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**Thermal spraying — Terminology,
classification**

Projection thermique — Terminologie, classification

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International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet iso@iso.ch

Printed 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 3.

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.

International standard, ISO 14917, was prepared by the European Committee for Standardization (as EN 657) and was adopted, under a special "fast-track procedure", by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings* in parallel with its approval by the ISO member bodies.

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Thermal spraying — Terminology, classification

1 Scope

This International Standard 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 normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document listed below. For undated references, the latest editions of the normative documents referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

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

ISO 6508:1986, *Metallic materials — Hardness test — Rockwell test (scales A - B - C - D - E - F - G - H - K).*

ISO 14916:1999, *Thermal spraying — Determination of tensile adhesive strength.*

3 Term and definition

For the purposes of this standard the following definition applies.

3.1 thermal spraying

processes 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 unfused

NOTE 1 Spray coatings can be applied by thermal spraying of material in its liquid or plastic pasty state.

NOTE 2 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;
- molten bath 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.

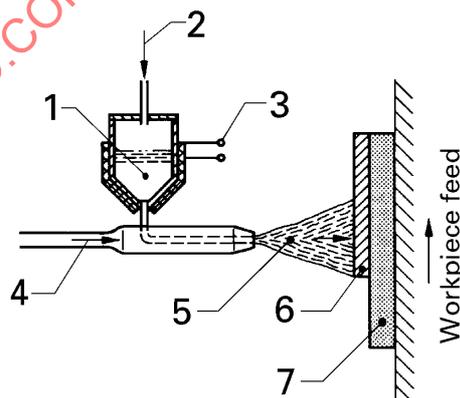
4.2.3 Automatic spraying

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.

4.3 Classification according to the energy carrier

4.3.1 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 atomizing gas, e.g., compressed air. See Figure 1.



Key

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

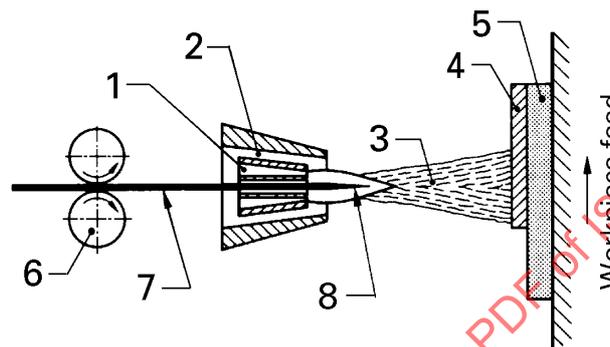
Figure 1 — Molten-bath spraying

4.3.2 Flame spraying

Flame spraying is a process in which a surfacing material is heated in an oxyfuel gas flame and then propelled in atomized 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 oxyfuel gas jet alone or with the additional aid of an atomizing gas, e.g., compressed air.

4.3.2.1 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 oxyfuel gas flame and propelled on to the prepared substrate surface by the additional aid of an atomizing gas, e.g., compressed air. See Figure 2.



Key

- | | |
|------------------|----------------------------------|
| 1 Gas mixture | 5 Substrate |
| 2 Compressed air | 6 Adjustable wire feed mechanism |
| 3 Spray stream | 7 Spray wire |
| 4 Spray deposit | 8 Melting wire tip |

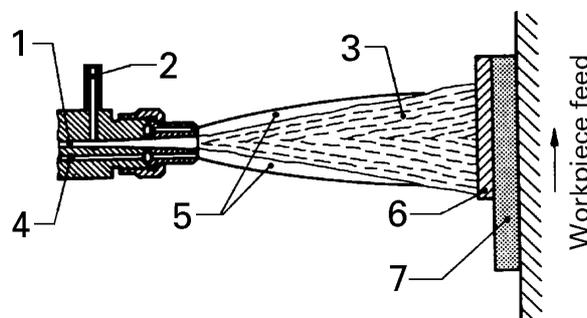
Figure 2 — Wire flame spraying

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.

4.3.2.2 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 molten state in the oxyfuel gas flame. It is propelled on to the prepared substrate by the expanding fuel gases. In some cases, an additional gas jet may be used to accelerate the powder particles. See Figure 3.



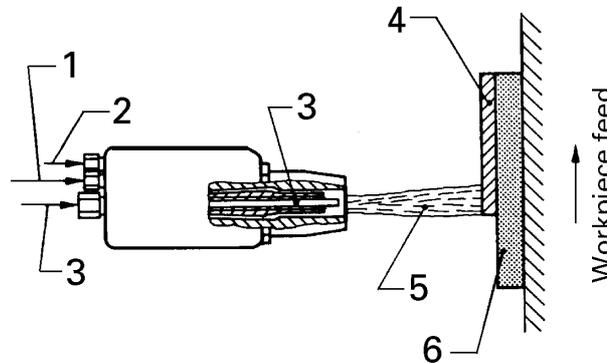
Key

- | | |
|----------------|-----------------|
| 1 Carrier gas | 5 Flame |
| 2 Powder inlet | 6 Spray deposit |
| 3 Spray stream | 7 Substrate |
| 4 Gas mixture | |

Figure 3 — Powder flame spraying

4.3.3 High velocity flame spraying

In high velocity flame spraying, continuous combustion is obtained in a combustion chamber. The high pressure generated in the chamber, in conjunction with an expanding nozzle at the chamber outlet, produce a particularly high velocity of flow in the gas jet. Material is fed into the high velocity gas stream, ensuring a rapid acceleration of the particles. See Figure 4.



Key

- | | |
|--------------------------|-----------------|
| 1 Fuel gas | 4 Spray deposit |
| 2 Oxygen | 5 Spray stream |
| 3 Powder and carrier gas | 6 Parent metal |

NOTE Blowpipe nozzle with or without water cooling.

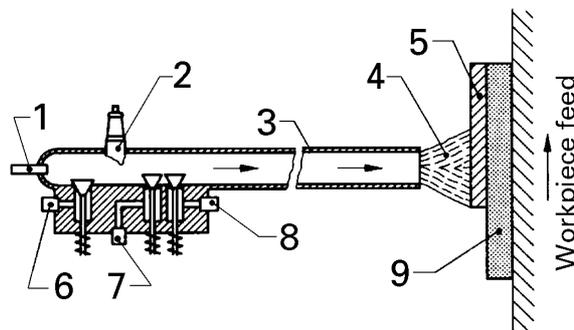
Figure 4 — High velocity flame spraying

Fuel gases, such as acetylene, propane, propylene, methylacetylene-propadiene, and hydrogen may be used, and liquid fuels, such as diesel or kerosene, may also be used.

4.3.4 Detonation spraying

In detonation spraying, the gun contains a chamber into which are injected certain quantities of a powder. 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 molten state and accelerates the particles as they leave the gun barrel.

The so-called *detonation gun* consists of the barrel and the gun chamber. The injected gas and powder mixture are detonated 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 5.



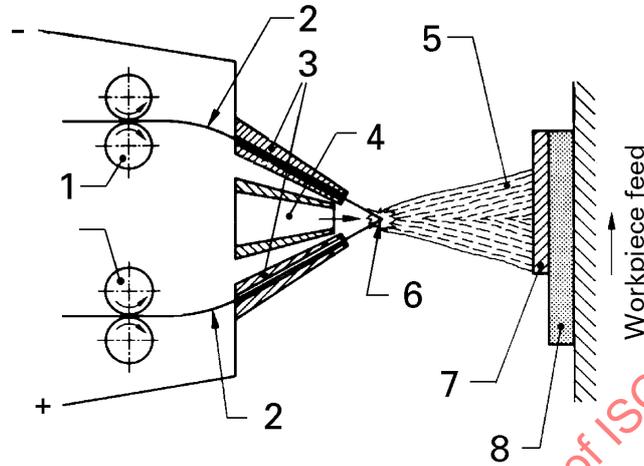
Key

- | | |
|-----------------|----------------|
| 1 Powder inlet | 6 Nitrogen gas |
| 2 Ignition | 7 Acetylene |
| 3 Gun barrel | 8 Oxygen |
| 4 Spray stream | 9 Substrate |
| 5 Spray deposit | |

Figure 5 — Detonation spraying

4.3.5 Arc spraying

Arc spraying utilizes 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, atomizes the molten metal and projects the particles on to the prepared substrate. See figure 6.



Key

- | | |
|----------------------------------|--------------------------------|
| 1 Adjustable wire feed mechanism | 5 Spray stream |
| 2 Spray wire | 6 Wire tips melting in the arc |
| 3 Contact tubes | 7 Spray deposit |
| 4 Atomizing gas | 8 Substrate |

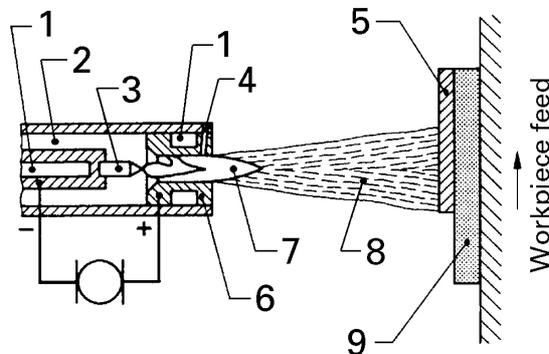
Figure 6 — Arc spraying

4.3.6 Plasma spraying

4.3.6.1 Plasma spraying in air

In plasma spraying in the atmosphere, a plasma jet is used to heat the spray material to its plastic or molten state and project it on to the prepared surface of the substrate. The powder may be injected by means of carrying gas into the plasma jet inside (internal feed) or outside (external feed) the nozzle.

The plasma is produced by an arc established between the electrode (cathode) and the nozzle (anode) (partial or complete ionization of the plasma gases), and the high velocity of the plasma jet emerging from the nozzle is generated by the thermal expansion of the gases. The plasma gases commonly used are argon, hydrogen, helium, nitrogen or mixtures of these gases. See Figure 7.



Key

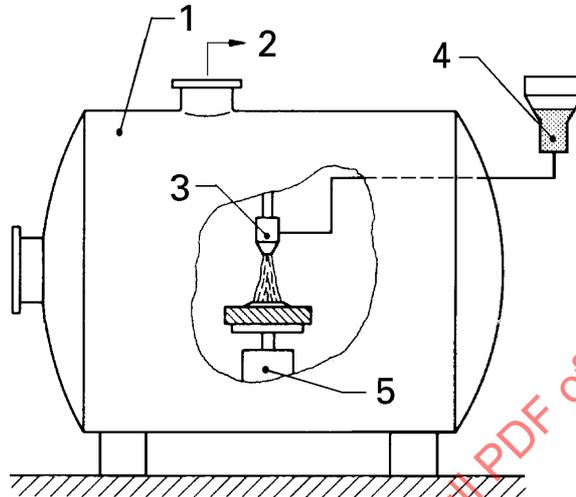
- | | | |
|-----------------|----------------|----------------|
| 1 Cooling water | 4 Powder inlet | 7 Plasma flame |
| 2 Plasma gas | 5 Spray stream | 8 Spray stream |
| 3 Cathode | 6 Anode | 9 Substrate |

Figure 7 — Plasma spraying in air

4.3.6.2 Plasma spraying in chambers

Plasma spraying is done in a sealed chamber containing a defined gas atmosphere.

The plasma gases commonly used are argon, helium, hydrogen, nitrogen or mixtures of these gases. Manipulation of torch and workpiece is done via suitable handling systems. Powder is continuously fed into the torch from external feeder units suitable for the specified conditions. See Figure 8.



Key

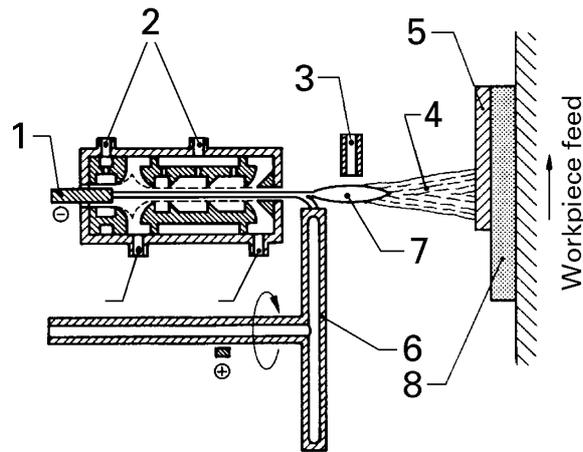
- | | |
|--------------|--------------------|
| 1 Chamber | 4 Powder feeder |
| 2 Pump | 5 Workpiece holder |
| 3 Plasma gun | |

Figure 8 — Plasma spraying in a chamber

Vacuum plasma spraying is a special case where the pressure in the chamber is reduced. Plasma spraying in chambers may also be done at elevated pressure. In the chamber, when the atmosphere is controlled, a substrate and deposit cooling system by jets of liquid gas sprayed in the form of fine droplets may, also, be combined.

4.3.6.3 Liquid-stabilized plasma spraying

In liquid-stabilized plasma spraying, the plasma gas is generated from liquids, e.g., water, ethanol or methanol. Between a graphite cathode and a rotating, water-cooled anode, an arc is established. The liquid is introduced into the chamber with a swirling motion to stabilize the arc and produce the plasma jet. The continuously regenerated sheath of liquid provides thermal, as well as electrical, insulation against the chamber wall and, at the same time, serves as a coolant. Some part of the stabilizing liquid evaporates and the high temperatures present in the chamber provide its dissociation and ionisation. The spray material is introduced into the high velocity plasma jet outside the nozzle, heated to the plastic or molten state and projected onto the prepared substrate. See figure 9.



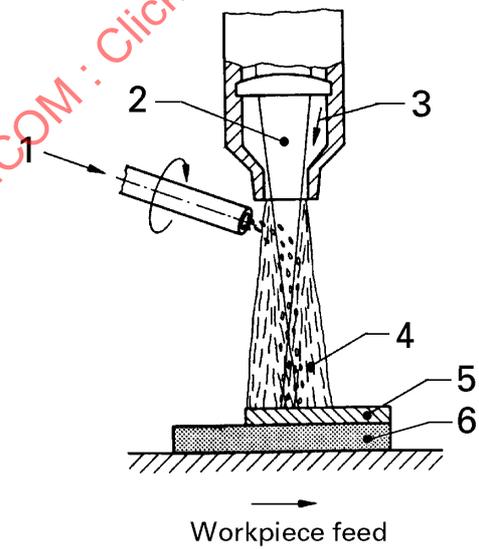
Key

- | | |
|----------------|-----------------|
| 1 Cathode | 5 Spray deposit |
| 2 Liquid inlet | 6 Anode |
| 3 Powder inlet | 7 Plasma |
| 4 Spray stream | 8 Substrate |

Figure 9 — Liquid-stabilised plasma spraying

4.3.7 Laser spraying

The process of laser spraying is characterized by the injection of a powder in the laser beam using a suitable powder nozzle. The laser radiation melts the powder. The spray particles are projected to the substrate by the carrier gas and by gravity. The deposit may be protected by a shielding gas. See Figure 10.



Key

- | | |
|-----------------|-----------------|
| 1 Powder | 4 Spray stream |
| 2 Laser beam | 5 Spray deposit |
| 3 Shielding gas | 6 Parent metal |

Figure 10 — Laser spraying

5 General terms

5.1 Spray gun

Unit with which the spraying material is heated to the plastic or molten state, accelerated and projected on to the prepared substrate surface.

5.2 Spray material

Coating material for thermal spraying initially different in form and/or composition to suit the employed process variation and type of application.

5.3 Spray deposit

Spray material as deposited.

5.4 Carrier gas

Carrying gas for the injection of spray material in powder form into the hot gas stream or flame.

5.5 Atomizing gas

Gas for the atomization and acceleration of molten spray material in wire, rod or cord form.

5.6 Propellant gas

Gas utilized to accelerate or spray particles.

5.7 Spray distance

Distance between the nozzle face and the workpiece surface.

5.8 Spray angle

The angle between the centre of the spray stream and the workpiece surface.

5.9 Masking

Protective measure for areas of a workpiece that are not to be coated.

5.10 Spray particles

Plastic or molten particles that emerge from the spray gun.

5.11 Spray losses

Total loss of spray material resulting from evaporation, burn-off, projection outside the intended substrate area, and rebound, i.e., material not contributing to producing the desired deposit.

5.12 Spray efficiency

Ratio of total weight of spray deposit to total weight of spray material applied.

5.13 Sprayed coating

Deposit applied by thermal spraying.

5.14 Thermal treatment

Controlled heat treatment before, during and/or after the thermal spraying operation.