BRITISH STANDARD

BS EN ISO 14923:2003

Thermal spraying — Characterization and testing of thermally sprayed coatings

The European Standard EN ISO 14923:2003 has the status of a British Standard

ICS 25.220.20

British Standards

National foreword

This British Standard is the official English language version of EN ISO 14923:2003. It is identical with ISO 14923:2003.

The UK participation in its preparation was entrusted to Technical Committee STI/40, Thermally sprayed inorganic finishes, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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Thermal spraying - Characterization and testing of thermally sprayed coatings (ISO 14923:2003)

Projection thermique - Caractérisation et essais des revêtements obtenus par projection thermique (ISO 14923:2003)

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

This document (EN ISO 14923:2003) 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of an identical text or by endorsement, at the latest by January 2004, and conflicting national standards shall be withdrawn at the latest by January 2004.

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, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard gives guidance on tests used for characterizations of coatings produced by thermal spraying. It is not possible in this document to go into details regarding the different types of coatings and large numbers of coatings due to the fact that all meltable materials can be processed by thermal spraying and that so many and varied thermal spraying processes exist.

The tests listed are procedures and test criteria in general use for thermally sprayed coatings. Test methods not mentioned here are only used in special cases or under laboratory conditions.

NOTE Continuous further development and technical improvements mean that this standard cannot make any claim to completeness.

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 (including amendments).

EN 571-1, Non destructive testing — Penetrant testing — Part 1: General principles (identical with ISO/DIS 3452-1:1996).

EN 582, Thermal spraying — Determination of tensile adhesive strength.

EN 623-2, Advanced technical ceramics — Monolithic ceramics — General and textural properties — Part 2: Determination of density and porosity.

EN 657, Thermal spraying — Terminology, classification.

EN 821-2, Advanced technical ceramics — Monolithic ceramics — Thermo-physical properties — Part 2: Determination of thermal diffusivity by the laser flash (or heat pulse) method.

EN 993-14, Methods of testing dense shaped refractory products — Part 14: Determination of thermal conductivity by the hot-wire (cross-array) method.

ENV 1071-1, Advanced technical ceramics — Methods of test for ceramic coatings — Part 1: Determination of coating thickness by contact probe profilometer.

EN 1071-2, Advanced technical ceramics — Methods of test for ceramic coatings — Part 2: Determination of coating thickness by the crater grinding method.

ENV 1071-3, Advanced technical ceramics — Methods of test for ceramic coatings — Part 3: Determination of adhesion by a scratch test.

ENV 1159-2, Advanced technical ceramics — Ceramic composites — Thermophysical properties — Part 2: Determination of thermal diffusivity.

EN 1274, Thermal spraying — Powders — Composition — Technical supply conditions.

EN 24624, Paints and varnishes — Pull-off test (ISO 4624:1978).

EN ISO 1463, Metallic and oxide coatings — Measurement of coating thickness — Microscopical method (ISO 1463:1982).

EN ISO 2064, Metallic and other inorganic coatings — Definitions and conventions concerning the measurement of thickness (ISO 2064:1996).

EN ISO 2178, Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method (ISO 2178:1982).

EN ISO 2360, Non-conductive coatings on non-magnetic basis metals — Measurement of coating thickness — Eddy current method (ISO 2360:1982).

EN ISO 3543, Metallic and non-metallic coatings — Measurement of thickness — Beta backscatter method (ISO 3543:2000).

EN ISO 3868, Metallic and other non-organic coatings — Measurement of coating thicknesses — Fizeau multiple-beam interferometry method (ISO 3868:1976).

EN ISO 3882, Metallic and other non-organic coatings — Review of methods of measurement of thickness (ISO 3882:1986).

EN ISO 4518, Metallic coatings — Measurement of coating thickness — Profilometric method (ISO 4518:1980).

EN ISO 4541, Metallic and other non-organic coatings — Corrodkote corrosion test (CORR test) (ISO 4541:1978).

EN ISO 6507-1, Metallic materials — Vickers hardness test — Part 1: Test method (ISO 6507-1:1997).

EN ISO 6507-2, Metallic materials — Vickers hardness test — Part 2: Verification of testing machines (ISO 6507-2:1997).

EN ISO 6507-3, Metallic materials — Vickers hardness test — Part 3: Calibration of reference blocks (ISO 6507-3:1997).

EN ISO 6508-1, Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)(ISO 6508-1:1999).

EN ISO 6988, Metallic and other non-organic coatings — Sulfur dioxide test with general condensation of moisture (ISO 6988:1985).

EN ISO 9220, Metallic coatings — Measurement of coating thickness — Scanning electron microscope method (ISO 9220:1988).

EN ISO 14919, Thermal spraying — Wires, rods and cords for flame and arc spraying — Classification — Technical supply conditions (ISO 14919:2001).

EN ISO 14922-1, Thermal spraying — Quality requirements of thermally sprayed structures — Part 1: Guidance for selection and use (ISO 14922-1:1999).

EN ISO 14922-2, Thermal spraying — Quality requirements of thermally sprayed structures — Part 2: Comprehensive quality requirements (ISO 14922-2:1999).

EN ISO 14922-3, Thermal spraying — Quality requirements of thermally sprayed structures — Part 3: Standard quality requirements (ISO 14922-3:1999).

EN ISO 14922-4, Thermal spraying — Quality requirements of thermally sprayed structures — Part 4: Elementary quality requirements (ISO 14922-4:1999).

IEC 60093, Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials.

IEC 60167, Methods of test for the determination of the insulation resistance of solid insulating materials.

IEC 60345, Method of test for electrical resistance and resistivity of insulating materials at elevated temperatures.

IEC 60468, Method of measurement of resistivity of metallic materials.

ISO 2063, Metallic and other inorganic coatings — Thermal spraying — Zinc, aluminium and their alloys.

ISO 3274, Geometrical Product Specifications (GPS) — Surface texture: Profile method — Nominal characteristics of contact (stylus) instruments.

ISO 4287, Geometrical Product Specification (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters.

ISO 4516, Metallic and related coatings — Vickers and Knoop microhardness tests.

ISO 8301, Thermal insulation — Determination of steady-state thermal resistance and related properties — Heat flow meter apparatus.

ISO 8894-1, Refractory materials — Determination of thermal conductivity — Part 1: Hot-wire method (cross-array).

ISO 9227, Corrosion tests in artificial atmospheres — Salt spray tests.

ISO 13565-1, Geometrical Product Specifications (GPS) — Surface texture: Profile method — Surface having stratified functional properties — Part 1: Filtering and general measurement conditions.

ISO 13565-2, Geometrical Product Specifications (GPS) — Surface texture: Profile method — Surface having stratified functional properties — Part 2: Height characterization using the linear material ratio curve.

ISO 14577-1, Metallic materials — Instrumentation indentation test for hardness and material parameters — Part 1: Test method.

ISO 14577-2, Metallic materials — Instrumentation indentation test for hardness and material parameters — Part 2: Verification and calibration of testing machines.

ISO 14577-3, Metallic materials — Instrumentation indentation test for hardness and material parameters — Part 3: Calibration of reference block.

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 657 and the following apply.

3.1
coating structure
sprayed coating is built up of lamellae. Process dependent factors such as materials (auxiliary materials), type of material and spray parameters affect the coating structure. The lamella type and size, structure, cracks, segmentation and similar features have to be differentiated

3.2
crack
parting of the coating structure or separation of the sprayed particles from one another, or within a particle

NOTE They occur vertical and/or parallel to the substrate surface as macro- or microcracks, or mixed.

3.3
flaking
area detached from the coating due to insufficient cohesion resulting from external loads (thermal and/or mechanical) or internal loads (internal stresses from the spraying process)

3.4
inclusion of the same or different material
particle which did not melt, or which solidified before contacting the coating surface

NOTE This can also be inclusions of blasting materials, nozzle/electrode burn-off, foreign powder particles or dust inclusions.

3.5
microstructure
crystal structure of single-component and/or material type two-component sprayed coatings in cross section, made visible by grinding, polishing, etching when viewing under the microscope

3.6
nodule
blister
local increase in height of the coating

NOTE They can be caused by covering over a cavity, unmelted or agglomerated spray particles, possibly mixed with debris removed from the nozzle by the spray action. The nodules or blisters are generally badly joined to the adjacent coating.

3.7
oxide
non-oxide spray particle, which in flight, whether desired or not, has reacted with oxygen due to contact with the atmosphere forming oxides

NOTE Such oxides frequently appear in the form of striations and/or segregates.

3.8
peeling
coating detached from the base material due to insufficient adhesion, resulting from external loads (thermal and/or mechanical) or internal loads (internal stresses from the spraying process)

3.9
pore
cavities of varying shapes and sizes within the sprayed coating, caused by the process used

4 Manufacturing the coating

4.1 General

The processes and categories for manufacturing thermally sprayed coatings are specified in EN 657.

4.2 Coating materials

4.2.1 Materials

The coating is produced by the spraying of spray materials, which can be in powder, wire, rod, or cord form. The technical delivery conditions of the spray additives are specified below:

powder in EN 1274;

wire in EN ISO 14919;

rod in EN ISO 14919;

cord in EN ISO 14919.

4.2.2 Chemical composition

Typical compositions are set out in EN 1274 for spray powders, and in EN ISO 14919 for wires, rods and cords. The compositions are given in mass fraction percent. Other compositions can be agreed on between the users, material manufacturers and suppliers.

4.3 Coating properties

4.3.1 General

Thermally sprayed coatings are more or less heterogeneous, anisotropic, microporous and contain microcracks, regardless of the spraying method employed and the materials used. Complete diffusion bonding of the sprayed material to the base material is not obtained. Adhesion of the sprayed particles generally takes place by mechanical adherence and anchoring of sprayed particles as they cool and contract, and by physical adhesion processes. Fusion or diffusion bonding of the sprayed coating with the base material can be achieved, for example with a self-fluxing alloy or vacuum sprayed coating, as soon as a fusing process or a diffusion heat treatment of the coating is carried out during or after the spraying process.

4.3.2 Description of features

The quality of sprayed coatings is mostly characterised by the structure of the coating, and the distribution and size of e.g. phases, pores, oxides, inclusions of the same or of different materials, segregations and cracks. These are assessed in etched or unetched cross-section micrographs. As these variables are difficult to quantify, assessment is made by comparison with a reference series for the coating.

4.3.3 External features

External features are surface unevenness, roughness or surface texture, with an even coloration and appearance in normal cases. The properties of the coating are significantly influenced by cracks, nodules, flaking, peeling and the coating thickness.

4.3.4 Internal features

Internal features are e.g. coating formation and structure (mechanical adherence or metallurgical bonding) and, depending on the manufacturing method, oxide inclusions, pores, and inclusions of the same or different materials. Spray materials depending on the process and spray parameters affect the coating structures. These are normally detected by metallographic methods.

4.4 Technological and physical properties

4.4.1 Technological properties

4.4.1.1 Wear resistance

The wear resistance of a material is understood as the property of resisting progressive mechanical removal of material caused by relative movement at the boundary between a solid body and another solid, liquid or gaseous body.

Wear, terms and system analysis of wear processes are described in national standards.

4.4.1.2 Corrosion resistance

The corrosion resistance of a material is understood as the property of resisting a chemical and/or physical reaction with the surrounding medium. Corrosion resistance depends on the material, the attacking corrosive medium and the physical and chemical conditions pertaining. It is described e.g. in EN ISO 4541 or in national standards.

Oxidation resistance is a specific form of corrosion resistance.

4.4.1.3 Machinability

Machinability of a sprayed coating is understood as its behaviour during shaping to the contour of the finished component by means of mechanical machining. The coating structure determined by the process employed shall be taken into account when machining, which gives rise to production engineering differences compared to solid material. Depending on the coating material used, the machining process can be turning, grinding or honing, for example.

4.4.1.4 Thermal shock resistance

Thermal shock resistance is understood as the resistance of a coating to a rapid change in temperature acting on all or part of a component. Thermal shock resistance exists when the coating can withstand an agreed number of thermal cycles without any significant damage. There is no common international standards for thermal shock testing for thermally sprayed coatings, but the burner test is commonly used.

4.4.1.5 Thermal cycling resistance

Thermal cycling resistance is understood as the resistance of a coating to a slow change in temperature acting on all or part of a component. Thermal cycling resistance exists when the coating can withstand an agreed number of thermal cycles without any significant damage.

4.4.1.6 Wettability

Wettability of a sprayed coating is understood as the property of a liquid placed upon it to spread out (irreversibly).

4.4.1.7 Liquid Absorption

The saturability of a sprayed coating is understood as the capability to absorb and store liquids due to certain internal and external features (pores, cracks). Saturability presupposes sufficient wettability. The liquids absorbed can be held in a coating unchanged (e.g. oils, grease) or can harden, thereby sealing the coating.

4.4.2 Physical properties

4.4.2.1 Hardness

Hardness is the resistance of a material to the penetration of an external body. The hardness of sprayed coatings can differ from that of a homogeneous or solid material of the same composition. Hardness is used as a measure for assessing the coating quality.

4.4.2.2 Bond strength

The bond strength is given by the degree of attachment of the individual sprayed particles to each other and to the substrate. Cohesion to each other and adhesion to the substrate are very much influenced by the type and nature and deformation of the sprayed particles on impact. The bond strength is adversely affected by inclusions of other materials, voids, oxide striations in metallic or metallic ceramic coatings, unmelted or re-cooled particles, and also blasting agent inclusions. Diffusion zones increase the bond strength. The bond strength is the strength given by the test force and the cross section of the test area. Tensile adhesive strength is used as a measure for assessing the coating quality, and is standardised in EN 582.

4.4.2.3 Conductivity

4.4.2.3.1 Thermal conductivity

Thermal conductivity (W/m·K) is a physical quantity, which represents a dimensional number for the thermal conductivity or transmission in a body. The thermal conductivity of thermally sprayed coatings can be assumed to be less than that for the same bulk material. It is described in EN 821-2, EN 993-14, ISO 8894-1 or ISO 8301 and national standards.

4.4.2.3.2 Temperature conductivity

The temperature conductivity determines the time required for temperature equalisation within a substance. In the case of composite coating/base material bodies, the determination is very complex as separate measurements have to be taken in the coating material and in the base material. For example, EN 821-2 describes the measurement on monolithic ceramics and ENV 1159-2 the thermal diffusivity of ceramic composites.

4.4.2.3.3 Electrical conductivity

Electrical conductivity is the reciprocal of specific resistance. Thermally sprayed coatings can be used for purposes of electrical conduction and also for electrical insulation, depending on the sprayed material. Test methods are described in IEC 60093, IEC 60167, IEC 60345 or IEC 60468.

4.4.2.4 Modulus of elasticity

This is a measure of the resistance a material exerts against elastic deformation of itself. In practice it is not determined for sprayed coatings.

4.4.2.5 Density

The density is the mass of the coating in relation to its volume. The density of a thermally sprayed coating depends on the structure of the coating, and particularly on the type, size and percentage of pores and oxide of the pores, as well as on the density of the sprayed material. In practice for sprayed coatings it is only determined in exceptional cases, e.g. EN 623-2 (monolithic ceramics, determination of density and porosity).

5 Tests

5.1 General

Guidelines for the individual features of the coatings and test specifications shall be drawn up jointly by the manufacturer and user for assessing the coating quality as required for various applications. Guidelines for quality assurance are described EN ISO 14922-1 to EN ISO 14922-4 or in national standards.

Technical delivery conditions for thermally sprayed components can be agreed in accordance with national standards.

5.2 Non-destructive test methods

5.2.1 General

The following properties of thermally sprayed coatings can be tested by non-destructive means: coating thickness, cracks opening outwards, surface unevenness such as nodules, roughness and colour. They give an indication of the quality of the sprayed coating.

5.2.2 Visual inspection and assessment

The visual inspection shall be carried out in adequate light conditions free of glare and with the naked eye. As a recommendation, a magnifier with 8-fold magnification shall be used if necessary. The visual inspection is made on sprayed coatings after machining or in the as-sprayed condition.

The following shall be assessed as a general rule: prescribed coating area, evenness, detachment of the coating, partial loosening, nodules, local discoloration, differences in roughness. Local discoloration's and differences in roughness indicate a change of the spray parameters, which may have affected the required coating properties.

5.2.3 Measuring the surface roughness

The surface roughness is standardised in ISO 4287, ISO 13565-1 and ISO 13565-2, or in national standards. Measuring equipment for its characteristic variables and their nominal values is described in ISO 3274. The characteristic variables and the measurement method shall be agreed upon.

Surface character, geometrical characteristics of surface texture, terms, definitions and symbols are described in national standards.

5.2.4 Surface impression, replica-technique

Using a specially suitable plastic, a negative impression is taken of the surface structure to be tested. Roughness, shape, and cracks open to the surface, flaking, etc. can be assessed from the replica. This is a suitable test method for non-destructive testing, for virtually inaccessible places, or as a special test.

5.2.5 Surface crack detection

Surface flaws are generally detected using the penetration method described in EN 571-1. This method requires a penetrate, a cleaning solvent and a developer. The penetration test is normally only suitable for thermally treated/ compressed/fused coatings, or for machined coatings produced by detonation spraying or high velocity flame spraying.

The surface to be tested shall be carefully cleaned, following the directions of the manufacturer of the testing agent. Linear indications (length greater than three times the width) are generally inadmissible. If point indications occur in large numbers close together before the developer is applied, a porous/cracked structure can be assumed, which as a rule is not permitted.

5.2.6 Hardness test (surface measurement)

The hardness test can preferably be carried out by determining the macrohardness of the surface in accordance with EN ISO 6508-1. In many cases the hardness indentations do not have any adverse effects on the function of the coating, so direct measurement on the component is possible. The surface shall be bare and machined, free of contamination and completely free of any lubricant. It should be borne in mind that a minimum coating and substrate thickness is necessary for satisfactory measurement.

5.2.7 Measuring the coating thickness

5.2.7.1 Mechanical, magnetic and electromagnetic measuring methods

See EN ISO 2064. The coating thickness is best measured non-destructively by means of simple mechanical measuring instruments such as rulers, vernier callipers, dial gauges, micrometers, etc., or magnetic and electromagnetic coating thickness measuring instruments. See EN ISO 3882. The coating thickness is given as an arithmetical mean of at least three and preferably five individual measurements.

Test methods are given in: ENV 1071-1, EN 1071-2, EN ISO 1463, EN ISO 2178, EN ISO 2360, EN ISO 3543, EN ISO 3868, EN ISO 4518, EN ISO 9220.

The coating thickness can also be determined in accordance with national standards.

5.2.7.2 Magnetic field (flux) measurement

See EN ISO 2178 and EN ISO 2360. The thickness of non-ferromagnetic coatings on ferromagnetic substrates can be measured non-destructively using these methods. The variation in magnetic flux is used for measuring the coating thickness here. The surface of the component shall be flat so that the pole shoe sits completely on the surface.

5.2.8 Thermal conductivity

The thermal conductivity of sprayed coatings can be determined using the hot wire method as described in EN 993-14, ISO 8894-1 or national standard, with a heat flow plate apparatus in accordance with ISO 8301 or national standard or by the laser flash (or heat pulse) method described in EN 821-2.

5.2.9 Electrical conductivity

Unlike solid materials, standards do not exist for thermally sprayed coatings (base material-coating composite). The high-voltage dielectric breakdown test can be carried out in accordance with e.g. IEC 60093. Other test methods are described in IEC 60167, IEC 60345, or IEC 60468.

5.3 Destructive test methods

5.3.1 Metallographic examination

5.3.1.1 Metallographic examination is indispensable if it is desired to carry out a reliable quality control of a thermally sprayed coating. However, experience of this is necessary. The sample shall be taken in accordance with established/agreed criteria. It shall be noted that the method of preparing the coating can affect the coating variables, e.g. porosity, clusters, flaking and flaws, as regards size, number and form, so that clear definitions of the individual preparation steps here are essential.

The samples of the sprayed coatings should if possible have been prepared with cutting-off machines, (semi-) automatic grinders and polishers in order to maintain reproducibility and above all flatness of the samples, so that the coating and the transition to the substrate can be correctly evaluated. Preparation and examination are described e.g. in national standards.

5.3.1.2 Typical test criteria are e.g. structure, the occurrence of pores / oxides / inclusions of the same and of other materials / cracks / phase distribution / melted and recooled particles, nodules, etc., which may effect the cohesion and adhesion of the coating. These are evaluated as regards permissible form, number, size, and distribution relative to the application. The phases of thermally sprayed coatings should be evaluated by type, form, size, quantity and distribution if possible. Apart from the coating thickness and porosity, all the above coating features are hard to quantify. For this reason it is advantageous to carry out the evaluation by comparison with a reference series, which presents certain coating features visually as permissible or inadmissible as regards form, number and size, relative to the application.

5.3.1.3 Measuring the coating thickness of a thermally sprayed coatings on a metallographic microsection should be carried out in accordance with EN ISO 1463 for example. A mean value from 10 individual measurements suffices as a rule.

5.3.2 SEM (Scanning Electron Microscope) examination

In individual cases the SEM examination of surfaces and microsections with or without microprobe analysis can yield important additional information for evaluation. However, as a rule it is not used in series production.

5.3.3 X-ray diffraction analysis (phase determination)

X-ray diffraction analysis uses monochromatic X-rays to ascertain microstructural information about crystalline materials. It is not used in series production as a rule.

5.3.4 Chemical analysis

Generally, chemical analyses of thermally sprayed coatings are not carried out (a test of the spray material prior to the process is more frequent).

5.3.5 Testing the bond strength

5.3.5.1 General

Bond strength values are dependent on the test method, the size and shape of the sample, local conditions at the interface surface and the properties of the substrate and coating materials. When evaluating bond strength tests the fracture picture shall always be evaluated as well. The results of different test methods cannot be compared with one another.

5.3.5.2 Tensile adhesive test

In most cases the test of tensile adhesive strength in accordance with EN 582 is used. It is used to determine the strength of thermally sprayed coatings and/or adhesion to the substrate. For protective coatings of zinc/aluminium other tests may be used in accordance with EN 24624.

5.3.5.3 Bend test

This test examines the deformation capability of a thermally sprayed coating and allows conclusions about the bond strength to be drawn by comparing with other samples (crack formation, peeling). A coated strip of metal plate is bent over a mandrel of specified diameter through 90° or 180° at an even bending speed. For example: Mandral diameter 12,5 mm, sample thickness 1,6 mm. It is important that the coating being tested is on the outer radius of the bend. The coating thickness affects the test result significantly and shall be specified. The test is described in national standards, for example.

5.3.5.4 Grid test

This is also known as a scratch test, and is used mainly for thin zinc and aluminium sprayed coatings. See ISO 2063 for metallic coatings or for ceramic coatings ENV 1071-3 (determination of adhesion by a scratch test). In the test, four to six parallel lines 1 mm to 3 mm apart and four to six parallel lines vertical to and crossing these are scratched with a steel or carbide point down to the base metal, thereby drawing a grid. Any detaching by the coating is a measure for evaluating the bond strength. The results of the measurements depend very much on the condition of the cutters and the speed at which they are pulled across.

5.3.5.5 Chisel test

This method shows good results for zinc and aluminium sprayed coatings, regardless of coating thickness. See ISO 2063. It is primarily suitable for use on site. The sprayed coating is cut with a narrow ground chisel with an edge length of 10 mm, for example. The coating is bonded adequately if no detaching takes place.

5.3.6 Hardness test (measurement in transverse microsection)

5.3.6.1 Vickers hardness test

The hardness test in transverse microsections of thermally sprayed coatings is not as simple and error-free as in compact materials due to the inhomogeneity of coatings with pores, cracks, etc. and the often narrow coating thickness. Measured values should always only be regarded as comparative values with other samples. The advantage of the Vickers hardness test is the continuous scale for the softest to the hardest materials. In practice, determining the coating hardness with 0,3 HV and 0,1 HV in accordance with EN ISO 6507-1 to EN ISO 6507-3, obtains suitable results.

In this hardness test high demands are placed on the surface quality of the test specimen (smooth, free of oxides, foreign substances and lubricants). For a perfect measurement, a minimum coating thickness of 3 times the indentation diagonal "d" is necessary.

The microhardness (test force < 10 N) is an important aid in interpreting the microstructure, as individual phases can be examined specifically. The test result is very dependent on the test force used and can only be compared with the same force and duration. The microhardness test is described in ISO 4516.

5.3.6.2 Scratch test

Simple and inexpensive test method for soft coatings. The surface is scratched with a sharp-edged, hard object at a constant pressure and speed. The penetration depth and the width of the scratch is a measure to compare the hardness of the different coatings.

5.3.6.3 Depth Sensing Hardness

Experiments recording simultaneously load and indentation depth of an indentor are an alternative to conventional hardness measurement techniques, where the elastic deformation under the indentor is not taken into account. An indentor penetrates the sample either under load or displacement control monitoring load and depth during loading and unloading. The hardness value is calculated from the indentation depth under working test load, knowing the geometry of indentor. From the recorded data information on both the plastic and the elastic properties of the coating can be deduced.

The most important limitation using recording hardness measurements is the surface roughness and the calibration routine of reference blocks[1].

5.3.7 Wear test

Due to the large number of tribological loads, wear mechanisms and the substances involved and many test methods arising from these, no recommendation on carrying out a wear test can be given.

But some general rules shall be followed when designing tribological tests and interpreting the results:

a) laboratory tests should be carried out by varying the test parameters (parameter screening). Following this condition the result enable a ranking with respect to the "wear resistance";

b) the ranking is only true for this test method and the specific parameter set used;

c) do not compare test results which had been generated with different test methods;

d) do not compare test results which had been generated with different sets of parameters.

In general every user has to be warned against calculating life time predictions on the basis of laboratory test results. Wear, terms, systematic analysis of wear are described in national standards.

5.3.8 Thermal shock test

The test for thermal shock resistance is a comparative test, which normally does not reflect the actual loading conditions. As thermal shock tests are not standardised internationally, it is advisable that agreement is reached regarding test methods and conditions, maybe upon national standards.

When carrying out the test for thermal shock two different methods are used:

heating with a gas burner and cooling with compressed air alternately on a sample coated on one side only;

immersing a sample coated on both sides in a hot and cold fluidised bed alternately.

The high and low temperatures and the heating and cooling rates need to be specified. The number of cycles which can be endured by the coating without damage such as peeling, or large cracks with flaking, is counted as the value for comparison purposes. After the test has been passed, a metallographic examination of the sample is advisable to confirm the test results as regards changes in the coating structure.

5.3.9 Test for corrosion resistance

5.3.9.1 General

Usable information about the corrosion behaviour of metallic materials is generally only obtained from corrosion trials under simulated operational conditions. Due to the large number of materials used and different corrosion media and mechanisms, it is advisable to carry out tests in accordance with agreed standards and to compare the results with references.

5.3.9.2 Zinc and aluminium sprayed coatings

The corrosion resistance of zinc and aluminium sprayed coatings can be determined comparatively by means of:

testing in a condensation water alternating climate with an atmosphere containing sulphur dioxide in accordance with EN ISO 6988, or

1) See ISO 14577-1, ISO 14577-2, ISO 14577-3.

spray mist test (salt spray test) in accordance with ISO 9227 or national standard in which case both the coating and base metal corrosion can act as test criteria;

Metallic and other non-organic coatings – Corrodkote corrosion test (CORR test) in accordance with EN ISO 4541.

5.3.9.3 Results

The result of accelerated tests should be used with cautions as they are not good indicators for long term performance.

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