INTERNATIONAL STANDARD

**ISO 14918**

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# Thermal spraying — Approval testing of thermal sprayers

*Projection thermique — Qualification des agents en projection thermique*



Reference number
ISO 14918:1998(E)

## 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.

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.

International Standard ISO 14918 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 5, *Thermal spraying*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this standard, read "...this European Standard..." to mean "...this International Standard...".

Annexes A and B form an integral part of this International Standard. Annexes C and ZA are for information only.





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## Contents

## Foreword

The text of EN ISO 14918:1998 has been prepared by Technical Committee CEN/TC 240 "Thermal spraying and thermally sprayed coatings", the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 107 "Metallic and other inorganic coatings".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 1999, and conflicting national standards shall be withdrawn at the latest by April 1999.

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

## Introduction

This standard covers the principles of the approval testing of sprayer performance for thermal spraying.

The quality of work involved in thermal spraying depends on the skill and job knowledge of the thermal sprayer.

The ability of the thermal sprayer to follow verbal and written instructions and testing of his skill are therefore important factors in ensuring the quality of the thermally sprayed product.

This standard is intended to provide the basis for the mutual recognition by examining bodies for approval relating to thermal sprayer's competence in the various fields of application. Tests shall be carried out in accordance with this standard unless more severe tests are specified by the relevant application standards when these shall be applied.

The thermal sprayer's skill and job knowledge continue to be approved only if the thermal sprayer is working with reasonable continuity on thermal spraying work within the extent of approval.

All new approvals are to be in accordance with this standard from the date of this issue.

## 1 Scope

This standard gives procedural instructions for approval testing of thermal sprayers. It defines essential requirements, ranges of approval, test conditions, acceptance requirements and certification for approval testing of thermal spray performance.

During the approval test the thermal sprayer shall be required to show adequate practical experience and job knowledge of thermal spraying processes, materials and safety requirements for which he is to be approved; information on these aspects is given in Annex A.

This standard shall be used when the thermal sprayer's approval is required by the standard, the purchaser, by inspection authorities or by other organisations.

The thermal spraying processes referred to in this standard include those spraying processes which are designated as manual or mechanized.

Due to the variety and specialisation of automatic systems for thermal spraying where the thermal sprayer has no direct influence on the spraying process, this standard is not applicable in those circumstances.

The certificate of approval testing is issued under the sole responsibility of the examiner or test body.

## 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 582
Testing of thermally sprayed coatings – Determination of adhesive tensile strength

EN 657
Thermal spraying – Terminology, classification

EN 1274
Powders for thermal spraying – Composition – Technical supply conditions

EN 1395
Acceptance inspection of thermal spraying equipment

EN 22063
Metallic and other inorganic coatings – Thermal spraying – Zinc, aluminium and their alloys

ISO 6507-1
Metallic materials – Hardness test – Vickers test – Part 1: HV 5 to HV 100

ISO 6508
Metallic materials – Hardness tests – Rockwell test (scales A – B – C – D – E – F – G – H – K)

ISO 8501-1
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

## 3 Definitions

For the purpose of this standard the definitions in EN 657 and the following apply.

**3.1 thermal sprayer:** a person who performs thermal spraying with a manual or mechanized system.

**3.1.1 manual thermal spraying:** where the spraying gun or torch is manipulated by hand.

**3.1.2 mechanized thermal spraying:** where some aspects of the process are mechanized, with the gun/torch not manipulated by hand.

**3.1.3 automatic thermal spraying:** all operations typical of the spraying process are fully mechanized including all handling, e.g. workpiece loading and unloading, and are integrated in a programmed system.

The terms of manual, mechanized and automatic thermal spraying are summarized in table 1.

**Table 1: Terms of thermal spraying**

| term | gun movement | workpiece movement | workpiece loading/ unloading |
|---|---|---|---|
| manual | manual | manual/mechanized | manual/mechanized |
| mechanized | mechanized | mechanized | manual |
| automatic | mechanized | mechanized | mechanized |

**3.2 examiner or examining body:** a person or organisation who verifies compliance with the application standard.

**3.3 specific acceptance criteria:** a document providing in detail the criteria by which a thermal sprayer can be tested to be approved for a particular spraying technique or application area.

**3.4 test piece:** in the sense of this standard, the thermal spray workpiece used for the approval test.

**3.5 test specimen:** in the sense of this standard, a portion cut from the test piece in order to perform a specified analytical test.

**3.6 test:** in the sense of this standard, a series of operations which will include the making of a thermally sprayed test piece and subsequent non-destructive and/or destructive testing and reporting of results.

## 4 Essential requirements for approval testing

### 4.1 General

The criteria specified in this clause shall be examined in order to identify the ability of the thermal sprayer in these areas.

The thermal sprayer's approval test shall be carried out on test pieces and is independent of the type of construction.

For all thermal spraying processes and operations there exists basic job knowledge and specific knowledge related to the process, on which the thermal sprayer shall be tested, see Annex A.

### 4.2 Equipment operation

The thermal sprayer shall be tested to determine his knowledge of the equipment. Further details see A.4.3.

### 4.3 Masking procedure

The thermal sprayer shall be tested to determine his knowledge of proper masking procedures for both surface preparation and spraying.

### 4.4 Surface preparation

The thermal sprayer shall approve the surface of the thermal spray test piece which are used for qualification. He should also maintain a properly prepared surface during the qualification testing.

### 4.5 Environmental conditions

The thermal sprayer shall approve the environmental conditions such as temperature, humidity, dew point, as being suitable for spraying the test pieces.

### 4.6 Application equipment

Test results, gained from test pieces sprayed with actual production equipment, or equipment similar to it in the view of the certifying examining body and representative of said equipment's quality, shall be utilised for thermal sprayer qualification.

## 5 Range of approval

### 5.1 General

Thermal sprayers shall be qualified for thermal spraying to a specific coating process and method of application. The qualification shall only be valid for that specific coating process and method of application. The thermal spraying processes and methods of application covered by this standard are identified in 5.2.

### 5.2 Thermal spraying processes

#### 5.2.1 Grouping of thermal spraying processes

This standard covers the following thermal spraying processes according to EN 657:

– flame spraying;

– arc spraying;

– plasma spraying;

– high velocity flame spraying;

– powder spraying;

– wire spraying /rods/cords.

#### 5.2.2 Application method

– manual

– mechanized

#### 5.2.3 Materials

The materials given in Annex B are the specific materials to be used in the approval test. The following materials are given only for information to show which material is appropriate for each process.

Appropriate materials for various processes:

Flame spraying: powder, wire or rods: / Arc spraying:

– Metals and alloys (for engineering purposes)
– Zinc and aluminium and their alloys (for corrosion protection)

Flame spraying: powder, wire or rods:

– Self-fluxing alloys

Plasma spraying

– Metals and alloys
– Ceramics
– Metal based carbides/carbides

High velocity flame spraying:

– Metals and alloys
– Metal based carbides

### 5.3. Qualification scope

The requirements for initial thermal sprayer qualification will be different for each of the classifications in 5.2 above. Qualification in one category (process and application method) would not imply any ability or experience in practising the specific thermal spraying technique in any other category.

The thermal sprayer qualification level shall be indicated by the thermal spray process, followed by the application method e.g. manual operation of plasma arc equipment would be written as "Plasma: Manual". Also information on the type of material (5.2.3) sprayed for qualification shall be available upon request by those invoking this standard.

### 5.4 Supervision

The thermal spraying and testing of the test pieces shall be witnessed by the certifying body .

### 5.5 Shapes and dimensions of test pieces

Shapes and dimensions of test pieces and test specimens are as detailed in the specific acceptance criteria for each thermal spraying process (see Annex B).

### 5.6 Test methods

These shall be as detailed in the specific acceptance criteria. When test specimens are metallographically examined, then they should be compared to test pieces which are known to be satisfactory, which have been mounted and polished in the same way, and at the same time, to avoid preparation discrepancies.

### 5.7 Acceptance requirements for test pieces

Acceptance requirements for test pieces are as detailed in the specific acceptance criteria. Test pieces shall be evaluated according to the acceptance requirements specified for each spray process and material type in the specific acceptance criteria.

### 5.8. Spray materials for tests

For each of the equipment categories listed in 5.2.1 there is a variety of consumable types as detailed in 5.2.3. The thermal sprayer can elect to be tested in any one of these categories but the specific material to be used within that category is fixed in the specific acceptance criteria.

For example a plasma thermal sprayer may choose to be tested spraying ceramics. In this category the specific acceptance criteria specifies aluminium oxide/titanium oxide 87/13 (Spray powder EN 1274 – 12.3 – 45/22 – blended) – as the actual material to be used.

## 6 Examination and testing

The thermal sprayer shall be tested in two ways. Firstly he shall complete a job knowledge test to determine his knowledge of the process, and secondly he shall undergo a practical test to demonstrate his skill in the appropriate area.

### 6.1 Job knowledge test

The thermal sprayer shall satisfactorily complete a test covering the appropriate coating process, application method and material. The written test should be prepared by the certifying body. For particular aspects to be tested, see Annex A.

### 6.2 Practical test

The thermal sprayer shall be tested to determine whether he has the practical skills necessary for the thermal spraying procedure, as detailed in the specific acceptance criteria (according to Annex A and Annex B)

## 7 Re-tests

### 7.1 General

In the event of the thermal sprayer's failure to meet the requirements of this standard, a re-test may be scheduled at the discretion of the examiner in accordance with the acceptance criteria, but not without additional training and not normally within three months of the last test.

### 7.2 Additional tests

If during spraying the thermal sprayer can show that there is some extraneous fault preventing spraying a good test piece, a new attempt may be made when the fault has been corrected.

## 8 Period of validity

### 8.1 Initial approval

The validity of the thermal sprayer's approval begins from the date when all the required tests are satisfactorily completed. This date may be different to the date of issue marked on the certificate.

A thermal sprayer's approval shall remain valid for a period of three years providing that the relevant certificate is signed at six month intervals by the employer/co-ordinator and that all the following conditions are fulfilled:

## 8.2 Prolongation

### 8.2.1 Period

A thermal sprayer shall require requalification every three years.

### 8.2.2 Thermal sprayer and production spraying

The thermal sprayer must carry out production spraying without lapses of 6 months or more.

### 8.2.3 Interruption periods in thermal spray works

A thermal sprayer who has not carried out production spraying for a period of six months shall follow the initial thermal sprayer qualification procedure to regain a qualified status.

## 8.3 Requirements

After the normal expiry of the certificate, the requalification requirement shall be satisfied by thermal spraying of acceptable test specimens. No job knowledge test should be required, providing said results have been obtained within a six months period of the requested re qualification.

## 8.4 Scheduling

It should be the responsibility of the thermal sprayer and the employer to ensure that requalification takes place as scheduled.

## 8.5 Thermal sprayers with an expired or cancelled qualification status

Thermal sprayers with an expired or cancelled qualification shall not be permitted to perform thermal spray operations on parts covered by this standard.

# 9 Certification

## 9.1 Final approval

Final approval should depend upon the thermal sprayer's ability to satisfactorily demonstrate his proficiency in operating the equipment and spraying the coating test pieces.

## 9.2 Records

Records of qualification and test results should be maintained by the certifying agent for a period of ten years.

## 10 Designation

The thermal sprayer approval test shall be designated by the following informations:

– Number of this standard

– Thermal spray process

– Application method

Thermal sprayer approval test EN ISO 14918 Flame spraying – manual

# Annex A (normative)

# Job knowledge

## A.1 General

For the initial qualification of thermal sprayers the test of job knowledge is required.

This annex outlines the job knowledge that a thermal sprayer shall have to ensure that the procedures are followed and common practices are complied with.

The actual tests of a thermal sprayer's job knowledge can be given by any of the following methods or combinations of these methods:

– written tests

– oral examination

– computer testing

– demonstration/observation testing

The test of job knowledge is limited to matters appropriate to the thermal spraying process used in the test.

## A.2 Requirements

The job knowledge of the thermal sprayer shall be specifically tested in the following areas:

### A.2.1 Thermal spraying equipment

Basics: including gas/electrical energy supply devices, essential components, cooling systems, for the specific process in which the thermal sprayer wants to pass the qualification test.

### A.2.2 Thermal spraying process

Basics: including preparation of the workpiece, geometrical aspects, masking, measuring methods during spraying, control of parameters, workpiece storage and post treatments.

### A.2.3 Substrate materials and consumables including identification, storage, handling.

### A.2.4 Safety and accident prevention

Basics: including safe assembly, setting up and closing down procedures, personal protection, fire hazards, dust explosions, electrical hazard, flash backs, leak detection, radiation, noise – specific to the process to be qualified in.

### A.2.5 Methods of testing thermal sprayed coatings

Visual inspection, basic knowledge about adhesion testing, coating structure and imperfections of the coating.

## A.3 Surface preparation during the qualification test

The thermal sprayer shall demonstrate an understanding of the interactions of cleaning, degreasing, different mechanical surface roughening methods, preheating and storage so that he is able to assess the quality of prepared substrate surfaces.

The thermal sprayer shall be able to recognise the suitability, or otherwise, of a surface to accept the proposed coating system.

The thermal sprayer shall demonstrate an awareness of the effects of blast cleanliness and profile and also of what level of preparation is required for different types of coating.

For examination purposes, inadequate, adequate and good test piece surfaces shall be presented to the thermal sprayer as follows:

a) surface blasted with ball shot to provide clean surface but without a sharp profile;

b) surface blasted for too short a time, leaving excessive contamination;

c) surface blasted too much, leading to polishing as the profile is reduced;

d) surface contaminated with oil or dust;

e) surface blasted correctly, giving a clean metal surface with a good sharp profile appropriate to the coating type. The surface as prepared shall be free of dust arising from other spraying operations, broken down blast media etc.

The thermal sprayer shall be questioned on which of the test pieces is acceptable and why. He should also be questioned on the reasons behind the acceptability, e.g. effect of contamination etc. The thermal sprayer shall also be aware of other factors which may reduce the receptiveness of the surface for spraying.

## A.4 Other factors to be tested during the qualification test

### A.4.1 Material storage

The thermal sprayer has to demonstrate his knowledge concerning conditions of storage and handling of spray materials (consumables) and their influence on coating quality.

### A.4.2 Masking Procedure

The thermal sprayer should be tested to determine his knowledge of proper masking procedures for both surface preparation and spray process. Where certain areas of a workpiece are not to be sprayed, these shall usually be masked off. This can be done using a variety of techniques, which may be appropriate depending upon the geometry of the piece and the type of coating being applied. For example, paper tape can be used to mask off zinc spray only but cannot be used for high melting point materials or as protection against blasting.

The thermal sprayer shall show an awareness of the correct method for the work in hand.

### A.4.3 Equipment operation

The thermal sprayer should be tested to determine his knowledge of the equipment. He shall put into operation thermal spray equipment according to the procedure and operating manual provided by the equipment manufacturer. The thermal sprayer's knowledge should not be limited to normal operation; rather, he should be sufficiently skillful to recognise when the equipment is not functioning normally.

### A.4.4 Application of the coating

The thermal sprayer has to show that he is able of assessing the preparation of the part to be sprayed, considering geometrical factors such as holes, fasteners etc. and operating the equipment by setting it up, spraying the coating and assessing the result.

### A.4.5 Safety aspects concerning personal health, safe handling of the entire equipment and environmental safety requirements

The thermal sprayer has to show his knowledge about these areas during the practical testing. Particular attention should be paid to the proper handling of all connections whether electrical, gas or air, as historically most accidents involving metal spraying equipment derive from these connections.

# Annex B (normative)

# Specific acceptance criteria

## B.1 Flame or arc spraying: Zinc, aluminium and their alloys for corrosion protection

### Instructions

The equipment, of whatever type, shall always be set up by the thermal sprayer and used in accordance with the manufacturers instructions.

a) Practical test – testing of thermal sprayer's skill

Particular points to note are that the spray gun is used at a range according to manufacturer's recommendations, as near normal to the surface as possible and that the coating produced is free from lumps, dust inclusions and coarse textured areas and is of a uniform thickness.

Test piece production

Test piece of low carbon steel according to figure B.1 of rolled 150 mm equal angle section, 8 mm thick at minimum and 500 mm long shall be prepared by grit blasting and the thermal sprayer shall not spray without first accepting the quality of the preparation and the suitability of the environment. The thermal sprayer shall then spray a coating of aluminium to a minimum thickness of 0,15 mm over both internal faces of the plate.

b) Testing of the sprayed coating:

Thickness test

The thermal sprayer shall be provided with a thickness gauge by which he may assess the thickness of the coating on no more than three occasions. Using the same gauge the assessor shall then test the plate as described in EN 22063 for general thickness and uniformity of thickness. If the coating thickness lies between 0,15 mm and 0,25 mm at all tested points, then the thermal sprayer shall be deemed to have passed this test.

Spray quality

Using the same sprayed plate the examiner shall inspect the coating for texture and freedom from lumps, dust inclusions and blisters. If no such imperfections are present the thermal sprayer shall be deemed to have passed this test.

Adhesion test

An adhesion test shall be performed in accordance with EN 22063.

## B.2 Flame or arc spraying: Metal and alloys for engineering purposes

### Instructions

The equipment, of whatever type, shall always be set up by the thermal sprayer and used in accordance with the manufacturers instructions.

a) Practical test – testing of thermal sprayer's skill

Particular points to note are that the spray gun is used at a range according to manufacturer's recommendations, as near normal to the surface as possible and that the coating produced is free from lumps, dust inclusions and coarse textured areas and is of a uniform thickness.

Test piece production:

The test piece according to fig. B.2 shall be a round bar of low carbon steel 75 mm diameter by 250 mm in length, undercut to a depth of 0,5 mm for a length of 150 mm centrally. The thermal sprayer shall spray sufficient stainless steel: spray powder EN 1274 – 6.5 – 45/22 – atomized, or equivalent wire material – to allow the deposit to be machined, by an appropriate technique, to the original 75 mm diameter.

b) Testing of the sprayed coating:

Thickness test:

It shall be the thermal sprayer's responsibility to determine what this thickness should be, but it should not exceed 1,0 mm in any case and 0,80 mm if a mechanical traverse is used. The coating thickness shall be tested in at least four places along the bar.

Spray quality

Using the same sprayed test piece the assessor shall inspect the coating for texture and freedom from lumps, dust inclusions, cracks and blisters. If no such imperfections are present the thermal sprayer shall be deemed to have passed this test.

Machining test

After visual inspection the bar shall be machined to 75 mm diameter to confirm an adequate coating thickness. Provided that the original thickness was not excessive, and that the coating cleans up over the entire surface upon machining, then the thermal sprayer shall be deemed to have passed the thickness test.

The machined surface shall be inspected for over-heating, excessive porosity, cracks, and detachment, bearing in mind the difference between spraying and machining effects.

Adhesion test

An adhesion test shall be performed in accordance with EN 582 using six test pieces and the results shall not fall below 20% of the highest value.



## B.3 Flame spraying: Self fluxing alloys for engineering purposes

### Instructions

The equipment, of whatever type, shall always be set up by the thermal sprayer and used in accordance with the manufacturers instructions.

a) Practical test – testing of thermal sprayer's skill

Particular points to note are that the spray gun is used at a range of between 100 and 150 mm, as near normal to the surface as possible and that the coating produced is free from lumps, dust inclusions and coarse textured areas and is of a uniform thickness.

Test piece production:

The test piece according to fig. B.3 shall be a round bar of low carbon steel generally 75 mm diameter by 250 mm in length. The two ends of the bar shall be reduced to 50 mm diameter to 75 mm from each end. The thermal sprayer shall spray sufficient nickel base 40 Rockwell C type self fluxing alloy – spray powder EN 1274 – 2.10 – 106/53 – atomized – to allow the deposit to be machined, after fusing, by an appropriate technique, to 77 mm and 52 mm respectively. It shall be the thermal sprayer's responsibility to determine what this thickness should be. The thermal sprayer shall then fuse the coating.

b) Testing of the sprayed and fused coating:

Spray quality

Using the same sprayed and fused test piece the assessor shall inspect the coating for texture and freedom from lumps, cracks and blisters. If no such imperfections are present the thermal sprayer shall be deemed to have passed this test.

Machining test

After visual inspection the bar shall be machined using a single point tool, to 77 mm and 52 mm diameter as appropriate to confirm an adequate coating thickness. Provided that the original thickness was not excessive, and that the coating cleans up over the entire surface upon machining, then the thermal sprayer shall be deemed to have passed the thickness test.

The machined surface shall be inspected for over-heating, excessive porosity, cracks, and detachment, bearing in mind the difference between spraying and machining effects.

Hardness test

A Rockwell C scale hardness test according to ISO 6508 shall be performed and the hardness shall be between 38 and 42 HRC.

## B.4 Plasma Spraying – Materials for engineering purposes: Metals and alloys

### Instructions

The equipment, of whatever type, shall always be set up by the thermal sprayer and used in accordance with the manufacturers instructions.

a) Practical test – testing of thermal sprayer's skill

The test piece according to figure B.4 shall be a round bar of low carbon steel 50 mm diameter by 250 mm in length, undercut to a depth of 0,5 mm for a length of 150 mm centrally. The thermal sprayer shall spray sufficient 80/20 nickel/chromium alloy – spray powder EN 1274 – 3.1 – 45/5 – atomized – to allow the deposit to be machined, by an appropriate technique, to the original 50 mm diameter.

b) Testing of the sprayed coating:

Thickness test:

It shall be the thermal sprayer's responsibility to determine what this thickness should be, but it should not exceed 1,0 mm in any case and 0,80 mm if a mechanical traverse is used. The coating thickness shall be tested in at least four places along the bar.

Spray quality

Using the same sprayed test piece the assessor shall inspect the coating for texture and freedom from lumps, dust inclusions, cracks and blisters. If no such imperfections are present the thermal sprayer shall be deemed to have passed this test.

Machining test

After visual inspection the bar shall be machined to 50 mm diameter to confirm an adequate coating thickness. Provided that the original thickness was not excessive, and that the coating cleans up over the entire surface upon machining, then the thermal sprayer shall be deemed to have passed the thickness test.

The machined surface shall be inspected for over-heating, excessive porosity, cracks, and detachment, bearing in mind the difference between spraying and machining effects.

Adhesion Test

An adhesion test shall be performed in accordance with EN 582 using six test pieces and the results shall be consistent to within 20 % of the highest value.

## B.5 Plasma Spraying – Materials for engineering purposes: Metal based carbides/carbides

### Instructions

The equipment, of whatever type, shall always be set up by the thermal sprayer and used in accordance with the manufacturers instructions.

a) Practical test – testing of thermal sprayer's skill

The test piece according to figure B.5 shall be a tube of low carbon steel of 50 mm (diameter) x 5 mm (wall thickness) x 150 mm (tube length). The thermal sprayer shall spray sufficient WC-Co 83/17 – spra{ powder EN 1274 – 11.13 – 45/10 – agglomerated and sintered – to allow the deposit to be machined, by an appropriate technique. The coating thickness shall be a minimum of 0,2 mm thick and shall not exceed 0,5 mm.

b) Testing of the sprayed coating:

Spray quality

Using the same sprayed test piece the examiner shall inspect the coating for texture and freedom from lumps, cracks and blisters. If no such imperfections are present the thermal sprayer shall be deemed to have passed this test.

Machining test

After visual inspection the tube shall be ground until the sprayed texture is removed. The ground surface shall be inspected for excessive porosity, cracks and detachment, bearing in mind the difference between spraying and machining effects.

Adhesion test

An adhesion test shall be performed in accordance with EN 582 using six test pieces and the result shall not fall below 20 % of the highest value.

Micro hardness

Micro hardness must be a minimum of 900 HV 0,3 Vicker's hardness test on a transverse section according to ISO 6507-1. No cracks from the corners of the indent should be present.

Metallographical investigation

Metallographical investigation of the coating is limited to transverse cracks, delamination, substrate-coating interface voids, which are not acceptable.

### B.6 Plasma Spraying: Materials for engineering purposes – Ceramics

## Instructions

The equipment, of whatever type, shall always be set up by the thermal sprayer and used in accordance with the manufacturers instructions.

a) Practical test – testing of thermal sprayer's skill

The test piece according to figure B. 5 shall be a tube of low carbon steel of 50 mm (diameter) x 5 mm (wall thickness) x 150 mm (tube length).. The thermal sprayer shall spray sufficient $Al_2O_3/TiO_2$ 87/13 – spray powder EN 1274 – 12.3 – 45/22 – blended – to allow the deposit to be machined, by an appropriate technique. The coating thickness shall be a minimum of 0,3 mm thick and shall not exceed 0,5 mm.

b) Testing of the sprayed coating:

Spray quality

Using the same sprayed test piece the examiner shall inspect the coating for texture and freedom from lumps, cracks and blisters. If no such imperfections are present the thermal sprayer shall be deemed to have passed this test.

Machining test

After visual inspection the tube shall be ground until the as-sprayed texture is removed. The ground surface shall be inspected for excessive porosity, cracks and detachment, bearing in mind the difference between spraying and machining effects.

Adhesion test

An adhesion test shall be performed in accordance with EN 582 using six test pieces and the result be consistent to within 20 % of the highest value.

Micro hardness

Micro hardness shall be the average of ten measurements of 700 HV 0,3 Vicker's hardness test on a transverse section according to ISO 6507-1.

Metallographical investigation

Metallographical investigation of the coating shall show no transverse cracks, delamination, substrate-coating interface voids, which are not acceptable.

## B.7 High velocity flame spraying: Materials for engineering purposes – Metals and alloys

### Instructions

The equipment, of whatever type, shall always be set up by the thermal sprayer and used in accordance with the manufacturers instructions.

a) Practical test – testing of thermal sprayer's skill

The test piece according to figure B. 5 shall be a tube of low carbon steel of 50 mm (diameter) x 5 mm (wall thickness) x 150 mm (tube length). The thermal sprayer shall spray sufficient 316 L -spray powder EN 1274 – 6.5 – 45/22 – atomized – to allow the deposit to be machined, by an appropriate technique. The coating thickness shall be a minimum of 0,3 mm thick and shall not exceed 0,5 mm.

NOTE: Alternative particle size distribution may be used, if the equipment is not suitable for this grade.

b) Testing of the sprayed coating:

Spray quality

Using the same sprayed test piece the examiner shall inspect the coating for texture and freedom from lumps, cracks and blisters. If no such imperfections are present the thermal sprayer shall be deemed to have passed this test.

Machining test

After visual inspection the tube shall be machined until the sprayed texture is removed. The machined surface shall be inspected for excessive porosity, cracks and detachment, bearing in mind the difference between spraying and machining effects.

Adhesion test

An adhesion test shall be performed in accordance with EN 582 using six test pieces and the result be consistent to within 20 % of the highest value.

Metallographical investigation

Metallographical investigation of the coating shall show no transverse cracks, delamination, substrate-coating interface voids.

## B.8 High velocity flame spraying: Materials for engineering purposes – Metal based carbides

### Instructions

The equipment, of whatever type, shall always be set up by the thermal sprayer and used in accordance with the manufacturers instructions.

a) Practical test – testing of thermal sprayer's skill

The test piece according to figure B. 5 shall be a tube of low carbon steel of 50 mm (diameter) x 5 mm (wall thickness) x 150 mm (tube length).. The thermal sprayer shall spray sufficient WC-Co 83/17 – spray powder EN 1274 – 11.13, 45/10 agglomerated and sintered – to allow the deposit to be machined, by an appropriate technique. The coating thickness shall be a minimum of 0,3 mm thick and shall not exceed 0,5 mm.

b) Testing of the sprayed coating:

Spray quality

Using the same sprayed test piece the examiner shall inspect the coating for texture and freedom from lumps, cracks and blisters. If no such imperfections are present the thermal sprayer shall be deemed to have passed this test.

Machining test

After visual inspection the tube shall be ground until the sprayed texture is removed. The ground surface shall be inspected for excessive porosity, cracks and detachment, bearing in mind the difference between spraying and machining effects.

Adhesion test

An adhesion test shall be performed in accordance with EN 582 using six test pieces and the result be consistent to within 20 % of the highest value. Minimum tensile adhesion strength 60 MPa.

Micro hardness

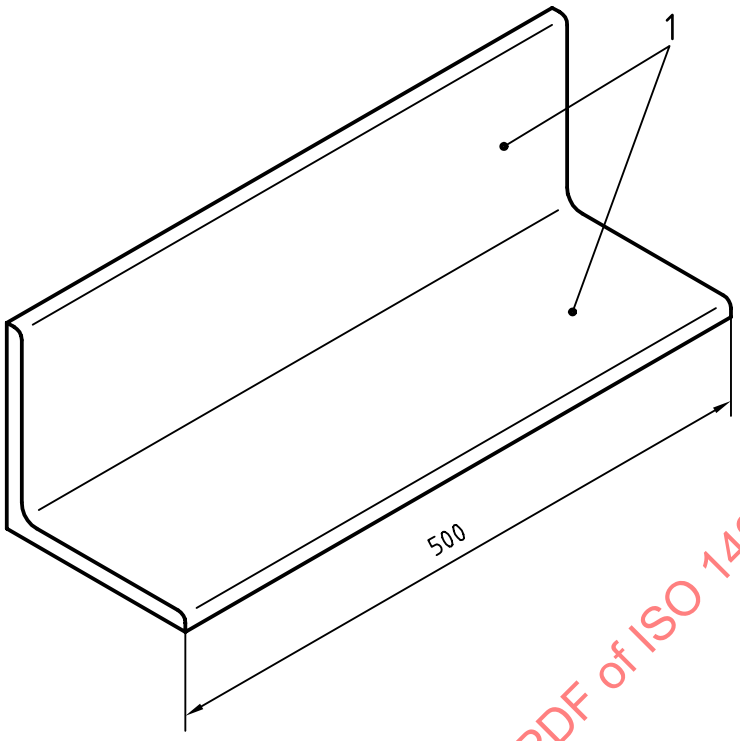
Micro hardness shall be the average of ten measurements of 1000 HV 0,3 Vicker's hardness test on a transverse section according to ISO 6507-1. No cracks from the corners of the indent should be present.

Metallographical investigation

Metallographical investigation of the coating shall show no transverse cracks, delamination, substrate-coating interface voids.

## B.9 Summary of specific acceptance criteria (Table B.1)

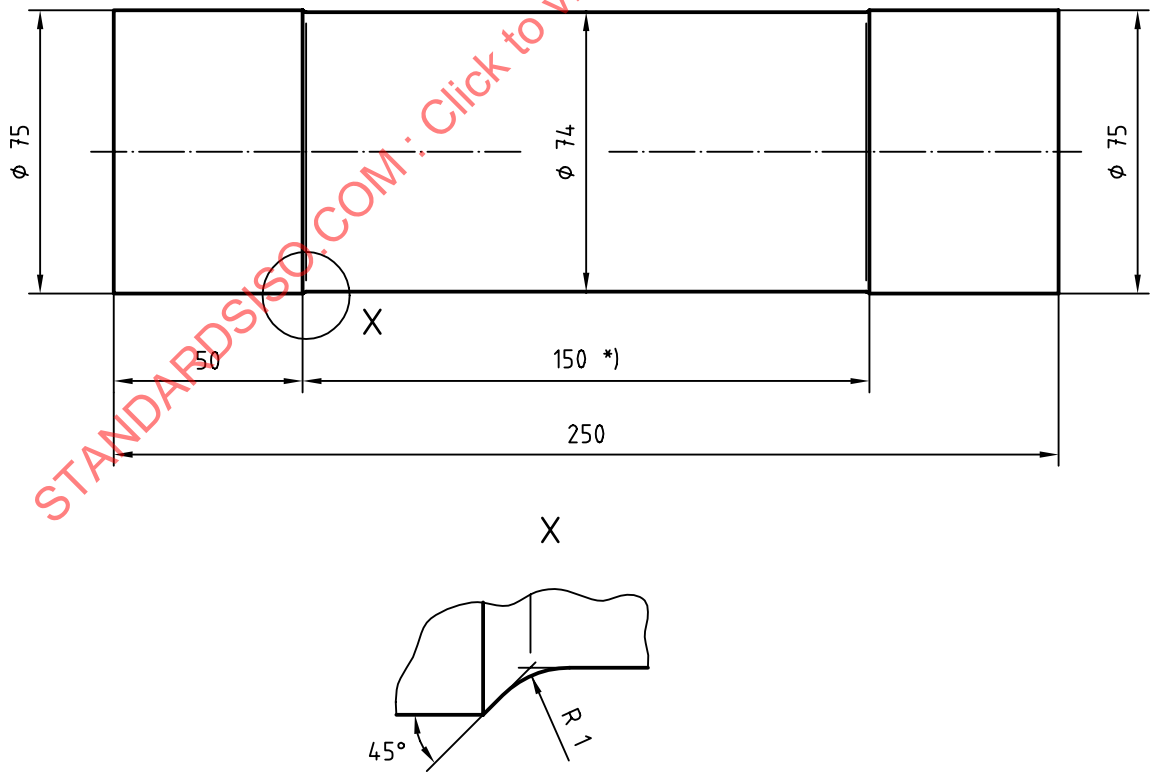
| Process | Flame spraying -powder/wire/rods / Arc spraying | | | Plasma spraying | | | High-speed flame spraying | |
|---|---|---|---|---|---|---|---|---|
| **Material group** | **Zn/Al and alloys** | **Metals and alloys** | **self-fluxing alloys** | **Metals and alloys** | **Metal based carb./carbides** | **Ceramics** | **Metals and alloys** | **Metal based carbides** |
| **Spray material Code No. EN 1274 particle size range** | Zn, Al and alloys | stainless steel: 6.5 45/22 atomized or equivalent wire | Ni basis alloy 40 HRC - 2.10, 106/53 atomized | 80/20 NiCr 3.1, 45/5 atomized | WC-Co 83/17 11.13 45/10 agglomerated and sintered | $Al_2O_3$-$TiO_2$ 87/13 12.3 45/22 blended | 316 L 6.5 45/22 atomized | WC/Co 83/17 11.13 45/10 agglomerated and sintered |
| **Shape of test piece** | plate with 90 ° angle 150 mm x 500 mm x 8 mm<br>figure B.1 | bar of 75 mm diameter undercut centrally<br>figure B.2 | bar of 75 mm diameter undercut at 2 ends<br>figure B.3 | bar of 50 mm diameter undercut centrally<br>figure B.4 | tube 50 mm x 5 mm x 150 mm<br>figure B.5 | tube 50 mm x 5 mm x 150 mm<br>figure B.5 | tube 50 mm x 5 mm x 150 mm<br>figure B.5 | tube 50 mm x 5 mm x 150 mm<br>figure B.5 |
| **Coating thickness Required** | > 0,15 mm und ≤ 0,25 mm | < 1,0 mm manual < 0,8 mm mechanized | | < 1,0 mm manual < 0,8 mm mechanized | ≥ 0,2 and < 0,5 mm | ≥ 0,3 mm and < 0,5 mm | ≥ 0,3 mm and < 0,5 mm | ≥ 0,3 mm and < 0,5 mm |
| **Visual inspection: freedom of** | | | | | | | | |
| **– lumps** | x | x | x | x | x | x | x | x |
| **– dust inclusions** | x | x | - | x | x | - | - | x |
| **– blisters** | x | x | x | x | x | x | x | x |
| **– cracks** | - | - | x | x | x | x | x | x |
| **Machining test** | - | x | x | x | x | x | x | x |
| **Adhesion test EN 22063** | x | - | - | - | - | - | - | - |
| **Adhesion test EN 582** | - | x | - | x | x | | x | ≥ 60 MPa |
| **Hardness test** | - | - | 38-42 HRC | - | ≥ 900 HV 0,3 | ≥ 700 HV 0,3 | - | ≥ 1000 HV 0,3 |
| **Metallographical investigation** | - | - | - | - | x | x | x | x |




1) spray both inside surfaces

dimensions in mm, tolerances ± 0,10 mm

**Figure B.1: Test piece for flame or arc spraying of Al/Zn and their alloys**




*) spray over this area

dimensions in mm, tolerances ± 0,05 mm

**Figure B.2: Test piece for flame or arc spraying of metals and alloys**