International Mg Society

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IMS 006:2025(E)

Magnesium and Magnesium Alloys

-- Technical Specifications for Chemical Conversion Coatings of Magnesium Alloy Die Castings

Foreword

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Any feedback or questions on this document should be directed to the secretariat of the Information Committee on IMS (Email: international_Mg@163.com)

Introduction

This document provides the general purpose of chemical conversion coating for magnesium alloy die castings, The establishment of lMS 006:2025 will meet the current manufacturing requirements to introduce chemical conversion coating.

This document guides the surface treatment process of magnesium alloy die castings to control the product quality and reduce the cost.

Magnesium and Magnesium Alloys

-- Technical Specifications for Chemical Conversion Coatings of Magnesium Alloy Die Castings

1 Scope

This standard specifies the classification, requirements, and test methods for chemical conversion coatings on magnesium alloy die castings.

It applies to chemical conversion coatings formed on magnesium alloy die castings. These coatings may serve as stand-alone corrosion protection coatings or function as pre-treatments for organic coatings.

The chemical conversion coatings of other types of magnesium components can refer to this document.

2 Normative references

The following documents contain provisions, which through normative reference in this text, constitute indispensable clauses of this document. For dated references, only the edition corresponding to that date applies to this document. For undated references, the latest edition (including all amendments) applies.

ISO 1463 *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method*

ISO 2409 *Paints and varnishes — Cross-cut test*

ISO 2810 *Paints and varnishes — Natural weathering of coatings — Exposure and assessment*

ISO 2812-1 *Paints and varnishes — Determination of resistance to liquids — Part 1: Immersion in liquids other than water*

ISO 2813 *Paints and varnishes — Determination of gloss value at 20°, 60° and 85°*

ISO 3497 *Metallic coatings — Measurement of coating thickness — X-ray spectrometric methods*

ISO 3892 *Conversion coatings on metallic materials — Determination of coating mass per unit area — Gravimetric methods*

ISO 4519 *Electrodeposited metallic coatings and related finishes — Sampling procedures for inspection by attributes*

ISO 7784-2 *Paints and varnishes — Determination of resistance to abrasion — Part 2: Method with abrasive rubber wheels and rotating test specimen*

ISO 8296 *Plastics — Film and sheeting — Determination of wetting tension*

ISO 9227 *Corrosion tests in artificial atmospheres— Salt spray tests*

ISO 10289 *Methods for corrosion testing of metallic with metallic and other inorganic coatings on metallic substrates — Rating of test specimens and manufactured articles subjected to corrosion tests*

ISO 10993-5 *Biological evaluation of medical devices — Part 5 — Tests for in vitro cytotoxicity*

ISO 15091 *Paints and varnishes —Determination of electrical conductivity and resistance*

ISO 15184 *Paints and varnishes — Determination of film hardness by pencil test*

ISO 16220 *Magnesium and magnesium alloys —Magnesium alloy ingots and castings*

ASTM D4935-18 *Standard test method for measuring the electromagnetic shielding effectiveness of planar materials*

ASTM E1461-13 *Standard test method for thermal diffusivity by the flash method*

IMS 001 *Magnesium and magnesium alloys— Terms and definitions of surface treatment*

3 Terms and definitions

For the purposes of this document, terms and definitions in IMS 001 and the following shall apply.

3.1 Acid activation

Acid activation is the process of removing oxides or other compounds from magnesium alloy surfaces through chemical action in acid solutions.

3.2 Alkaline cleaning

Alkaline cleaning is the process of removing greases or neutralizing acid-activated corrosion products generated in alkaline solutions from the magnesium alloy surfaces.

3.3 Acid etching

Acid etching is the process of removing mould release agents on magnesium alloy surfaces left during die-casting with acidic solutions.

3.4 Bleaching

Bleaching is the process of using an alkaline solution to dissolve the black oxide film formed after acid etching of magnesium alloys and restore the base metal appearance.

4 Classification

Chemical conversion coatings can be divided into three major categories based on functions：

Type Ⅰ: Stand-alone corrosion protection coatings;

Type Ⅱ: Pre-coatings.

5 Performances

The performance of chemical conversion coatings shall be in accordance with Table 1.

Table 1 — Performances and requirements

Number	Performances	Requirements	
		Type Ⅰ	Type Ⅱ
1	Adhesion	Grade 0	
2	Appearance	Subject to mutual agreement	
3	Corrosion resistance	48 h Grade8	/
4	Abrasion resistance	Determined through negotiation between the supply and the demand	
5	Biocompatibility		
6	Contact resistance		
7	Chemical resistance		
8	Electromagnetic shielding		
9	Gloss		
10	Hardness		
12	Thermal conductivity		
13	Thermal control performance		
14	Thickness		
15	Weatherability		
16	Wetting tension	/	＞ 40 mN/m.

6 Quality assurance provisions

6.1 Surface pre-treatment

6.1.1 Substrate requirements

All magnesium alloy die castings can undergo chemical conversion coating treatment, provided that their composition and properties comply with the requirements specified in ISO 16220.

Unless otherwise specified, chemical conversion treatment of magnesium alloy die castings shall be performed after completion of all manufacturing and thermal processing operations (e.g., forming, machining, heat treatment and welding).

6.1.2 Process flows

Two process flows shown in Figure 1 may be used, or the sequence can be adjusted based on factory conditions. However, the following rules shall apply:

（1） After acid activation, alkaline cleaning shall be performed;

（2） After acid etching, bleaching treatment shall be applied;

（3） Rinsing by deionized water (<100 μS/cm conductivity) shall be performed between two processing steps.

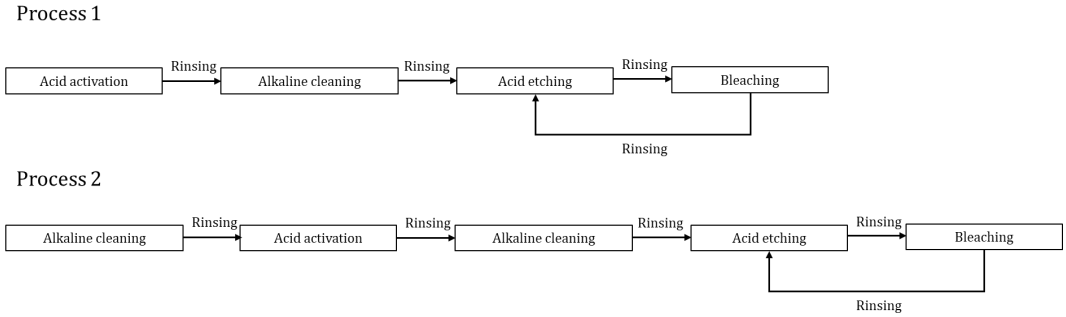

Figure 1 Process flows

6.1.3 Pre-treatment process and requirements

Pre-treated castings shall satisfy the following requirements:

（1） Alkaline cleaning

Alkaline cleaning can be performed using the methods specified in Table 2.

Compressed air or an ultrasonic bath can be introduced to agitate the solution.

Table 2—Alkaline cleaning solution and operating process

Bath composition	Temperature, ℃	pH	Cleaning time, s

Components	Content, wt.%	50-60	13-14	180-300
NaOH	5-10			
$Na_2SiO_3 \cdot 5H_2O$	3-8			
Emulsifier	5-8			
Deionized water	Balance			

（2） Acid activation

Acid activation can be performed using the methods specified in Table 3.

Table 3—Acid activation solution and operating process

Bath composition		Temperature, ℃	pH	Cleaning time, s
Components	Content, wt.%	20-40	0-1	30-90
NH_4HF_2	5-15			
H_3PO_4	2-5			
Deionized water	Balance			

（3） Acid etching

Acid etching can be performed using the methods specified in Table 4.

Table 4—Acid etching solution and operating process

Bath composition		Temperature, ℃	pH	Cleaning time, s
Components	Content, wt.%	50-60	2.5-3.5	90-150
$C_6H_8O_7$	5-10			
$C_4H_6O_5$	5-10			
Deionized water	Balance			

（4） Bleaching

Bleaching can be performed using the methods specified in Table 5.

Table 5—Bleaching solution and operating process

Bath composition		Temperature, ℃	pH	Cleaning time, s
Components	Content, wt.%	70-80	13-14	180-300
KOH	5-15			

$Na_3C_6H_5O_7 \cdot 2H_2O$	2-5			
Deionized water	Balance			

6.2 Chemical Conversion Treatment

6.2.1 Conversion solutions

The conversion solutions typically contain primary salts, complexing agents and additives.

The components can be treated by the methods listed in Table 6.

The solution shall show no turbidity or insoluble precipitates. It shall be maintained per specifications with timely replacement of depleted baths.

Table 6—Chemical conversion solutions and operating process

Mass concentration and process conditions		Method 1	Method 2	Method 3
Concentration, g/L	Na_2HPO_4	20	-	-
	H_3PO_4, ml/L	7.4	50	-
	$NaNO_2$	3	-	-
	$NaNO_3$	1.84	2	-
	$Zn(NO_3)_2$	5	-	-
	NaF	1	-	-
	CaH_2PO_4	-	100	-
	$KMnO_4$	-	-	40
	KH_2PO_4	-	-	150
Process conditions	Temperature, ℃	40-50	20-40	40-70
	pH	3.0-4.0	2.0-3.0	4.0-5.5
	Time, s	180-300	30-60	300-600

6.2.2 Application methods

Immersion is generally used, while spray application, brushing, roll-coating, or swabbing are also allowed.

6.2.3 Sealing

Sealing treatment (inorganic or organic sealing) is necessary for type Ⅰ, while optional for type Ⅱ.

Inorganic sealing should be performed when low electrical resistance is required for the components.

The solutions and conditions for inorganic sealing are listed in Table 7.

Sealants used for organic sealing include acrylic resin, epoxy resin, polyurethane resin, silicone and waxes.

Table 7—Inorganic sealing solution and operating process

Mass concentration and process conditions		Method 4	Method 5
Concentration, g/L	Na_2SiO_4	20	-
	NH_4VO_3	-	10-30
	NaOH	1-3	-
Process conditions	Temperature, ℃	50-70	45-60
	pH	13-14	6.5-7.5
	Time, min	10-20	3-5

6.2.4 Rinsing

Conversion coatings shall be rinsed with deionized water. Hot water rinsing is recommended to remove residual contaminants.

6.2.5 Drying

Coatings shall be dried immediately after rinsing. Drying temperature should range from 100 to 150°C, and drying time should range from 20 to 30 minutes.

All relevant tests shall be conducted after the drying process.

7 Testing methods

7.1 Alternative specimens

When actual conversion-coated components are unsuitable for testing, or cannot be submitted for destructive tests due to low quantity or high value, alternative specimens may be used to measure the adhesion, corrosion resistance, and other properties.

Specimens shall share identical alloy composition and surface condition with represented components, and undergo conversion treatment simultaneously with production parts.

The demander shall specify specimen usage methodology, including quantity, material, geometry, and dimensions.

7.2 Adhesion

Coatings shall adhere firmly to the substrate without powdery residue. Unless otherwise specified, paint film adhesion over conversion coatings shall be tested in accordance with ISO 2409. A cross-cut test on a flat surface of the die casting shall be conducted to assess the adhesion. If no suitable area exists on the casting itself, substitute test specimens should be prepared. Three different measurement locations shall be selected on the specimen, with both the distance between adjacent measurement points and the distance from any measurement point to the specimen edge being $\geqslant$ 5 mm.

7.3 Appearance

When examined without magnification, conversion coatings on critical surfaces shall be uniform and free from: roughness, powdering, sagging, blisters, inclusions, depressions, dark spots, pinholes, scratches, abrasions, or any substrate-exposing damage.

The coating colour may range from transparent, light gold, iridescent, grey-white to black when examined under unaided or corrected vision. Colour requirements shall be determined using reference specimens.

7.4 Corrosion resistance

Corrosion resistance shall be evaluated by neutral salt spray (NSS) testing in accordance with ISO 9227. The tested specimens shall be rated in accordance with ISO 10289.

The type, quantity, shape, and dimensions of test specimens shall be selected in accordance with the relevant specifications of the material or product under evaluation. In the absence of such specifications, these parameters may be mutually agreed upon by the concerned parties. Unless otherwise stipulated or agreed, test specimens shall be processed into 150 mm × 100 mm × 1 mm.

Where no alternative requirements exist, specimens shall be cleaned before testing. Abrasives or solvents that may corrode the specimen surface shall not be used during cleaning. Post-cleaning specimens shall be protected against recontamination.

If specimens are sectioned from components, the adjacent coatings near the cut area shall remain undamaged. Unless otherwise specified, cut edges shall be protected using appropriate protective coatings such as paint, paraffin and adhesive tape.

7.5 Abrasion resistance

Abrasion resistance testing shall be in accordance with ISO 7784-2 or subject to mutual agreement.

7.6 Biocompatibility

Biocompatibility testing shall be in accordance with ISO 10993-5 or subject to mutual agreement.

7.7 Contact resistance

Contact resistance testing shall be in accordance with ISO 7784-2 or subject to mutual agreement.

7.8 Chemical resistance

Chemical resistance testing shall be in accordance with ISO 2812-1 or subject to mutual agreement.

7.9 Electromagnetic shielding

Electromagnetic shielding testing shall be in accordance with ASTM D4935 or subject to mutual agreement.

7.10 Gloss

Gloss testing shall be in accordance with ISO 2813 or subject to mutual agreement.

7.11 Hardness

Hardness testing shall be in accordance with ISO 15184 or subject to mutual agreement.

7.12 Thermal conductivity

Thermal conductivity testing shall be in accordance with ISO 22007-2 or subject to mutual agreement.

7.13 Thermal control performance

Thermal control performance testing shall be in accordance with ASTM E1461 or subject to mutual agreement.

7.14 Thickness

Thickness testing shall be in accordance with ISO 1463/ISO 3497 or subject to mutual agreement.

7.15 Weatherability

Weatherability testing shall be in accordance with ISO 2810 or subject to mutual agreement.

7.16 Wetting tension

Wetting tension testing shall be in accordance with ISO 8296 or subject to mutual agreement.

8 Acceptance rules

8.1 Inspection and acceptance

The supplier shall inspect the specimens for compliance with this document and the purchase order.

The demander may inspect received products against this document and the purchase order. If results are non-compliant, both parties shall resolve the matter through negotiation.

8.2 Testing lot

Products shall be inspected by lots. Each lot consists of all parts processed simultaneously in the same bath.

8.3 Performance testing and sampling

The performance testing and sampling requirements shall be in accordance with Table 8.

Table 8 — Performance testing and sampling

Necessity	Performances	Sampling size	Performance requirements	Testing method
Mandatory	Appearance	Piece-by-piece inspection	See Table 1	See 7.3
	Adhesion	Randomly select 3-5 specimens or subject to mutual agreement		See 7.2
	Corrosion resistance			See 7.4
Non-mandatory	Abrasion resistance			See 7.5
	Biocompatibility			See 7.6
	Contact resistance			See 7.7
	Chemical resistance			See 7.8
	Electromagnetic shielding			See 7.9
	Gloss			See 7.10
	Hardness			See 7.11
	Thermal conductivity			See 7.12
	Thermal control performance			See 7.13
	Thickness			See 7.14
	Weatherability			See 7.15
	Wetting tension			See 7.16

8.4 Passing criteria

If any specimen fails the appearance check, the whole lot shall be rejected. Conforming items may be delivered after individual inspection.

If any specimen fails adhesion or corrosion tests, the whole lot shall be rejected.

The passing criteria for non-mandatory performances shall be subject to mutual agreement.

9 Packaging and storage

9.1 Packaging

Coated parts shall be packaged to ensure that the parts are protected during shipment and storage against damage due to mishandling, exposure to the weather, or any hazard.

9.2 Storage

Coated parts shall be stored in accordance with the following requirements:

(1) Storage in a low-humidity environment (RH≤40%, 20-25 ℃);
(2) Keep clear of fires, acids, alkalis and strong oxidizers.