International Mg Society

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Magnesium and Magnesium Alloys

-- Powder coating selection guide for magnesium surface spraying

Foreword

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Magnesium and Magnesium Alloys — Powder coating selection guide for magnesium surface spraying

1 Scope

This standard specifies the powder type and coating characteristics for magnesium surface spraying; applicable environment, product and coating of powder; quality assurance, powder performance and test methods, quality instructions, and purchase order (or contract) contents.

This standard applies to the use and selection of powder for magnesium and magnesium alloy surface spraying.

2 Normative References

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

3 Powder Type and Coating Characteristics

The powder type and coating characteristics are shown in Table 1.

Table 1 Powder type and coating characteristics

Powder type			Typical coating characteristics						
Type	Code	Major component	Weatherability	Corrosion resistance	Flexibility	Leveling	Decorative nature	Hardness	Adhesion
Epoxy powder	EP	The powder is thermosetting and composed of epoxy resin, curing agent, pigment filler, additive, etc.	Bad	Excellent	Good	Good	Good	Good	Excellent
Polyester epoxy powder	PE-EP	The powder is thermosetting and mainly composed of saturated carboxyl polyester and epoxy resin.	Worse than normal	Good	Good	Good	Good	Good	Good
Polyester powder	PE	The powder is thermosetting and mainly composed of saturated carboxyl polyester and a special curing agent (mainly TGIC and HAA).	Good	Normal	Good	Normal	Normal	Good	Good
Polyurethane powder	PUR	The powder is thermosetting and mainly	Good	Good	Normal	Excellent	Excellent	Excellent	Good

Powder type			Typical coating characteristics						
Type	Code	Major component	Weatherability	Corrosion resistance	Flexibility	Leveling	Decorative nature	Hardness	Adhesion
		composed of saturated hydroxy polyester and corresponding curing agent (mainly isocyanate and amino resin).							
Acrylic acid powder	AY	The powder is thermosetting and mainly composed of acrylic resin and curing agent.	Good	Normal	Normal	Good	Good	Good	Normal
FEVE powder	FEVE	The powder is thermosetting and mainly composed of FEVE resin and curing agent isocyanate.	Excellent	Excellent	Normal	Normal	Normal	Good	Normal
PVDF powder	PVDF	The powder is thermoplastic and mainly composed of PVDF resin.	Excellent	Excellent	Below Normal		Below Normal	Good	Below Normal
Silicone resin powder	SP(SI)	The powder is thermosetting and mainly composed of silicone resin, other resins, and their corresponding curing agents.	Good	Good	Excellent	Normal	Normal	Below Normal	Normal

4 Applicable Environment, Product, and Coating of Powder

4.1 Environment type and suitable coating

The suitable powder coating shall be selected according to the environment type with reference to Table 2.

Table 2 Environment type and a suitable coating

Environment type					Suitable coating
Type	Corrosion index	Ultraviolet intensity grade	Typical example		Coating code
1	C1, C2	0	Dry and clean indoor area with low ultraviolet radiation	Storage room internal structure support	PE40, PE-EP40, PE-EP10, PVDF40, FEVE40, PUR40, EP40, AY40, SO40
2	C1, C2	Ⅰ		Furniture	PE40, PE-EP40, PVDF40, FEVE40, PUR40, AY40, SP40
3	C1, C2	Ⅱ	Rural outdoor areas with medium ultraviolet radiation intensity and no industrial pollution		PE40 of Class Ⅱ, PUR40 of Class Ⅱ, PVDF40, FEVE40
4	C1, C2	Ⅲ	Outdoor desert area with high ultraviolet radiation intensity		PVDF40, FEVE40
5	C3, C4	0	Damp basement		PE40, PE-EP40, PVDF40, FEVE40, PUR40, EP40, AY40, SP40
6	C3, C4	Ⅰ	Indoor hot spring area		PE40, PE-EP40, PVDF40, FEVE40, PUR40, EP40, AY40, SP40
7	C3, C4	Ⅱ	Outdoor areas of cities (or light marine areas) with general ultraviolet radiation intensity and general industrial pollution		PE40 of Class Ⅱ, PUR40 of Class Ⅱ, PVDF40, FEVE40

Environment type					Suitable coating
Type	Corrosion index	Ultraviolet intensity grade	Typical example		Coating code
8	C3, C4	Ⅲ	Outdoor areas of cities (or light marine areas) with high ultraviolet radiation intensity and serious industrial pollution		PVDF40, FEVE40
9	C5, C6	0	Salt mine		EP40, PE-EP60, PE60, PUR60, SP60, PVDF40, FEVE40
10	C5, C6	Ⅰ	Outdoor coastal areas with general ultraviolet radiation intensity and high salinity	Indoor partition	PE40, PUR40, SP40, PVDF40, FEVE40
11	C5, C6	Ⅱ		Balcony guardrail	PE40 of Class Ⅱ, PUR40 of Class Ⅱ, PVDF40, FEVE40
12	C5, C6	Ⅲ	Outdoor coastal areas with high ultraviolet radiation intensity, such as ship superstructure		PVDF40, FEVE40

4.2 Product field and suitable powder type

The suitable powder type shall be selected according to the product field with reference to Table 3.

Table 3 Product field and a suitable powder

Typical product field	Suitable powder type	Remarks
Auto parts	Epoxy powder	It is generally used for the primer coating of wheel hubs and other parts.
	Polyester epoxy powder	It is applicable to the coating of automobile engine cooling parts, internal connecting rods, and other parts.
	Acrylic acid powder	It is applicable to the finishing paint applied to the wheel hub and the exterior coating of the vehicle body.
	Polyester powder	It is applicable to the coating of the wheel hub, exterior body trim, and other parts.
	Polyurethane powder	It is applicable to the coating of instrument panels, steering wheels, and other automobile interiors.
Rail transit	Polyester powder	It is applicable to the coating of doors, windshields, headstock opening and closing mechanisms, contactor boxes, inverter boxes, luggage racks, roof plates, subway doors, screen doors, escape doors, side walls, and other parts of bullet trains.
	Polyester epoxy powder	It is applicable to the coating of table and chair decorations in rail transit.
Pipeline anti-corrosion and other heavy anti-corrosion products	Epoxy powder	It is applicable to the coating of natural gas, oil pipelines, sewage pipelines, etc.
Ship superstructure	Polyurethane powder	It is applicable to the coating of ship superstructure decorative parts.
Furniture (furniture, cooker, sanitary ware, lamps, etc.), interior decoration (mirror frame, ceiling, etc.)	Polyester epoxy powder	It is applicable to the coating of furniture, cookers, sanitary ware, lamps, mirror frames, ceilings, and other products.
	Epoxy powder	It is applicable to the decorative texture coating of furniture, cookers, sanitary ware, lamps, mirror frames, ceilings, etc.
	Polyester powder	It is applicable to the coating of furniture, cookers, sanitary ware, lamps, frames, ceilings, and other products.
	Polyurethane powder	It is applicable to the coating of all-magnesium furniture, mirror frames, ceilings, and other products.
	Silicone resin powder	It is applicable to the coating of high-temperature parts such as oven and grill.
Household electric appliances	Polyester epoxy powder	It is applicable to the coating of TV frames, washing machines, refrigerators, water heaters, and other products.
	Polyester powder	It is applicable to the coating of outdoor units, indoor units, and other products of air conditioners.
Radiator	Polyester epoxy powder	It is applicable to the coating of radiators, putty, heaters, and other products.
	Polyester powder	It is applicable to the coating of radiators, putty, heaters, and other products.
Electronics and electrical appliances	Polyester powder	It is applicable to the coating of instrument housing, electricity meters, computer cases, and other parts.
	Epoxy powder	It is applicable to the coating of internal components of the electric control cabinet.
	Polyester epoxy powder	It is applicable to the coating of computer cases, instrument shells, electricity meters, and other products.
Doors, windows, fences, outdoor sports facilities	Polyester powder	It is applicable to the coating of doors and windows, curtain walls, outdoor sports facilities, fences, and other products.
	Polyurethane powder	It is applicable to the surface coating of doors and windows, curtain walls, outdoor sports facilities, fences, and other facilities with low powder wood grain transfer printing, or products with anti-graffiti requirements.
	PEVE powder	It is applicable to the coating of doors and windows, curtain walls, outdoor sports facilities, fences, and other products.
	PVDF powder	It is applicable to the coating of doors and windows, curtain walls, outdoor sports facilities, fences, and other products.

4.3 Coating color and suitable powder

a) The suitability of the powder color shall be evaluated when selecting the coating color. Black, red, yellow, dark green, dark blue, and metal colors are suitable for high-temperature resistant (above 300 °C) coatings. Light colors are not applicable to high-temperature resistant coating. Metal color (excluding pearlescent color) is not applicable to anti-corrosion powder coating.

b) The powder and color of the corresponding weathering grade shall be selected according to the weathering grade of the coating. RAL color scale or similar colors shall be selected. The use of colors other than the RAL color scale will increase the risk of unqualified weatherability of powder or coating.

5 Quality Assurance

The production process of powder and the quality of raw materials have a great impact on the performance of powder. The powder ordering party shall sign a corresponding technical agreement with the powder coating manufacturer, which indicates the requirements for the powder production process (see A.1) and the coating forming substances (see A.2). If necessary, the powder manufacturer shall be visited for inspection.

6 Quality Assurance Certificate

To ensure the reliability of powder coating quality (especially weatherability and corrosion resistance), the content of the quality assurance certificate shall be negotiated with the powder coating manufacturer. The quality assurance certificate shall at least include the following contents. The format of the quality certificate is shown in Table 4.

a) The serial number of the implementation standard;
b) Product name;
c) Production process, including curing temperature and curing time;
d) Density of powder coating;
e) Curing agent system;
f) Type of pigment in powder coating;
g) Weathering grade of powder coating, acetic acid salt spray test results, and impact resistance test results of chromium-free chemical pretreatment (except anodic oxidation pretreatment) powder-coated test panels;
h) Resin content, acid value (or hydroxyl value), viscosity, gelatinization time (characterizing and reflecting activity), glass transition temperature, molecular weight distribution, and color of powder coating;
i) For outdoor powder coatings, natural exposure test results shall be provided (according to formula components, including color difference value and gloss value);

j) The resin manufacturer's name, resin batch number and resin model, and the natural exposure test results (including color difference value and gloss value) shall be provided for the resin used for outdoor powder coating;
k) The black and white standard plate was prepared with resin according to the standard formula and the QUV and high-pressure water immersion test report of the standard plate;
l) The standard formula for preparing black and white standard plates with resin.

Table 4 Format of the quality assurance certificate

<table>
<tr><td>Name of supplier (seal)</td><td colspan="5"></td></tr>
<tr><td>Product name00</td><td colspan="2"></td><td>Implementation standard</td><td colspan="2"></td></tr>
<tr><td>Color</td><td></td><td>Type of pigment</td><td></td><td>weathering grade</td><td></td></tr>
<tr><td>Minimum coating thickness</td><td></td><td>Curing temperature</td><td></td><td>Curing time</td><td></td></tr>
<tr><td>Curing agent system</td><td></td><td>Powder coating density</td><td></td><td>Gelatinization time</td><td></td></tr>
<tr><td>Resin content</td><td></td><td>Glass transition temperature</td><td colspan="2">T_{g1}:</td><td>T_{g2}:</td></tr>
<tr><td>Salt spray test results</td><td colspan="2"></td><td>Impact resistance</td><td colspan="2"></td></tr>
<tr><td colspan="2">Natural exposure results of powder coating</td><td colspan="2">Color difference:</td><td colspan="2">Gloss:</td></tr>
<tr><td colspan="6">Resin</td></tr>
<tr><td>Resin manufacturer name</td><td colspan="5"></td></tr>
<tr><td>Resin model</td><td colspan="2"></td><td>Resin batch number</td><td colspan="2"></td></tr>
<tr><td>Viscosity</td><td colspan="2"></td><td>Acid value (hydroxyl value)</td><td colspan="2"></td></tr>
<tr><td>Natural exposure results</td><td colspan="3">Color difference:</td><td colspan="2">Gloss:</td></tr>
<tr><td rowspan="2">Black-and-white board</td><td colspan="5">Formula:</td></tr>
<tr><td>QUV</td><td colspan="2"></td><td>High-pressure water immersion</td><td></td></tr>
</table>

7 Purchase Order (or Contract)

Relevant technical requirements shall be presented in the purchase order (or contract) after completing the powder coating calculation. The powder purchase order (or contract) shall indicate the following contents. Details of the purchase order are shown in Table 5.

a) Serial number of the implementation standard;
b) Product name;
c) Powder type;
d) Color number and glosses;
e) Mass fraction of burning residue;
f) Particle size distribution;
g) Hiding power;
h) Weatherability and other coating performance grades or requirements;
i) Net weight;
j) Other special requirements.

Table 5 Details of the purchase order

Company name							
Product name		Implementation standard					
Powder type		Color Number		Glasses		Order Quantity	
Mass fraction of burning residue				Weathering grade			
Particle size distribution requirements				Hiding power			
Coating performance							
Other requirements							

Annex A
(Normative annex)

Quality Requirement

A.1 Production Process Requirements

A.1.1 Typical powder

The production process of typical powder is shown in Figure A.1.

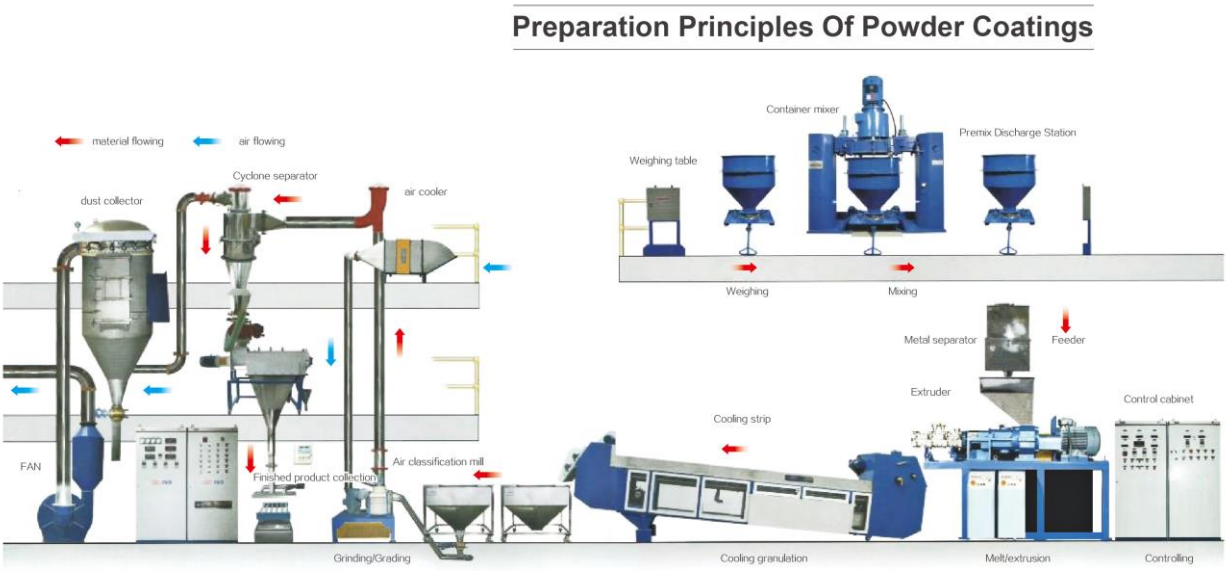

Figure A.1.Preparation principles of powder coatings.

A.1.1.1 During the pre-mixing of raw materials, the feeding amount shall be controlled at 20% ~ 80% of the capacity of the pre-mixing cylinder. The mixing time shall be controlled at 3 min ~ 5 min, The temperature of the mixing section of the extruder shall be 10 °C ~ 20 °C higher than the softening point of the resin, The thickness of the sheets pressed by the tablet press shall be 1 mm ~ 2 mm, and the material temperature before fine crushing shall be controlled below 32 °C.

A.1.1.2 Textured powder, two-component powder, and powder with additives added later shall be mixed with the same batch of powder in a double barrel V-type mixer to eliminate the quality difference of the same batch of products. To eliminate the quality difference of the same batch of products, the Double-barrel V-type mixer shall be used in the Later Mixing Process for three types of powders (1. Textured powder; 2. Two-component powder; 3. Powder with additives added later).

A1.1.3 The ambient temperature shall be controlled below 30 °C during the fine crushing process and for the storage of finished products, and the air in the production and storage areas shall be kept dry.

A.1.2 Metallic powder

The production process of metallic powder is shown in Figure A.2.

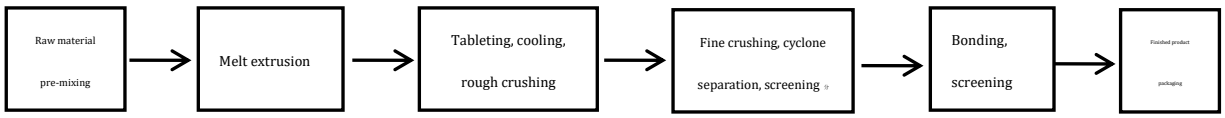

Figure A.2 Production process flow chart of metallic powder.

A.1.2.1 A Bonding process shall be adopted for metallic powder to improve the stability of the spraying process.

A.1.2.2 The feeding amount of bonding shall be controlled at 30% ~ 70% of the capacity of the bonding kettle to ensure the raw materials are well-mixed and the quality of bonding powder is stable.

A.2 Quality Requirement of coating-forming substances

See Table A.1 for the requirements of coating-forming substances used in various powders.

Table A.1 Requirements for coating-forming substances of powder

Powder type	Requirements
Polyester powder	The acid value of the resin in the polyester powder determines the amount of curing agent. Viscosity and reactivity are the main factors affecting the surface leveling. The vitrification point affects the storage stability of the powder. Acid value or hydroxyl value, viscosity, vitrification point, and color reflect the physical and chemical characteristics of the resin batch stability. The polyols used for synthesizing polyester are usually based on neopentyl glycol. Other polyols without hydrogen can also be used. Attention should be paid to the purity of polyols. Neopentyl glycol shall be produced by the hydrogenation method. It is not recommended to use ethylene glycol, diethylene glycol, or propylene glycol.
Polyester powder	There isn't any requirement for indoor polyester. For the selection of outdoor polyester, the comprehensive performance, stability, and weather ability shall be considered. The comprehensive performance should be selectively evaluated based on the application environment, with a focus on some major performance. Two-component resin can be used for matting powder with durability and stability requirements. Stability requires resins with stable quality and narrow molecular weight distribution in practical use. Weatherability is evaluated mainly according to the natural exposure test and the long-term stability of the application. Accelerated aging test in the laboratory is only a reference for auxiliary evaluation In the field of super weatherproof polyester, it will improve the wearability of the powder, if the mass fraction ratio of intermediate phthalic acid (or another diprotic acid with better weatherability than isophthalic acid) to terephthalic acid in the resin is improved. Simply adding raw materials alone cannot guarantee the performance of the resin, instead, it requires controlling the processes of resin synthesis, powder formulation, production, and operative skill. It also requires practical application results to be verified as a super weather-resistant resin Natural exposure test is the most reliable and safe method for testing super weather-resistant resin. Low-temperature curing resin can also be used on the premise of meeting performance and quality requirements. The curing agent of polyester powder includes HAA and TGIC systems. The HAA system is relatively environment-friendly, and the powder storage stability is good, but a small amount of water molecules occurred when the coating was solidified. Pinholes are not prone to appear on the coating of the TGIC system, but human contact with TGIC will cause irritation and other allergic reactions. Please refer to the environmental protection label of the product for details.

Powder type	Requirements
Polyester epoxy powder	Requirements for epoxy resin in polyester epoxy powder: Epoxy resin shall have good storage stability, no mechanical impurities, and good flexibility. The curing agent shall have an active crosslinking reaction such as a reaction with epoxy group in epoxy resin. The curing agent shall have high purity, less volatile matter, and less smoke. Softening point: 89 ~ 94; Epoxy equivalent: 730 ~ 850; Organic chlorine content ≤ 0.0028 mol/100 g; Inorganic chlorine content ≤ 0.0005 mol/100 g; BPA residue ≤ 5×10^{-6}; Volatile matter ≤ 0.3%.
Polyurethane powder	The hydroxyl value of the resin in the polyurethane powder determines the amount of curing agent. Viscosity and reactivity are the main factors affecting surface leveling. The vitrification point affects the storage stability of the powder. Acid value or hydroxyl value, viscosity, vitrification point, and color reflect the physical and chemical characteristics of the resin batch stability. To ensure the weatherability and other relevant properties of the coating, the total mass fraction of resin and curing agent in the powder shall not be less than 60%. Polyurethane resin is required to pass the natural exposure weathering test, and the curing agent is required to have less interference effects. Curing agents in polyurethane powder can be divided into externally sealed aliphatic isoflurone diisocyanate or internally sealed isocyanate. The coating in such a system has good weatherability and chemical resistance and has good ink penetration when used in wood grain transfer printing coating. Externally sealed aliphatic isophorone diisocyanate will release the sealing agent acetolactate when baking the coating.
Epoxy powder	The epoxy resin shall have good storage stability, no mechanical impurities, and good flexibility. The curing agent shall have an active crosslinking reaction such as a reaction with epoxy group in epoxy resin. The curing agent shall have high purity, less volatile matter, and less smoke. Softening point: 89 ~ 94; Epoxy equivalent: 730 ~ 850; Organic chlorine content ≤ 0.0028 mol/100 g; Inorganic chlorine content ≤ 0.0005 mol/100 g; BPA residue ≤ 5×10^{-6}; Volatile matter ≤ 0.3%.
Acrylic acid powder	Acrylic resin shall have good storage stability and pass the natural exposure test.
FEVE powder	Trifluorochloroethylene vinyl ether (FEVE), theoretically with a fluorine content of 27% to 29%, and FEVE fluorocarbon coating is a thermosetting powder. The curing agent shall be externally sealed aliphatic isoflurone diisocyanate or internally sealed isocyanate, and the externally sealed aliphatic isoflurone diisocyanate will release acid amine within the sealing agent when baking the coating. The curing agent shall be of high purity and less volatile. FEVE fluorocarbon powder is divided into fluorocarbon polyester composite powder and pure fluorocarbon powder. The resin mass fraction (excluding the curing agent) in fluorocarbon powder shall not be less than 60%. The amount of FEVE fluorocarbon resin in the composite fluorocarbon powder shall not be less than 50% of the amount of the main coating-forming resin.
FVDF powder	Fluorocarbon powder resin includes polyvinylidene fluoride (PVDF for short), and its fluorine content is 59.3% theoretically. PVDF fluorocarbon resin coating requires about 30% acrylic resin, and the baking temperature of the coating is high. PVDF fluorocarbon coating is a thermoplastic powder without a curing agent.
Silicone resin powder	Organic silicon powder is divided into three types. The coating of organic silicon graft modified polyester powder can withstand 300 °C for a short time; The coating of polyester (or silicone grafted polyester) and silicone oligomer mixed powder can withstand 300 °C for a longer time; The coating of polyester (or silicone graft modified polyester) and silicone resin powder can withstand 300 °C ~ 500 °C. With the increase of silicone oligomer or silicone resin in the powder coating-forming substances, the temperature resistance of the powder coating is increased and the temperature resistance time is extended, but the mechanical properties of the coating are correspondingly reduced.