INTERNATIONAL STANDARD

ISO 14744-1

Second edition
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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

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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 the member bodies casting a vote.

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

ISO 14744-1 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

This second edition cancels and replaces the first edition (ISO 14744-1:2000) which has been technically revised.

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*

Requests for official interpretations of any aspect of this part of ISO 14744 should be directed to the Secretariat of ISO/TC 44/SC 10 via your national standards body, a complete listing of which can be found at www.iso.org.

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 characteristics) 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.

ISO 14744 [any part(s)] can 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.

Welding — Acceptance inspection of electron beam welding machines —

Part 1: Principles and acceptance conditions

1 Scope

This part of ISO 14744 specifies requirements for acceptance inspection of electron beam welding machines preferably when first installed on the user's premises.

2 Normative references

The following referenced documents are indispensable for the application 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 17662, *Welding — Calibration, verification and validation of equipment used for welding, including ancillary activities*

3 Symbols and abbreviated terms

For the purposes of this part of ISO 14744, the following symbols apply:

A_F	focal distance, in millimetres
A_W	work distance, in millimetres
a_x; a_y; a_z	deviation, in millimetres, of electron beam axis from weld groove centre or of beam focus from groove centre on weld surface in the x-, y- or z-direction of feed, as a measure of the run-out accuracy
D	diameter, in millimetres or in centimetres, of a circumference weld seam
I_B	beam current, in milliamperes
$I_{B\,max}$	maximum beam current, in milliamperes, corresponding to $U_{A\,max}$ and $U_{A\,min}$, respectively
$I_{B\,min}$	minimum beam current, in milliamperes, corresponding to $U_{A\,max}$ and $U_{A\,min}$, respectively
I_L	lens current, in milliamperes
$I_{L\,max}$	lens current, in milliamperes, at $U_{A\,max}$ and for $A_{F\,min}$
$I_{L\,min}$	lens current, in milliamperes, at $U_{A\,min}$ and for $A_{F\,max}$

m	load, in kilograms force, on the work table or on rotating fixture resulting from workpiece mass including that of any clamping device
n	rotational frequency, in reciprocal minutes, of rotating fixture
t_w	time, in seconds, for welding a seam
$t_{w\,max}$	maximum time, in seconds, for welding a seam
Q	pressure rise rate, in pascal cubic decimetres per second, or millibar·litres per second
U_A	indicated accelerating voltage, in kilovolts
$U_{A\,max}$	maximum indicated accelerating voltage, in kilovolts, within the setting range
$U_{A\,min}$	minimum indicated accelerating voltage, in kilovolts, within the setting range
U_a	monitored voltage for measuring the accelerating voltage, in millivolts
U_b	monitored voltage, in millivolts, for measuring the beam current, in millivolts
U_v	monitored voltage, in millivolts, for measuring the welding speed
v	welding speed, in millimetres per second, in centimetres per minute or in metres per minute

4 Conditions for acceptance inspection

4.1 General

Acceptance inspection shall be performed after the first installation or before the first operation of the welding machine. The following tests shall be done:

— accelerating voltage characteristics;

— beam current characteristics;

— lens current characteristics;

— speed characteristics of movement devices;

— run-out accuracy of movement devices;

— stability of spot position.

And the following test may be agreed:

— pressure rise rate.

After changing of equipment location the following test shall be done:

— speed characteristics of movement devices;

— run-out accuracy of movement devices;

— stability of spot position.

And the following test may be agreed:

— pressure rise rate.

After rebuilding, maintenance or changing the conditions of operation the following tests shall be done:

— tests of all affected machine components.

The acceptance inspection may be extended on parameters, characteristics and additional devices, when there are no requirements described in ISO 14744 (all parts). In these cases, requirements and limit deviations shall be agreed. However, measurement of accelerating voltage may be performed prior to delivery of the welding machine in accordance with 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 part of ISO 14744 does not cover inspection of safety devices and other safety aspects.

IMPORTANT — 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.

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 part of ISO 14744. The tests have to be specified by the supplier of the machine.

In addition, it is 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; electromagnetic compatibility; low-voltage equipment) and supplementary national requirements in at least some countries. See also IEC 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 shall be compatible with the limit deviations specified in this part of ISO 14744, see Table 1.

In accordance with ISO 17662, no calibration, no verification, and no validation of measurement equipment is necessary.

5 Principles of acceptance inspection

5.1 Setting range

The setting range shall be specified for the machine to undergo the acceptance inspection, 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;

— load resulting from workpiece and fixture mass;

— pressure rise rate (if necessary).

5.2 Limit deviations for machine parameters and characteristics

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 electron beam welding machines without special requirement. Alternative deviations may be agreed by contract for special machines or special applications.

Table 1 — Limit deviations for machine parameters and characteristics

Parameters and characteristics	Limit deviations of the measured value
Accelerating voltage:	
ripple	2 % (peak-to-peak value)
stabilization	±1 %
reproducibility	±1 %
Beam current:	
ripple	5 % (peak-to-peak value)
stabilization	±1 %
reproducibility	±1 %
Lens current:	
ripple	0,5 % (peak-to-peak value)
stabilization	±0,5 %
reproducibility	±0,5 %
Welding speed:	
short-term stability	±2 %
long-term stability	±1 %
reproducibility	±1 %
Run-out accuracy, longitudinal and circumferential welds	±0,1 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 up to a focal distance of 300 mm Stability of spot position for longer focal distance to be agreed
Pressure rise rate	To be agreed (see Annex A)

5.3 Test report

All inspection results shall be recorded in a test report which includes:

— reference to this part of ISO 14744;

— all measured results;

— assessment of all measurement results;

— the name of the responsible welding supervisor; and

— description the setting range, which complies with the requirements of this part of ISO 14744.

The test report has to be signed by the examiner.

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 has to be assessed for such special applications.

6.2 Accelerating voltage, beam current, and lens current

6.2.1 Measurement procedure

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 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 $I_{L\,min}$.

Instead of 0,1 $I_{B\,max}$ the value of $I_{B\,min}$ may be related to the application.

6.2.3 Stability

The measurement shall be made over an operating time of $2t_{w\,max}$, minimum 30 min, 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 ($I_{L\,max} + I_{L\,min}$).

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 characteristics

6.3.1 Measurement procedure

ISO 14744-4 specifies details of the method of measurement, test arrangement and measurement procedure. The welding speed characteristics 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, shall be measured in all the primary directions for welding, for m_{max} and for m = 0.

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 load over an operating time equal to at least twice 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 load 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

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 load. Where applicable, the run-out accuracy of the movable electron gun is also to be measured.

6.5 Stability of spot position

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 ISO 14744-6:2000, Clause 5) 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

Annex A contains information on pressure rise rate.