INTERNATIONAL STANDARD

ISO 14921

Second edition
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Thermal spraying — Procedures for the application of thermally sprayed coatings for engineering components

Projection thermique — Mode opératoire d'application de revêtements obtenus par projection thermique pour les pièces mécaniques

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 14921 was prepared by Technical Committee CEN/TC 240, *Thermal spraying and thermally sprayed coatings* of the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee ISO/TC 107, *Metallic and other inorganic coatings* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 14921:2001), which has been technically revised.

Introduction

Components might fail if the surface does not fulfil the physical, chemical, and/or technological requirements. For several applications, this deficiency can be avoided by a thermally sprayed coating.

Where appropriate, a coating may be applied to protect the component's surface or to improve its behaviour by increasing the resistance against wear and/or corrosion, or the electrical or thermal conductivity or insulation or by reducing the friction coefficient.

There are limits to the applicable thickness of some thermally sprayed coatings. However, several different coatings may be built up one upon another. In the case of extensive loss of material through corrosion or wear, an alternative suitable spraying material may be applied prior to the top coat or the bond and top coat.

Thermal spraying — Procedures for the application of thermally sprayed coatings for engineering components

1 Scope

This International Standard specifies the general procedure, when a thermally sprayed coating is applied to enhance the surface properties of a component or to reclaim worn and non-conforming parts.

This International Standard does not provide definitive methods for specific work due to the variety of the technological, physical and/or chemical requirements and of the component's shape.

This International Standard specifies the general conditions for the selection of the spraying procedure and materials for this purpose. It does not apply to thermally sprayed zinc and/or aluminium coatings for protection of steel structures against atmospheric corrosion, for which ISO 2063 applies.

This International Standard also does not apply to coatings of self-fluxing alloys which are subsequently fused. That procedure is covered by ISO 14920.

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 14923, *Thermal spraying — Characterization and testing of thermally sprayed coatings*

EN 657:2005, *Thermal spraying — Terminology, classification*

EN 13507, *Thermal spraying — Pre-treatment of surface of metallic parts and components for thermal spraying*

EN 15520, *Thermal spraying — Recommendations for constructional design of components with thermally sprayed coatings*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 657:2005 apply.

4 Component and coating design considerations

4.1 General

If any of the considerations in 4.2 to 4.4 cannot be met satisfactorily, thermal spraying is not recommended. Factors which should be considered are illustrated in the flow chart shown in Annex A.

Judgements of the possibility for coating new parts may be carried out by assessing the drawing of the component and the area to be sprayed.

If a coating specification defines the spraying material, the factors to be considered are reduced.

4.2 Pre-inspection in the case of repair

Before carrying out a preparation procedure on the component, it shall be inspected to assess its suitability for spraying. Attention shall be given to the following:

— The concentricity and straightness of parts which rotate when operating and the shape and geometry of parts operated with a reciprocating or sliding motion shall be checked and, where necessary, corrected.

— The surface to be coated shall be inspected to check that it is free from cracks or other damage which can affect the performance of the coating. If any serious defects cannot be removed or repaired, spraying cannot be carried out satisfactorily.

— Establish dimensions of the area to be sprayed.

— The component shall be checked for any evidence of a previous coating, which, if present, shall usually be removed.

— Check and take into account the surface hardness of the work piece.

4.3 Component substrate

To establish whether a thermally sprayed coating is suitable for the intended purpose, consideration should be given to the following.

— Certain substrate materials are not suitable for thermal spraying or require special consideration in processing.

— Thermally sprayed coatings do not increase the strength of the part generally, and therefore the effects of any reduction in the dimensions of the original component shall be considered.

— The fatigue strength can be affected by the method of surface preparation, the spray material and the spray procedure.

— Certain processes to improve the surface condition, such as nitriding, can leave gaseous inclusions which can have a detrimental effect on the surface preparation, bonding, and porosity in the coating.

— Where hardened surfaces prevent a proper preparation, the limitations of the coating system which can be applied, and the properties subsequently derived, shall be considered.

— The area to be coated shall be accessible for applying the complete coating procedure. Therefore, the requirements for the processes of preparing, spraying and testing, spray gun with its electrical and/or gas connections, required distance and spray angle shall be considered.

4.4 Coating

The spray process and spray material can exert a tremendous influence on the coating properties. To determine the most suitable coating system, consideration of the following is required:

— bond strength requirement;

— thickness requirement;

— surface requirement (roughness);

— surface load; thermally sprayed coatings are sensitive to spot or line stress;

— the coating properties required, e.g. resistance to different types of wear mechanism, corrosion, chemical attack, temperature, thermal cycling, and other environmental conditions;

— where the level of porosity in the coating is unacceptable, it is to be checked, whether a suitable method of sealing, and type of sealant is available;

— is it possible to keep the oxide content within the accepted tolerance by control of process variables and the spray material?

Annex B gives a check list which details the information required to determine the most suitable coating system for the intended purpose.

5 Preliminary machining by turning, milling or grinding

Coatings which have to be renewed shall be removed completely. However, consideration shall be given to the condition of a surface treatment previously applied, e.g. for increasing fatigue strength.

Pre-machining shall be carried out to remove wear profiles, if applicable, and to ensure a uniform coating thickness. Sharp edges shall be avoided and shall be rounded or chamfered. Coatings shall be “inlaid” in the component, where possible, or continued around the rounded or chamfered edge. Recommendations for design are given in EN 15520.

The surface to be coated shall be machined concentrically to the relevant axis, to ensure a uniform thickness of the deposit.

Wherever possible, pre-machining shall be carried out without the use of a lubricant. This is particularly important in the case of porous substrate materials.

Where necessary, the component shall be degreased after preliminary machining.

6 Masking

Where appropriate, surfaces that shall not be sprayed can be masked with a suitable material. This material should be resistant to abrasive grit blasting and thermal spraying. Otherwise, separate masking for each operation shall be used.

Precautions shall be taken to ensure that the surface to be sprayed will not be contaminated by the masking material or otherwise at all times.

7 Methods of surface preparation

Contamination caused by pre-treatments shall be removed and the surface shall be cleaned immediately before the specific surface preparation commences.

A suitable surface preparation is required to achieve maximum bond strength to metallic substrates. Grit blasting is the normal method.

The surface preparation shall be in accordance with EN 13507. Deviations from this shall be agreed between the contracting parties.

8 Thermal spraying

The thermally sprayed coating should be applied as soon as possible after preparation, with parameters as given in the thermal spraying procedure specification. Reasonable precautions shall be taken to prevent contamination of the prepared surface during the time period between blasting and spraying.

Where appropriate, the surface to be sprayed may be pre-heated immediately prior to spraying. However, no contamination or local overheating (visible by tempering colour) of the prepared surface shall appear.

Before and during spraying, the surface shall be warm enough to prevent moisture by condensation.

During spraying, control of the temperature is necessary to avoid excessive residual stresses and impairment of the coating performance.

Dust entrapment in the coating shall be minimized.

The spraying equipment shall be operated in accordance with the manufacturer's instructions.

The thermal sprayer or operator should be qualified according to ISO 14918, or an equivalent qualification should be agreed upon by the parties concerned.

9 Inspection after spraying

Inspection of the thermally sprayed coating shall be carried out after cooling down to ambient temperature by

— visual inspection of the coating in accordiance with ISO 14923, and

— measurement of coating thickness.

If any defects are observed, such as de-bonding, cracking or other unacceptable imperfections and deviations from an agreed specification, the coating shall be removed completely and the complete spray procedure including the preparation shall be repeated, perhaps, using a revised spray procedure specification.

10 Sealing

Thermally sprayed coatings can be sealed, where required. For sealing, a range of different sealants and procedures are available. The supplier's instruction shall be followed.

The sealing should be carried out as soon as possible after spraying. If the sealant contains a solvent, this operation shall be carried out after the coating has cooled to an appropriate temperature.

11 Finishing

Coatings can be finished by surface finishing techniques, e.g. turning, milling or grinding. ISO 14924 presents recommendations for machining and other post-treatments of several thermally sprayed coatings.

12 Final inspection

The finished coating should be inspected with regard to the following aspects:

— dimensional accuracy within the required tolerances, as specified;

— specified surface roughness obtained;

— visible coating defects, for example, cavities, score marks, cracks, or spalling (see ISO 14923);

— overspray removal;

— cleanliness of the component;

— other specified requirements, e. g. on accompanying specimens.

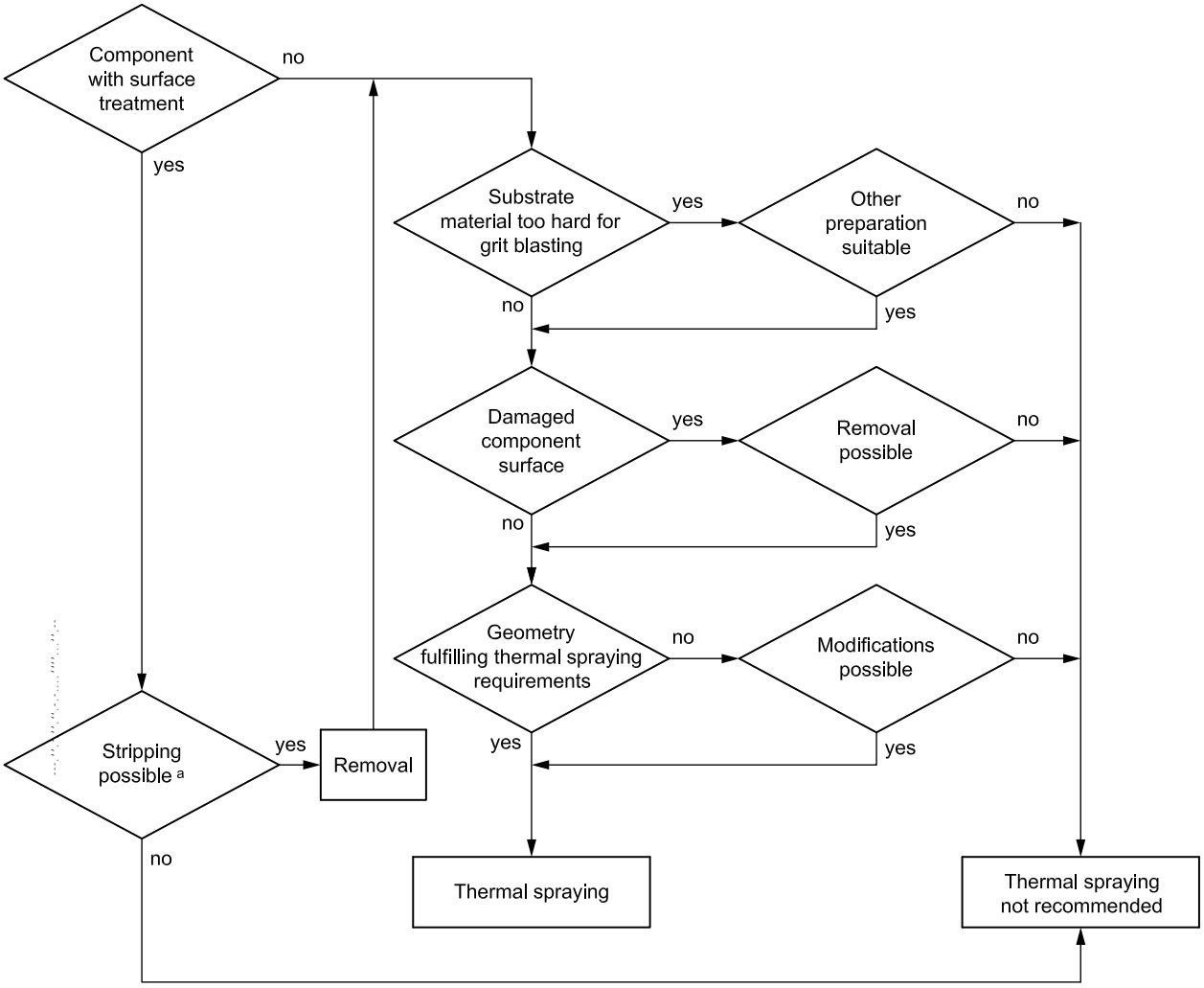
13 Documentation

To meet the requirements of quality management, a record of the applied procedure should be established containing all manufacturing steps and, if required, any results of the inspections and measurements.

Annex C shows an example of a record for the applied thermal spray procedure. This record can also be used as a guideline for a spray procedure specification.

Annex A
(informative)

Flow chart for assessment of suitability of thermal spraying



a Stripping by grinding or chemical or electrochemical means possible.

Annex B
(informative)

Check list for evaluation of the most suitable coating system for the intended purpose

(The user of this form is allowed to copy it.)

The following data should be determined:

1) Designation of the component.
2) Brief description of its function.
3) The area to be coated.
4) Areas to be masked off.
5) Any special precautions to be taken during handling or processing.
6) Function of the coating.

   Is it a running surface? Yes/No

   If “Yes”, against what?

   Lubricated? Yes/No

   If “No”, is it subject to abrasion? Yes/No

   If “Yes”, state media.
7) Is it subject to chemical attack by liquids or gases? Yes/No

   If “Yes”, state chemical and concentration.
8) Is operating temperature similar to ambient temperature? Yes/No

   If “No”, state operating temperature.
9) Is any thermal shock applied? Yes/No

   If “Yes”, give details.
10) State thickness requirement.
11) Is the coating to be finished? Yes/No

    If “Yes”, state finish technique, size, tolerance and roughness.
12) Where applicable, state concentricity requirement.
13) State any special requirement not covered by the above.

Annex C
(informative)

Record for the applied thermal spray procedure

(The user of this form is allowed to copy it.)

Manufacturer: ..... Location (workshop, on site, client): .....

Reason for repair: .....

Component description: ..... Substrate material: .....

Function of coating: ..... Chemical analysis: .....

Preliminary machined by: .....

Preliminary machining **Sketch** (if applicable)

Method of preparation and cleaning: .....

Surface preparation:

Program No.: .....

Blasting procedure: ..... Number of sequences: .....

Type of grit: ..... Grain size: .....

Blasting pressure: .....bar Blasting distance/angle: .....

Visual inspection: Cleanliness, uniformity, e.g. according to ISO 8501-1: .....

Roughness, e.g. according to ISO 8503-1: .....

Time period between blasting and spraying: .....

Spray procedure, generally

Spray material: Designation according to standard: .....

Grain size/wire diameter: .....

Other designation: .....

Preheating: yes/no Preheating temperature: ..... °C

Cooling: yes/no Cooling medium: .....

Coating thickness: as sprayed: ..... Finished: .....

Masking material: ..... Device No.: .....

Spray device, if applicable, No.: .....

Motion: manually/mechanised: industrial robot/x-y-z-manipulator/manipulator for rotating parts

Spraying program No.: .....Rev. index: .....Movement program No.: .....Rev. index: .....

Spraying distance: ..... mm Surface speed: .....(m/min)
(relative speed between spray torch and the part's surface)

Spraying sequences: (kind, number/ thickness of passes).....

Thermal sprayer/operator: .....

Surface post-treatment: ..... Program No.: .....

Temperature/time period: .....

Spray procedure, specific data applied (for several spray procedures)

Spraying procedure (according to EN 657): **Arc spraying**

Arc spraying system: .....

Type of nozzle: closed arc/open arc/arc jet

Current: ..... A Voltage: V

Atomising gas pressure: ..... (MPa)

Arc jet pressure: ..... (MPa)

Spraying procedure (according to EN 657): **Wire flame spraying**

Flame spraying system:.....

Type of nozzle: .....

Wire feed rate: ..... m/min

Oxygen flow rate[1)]: ..... Nl/min

Fuel type: ..... Fuel flow rate[1)]: ..... Nl/min

Compressed air flow rate/setting: .....

Spraying procedure (according to EN 657): **Powder flame spraying**

Flame spraying system:.....

Type of nozzle: .....

Powder injector: diameter: ..... mm Position to nozzle: ..... angle: ..... degrees

Powder feed rate: ..... g/min

Powder carrier gas: ..... Carrier gas flow rate[1)]: ..... Nl/min

Oxygen flow rate[1)]: ..... Nl/min

Fuel type: ..... Fuel flow rate[1)]: ..... Nl/min

Compressed air flow rate/setting: .....

1) 0 °C (273,15 K) and 101,325 kPa.

Spraying procedure (according to EN 657): **High velocity flame spraying (HVOF)**

HVOF spraying system: .....

Nozzle, inner diameter: ..... mm

Powder injector: diameter: ..... mm Position to nozzle: ..... angle: ..... degrees

Powder feed rate: ..... g/min

Powder carrier gas: ..... Carrier gas flow rate[1)]: ..... Nl/min

Oxygen flow rate[1)]: ..... Nl/min

Fuel type: ..... Fuel flow rate[1)]: ..... Nl/min

Spraying procedure (according to EN 657): **Atmospheric plasma spraying (APS)**

APS spraying system: .....

Nozzle, inner diameter: ..... mm

Powder injector: diameter: ..... mm Position to nozzle: ..... angle: ..... degrees

Powder feed rate: ..... g/min

Powder carrier gas: ..... Carrier gas flow rate[1)]: ..... Nl/min

Primary gas: ..... Primary gas flow rate[1)]: ..... Nl/min

Secondary gas: ..... Secondary gas flow rate[1)] ..... Nl/min

Current: ..... A Voltage nominal: ..... V (new electrode/nozzle)

..... Voltage min.: ..... V (operated)

Electrical power, nominal: ..... kW Kept constant: yes / no

Voltage drop compensated: yes/no Voltage drop to minimum compensated by: .....

Spraying procedure (according to EN 657): **Cold spraying (CGS)**

Cold spraying system: .....

Nozzle, inner diameter: ..... mm

Powder injector: diameter ..... mm

Powder feed rate: ..... g/min

Powder carrier gas: ..... Carrier gas flow rate[1)]: ..... Nl/min

Gas type: ..... Gas flow rate[1)]: ..... Nl/min

Gas temperature: ..... °C Gas pressure: ..... MPa

Inspection and test results (Example)

Inspection/Test	Procedure/ Specification	Executed by:	Record No.	Test results		Remarks
				Passed	Failed	
Visual inspection	ISO 14923					
Coating thickness						
Penetrant test	EN 571-1					
Hardness test						
Roughness test						
Materialographic examination						
Determination of adhesive tensile strength	EN 582					

Date of issue: .....

Signature: .....

Name: .....

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