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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Thermal Spray Society (JTSS)/Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS H 8304** : 2017), which has been technically revised.

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Ceramic sprayed coatings

1 Scope

This Japanese Industrial Standard specifies requirements for ceramic sprayed coatings (hereafter referred to as sprayed coatings) applied to metallic substrates such as metallic parts and products, for the purposes of giving them wear resistance, corrosion resistance, heat resistance, heat insulation, electrical insulation or other desired characteristics.

2 Normative references

Part or all of the provisions of the following standards, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS C 2110-2 *Solid electrical insulating materials — Test methods for electric strength — Part 2 : Tests using direct voltage*

JIS G 3101 *Rolled steels for general structure*

JIS H 8200 *Thermal spraying terms*

JIS H 8250 *Graphical symbol for thermal spraying*

JIS H 8260 *Powders for thermal spraying*

JIS H 8261 *Wires, rods and cords for flame and arc thermal spraying*

JIS H 8302 *Build-up thermal spraying*

JIS H 8401 *Methods of thickness measurement for sprayed coatings*

JIS H 8402 *Test methods of tensile adhesive strength for thermal-sprayed coatings*

JIS H 8451 *Testing methods for measuring thermal cycle resistance and thermal shock resistance for thermal barrier coatings*

JIS Z 2244-1 *Vickers hardness test — Part 1 : Test method*

JIS Z 2371 *Methods of salt spray testing*

JIS Z 8402-6 *Accuracy (trueness and precision) of measurement methods and results — Part 6 : Use in practice of accuracy values*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS H 8200** apply.

4 Classification and symbols

The classification and symbols of sprayed coatings shall be as follows.

- a) Symbols indicating the thermal spraying, thermal spraying method, coating thickness and post-treatment shall be in accordance with **JIS H 8250**.
- b) Symbols indicating the classification of sprayed coatings shall be as follows.
 - 1) Symbol indicating the classification of oxide powders and phosphate powders given in Table 12 of **JIS H 8260**
 - 2) Symbol indicating the classification of oxide ceramics given in Table 9 of **JIS H 8261**

For a material which cannot be discriminated only by the above symbol, the above symbol shall be followed by a hyphen and a code number for the purpose of identification. For a sprayed coating for wear resistance specified in **6.3**, the symbol indicating the classification of the sprayed coating and the symbol with a number indicating the grade shall be used.

5 Spraying process

5.1 General

Thermal spraying shall be carried out in conformance with the requirements specified in **5.2** to **5.6** and with adequate attention to safety and health (see relevant laws and regulations).

An example of typical operation standard for thermal spraying is given in Annex A for reference.

5.2 Structure, shape and surface condition of sprayed product

The structure and shape of the product or part to be thermal sprayed shall not be such as to cause undelivered sprayed particles due to blind spots, deformation, or poor ventilation in the internal spraying operation of the product. The substrate surface should be free from significant deposits of oils and fats, etc. and noticeable oxidized scale, rust, flaws, etc.

5.3 Pretreatment

The substrate surface to be thermal sprayed shall be sufficiently cleaned by degreasing cleaning, oil removal, oxides removal, and roughened by abrasive blasting using an adequate blasting material so that it is brought to a dry and clean condition free from contaminants such as dust, oils and fats, oxidized scale and rust immediately before the test. Depending on the intended use of the sprayed product, the substrate surface shall be given a proper pretreatment (such as threading, grooving, knurling, slotting or undercoat spraying) to improve adhesiveness.

5.4 Thermal spraying

The thermal spraying shall be completed while the substrate surface of the sprayed product is clean and dry, and before any visible signs of oxidation are observed. The air used for thermal spraying or cooling shall be clean and dry. Where necessary, preheating shall be carried out for removing water and relaxing the thermal stress of the coating. The spraying angle shall be 90° whenever possible, and at least 45°. If neces-

sary, the thermal spraying shall be carried out with cooling.

5.5 Post-treatment

According to the intended use of the sprayed product, the sealing treatment, heating treatment, machining treatment, chemical treatment, etc. shall be carried out for improvement of coating function. The sealing treatment shall be carried out either by chemical reforming of the coating surface or by using an appropriate sealer to fill the pores of the coating.

5.6 Outdoor thermal spraying work

Thermal spraying materials, thermal spraying facilities or the like used for the outdoor thermal spraying work shall be adequately protected from exposure to the weather by means of e.g. a safe protective sheet so as to prevent deterioration by weathering and consequent adverse affects on the coating quality of sprayed products.

6 Quality

6.1 General

The sprayed coatings shall satisfy both the general quality requirements and specific quality requirements according to application, as given in Table 1.

Table 1 General quality requirements and specific quality requirements according to application

Application	General quality				Specific quality according to use			
	Appearance	Structure of coating cross-section	Coating thickness	Adhesive strength	Coating hardness	Thermal shock resistance	Corrosion resistance	Electrical insulation
Wear resistance	○	○	○	○	○	—	—	—
Heat resistance and heat insulation	○	○	○	○	—	○	—	—
Corrosion resistance	○	○	○	○	—	—	○	—
Electrical insulation	○	○	○	○	—	—	—	○

6.2 General quality requirements

6.2.1 Appearance

The surface of the coating, when its appearance is examined according to 7.2, shall be uniform in texture and free from cracks, blisters, exfoliation, spatter, deposits of foreign matters and other defects detrimental to use.

6.2.2 Structure of coating cross-section

The structure of the coating cross-section, when tested according to **7.3**, shall show uniform dispersion of spray particles and shall be free from harmful defects such as cracks, and harmful contaminants (foreign matters) or voids at the boundary between the substrate and the coating.

6.2.3 Coating thickness

The coating thickness shall be tested according to **7.4**, and meet the coating thickness value agreed between the purchaser and the manufacturer.

6.2.4 Adhesive strength

The adhesiveness between the coating and the substrate, when tested according to **7.5**, shall meet the adhesiveness strength requirement given in Tables 2 to 4, or that agreed between the purchaser and the manufacturer according to the intended use.

6.3 Specific quality requirements according to application

6.3.1 Coating hardness (sprayed coatings for wear resistance)

The hardness of sprayed coating for wear resistance, when tested according to **7.6**, shall meet the hardness requirement given in Tables 2 to 4, or that agreed between the purchaser and the manufacturer according to the intended use. The hardness of aluminium oxide sprayed coating (Al_2O_3), aluminium oxide/titanium oxide sprayed coating ($\text{Al}_2\text{O}_3\text{-TiO}_2$ 97 3A) and chromium oxide sprayed coating (Cr_2O_3 A and Cr_2O_3), among other plasma sprayed coatings, shall conform to the specially provided grades of sprayed coating hardness, Class 1 and Class 2, as specified in Table 2.

The test method of wear resistance is given in Annex B for reference.

6.3.2 Thermal shock resistance (sprayed coatings for heat resistance and sprayed coatings for heat insulation)

When the thermal shock resistance of sprayed coating for heat resistance and heat insulation is tested according to **7.7**, there shall be no cracking, peeling or exfoliation of coating.

6.3.3 Corrosion resistance (sprayed coatings for corrosion resistance)

The corrosion resistance of sprayed coatings for corrosion resistance shall be tested according to **7.8**. In the salt spray test specified in **7.8.2**, the conformance shall be judged by the test result specified in **JIS Z 2371** or the agreement between the purchaser and the manufacturer. In the immersion test specified in **7.8.3**, there shall be no blisters, peeling or rust.

6.3.4 Electrical insulation (sprayed coatings for electrical insulation)

The electrical insulation of sprayed coatings for electrical insulation, when tested according to **7.9**, shall be not less than 10 kV/mm, or meet the dielectric breakdown strength agreed between the purchaser and the manufacturer.

Table 2 Adhesive strength and hardness of plasma sprayed coatings

Classification	Code number ^{a)}	Symbol	Adhesive strength of sprayed coating MPa	Hardness of sprayed coating HV ^{b)}
Aluminium oxide sprayed coatings	12.1	Al ₂ O ₃ -1	20 min.	1 000 or over (Class 1)
		Al ₂ O ₃ -2		800 or over to and excl. 1 000 (Class 2)
Aluminium oxide/titanium oxide sprayed coatings	12.2A	Al ₂ O ₃ -TiO ₂ 97 3A-1	14 min.	900 or over (Class 1)
		Al ₂ O ₃ -TiO ₂ 97 3A-2		800 or over to and excl. 900 (Class 2)
	12.3	Al ₂ O ₃ -TiO ₂ 87 13	30 min.	800 or over
	12.4	Al ₂ O ₃ -TiO ₂ 60 40	20 min.	750 or over
Aluminium oxide/chromium oxide sprayed coatings	12.7	Al ₂ O ₃ -Cr ₂ O ₃ 98 2	20 min.	750 or over
	12.8	Al ₂ O ₃ -Cr ₂ O ₃ 90 10		
	12.9	Al ₂ O ₃ -Cr ₂ O ₃ 50 50		
Chromium oxide sprayed coatings	12.20A	Cr ₂ O ₃ A-1	30 min.	1 100 or over (Class 1)
		Cr ₂ O ₃ A-2		900 or over to and excl. 1 100 (Class 2)
	12.21	Cr ₂ O ₃ -1		1 100 or over (Class 1)
		Cr ₂ O ₃ -2		900 or over to and excl. 1 100 (Class 2)
Titanium oxide sprayed coatings	12.30A	TiO ₂ 98A	20 min.	700 or over
Zirconium oxide sprayed coatings	12.40	ZrO ₂ -CaO 95 5	20 min.	— ^{c)}
	12.40A	ZrO ₂ -CaO 93 7A		
	12.41	ZrO ₂ -CaO 90 10		
	12.42	ZrO ₂ -CaO 70 30		
	12.43A	ZrO ₂ -MgO 76 24A		
	12.44A	ZrO ₂ -Y ₂ O ₃ 92 8A	22 min.	
	12.44B	ZrO ₂ -Y ₂ O ₃ 88 12B		
	12.45	ZrO ₂ -Y ₂ O ₃ 80 20		
	12.46	ZrO ₂ -SiO ₂ 65 35	20 min.	
	12.47	ZrO ₂ -CeO ₂ -Y ₂ O ₃ 68 25 3	22 min.	
	12.48A	ZrO ₂ A	20 min.	
Note ^{a)} See JIS H 8260 .				
Note ^{b)} To determine the grade, measure the cross-section of the coating with a test force of 1.961 N (HV 0.2) at a coating thickness of 0.3 mm or greater.				
Note ^{c)} Not specified because this coating is not used for wear resistance.				

Table 3 Adhesive strength and hardness of powder flame sprayed coatings

Classification	Code number ^{a)}	Symbol	Adhesive strength of sprayed coating MPa	Hardness of sprayed coating HV
Aluminium oxide sprayed coatings	12.1	Al ₂ O ₃	9 min.	600 min.
Aluminium oxide/titanium oxide sprayed coatings	12.2B	Al ₂ O ₃ -TiO ₂ 97 3B	7 min.	
	12.3	Al ₂ O ₃ -TiO ₂ 87 13	9 min.	650 min.
	12.4	Al ₂ O ₃ -TiO ₂ 60 40		550 min.
Chromium oxide sprayed coatings	12.20A	Cr ₂ O ₃ A	10 min.	700 min.
Chromium oxide/titanium oxide sprayed coatings	12.23	Cr ₂ O ₃ -TiO ₂ 45 55	8 min.	700 min.
Zirconium oxide sprayed coatings	12.40A	ZrO ₂ -CaO 93 7A	7 min.	— ^{b)}
	12.42	ZrO ₂ -CaO 70 30		
	12.43A	ZrO ₂ -MgO 76 24A		
	12.44A	ZrO ₂ -Y ₂ O ₃ 92 8A	8 min.	
	12.44B	ZrO ₂ -Y ₂ O ₃ 88 12B		
	12.46	ZrO ₂ -SiO ₂ 65 35	7 min.	
	12.48A	ZrO ₂ A	6 min.	
Note ^{a)} See JIS H 8260 .				
Note ^{b)} Not specified because this coating is not used for wear resistance.				

Table 4 Adhesive strength and hardness of rod and cord flame sprayed coatings

Classification	Code number ^{a)}	Symbol	Adhesive strength of sprayed coating MPa	Hardness of sprayed coating HV
Aluminium oxide sprayed coatings	8.4	Al ₂ O ₃	7 min.	600 min.
Aluminium oxide/titanium oxide sprayed coatings	8.5	Al ₂ O ₃ TiO ₂ 97 3		
	8.6	Al ₂ O ₃ TiO ₂ 87 13		
	8.7	Al ₂ O ₃ TiO ₂ 60 40		
Chromium oxide sprayed coatings	8.3	Cr ₂ O ₃	8 min.	700 min.
Zirconium oxide sprayed coatings	8.1	ZrO ₂ CaO 95 5	7 min.	— ^{b)}
	8.2	ZrO ₂ CaO 70 30		
	8.10	ZrO ₂ SiO ₂ 62 31		
Note ^{a)} See JIS H 8261 .				
Note ^{b)} Not specified because this coating is not used for wear resistance.				

7 Test methods

7.1 General

The test methods shall be in accordance with 7.1 to 7.9.