INTERNATIONAL STANDARD

ISO 14744-1

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Welding — Acceptance inspection of electron beam welding machines —

Part 1: Principles and acceptance conditions

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

Partie 1: Principes et conditions de réception

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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 14744-1 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*

Annexes A and B of this part of ISO 14744 are for information only.

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Foreword

The text of EN ISO 14744-1:2000 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.

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Introduction

Components, failure of which will endanger life, are subject to comprehensive test and acceptance specifications, which, among other things, require production equipment to be of proven type and in accordance with the state of the art. Similarly, in welding practice, standards apply that specify, for example, the required manual skills which a welder must have for controlling the weld.

In welding processes that are not under direct manual control, such as in electron beam welding, requirements for various machine parameters are established. This standard series on acceptance inspection of electron beam welding machines is based on the concept that the production of continuously high-quality welds is ensured if, among other things, the settings, within defined limits, are reproducible during the operating period.

Taking this into account, this standard specifies details of the main machine parameters (accelerating voltage, beam current, lens current and welding speed) together with deviations permitted in short-term or long-term operation. It also includes requirements regarding the run-out accuracy of the devices positioning the workpiece and regarding the stability of the spot position of the electron beam. Users, manufacturers, research experts and inspection bodies are all agreed that electron beam welding machines complying with the requirements are suitable for welding components subject to acceptance inspection, such as aircraft equipment, pressure vessels, valves, etc., within specified setting ranges, assuming that other conditions (e.g. qualified staff, quality control) are fulfilled.

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1 Scope

The main purpose of this standard is to provide requirements for acceptance inspection of electron beam welding machines preferably when first installed on the user's premises. This standard can (in full or in part) be referred to in contracts for supply of electron beam welding machines. Further tests are not normally required if proof of satisfactory welding results is provided in the form of routine inspection documentation. However, the requirements of the standard can also be used for inspection as part of maintenance, if required by contract.

If modifications are made to an electron beam welding machine (rebuilding, repairs, modification to the operating conditions etc.) such as may have an effect on the acceptance inspection, repeat tests can be necessary covering the machine parameters affected by such modifications.

If a welding machine that has already been accepted is dismantled (e.g. in order to change its location), such tests would involve verification according to the requirements in clauses 4, 6.2 to 6.4 and 7.

2 Normative references

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 (including amendments).

EN ISO 14744-2
Welding – Acceptance inspection of electron beam welding machines – Part 2: Measurement of accelerating voltage caracteristics (ISO 14744-2 : 2000)

EN ISO 14744-3
Welding – Acceptance inspection of electron beam welding machines – Part 3: Measurement of beam current caracteristics (ISO 14744-3 : 2000)

EN ISO 14744-4
Welding – Acceptance inspection of electron beam welding machines – Part 4: Measurement of welding speed (ISO 14744-4 : 2000)

EN ISO 14744-5
Welding – Acceptance inspection of electron beam welding machines – Part 5: Measurement of run-out accuracy (ISO 14744-5 : 2000)

EN ISO 14774-6:2000
Welding – Acceptance inspection of electron beam welding machines – Part 6: Measurement of stability of spot position (ISO 14744 : 2000)

3 Symbols

For the purposes of this standard, the following symbols apply:

a_x; a_y; a_z	deviation of electron beam axis from weld groove centre or of beam focus from groove centre on weld surface in *X*, *Y* or *Z* direction of feed, as a measure of the run-out accuracy, in mm;
A_W	work distance, in mm;
A_F	focal distance, in mm;
D	diameter of a circumference weld seam in mm or cm;
I_L	lens current, in mA;

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$I_{L\,max}$ lens current at $U_{A\,max}$ and for $A_{F\,min}$, in mA;

$I_{L\,min}$ lens current at $U_{A\,min}$ and for $A_{F\,max}$, in mA;

I_B beam current, in mA;

$I_{B\,max}$ maximum beam current, corresponding to $U_{A\,max}$ and $U_{A\,min}$ respectively, in mA;

m loading of work table or of rotating fixture resulting from workpiece mass including that of any clamping device, in kg;

n speed of rotating fixture, in min^{-1};

U_A indicated accelerating voltage, in kV;

$U_{A\,max}$ maximum indicated accelerating voltage within the setting range, in kV;

$U_{A\,min}$ minimum indicated accelerating voltage within the setting range, in kV;

U_a monitored voltage for measuring the accelerating voltage, in mV;

U_b monitored voltage for measuring the beam current, in mV;

U_v monitored voltage for measuring the welding speed, in mV;

v welding speed, in mm/s, cm/min or m/min;

Q pressure rise rate, in Pa . dm^3/s, or mbar . l/s

4 Conditions for acceptance inspection

4.1 General

Acceptance inspection shall be performed after installation of the welding machine, prior to production. However, measurement of accelerating voltage may be performed prior to delivery of the welding machine in accordance with EN ISO 14744-2.

4.2 Installation of electron beam welding machine

Electron beam welding machines shall be installed so that acceptance inspection and machine performance are not interfered with by vibration or by electrical or magnetic fields.

4.3 Power source

The power source for electron beam welding machines shall be an electrical mains system with voltage fluctuations not exceeding ±10 %.

4.4 Safety precautions

This standard does not cover inspection of safety devices and other safety aspects.

NOTE Machines for electron beam welding have several features which assure safe operation. The electron beam generates X-rays during welding and the work chamber walls, the work chamber windows and other parts have to reduce the radiation outside the machine to low safe levels so as to permit operators and other personnel to work safely close to the machine. The parts of the machine subject to high-voltages should, of course, be protected and inaccessible when under high tension.

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Some of the features which assure safe operation may have to be tested after installation of the machine, prior to any use of the machine in production. Any such test is, however, outside the scope of this standard. The tests have to be specified by the supplier of the machine.

It is also important to consider that the design of machines for electron beam welding, protection against x-rays etc., are subject to several legal requirements at the European level (e.g. directives for machines, EMC, low voltage equipment) and also supplementary national requirements in at least some countries. See also EN 60204-1.

4.5 Operating instructions

The operating instructions for the electron beam welding machine shall be complied with.

4.6 Instruments

The accuracy of all instruments for measurement have to be compatible with the limit deviations specified in this standard, see table 1.

The procedures for measurement are such that it is possible to use calibrated and traceable instruments for measurement, if required by contract.

5 Principles of acceptance inspection

5.1 Setting range

It is to be specified for which setting range of the machine the acceptance inspection is to be carried out, giving setting ranges for the following parameters:

– accelerating voltage;

– beam current;

– lens current;

– welding speed in all primary welding directions;

Other parameters necessary for proper control of the welding machine shall also be specified, e.g.:

– focal distance;

– loading resulting from workpiece and fixture mass;

– pressure rise rate and leak rate in work chamber (if necessary).

5.2 Normal acceptance

According to this standard normal acceptance inspection of the welding machine for the intended machine setting shall be deemed to have been provided if the limit deviations given in table 1 are not exceeded.

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Table 1 - Limit deviations for machine parameters and characteristics

Parameters and characteristics	Limit deviations of the measured value
Accelerating voltage: ripple stabilization reproducibility	 2 % (peak-to-peak value) ±1 % ±1 %
Beam current: ripple stabilization reproducibility	 5 % (peak-to-peak value) ±1 % ±1 %
Lens current: ripple stabilization reproducibility	 0,5 % (peak-to-peak value) ±0,5 % ±0,5 %
Welding speed: short-term stability: v_{max} v_{min} = 0,1 v_{max} long-term stability reproducibility	 ±2 % ±5 % ±1 % ±1 %
Run-out accuracy, longitudinal and circumferential welds	±0,05 mm. Unless otherwise agreed, requirements may be relaxed for welding of large pieces
Stability of spot position in the plane perpendicular to the beam axis	±0,1 mm at a focal distance of 300 mm
Pressure rise rate and leak rate	To be agreed
Welding penetration deviation	To be agreed

The limit deviations given in table 1 relate to the mean of the measured values concerned, unless otherwise specified. The limit deviations relate to the use of normal electron beam welding machines for normal applications. Alternative deviations may be agreed by contract for special machines or special applications.

5.3 Limited or more extensive acceptance inspection

If the requirements given in table 1 are met only for a part of the specified setting range, the acceptance inspection shall only be deemed to apply to that part.

The acceptance inspection may also be extended to cover accessory equipment for which no requirements are given in table 1, any additional requirements being specified separately.

Any departures from a normal acceptance inspection (including the resulting changes to the scope of testing) shall be stated in the test report.

5.4 Record of inspection results

All inspection results shall be recorded.

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6 Acceptance inspection

6.1 General

The acceptance inspection specified below is applicable for general applications for electron beam welding machines. Alternative conditions may be agreed for special applications. However, the applicability of limit deviations specified in table 1 have to be assessed for such special applications.

6.2 Accelerating voltage, beam current and lens current

6.2.1 Measurement procedure

EN ISO 14744-2 specifies details of the method of measurement, the test arrangement and the procedure to be followed in measuring the accelerating voltage characteristics and EN ISO 14744-3 specifies the beam current characteristics. Lens current shall be measured by inserting a current meter into the lens current circuit or using special measuring connections at the lens current amplifier.

6.2.2 Ripple

The ripple of the accelerating voltage and of the beam current shall be measured for the following settings:

a) $U_{A\,max}$ and $I_{B\,max}$; $U_{A\,max}$ and 0,5 $I_{B\,max}$; $U_{A\,max}$ and 0,1 $I_{B\,max}$;

and

b) $U_{A\,min}$ and $I_{B\,max}$; $U_{A\,min}$ and 0,5 $I_{B\,max}$; $U_{A\,min}$ and 0,1 $I_{B\,max}$.

The lens current ripple shall be measured at $I_{L\,max}$ and $I_{L\,min}$.

6.2.3 Stability

The measurement shall be made over an operating time of 30 minutes by continuous recording of the accelerating voltage, the beam current and the lens current set at $U_{A\,max}$, 0,1 $I_{B\,max}$ and 0,5 ($I_{L\,max}$ + $I_{L\,min}$), respectively.

6.2.4 Reproducibility

With the high voltage power supply of the welding machine set at average accelerating voltage 0,5 ($U_{A\,max}$ + $U_{A\,min}$), average beam current set at 0,5 $I_{B\,max}$ and average lens current set at 0,5 ($I_{L\,max}$ + $I_{L\,min}$) the machine shall be switched off and on five times with identical settings. The resulting accelerating voltage, beam current and lens current shall be measured.

6.3 Welding speed

6.3.1 Measurement procedure

EN ISO 14744-4 specifies details of the method of measurement, test arrangement and measurement procedure. The welding speed shall be measured directly at the work table, at the rotating fixture or at the movable electron gun.

6.3.2 Short-term stability

The welding speed v_{max} and v_{min} shall be measured in all the primary directions for welding, for m_{max} and for m equal to zero.

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6.3.3 Long-term stability

In the case of devices positioning the workpiece and designed for an uninterrupted welding time of more than one minute, the long-term stability shall be measured, measurements being made by continuous recording at an average welding speed and a medium loading over an operating time equal to at least three times the maximum welding time.

6.3.4 Reproducibility

With the devices positioning the workpiece first set to v_{max} and then to v_{min}, at a medium loading 0,5 m_{max}, the moving devices shall be switched off and on five times without alteration to the settings, and the resulting welding speed measured.

6.4 Run-out accuracy

EN ISO 14744-5 specifies details of the test arrangement and the measurement procedure. The run-out accuracy of the work table and rotational movements shall be measured both in the unloaded state and at maximum loading. Where applicable, the run-out accuracy of the movable electron gun is also to be measured.

6.5 Stability of spot position

EN ISO 14744-6 specifies details of the test arrangement and the measurement procedure. For testing the 'continuous operation mode' of the welding machine (as specified in clause 5 of EN ISO 14744-6 : 2000) the electron beam shall be set to $U_{A\,max}$ and 0,1 $I_{B\,max}$, switched on and maintained at this setting for 15 min.

Then the work chamber shall be ventilated, evacuated and continuous operation with the same parameters resumed for at least 15 min.

7 Supplementary acceptance inspections

Annexes A and B contain information on pressure rise rate and leak rate and penetration deviation.

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