INTERNATIONAL STANDARD 2401

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

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

First edition — 1972-05-01

UDC 621.791.7

Ref. No. ISO 2401-1972 (E)

Descriptors : welding electrodes, covered electrodes, efficiency, steels.

Price based on 3 pages

FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

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 2401 was drawn up by Technical Committee ISO/TC 44, *Welding*.

It was approved in November 1971 by the Member Bodies of the following countries :

Belgium	Ireland	South Africa, Rep. of
Canada	Israel	Sweden
Czechoslovakia	Italy	Switzerland
Egypt, Arab Rep. of	Japan	Thailand
Finland	Netherlands	Turkey
France	New Zealand	United Kingdom
Germany	Norway	U.S.A.
India	Romania	U.S.S.R.

No Member Body expressed disapproval of the document.

Printed in Switzerland

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

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies a method for the determination of the efficiency, weld metal recovery and deposition coefficient of carbon steel and low alloy high tensile steel covered electrodes in the sizes 3.15 to 6.3 mm[1].

For the practical use of this International Standard, the precision of measurement specified is sufficient because of the inherent variation in characteristics of individual electrodes.

Section 4 specifies the measurement of a number of different values. It is, however, necessary to measure only those values required for the calculation of the particular factors being determined.

2 TERMS AND DEFINITIONS

2.1 nominal electrode efficiency, R_N : The ratio of the mass of weld metal deposited under standard conditions to the mass of nominal diameter core wire consumed for a given electrode.

2.2 effective electrode efficiency, R_E : The ratio of the mass of weld metal deposited under standard conditions to the actual mass of core wire consumed.

2.3 overall weld metal recovery, R_G : The ratio of the mass of weld metal deposited under standard conditions to the total mass of a given electrode tested.

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

2.5 deposition coefficient, D : The mass of weld metal deposited under standard conditions per ampere minute for a given electrode.

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 $R_N \sim$

3 TEST PLATES

3.1 Number

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

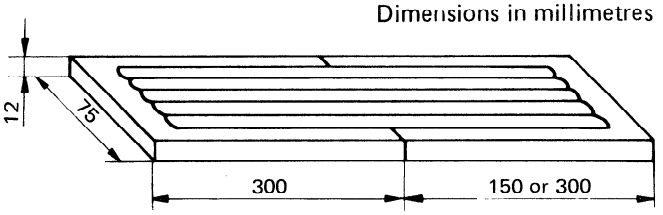
3.2 Specification

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 will be 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).

Dimensions in millimetres



FIGURE

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.

1) The method described can be applied to other sizes of electrodes.

4 PROCEDURE

4.1 Three or five electrodes[1] of the diameter to be tested shall be used on the test plate. Before welding, the electrodes shall be weighed to ± 1 g. The total mass of three or five electrodes is called m_E. The mass of three or five core wires, obtained by carefully removing the covering from another three or five electrodes of the same batch, is called m_W. The mass of three or five 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.

4.2 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 on the packet. Its value shall be measured by means of a damped ammeter of Class 2 precision for electrical measuring apparatus. For AC, the root mean square (RMS) value of the current shall be measured. The machine setting shall not be changed during the whole test. For the calculation of the deposition coefficient, the average value I_m of the root mean square values of the current measured during the test shall be used.

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

4.4 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.

4.5 Electrodes suitable for welding on either DC or AC shall be tested on alternating current and, in this case, the following provisions regarding the welding transformer are recommended :

a) the transformer should have an open circuit voltage not more than 10 V higher than the minimum value indicated by the electrode marking;

b) for the setting used for welding, the current waveform supplied by the transformer in short-circuit conditions should have a form factor F[2] included within the following limits :

$$1.11 < F < 1.2$$

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

4.7 The arcing time of each electrode shall be measured with a precision of ± 0.2 s, and the total time t for the three or five electrodes calculated in minutes.

4.8 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.

4.9 After welding each run, the stub ends shall be retained, avoiding any loss of unfused covering, and, when cooled down, the three or five 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.

4.10 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 4.1.

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

5 CALCULATION OF EFFICIENCY AND METAL RECOVERY

5.1 The total nominal mass of the consumed lengths of the core wire of the three or five 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 or five stub ends (L_S). The density of steel is assumed to be 7.85 g/cm^3.

1) If the mass of the deposit from each electrode is more than 100 g, it is permissible to use only three electrodes.

2) For an alternating current, the "form factor" F is the ratio of its RMS value to its mean value. The limits given above correspond to those observed on common welding transformers in short-circuit conditions. The form factor F can be determined either by oscillographic recording or using simultaneously two ammeters in series, one having a scale in RMS values of the current and not very sensitive to the wave shape (for example, ferromagnetic or thermal type), the other having a scale in mean values of the current (for example, magneto-electric with rectifier type).

5.2 The total effective mass of the consumed length of the core wire of the three or five electrodes m_{CE} is given by the formula

$$m_{CE} = m_w \left(1 - \frac{L_s}{L_w}\right)$$

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 the formula

$$m_{CE} = m_w - m_{ws}$$

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

5.3 The nominal electrode efficiency is given by the ratio

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

where

m_D is the mass of deposited weld metal;
m_{CN} is the nominal mass of consumed core wire.

5.4 The effective electrode efficiency is given by the ratio

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

5.5 The overall weld metal recovery is given by the ratio

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

where m_E is the total mass of electrodes tested.

5.6 The deposition efficiency is given by the ratio

$$R_D\ \% = \frac{m_D}{m_E - m_s} \times 100$$

where m_s is the total mass of the stub ends.

The values of the efficiencies and recoveries calculated according to 5.3 to 5.6 shall be expressed as rounded whole numbers, i.e. without decimals (for example, 93.4 % would become 93 %, 93.5 % would become 94 %).

6 CALCULATION OF DEPOSITION COEFFICIENT

The deposition coefficient, expressed in grams per ampere minute, is given by the ratio

$$D = \frac{m_D}{I_m \times t}$$

where

m_D is the mass of deposited metal, in grams;
I_m is the welding current, in amperes;
t is the arcing time, in minutes.

The values calculated as above shall be expressed with two places of decimals [for example, 0.16 g/(A·min) for 0.164 g/(A·min) and 0.17 g/(A·min) for 0.165 g/(A·min)].

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