INTERNATIONAL STANDARD

ISO 14231

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Thermal spraying — Acceptance inspection of thermal spraying equipment

Projection thermique — Contrôle d'acceptation du matérial de projection thermique

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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 the member bodies casting a vote.

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

International Standard ISO 14231 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*.

Annexes A to D of this International Standard are for information only.

Thermal spraying — Acceptance inspection of thermal spraying equipment

1 Scope

This International Standard specifies requirements for the acceptance inspection of thermal spraying equipment including plasma, arc and flame spraying plants that produce high-quality sprayed coatings.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 14232, *Thermal spraying — Powders — Composition and technical supply conditions*.

3 Purpose

The purpose of acceptance inspection of spraying equipment is to provide proof that the equipment is suitable for producing thermally sprayed coatings of uniform quality by satisfying the requirement of this International Standard, as part of the total quality assurance programme.

This International Standard is also intended to form the basis of technical delivery conditions.

Proof of the suitability of thermal spraying equipment shall be provided by the supplier when delivering a spray unit for the first time, but may also be verified by the user as described in clause 6. The values obtained and any other data of significance in deciding on the suitability of the equipment shall be recorded in inspection reports described in annexes A, B and C. The spraying equipment may be considered adequately designed if all the requirements specified in clause 6 are confirmed by the tests described in clause 7

4 Conditions for acceptance inspection

Spraying equipment shall comply with all relevant safety requirements. The equipment shall be installed so that the spraying process is not impaired by other production equipment or environmental conditions.

The gas supply provided shall be adequate in volume and purity.

Care shall be taken to ensure that no interference by fluctuations of the main power supply affects the set electrical values. All equipment shall be supplied with an operating and maintenance instruction manual.

The equipment shall be tested with the thermal spraying gun in a fixed position and in a manner agreed upon between purchaser and manufacturer.

5 Designation

Acceptance inspection of thermal spraying equipment shall be designated as follows:

Acceptance inspection according to ISO 14231

6 Principles of acceptance inspection

6.1 Plasma spraying equipment

6.1.1 Electrical power

The maximum power level shall be maintained for continuous operation of the plasma spraying equipment, provided that the spraying gun is designed for such performance limits.

6.1.2 High voltage ignition device

Other components and functions of the spraying equipment shall not be affected by operation of the high voltage ignition device.

6.1.3 Cooling water circuit

The cooling water circuit shall be adequately sized and should include devices to maintain and control water quality, temperature and flow rate.

6.1.4 Gases

A plasma spraying unit shall be designed to permit spraying with the gases or a gas mixture specified by the user.

6.1.5 Plasma nozzle

Processing of the spraying powder shall not produce any deposits on and/or in the nozzle, that interfere with spraying operations.

6.1.6 Powder feed unit

The following requirements shall be met by the powder feed unit:

a) the unit shall be a stand-alone system even if it consists of several components, and shall function irrespective of the setting of the gas volume flow rate or the type of electrical control of the spraying equipment;

b) the powder flow rate shall be controllable, the selected values shall be constant and reproducible and the test shall be carried out using the powder specified by the parties concerned;

c) the unit shall permit uniform feed of powder mixtures, without de-mixing, during powder processing, in accordance with the supplier's specifications;

d) the feeding of fine grained spraying powders (see ISO 14232) shall be possible.

6.1.7 Control and monitoring unit

Deviations from the set values of gas pressure, gas volume flow rate, powder feed rate, arc amperage and arc voltage during the spraying process shall be monitored and controlled by means of appropriate instruments that can be read clearly and correctly. These values shall be recorded during acceptance inspection. The limits of error

of the measuring instruments shall not exceed 5 % for all set values. The maximum permissible error shall be 2,5 % of the measuring span for pressure gauges and electrical measuring devices (see also 7.2.7).

In case of lack of water supply or excessive deviations from the selected operating parameters, the system shall be designed to shut down automatically.

6.2 Arc spraying equipment

6.2.1 Electrical power

The maximum level of power shall be maintained during continuous operation of an arc spraying system, provided that the diameter of the spraying wire is adequate and the spraying head is designed for such power ratings.

6.2.2 Atomizing gas feed

The atomizing gas tube and the control device shall be designed to ensure undisturbed operation.

6.2.3 Nozzle system

The nozzle system (contact tubes plus air nozzle) shall permit a constant arc to be maintained and shall provide atomization without creating deposits that interfere with operation.

6.2.4 Spraying wire feed system

A continuously controllable and reproducible wire feeding system shall be provided, a precondition being constant air pressure and adequate electrical power supply.

6.2.5 Monitoring

Deviations from set values of the atomizing gas pressure, current and voltage during the spraying process shall be capable of being monitored and controlled by means of appropriate instruments that can be and read clearly and correctly. These values shall be recorded during acceptance inspection. The limits of error of the measuring instruments shall not exceed 5 % for all the selected parameters. The maximum permissible error for pressure gauges and for electrical measuring instruments shall be 2,5 % of the measuring span or scale.

6.3 Flame spraying equipment for powder, wire, rod and cord

6.3.1 Gases

Flame spraying equipment shall permit spraying with the combustible gas for which it was designed, as well as with atomizing and carrier gases, as required.

6.3.2 Nozzles

Processing of the spraying material shall be possible without the formation of deposits on burner and air nozzles that interfere with spraying operations.

6.3.3 Spraying material feed unit

The spraying material feed unit shall comply with the following conditions:

a) the unit shall permit uniform processing of the consumables for which it was designed;

b) the spraying material feed rate shall be capable of being adjusted;

c) the selected parameters shall be constant and reproducible, preconditions being that carrier gas pressure or actuating air pressure, and supply of electrical power be maintained at constant and controllable levels.

6.3.4 Monitoring

Any deviations from the selected parameters, gas pressure and gas volume flow rate, that occur during the spraying process shall be capable of being monitored and controlled by means of appropriate instruments that can be read clearly and correctly. The limits of error of the instruments shall not exceed 5 % for all selected parameters. The maximum permissible error for pressure gauges and electrical measuring instruments shall be 2,5 % of the measuring span or scale (see also 7.4.5).

7 Acceptance inspection procedure

7.1 General

Spraying equipment shall be deemed to be adequately designed for all relevant spraying applications and for use with all customary spraying materials if it complies with the requirements given in 7.2 to 7.4.

7.2 Plasma spraying equipment

7.2.1 Electrical power

Proof of the power rating shall be given by spraying aluminium oxide for 20 min using the parameters recommended by the equipment manufacturer.

During the test the following items shall be examined:

a) gas control;

b) electrical control;

c) cooling temperature.

The percentage limitations for selected parameters are given in annex A, classes A, B and C.

Upon stabilization, the deviation of the voltage (a variable parameter) from the selected value shall not exceed 3 % for class A, 6 % for class B and 12 % for class C. The time for the voltage to stabilize shall be recorded.

7.2.2 High voltage ignition devices

The high voltage ignition device shall be deemed to meet the requirements given in 6.1.2 if it does not interfere with any appliances and functions of the spraying equipment during the test specified in 7.2.1.

7.2.3 Cooling water circuit

The cooling water circuit shall be tested by measuring its capacity. The minimum volume flow rate, as specified by the manufacturer, shall be confirmed.

7.2.4 Plasma gases

The system shall be deemed to comply with the requirements specified in 6.1.4 if the values of the gas pressure and gas volume flow rate do not deviate from the selected parameters by more than ± 1,5 % for class A, ± 3 % for class B and ± 5 % for class C during a 20 min period of spraying.

If the secondary gas is the variable parameter, the deviations from the selected value, after stabilization, shall not exceed 3 % for class A, 6 % for class B and 12 % for class C.

7.2.5 Nozzle

The nozzle is deemed to comply with the requirements of 6.1.5 if no deposits interfere with the spraying operation specified in 7.2.1.

7.2.6 Powder feed unit

Compliance with the requirements specified in 6.1.6 shall be tested as follows:

a) A change in the primary gas flow, as indicated on the control panel, shall not affect the carrier gas flow.

b) To determine the mass of powder fed over a given period, the system shall be operated in the "cold run" mode, i.e., with the arc not operated for at least 1 min. During this process, which is to be repeated twice more, the variation in the mass of powder fed shall not exceed ± 5 % for class A, ± 10 % for class B and ± 15 % for class C. The particle size of the test powder shall be selected by agreement between the parties concerned (see ISO 14232). To check reproducibility, the same feed rates and the same deviations shall be achieved after shut-down of the equipment for at least 6 h and after recharging with the same type and amount of powder.

c) This test shall be conducted with a powder in accordance with ISO 14232 selected by agreement between the parties concerned. A sample of 6,4 kg is taken from a well-mixed powder and split into four equal parts. The procedure for mixing and splitting of each quarter is repeated until a sample of 100 g is obtained. This sample shall be analysed chemically and its particle size determined before feeding. The powder container shall then be filled with 1 000 g of the spraying powder. After feeding through about 900 g with the equipment in the "cold-run" mode, in accordance with the manufacturer's operating instructions, the remaining quantity of about 10 % shall be analysed chemically and its particle size determined. The chemical analysis may be limited to the determination of the principal constituent. The deviation caused by de-mixing of the powder shall not exceed 3 % of the initial values.

7.2.7 Monitoring

The limits of error of the measuring instruments and control units shall not exceed 5 % for all selected parameters and the maximum permissible error shall be 2,5 % of the measuring span or scale. The reproducibility of the setting shall be demonstrated.

7.2.8 Inspection report

An example of an inspection report for plasma spraying equipment is given in annex A.

7.3 Arc spraying equipment

7.3.1 Electrical power and wire feed unit

Power rating requirements for continuous operation, as specified in 6.2.1, and feed unit requirements, as specified in 6.2.4, shall have been met if no deviations of the adjusted electrical values of more than ± 5 % occur. Further, these requirements shall be met if other disturbances due to increased thermal loading are observed while operating the system at maximum capacity for 20 min with an appropriate coating material, such as unalloyed or low-alloy steel wire.

7.3.2 Atomizing gas

The equipment shall be deemed to comply with the requirements of 6.2.2 if the atomizing gas pressure indication does not deviate by more than ± 5 % from the selected value during a 20 min period of spraying.

7.3.3 Nozzle system

The nozzle system shall be deemed to comply with the requirements of 6.2.3 if, after testing according to 7.3.1, no disturbances occur in the arc and no deposits build up in the system due to molten spray material.

7.3.4 Monitoring

The limits of error of the measuring instruments and control units shall not exceed 5 % for all selected parameters and the maximum permissible error shall be 2,5 % of the measuring span or scale. The reproducibility of the setting shall be demonstrated.

7.3.5 Inspection report

An example of an inspection report for arc spraying equipment is given in annex B.

7.4 Flame spray equipment using powders, wires, rods or cords

7.4.1 Gases

Flame spraying equipment shall be deemed to comply with the requirements of 6.3.1 if the values of gas pressure and gas volume flow do not deviate from the selected values by more than 2 % for class A and 5 % for class B during a 20 min period of spraying.

7.4.2 Nozzles

Nozzles shall be deemed to comply with the requirements of 6.3.2, if no deposits build up that interfere with spraying after 20 min of continuous operation using nozzle-compatible materials at the maximum spray rate.

7.4.3 Spraying material feed unit

7.4.3.1 General

Compliance with the requirements of 6.3.3 shall be determined as follows:

7.4.3.2 Flame spraying with powders

The test is carried out with a powder in accordance with ISO 14232 selected by agreement between the parties concerned. A sample of 6,4 kg is taken from a well-mixed powder and split into four equal parts. This procedure of mixing and splitting shall be repeated for each quarter until a sample of 100 g is obtained. The sample shall be analysed chemically and its particle size determined prior to feeding. With the powder being fed in the "cold-run" mode and the carrier gas volume flow set at the value recommended by the manufacturer of the device, the mass of test powder fed is measured at the end of 1 min of operation. This measurement shall be repeated twice more, the variations in mass of powder not exceeding 5 %. If the powder feed unit is a separate device, the test shall be in accordance with the procedure given in 7.2.6. The residual powder in the powder feed unit shall be analysed for chemical composition and particle size. The deviation from the initial values shall not exceed 3 %.

7.4.3.3 Flame spraying with wires

The suitability of the system shall be tested with the flame burning by measuring the length of wire fed in 1 min. The determination shall be repeated twice more and the variations in length shall not exceed 5 %. A molybdenum or aluminium wire of agreed diameter shall be used for this test.

7.4.3.4 Flame spraying with rods or cords

Testing shall be carried out for 1 min using Al_2O_3 rods or cords of the agreed diameter.

7.4.4 Backfire of flame

Backfire of the fuel gas/oxygen flame shall not occur if the spraying equipment is operated according to the manufacturer's instructions.

7.4.5 Monitoring

The limits of error of the measuring instruments and control units shall not exceed 5 % for all selected parameters and the maximum permissible error shall be 2,5 % of the measuring span or scale. The reproducibility of the setting shall be demonstrated.

7.4.6 Inspection report

An example of an inspection report for flame spraying equipment using wire, rod or cord is given in annex C. For flame spraying with powder, an example of an inspection report is given in annex D.

8 Validity of inspection reports and re-tests

8.1 Validity of the inspection report

The equipment shall be considered acceptable as long as all specifications of this International Standard are complied with in the report.

8.2 Re-tests

8.2.1 Repair work

If the values obtained during acceptance inspection of a thermal spraying system are altered by modification or repair of the equipment, re-testing of the properties affected shall be carried out.

8.2.2 Re-testing procedure

Re-tests shall be carried out in the same way as the initial tests described in this International Standard.

Annex A
(informative)

Inspection report for plasma spraying equipment

Initial test/Re-test

Manufacturer:	Type of equipment:
User:	Type of burner:
Year of manufacture:	Type of powder feed unit:

Item tested	Set value	Actual value	Change after 20 min continuous testing				Evaluation	
			Limit deviations %			Actual deviation %		
			Class A	Class B	Class C		Passed	Failed
Current, A			± 1,5	± 3	± 5			
Voltage, V			± 1,5	± 3	± 5			
Primary gas pressure, bar			± 1,5	± 3	± 5			
Primary gas flow rate, l/min			± 1,5	± 3	± 5			
Secondary gas pressure, bar			± 1,5	± 3	± 5			
Secondary gas flow rate, l/min			± 1,5	± 3	± 5			
Carrier-gas pressure, bar			± 1,5	± 3	± 5			
Carrier-gas flow rate, l/min			± 1,5	± 3	± 5			
Cooling-water temperature, °C			± 5	± 10	± 15			
Cooling-water flow rate, l/min			± 5	± 10	± 15			

High-voltage ignition device interferes with other devices or functions: YES/NO
Nozzle deposits: YES/NO
Nozzle disturbances: YES/NO
Time needed for stabilization:

Inspection of powder feed unit (in "cold-run" mode)										
Spraying powder used for testing:										
Particle size, in accordance with ISO 14232:										
Feed time, min:										
	Set value	**1st test**	**2nd test**	**3rd test**	**Limit deviations** %			**Actual deviation** %	**Evaluation**	
					Class A	**Class B**	**Class C**		**Passed**	**Failed**
Mass of powder fed in g/min					± 5	± 10	± 15			
Re-test after 6 h					± 5	± 10	± 15			

Powder demixing test (in "cold-run" mode)					
Spraying powder used for testing, by agreement of parties concerned:					
Powder particle size:					
		Demixing		**Evaluation**	
		Limit deviation %	**Actual deviation** %	**Passed**	**Failed**
Initial mass, 1 000 g	Chemical analysis of initial mass, %	± 3			
Residual mass, ca. 100 g	Chemical analysis of residual mass, %	± 3			

Particle size analysis							
Particle size	**Initial mass**		**Residual mass**		**Demixing**		**Evaluation**	
					Limit deviation %	**Actual deviation** %	**Passed**	**Failed**
µm	g	%	g	%	± 3			
µm	g	%	g	%	± 3			

Automatic energy shutdown
Lack of gas: YES/NO
Lack of water: YES/NO
Excessive variations in feed: YES/NO

Measuring equipment capability	
Limits of error of measuring equipment:	% of selected value (max. 5 %)
Maximum permissible error of 2,5 % of the measuring span: YES/NO	

Comments:

Date: ..... **Inspector's signature:** .....

Annex B
(informative)

Inspection report for arc spraying equipment

Initial test/Re-test

Manufacturer:				Type of equipment		
User:				Type of head:		
Year of manufacture:				Power supply:		
Type of drive:						
Performance data (from manufacturer)						
Power supply: current:	A			Power supply: voltage	V *	
Spraying head: current	A			Spraying head: voltage	V *	
Spraying wire used for testing:				Diameter of the spraying wire:		
Item tested	**Set value**	**Actual value**	**Change after 20 min continuous testing**		**Evaluation**	
			Limit deviations %	**Actual deviation** %	**Passed**	**Failed**
Electric power and feed unit: voltage, V			± 5			
Electric power and feed unit: current, A			± 5			
Atomizing gas: pressure, bar			± 5			

* At 100 % duty cycle

Nozzle disturbances: YES/NO
Nozzle deposits: YES/NO
Limits of error of measuring instruments: % of set value (max. 5 %)
Maximum permissible error as a percentage of the measuring span, 2,5 %: YES/NO

Comments:

Date: ..... **Inspector's signature:** .....

Annex C
(informative)

Inspection report for flame spraying equipment using wire, rod or cord

Initial test/Re-test

Manufacturer:	Type of drive:
User:	Type of equipment:
Year of manufacture:	Type of nozzle:

Item tested	Set value	Actual value	Change after 20 min continuous operation			Evaluation	
			Limit deviations %		Actual deviation %		
			Class A	Class B		Passed	Failed
Fuel gas pressure, bar			± 2	± 5			
Fuel gas flow rate, l/min			± 2	± 5			
Oxygen pressure, bar			± 2	± 5			
Oxygen flow rate, l/min			± 2	± 5			
Atomizing gas pressure, bar			± 2	± 5			
Atomizing gas flow rate, l/min			± 2	± 5			

Spraying material used for testing:	Spray material diameter:

Spraying material feed unit	Set value	1st test	2nd test	3rd test	Limit deviations %		Actual deviation %	Evaluation	
					Class A	Class B		Passed	Failed
Fed length, mm/min					± 5	± 10			

Nozzle disturbances: YES/NO
Nozzle deposits: YES/NO
Limits of error of measuring instruments: % of set value (max. 2,5%)
Maximum permissible error as a percentage of the measuring span, 2,5 %: YES/NO

Comments:

Date: ..... **Inspector's signature:** .....

Annex D
(informative)

Inspection report for flame spraying equipment using spraying powder

Initial test/Re-test

Manufacturer:	Year of manufacture
User:	Type of equipment:

Item tested	Set value	Actual value	Change after 20 min continuous operation			Evaluation	
			Limit deviations %		Actual % deviation		
			Class A	Class B		Passed	Failed
Fuel gas pressure, bar			± 2	± 5			
Fuel gas flow rate, l/min			± 2	± 5			
Oxygen pressure, bar			± 2	± 5			
Oxygen flow rate, l/min			± 2	± 5			
Atomizing gas pressure, bar			± 2	± 5			
Atomizing gas flow rate, l/min			± 2	± 5			

Nozzle disturbances: YES/NO
Nozzle deposits: YES/NO
Sustained backfire of flame: YES/NO
Limits of error of measuring instruments: % of set value (max. 2,5%)
Maximun permissible error as a percentage of the measuring span, 2,5 %: YES/NO

Inspection of powder feed unit (in "cold-run" mode)									
Spraying powder used for testing:									
Particle size: according to ISO 14232:									
Feed time, min:									
	Set value	**1st test**	**2nd test**	**3rd test**	**Limit deviations** %		**Actual deviation** %	**Evaluation**	
					Class A	**Class B**		**Passed**	**Failed**
Mass of powder fed in g/min					± 5	± 10			

Powder demixing test (in "cold-run" mode)					
Spraying powder used for testing, by agreement of parties concerned:					
Powder particle size, according to ISO 14232:					
		Demixing		**Evaluation**	
		Limit deviation %	**Actual deviation** %	**Passed**	**Failed**
Initial mass, 1000 g	Chemical analysis of initial mass, %	± 3			
Residual mass, ca. 100 g	Chemical analysis of residual mass, %	± 3			

Particle size analysis							
Particle size	**Initial mass**		**Residual mass**		**Demixing**		**Evaluation**	
					Limit deviation %	**Actual deviation** %	**Passed**	**Failed**
μm	g	%	g	%	± 3			
μm	g	%	g	%	± 3			

Comments:

Date: ..... **Inspector's signature:** .....

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