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Thermal spraying — Terminology, classification

Projection thermique — Terminologie, classification

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Foreword

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*.

This second edition cancels and replaces the first edition (ISO 14917:1999), which has been technically revised.

Introduction

Requests for official interpretations of technical aspects of this document should be directed to the Secretariat of ISO/TC 107, *Metallic and other inorganic coatings*, via your national standards body; a listing of these bodies can be found at www.iso.org.

Thermal spraying — Terminology, classification

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. It specifies abbreviations for spray processes, sprayed coatings, and manufacturing steps.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

ISO 17836, *Thermal spraying — Determination of the deposition efficiency for thermal spraying*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

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 onto a prepared surface

Note 1 to entry: The substrate may undergo some localized surface melting in the particle impact area only.

Note 2 to entry: To obtain specific properties of the deposit, a subsequent thermal, mechanical or sealing treatment may be used.

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;

— suspension spraying.

4.2 Classification according to the operation

4.2.1 Manual spraying

All operations typical of the spraying process are manual.

4.2.2 Mechanized spraying

All operations typical of the spraying process are mechanized.

4.2.3 Automatic 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. Also, monitoring and controlling of the entire spraying process can be included according to the closed loop method.

4.3 Classification and abbreviations for thermal spraying, coatings and their technological properties, post-treatments

4.3.1 Thermal spraying, coatings and properties

See Table 1.

Table 1 — Thermal spraying, coatings and properties (abbreviations in capital letter)

Abbreviation	Item	Specified in section	Specified in a standard
TS	Thermal spraying (in general)	3.1	—
BC	Bond coat	6.4.3	—
TC	Top coat	6.4.4	—
SF	Self-fluxing alloy		ISO 14920/ISO 14232
DE	Deposition efficiency	6.3.16	ISO 17836
R_H	Tensile adhesive strength	6.5.1	ISO 14916

4.3.2 Condition of spray coatings and post-treatments

See Table 2.

Table 2 — Condition of spray coatings and post-treatments (abbreviations in small letters)

Abbreviation	State	Specified in standard resp. described in section
as	as sprayed	6.4.1
f	fused	ISO 14920
sm	linished	ISO 14924
m/c	machined	ISO 14924
s	sealed	ISO 14924

4.3.3 Classification according to the energy carrier and/or to the type of spray material — Abbreviations for spray processes and special surfacing processes by welding

In classification according to the energy carrier, sub-classifications are necessary due to different spray materials. Figure A.1 provides a master chart of the spray processes with sub-classifications. See also Tables 3 and 4.

Table 3 — Classification and abbreviations of spray processes (abbreviations in capital letters)

Standard spray processes		Process abbreviations	Process description in section
TS by means of gaseous or liquid fuels	**Flame spray processes**		5.1
	Wire flame spraying (Combustion wire spray)	WFS	5.1.2
	Cord flame spraying	CFS	5.1.2
	Rod flame spraying	RFS	5.1.2
	Powder flame spraying	PFS	5.1.3
	High velocity flame spraying		5.2
	High velocity oxy-fuel spraying	HVOF	5.2.1
	High velocity air fuel spraying	HVAF	5.2.1
	High velocity flame suspension spraying	HVFSS	5.2.3
	Detonation spraying (Detonation gun spr.)	DGS	5.2.4
TS by means of expansion of highly pressurized gases without combustion	Cold spraying (Cold gas spraying)	CGS	5.3
TS by means of electric arc or gas discharge	Arc spraying (Arc wire spraying)	AS	5.4
	Atmospheric plasma spraying	APS	5.5.1
	Atmospheric plasma suspension spraying	APSS	5.5.2
	Vacuum plasma spraying/ Low pressure plasma spraying	VPS (Europe) LPPS™ (US, Asia)[a]	5.5.3
	Controlled atmosphere plasma spraying	CAPS	
TS by means of electric arc or gas discharge (only few users)	Water-stabilized plasma spraying	WSPS	5.6.1
	Inductively coupled plasma spraying	ICPS	5.6.2
	Plasma transferred wire arc spraying	PTWA	5.6.3

[a] LPPS™ is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

Table 4 — Classification and abbreviations of special surfacing processes by welding (abbreviations in capital letters)

Special surfacing processes by welding		Process abbreviations	Process description in section
Surfacing by means of a bundled beam of light	Laser cladding	LC	5.7
Surfacing by means of electric arc or gas discharge	Plasma transferred arc surfacing	PTA	5.8

5 Process descriptions

5.1 Flame spraying

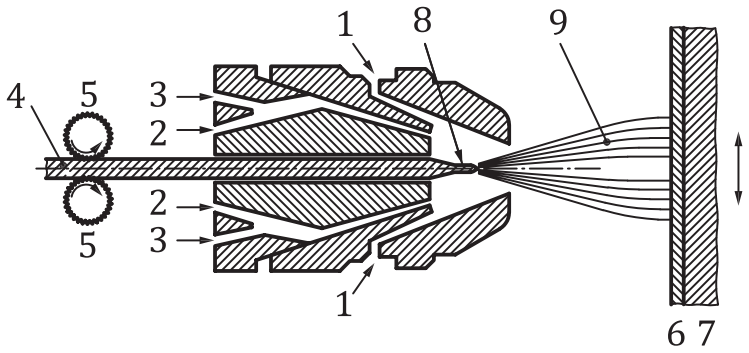
5.1.1 General

Flame spraying is a process in which a surfacing material is heated in an oxy-fuel gas flame and then propelled onto a substrate. The material may be initially in the form of powder, rod, cord or wire. The

hot material is projected onto the substrate by the oxy-fuel gas jet alone or with the additional aid of an atomizing gas, e.g. compressed air.

5.1.2 Wire flame spraying (Combustion wire spray)

In wire flame spraying, the metal wire (solid or cored wire type) to be deposited is supplied to the gun continuously. It is heated to the molten state by the oxy-fuel gas flame and propelled onto the prepared substrate surface by the additional aid of an atomizing gas, e.g. compressed air. See Figure 1.



Key

1	compressed air	6	spray deposit
2	fuel gas	7	substrate
3	oxygen	8	melting wire tip
4	wire cord or rod	9	spray stream
5	wire feed mechanism		

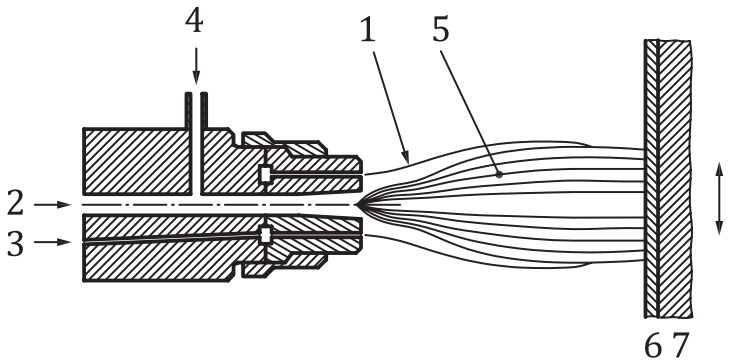
Figure 1 — Wire flame spraying

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

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

5.1.3 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 onto 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 2.



Key

1	flame	5	spray stream
2	fuel gas	6	spray deposit
3	oxygen	7	substrate
4	powder and carrier gas		

Figure 2 — Powder flame spraying

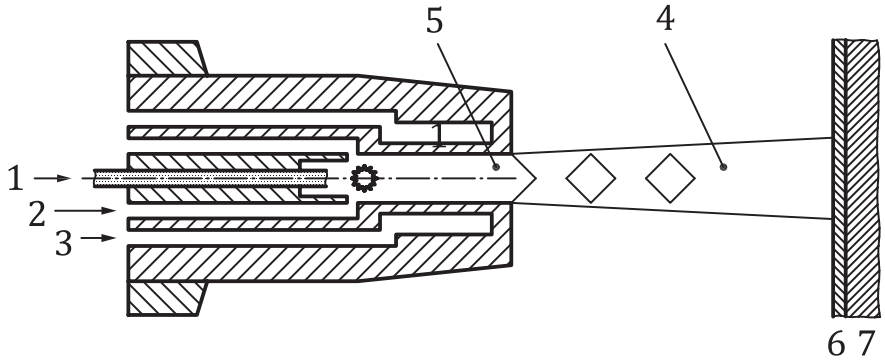
5.2 High velocity flame spraying

5.2.1 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 radial into the high velocity gas stream. Pressurized air or nitrogen is commonly used as shroud gas.

The location of the powder injector 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 3.

Fuel gases like acetylene, propane, propylene, methyl-acetylene-propadiene and hydrogen can be used in conjunction with oxygen (HVOF) or air (HVAF) in order to create the combustion.



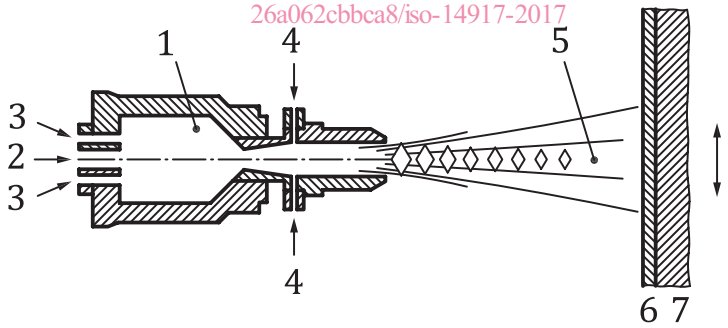
Key

1	powder and carrier gas	5	combustion
2	oxygen fuel resp. air fuel	6	spray deposit
3	burner cooling (water or air)	7	substrate
4	spray jet		

Figure 3 — High velocity flame spraying with gaseous fuels

5.2.2 High velocity flame spraying with liquid fuel

In high velocity flame spraying with liquid fuel like kerosene, N-paraffin[1)], etc., higher combustion pressure is created as compared to spraying with gaseous fuel. The spray powder is radially injected at a position where the combustion gases are already fully expanded and somewhat cooled down. This creates coatings of higher density and higher adhesive strength values. Occasionally, residual compressive stresses may be created in the coating. See Figure 4.



Key

1	combustion chamber	5	spray stream
2	liquid fuel	6	spray deposit
3	oxygen/air	7	substrate
4	powder and carrier gas		

Figure 4 — High velocity flame spraying with liquid fuel

5.2.3 High velocity flame suspension spraying

Suspensions represent an alternative feedstock material. Use of suspensions focuses mainly on APS and HVOF spraying. Their use is currently emerging. Suspensions are mostly based on water and alcohol

1) N-paraffin is in common use in US.