INTERNATIONAL STANDARD

ISO 2401

Second edition
2018-08

Welding consumables — Covered electrodes — Determination of the efficiency, metal recovery and deposition coefficient

Électrodes enrobées — Détermination de l'efficacité, du rendement du métal et du coefficient de dépôt

Reference number
ISO 2401:2018(E)

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Published in Switzerland

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Foreword

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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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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 Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

Any feedback, question or request for official interpretation related to any aspect of this document should be directed to the Secretariat of ISO/TC 44/SC 3 via your national standards body. A complete listing of these bodies can be found at www.iso.org/members.html. Official interpretations, where they exist, are available from this page: https://committee.iso.org/sites/tc44/home/interpretation.html.

This second edition cancels and replaces the first edition (ISO 2401:1972), which has been technically revised. The main changes compared to the previous edition are as follows:

— the Scope has been clarified;

— the document has been updated to the latest ISO style, including addition of Clause 2 and subsequent renumbering;

— the term 3.1, electrode efficiency has been added;

— Clause 5 has been revised and the option of eight electrodes introduced;

— in Subclauses 6.1 and 6.2, the option of eight electrodes has been introduced;

— Clause 7 has been introduced to align with other ISO/TC 44/SC 3 documents;

— in Clause 8, requirements on rounding procedure have been reworked (example deleted).

Welding consumables — Covered electrodes — Determination of the efficiency, metal recovery and deposition coefficient

1 Scope

This document specifies methods for the determination of the efficiency, weld metal recovery and deposition coefficient of covered electrodes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 80000-1:2009, *Quantities and units — Part 1: General.* Corrected by ISO 80000-1:2009/Cor 1:2011

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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/

3.1
electrode efficiency
ratio of the mass of weld metal deposited, under standard conditions, to the mass of core wire consumed

3.1.1
nominal electrode efficiency
R_N
electrode efficiency (3.1) calculated from the nominal diameter and specific weight of the core wire

Note 1 to entry: The value of R_N obtained using this document can be very close to the value of R_E.

Note 2 to entry: Specific weight for non-alloy, fine grained, high strength and creep resisting steels 7,85 gcm^{-3}.

3.1.2
effective electrode efficiency
R_E
electrode efficiency (3.1) determined using the actual mass of core wire consumed

Note 1 to entry: The value of R_E obtained using this document can be very close to the value of R_N.

3.2
overall weld metal recovery
R_G
ratio of the mass of weld metal deposited under standard conditions to the total mass of a given electrode tested

3.3
deposition efficiency
R_D
ratio of the mass of weld metal deposited under standard conditions to the total mass of a given electrode consumed, exclusive of stub ends

3.4
deposition coefficient
D
mass of weld metal deposited under standard conditions per ampere minute for a given electrode

Note 1 to entry: When reporting the results of tests, a further suffix shall be added to the above abbreviations R_N, R_E, R_G, R_D and D to indicate the type of current used to establish the values. These suffixes shall be used as follows:

— DC positive R_N +

— DC negative R_N –

— AC R_N ~

4 Test plates

4.1 Number

For each diameter of electrode to be tested, one test plate shall be welded.

4.2 Specification

The test plate shall be of carbon steel (up to 0,25 % C) and shall have approximately the following dimensions:

— width = 75 mm;

— length = 300 mm;

— thickness = 12 mm.

In most cases, a single test piece is long enough; if this is not the case, a second test piece having a length of 150 mm or, if necessary, 300 mm shall be placed end to end with the first test piece (see Figure 1).

Dimensions in millimetres

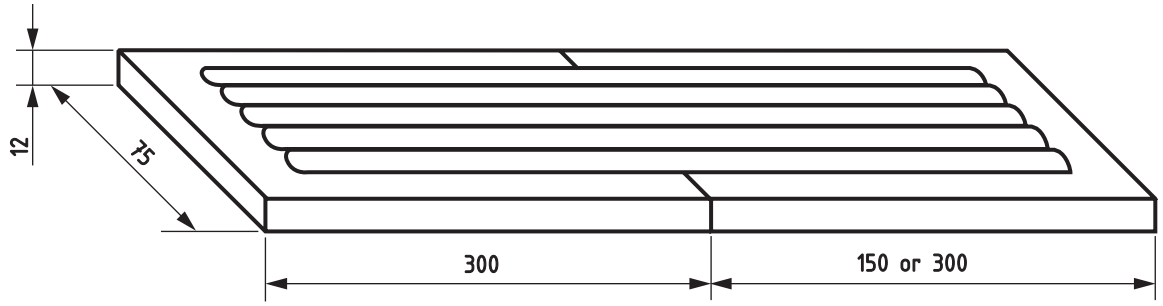

Figure 1 — Test plate

In order to facilitate weighing after welding, the test plate may, where two plates have been used, be broken into two parts.

The surface of the plate on which the deposit is to be made shall be cleaned, if necessary, by light grinding or other suitable means so that it is free from scale, rust, paint, oil, etc. After cleaning and before welding, the plate shall be weighed with a precision of ±1 g.

5 Procedure

5.1 Three, five or eight electrodes of the diameter to be tested shall be used on the test plate. If the mass of the deposit from each electrode is more than 100 g, it is permissible to use only three electrodes.

5.2 Before welding, the electrodes shall be weighed to ±1 g. The total mass of the electrodes is m_E. The mass of the core wires, obtained by carefully removing the covering from the same number of electrodes of the same batch, is m_w. The mass of the core wires, m_w, can also be obtained by calculation after measuring the diameter and the total length, L_w, of the core wire of the electrodes to be tested, assuming the density of steel to be 7,85 g cm^{-3}.

5.3 The welding current, I, shall be equal to about 90 % of the maximum value of the range for the flat position indicated by the electrode manufacturer. The machine setting shall not be changed during the whole test.

5.4 The arc length and welding procedure shall be typical for the electrode being used and the deposited bead shall be free from major defects.

5.5 Electrodes suitable for welding on DC only, or those for which the manufacturer specified that DC is preferable, shall be tested on DC with the polarity recommended by the manufacturer.

5.6 Electrodes suitable for welding on either DC or AC shall be tested on alternating current.

5.7 Each electrode shall be deposited in the flat position and used without interruption until a stub length of approximately 50 mm remains. (It is recommended that the required length of stub end be marked on the electrode before starting to weld.)

5.8 The arcing time of each electrode shall be measured with a precision of ±1 s, and the total time, t, for the number of electrodes tested (three, five or eight) calculated in minutes.

5.9 After each run, the test plate may be cooled in water, but the test plate shall be dry before welding is resumed. The slag and spatter adhering to the test plate shall be carefully removed before depositing subsequent runs. The interpass temperature shall not exceed 100 °C.

5.10 After welding each run, the stub ends shall be retained, avoiding any loss of unfused covering, and, when cooled down, the stub ends can be:

1) weighed with a precision of ±1 g and their total mass, m_s, determined;

2) weighed after careful removal of all the remaining covering and their total mass, m_{ws}, determined;

3) measured for the length of the core wire (to ±1 mm) to determine the measured total length of the stub ends, L_s.

5.11 After completion of welding, the test plate shall be cooled to room temperature and, after removal of any slag and spatter adhering to the test plate (and also after drying if water cooling has been applied), it shall be weighed with a precision of ±1 g. The total mass of the deposit, m_D, can be determined from the difference with the original mass of the plate as found in 4.2.

5.12 The total length of stub ends shall be between 144 mm and 156 mm for three electrodes, between 240 mm and 260 mm for five electrodes and between 384 mm and 416 mm for eight electrodes. If the total stub end length is outside these limits, testing shall be repeated.

6 Calculation of efficiency and metal recovery

6.1 The total nominal mass of the consumed lengths of the core wire of the three, five or eight electrodes, m_{CN}, shall be calculated, taking as a basis the nominal diameter and the nominal length less the measured length (to ±1 mm) of core wire in the three, five or eight stub ends, L_s. The density of steel is assumed to be 7,85 g cm^{-3}.

6.2 The total effective mass of the consumed length of the core wire of the three, five or eight electrodes, m_{CE}, is given by Formula (1):

$$m_{CE} = m_W \left(1 - \frac{L_s}{L_W}\right) \tag{1}$$

where

m_w is the total mass of the core wires;

L_s is the measured total length of the stub ends;

L_w is the measured total length of the core wires;

or, alternatively, by Formula (2):

$$m_{CE} = m_w - m_{ws} \tag{2}$$

where m_{ws} is the total mass of the core wires in the stub ends.

6.3 The nominal electrode efficiency is given by Formula (3):

$$R_N\,\% = \frac{m_D}{m_{CN}} \times 100 \tag{3}$$

where

m_D is the mass of deposited metal;

m_{CN} is the nominal mass of consumed core wire.

6.4 The effective electrode efficiency is given by Formula (4):

$$R_E\,\% = \frac{m_D}{m_{CE}} \times 100 \tag{4}$$

6.5 The overall weld metal recovery is given by Formula (5):

$$R_G\,\% = \frac{m_D}{m_E} \times 100 \tag{5}$$

where m_E is the total mass of electrodes tested.

6.6 The deposition efficiency is given by Formula (6):

$$R_D\,\% = \frac{m_{\mathrm{D}}}{m_{\mathrm{E}} - m_{\mathrm{s}}} \times 100 \tag{6}$$

where m_s is the total mass of the stub ends.

7 Rounding procedure

Actual test values obtained shall be subject to ISO 80000-1:2009, B.3, Rule A. If the measured values are obtained by equipment calibrated in units other than those of this document, the measured values shall be converted to the units of this document before rounding. If an average value is to be compared to the requirements of this document, rounding shall be done only after calculating the average. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

8 Calculation of deposition coefficient

The deposition coefficient, expressed in grams per ampere minute, is given by Formula (7):

$$D = \frac{m_{\mathrm{D}}}{I_{\mathrm{m}} \times t} \tag{7}$$

where

m_{D} is the mass of deposited metal, in grammes;

I_{m} is the welding current, in amperes;

t is the arcing time, in minutes.

The values calculated as above shall be rounded to two decimal places.