INTERNATIONAL STANDARD

ISO 14744-3

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Welding — Acceptance inspection of electron beam welding machines —

Part 3: Measurement of beam current characteristics

Soudage — Essais de réception des machines de soudage par faisceau d'électrons —

Partie 3: Mesure des caractéristiques de l'intensité du faisceau

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 14744 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14744-3 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this standard, read "...this European Standard..." to mean "...this International Standard...".

ISO 14744 consists of the following parts, under the general title *Welding — Acceptance inspection of electron beam welding machines*:

— *Part 1: Principles and acceptance conditions*

— *Part 2: Measurement of accelerating voltage characteristics*

— *Part 3: Measurement of beam current characteristics*

— *Part 4: Measurement of welding speed*

— *Part 5: Measurement of run-out accuracy*

— *Part 6: Measurement of stability of spot position*

Contents

Page

Foreword

The text of EN ISO 14744-3:2000 has been prepared by Technical Committee CEN/TC 121 "Welding", the secretariat of which is held by DS, in collaboration with Technical Committee ISO/TC 44 "Welding and allied processes".

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 October 2000, and conflicting national standards shall be withdrawn at the latest by October 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, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This draft European Standard is composed of the six following parts:

– Part 1: Principles and acceptance conditions;

– Part 2: Measurement of accelerating voltage characteristics;

– Part 3: Measurement of beam current characteristics;

– Part 4: Measurement of welding speed;

– Part 5: Measurement of run-out accuracy;

– Part 6: Measurement of stability of spot position.

1 Scope

This standard is intended for use when the beam current of electron beam welding machines complying with EN ISO 14744-1:2000 is to be measured in connection with an acceptance inspection. It provides essential information on the procedure and apparatus to be used for making the measurements.

The beam current is one of the significant parameters in electron beam welding. When the beam current impinges on the workpiece, it should be stable and reproducible within given short-term and long-term limits. The purpose of the measurement is thus to check whether the variations in beam current are within these limits.

2 Normative reference

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN ISO 14744-1:2000
Welding – Acceptance inspection of electron beam welding machines – Part 1: Principles and acceptance conditions (ISO 14744-1 : 2000)

3 Terms and definitions

For the purposes of this European Standard, the following term and definition applies,

3.1
Beam current

current produced by the sum of the accelerated electrons before these impinge on the workpiece, measured at a distance roughly corresponding to the work distance

NOTE Although this current is somewhat lower than the electron current emitted from the cathode, it is the factor crucial to the welding procedure.

4 Test arrangement

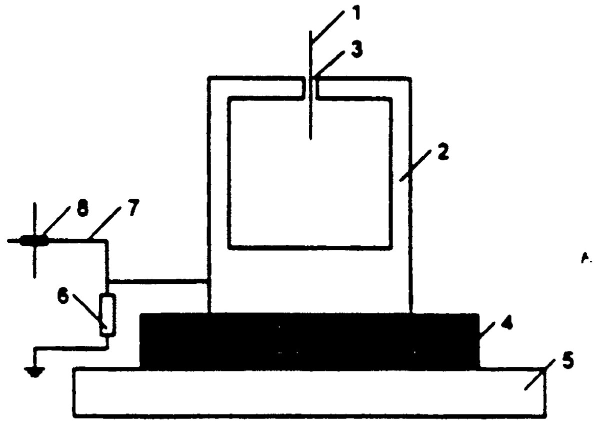
4.1 General

The beam current is to be measured at specified levels covering the entire power range of the welding machine.

As there is no solid conductor, a Faraday cup shall be used that, as far as possible, collects all the electrons emitted from the cathode and causes them to flow to earth through a resistor of given rating (see figure 1).

The Faraday cup shall be designed so that it:
a) sustains the thermal load even at high beam powers over a period equal to several times the measurement period;

b) prevents, as far as possible, the escape of primary and secondary electrons and charged vapour.



Key
1 Electron beam
2 Faraday cup
3 Faraday cup orifice
4 Insulation
5 Work table
6 Resistor
7 Screened cable to oscilloscope
8 Feedthrough to pass cable through work chamber wall

Figure 1 - Diagrammatic representation of beam current measurement using a Faraday cup

4.2 Faraday cup and electrical connections

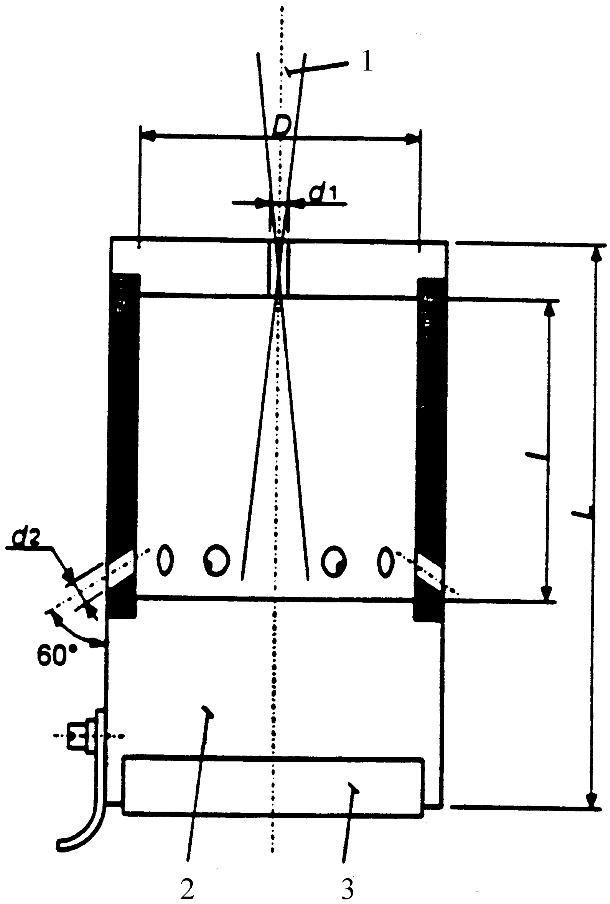
Figure 2 and table 1 provide recommended dimensions on the design of Faraday cups of copper for various beam powers up to 30 kW which may be adapted to meet practical requirements. For beam powers above 15 kW, water cooling is necessary.

Table 1 - Faraday cup. Recommended dimensions (see figure 2)

values in mm

Maximum accelerating voltage, in kV	Maximum beam power, in kW	d_1	D	l	L	$n \times d_2$
60	15	6	100	90	220	10 × 6
60	30	10	170	270	445	10 × 10
150	6	6	100	100	200	10 × 6
150	30	10	100	300	500	10 × 10

NOTE 1 Dimension d_1 should be kept small enough just to accommodate a focused electron beam including fringe beam, while preventing the escape of electrons.



Key
1 Electron beam
2 Copper
3 Ceramic insulator

Figure 2 - Faraday cup assembly

NOTE 2 The bores around the Faraday cup barrel allow a rapid escape of metal vapour whilst avoiding escape of electrons.

The Faraday cup shall be insulated electrically from the work table by means of a ceramic insulator.

A resistor shall be connected between the Faraday cup and earth at a sufficient distance to prevent it being thermally influenced. As shown in figure 1, a screened cable shall be passed to the measuring instrument via a feed-through in the work chamber wall.

5 Measurement procedure

5.1 General

The measurements shall be carried out with the welding machine set as specified in 6.2 of EN ISO 14744-1:2000.

5.2 Current losses

The beam current entering the Faraday cup shall be measured and compared with the emission current (i.e. the rated beam current). Excessive deviations indicate inaccurate positioning of the electron beam with respect to the diameter of the Faraday cup orifice, d_1, or adjustment errors in the beam source which are to be corrected. For all operations, when using the Faraday cup, the electron beam shall be focused on the centre of the orifice (see figure 2). Beam parameters and position of the Faraday cup shall be adjusted to obtain maximum monitored voltage prior to testing.

5.3 Measuring the ripple

An oscilloscope shall be used to determine the maximum range (peak-to-peak value) in the instantaneous value U'_b of the monitored voltage, U_b.

The percentage deviation shall be calculated as follows:

$$\frac{U'_{b\ max} - U'_{b\ min}}{U_b} \times 100$$

where $U'_{b\ max}$, $U'_{b\ min}$ and U_b are maximum, minimum and average values observed during the period of observation (see figure 3).

5.4 Measuring the stability

The average voltage shall be recorded continuously for a given operating period, using an instrument eliminating ripple.

The percentage deviation shall be calculated as follows:

$$\frac{U_{b\,max} - U_b}{U_b} \times 100 \quad \text{or} \quad \frac{-U_{b\,min} + U_b}{U_b} \times 100$$

whichever is the largest and where $U_{b\,max}$ and $U_{b\,min}$ are maximum and minimum observed values and U_b is the initial value.

5.5 Measuring the reproducibility

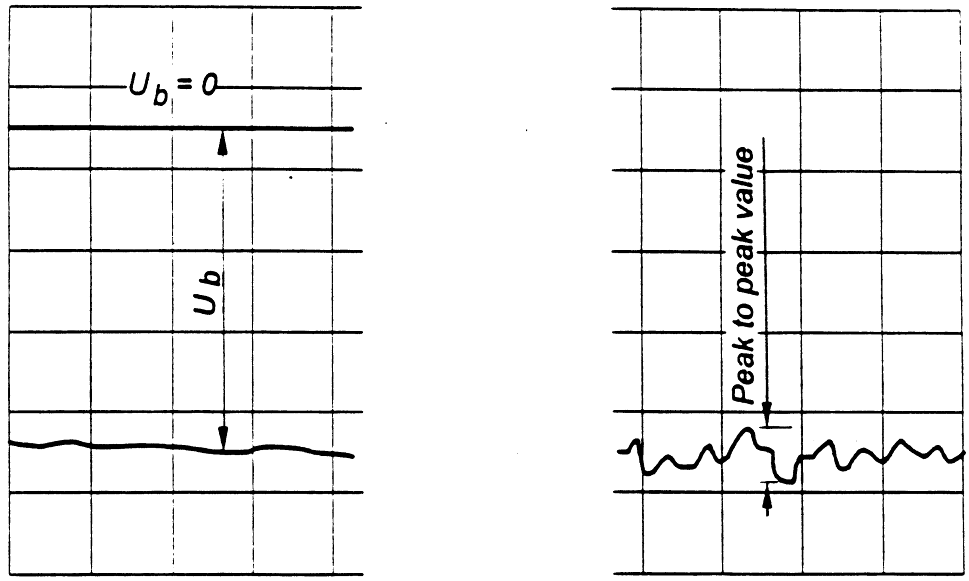
The beam current shall be switched on and the average monitored voltage shall be measured, using an instrument eliminating ripple.

The specified beam current shall subsequently be switched off and on several times and the corresponding average monitored voltages shall be recorded.

The reproducibility shall be calculated as follows:

$$\frac{U_{b\,max} - U_b}{U_b} \times 100 \quad \text{or} \quad \frac{-U_{b\ min} + U_b}{U_b} \times 100$$

whichever is the greater where $U_{b\,max}$ and $U_{b\,min}$ are maximum and minimum average values observed and U_b is the initial value.



a) Measurement of U_b

b) Measurement of peak-to-peak value (greater sensitivity of indication in the Y direction than for item a)

Figure 3 - Screen indications for measuring the beam current ripple

6 Problems in measurement

The problem most frequently met with, particularly when measuring high beam currents, is a high frequency fluctuation of the beam current on the display, which is associated with an over-large fusion area in the bottom of the Faraday cup. Such problems are best overcome by keeping to short measurement times and providing for long cooling intervals, or if possible using a water cooled Faraday cup.

7 Evaluation

The measured values of ripple, stability and reproducibility shall be assessed by comparing them with the limit deviations specified in EN ISO 14744-1:2000.

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