test sample to ensure it is free from burrs, scratches, and foreign particles. Deburr, identify a scratch-free test location, and wipe with a soft lint-free cloth if necessary.

5.2 **Calibration**—To achieve the greatest uniformity between instruments on sheet surface texture measurements, the instrument must be calibrated prior to use. Frequency of calibrations and calibration procedure should be performed based on manufacturer's instructions/recommendations of the individual equipment used, and on the pattern of use (heavy use of the instrument might necessitate more frequent calibrations). The guidelines outlined in 5.2.1 (of this document) for Calibration measurements shall apply when specific manufacturer's instructions are absent or when such instructions are inferior to those of 5.2.1.

5.2.1 **CALIBRATION MEASUREMENTS**—After preparation as described in 5.1, calibration measurements on the precision reference specimen shall be made to establish satisfactory operation of the instrument. The calibration reading for average roughness (R_a) should be obtained from an average of **ten** readings taken on the reference specimen. The instrument should be set up to obtain the readings in the direction (see Section 6, note (b)) indicated on the precision reference specimen (usually two parallel arrows), and should be fairly distributed over the designated measurement area (usually a rectangle enclosed by the two parallel arrows). If the average of the ten measurements on the precision reference specimen differs by more than 5% of the assigned value, instrument adjustment and recalibration (as described previously) are in order. Instrument adjustments should be performed following manufacturer's instructions.

5.3 **Sample Roughness Average (R_a) and Peak Count (PC) Measurements**—Sheet sample roughness average and peak count should be obtained from a calculated average of ten readings (see exception as follows) obtained in the following manner. Five readings are taken parallel to the direction of rolling of the sheet sample and approximately 2 mm (0.1 in) apart. The sheet metal sample is then rotated 90 degrees and five additional measurements are taken perpendicular to the rolling direction (i.e., the transverse direction). An average of the ten readings obtained in this manner is calculated, recorded, and reported along with test equipment identification and test operating variables.