

Method for

**Statistically estimating the
volume fraction of phases and
constituents by systematic
manual point counting with a
grid**

Confirmed
December 2009

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Iron and Steel Standards Policy Committee (ISM/-) to Technical Committee ISM/72, upon which the following body was represented:

British Steel Industry

This British Standard, having been prepared under the direction of the Iron and Steel Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 October 1992

© BSI 1992

The following BSI references relate to the work on this standard:
Committee reference ISM/72
Draft for comment 91/37958 DC

ISBN 0 580 21089 8

Amendments issued since publication

Amd. No.	Date	Text affected

Contents

	Page
Committees responsible	Inside front cover
Foreword	2
Method	
1 Scope	3
2 Informative references	3
3 Principle	3
4 Symbols	3
5 Apparatus	3
6 Test samples	6
7 Procedure	6
8 Calculation of the volume fraction of α -phase V_v , the 95 % confidence interval CI and the relative error	8
9 Improving the volume fraction estimate	9
10 Test report	9
Annex	
A (informative) Worksheet for the determination of volume fraction by systematic manual point count	10
Tables	
1 Guidelines for grid size selection (total number of points on a grid) for visually estimated area fractions	6
2 Number of fields (n) for a relative error of 33 % for a given volume fraction and grid size	7
3 Number of fields (n) for a relative error of 20 % for a given volume fraction and grid size	7
4 Number of fields (n) for a relative error of 10 % for a given volume fraction and grid size	7
5 Number of fields (n) for a relative error of 5 % for a given volume fraction and grid size	8
6 Multipliers for calculation of 95 % confidence interval	8
Figures	
1 Examples of circular grid configurations	4
2 Examples of square grid configurations	5
List of references	Inside back cover

Foreword

This British Standard has been prepared under the direction of the Iron and Steel Standards Policy Committee. It is related to ISO 9042 : 1988, published by the International Organization for Standardization (ISO).

Compared with ISO 9042, tables 2 to 6 of this British Standard are more comprehensive and their relationship to the procedure given in clause 7 is clearer; the requirements for the test report in clause 10 are more readily achieved. Annex A includes a worksheet describing a step-by-step procedure designed to assist in the use of this British Standard.¹⁾

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced personnel.

This British Standard calls for the use of substances and/or procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

¹⁾ Annex A is also separately available from BSI.

Method

1 Scope

This British Standard describes a method for statistically estimating the volume fraction of clearly defined constituents or phases in the microstructure of a steel on a metallographically prepared section using a systematic manual point counting technique.

2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Principle

3.1 The method is based on the statistical principle that, when a regular array of points is systematically placed over a two-dimensional section through a uniform microstructure, the proportion of points which fall within a randomly distributed second phase or constituent, designated α -phase, in the structure is equal both to the area fraction of the second phase in a random planar section through the microstructure and to the volume fraction of the second phase.

This mathematical relationship can be summarized as follows:

$$V_v = \frac{V_\alpha}{V} = \frac{A_\alpha}{A} = \frac{P_\alpha}{P} \quad (1)$$

where

V_v is the volume fraction of the α -phase in a three-dimensional sample;

V_α is the volume of the α -phase in the three-dimensional sample;

V is the total volume of the three-dimensional sample;

A_α is the area of the α -phase in a random planar section;

A is the total area of the random planar section;

P_α is the number of points falling in the α -phase in a random planar section;

P is the total number of points laid down in the random planar section.

3.2 The method consists of superimposing a point grid over a number of different representative fields on the microstructure, counting the number of points included in the constituent or phase, and then calculating the volume fraction of the phase. A predetermined number of fields have to be examined to obtain particular specified levels of precision.

3.3 Any number of clearly identifiable phases or constituents can be counted at the same time using the method.

4 Symbols

n Number of fields examined, i.e. number of grid placements

P_T Total number of points in the grid

P_i Point count on i th field, i.e. number of grid points falling on the constituent of interest in the i th field

$P_{p(i)}$ Proportion of grid points in the constituent of interest on the i th field expressed as a percentage of the total number of points in the grid

$$P_{p(i)} = \frac{P_i}{P_T} \times 100 \quad (2)$$

$\bar{P}_p$ Mean of $P_{p(i)}$

$$\bar{P}_p = \frac{1}{n} \sum_{i=1}^n P_{p(i)} \quad (3)$$

s Estimate of standard deviation (σ)

$$s = \left\{ \frac{1}{n-1} \sum_{i=1}^n (P_{p(i)} - \bar{P}_p)^2 \right\}^{1/2} \quad (4)$$

CI 95 % confidence interval

$$CI = \pm \frac{2s}{\sqrt{n}} \quad (5)$$

5 Apparatus

5.1 A *microscope* or other suitable means of observation with either:

a) a viewing screen; or

b) a monocular or binocular eyepiece.

NOTE. The microscope should preferably have a stage with graduated X and Y translation controls.

5.2 A *test grid* which consists of a specified number of equally and regularly spaced points formed by the intersection of very thin lines.

NOTE 1. The grid may be a suitably marked transparency which is superimposed onto the viewing screen of the microscope or on photomicrographs.

The grid may also be an eyepiece graticule which is placed in the eyepiece of the microscope.

NOTE 2. An error can arise from the accuracy of detection of the intersection point within a phase (see 7.6.2). Thus it is recommended that grid lines should be as fine as possible to improve the sharpness of the intersection point.

NOTE 3. The grids may be constructed by the user or obtained commercially.

Examples of different types of grid pattern and size (circular or square array) are shown in figures 1 and 2.

It is useful to have a range of grids available consisting of 1, 4, 12, 16, 25 and 100 intersecting points.

