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Acceptance tests for Nd:YAG laser beam welding machines — Machines with optical fibre delivery —

Part 1: Laser assembly

Essais de réception pour les machines de soudage par faisceau laser Nd:YAG — Machines avec transport de faisceau par fibre optique —

Partie 1: Ensemble laser

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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 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 22827-1 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

ISO 22827 consists of the following parts, under the general title *Acceptance tests for Nd:YAG laser beam welding machines — Machines with optical fibre delivery*:

— *Part 1: Laser assembly*

— *Part 2: Moving mechanism*

Introduction

Requests for official interpretations of any aspect of this part of ISO 22827 should be sent to the Secretariat of ISO/TC 44/SC 10 via the member body in the user's country, a complete listing of which can be found at www.iso.org.

Acceptance tests for Nd:YAG laser beam welding machines — Machines with optical fibre delivery —

Part 1: Laser assembly

1 Scope

This part of ISO 22827 specifies basic requirements and test methods for acceptance testing of high-power (average power more than 100 W), lamp-pumped or laser-diode-pumped Nd:YAG laser beam welding machines for seam welding with optical fibre delivery systems.

The requirements can also be applied as a part of verification testing as part of maintenance, as appropriate.

If modifications are made to a laser beam machine (rebuilding, repairs, modifications to the operating conditions, etc.) that have an effect on the acceptance testing, a repeat test may be necessary to cover the machine parameters affected by such modifications.

This part of ISO 22827 applies to the beam generating system, the optical delivery system and the devices for shielding and assist gases.

NOTE The moving mechanism is covered by ISO 22827-2.

This part of ISO 22827 can be applied as a part of the acceptance conditions for the delivery of the optic laser beam welding cell.

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 11553-1, *Safety of machinery — Laser processing machines — Part 1: General safety requirements*

ISO 11554, *Optics and photonics — Lasers and laser-related equipment — Test methods for laser beam power, energy and temporal characteristics*

ISO 15614-11, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 11: Electron and laser beam welding*

ISO 17662, *Welding — Calibration, verification and validation of equipment used for welding, including ancillary activities*

ISO 22827-2, *Acceptance tests for Nd:YAG laser beam welding machines — Machines with optical fibre delivery — Part 2: Moving mechanism*

IEC 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60825-1, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide*

3 Terms and definitions

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

3.1
laser assembly
laser device together with specific, normally optical, mechanical and/or electrical components for beam handling and forming

[ISO 11145:2001, 3.27]

4 Environmental conditions and operating conditions of acceptance tests

4.1 Installation environment

Laser beam welding machines shall be installed in welding cells, which also include moving mechanisms for the welding head and/or the component to be welded.

The laser beam machine shall be erected and installed in such a way that the processing operation is not disturbed by environmental factors, e.g. vibrations, large temperature variations, contaminated atmosphere. The conditions specified by the laser system manufacturer shall be fulfilled during erection and installation.

4.2 Power supply

The electricity supply shall be sufficient to power the laser beam welding machine and cooling system. Voltage fluctuations shall be within ± 10 % of the voltage specified by the laser beam welding machine manufacturer.

4.3 Cooling system

The temperature, flow rate, water pressure and quality of water used in the cooling system shall be in accordance with the requirements of the laser beam welding machine manufacturer.

When industrial water or ground water is used for cooling, installation of a particle filter or other system may be necessary to prevent impurities from entering the cooling system and to obtain the required water quality.

Low-quality cooling water may result in contamination of the inner surfaces of hoses, pipes and heat exchangers, which can reduce water flow rates and diminish the efficiency of heat exchangers. This can result in overheating and failure of the laser beam machine.

4.4 Pumping light source

Replacement of the pumping light sources (lamps or laser diodes) is a major maintenance operation which can necessitate renewed testing of beam power, in particular if the replacement light sources do not comply with the original specification.

4.5 Shielding and assist gas

If a shielding gas or assist gas is used, they shall be in accordance with the relevant welding procedure specification and of the required quality.

4.6 Operating instruction for users

Technical information necessary for operation, maintenance and control of the Nd:YAG laser beam welding machines, and at least the minimum information related to the safety of laser processing machines, shall be provided by the supplier.

5 Acceptance test

5.1 General

Acceptance testing of laser machines shall include at least the tests as specified in 5.2 to 5.5 and a test of accuracy of the moving mechanism (see ISO 22827-2).

5.2 Check of parts

It shall be checked that all specified parts of the equipment are available and properly installed.

5.3 Acceptance tests for laser power and optical system

5.3.1 Testing of laser power

5.3.1.1 Laser power

The laser power shall be measured in accordance with ISO 11554.

5.3.1.2 Testing of stability of laser power

The stability of the laser power is classified as follows:

A: Very high stability

B: High stability

C: Ordinary stability

D: Low stability

The laser power stability shall be measured in accordance with ISO 11554. However, the stability shall only be measured only after a warm-up period of at least 30 min and during a time interval of 20 min at maximum and minimum power, respectively in accordance with Table 1.

Table 1 — Range of stability of laser power

Item	Acceptance criteria for class			
	A	B	C	D
Stability at the maximum rated power	± 1,5 %	± 2,5 %	± 5,0 %	± 10 %
Stability at the minimum rated power	± 1,5 %	± 2,5 %	± 5,0 %	± 10 %

Measurement of the stability of the laser power shall be made at the laser beam output port of the laser device. However, when measurement at the laser beam output port of the laser device is not possible, measurements may be taken on the processing surface after optical fibre beam delivery.

5.3.2 Acceptance criteria for optical system

The beam power shall be measured before and after the optical system at maximum beam power. The optical system includes the fibre and also the final processing optics, if specified. The power loss of the optical system shall be within the value specified.

However, if measurement of the beam power before the optical system is not possible, measurement of power loss can be omitted.

The bending curvature of the optical fibre, during and after installation, shall be verified not to exceed the specified value along the whole length of the installation.

5.3.3 Acceptance tests for optical observation system

The maximum deviation between the centre indication on the monitor (such as the cross-line indicated in the visual field of the optical observation system) and the centre position of the beam actually emitted on the work shall be in accordance with Table 2.

Table 2 — Range of accuracy of optical observation system

Item	Acceptance criteria
Amount of deviation between monitor centre and beam centre	± 0,1 mm max.

5.3.4 Acceptance tests for optical processing system

For acceptance testing of the optical processing system, the parameters specified in Table 3 shall be verified. Testing of some parameters is, however, optional. A beam profiler should be used in principle, but the processing-spot diameter may be obtained by the processing mark on a test piece.

NOTE The processing mark is different from but closely related to beam diameter.

Table 3 — Range of accuracy of optical processing system

Items	Acceptance criteria
Beam-waist diameter deviation at focal point	± 0,1 mm max.
Beam-waist position deviation from the optical axis of the focal point (optional)	± 1 % max. of the focal length of the focusing lens
Deviation of mechanical centre and irradiation position (optional)	± 0,1 mm max.
Optical-axis deviation (optional)	± 1 mm max./100 mm

5.4 Test for laser beam safety

Nd:YAG laser beam welding machines shall satisfy the minimum safety requirements in accordance with ISO 11553-1, IEC 60825-1 and IEC 60204-1. Compliance shall be confirmed, if required. Furthermore, the following safety specifications shall be verified, as appropriate:

a) all interlocking systems shall operate properly;

b) all optical fibres shall be free from damage (e.g. burns, dirt, colour changes or cracks in protection);

c) the function of safety devices which interrupt the beam power, in case the beam is directed in unpermitted directions;

d) the shut-down device, operating when an optical fibre is broken or dismantled;

e) check that required emergency stops are installed and operational;

f) laser oscillation shall stop immediately when the emergency stop signal is detected;

g) the emergency stop signal shall be simulated for the case of the system-control software freeze (looped or halt);

h) check that the laser cannot be restarted unintentionally when an emergency stop is released.

5.5 Test of pressures and flow rates of assist and shielding gases

The pressures and flow rates of assist and shielding gases are usually measured at either of the two positions:

— at the primary source, e.g. a gas cylinder;

— at the outlet at the welding nozzle.

The instruments shall be checked by master instruments, at pressures and flow rates representative of normal applications. See ISO 17662 for further guidance.

The accuracy of the instruments shall be in accordance with Table 4.

Table 4 — Required accuracy of instruments for measurement of gas flow and pressure

Item	Acceptance criteria for deviation from specified value
Gas flow	± 10 % max.
Gas pressure	± 10 % max.

6 Welding test

Unless otherwise specified, a representative welding procedure test, in accordance with ISO 15614-11, shall be carried out as part of the acceptance testing.

7 Records of test results

All tests shall be properly recorded, and the documents shall be filed as appropriate.

The following items shall be clearly stated in the report of test results:

a) type and designation of laser beam welding machine;

b) manufacturing number;

c) date of test;

d) place of test;

e) names of persons responsible for the test;

f) welding test conditions and test results;

g) other test items and test results.

Annex A provides an example of a test report form.

Annex B shows an example of optional parameters that it is desirable to be specified and verified. However, it should be noted that some of them are very time consuming and may be expensive to achieve.

Annex A
(informative)

Example of a test report form

Table A.1 — Example of a test report form

Model name of laser beam welding machine:	**Manufacturing number:**	
	Date of test:	**Place of testing:**
Name of tester:		
Model name of power meter:	**Manufacturing No.:**	
Type of fibre, diameter of core, value of (numerical aperture) N.A.: SI (Step Index type) or GI (Graded Index type)		

Items	Request classification	Inspection items	Inspection results
Quantity check	necessary	Quantity check	Sufficient or insufficient
Laser power, power stability and other laser parameters	A B C D necessary or not necessary	— Stability for 20 min at:	
		— maximum rated power	%
		— minimum rated power	%
		— maximum output (processing surface)	W
		— Minimum output (processing surface)	W
		— Calculated power loss	Delta W
		— Transmission	%
	Implementation necessary or not necessary	— Beam quality M^2:	M^2 value:
		— beam parameter product	mm × mrad
		— raw beam diameter or width, x/y	mm
		— Reproducibility of power setting	%
		— For 8 h stability	%
		— Warm-up time for maximum power stability	min
		— Delay time at 90 %	ms
		— Beam profile data	Desirable if available
Observation optical system	necessary or not necessary	— Monitor centre-position deviation	± mm
Processing optical system	necessary or not necessary	— Beam-waist diameter	± mm
		— Beam-waist position deviation	mm
		— Deviation of mechanical centre and irradiation position	± mm
		— Optical-axis deviation	± mm/100 mm