SWEDISH STANDARDS INSTITUTE

SVENSK STANDARD
SS-EN 14616:2005

Fastställd 2005-09-14

Utgåva 1

Termisk sprutning – Rekommendationer för termisk sprutning

Thermal spraying – Recommendations for thermal spraying

ICS 25.220.20

Språk: engelska

Publicerad: december 2005

Europastandarden EN 14616:2004 gäller som svensk standard. Detta dokument innehåller den officiella engelska versionen av EN 14616:2004.

The European Standard EN 14616:2004 has the status of a Swedish Standard. This document contains the official English version of EN 14616:2004.

Upplysningar om **sakinnehållet** i standarden lämnas av SIS, Swedish Standards Institute, telefon 08 - 555 520 00.

Standarder kan beställas hos SIS Förlag AB som även lämnar **allmänna upplysningar** om svensk och utländsk standard.
Postadress: SIS Förlag AB, 118 80 STOCKHOLM
Telefon: 08 - 555 523 10. *Telefax*: 08 - 555 523 11
E-post: sis.sales@sis.se. *Internet*: www.sis.se

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 14616

November 2004

ICS 25.220.20

English version

Thermal spraying - Recommendations for thermal spraying

Projection thermique - Recommandations pour la projection thermique

Thermisches Spritzen - Empfehlungen für das thermische Spritzen

This European Standard was approved by CEN on 13 September 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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 Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 14616:2004: E

Contents

Foreword

This document (EN 14616:2004) has been prepared by Technical Committee CEN/TC 240 “Thermal spraying and thermally sprayed coatings”, the secretariat of which is held by DIN.

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 May 2005, and conflicting national standards shall be withdrawn at the latest by May 2005.

This document includes a Bibliography.

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

Introduction

Thermal spraying compasses processes used in the production of coatings and free standing bodies in for which spray materials are surface melted, melted off or melted and then propelled onto suitably prepared workpiece surfaces. The workpiece surfaces are not surface melted. In order to achieve specific coating properties, the spray coating can undergo additional post-treatment, either thermal or otherwise, for example, sealing.

Thermally sprayed coatings serve to improve the surface properties of a workpiece by manufacturing or repair operations. This can be done, for example, in relation to wear, corrosion, heat transfer or heat insulation, electrical conductivity or insulation, appearance and/or for restoring the part to working order. In certain cases, a spray coating can render a surface being solderable.

Chiefly due to their bonding mechanism, thermally sprayed coatings without thermal post-treatment can be distinguished from coatings applied with other processes such as deposition welding, brazing, physical vapour deposition (PVD) or chemical vapour deposition (CVD).

The advantages of thermal spraying are:

— the workpieces to be coated are only slightly heated so that distortion and any other undesired structural changes to the parent material are avoided. This does not apply if the coatings are thermally treated during or after the spray process;

— the application is not dependent on the size of the workpiece or component. The operation can be stationary or mobile depending on the spray process;

— even geometrical complex components can be coated using the appropriate spray set-up;

— the untreated surface of spray coatings generally provides a good bond coat for paintings;

— depending on the spray process and spray material, different coating thickness can be applied, although a coating thickness of approximately 10 µm is currently considered to be the lower limit.

Process-related disadvantages are as follows:

— the bond strength of thermally sprayed coatings without thermal post-treatment derives from adhesive forces only;

— the bond strength can be influenced due to expansion mismatch between coating and substrate material, especially in case of high operation temperature;

— spray coatings are micro porous;

— the thicker the spray coating, the higher the residual stresses in the coating; and the degree of multi-axial stress thus increases;

— spray coatings without additional thermal post-treatment are sensitive to edge pressure, localised and linear loads and to impact stresses;

— there are restrictions in relation to the geometric dimensions, e.g. for the inner coatings of workpieces whose inner diameter is too small.

1 Scope

This document includes general guidelines for the workmanlike production of metallic, metal-ceramic, oxide-ceramic and plastic coatings by means of thermal spraying on metallic and non-metallic parent materials.

It offers recommendations for an appropriate and practical spray set-up, faultless manufacturing, monitoring, quality assurance and for non-destructive and destructive tests on the component and accompanying specimen. It describes details about negative effects which can occur. It gives advice on how to prevent such effects. Permissible coating loads and evaluation categories for quality are not the subject of this standard, as they are dependent on the operating conditions.

This document can be used for contract purposes.

2 Normative references

Not applicable.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
shot-peening effect
pressure strengthening by grit-blasting

3.2
sound pressure level
mean value of emitted sound, measured in dB

3.3
etching
removing of surface material

NOTE Etching can be applied using liquid agents (wet chemical etching) or using gases in a recipient (dry etching, plasma etching). The etching agent reacts chemically with the substrate.

3.4
ion-etching
material removed by shooting the surface with high energetic particles like ions

NOTE The ions cut off material at the impact point. The procedure is used in plasma technology application (vacuum coating technology).

3.5
corona discharge
dielectric discharge in air after exceeding the break down field intensity; air molecules will be ionized by generating of short living ozone

4 Parent material

Virtually every kind of solid-state material can be coated by means of thermal spraying, provided its surface is suitably prepared. The achievable bond strength of the coating to the substrate is dependent on the spray material, spray process and the physical and technological properties of the parent material used. The bond strength, amongst other things, is particularly influenced by the thermal conductivity of the parent material in comparison to the conductivity of the spray coating and the state of the parent material's surface. In general hardened materials need a bond coat to give adequate bond strength. The possible coating thickness may be limited, depending on the bonding material being used. Certain surface hardening processes e.g. "nitriding" may leave gaseous inclusions which would prevent proper bonding.

A variety of plastics as well as glass and paper can be thermally sprayed when using the appropriate spray process and a surface treatment method adapted for the respective material.

As the workpieces to be coated by means of thermal spraying are generally only slightly heated, undesired structural changes to the parent material and changes to the component's geometry due to distortion are avoided to the greatest possible extent. However, distortions resulting from intensive grit-blasting during surface preparation, especially with thin-walled parts or as a result of residual compressive stresses on the surface of the substrate caused by process-related shot-peening effects can occur. If coatings are thermally treated during spraying (processes with simultaneous fusing) or subsequently, undesired structural changes and significant geometric changes can occur.

For purposes of quality assurance during the manufacturing process, the parent materials and components to be coated should be stored in such a way that damage and/or not desired changes to the shape or surface are avoided.

5 Component geometry

The application of thermal spraying is independent, to the greatest possible extent, of the size of the workpiece or component to be coated. This is mainly true for flame and arc spraying. For plasma and HVOF (high velocity oxygen-fuel) spraying, closed-off spray booths are normally required due to the high noise and dust emissions. As a result, there may be restrictions to size of the component.

Certain prerequisites concerning the practical set-up shall be considered when using thermal spraying. If these rules are followed, even complex geometric parts can be coated with expertise. The most important rules can be summarised as follows:

— the area to be coated shall be accessible to the spray gun with all its electrical and/or gas connections, and the necessary spray distance and spray angle shall be maintained;

— sharp edges should be avoided; they cannot be covered with a spray coating;

— narrow radii should be avoided, otherwise turbulence in the spray jet can occur, which can lead to unsatisfactory coatings in terms of bond strength and density;

— problems with turbulence and undesired, loose particles sticking to the walls especially occur when spraying in narrow bores or blind holes;

— to prevent the coating from spalling, it has proved advantageous to pull the coating around rounded or chamfered edges;

— the arguments listed for thermal spraying, i. e. accessibility, sharp edges, narrow radii, bores and blind holes, also apply to grit-blasting when preparing the surface to be sprayed.

6 Spray materials

6.1 General

The spray materials used for thermal spraying cover a wide range of very different materials. It is virtually possible to spray any material which can be produced as a solid wire, cored wire, rod, cord or powder, and which does not sublimate in the arc or plasma or decompose when passing through the flame. In the special case of molten-bath spraying, the material is processed in its liquid state.

Generally, the following spray materials can be used for thermal spraying:

- metals and metal alloys;
- metal ceramics;
- hard phases embedded in a matrix material;
- oxide ceramics, plastics, as well as various hybrid materials.

6.2 Selection of spray materials

An important task for the designer and/or person responsible for the spray technology is the selection of the spray material which is most suited to the application. Fundamental to the selection are the demand's profile of the coating, the subsequent operating conditions and the most suitable spray process. Corrosion and/or wear loads, for example, can determine the demand's profile. The operating conditions in a tribological system can be determined by an increased operating temperature or by operating temperatures which fluctuate in level and, in some cases, also speed. The most suitable spray process distinguishes itself in terms of its ability to fulfil coating requirements such as density, bond strength, porosity, purity, etc. Here, the relevant process data such as temperature level in the flame, in the arc or in the plasma, the dwell time of the spray particles in the hot zone and the particle velocity in flight and on impact on the substrate play a decisive role.

The most important spray materials have been standardised. Specified in standards are: chemical composition of the material and its supply form as powder with its special features based on manufacturing process, particle shape and particle size distribution, or as wire, rod or cord.

The following standards apply:

- for powder EN 1274;
- for wires, rods and cords EN ISO 14919.

6.3 Supply, handling and storage

The supply form and its constancy from batch to batch, especially with spray powders, plays a fundamental role in assuring a uniform quality for the finished coating. For this reason, it is recommended that manufacturing, supply and distribution be assessed and monitored by a suitable quality management system. Details concerning such a procedure are described in EN 12074.

7 Gases for spraying

Industrial gases are used in all thermal spray processes. Depending on the spray process, these gases or their mixtures are employed as a fuel, combustion accelerator, plasma gas, shroud gas, propelling or atomising gas, powder feed gas or for cooling the part to be coated or even the spray gun.

The physical and chemical characteristics of the industrial gases used for thermal spraying differ quite markedly from each other. Paying attention to these parameters, a gas or gas mixture, which fulfils the process and material requirements, can be selected for any thermal spray application.

The following gases are mainly used:

- as a fuel gas: acetylene (C_2H_2), propane (C_3H_8), propylene (C_3H_6), ethane (C_2H_4), hydrogen (H_2), natural gas;
- as a plasma gas: argon (Ar), helium (He), hydrogen (H_2), nitrogen (N_2) and their mixtures;

- as a combustion accelerator: oxygen (O_2);
- as a shroud gas: argon (Ar), nitrogen (N_2);
- as a propelling or atomising gas: compressed air, nitrogen (N_2), argon (Ar);
- as a powder feed gas: argon (Ar), nitrogen (N_2);
- for cooling: compressed air, carbon dioxide (CO_2).

Depending on the spray process and the purpose of the application, varying high purity levels are demanded of the gases. The gas producer is responsible for the gas purity whose level shall then be maintained at the user's premises during the filling process, transport and withdrawal, and in the pipeline system.

In general, it is sufficient to indicate the purity of the gases used in thermal spraying with numerical values according to the number of "nines" before and after the point (4,6 = 99,996 %). Typical gas purity for thermal spraying are:

- Ethene 3,5
- Oxygen 3,5
- Hydrogen 3,0
- Nitrogen 4,6
- Argon 4,6
- Helium 4,6

For plasma spraying in particular, the purity of the gases has a big influence on the lifetime of the nozzle electrode system.

8 Liquid fuels for spraying

In several applications the high velocity flame spraying process is applied using liquid fuels, e.g. kerosene, N-paraffin, test benzene or petroleum. A low sulphur content has to be kept due to environmental reasons. Flash point, evaporation point and purity have to be considered as well as additional instructions from the equipment supplier.

9 Spray equipment

9.1 General

The thermal spray equipment includes the spray device with all the electrical and gas supply and regulating equipment, possibly the handling system, plus the peripheral installations such as exhaust and filter systems, spray booth and soundproofing. Modern installations often include additional equipment for monitoring spray parameters and motion sequences by means of video cameras.

9.2 Spray device

Spray device is defined in EN 657 as the equipment required for thermal spraying.