GM	WORLDWIDE ENGINEERING STANDARDS	Material Specification	GMW16209

Inorganic Coatings for Exterior Anodized Aluminum Parts

1 Scope

1.1 Material Description. This specification covers requirements for anodized surfaces of pure aluminum or pure aluminum alloys with an additional inorganic coating (example: sol gel process). This coating is applied to an incompletely sealed anodized surface.

1.2 Symbols. Not applicable.

1.3 Applicability. This additional coating is used to improve the chemical resistance of anodized aluminum parts for exterior decorative applications.

1.4 Remarks. This coating may be used to meet the Decorative Exterior Colored/Transparent (DEC/DET) requirements of GMW14665-DEC-Class A and GMW14665-DET-Class A. For conventional anodize and seal (without topcoat), see GMW14665-DET-Class B. For organic clearcoat over anodizing, see GMW16929.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM D7869	ISO 2808	ISO 20566	SAE J2527

2.2 GM Standards/Specifications.

GMW3059	GMW14334	GMW14701	GMW14873
GMW3286	GMW14458	GMW14729	GMW15287
GMW14124	GMW14665	GMW14829	GMW16929
GMW14270	GMW14698	GMW14865	GMW17103

2.3 Additional References.

- American Association of Textile Chemists and Colorists can be found @ https://www.aatcc.org/

3 Requirements

See Appendix A, Table A1 and Table A2 for additional information.

3.1 Appearance. Parts with an additional coating to this specification shall not show defects such as high film build on edges or any orange peel. The general finish of the part must be free from polish defects, scratches, or other similar defects. There shall be no dull/matte areas or cloudiness.

3.2 Coating Thickness. Measure coating thickness per ISO 2808.

3.2.1 The supplier shall report the thickness of anodizing and topcoat layers individually. For each inorganic topcoat technology, GM Materials Engineering and the supplier shall establish minimum and maximum values for each attribute which ensure all coating performance requirements are met.

3.3 Initial Adhesion. Test per GMW14829, method A. Coating shall exhibit a rating of zero (0) or one (1).

3.3.1 Humidity plus Tape Adhesion. Expose samples to 240 h of humidity per GMW14729, Option B. Samples shall exhibit a maximum rating of one (1) after 120 h. No cracks, blisters, delamination, or crazing are permitted after 240 h.

3.4 Filiform Corrosion. Expose samples per GMW15287. Samples shall exhibit 4 mm maximum creepback from scribe line at the end of the test. No cracks, blisters, delamination, or crazing are permitted after the

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exposure. Also, there shall be no filament growth on the non-scribed test surfaces at the end of the test, excluding sample prepared cut edges.

3.5 Neutral Salt Spray (NSS). The test shall be done per GMW3286. After 480 h of testing, the parts shall show no base metal corrosion.

3.6 Acidified Salt Spray (CASS). Expose samples per GMW14458 for a minimum of 8 h. No base metal corrosion shall be permitted at the end of the test.

3.7 Scratch Resistance. Perform scratch resistance per GMW14698 in the as-received condition and after 144 h of humidity (GMW14729, Option B). The spring tension at which the tip of the test rod just fails to penetrate the coating shall be recorded. A minimum spring tension of 4.0 N with no penetration is required.

3.8 Resistance of Coatings to Chemical Etching and Distortion. For initial approval, samples must achieve the following minimum ratings for materials listed in GMW14701 after performing Method 2:

- Rating 8: Egg Albumin, Acid Rain pH 3 and pH 4, Tap Water, Sulfuric Acid pH 4.
- Rating 6: Sulfuric Acid pH 0 and pH 2.
- No requirement: Brake Fluid.
- Rating 10: All other materials listed in GMW14701.

Any temporary/reversible changes in the coating due to exposure to any material must be reported to GM Materials Engineering.

3.9 Automotive Environmental Cycling (see GMW14124). There shall be no coating cracking or adhesion loss after fifteen (15) cycles of Cycle A plus 96 h of humidity (see GMW14729, Option B). Adhesion (see GMW14829, Method A) must be run after humidity. A maximum rating of one (1) is allowed.

3.10 Extreme Alkaline Resistance (pH 13.5) Test samples shall be dipped at 20 °C to 23 °C in the test solution for 10 minutes + 30 s then rinsed with water and air dried. The surface may not change its appearance (polishing is not allowed, but samples may be lightly wiped with a soft cloth while rinsing). Any temporary or reversible changes in appearance after dipping in the test solution must be reviewed with GM Materials Engineering for judgement and acceptance.

Note: Only virgin/non-cut edges of samples shall be used for the test.

Test solution: For a 1 L test solution with a calculated pH of 13.5, dissolve the following in 1 L deionized water:

- 12.7 g Sodium Hydroxide (NaOH)
- 4.64 g Sodium Phosphate Dodecahydrate (Na_3PO_4 + 12 H_2O)
- 0.33 g Sodium Chloride (NaCl)

Note: For solution preparation see 3.15.

3.11 Chemical and Mechanical Preload Tests. The alkaline resistance test referenced in 3.10 also must be passed after each of the following exposures. For each exposure, the surface may not change its appearance (dull areas, lost color, etc.,) by more than a factor of one (1) per the American Association of Textile Chemists and Colorists ((AATCC) see 2.3) gray scale for staining.

3.11.1 Sulfuric Acid Pre-soak. Test samples shall be dipped at 20 °C to 23 °C in the test solution in 3.11.1.1 for 10 minutes (+30 s) then rinsed with water and towel-dried. Samples are then dipped in the high-pH solution (see 3.10) and evaluated.

3.11.1.1 Test Solution. For a 100.0 g test solution, add the following to 63.0 g of DI water:

- 10.0 g Sodium Xylene Sulfonate, 40%
- 14.0 g Dodecyl Benz Sulfonic Acid, 70%
- 3.0 g Octylphenol Ethoxylate 9.5 M , “Triton X100”
- 5.0 g Ethylene Glycol Monobutyl Ether (CAS 111-76-2)
- 5.0 g Sulfuric Acid, 93%

This “test solution” is then diluted 10:1 (by volume) with DI water to provide a pH of approximately 1.6.

Note: For solution preparation see 3.15.

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3.11.2 Simulation of Car Wash Installations. The alkaline resistance test (see 3.10) must also be conducted after exposure to car wash abrasion testing. Abrasion testing may be conducted per GMW17103 (4 minutes), ISO 20566 (ten (10) double strokes), or GMW14865 (200 double strokes). The performance criteria also includes no delamination of the coating. After testing, there shall be no more than a 20% change in gloss value (examples: an initial gloss reading of 80 shall not be reduced to lower than 64, and an initial gloss reading of twenty (20) shall not be reduced to lower than sixteen (16)). Coating tested may also compare favorably to an approved control sample. Final acceptability judgment is to be made by GM Materials Engineering.

Note: For coating development and process control, the following procedure may be used. This procedure may not be used for chemical approval or Production Part Approval Process (PPAP) testing.

Take a 1 kg hammer (or equivalent mass with handle) and wrap the flat head with soft cotton cloth (i.e., cheesecloth). Stroke the cloth-covered hammer back and forth 30 times along the test part (the cloth should provide an area contact, not a line contact). Then, expose the sample to the appropriate alkaline resistance tests.

3.12 Temperature Resistance. 1 h at 100 °C ± 3 °C. No cracks, blisters, or other discontinuities visible on the surface are permissible after the exposure.

3.13 Resistance to Cleaning Agents. Test per GMW14334, using agents appropriate exterior coatings (identified as “Code B” in GMW14334). Requirement: Rating 2.

3.14 Weathering. Accelerated weathering tests (Xenon) are used as an aid in predicting long-term durability performance (outdoor weathering). All tests must be conducted with control samples painted with an approved body Basecoat/Clearcoat (BC/CC) system. Outdoor exposure performance takes precedence over accelerated exposure performance in the event of disagreement.

3.14.1 Accelerated Weathering (Xenon Exposure). Exposure is per SAE J2527 with extended Ultra-Violet (UV) filter or ASTM D7869 plus 96 h humidity per GMW14729, Option B and tape adhesion per GMW14829, Method A. Total test exposure is to be 3500 kJ/m².

3.14.2 Outdoor Weathering of Automotive Exterior Materials (see GMW14873). Coatings must have a minimum of 24 months exposure on the exact system. Five south black box exposure is to be followed. Following exposure, parts should be subjected to 96 h humidity per GMW14729, Option B and tape adhesion per GMW14829, Method A.

3.14.3 Visual Evaluation. For both Accelerated and Outdoor weathering exposures, the following performance criteria apply:

3.14.3.1 Wash weathered specimens prior to making measurements and observations. Wash with scrubbing action, using a sponge that is saturated with a solution consisting of soap and deionized water at 23 °C ± 3 °C.

3.14.3.2 Exposed parts shall not exhibit any indications of surface tackiness or embrittlement, change in hardness, blooming, blistering or other factors that might affect the function or appearance of the part. The color change shall not exceed a ΔE of ≤ 3.0 units. Parts shall have a minimum of 70% gloss retention (unpolished) (or 80% polished) and no cracking. Samples shall have a maximum adhesion rating of one (1) after xenon exposure +96 h humidity + tape adhesion. Inspect test materials per GM Engineering agreement, throughout the test. Rate panels for gloss and Distinctness of Image (DOI) retention, cracking, color change, and yellowing. Evaluate polish back (hand polish only), if gloss retention is below minimum specification, using a non-abrasive polishing compound.

3.14.3.3 Visual color change that is considered objectionable shall override the ΔE measurement. Part must not exhibit objectionable color change.

3.15 Use of Chemical Test Solutions. Alkaline resistance tests are extremely sensitive to temperature. In order to control the test solution temperature within 20 °C to 23 °C, solution container(s) should be placed in a larger pan of water at slightly below best temperature, then stirred and monitored as temperature rises to the use point. Test solution should be stirred before use to avoid temperature stratification.

3.16 All materials supplied to this standard must comply with GMW3059, **Restricted and Reportable Substances**, including the requirement to obtain a GM-approved International Material Data System (IMDS) submission.

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