Designation: E1268 – 19

Standard Practice for Assessing the Degree of Banding or Orientation of Microstructures[1]

This standard is issued under the fixed designation E1268; 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.

INTRODUCTION

Segregation occurs during the dendritic solidification of metals and alloys and is aligned by subsequent deformation. Solid-state transformations may be influenced by the resulting microsegregation pattern leading to development of a layered or banded microstructure. The most common example of banding is the layered ferrite-pearlite structure of wrought low-carbon and low-carbon alloy steels. Other examples of banding include carbide banding in hypereutectoid tool steels and martensite banding in heat-treated alloy steels. This practice covers procedures to describe the appearance of banded structures, procedures for characterizing the extent of banding, and a microindentation hardness procedure for determining the difference in hardness between bands in heat treated specimens. The stereological methods may also be used to characterize non-banded microstructures with second phase constituents oriented (elongated) in varying degrees in the deformation direction.

1. Scope

1.1 This practice describes a procedure to qualitatively describe the nature of banded or oriented microstructures based on the morphological appearance of the microstructure.

1.2 This practice describes stereological procedures for quantitative measurement of the degree of microstructural banding or orientation.

NOTE 1—Although stereological measurement methods are used to assess the degree of banding or alignment, the measurements are only made on planes parallel to the deformation direction (that is, a longitudinal plane) and the three-dimensional characteristics of the banding or alignment are not evaluated.

1.3 This practice describes a microindentation hardness test procedure for assessing the magnitude of the hardness differences present in banded heat-treated steels. For fully martensitic carbon and alloy steels (0.10–0.65 %C), in the as-quenched condition, the carbon content of the matrix and segregate may be estimated from the microindentation hardness values.

1.4 This practice does not cover chemical analytical methods for evaluating banded structures.

1.5 This practice deals only with the recommended test methods and nothing in it should be construed as defining or establishing limits of acceptability.

1.6 The measured values are stated in SI units, which are regarded as standard. Equivalent inch-pound values, when listed, are in parentheses and may be approximate.

1.7 *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.*

1.8 *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]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

E3 Guide for Preparation of Metallographic Specimens

[1] This practice is under the jurisdiction of ASTM Committee E04 on Metallography and is the direct responsibility of Subcommittee E04.14 on Quantitative Metallography.

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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.

E7 Terminology Relating to Metallography
E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness
E384 Test Method for Microindentation Hardness of Materials
E407 Practice for Microetching Metals and Alloys
E562 Test Method for Determining Volume Fraction by Systematic Manual Point Count
E883 Guide for Reflected–Light Photomicrography

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, see Terminology E7.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *banded microstructure*—separation, of one or more phases or constituents in a two-phase or multiphase microstructure, or of segregated regions in a single phase or constituent microstructure, into distinct layers parallel to the deformation axis due to elongation of microsegregation; other factors may also influence band formation, for example, the hot working finishing temperature, the degree of hot- or cold-work reduction, or split transformations due to limited hardenability or insufficient quench rate.

3.2.2 *feature interceptions*—the number of particles (or clusters of particles) of a phase or constituent of interest that are crossed by the lines of a test grid. (see Fig. 1).

3.2.3 *feature intersections*—the number of boundaries between the matrix phase and the phase or constituent of interest that are crossed by the lines of a test grid (see Fig. 1). For isolated particles in a matrix, the number of feature intersections will equal twice the number of feature interceptions.

3.2.4 *oriented constituents*—one or more second-phases (constituents) elongated in a non-banded (that is, random distribution) manner parallel to the deformation axis; the degree of elongation varies with the size and deformability of the phase or constituent and the degree of hot- or cold-work reduction.

3.2.5 *stereological methods*—procedures used to characterize three-dimensional microstructural features based on measurements made on two-dimensional sectioning planes.

NOTE 2—Microstructural examples are presented in Annex A1 that illustrate a quantitative method to assess the degree of banding (BR)[3,4]. The degree of banding varies: BR<1.3 - no banding; BR >1.9 - one or two solid bands across the whole field of view and several broken bands; BR>2.6 - several solid bands intersecting the whole field of view; BR>4 and BR>5 - uniform and non-uniform solid bands alternately intersecting the whole field of view. Fig. 2 describes this classification using a qualitative description of the nature and extent of the banding or orientation of microstructures.

3.3 *Symbols:*

$N_\perp$ = number of feature interceptions with test lines perpendicular to the deformation direction.

$N_{\parallel}$ = number of feature interceptions with test lines parallel to the deformation direction.

$P_\perp$ = number of feature boundary intersections with test lines perpendicular to the deformation direction.

$P_{\parallel}$ = number of feature boundary intersections with test lines parallel to the deformation direction.

$L_{\parallel}$ = summarized length of feature interceptions by a single test line, parallel to the deformation direction (mm).

$L_\perp$ = summarized length of feature interceptions by a single test line, perpendicular to the deformation direction (mm).

M = magnification.

L_t = true test line length in mm, that is, the test line length divided by M.

$N_{L\perp} = \frac{N_\perp}{L_t}$

$N_{L\parallel} = \frac{N_\parallel}{L_t}$

$P_{L\perp} = \frac{P_\perp}{L_t} \cong 2N_{L\perp}$

$P_{L\parallel} = \frac{P_\parallel}{L_t} \cong 2N_{L\parallel}$

$L_{L\parallel}$ = linear fraction of a feature on a single test line parallel to the deformation direction

$L_{L\perp}$ = linear fraction of a feature on a single test line perpendicular to the deformation direction

$L_{L\parallel} = \frac{L_\parallel}{L_t}$

$L_{L\perp} = \frac{L_\perp}{L_t}$

[3] Kazakov A., Kiselev D., Andreeva S., Chigintsev L., Golovin S., Egorov V., and Markov S., "Development of a procedure for the quantitative estimation of microstructural banding of low-alloyed pipeline steels using an automatic image analyzer ," *Chernye metally*, 2007, No. 7-8, pp. 31-37.

[4] Kazakov, A., Kiselev, D., Kazakova, E., Vander Voort, G. F., and Chigintsev, L., "Quantitative Description of Microstructural Banding in Steels," *Materials Performance and Characterization*, Vol. 6, No. 3, 2017, pp. 224-236, https://doi.org/10.1520/MPC20160009.