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Standard Test Methods for Characterizing Duplex Grain Sizes[1]

This standard is issued under the fixed designation E1181; 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

Test methods are well established for the determination of average grain size, and estimation of largest grain size, in products assumed to contain a single log-normal distribution of grain sizes. The test methods in this standard are set forth to characterize grain size in products with any other distributions of grain size.

The term "duplex grain size" is chosen to describe any of these other distributions of grain size, because of its common usage and familiarity. However, the use of that term does not imply that only two grain size distributions exist.

These test methods are equally aimed at describing the nature of the deviation from a single log-normal distribution of grain sizes, and at describing with reasonable accuracy the distributions of sizes that actually exist.

1. Scope

1.1 These test methods provide simple guidelines for deciding whether a duplex grain size exists. The test methods separate duplex grain sizes into one of two distinct classes, then into specific types within those classes, and provide systems for grain size characterization of each type.

1.2 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard may involve hazardous materials, operations, and equipment. 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.*

1.4 *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]

E3 Guide for Preparation of Metallographic Specimens
E7 Terminology Relating to Metallography
E112 Test Methods for Determining Average Grain Size
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
E930 Test Methods for Estimating the Largest Grain Observed in a Metallographic Section (ALA Grain Size)

2.2 *ASTM Adjuncts:*

Comparison Chart for Estimation of Area Fractions[3]

3. Terminology

3.1 *Definitions:*

3.1.1 All terms used in these test methods are either defined in Terminology E7, or are discussed in 3.2.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bands or banding*— in grain size, alternating areas of significantly different grain sizes. These areas are usually elongated in a direction parallel to the direction of working.

3.2.2 *grain size*—equivalent in meaning to the average of a distribution of grain sizes.

[1] These test methods are under the jurisdiction of ASTM Committee E04 on Metallography and are the direct responsibility of Subcommittee E04.08 on Grain Size.

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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] This comparison chart shows different area percentages of light grains among dark grains. Available from ASTM Headquarters. Order Adjunct: ADJE1181.

3.2.3 *necklace or necklace structure*—individual coarse grains surrounded by rings of significantly finer grains.

3.2.4 *topologically varying*—varying nonrandomly, in some definable pattern; that pattern may be related to the shape of the specimen or product being examined.

4. Summary of Test Method

4.1 These test methods provide means for recognizing the presence of duplex grain size. The test methods separate duplex grain sizes into two classes (randomly varying, and topologically varying), and define specific types of duplex grain sizes within these classes. The test methods provide means for estimating area fractions occupied by distinct grain sizes, and offer existing standard methods (Test Methods E112, Test Methods E930) for determining grain size in specific identified areas. The test methods provide for reporting of specific, distinctive information for each type of duplex grain size. And, as an alternative, the test methods offer a procedure for statistically determining the distribution of all the grain sizes present in a duplex grain size specimen.

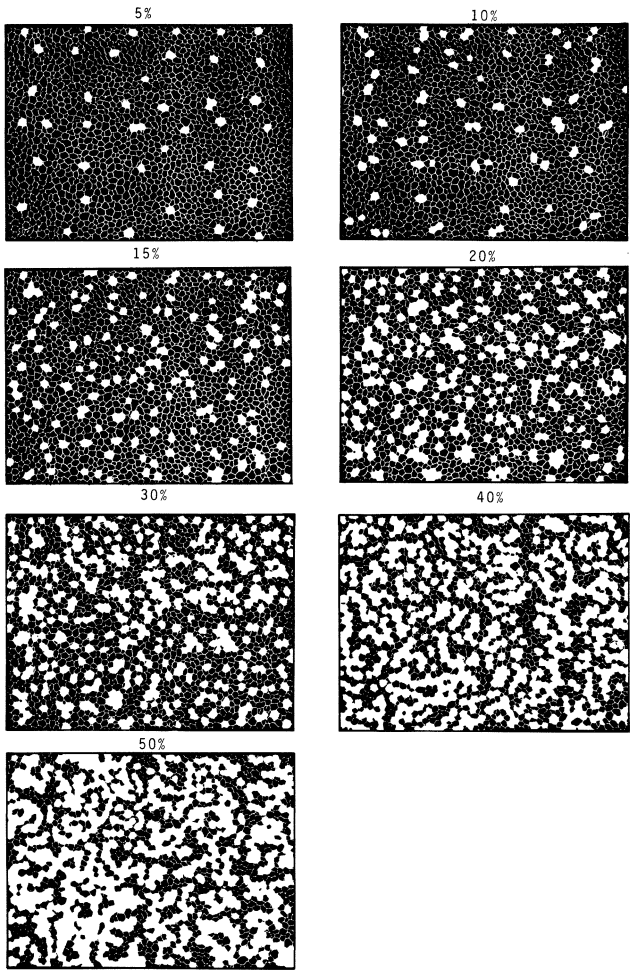

FIG. 1 Comparison Chart for Estimation of Area Fractions[1]
(Showing area percentages of light grains among dark grains)

5. Significance and Use

5.1 Duplex grain size may occur in some metals and alloys as a result of their thermomechanical processing history. For comparison of mechanical properties with metallurgical features, or for specification purposes, it may be important to be able to characterize grain size in such materials. Assigning an average grain size value to a duplex grain size specimen does not adequately characterize the appearance of that specimen, and may even misrepresent its appearance. For example, averaging two distinctly different grain sizes may result in reporting a size that does not actually exist anywhere in the specimen.

5.2 These test methods may be applied to specimens or products containing randomly intermingled grains of two or more significantly different sizes (henceforth referred to as random duplex grain size). Examples of random duplex grain sizes include: isolated coarse grains in a matrix of much finer grains, extremely wide distributions of grain sizes, and bimodal distributions of grain size.

5.3 These test methods may also be applied to specimens or products containing grains of two or more significantly different sizes, but distributed in topologically varying patterns (henceforth referred to as topological duplex grain sizes). Examples of topological duplex grain sizes include: systematic variation of grain size across the section of a product, necklace structures, banded structures, and germinative grain growth in selected areas of critical strain.

5.4 These test methods may be applied to specimens or products regardless of their state of recrystallization.

5.5 Because these test methods describe deviations from a single, log-normal distribution of grain sizes, and characterize *patterns* of variation in grain size, the total specimen cross-section must be evaluated.

5.6 These test methods are limited to duplex grain sizes as identifiable within a single polished and etched metallurgical specimen. If duplex grain size is suspected in a product too large to be polished and etched as a single specimen, macroetching should be considered as a first step in evaluation. The entire macroetched cross-section should be used as a basis for estimating area fractions occupied by distinct grain sizes, if possible. If microscopic examination is subsequently necessary, individual specimens must be taken to allow estimation of area fractions for the entire product cross-section, and to allow determination of grain sizes representing the entire cross-section as well.

5.7 These test methods are intended to be applied to duplex grain *sizes*. Duplex grain *structures* (for example, multiphase alloys) are not necessarily duplex in grain size, and as such are not the subject of these methods. However, the test methods described here for area fraction estimation may be of use in describing duplex grain structures.

6. Apparatus

6.1 Certain items may be helpful or necessary in applying the various procedures of these test methods. These items are