



BSI Standards Publication

Welding - Determination of Ferrite Number (FN) in austenitic and duplex ferritic-austenitic Cr-Ni stainless steel weld metals

National foreword

This British Standard is the UK implementation of EN ISO 8249:2018. It is identical to [ISO 8249:2018](#). It supersedes [BS EN ISO 8249:2000](#), which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/-/1, Briefing committee for welding.

A list of organizations represented on this committee can be obtained on request to its secretary.

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© The British Standards Institution 2018
Published by BSI Standards Limited 2018

ISBN 978 0 580 98123 4

ICS 25.160.40; 25.160.20

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2018.

Amendments/corrigenda issued since publication

Date	Text affected
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English Version

**Welding - Determination of Ferrite Number (FN) in
austenitic and duplex ferritic-austenitic Cr-Ni stainless
steel weld metals (ISO 8249:2018)**

Soudage - Détermination de l'indice de ferrite
(FN) dans le métal fondu en acier inoxydable
austénitique et duplex ferritique-austénitique
au chrome-nickel (ISO 8249:2018)

Schweißen - Bestimmung der Ferrit-Nummer
(FN) in austenitischem und ferritisch-
austenitischem (Duplex-)Schweißgut
von Cr-Ni-Stählen (ISO 8249:2018)

This European Standard was approved by CEN on 8 September 2018.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

This document (EN ISO 8249:2018) has been prepared by Technical Committee ISO/TC IIW "International Institute of Welding " in collaboration with Technical Committee CEN/TC 121 "Welding and allied processes" the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2019, and conflicting national standards shall be withdrawn at the latest by March 2019.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 8249:2000.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of [ISO 8249:2018](#) has been approved by CEN as EN ISO 8249:2018 without any modification.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by IIW, the International Institute of Welding, Commission II.

Any feedback, question or request for official interpretation related to any aspect of this document should be directed to IIW via your national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This third edition cancels and replaces the second edition (ISO 8249:2000), which has been technically revised. The main changes compared to the previous edition are as follows:

- corrections have been made to [Table 2](#) (previously Table 1);
- minor editorial changes in [Clause 9](#) (previously Clause 8) and throughout the document have been made.

Introduction

At present, there is no universal opinion concerning the best experimental method that gives an absolute measurement of the amount of ferrite in a weld metal, either destructively or non-destructively. This situation has led to the development and use, internationally, of the concept of a "Ferrite Number" or FN. A Ferrite Number is a description of the ferrite content of a weld metal determined using a standardized procedure. Such procedures are laid down in this document. The Ferrite Number of a weld metal has been considered approximately equivalent to the percentage ferrite content, particularly at low FN values. More recent information suggests that the FN can overstate the volume percent ferrite at higher FN by a factor in the order of 1,3 to 1,5, which depends to a certain extent on the actual composition of the alloy in question.

Although other methods are available for determining the Ferrite Number, the standardized measuring procedure, laid down in this document, is based on assessing the tear-off force needed to pull the weld metal sample from a magnet of defined strength and size. The relationship between tear-off force and FN is obtained using primary standards consisting of a non-magnetic coating of specified thickness on a magnetic base. Each non-magnetic coating thickness is assigned an FN value.

The ferrite content determined by this method is arbitrary and is not necessarily the true or absolute ferrite content. In recognition of this fact, the term "Ferrite Number" (FN) is used instead of "ferrite per cent" when quoting a ferrite content determined by this method. To help convey the message that this standardized calibration procedure has been used, the terms "Ferrite Number" and "FN" are capitalized as proper nouns.

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Welding - Determination of Ferrite Number (FN) in austenitic and duplex ferritic-austenitic Cr-Ni stainless steel weld metals

1 Scope

This document specifies the method and apparatus for:

- the measurement of the delta ferrite content, expressed as Ferrite Number (FN), in largely austenitic and duplex ferritic-austenitic stainless steel¹⁾ weld metal through the attractive force between a weld metal sample and a standard permanent magnet;
- the preparation and measurement of standard pads for manual metal arc covered electrodes. The general method is also recommended for the ferrite measurement of production welds and for weld metal from other processes, such as gas tungsten arc welding, gas shielded metal arc welding and submerged arc welding (in these cases, the way of producing the pad should be defined);
- the calibration of other instruments to measure FN.

The method laid down in this document is intended for use on weld metals in the as-welded state and on weld metals after thermal treatments causing complete or partial transformation of ferrite to any non-magnetic phase. Austenitizing thermal treatments which alter the size and shape of the ferrite change the magnetic response of the ferrite.

The method is not intended for measurement of the ferrite content of cast, forged or wrought austenitic or duplex ferritic-austenitic steel samples.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Principle

The measurement of the ferrite content of largely austenitic stainless steel weld metal through the attractive force between a weld metal sample and a permanent magnet is based on the fact that the attractive force between a two-phase (or multiphase) sample containing one ferromagnetic phase and one (or more) non-ferromagnetic phase(s) increases as the content of the ferromagnetic phase increases. In largely austenitic and duplex ferritic-austenitic stainless steel weld metal, ferrite is magnetic, whereas austenite, carbides, sigma phase and inclusions are non-ferromagnetic.

1) The term "austenitic-ferritic (duplex) stainless steel" is sometimes applied in place of "duplex ferritic-austenitic stainless steel".

5 Calibration

5.1 Coating thickness standards

The coating thickness standards shall consist of non-magnetic copper applied to an unalloyed steel base of size 30 mm × 30 mm. The thickness of the unalloyed steel base shall be equal to or greater than the experimentally determined minimum thickness at which a further increase of the thickness does not cause an increase of the attractive force between the standard permanent magnet and the coating thickness standard. The thickness of the non-magnetic copper coating shall be known to an accuracy of ± 5 % or better. The chemical composition of unalloyed steel shall be within the limits given in [Table 1](#).

Table 1 — Chemical composition limits — unalloyed steel

Element	Limit % (by mass)
C	0,08 to 0,13
Si	0,10 maximum
Mn	0,30 to 0,60
P	0,040 maximum
S	0,050 maximum

The copper coating may be covered by a chromium flash. The force required to tear off a given permanent magnet from the copper coating side of such a standard increases as the thickness of the copper coating decreases.

To ensure adequate reproducibility of the calibration, the coating thickness standards defined above should be used. In particular, coating thickness standards produced by the US National Institute of Standards and Technology (NIST, formerly National Bureau of Standards or NBS) may be used.

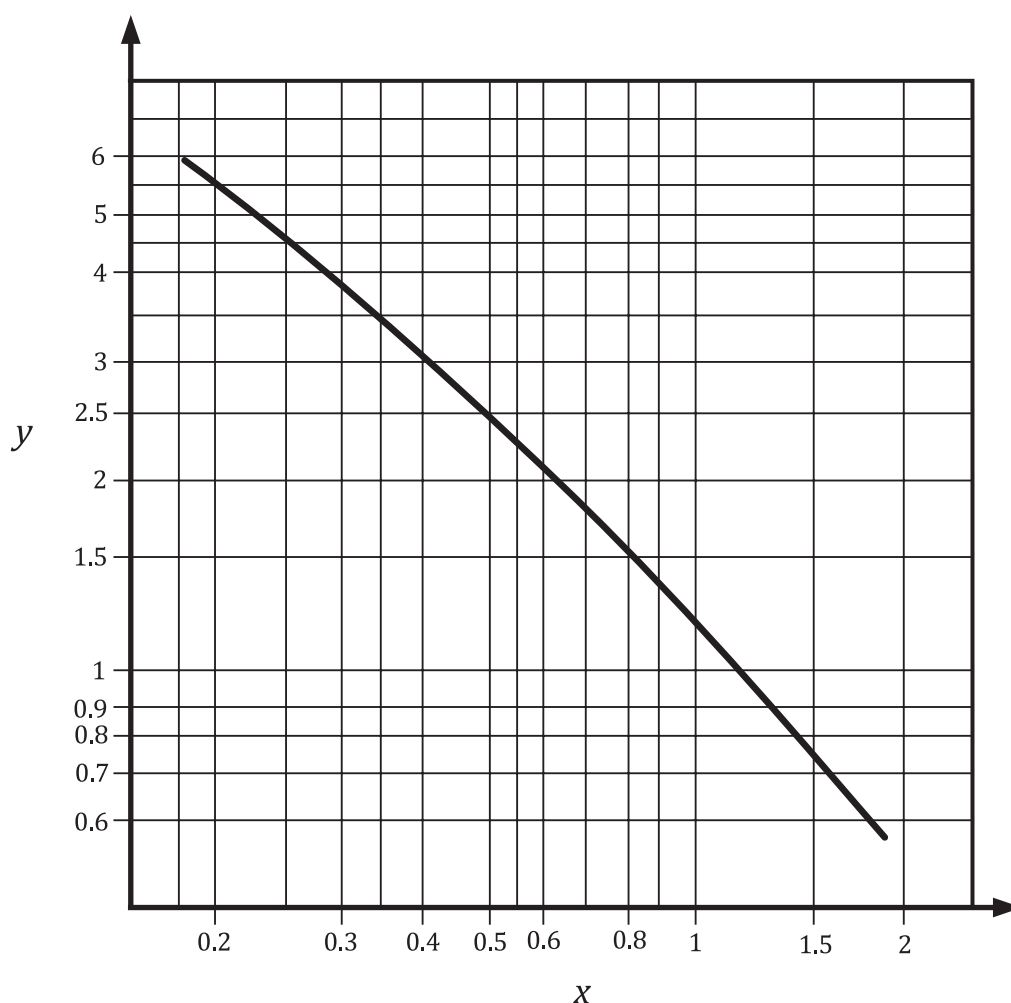
5.2 Magnet

The standard magnet shall be a permanent magnet of cylindrical shape, 2 mm in diameter and about 50 mm in length. One end of the magnet shall be hemispherical, with a 1 mm radius and polished. As an example, such a magnet can be made of 36 % cobalt magnet steel, 48,45 mm $\pm$ 0,05 mm long, magnetically saturated and then diluted to 85 %. The magnetic strength of the magnet shall be such that the force needed to tear off the standard magnet from the different coating thickness standards is within ± 10 % of the relationship shown in [Figure 1](#) (the weight of the magnet excluded). This is equivalent to a relationship between tear-off force and Ferrite Number of 5,0 FN/g $\pm$ 0,5 FN/g.

5.3 Instruments

The measurement by this method shall be made by an instrument enabling an increasing tear-off force to be applied to the magnet perpendicularly to the surface of the test specimen. The tear-off force shall be increased until the permanent magnet is detached from the test specimen. The instrument shall accurately measure the tear-off force which is required for detachment. The reading of the instrument may be directly in FN or in grams-force or in other units. If the reading of the instrument is in units other than FN, the relationship between the FN and the instrument reading shall be defined by a calibration curve.

NOTE Many instruments used to measure the thickness of a non-magnetic coating over a ferromagnetic base are suitable (e.g. MAGNE-GAGE of USA origin) and some commercially available instruments are designed directly for measurement of ferrite content (e.g. ALPHA-PHASE-METER of former USSR origin). In addition, after suitable in-house alterations, some laboratory balances can be used.

**Key**

- x non-magnetic coating thickness, millimetres (mm)
 y tear-off force, gram force (gf)

Figure 1 — Relationship between the tear-off forces of the standard magnet defined in 5.2 and the coating thickness standards defined in 5.1

5.4 Calibration curve

In order to generate a calibration curve, determine the force needed to tear off the standard magnet defined in 5.2 from several coating thickness standards defined in 5.1. Then, convert the thickness of non-magnetic coating of the coating thickness standards into FN in accordance with Table 2, or in accordance with Formula (1)^[4]:

$$FN = \exp\{1,805\,9 - 1,118\,86 [\ln(t)] - 0,177\,40 [\ln(t)]^2 - 0,035\,02 [\ln(t)]^3 - 0,003\,67 [\ln(t)]^4\} \quad (1)$$

where t is the non-magnetic coating thickness, expressed in millimetres.

Finally, plot the calibration curve as the relationship between the tear-off force in the units of the instrument reading and the corresponding FN.

To calibrate the instrument for measurement of ferrite content within the range from 0 FN to approximately 30 FN, which is appropriate for nominally austenitic stainless steel weld metals, a set