SLOVENSKI STANDARD
SIST EN 657:2005

01-maj-2005

Nadomeğļ a:
SIST EN 657:1999

Vroļ e brizganje - Terminologija, razvrstitev

Thermal spraying - Terminology, classification

Thermische Spritzen - Begriffe, Einteilung

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Projection thermique - Terminologie, classification

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ICS:

01.040.25	Izdelavna tehnika (Slovarji)	Manufacturing engineering (Vocabularies)
25.220.20	Površinska obdelava	Surface treatment

SIST EN 657:2005 **en**

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 657

March 2005

ICS 01.040.25; 25.220.20

Supersedes EN 657:1994

English version

Thermal spraying - Terminology, classification

Projection thermique - Terminologie, classification

Thermische Spritzen - Begriffe, Einteilung

This European Standard was approved by CEN on 3 February 2005.

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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 Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 657:2005) 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of an identical text or by endorsement, at the latest by September 2005, and conflicting national standards shall be withdrawn at the latest by September 2005.

This document supersedes EN 657:1994.

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.

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1 Scope

This document defines processes and general terms for thermal spraying. It classifies thermal spraying processes according to type of spray material, to type of operation and to type of energy carrier.

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 14923, *Thermal spraying — Characterization and testing of thermal sprayed coatings (ISO 14923:2003)*

EN ISO 17836, *Thermal spraying — Determination of the deposition efficiency for thermal spraying (ISO 17836:2004)*

3 Terms and definitions

For the purposes of this document, the following term and definition applies.

3.1
thermal spraying (TS)
process in which surfacing materials are heated to the plastic or molten state, inside or outside of the spraying gun/torch, and then propelled on to a prepared surface; the substrate remains unmelted

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NOTE To obtain specific properties of the deposit, a subsequent thermal, mechanical or sealing treatment may be used.

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4 Process variations

4.1 Classification according to the type of spray material

Distinction of the following variations:

- wire spraying;
- rod spraying;
- cord spraying;
- powder spraying;
- molten-bath spraying.

4.2 Classification according to the operation

4.2.1 Manual spraying

All operations typical of the spraying process are manual.

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4.2.2 Mechanised spraying

All operations typical of the spraying process are mechanised.

4.2.3 Automatic spraying

All operations typical of the spraying process are fully mechanised including all handling, e.g. workpiece loading and unloading, and are integrated in a programmed system.

4.3 Classification according to the energy carrier – Abbreviations of spray processes listed

In classification according to the energy carrier sub-classifications are necessary due to different spray materials. Annex A provides a master chart of the spray processes with sub-classifications.

Table 1 — Classification and abbreviations of spray processes

Spray processes – Classification according to energy carrier		Process abbreviations	Process description in subclause
TS by atomising a melt	Molten-bath spraying	MBS	5.1
TS by means of gaseous or liquid fuels	Wire flame spraying	WFS	5.2.2
	High velocity wire flame spraying	HVWFS	5.2.3
	Powder flame spraying	PFS	5.2.4
	High velocity flame spraying	HVOF	5.3 / 5.3.1 / 5.3.2
	Detonation spraying	DGS	5.4
TS by means of expansion of highly pressurised gases without combustion	Cold spraying	CGS	5.5
TS by means of electric arc or gas discharge	Arc spraying	AS	5.6.1
	Shrouded arc spraying	SAS	5.6.2
	Plasma spraying in air	APS	5.7.1
	Shrouded plasma spraying	SPS	5.7.2
	Plasma spraying in a chamber under vacuum	VPS	5.7.3
	Plasma spraying in a chamber at pressures exceeding 1 bar	HPPS	5.7.3
	Liquid stabilised plasma spraying	LSPS	5.8.1
	Inductively coupled plasma spraying	ICPS	5.8.2
TS by means of a bundled light stream	Laser spraying	LS	5.9

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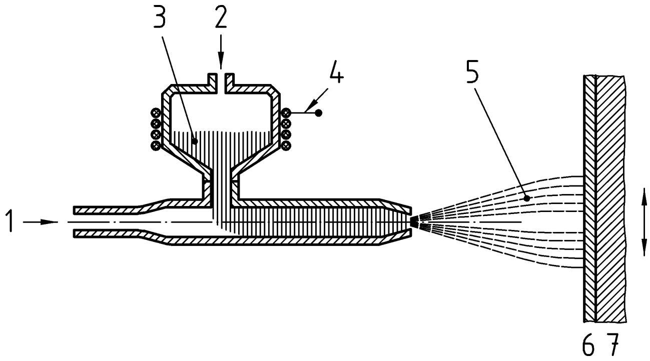
5 Process descriptions

5.1 Molten-bath spraying

A surfacing material is heated to the molten state, in most cases in a reservoir, and propelled on to the prepared substrate by a preheated atomising gas, e.g. compressed air. See Figure 1.



Key

1 Atomising gas
2 Gas inlet
3 Molten metal
4 Resistance heating
5 Spray stream
6 Spray deposit
7 Substrate

Figure 1 — Molten-bath spraying

5.2 Flame spraying

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5.2.1 General

Flame spraying is a process in which a surfacing material is heated in an oxy-fuel gas flame and then propelled in atomised form on to a substrate. The material may be initially in the form of powder, rod, cord or wire. The hot material is projected on to the substrate by the oxy-fuel gas jet alone or with the additional aid of an atomising gas, e.g. compressed air.

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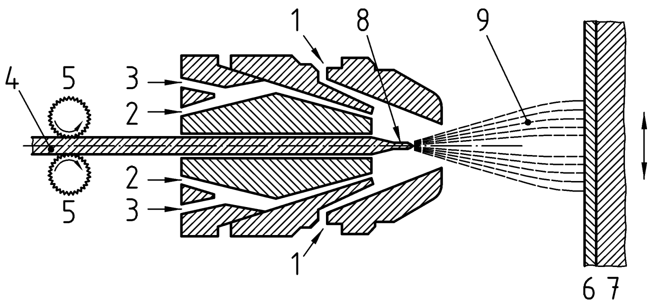
5.2.2 Wire flame spraying

In wire flame spraying, the metal wire to be deposited is supplied to the gun continuously. It is heated to the molten state by the oxy-fuel gas flame and propelled on to the prepared substrate surface by the additional aid of an atomising gas, e.g. compressed air. See Figure 2.



Key

1 Compressed air
2 Fuel gas
3 Oxygen
4 Wire or rod
5 Wire feed mechanism
6 Spray deposit
7 Substrate
8 Melting wire tip
9 Spray stream

Figure 2 — Wire flame spraying

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The fuel gases predominantly used are, e.g. acetylene, propane and hydrogen.

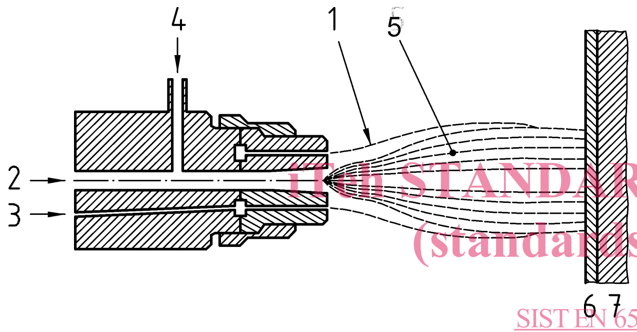
Variations are rod flame spraying where cut lengths of material rod are used, and cord flame spraying where cords of surfacing material are used.

5.2.3 High velocity wire flame spraying

Essential higher gas pressures are used for high velocity wire flame spraying contrary to processes usually applied. Consequently, a finer atomisation of the molten wire tip and higher particle velocities are obtained. In addition, these systems use a stream of compressed air, which serves for cooling as well as for accelerating the flame stream. The coating properties are improved due to less porosity and higher tensile adhesive strength.

5.2.4 Powder flame spraying

With this method, the material to be sprayed is supplied to the gun in powder form and heated to the plastic or partially or completely molten state in the oxy-fuel gas flame. It is propelled on to the prepared substrate by the expanding fuel gas. In some cases, an additional gas jet may be used to accelerate the powder particles. See Figure 3.



Key

1 Flame
2 Fuel gas
3 Oxygen
4 Powder and carrier gas
5 Spray stream
6 Spray deposit
7 Substrate

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Figure 3 — Powder flame spraying

5.3 High velocity flame spraying

5.3.1 High velocity flame spraying with gaseous fuel

In high velocity flame spraying continuous combustion is obtained in the combustion chamber which, in conjunction with the expanding nozzle, produces an extremely high velocity in the gas jet. The spray material is injected axially into the combustion chamber or radially into the high velocity gas stream.

The location to the powder injection will result in a different dwell time in the flame, which will affect the particle velocity and temperature. Coatings of high density and adhesion are produced by the high kinetic energy imparted to the spray stream. See Figure 4.

Fuel gases like acetylene, propane, propylene, methylacetylene-propadene and hydrogen can be applied.

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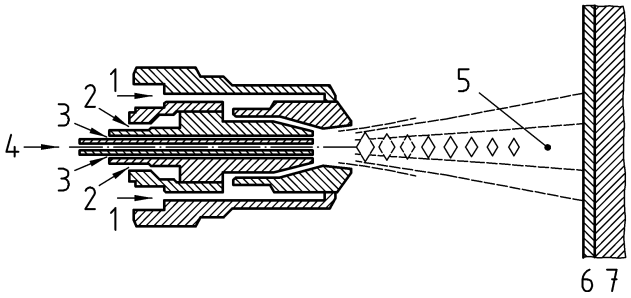


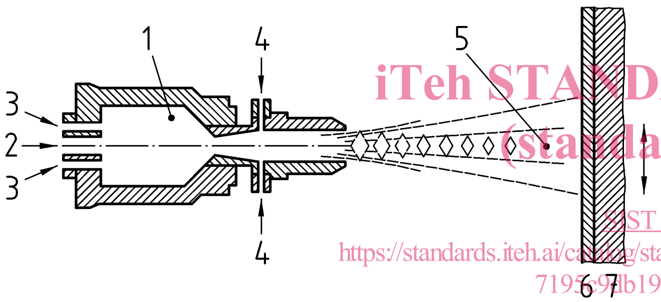
Key

1 Compressed air
2 Fuel gas
3 Oxygen
4 Powder and carrier gas
5 Spray stream
6 Spray deposit
7 Substrate

Figure 4 — High velocity flame spraying with gaseous fuels

5.3.2 High velocity flame spraying with liquid fuel

In high velocity flame spraying with liquid fuel like kerosene, N-paraffin a. o. higher combustion pressure are applied compared to spraying with gaseous fuel. The spray powder is radially injected at a position, where the combustion gases are expanded completely and already somewhat cooled down. This creates coatings of higher density and higher adhesive strength values. Eventually, residual stresses on pressure may be generated in the coating. See Figure 5.



Key

1 Combustion chamber
2 Liquid fuel
3 Oxygen
4 Powder and carrier gas
5 Spray stream
6 Spray deposit
7 Substrate

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Figure 5 — High velocity flame spraying with liquid fuels

5.4 Detonation spraying

In detonation spraying, the gun contains a chamber into which certain quantities of a powder are injected. The gas mixture in the chamber is detonated at controlled intervals. This creates a hot, high velocity gas stream that heats the powder to its plastic or partially or completely molten state and accelerates the particles as they leave the gun barrel.

The detonation gun consists of the barrel and the gun chamber. The injected gas and powder mixture are ignited by an electric spark. The resulting shock wave generated in the barrel accelerates the particles, which are further heated in the flame front and are propelled in a directed jet on to the prepared substrate. Nitrogen is used to flush clean the gun chamber and barrel after every detonation. See Figure 6.

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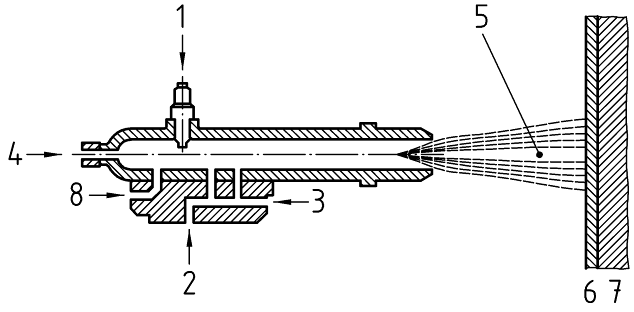

Key

1 Ignition
2 Fuel gas
3 Oxygen
4 Powder and carrier gas
5 Spray stream
6 Spray deposit
7 Substrate
8 Flush gas nitrogen

Figure 6 — Detonation spraying

5.5 Cold spraying

In the cold spraying process a gas (especially nitrogen) is accelerated to supersonic velocity in a de-Laval-type nozzle. The spray material is injected into the gas jet in powder form upstream of the nozzle and then propelled with high kinetic and less thermal energy on to the substrate. Above a certain particle velocity which is characteristic of the respective spray material, the particles form a dense and solid adhesive coating upon impact. External heating up the gas jet – e.g. in an electric heated continuous heater – increases the flow velocity of the gas and also the particle velocity. The related rise in particle temperature assists the deformation upon impact. However, the gas temperature is clearly below the melting temperature of the spray material, which means the particles cannot be melted in the gas jet.

Consequently, drawbacks like oxidation and other phase transformations can be avoided. Figure 7 shows the process schematically.

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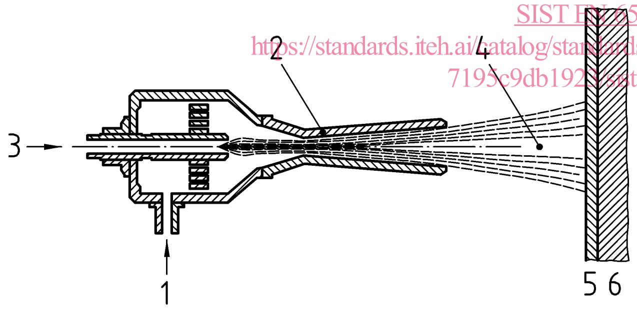

Key

1 Process gas
2 Laval nozzle
3 Powder and carrier gas
4 Spray stream
5 Spray deposit
6 Substrate

Figure 7 — Cold spraying

5.6 Arc spraying processes

5.6.1 Arc spraying

Arc spraying utilises an electric arc between two wires to melt their tips; the wires may be of identical or dissimilar composition. A jet or jets of gas, normally compressed air, atomises the molten metal and projects the particles on to the prepared substrate. See Figure 8.