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Steel, non-alloy and low-alloy — Determination of depth of decarburization

Aciers non alliés et faiblement alliés — Détermination de la profondeur de décarburation

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FOREWORD

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Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3887 was drawn up by Technical Committee ISO/TC 17, *Steel*, and was circulated to the Member Bodies in July 1975.

It has been approved by the Member Bodies of the following countries:

Australia	India	Romania
Belgium	Iran	South Africa, Rep. of
Brazil	Ireland	Spain
Canada	Italy	Sweden
Czechoslovakia	Japan	Switzerland
Denmark	Korea, Dem. P. Rep. of	Turkey
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No Member Body expressed disapproval of the document.

Steel, non-alloy and low-alloy — Determination of depth of decarburization

1 SCOPE AND FIELD OF APPLICATION

This International Standard defines decarburization and also specifies three methods of measuring the depth of decarburization of non-alloy and low-alloy steels.

2 REFERENCE

ISO/R 437, *Chemical analysis of steels — Determination of total carbon (Gravimetric method after combustion in a stream of oxygen).*

3 DEFINITIONS

3.1 decarburization : The loss of carbon from the surface layer of the metal. This loss may be either :

a) partial decarburization; or

b) complete (or almost complete) decarburization.

3.2 total decarburization : The sum of the two types of decarburization, namely both partial and complete.

3.3 depth of total decarburization : The distance between the surface of the product and the point at which the carbon content is that of the unaffected core.

If the product has undergone a process involving carburization, the definition of the "core" shall form the subject of an agreement between the parties concerned.

NOTE — The permissible depth of decarburization shall be specified in the appropriate standard covering the product or shall be the subject of an agreement between the parties concerned.

4 MEASURING METHODS

The choice of the method and its accuracy depend on the degree of decarburization, the microstructure, the carbon content of the product examined and the shape of the component.

The usual methods employed on finished products are :

— the micrographic method (see 4.1);

— the method for measuring the micro-hardness (Vickers) for steels in the hardened state (see 4.2);

— the method for the determination of the carbon content by chemical or spectrographic analysis (see 4.3).

The inclusion of several methods of measurement, each having its own sphere of application, avoids the necessity for further heat treatment. The samples should be examined in the condition of delivery. Nevertheless, if, by agreement between the parties concerned, a supplementary heat treatment is applied, every precaution should be taken to prevent changes in the distribution of carbon, i.e. a small sample, a short austenitization time, a neutral atmosphere.

In the absence of an indication of the choice of method in the product standard, this shall form the subject of an agreement between the parties concerned.

4.1 Micrographic method

This consists in examining the variations of structure associated with the change in carbon content of the product, starting from the periphery towards the centre.

This method, when used correctly, is especially valid for steels showing an annealed (or ferrite-pearlite) structure. It may apply, with reservations, for products showing a hardened, or tempered, or as-rolled, or forged structure where the interpretation of the structural variations becomes difficult.

4.1.1 *Selection and preparation of the sample*

The sample selected shall consist of a section perpendicular to the longitudinal axis of the product. For products with no longitudinal axis, selection of the sample shall form the subject of an agreement between the parties concerned.

Small samples (section less than 4 cm^2) shall be examined over their entire periphery. For large samples, several sections shall be taken in order to ensure that the sampling is representative. Sections taken near corners of polygonal products and/or points of extreme depth of decarburization shall be excluded. The number and the relative position of the various samples shall be specified by agreement between the parties concerned.

The micrographic polishing, carried out according to the usual methods, shall not round the edges. For this, the sample can be mounted or held in a clamp, and the surface of the product can, if necessary, be protected by a metallic deposit obtained electrolytically.

Etching in nital, for example 2 to 4 % (2 to 4 % nitric acid in ethanol) will reveal the structure of the steel.

4.1.2 *Measurement proper*

In general, the structures observed are differentiated by the relative variation in the ferrite in relation to the other constituents in hypoeutectoid steels, and by the relative variation of the quantity of the carbides in the hypereutectoid steels.

The distance from the surface to the point at which the structure does not differ from the structure of the core shall be measured either with the aid of a micrometric eye-piece, or directly on the ground glass screen of the microscope.

The choice of magnification depends on the depth of the decarburization and shall form the subject of an agreement between the parties. A magnification of 100 × is recommended for the majority of instances.

A preliminary examination at low magnification will ensure that there is no great variation in the depth of decarburization along the periphery observed.

For each example, several measurements (five at the minimum) shall be carried out in the deepest uniformly decarburized zone. The average of these measurements defines the maximum depth of total decarburization (see 3.3). Points of extreme depth of decarburization shall be excluded except if agreed to the contrary by the parties concerned.

4.2 Method for measuring the micro-hardness (Vickers)

This method consists in determining the gradient of the micro-hardness on a cross-section of the product along a line perpendicular to the surface.

This technique applies only to hypoeutectoid steels in the hardened condition, and to decarburized layers which are relatively deep but small in relation to the thickness of the hardened zone, in order to avoid the occurrence of variations in hardness due to imperfect penetration of the hardening. This method becomes inaccurate for low-carbon steels.

4.2.1 *Selection and preparation of the sample*

The selection and preparation of the sample shall be identical to that employed in the micrographic method (see 4.1.1), although, in general, the sample shall not be etched, in order to facilitate the measurement of the size of the impression. Precautions shall be taken to avoid overheating the sample.

4.2.2 *Measurement proper*

The load shall be as high as possible, in order to minimize the scatter of the measurements; in principle, this load will be between 0,49 N and 4,9 N (0,05 and 0,5 kgf). The distance between impressions shall be at least 2,5 times the diagonal of the impression.

The depth of total decarburization is defined by the distance from the surface to the point at which the required hardness is attained, taking into account the scatter of the measurements.

In principle, at least two series of measurements shall be carried out in locations as remote as possible from each other. The average of the two depth measurements defines the depth of the total decarburization (see 3.3).

4.3 Methods of determination of carbon content

The methods consist in determining the gradient of the carbon content in a direction perpendicular to the surface. It applies whatever the structure of the steel.

4.3.1 *Chemical analysis*

4.3.1.1 GENERAL

This applies only to products with an exact geometry (round base cylinder or plain faced polyhedron), and of a size consistent with machining facilities, provided that sampling does not require any heat treatment[1].

4.3.1.2 SELECTION OF SAMPLES AND TEST

Successive layers 0,1 mm thick, parallel to the surface of the piece, shall be taken by dry machining, avoiding all contamination. Any film of oxide shall be removed beforehand.

The metal collected at each level shall be submitted to a carbon determination by chemical means, in conformity with ISO/R 437.

4.3.2 *Spectrographic analysis*

4.3.2.1 GENERAL

This applies only to products with flat faces of adequate size.

4.3.2.2 SELECTION OF SAMPLES AND TEST

The flat sample shall be subjected to successive grinding operations to different levels 0,1 mm apart. Spectrographic determination of the carbon shall be carried out at each level in such a way that successive sparkings are not superimposed.

4.3.3 *Interpretation of the results (chemical and spectrographic methods)*

The methods described in 4.3.1 (chemical analysis) and 4.3.2 (spectrographic analysis) permit the determination of the depth of decarburization, by measuring the distance from the surface to the point where the carbon content is that specified.

1) In certain instances and after agreement between the parties, a preparation heat treatment is allowed, provided that it does not affect the depth of decarburization.

If such a carbon content is not specified, the distance to be measured shall be the distance from the surface to the point where the carbon content does not differ from the minimum of the nominal range for the product, after making allowance for permissible variations from the analysis, by more than the values shown below :

Nominal content of the product, %	Maximum permissible deviation
$C < 0,60$	0,03 % C
$C \geqslant 0,60$	5 % of the nominal content of the product

5 TEST REPORT

The test report shall include the following particulars :

a) the number and the location of the samples taken from the piece;

b) the method used;

c) the results of the measurements permitting the depth of decarburization to be defined.

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