Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal
Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal

6th Edition


Prepared by the American Welding Society (AWS) A5 Committee on Filler Metals and Allied Materials

Under the Direction of the AWS Technical Activities Committee

Approved by the AWS Board of Directors

Abstract

Calibration procedures are specified for a number of commercial instruments that can then provide reproducible measurements of the ferrite content of austenitic stainless steel weld metals. Certain of these instruments can be further calibrated for measurements of the ferrite content of duplex ferritic-austenitic stainless steel weld metals. Calibration with primary standards (non-magnetic coating thickness standards from the U.S. National Institute of Standards and Technology) is the preferred method for appropriate instruments. Alternatively, these and other instruments can be calibrated with weld-metal-like secondary standards.

Reproducibility of measurement after calibration is specified. Problems associated with accurate determination of ferrite content are described.
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Foreword

This foreword is not part of this standard but is included for informational purposes only.

This document is an adoption of ISO 8249:2018 with additional normative and informative annexes to replace AWS A4.2M, Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal, first published in 1974 and revised in 1986 and again in 1991. These revisions were prepared by the Subcommittee on Welding Stainless Steel of the Welding Research Council and by the AWS Committee on Filler Metals. Then it was revised again in 1997 and in 2006 by AWS A5 Committee on Filler Metals and Allied Materials. The current revision is the third to use the SI system of measurement as the primary system, and updates the standard in the light of new information.

A certain minimum ferrite content in most austenitic stainless steel weld metals is useful in assuring freedom from microfissures and hot cracks. Upper limits on ferrite content in austenitic stainless steel weld metals can be imposed to limit corrosion in certain media or to limit embrittlement due to transformation of ferrite to sigma phase during heat treatment or elevated temperature service. Upper limits on ferrite content in duplex ferritic-austenitic stainless steel weld metals can be imposed to help assure ductility, toughness, and corrosion resistance in the as-welded condition.

Reproducible quantitative ferrite measurements in stainless steel weld metals are therefore of interest to filler metal producers, fabricators of weldments, weldment end users, regulatory authorities, and insurance companies.

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 nondestructively. 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 described in this Standard. 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 may 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 upon the actual composition of the alloy in question.

Although other methods are available for determining the Ferrite Number, the standardized measuring procedure, described in this Standard, 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) shall be used instead of “ferrite percent” 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.

Document Development

AWS A4.2-74  Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic Stainless Steel Weld Metal

ANSI/AWS A4.2-86  Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic Stainless Steel Weld Metal

ANSI/AWS A4.2-91  Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Austenitic-Ferritic Stainless Steel Weld Metal
Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal

NOTE: The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the standards developer.

Please note that ISO uses commas (,) and AWS uses periods (.) for decimals. The ISO decimal commas have been replaced by periods in this document for consistency.

Substantive change is correcting FN number in Table 1 for coating thickness 0.052 mm which is shown in *Italic* font.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS A5 Committee on Filler Metals and Allied Materials, American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.
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Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal

1. Scope

1.1 This standard 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 steel\(^1\) weld metal through the attractive force between a weld metal sample and a standard permanent magnet;

- the preparation and measurement of standard pads for shielded 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 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 described in this standard 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 will 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.

1.2 Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided, but such issues are not fully addressed herein. Safety and health information is available from the following sources:

American Welding Society:

(1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*

(2) AWS Safety and Health Fact Sheets

(3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

(1) Safety Data Sheets supplied by materials manufacturers

(2) Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

Work performed in accordance with this standard may involve the use of materials that have been deemed hazardous and may involve operations or equipment that may cause injury or death. This standard does not purport to address all safety and health risks that may be encountered. The user of this standard should establish an appropriate safety program to address such risks as well as to meet applicable regulatory requirements. ANSI Z49.1 should be considered when developing the safety program.

\[^1\] The term “austenitic-ferritic (duplex) stainless steel” is sometimes applied in place of “duplex ferritic-austenitic stainless steel”.