INTERNATIONAL STANDARD

ISO 14924

First edition
2005-08-15

Thermal spraying — Post-treatment and finishing of thermally sprayed coatings

Projection thermique — Traitement et finition des revêtements obtenus par projection thermique

Reference number
ISO 14924:2005(E)

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

Published in Switzerland

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14924 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read “...this European Standard...” to mean “...this International Standard...”.

Contents

Foreword

This European Standard (EN ISO 14924:2005) 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 February 2006, and conflicting national standards shall be withdrawn at the latest by February 2006.

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

The successful service of a thermally sprayed component depends decisively on the right choice of procedure for post treatment and/or finishing after spraying. In order to work and/or to treat a thermally sprayed coating especially the property of the lamellae structure needs to be taken into account. The structure is quite different from those of the same materials in the cast or wrought state and finishing techniques which may be suitable in these latter cases would be likely to damage thermally sprayed coatings.

1 Scope

This European Standard specifies the treatment and finishing of thermally sprayed coatings. It is applicable to different types of mechanical post treatment, chemical treatment, and thermal treatment, including chip cutting and other mechanical processes, to sealing, pickling and painting, and fusing, diffusion annealing and hot isostatic pressing.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references the latest edition of the referenced document (including any amendments) applies.

EN ISO 2063, *Thermal spraying - Metallic and other inorganic coatings - Zinc, aluminium and their alloys (ISO 2063:2005)*

EN ISO 12944-5, *Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 5: Protective paint systems (ISO 12944- 5:1998)*

EN ISO 14920, *Thermal spraying – Spraying and fusing of self-fluxing alloys (ISO 14920:1999)*

ISO 504, *Turning tools with carbide tips – Designation and marking*

3 Mechanical post treatment

3.1 Chip cutting

3.1.1 General

For the reasons stated in the Introduction, the common basis of chip cutting techniques cannot be applied to thermally sprayed coatings because of their different properties. There are many different hard phases in sprayed coatings such as oxides, carbides, borides, silicides and others. These require specific attention to the geometry of the cutting edge to prevent high wear of the flank.

3.1.2 Turning

The possibility of turning a thermally sprayed metal coating depends upon the specific property of a thermal spray coating e.g. structure and hardness as well as any previously applied thermal spray process.

a) Tool selection:

Due to hard phases in metallic thermal spray coatings and the partly extremely hardening spray particle the turning tool is more heavily loaded compared to cast or forged material consisting out of the same or similar material.

Because of this reason hard metals and ceramic cutting materials are required. The ones commonly used for turning grey cast iron, chilled cast iron and short cutting chip malleable cast iron. In contrast thermally sprayed aluminium or copper coatings can be turned economically using high speed steel cutting tools. Good operation times are achieved by using hard metal quality K01 and K10 according to ISO 504.

Thermally sprayed coatings with hardnesses x > 700 HV (60 HRC) may be turned satisfactorily using boron nitride tools, consisting of poly-crystalline, cubic boron nitride (CBN), which are sintered to a hard metal body.

Thermally sprayed copper and aluminium coatings can be turned economically using high-speed steel.

b) Cutting speed:

The optimum cutting speeds for thermal spray coatings are different. They are lower because of embedded hard phases compared to homogeneous materials and require sharp cutting tools with cutting radius R 0,4 mm - 1,2 mm.

Tables A.1 to A.4 show approximate values which may be adjusted from case to case. A test cut is recommended in order to avoid unfavourable results.

NOTE Applying excessive cutting velocities the thermal spray coating acts like a lapping tool causing an uneconomic lifetime of the tool. The blunt cutting tool generates a high surface load and can lead to coating damage.

c) Traverse feed:

Traverse feed per revolution shall be of the order of particle diameter of thermal spray coating. Tables A.1 to A.4 show approximate values for turning of thermally sprayed metal coatings which may be adjusted from case to case.

3.1.3 Milling

In some cases thermal spray coatings may be machined also by milling. Concerning selection of tool and choice of feed and speed the same considerations as for turning shall be taken into account.

3.1.4 Cooling during chip cutting operations

When coatings of self-fluxing alloys, which are fused to provide a dense structure, are machined, a coolant may be used in order to prevent overheating (This does not apply when CBN cutting tools are used).

Otherwise a coolant shall not be used when 'as sprayed' coatings (which are not fused) are being machined. The micro porosity of the coating permits penetration of the coolant causing discolouration and other problems.

If coolant is used areas of high hydraulic pressure can wholly or partially remove particle giving a poor surface finish.

3.1.5 Grinding

3.1.5.1 General

Wet grinding shall be preferred to dry grinding in order to avoid over heating of the thermally sprayed coating as well as of the work piece.

3.1.5.2 Preparation

It is advantageous to seal the coating before grinding. This will prevent penetration of the coolant to the interface with the substrate material causing possible corrosion problems (see 4.1). It will also minimise the generation of grinding debris which may contaminate the returned coolant.

Care should be taken to the choice of sealant, so that the sealant do not get burnt or smeared onto the grinding wheel, due to the sometimes high contact temperatures during grinding.

Additionally, sealing of ceramic coatings is also preferred before grinding to prevent unsightly staining of the coating due to penetration of the coolant.

3.1.5.3 Selection of grinding process

All thermally sprayed coatings may be ground. The loading of the thermally sprayed coating is lower compared with that of turning. Tables B.1 and B.2 show details for grinding.

3.1.5.4 Selection of grinding wheel

The shape of the grinding wheel will vary depending on the geometry of the component to be ground. e.g. cup wheels may be used where appropriate. Dry grinding may be carried out although the use of a coolant, where possible, is preferred.

Tables B.1 to B.3 show the kind of wheels to be used, which will depend on the thermal spray material used.

3.1.5.5 Belt grinding

Where a smooth finish is required and dimensional accuracy is not important, belt grinding may be used. Typically silicon carbide or diamond belts are used for this purpose.

3.1.6 Other cutting processes

3.1.6.1 Chip cutting with geometrically defined tool edges (drilling)

Certain thermal spray coatings can be drilled using sharp spiral drills.

3.1.6.2 Planning, sawing, reaming, broaching

Precautions shall be taken when using these processes due to the risk of damaging the coatings.

3.1.6.3 Chip cutting with geometrically undefined but hard tool edges

a) Abrasive cutting, honing:

For these cutting processes the same recommendations as for grinding shall be taken into account.

b) Applying loose grains:

– Polishing, lapping: Polishing of ground or turned metallic thermally sprayed coatings may be carried out by using polishing machines and applying polishing filler materials. A heat build up shall be avoided to prevent coating damage.

– Super finishing: Thermal Spray coatings especially ceramic coatings (e.g. Cr_2O_3, Al_2O_3/TiO_2, blends of these respectively alloys with other ceramics as well as hard materials) can be super finished in order to achieve very low coating roughness (R_a down to 0,05). These results can be achieved by using appropriate powders, thermal spray equipment and wet operating finishing procedures.

3.2 Other mechanical processes

3.2.1 Shot peening

In special case metallic thermal sprayed coatings can be post-treated by shot peening. The shot peening process densifies the coating and can generate a compressive stress. This post-treatment can increase the corrosion resistance of especially arc and flame sprayed coatings. Care has to be taken that the thermally sprayed coating is not too highly loaded locally during shot peening to avoid spalling.

3.2.2 Brushing

Thermal sprayed coatings can be brushed in order e.g. to smooth the surface, to remove spray dust to achieve clean surfaces or decorative effects.

4 Chemical treatment

4.1 Sealing

4.1.1 General

Untreated thermally sprayed coatings contain micro porosity. In many cases it is desirable to close the pores using specially formulated sealing materials which will penetrate the pores and not simply lie on the surface. Control of the viscosity of the sealant is vitally important in this respect. It is also important that the coating does not take up moisture or become otherwise contaminated between spraying and sealing.

4.1.2 Sealing for hydraulic and pneumatic applications

In order to avoid a loss of static or dynamic pressure, the pores in the coating shall be closed by applying a suitable sealant.

4.1.3 Sealing for increasing the corrosion resistance

Avoiding interfacial corrosion of thermally sprayed coated components is important.

Where base materials have to be coated with electrochemically more negative spray materials (e.g. steel with nickel alloys), the galvanic series is significant and has to be considered. Several sealants are available on the market such as liquid phenol resin, hard wax, anaerobic materials etc.

4.1.4 Sealing for influencing friction and sliding properties

The friction and sliding coefficient of thermally sprayed coatings can be decreased by applying appropriate sealers (e.g. Poly Tetra Fluor-Ethylene (PTFE)). Thus the friction and sliding properties are improved.

4.1.5 Sealing for achieving special surface properties

Beside the application fields named above several suitable sealers exist in order to achieve special surface properties.

Examples are as following:

EXAMPLE 1 Sealing of thermally sprayed coatings for electrical insulation in order to avoid penetration of moisture, for instance into an alumina coating which will reduce the insulation.

EXAMPLE 2 Sealing in order to achieve anti sticking properties, e.g. glue applying rolls.

EXAMPLE 3 Sealing in order to achieve wetting or non-wetting (hydrophilic / hydrophobic). The printing industry is a typical example for this application.

EXAMPLE 4 Sealing in order to achieve visual properties as is required for artistic pieces or architectural effects.

4.2 Chemical conversion

For visual purposes metallic thermally sprayed coatings can be chemically post treated. By wiping with suitable solutions colouring of the metal spray coating can be achieved.

4.3 Painting

Thermally sprayed coatings may be painted in order to improve the aesthetic appearance and also increase lifetime of corrosion protective Al-/Zn-coatings. In the case where zinc or aluminium sprayed coatings are covered with an organic coating, it shall be applied directly after thermal spraying (see EN ISO 2063). According to EN ISO 12944-5 the space of time is limited to maximum 4 h.

NOTE Special care should be taken when painting porous coatings to avoid blistering (bubbling). Normally low viscosity paints or wash primers are used.

5 Thermal treatment

5.1 Fusing

Flame sprayed self-fluxing alloys (NiCrBSi and others) are usually post-treated by fusing (see EN ISO 14920).

5.2 Diffusion annealing

In special cases thermally sprayed coatings can be post treated by a diffusion annealing procedure which provides diffusion between the coating and the substrate, thus increasing the bond strength. This process shall be carried out in a vacuum chamber, or in a controlled inert atmosphere in order to avoid an undesired oxide formation within and on the coating.

5.3 Hot isostatic pressing

The density and adhesion of thermally sprayed coatings may be enhanced by subjecting the coated component to a hot isostatic treatment in a controlled manner.

6 Health and safety

In carrying out these treatments all protective labour and environmental guide lines for the processes and procedures shall be followed.

Annex A
(informative)

Some estimated values for chip cutting of thermally sprayed coatings

Table A.1 — Chip cutting applying hard metal tools on thermally sprayed coatings (non fused)

coating hardness X	hard metal quality	cutting angle	clearance angle	cutting velocity (m/min)	feed (mm/revolution)		cutting depth (mm)		cooling
					rough machined	finish-machined	rough machined	finish-machined	
X < 200 HV (95 HRB)	K10	+8° to 10°	5°	up to 70	0,2	0,05 to 0,08	0,5	0,05	no
200 HV (95 HRB) ≤ X < 300 HV (30 HRC)	K10	+5°	5°	up to 50	0,1 to 0,2	0,05 to 0,08	0,5	0,05	no
300 HV (30 HRC ≤ X ≤ 700 HV (60 HRC)	K01	-5°	5°	up to 30	0,1 to 0,2	0,05 to 0,08	0,5	0,05	no

Table A.2 — Chip cutting applying hard metal tools on thermally sprayed coatings (fused)

coating hardness X	hard metal quality	cutting angle	clearance angle	cutting velocity (m/min)	feed (mm/revolution)		cutting depth (mm)		cooling
					rough machined	finish-machined	rough machined	finish-machined	
X < 200 HV (95 HRB)	K10	+5°	5°	up to 50	0,1 to 0,2	0,05 to 0,08	0,5	0,05	yes
200 HV (95 HRB) ≤ X < 300 HV (30 HRC)	K01	- 5°	5°	up to 30	0,1 to 0,2	0,05 to 0,08	0,5	0,05	yes
300 HV (30 HRC ≤ X ≤ 700 HV (60 HRC)	K01	- 5°	5°	up to 20	0,1 to 0,2	0,05 to 0,08	0,5	0,05	no

Table A.3 — Chip cutting applying boron nitride tools on thermally sprayed coatings (non fused)

coating hardness X	cutting angle	clearance angle	cutting velocity (m/min)	feed (mm/revolution)		cutting depth (mm)		cooling
				rough machined	finish-machined	rough machined	finish-machined	
X = 350 HV (35 HRC)	+5°	5°	up to 170	up to 0,1	up to 0,05	0,5	0,05	no

Table A.4 — Chip cutting applying boron nitride tools on thermally sprayed coatings (fused)

coating hardness X	cutting angle	clearance angle	cutting velocity (m/min)	feed (mm/revolution)		cutting depth (mm)		cooling
				rough machined	finish-machined	rough machined	finish-machined	
500 HV (50 HRC) ≤ X < 700 HV (60 HRC)	-5°	5°	100 to 160	up to 0,1	up to 0,08	0,3	0,05	yes
X = 700 HV (60 HRC)	-5°	5°	up to 80	up to 0,1	up to 0,08	0,3	0,05	yes

Annex B
(informative)

Some estimated values for grinding of thermally sprayed coatings

Table B.1 — Grinding applying silicon carbide and corundum wheels on thermally sprayed coatings (non fused)

coating material	coating hardness	grinding procedure	abrasive	particle size / mesh	degree of hardness	structure	type of binding	surface speed (m/min)	cooling
Ni/Cr-Alloy		external cylindrical grinding	89A	80	Jot	8A	V	25 to 30	yes
		surface grinding	80A	54	I	9A	V	20 to 25	yes
		Internal grinding	80A	60	Jot	8A	V	15 to 20	yes
Cu/Al-Alloy		external cylindrical grinding	1C	80/2	H	8A	V	25 to 30	yes
		surface grinding	1C	54/2	I	7	V	20 to 25	yes
		Internal grinding	1C	46	I	5	V	15 to 20	yes
Ceramic Alloy	X > 700 HV	external cylindrical grinding	5C	70/7	Jot	5/82	Ke (V)	25 to 30	yes

Table B.2 — Grinding applying silicon carbide and corundum wheels on thermally sprayed coatings (fused)

coating material	coating hardness (HRC)	grinding procedure	abrasive	particle size / mesh	degree of hardness	structure	type of binding	surface speed (m/min)	cooling
Ni/Cr-Alloy	35 to 45	external cylindrical grinding	C	60	K	5	V	25 to 30	yes
		surface grinding	C	60	Jot	7	V	20 to 25	yes
		Internal grinding	C	46	I	5	V	15 to 20	yes
Ni/Cr-Alloy	45 to 60	external cylindrical grinding	C	80	H	8	V	25 to 32	yes
		surface grinding	C	80	I	8	V	25 to 32	yes
		Internal grinding	C	60	H	5	V	15 to 20	yes
WC-/NiCr-Alloy	> 60	external cylindrical grinding	C	80	I	8	V	18 to 25	yes
		surface grinding	C	80	I	8	V	18 to 25	yes
		Internal grinding	C	60	H	5	V	15 to 20	yes

Table B.3 — External cylindrical grinding using diamond wheels on thermally sprayed coatings (fused and ceramic coatings)

coating material	coating hardness (HRC)	particle size / mesh	concentration	wet	dry	synthetic resin binding (B) surface speed (m/min)	metallic binding (M) surface speed (m/min)
WC-/NiCr-alloy	60 to 75	D151	75	no	yes	8 to 16	8 to 12
		D151	75	yes	no	18 to 22	12 to 28
ceramic alloy		D151	75	yes	no	18 to 22	12 to 28

Annex C
(informative)

Information on abrasives

1. abrasive	2. particle size / mesh	3. degree of hardness	4. structure	5. type of binding
	The particle size is given by a number which relates to a mesh of a sieve.	Degree of hardness corresponds to a strength binding each abrasive particle.	The structure number characterises the relation between abrasive.	There are two types of binding groups.
standard grade corundum: 11A, 12A, 14A semi high grade corundum 41A, 42A, 43A high grade corundum 81A, 82A, 85A, 89A silicon carbide 1C, 2C	very rough 8, 10, 12, 14 rough 16, 20, 24, 30, 36 medium 46, 54, 60, 70, 80 fine 90, 100, 120, 150, 180, 220 very fine 240, 280, 320, 400, 500, 600, 800, 1000	extremely soft A, B, C, D very soft E, F soft G, H, I medium Jot, K, L, M hart N, O, P, Q very hart R, S, T extremely hart U, V, W, X, Y, Z	dense 1, 2, 3 medium 4, 5, 6 open 7, 8, 9 very open 10, 11, 12, 13, 14	**1.** binding of inorganic basis (hard) V: glazed, based on glass- or ceramic basis, burning temperature up to 1300°C S: silicate binding Mg: magnetise binding **2.** binding of organic basis (soft) B and BF: synthetic resin E: shellac binding R and RF: india rubber binding
Example for designation:				
1C	**80**	**H**	**5**	**V**

ICS 25.220.20

Price based on 10 pages