AEROSPACE MATERIAL SPECIFICATION	AMS2315™	REV. H
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Determination of Delta Ferrite Content

RATIONALE

AMS2315H revises specimen selection for tubing (3.1.3.3), Heat Treatment (3.1.4), Procedure for Limited Delta Ferrite Criterion (3.2), Relative Accuracy requirement (3.2.1.3.5.1), Reports (4.4), and results from a Five-Year Review and update of this specification.

1. SCOPE

This specification covers two methods for determining the percentage of delta ferrite in steels and other iron alloys. When applicable, this specification will be invoked by the material specification.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E3 Preparation of Metallographic Specimens

ASTM E1245 Determining the Inclusion or Second-Phase Constituent Content of Metals by Automatic Image Analysis

3. TECHNICAL REQUIREMENTS

3.1 Specimen Preparation

3.1.1 Heat Qualification

Sampling shall be in accordance with 4.3.1. Samples shall be converted into test specimens in accordance with 3.1.3.

3.1.2 Product Qualification

Product from a heat not qualified, based on sampling as in 4.3.1, shall be sampled in accordance with 4.3.2. Samples shall be converted into test specimens in accordance with 3.1.3.

3.1.3 Specimen Selection

Samples of sufficient size to provide specimens having approximately 0.25 to 0.5 in^2 (161 to 323 mm^2) prepared surface area or of an area sufficient to randomly select the required number of fields to accurately examine the sample, shall be cut from the product as in 3.1.3.1, 3.1.3.2, or 3.1.3.3, as applicable. Each specimen shall be marked in such a manner that its orientation with respect to the direction of rolling, drawing, or extruding is easily identifiable.

3.1.3.1 Round, Hexagonal, or Square Product

Specimens shall be selected from an area midway between the edge and the center of the sample.

3.1.3.2 Rectangular Product

Specimens shall be selected from an area midway between the longitudinal edge and the center of the sample.

3.1.3.3 Tubing and Other Hollow Shapes

Specimens shall be selected from samples which include the full wall thickness of the product if the full wall thickness is 0.500 inch or under and mid-wall if the full wall thickness is over 0.500 inch.

3.1.4 Heat Treatment

Specimens, except as specified in 3.1.4.1, may be austenitized at the normal recommended temperature for the grade of steel being examined and adequately quenched. The quenched specimens shall be tempered at a sufficiently high temperature to develop good metallographic contrast.

3.1.4.1 Solution and precipitation hardenable steels may be solution heat treated and may be precipitation heat treated to develop good metallographic contrast.

3.1.5 Polishing

After heat treatment as in 3.1.4, a face of each specimen, perpendicular to the direction of maximum deformation, shall be ground and polished, using standard metallographic polishing techniques in accordance with ASTM E3 to produce a surface suitable for microscopic examination.

3.1.6 Etching

The polished surface of each specimen shall be suitably etched to reveal delta ferrite (see 8.4).

3.2 Procedure for Limited Delta Ferrite Criterion

Inspect the specimen surface at a magnification appropriate to observe the relative amount and distribution of delta ferrite present. If it is evident that many fields to be measured will have zero value, and no single field will have a value exceeding the material specification maximum, then measure a set number of fields defined in a laboratory procedure sufficient to ensure that the upper control limit of the mean is less than 50% of the material specification maximum at the 95% confidence level as in 3.2.1 or 3.2.2. A 10% relative accuracy level is not required. In case of dispute over the percentage of delta ferrite, the value determined as in 3.2.2 shall govern.

3.2.1 Point Count Method

3.2.1.1 Field Measurement

Project the image of the microstructure of each specimen onto the ground-glass screen of a reflection-type microscope or metallograph. Place a transparent point-counting grid template either in front of or behind the ground glass. The template should consist of either 100 or 500 systematically spaced grid points, either in the form of fine crosses or a grid lattice. The magnification chosen should be high enough to clearly resolve the delta ferrite grains but not so high that the number of grid points falling in the ferrite grains exceeds one, on the average. For each specimen, count the number of grid points (i.e., the intersection point of the crosses or grid blocks) that fall within the ferrite grains as one and those that fall on the phase boundaries as one-half.

3.2.1.2 Field Selection

Select the fields to be measured randomly, that is, without looking at the image, by moving the stage controls. Do not alter the position so that grid points fall on or miss ferrite grains. Space the fields selected around the specimen surface in a systematic pattern. Measure a sufficient number of fields so that the relative accuracy (see 3.2.1.3.5) is 10% or less. The relative accuracy of the measurement is influenced by the volume fraction of the ferrite, the magnification, the grid point density, the number of fields measured, and the field-to-field variation of the ferrite phase.

3.2.1.3 Calculation

3.2.1.3.1 Ferrite Per Field

Calculate the volume fraction of ferrite using Equation 1 for each field measured.

$$V_{\delta,i} = \frac{P_{\delta,i}}{P_t} \times 100 \qquad \text{(Eq. 1)}$$

where:

$V_{\delta,i}$ = volume fraction of ferrite in % of each field

$P_{\delta,i}$ = number of grid points in the ferrite phase or on the phase boundaries

P_t = number of grid points

3.2.1.3.2 Ferrite Per Specimen

Determine the mean value of the volume fraction of ferrite using Equation 2.

$$\bar{V}_\delta = \Sigma \frac{V_{\delta,i}}{n} \qquad \text{(Eq. 2)}$$

where:

$\bar{V}_\delta$ = mean volume fraction of ferrite per specimen

n = number of fields measured in the specimen

3.2.1.3.3 Calculate the standard deviation of the field-to-field variation of the volume fraction of ferrite using Equation 3.

$$s = \left(\frac{\Sigma\ (V_{\delta,i} - \bar{V}_\delta)^2}{n-1} \right)^{1/2} \qquad \text{(Eq. 3)}$$

where:

s = standard deviation of the volume fraction measurements

3.2.1.3.4 Calculate the 95% confidence limit (95% CI) of the volume fraction measurements using Equation 4.

$$\pm 95\%\ \text{CI} = \pm \frac{ts}{\sqrt{n}} \qquad \text{(Eq. 4)}$$

where:

t = t-value for Student t-distribution for (n-1) degree of freedom for a 95% confidence interval are tabulated in most statistical textbooks, see Table 1 for examples: