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Thermal spraying — Zinc, aluminium and their alloys —

Part 2: Execution of corrosion protection systems

Projection thermique — Zinc, aluminium et alliages de ces métaux —
Partie 2: Exécution des système de protection contre la corrosion

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*.

This document, together with ISO 2063-1:2017, cancels and replaces ISO 2063:2005, which has been technically revised.

A list of all the parts in the ISO 2063 series can be found on the ISO website.

Thermal spraying — Zinc, aluminium and their alloys —

Part 2:
Execution of corrosion protection systems

1 Scope

This document specifies requirements for corrosion protection of steel structures, components or parts, which are coated by thermal spraying of zinc, aluminium or their alloys.

This document specifies requirements for coating manufacturers of surface preparation, thermal spraying, testing and post treatments, e.g. sealing of the coating. This document applies to metallic corrosion protection coatings in the case of new fabrication in the workshop, as well as on-site and for repair on-site after assembly.

Requirements for coating thickness, minimum adhesive strength and surface conditions, specified in a coating specification, are given.

Recommendations are given for suitable process steps and quality assurance measures for new production and maintenance and for supervising of corrosion protection works.

This document covers the application of thermal-sprayed zinc, aluminium and their alloys for protection against corrosion in the temperature range between –50 °C to +200 °C. Heat-resistant protective coatings of aluminium are covered by ISO 17834 and are not in the scope of this document.

This document specifies requirements for the equipment, the working place and the qualification of the spray and testing personnel.

NOTE ISO 2063-1:2017 is addressed to the designer and to the planning engineer of corrosion protection system.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method*

ISO 2063-1, *Thermal spraying —Zinc, aluminium and their alloys — Part 1: Design considerations and quality requirements for corrosion protection systems*

ISO 2178, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method*

ISO 4624, *Paints and varnishes — Pull-off test for adhesion*

ISO 8044, *Corrosion of metals and alloys — Basic terms and definitions*

ISO 8501-1:2007, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 8503-1, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces*

ISO 14916, *Thermal spraying — Determination of tensile adhesive strength*

ISO 14917, *Thermal spraying — Terminology, classification*

ISO 14918, *Thermal spraying — Approval testing of thermal sprayers*

ISO 14922-1, *Thermal spraying — Quality requirements of thermally sprayed structures — Part 1: Guidance for selection and use*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14917, ISO 8044 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
minimum local thickness
lowest value of the local thickness found on surface of a single article

3.2
dew point
temperature to which a volume of humid air should be cooled, at constant barometric pressure, for water vapour to condense into liquid water on a solid surface

3.3
local repair
restoring of the thermal-sprayed metallic corrosion protection coating by applying a suitable corrosion protection system on small defective areas, such as are caused by damage on transport, erection or by destructive tests

3.4
manufacturing sequence plan
manufacturing and test operations listed step by step

3.5
job control record
JCR
manufacturing sequence plan used for control that each single operation step is really carried out

3.6
job reference specimen
JRS
specimen simulating production conditions and which represents the part to be coated and is comparable in material and size

3.7
job reference qualification
JRQ
qualification of an application or of a thermal sprayer applying a job reference specimen for the test

3.8
pre-production spraying test
thermal spraying test having the same function as a spray procedure test, but is based on a job reference specimen (non-standard test piece, simulating production conditions)

4 Requirements for the manufacturer

4.1 General

The manufacturer of thermal spray coating shall possess a quality management system, which can fulfil the necessary quality requirements in accordance with this document or to the quality assurance system in accordance with ISO 14922-1 (A, B or C), shall employ qualified personnel, is responsible to keep the function of the spray and necessary ancillary equipment in proper condition and shall fulfil applicable requirements concerning health and safety and environment protection. For that purpose, the instructions and information provided by the CEN/TR 15339 series may be helpful.

4.2 Qualification of the manufacturer

4.2.1 Qualification of the equipment

The manufacturer shall provide blasting and spraying equipment and ancillary equipment which is fit for the purpose. The continued proper functioning of the equipment shall be proven through inspection reports or results of successfully applied tests (e.g. if a component related procedure qualification has passed). Testing may be carried out in accordance with the appropriate part of the standard series EN 1395-1 to EN 1395-3, EN 1395-6 or EN 1395-7.

The manufacturer is also responsible for providing an adequate calibration and validation of the instruments for measuring, testing and for supervision. The results of the tests, calibration and maintenance shall be documented.

4.2.2 Qualification of supervision personnel

The manufacturer of the thermal-sprayed coating shall employ qualified supervisors according to the requirements of the component and of the required quality in accordance with ISO 2063-1 and to this document. The education and qualification of the supervisor should be carried out in accordance with ISO 12690.

When an additional coating with organic materials is part of the order, an adequate qualified person shall be available for supervision of this part of the corrosion protection, e.g. with the scope of responsibility in accordance with ISO 12944-7.

4.2.3 Qualification of spraying personnel

In case of manual spraying, the manufacturer of the thermal-sprayed coating shall employ qualified thermal sprayers in accordance with ISO 14918 or sprayers who are instructed and trained adequately (e.g. with long lasting and proved experience in thermal spraying). This requirement shall be in accordance with the requirements of the component, the quality assurance system in accordance with ISO 14922-1 and of this document or of the contract.

4.2.4 Qualification of test personnel

The manufacturer of the thermal-sprayed coating shall only employ inspectors who possess the required qualification for the test procedure concerned in accordance with the requirements of the component and the required quality in accordance with ISO 2063-1 and this document.

When an additional coating with organic materials is part of the order, an adequate qualified person shall be available for supervision of this part of the corrosion protection, e.g. with the responsibility in accordance with ISO 12944-7.

4.3 Coating specification for the thermal-sprayed coating

The manufacturer of the thermal-sprayed coating of a component shall fulfil any requirements, which are stipulated in the contract and/or coating specification. If neither a coating specification is present nor rated values of the minimum coating thickness, minimum tensile adhesive strength, admissible imperfections, post treatments, e.g. sealing, and tests and their scope are specified in the coating specification or in the manufacturing instructions, they shall be agreed upon between the contracting parties or be taken from this document.

Test specifications shall be prepared by the manufacturer of the coating, if required in agreement with the contractor, when they are not part of the coating specification.

4.4 Assessment of the coating on the basis of reference areas

If in the case of a thermal-sprayed coating for very large surfaces, representative areas can be coated. Location and size of the areas shall be unambiguously defined and documented.

5 Quality assurance measures for the manufacturer

5.1 General

This clause describes the measures that shall be taken by the coating manufacturer, in order to ensure an adequate order management, quality assurance and reproducibility of manufacturing.

5.2 Assessment of the design to coatability

In the frame of the contract and design review, the coatability of the component shall be checked. Checking is necessary for working in the workshop, as well as for working on-site and repairs, in the case of maintenance work. If the main principles are considered when executing the constructive design (dealt in ISO 2063-1) and the questions of the check list (see Annex F) can be positively answered, the work piece would be considered coatable.

5.3 Establishing the manufacturing instructions — Manufacturing sequence plan

The manufacturer of spray coatings shall establish manufacturing instructions, detailing all single work and test steps listed in chronological order, including the surface preparation, thermal spraying, post-treatments, e.g. smoothing or sealing of the coating and establishing the documentation. Spray procedure specifications necessary for each single process shall be indicated. This manufacturing sequence plan can be used as a job control record (JCR).

5.4 Establishing the thermal spray procedure specification

The coating manufacturer is responsible for establishing and following the thermal spray procedure specification (TSPS). This procedure should include information on the coating specification and to the manufacturing instructions, as well as parts lists, substrate and spray materials data, drawings and test instructions. All relevant information should be available for the thermal sprayer in written form, if appropriate.

The TSPS shall contain all parameters of the procedure required for the spray process.

The required spray parameters shall be determined using sprayed specimens or can be taken from similar applications. The TSPS can be qualified by a procedure qualification in accordance with

EN 15648, if this is required by the quality management system of the manufacturer generally, or by the contractor.

The preparation of the surface to be coated shall be specified in the TSPS, together with the required cleanliness level. For further instructions, see 6.2.

Any changing of a parameter or the spray materials, ancillary substances, the design, the spray procedure or the spray equipment requires a checking of the coating quality. If necessary, the TSPS shall be corrected or prepared again.

5.5 Qualification of the TSPS and scope of the TSPS

Coating manufacturers can achieve qualification of the TSPS by a component-related procedure qualification in accordance with EN 15648 or by testing on test sheets, if the requirements are fulfilled, which are stipulated in the coating specification for the respective part.

The scope can also be agreed upon by the contracting parties for similar parts, if the substrate material is comparable in its technological, metallurgical, physical and chemical properties. Comparability is given to the level of difficulty for the thermal spraying.

5.6 Qualification of the TSPS by a specific job reference qualification

Due to shape and dimension of very large components the qualification of a spray procedure specification (TSPS) by a component related qualification maybe too complicated and expensive. A job reference qualification (JRQ) can be used to assess the suitability of the application process. By that way job reference specimens (JRSs) shall represent the spray positions to be performed and shall be comparable to the level of difficulty on preparation and thermal spraying of the component. The procedure shall be agreed upon between contracting parties.

5.7 Special job qualification by performance on mock-ups, if required

If required by the contractor, a referencing mock-up shall be manufactured to simulate the angles for steel assemblies exhibiting acute angles between structural members to be sprayed after welding or assembly. Details of the acceptance criteria should be agreed upon.

6 Manufacturing of thermal-sprayed coatings

6.1 General

This clause deals with the operations and measures of the applicator of the spray coating, which belong to a conforming manufacturing route for the deposition of a thermal-sprayed coating. This procedure applies to the component as well as to accompanying specimens, if they are required.

It may be helpful to check accessibility for preparation, spraying, post treatments and testing, and to follow the design considerations of the area to be sprayed according to general requirements, e.g. EN 15520. A useful checklist is presented in Annex F.

If possible, very large surfaces should be separated into sectors to be coated, in order to fulfil the requirement to start with the thermal spraying immediately without any delay after finishing the surface preparation.

NOTE 1 The term “immediately without any delay” means without any culpable delay.

NOTE 2 Usually, such a section would not exceed 40 m^2 to 45 m^2. In some cases, such a sectioning will be impossible, especially in long beams. The surface preparation in overlapping zones needs special attention so as not to damage the coating already partially applied by blasting of the next section. Usually, a time period of 4 h is adequate in zones with temperate climate.

For climate zones with a high continuous humidity, this rule is not valid. In such cases, the size of sections and the 4 h period should be significantly reduced and special measures for drying should be applied. Otherwise, thermal spraying cannot be applied without loss in quality.

6.2 Preparation of the surface to be coated

6.2.1 Masking of areas not to be coated

Areas of the part that are not to be coated shall be masked prior to blasting and prior to spraying.

The masking material should withstand the grit when blasting and the hot spray particles when spraying. Otherwise, separate masking should be applied for each process.

Precautionary measures should be taken to avoid contamination of the surfaces to be coated by a masking material.

6.2.2 Preparation of the surface to be coated by blasting

EN 13507 (or similar) should be followed in the preparation of the surface to be coated when no instructions are stipulated in the TSPS. The blasting parameter shall be determined using a plate as a test specimen if no parameter is stipulated in the TSPS or in the manufacturing instructions.

NOTE Important parameters are type and grain size of the blasting material, state of wear (sharp or rounded edges), blasting time, distance and angle, air pressure and type of the spray equipment.

The surface to be prepared, including occasional weld areas (if available) shall be cleaned and blasted using pressurized air blast equipment and an adequate blasting material, until the part's surface gives a metallic appearance with uniform structure in accordance with ISO 8501-1, Sa 2 ½ G for Zn/ZnAl15 and Sa 3 G for Al/AlMg5. This state shall be confirmed by visual comparison to the reference sample G (grit) in accordance with ISO 8503-1, if no other commitment is agreed upon between the contracting parties.

Usually, surface roughness (R_z) should be in the range of 50 µm to 100 µm, depending on the spray process and spray material.

Safe access and sufficient lighting of the surface to be blasted and adequate work conditions (low humidity, sufficient temperature of environment and component for instance not falling below the dew point, protection against ice, rain and wind) shall be ensured for blasting and subsequent testing. Specific measures shall be taken in the case of working on-site.

The blasting material shall be adequately stored and protected from pollution.

Sufficient cleaning of the blasted surface from grit residues should be carried out in accordance with EN 13507 (or similar). For further details, see Annex H.

After blasting, spraying shall be started as soon as possible to avoid any contamination and build-up of moisture on the surface.

6.2.3 Testing of the prepared surface

The condition of the surface to be coated shall be checked for cleanliness in accordance with ISO 8501-1 and to the desired uniform roughness by visual comparison. Reference samples in accordance with ISO 8503-1 are adequate aids.

6.3 Thermal spraying

6.3.1 General

Before spraying, the surface prepared for coating shall be visually checked. If imperfections on the surface to be coated are visible the surface preparation shall be repeated.

6.3.2 Spray material

The spray material stipulated in the TSPS shall be applied. Proof shall be delivered on the conformity of the spray material by comparison with the accompanying supply instructions and designations. The instructions of the manufacturer/supplier for storage and use of the spray material shall be considered.

6.3.3 Pre-conditions for the execution of thermal spraying process

When the spray equipment is not in operation, checking of the parameter setting should be carried out. Applying a bend test (or, if required, an adhesion test in accordance with ISO 4624) can be helpful. For details, see Annex G.

After finishing the surface preparation (blasting and masking, if appropriate, and testing) spraying shall be started immediately. The spray coating shall be produced using the parameter stipulated in the TSPS in one manufacturing step without interruption.

An assessment of the atmospheric conditions (humidity, dew point and ambient air temperature) shall be carried out and recorded before thermal spray application begins. When large components are to be thermally coated, these conditions shall be checked in adequate periods of time while spraying is running. Spraying should not be performed unless the ambient requirements for thermal spraying or sealing are met. If the general climate conditions allow (temperate climate zones), the following environmental conditions should be present prior to thermal spraying:

— surface temperature: > 3 °C above the dewpoint of the air (determined in accordance with ISO 8502-4);

— relative humidity: < 85 %;

— air temperature: > 5 °C (determined in accordance with ISO 8502-4).

6.3.4 Execution of thermal spraying

Thermal spraying shall be carried out according to the instructions of the TSPS. For further details, see 5.4.

The following spraying parameters shall be supervised in adequate periods of time by the spray coordinator/supervisor or the sprayer:

— values of current, voltage, gas flows;

— motion rate in the case of mechanical spraying;

— component's surface temperature;

— right use of the spray material applied;

— dimensional and visual inspection of the coating.

Spray dust shall be exhausted, as thoroughly as possible. Entrapment of dust in the coating shall be minimized. An intermediate cleaning of the sprayed layers during interruption of the spray process may be necessary, especially when spraying in vertical or downward position. In that way, dust and loose particles can be removed by exhausting or blowing oil-free and dry compressed air.

6.3.5 Inspection after spraying

The as-sprayed coating and the accompanying specimen, if applicable, shall be inspected according to the following aspects:

— measuring of the coating thickness (see 7.3);

— measuring of the adhesion strength by pull-off testing in accordance with ISO 4624 on accompanying specimens, if possible and required;

— visual inspection to coating defects, e.g. cavities, score marks, cracks, overspray not removed, damages, or spalling (see 7.4.1);

— checking the surface roughness (see 7.4.2), if required;

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

Any testing shall be indicated in the JCR and any test results in a test report.

If defects are found, such as de-bonding, spalling, cracks or other unacceptable imperfections (defects), as a minimum, the coating shall be completely removed from the defect zone. The spray procedure, including surface preparation and thermal spraying, shall be repeated. In the case of general or systematic defects, the TSPS shall be revised or a new one shall be prepared and qualified. For further details, see 7.5.

The sprayed coating can be released for the next operation step (sealing) when the inspection of the thermal-sprayed coating shows no unacceptable imperfections (defects).

When no other proof is delivered or commitments are taken between the contracting parties, the spray coordinator/supervisor is responsible for applying the required tests in accordance with the rules. The testing shall be executed by a qualified person and the test results documented in a test report.

6.4 Sealing of the coating

The thermal-sprayed metallic coating (TSMC) should be sealed. The sealing shall be started immediately after finishing the spraying process and cooling down of the sprayed coating before visible oxidation of the surface occurs and in order to avoid a contamination of the sprayed coating surface by dirt or moisture.

A thorough cleaning of the sprayed surface from spray dust and loose spray particles is necessary prior to deposit the sealant.

The spray coordinator/supervisor is responsible for following the manufacturer's instructions for storage and use of the sealant and for the disposal of superfluous sealant. For further details, see Annex I.

6.5 Advice for welding in combination with thermal spraying

Welding works shall be done prior to thermal spraying in the workshop when they are not intended to be applied on-site.

Prior to thermal spraying, slag, alkali residues and other welding residues shall be removed from the area to be coated. The welds shall be free of undercuts, open pores, craters and spatters on or next to the weld. Such imperfections shall be removed by blasting or grinding. Moreover, prime coats (if available) or their leavings near the weld shall be removed prior to thermal spraying.

If weld bevels on a component are prepared for welding on-site, the areas next to the weld shall be covered on a width of approximately 100 mm, measured from the weld bevel, prior to thermal spraying in the workshop.

6.6 Thermal spraying of corrosion protected fastenings

Zones where fastenings are applied, which are already protected against corrosion, shall be corrosion protected by thermal spraying after assembly by bonding or by welding according to the manufacturing instructions or agreements between the contracting parties.

7 Tests — Test procedures

7.1 General

Tests and their scope shall be specified in the coating specification or in the manufacturing instructions. Test specifications shall be prepared by the applicator of the spray coating, if required, by mutual agreement with the contractor.

When test methods are not specified in the coating specification nor agreed upon between the contracting parties, tests shall be carried out in accordance with this document.

Whenever possible, the required tests shall be performed on the component. If this is not possible, accompanying specimens shall be subjected to such tests.

Tests and scope of testing shall be representative for the component.

7.2 Manufacturing of the accompanying specimens

Accompanying specimens shall be provided for tests that cannot be carried out non-destructively on the component. This is predominantly applicable when testing the pull-off strength in accordance with ISO 4624, especially the tensile adhesive strength in accordance with ISO 14916 and for metallographic investigations. Adequate dimensions of the specimens are described in E.4.

The accompanying specimens shall be sprayed using the same parameters as stipulated for the component itself. Different spray positions (horizontal, overhead, vertical down), the deposition method (carried out manually or mechanically) and the general spray conditions (in the workshop or on-site) shall be considered.

7.3 Coating thickness

7.3.1 General

The coating thickness shall be non-destructively measured on the component.

If measuring on the component is not possible due to geometrical or material reasons, the coating thickness should be checked on accompanying specimens.

When the frequency of measuring the coating thickness is not specified in the manufacturing instructions, the frequency shall be determined according to the size of the coating's surface. Applying an adequate selection of number and location of the measuring points, the test result shall be representative for the whole coated surface of the component. When selecting the measuring points, the method of applying the coating, manually or mechanically, shall be considered.

The arithmetic mean value of three readings of the coating thickness measured within an area of 1 cm^2 according to Figure 1 shall be called local coating thickness. Its value represents the result of one measuring point.

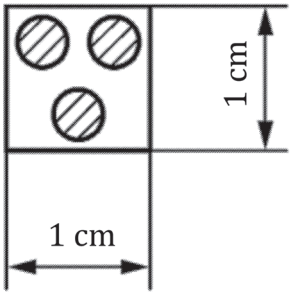


Figure 1 — Distribution of measurement points in the reference square centimetre

7.3.2 Coatings with a surface below 1 m²

In the case of thermal-sprayed coatings with a surface below 1 m², the local thickness shall be measured at an adequate reference surface of 1 dm², at measuring points distributed corresponding to Figure 2. Five measuring points shall be taken in the case of manual spraying and three measuring points in the case of mechanical spraying.

Figure 2 — Distribution of measurement points on the coated surface and used as reference square decimetre

7.3.3 Coatings with surfaces greater than 1 m²

In the case of coatings with surface areas larger than 1 m², the thickness of the coating measured at any point shall be called local thickness, when it is measured on a reference square of about 1 dm². That way, the local thickness is defined to be the arithmetic mean value of three with five measuring points, according to Figure 2. Regarding the number of the measuring points, see 7.3.4.

7.3.4 Number of thickness test points

When location and number of the measuring points are not specified or agreed upon, the selection of these points is left to the discretion of the applicator. In the case of coating surfaces larger than 1 m² up to 45 m², two locations per m² shall be chosen in minimum where measurements according to the reference square decimetre (dm²) and also distributed according to Figure 2 shall be applied.

The spray method (manual or mechanical) shall be considered to determine the number of measurements of each reference square. For larger surfaces to be coated, the number of reference squares related to the size of the surfaces to be coated shall be agreed upon.

Table 1 — Number of thickness measurements

Number of thickness measurements	**Surface to be thermally sprayed** (m²)					
	< 1	1 to 5	5 to 10	10 to 45	45 to 90	> 90
Number of reference squares (test area)	2	3	4	6	8	to be agreed upon

7.3.5 Measurement of the coating thickness

Measurement of the thickness shall be carried out by means of electromagnetic measuring methods in accordance with ISO 2178. The measuring instrument shall be calibrated prior to use; the instructions of the producer/supplier are to be considered.

Due to the often high roughness of the coating's surface, measuring the coating thickness might create some problems and doubt. Measurements taken on roughened thermal-sprayed coating on roughened substrates will therefore be higher than the real value of the coating thickness above the peaks of the profiles. The thickness of the coating above the peaks of the profile is defined as the measuring instrument reading minus an appropriate correction value.

7.4 Appearance of the coating surface and tests

7.4.1 Visual inspection

The surface of the coating shall be of uniform in appearance, without blisters or bare patches, and free from non-adhering particles and defects. In the case of a visual inspection, an assessment of the surface characteristics shall be carried out in accordance with ISO 14923. Visual inspection at 100 % shall be applied after finishing the coating, even if it is not specified in the manufacturing instructions.

7.4.2 Roughness

The desired roughness may be stipulated in the coating specification or committed by agreement.

The roughness to be achieved in the as-sprayed condition depends on the spray process, the spray parameter and the spray method (manual or mechanical). The necessary or desired roughness depends on the subsequent treatments:

— only sealing: less roughness;

— with additional organic coating: higher roughness required.

Roughness values of flame spraying coatings are usually lower by comparing with the values of arc spraying.

7.4.3 Adhesion strength

If required, the tensile adhesive strength for acceptance criteria shall be determined on accompanying specimens by pull-off tests in accordance with ISO 4624 and as described in A.1, when no other test procedure had been agreed upon between the contracting parties.

Typical values for adhesive strength can be found in Table A.1.

A tensile adhesive test in accordance with ISO 14916 should only be applied when this measurement is required by the contractor, e.g. for qualification purposes. The number of accompanying specimens should be agreed upon.

7.4.4 Metallographic examination of the coating

If the coating thickness shall be determined by a metallographic examination, a cross-section of a specimen shall be taken and the examination carried out in accordance with ISO 1463. Ten measurements shall be equally distributed along one side of the cross-section on a length of approximately 20 mm to determine the mean value.

7.5 Defects in the coating and their repair

7.5.1 Defects on the surface and in the coating and their repair

Small local defects, e.g. short cracks, bare patches, inclusions and damages due to assembly works or caused by destructive tests, which can impair the corrosion protection, can be repaired using organic coatings, e.g. zinc powder coatings, after an adequate surface preparation, if there are no specific agreements against this procedure. However, the entire defective surface should not exceed 1 % of the entire coating's surface and a single defect shall not exceed 10 cm^2.

In the case of larger flat defects, the defective coating shall be removed entirely or partially and renewed by thermal spraying. Longer cracks or bare patches on and next to the weld shall be cleaned according to level Sa 2 ½ G for Zn/ZnAl15 and Sa 3 G for Al/AlMg5 in accordance with ISO 8501-1:2007 and roughened in accordance with ISO 8503-1 and protected by thermal spraying. The quality requirements for the corrosion protection of such coating areas shall correspond to those of the component itself.

In each individual case the availability of specific guidelines or agreements for removal of defects shall be checked and considered.

7.5.2 Reasons for the rejection of a defective sprayed coating

If a sprayed coating or the accompanying specimens do not fulfil the requirements specified in the test specification, the spray coating concerned shall be removed. After cleaning and surface preparation, the spray coating can be applied again using the existing TSPS. If it is noticeable that the requirements of the coating specification cannot be fulfilled by the existing TSPS, it shall be corrected or a new TSPS shall be prepared and qualified again.

The tests and their scope shall be carried out as stipulated in the test specification.

8 Health and safety and environment protection

For the manufacturing of thermal-sprayed corrosion protection coatings, applicable requirements concerning health and safety and environment protection shall be fulfilled. For further details, see Annex J.

9 Additional requirements for working on-site

9.1 General

When working on-site, negative influences of the environment to a safe work are to be expected. The employer shall avoid or minimize them by organizational and technical measures.

9.2 Supervision of spraying on-site

For operations on-site, the conditions defined in 4.2.2 apply. A supervisor for thermal spraying shall be present on-site during the course of the manufacturing. This spray coordinator/supervisor shall supervise the qualified thermal sprayers working on-site and ensure that the required tests are carried out according to current manufacturing steps.

Where no supervisor is nominated by the producer, the spray coordinator shall be responsible for health and safety and environment protection matters.

9.3 Job reference qualification for spray personnel working on-site

Before the thermal sprayer begins to work on-site, the thermal sprayer shall, if required by the TSPS, be qualified by a job reference qualification applying a specimen, which shall be coated in the most challenging position required. By applying an adequate job reference specimen (JRS) the thermal sprayer can get permission for the employment on-site, if all quality requirements are fulfilled when testing.

The qualification shall be carried out under leadership and in response of the spray coordinator/supervisor.

The specimens defined in Annex E can be used for the sprayer's qualification so that the required spray position can be covered. For details, see Table E.1. This personnel qualification can also be executed using a plate for a JRS according to 5.6.

9.4 Execution of spray works in the case of planned work on-site or not planned repairs on new manufactured parts

9.4.1 General

An execution of thermal spraying planned to be carried out on-site can be necessary due to the component's dimension or transport capacity or unplanned work in the case of repair of damages that occurred during transportation or assembly. Such damages shall be identified by the inspector and repaired according to available specifications or commitments.

Welding shall be carried out prior to thermal spraying. Generally, the details given in 6.5 apply also for works on-site.

The spraying coordinator or supervisor is responsible for ensuring that the works follow the manufacturing sequence plan and the instructions for manufacturing and testing, as required.

9.4.2 Surface preparation

The surface preparation shall be carried out according to 6.2.

If the zone next to a weld is protected by a primer, this primer shall be removed prior to blasting for surface preparation.

Furthermore, it shall be ensured that no residues of former coatings remain on the surface to be coated and the cleaned and prepared surface will not be contaminated, e.g. not to be touched with bare hands or not to fall below dew point, and kept be free of any contaminants.

9.4.3 Masking

Masking shall be carried out according to 6.2.1.

The masking material shall be stored safely and dry and the masking itself protected from condensation of moisture.

9.4.4 Thermal spraying

Thermal spraying shall be carried out according to 6.3.

Due to the weather and usual climate conditions on-site, a higher risk of rusting can be expected. The spraying supervisor shall ensure that the period of time between blasting and thermal spraying is as short as possible.

The spraying supervisor or the sprayer shall take care that the dew-point of the air is known and the surface temperature of the component in the area to be coated can be kept constantly to at least 3 °C above the dew-point. If this is not possible, thermal spraying should not be carried out.

9.4.5 Spraying of accompanying specimens

For manufacturing and testing, 7.2 applies. Size and number of specimens depend on the test procedures, which are required for the investigation. If testing of the zone next to a weld is required, this test shall be applied on a welded accompanying specimen, e.g. according to Figure E.2.

9.4.6 Sealing

Sealing should be carried out according to 6.4.

10 Execution of spray works on-site in the case of planned maintenance of a service operated coating

10.1 General

Deterioration and damage of the TSMC can occur by impact with other objects, abrasion and corrosion.

A repair can vary from entire replacement of the coating to minor touch-up depending on the extent of the damage.

NOTE Maintenance is usually applied if a metallic or organic coating looks shabby or the coating thickness is reduced. Local repair can be carried out if rust did not occur. Rusting of the metal surface can be ruled out when the rest of the metallic coating not attacked by rust is more than 50 µm in thickness. Since such rusting of the metal surface is not easy to recognize, this procedure can only be partly recommended. Renewing of the coating is required, where rust appeared on the substrate and the required design life of the component will not be reached. Usually, such work is carried out on-site.

Welding planned to be carried out on-site or which was found to be necessary in the case of maintenance of a service loaded structure and coating shall be carried out prior to thermal spraying. Generally, the details specified in 6.5 shall be kept for working on-site too.

10.2 Pre-inspection for assessment of the repair possibility applied by thermal spraying

Usually, a pre-inspection is required, if a weathered, strongly attacked coating shall be maintained. A report of the actual status shall be established.

10.3 Execution of repair-works by thermal spraying

10.3.1 General

All the works for thermal spraying shall be carried out according to the status report, as described in 10.2 and 10.3 and stipulated in the order. The procedures as specified in Clause 9 shall be considered, when they are applicable in the specific case.

If the substrate is already rusty, the substrate shall be repaired at first like a corroded but uncoated or only organic coated steel by blasting, grinding, or welding. Further details can be taken from Annex K.

10.3.2 Quality control after repair

During and after the execution of repair works by thermal spraying, quality control measures shall be applied (control and testing, e.g. according to 6.2, 6.3, 7.3 and 7.4), if required. This includes control of adequate ambient air and environment conditions, surface temperature, surface cleanliness, adhesion strength, thickness of the metallic coating, sealant and sealing; and thickness of painted coats, if applying of the organic top coat belongs to the order.

The criteria for repairs shall be applied according to 7.5.

11 Tests — Test procedures

The tests shall be carried out on the component when possible. If no other test procedures are agreed upon between the contracting parties, the tests shall be carried out according to 7.1 to 7.4.

The test results shall be indicated in a report (e.g. according to Annex B). If all requirements are fulfilled, release for further manufacturing is given by this report. If the requirements are not fulfilled, rejection of the coating is given by the report and correcting measures will be required. For details, see 7.5. If necessary, further conditions are to be agreed upon between the contracting parties.

12 Documentation of the procedure and tests in the case of maintenance

Annex B provides a test report form for the documentation of the manufacturing steps applied. The thermal spraying process and the test results shall be indicated. The form is intended to the case of a planned maintenance. It can be used for activities in a workshop, as well as on-site.

13 Health and safety and environment protection on-site

Generally the instructions and determinations from Clause 8 apply also for thermal spraying on-site.

Due to the different weather and climate conditions that can be expected on-site, measures are required to protect the environment when surface preparation, thermal spraying, sealing, testing and organic coating is carried out, if appropriate.

Annex A
(normative)

Adhesion testing using the pull-off test in accordance with ISO 4624

A.1 General requirements

In the case of acceptance control, the tensile adhesive strength tests shall be carried out in accordance with ISO 4624 using accompanying specimens prepared according to 7.2. The number of the accompanying specimens to be tested according to E.4 shall be taken from the manufacturing or testing instructions (in accordance with ISO 4624, minimum of six test pieces). If no instructions for testing and for minimum values of the tensile adhesive strength are stipulated in the coating specification or contract, the instructions of this document apply.

If the pull-off test is carried out on the component itself and is applied until rupture occurs, the local damage shall be repaired. The location of testing shall be representative for the sprayed coating.

A.2 Preparation of the test dolly (pull stub)

Remnants from previous tests (former coating or adhesive) shall be removed from the test dolly. The dolly shall be degreased with an adequate solvent such as alcohol.

A.3 Preparation of the coating

The TSMC surface is sufficient for bonding usually. If necessary, the metal coating may be slightly abraded with a grit paper. Afterwards, it shall be degreased and any lose material removed.

A.4 Applying adhesive

The bond strength of the adhesive shall be higher than the bond strength at the coating substrate interface.

Due to the spray procedure, related porosity adhesives with a higher viscosity (paste type) are preferred. If the adhesive penetrates the coating to the substrate, the adhesive strength value will be remarkably influenced. If appropriate, a comparison test should be applied for the selection of an adequate adhesive.

When selecting the adhesive, the kind and roughness of the sprayed coating should be considered. The quantity of the adhesive should cover the bond area of the test dolly evenly and even out the roughness.

The dolly shall be pressed by hand straight down without any bending or torsion momentum onto the test surface. The pressure shall be kept constantly for about half a minute. This will cause the air to be displaced and will evenly spread out the thickness of the adhesive. Around the border of the specimen a slight bulge will be created that should be removed as soon as possible. The adhesive shall then cure. Instructions for applying the adhesive from the manufacturer or supplier shall be considered.

A.5 Before tension test

When nothing to the contrary is agreed upon between the contracting parties, a sharp edged tool shall be used to carefully cut around the periphery of the dolly to remove excess adhesive. The cut shall penetrate to the substrate.

NOTE Because the cutting eliminates the lateral bond within the coating, cracks can be introduced, which then undermine the dolly, resulting in a lower breaking stress.

A.6 Tensile test

The suspension on tensile test equipment or a pneumatically or hydraulically working tester shall be placed in such a way that the tensile force can be applied vertically and free of bending and torsion momentum. The force on the dolly (pull stub) shall be gradually increased until the bond breaks. For details, see ISO 4624.

A.7 Assessment

The exact fracture location shall be determined in order to specify the mode of failure:

— failure along the interface between coating and substrate;

— failure in the glue;

— cohesive failure within the applied coating;

— mixed fracture with portions of interfacial failure and adhesive or cohesive fail.

The test results shall be indicated in the test report, together with additional details to coating thickness, type of adhesive, test instrument and whether cut around the dolly or not.

A.8 Typical values of adhesion strength of thermal spray coatings

See Table A.1.

Table A.1 — Typical values of the pull-off strength in accordance with ISO 4624 of unsealed TSMCs

Spray material		**Pull-off strength** (min. MPa)[a]
		Wire flame spraying/Arc spraying
Zn, ZnAl15	Zinc, 85/15 Zinc-Aluminium	4
Al, AlMg5	Aluminium, 95/5 Aluminium-Magnesium	4,5

a) If the coating is not cut, 20 % to 25 % higher values are typical.

NOTE 1 If the measured values are remarkably lower than the typical ones, an insufficient coating quality (surface preparation included) can be expected.

NOTE 2 Values are influenced by

- sealing:
  - not cut around the dolly;
  - mechanically sprayed;
  - insufficient spray position (overhead and vertically down);
- on-site conditions;
- surface preparation, blasting material.

NOTE 3 The pull-off test can be interrupted, when the minimum value of the specified adhesion strength is reached. This method avoids the necessity of repair in the areas damaged by the test. The bonded dolly can be removed by softening of the adhesive through heating and by beating to the side of the dolly. This test method may only be executed in the case of quality assurance measures in the manufacturing sequence. The coating quality can be impaired.

Annex B
(informative)

Documentation of the applied maintenance procedure, the thermal spray procedure and test results in the case of a planned maintenance

B.1 Sample documentation

This form may be copied by the user of this document regardless of copyright.

Manufacturer:		Contractor:	
Reason for maintenance:			
Location:	workshop/on-site if on-site, where: countryside/town/near to coast		
Component description:			
Substrate material:			
Function of coating: corrosion protection /.....			
Existing coating system metallic bond coat: type: ..... synthetic top coat: type:		sealed/unsealed	
No. of inspection report about actual conditions of coating system Existing synthetic top coat to be removed: Existing metallic bond coat to be removed: Re-sealing necessary: Welding repair required:		entirely/partially entirely/partially/remaining yes/no yes/no	
Welding procedure specification (**WPS**), if required:			
Thermal spray procedure specification (**TSPS**):			
Method of preparation and cleaning:			
Surface preparation Programme no. (if mechanical): ..... Blasting procedure: ..... Type of grit: ..... Grain size:			
Blasting pressure:	bar	Blasting distance/angle:	
Visual inspection: Cleanliness, uniformity, e.g. as per ISO 8501-1:			
Masking (if necessary) Imperfections: existing: yes/no Intermediate cleaning by extraction/blowing		Removed: yes/no Done: yes/no	
Masking material:			
Time period between blasting, masking and spraying:			
Environment conditions:	Temperature/dew-point: / °C	degrees above dew-point: °C	

Spray procedure, generally (if not specified or no TSPS available)	
Spray material: designation acc. with ISO 14919:	Wire diameter:
Preheating: yes/no	Preheating temperature: °C
Required coating thickness: as sprayed: µm	
Spray procedure to be applied: manual/mechanical	
Spraying distance: mm	Spraying positions:
Spraying sequences: up and down; left to right direction/crossing right-angled	
Spray procedure, specific data applied (if not specified or no TSPS available)	
Spraying procedure (per ISO 14917): **Arc spraying**	
Arc spraying system:	
Type of nozzle: closed arc/open arc	
Current (A):	Voltage (V):
Atomizing gas pressure (MPa):	Arc jet pressure (MPa):
Spraying procedure (per ISO 14917): **Wire flame spraying**	
Flame spraying system:	
Type of nozzle:	
Wire feed rate/adjustment:	
Oxygen flow/adjustment:	
Fuel type:	Flow setting:
Compressed air adjustment:	
Spraying procedure (per ISO 14917): **Powder flame spraying**	
Flame spraying system:	
Powder feed rate/setting:	
Oxygen flow/setting:	
Type of fuel:	Flow setting:
Pressured air setting:	
Thermal sprayers, qualified acc. with ISO 14918 and/or by a job reference qualification (JRQ):	
Name/Personal no.:	

B.2 Inspection and test results

Inspection/ Test	Specification	Required	Executed by:	Record No.	Test results		Remarks
		Yes/No			Passed	Failed	
Visual inspection	ISO 14923						
Coating thickness[a]	ISO 2178						
Determination of the pull-off strength[b]	ISO 2063-2/ISO 4624						

[a] Single values are to be taken from the report.

[b] Single values and positions of the tests are to be taken from the report.

Date of issue: .....

Spraying coordinator:

Signature: .....

Name: .....

Inspector:

Signature: .....

Name: .....

Annex C
(informative)

Documentation of the applied thermal spray procedure and test results in the case of a new manufacturing

C.1 Sample documentation

This form may be copied by the user of this document regardless of copyright.

Manufacturer:		Contractor:	
Location:	workshop/on-site if on-site, where: countryside/town/near to coast		
Component description:			
Substrate material:			
Function of coating: corrosion protection /.....			
Welding procedure specification (**WPS**), if required:			
Thermal spray procedure specification (**TSPS**):			
Method of preparation and cleaning:			
Surface preparation Programme no. (if mechanical): ..... Blasting procedure: ..... Type of grit: ..... Grain size:			
Blasting pressure:	bar	Blasting distance/angle:	
Visual inspection: Cleanliness, uniformity, e.g. as per ISO 8501-1:			
Masking (if necessary) Imperfections: existing: yes/no Removed: yes/no Intermediate cleaning by extraction/blowing Done: yes/no			
Masking material:			
Time period between blasting, masking and spraying:			
Environment conditions:	Temperature/dew-point: / °C	degrees above dew-point:	°C
Thermal spray procedure specification, generally (if not specified or no TSPS available)			
Spray material: designation acc. with ISO 14919:		Wire diameter:	
Preheating: yes/no		Preheating temperature:	°C
Required coating thickness: as sprayed: µm			
Spray procedure to be applied: manual/mechanical			
Spraying distance: mm		Spraying positions:	
Spraying sequences: up and down; left to right direction/crossing right-angled			
Spray procedure, specific data applied (if not specified or no TSPS available)			
Spraying procedure (per ISO 14917): **Arc spraying**			
Arc spraying system:			
Type of nozzle: closed arc/open arc			

Current (A):	Voltage (V):
Atomizing gas pressure (MPa):	Arc jet pressure (MPa):
Spraying procedure (per ISO 14917): **Wire flame spraying**	
Flame spraying system:	
Type of nozzle:	
Wire feed rate/adjustment:	
Oxygen flow/adjustment:	
Fuel type:	Flow setting:
Compressed air adjustment:	
Spraying procedure (per ISO 14917): **Powder flame spraying**	
Flame spraying system:	
Powder feed rate/setting:	
Oxygen flow/setting:	
Type of fuel:	Flow setting:
Pressured air setting:	
Thermal sprayers, qualified acc. with ISO 14918 and/or by a job reference qualification (JRQ):	
Name/Personal no.:	

C.2 Inspection and test results

Inspection/ Test	Specification	Required	Executed by:	Record No.	Test results		Remarks
		Yes/No			Passed	Failed	
Visual inspection	ISO 14923						
Coating thickness[a]	ISO 2178						
Determination of the pull-off strength[b]	ISO 2063-2/ISO 4624						

[a] Single values are to be taken from the report.

[b] Single values and positions of the tests are to be taken from the report.

Date of issue: .....

Spraying coordinator: Inspector:

Signature: ..... Signature: .....

Name: ..... Name: .....

Annex D
(informative)

Test certificate for job reference qualification for thermal sprayers working on-site in accordance with ISO 2063-2

D.1 Sample documentation

This form may be copied by the user of this document regardless of copyright.

Name of thermal sprayer:				Personal no.	
Date of birth:		Place of birth:		Country:	
Employed in company:					
Location of company:					
Thermal sprayer, qualified acc. with ISO 14918: Spray process:				manually/mechanically	
Validity of testing until:					
Trained and instructed by spray coordinator:					
Test standard for JRS: ISO 2063-2					
Test location: on-site:					

Spray procedure			
Thermal spray process: e.g. WFS (wire flame spraying):			
Application method: e.g. manual:			
Spray procedure specification: TSPS:		state of revision:	

Test designation:	
For example: **JRS ISO 2063-2–manual–ISO 14919:2015-2.3 (ZnAl15)**	

D.2 Tests and test results

Inspection/ Test	**Specification**	**Readings in different positions** Direction spray jet/ direction motion				**Test result**		**Inspector**
		V / H	**H / V**	**O / H**	**R**	**P**	**F**	
Visual inspection	ISO 14923							
Coating thickness	ISO 2178							
Roughness test	ISO 8501-1							
Determination of adhesive tensile strength	ISO 2063-2/ISO 4624							
Positions: V = vertical H = horizontal O = overhead R = Radius (r = 6mm)								
Test result: P = passed F = failed								

Date of JRS spraying: ..... on-site: .....

Date of JRS testing: ..... on-site: .....

Test certification: ..... valid until: .....

Date of issue: .....

Valid for site: .....

Signatures

Responsible spray supervisor: Inspector/employment/test body:

....

(Name in printed letters) (Name in printed letters)

The acceptance for spraying is extended for the site: .....

Signature

Responsible spray supervisor/coordinator:

.....

(Name in printed letters)

Annex E
(informative)

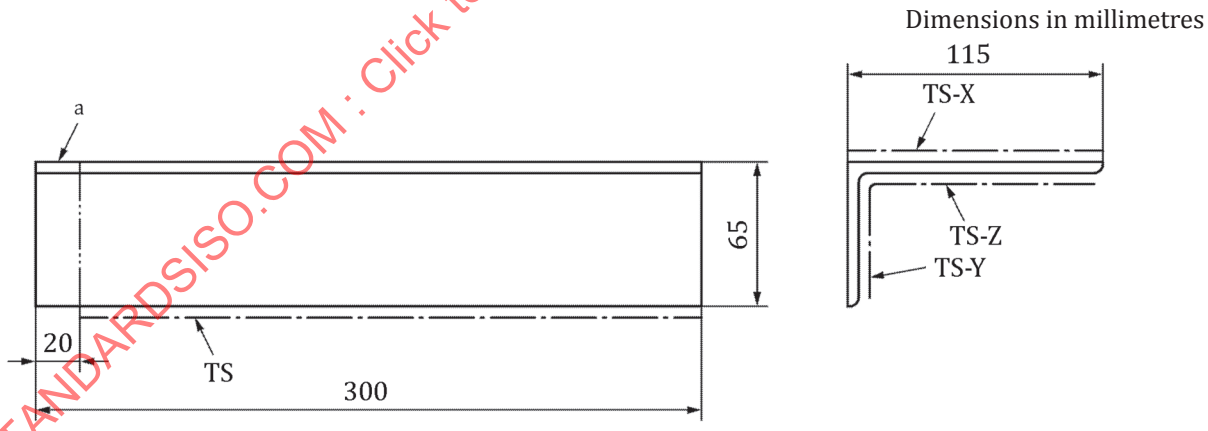
Test specimens — Spray positions

E.1 Specimen's arrangement and spray positions for job reference specimens

Table E.1 — Specimen's arrangement and spray positions for job reference specimens

Type of specimen	Arrangement of specimen	Positions for spraying		
Plate	Horizontal	Flat (vertically down)		Overhead (vertically up)
	Vertical	Horizontally		
L-profile (65 × 115 × 6) mm	Horizontal	Flat, vertically down onto a horizontal surface of the L-profile	Horizontally onto a vertical surface of the L-profile	Overhead
	Vertical		Horizontally onto a vertical surface of the L-profile	Horizontally onto a vertical surfaces of the L-profile inclusive a radius

E.2 Example for JRS — Test specimen for operation on-site



TS – X = vertically onto horizontal surface

TS – Y = horizontally onto vertical surface

TS – Z = overhead

[a] Masked.

Figure E.1 — Specimen: L-Type profile steel (65 × 115 × 6) mm for sprayers qualification for different working positions

E.3 Example for welded JRS for assessment and testing of the coating next to the weld

Dimensions in millimetres

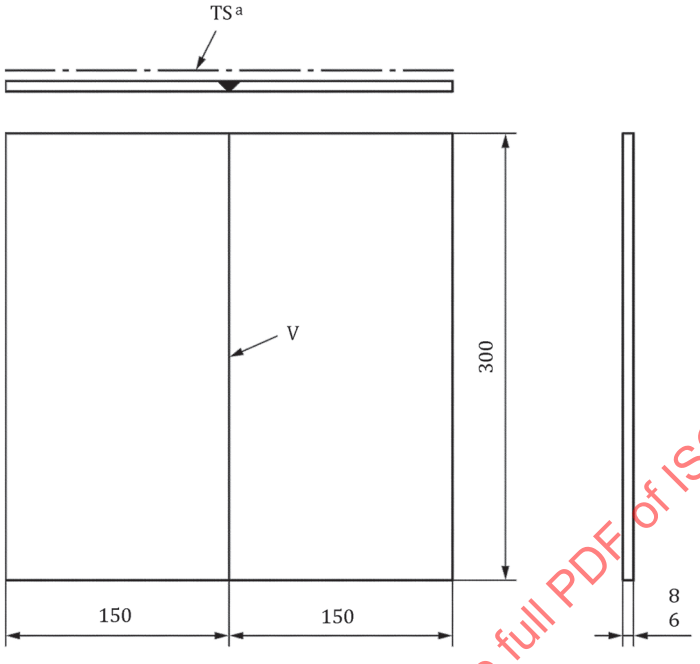


Figure E.2 — Welded JRS

E.4 Example for accompanying specimen for destructive testing of the coating

Dimensions in millimetres

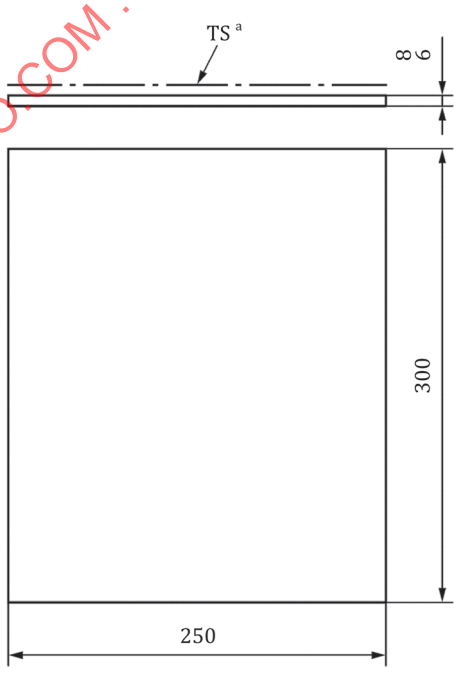


Figure E.3 — Accompanying specimen

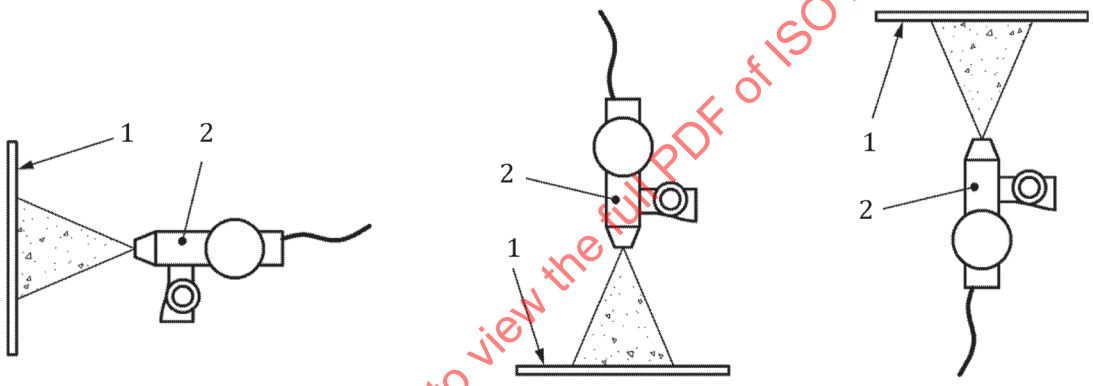
E.5 Spray positions

The spray position represents the position of the spray gun or spray torch in front of the substrate to be coated. The spray gun or spray torch should be used in such a way that the spray jet strikes the surface of the part at a right angle. The striking angle of the spray jet to the surface to be coated should be around 90° and no less than 45°.

The spray distance shall be taken from the TSPS. It varies depending on the spray process and spray parameter. It should be kept in the stipulated range of tolerance.

The horizontal position is recommended for spraying, see Figure E.4 for details. Other spray directions can be applicable; for example, in the case of large components or twisty structures, spraying in flat position (vertical down) and/or overhead position may be needed. Coating quality shall be guaranteed in any direction.

In general, spraying onto flat or cylindrical surfaces shall be applied, crossing at right-angle. An adequate overlapping of the spray traces is necessary in any case.



a) Horizontal position **b) Flat position (vertically down)** **c) Overhead position (vertically up)**

Key

1 substrate
2 spray torch

Figure E.4 — Spray positions: horizontal — flat, vertical down — overhead (e.g. wire flame spraying)

Annex F
(informative)

Assessment of the coatability

Table F.1 — Example checklist

No	Item	Yes/No
1	Is access possible for the surface preparation by cleaning and blasting, for removal of grit residues, for the thermal spraying and the sealing and, if appropriate, for the removal of worn coatings or of further organic coatings?	
2	Can the blasting material or the spray material meet the surface as vertically as possible?	
3	Can a striking angle of > 45° be kept?	
4	Is the minimum distance of about 300 mm to the surface available for motion of the sprayer when spraying manually resp. for motion of spray gun with the hose assembly when spraying mechanically?	
5	Are narrow gaps, recesses, deep pockets, sharp edges and acute angles avoided?	
6	Are open L-, wide U- or T-profiles intended for reinforcements?	
7	Are edges intended to be rounded or chamfered?	
8	Have inner corners and inner radii adequate radii values?	
9	Is a smooth surface designed, that residues of moisture and dirt can drain away and supervision, cleaning and maintenance can easy be applied?	
10	Are thin walled plates or profiles reinforced designed in such a way, that they cannot be unacceptable deformed when blasting?	
11	Do close spaces, e.g. container and tanks, contain sufficient openings as for manholes and for exhausting of dust, smoke and gases?	
12	Is a free opening for ventilation available?	
13	Can the considerable volume of dust resp. metal dusts and heat created by blasting and spraying effectively be exhausted?	
14a	Can intermediate walls, bulkheads, fittings, etc. inside of tanks and hollow bodies be disassembled?	
14b	If this is not possible, will a reduced quality be accepted?	
14c	Is thermal spraying the adequate process?	
15	Are expansion and shrinkage minimized by the design in the case of sudden temperature change, if applicable?	
16	Are areas to be coated marked specifying the minimum thickness in accordance with the instructions of ISO 12671 or unequivocally described in the manufacturing instructions?	
17	Can the required legal work and environment conditions be kept?	

Annex G
(informative)

Bend test and its execution

G.1 Bend test to evaluate equipment set up

The bend test is a qualitative test used to confirm that the equipment is in proper working condition. At any time where the thermal spray equipment is to be used, the bend test can be applied using test panels and standard parameter of the intended spray process. The test result should be in accordance with the requirements. The results of the bend test should be recorded and the test panels labelled and saved. The bend test can also be applied to reach a qualification of the TSPS.

G.2 Performance of the bend test

G.2.1 General

The coating should be applied to prepared test panels and the bend test conducted. The test consists of bending coated steel panels around a cylindrical mandrel and examining the coating for cracking.

G.2.2 Test panels

The test panels should be a cold rolled steel measuring (75 × 150 × 1,25) mm (3 × 6 × 0,050) in. The panels should be cleaned and blasted in the same fashion as will be used for the job.

G.2.3 Application of the thermal spray coating

The thermal spray coating should be applied to five test panels using the identical spray parameters, the same number of overlapping spray passes in a cross hatch pattern and the average specified thickness that will be used for the job. The coating thickness should be measured to confirm that it is within the specified range.

G.2.4 Bend test to be conducted

Test panels are bent 180° around a steel mandrel of a specified diameter 12,5 mm (0,5 in.). Pneumatic and manual mechanical bend test apparatus may be used to bend the test panels.

G.2.5 Bend test panels to be examined

Test panels should be examined visually without magnification. The bend test is deemed to be accepted if the coating shows no cracks or exhibits only minor cracking with no lifting of the coating from the substrate. If the bend test fails and the coating lifts from the substrate, corrective measures of the spray parameter and/or on the spraying equipment should be taken. Figure G.1 depicts representative bend test results.