GM	WORLDWIDE ENGINEERING STANDARDS	Material Specification	GMW14668

Minimum Performance Requirements for Decorative Chromium Plated Plastic Parts

1 Scope

This specification covers basic requirements for copper-nickel-chromium electroplated plastic parts.

1.1 Material Description. This standard is intended for the following applications:

1.1.1 Interior (Code A). Interior applications do not require the use of discontinuous chromium or multiple layer nickel systems. For interior applications, non-discontinuous chrome (r) is permissible.

- **Type 1:** Standard interior usage.
- **Type 2:** Applications where higher coating thicknesses are required and/or performance requirements are not met with Type 1 (e.g., inside door handles, manual shifter decor rings, or bezels, may require Type 2).
- **Type 3:** Small parts such as radio control knob bezels. These parts do not require full plating approval per GMW16193, but only require demonstration of plating performance per this specification at Production Part Approval Process (PPAP). Refer to Appendix B, Figure B3, for geometry limitations.

Note: If no interior type is listed on the detail drawing, Type 1 is assumed.

1.1.2 Exterior (Code B). For exterior applications, discontinuous chromium plate (microporous (mp) or microcracking (mc)), in addition to a multiple layer nickel system, shall be used.

- **Type 1:** Legacy type (not used for new programs/approvals).
- **Type 2:** Standard exterior usage.
- **Type 3:** High corrosion service conditions (wheel claddings and caps).
- **Type 4:** High corrosion calcium chloride resistant (Russian mud) chromium.

Note: If no exterior type is listed on the detail drawing, Type 2 is assumed.

1.2 Symbols. Not applicable.

1.3 Applicability. This type of finish shall be principally used for decorative purposes. Bright and other (e.g., satin, brushed, dark, or grained) appearances are for interior and exterior plastic applications, as defined by styling and specific appearance standards.

2 References

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

2.1 External Standards/Specifications.

ASTM B368	ASTM B571	ASTM B995	ISO 3497
ASTM B456	ASTM B604	ISO 1463	ISO/IEC 17025
ASTM B533	ASTM B764	ISO 2177	ISO/TS 16949

2.2 GM Standards/Specifications.

GMW3059	GMW14829	GMW16882	GMW17406
GMW14458	GMW16193	GMW17083	

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2.3 Additional References.

- 9591083 – GM Part Number - Global Wheel/Wheel Trim Surface Standard
- GM1920 GP-12: Early Production Containment
- GM1927-3 Supplier Quality Statement of Requirements (SOR)
- SOR Appendix F5

3 Requirements

See Appendix B, Table B1 for summary of requirements. This table (or an equivalent form) should be completed by Production Part Approval Process (PPAP) submissions. The requirements are described in detail in Section 3.

3.1 Appearance Requirements. Parts must meet appearance requirements as stated in the Statement of Requirements (SOR) Appendix F5. For Deviations, e.g., Wheel Trim and Cladding, see Dev 3.1, in the Deviations Section at the end of this specification.

3.2 Base Material/Substrate. Only plastics approved by GM for chrome plating shall be used. No regrind is allowed in plated parts. For substrate types, see Table 1. Not all types are suitable for all parts. For example, high temperature parts like wheel trim shall not use Acrylonitrile Butadiene Styrene (ABS). Reference the part drawing for the type to use.

Table 1: Typical Approved Substrate Types

Substrate Type	Typical Maximum Use Temperature
ABS	+90 °C ± 3 °C
ABS/PC	+110 °C ± 3 °C
PA6, PA66 - MF (10 to 40)	+120 °C ± 3 °C
PA6, PA66 - GF (10 to 30)	+130 °C ± 3 °C

ABS = Acrylonitrile Butadiene Styrene, **GF** = Glass Filled, **MF** = Mineral Filled, **PA** = Polyamide (Nylon), **PC** = Polycarbonate.

3.2.1 Substrate Structure. Parts shall demonstrate no defects like cracks, splay, pits, or sink marks. Parts shall be free of any internal stresses which adversely influence adhesion, dimensional stability or appearance of the finish.

3.2.2 Substrate Surface. The surface shall be smooth, free of flow lines, cracks, sink marks, craters or substrate stratifications which may influence the approved appearance or part properties. Some molding artifacts such as parting lines flash and gate marks can have a deleterious effect on the durability of the finish and must be minimized. Rework of substrate surfaces by sanding, plasma treatment or other means must be approved by GM Engineering and Supplier Quality. Before parting line rework can be approved, testing to this standard must be completed on parts which include the proposed rework process. GM Supplier Quality must review and approve any parting line rework process before use.

3.2.3 Substrate Surface Stress Test (only for ABS and for ABS/PC). A substrate surface stress test is required for any new mold sets, process changes, or when high surface stress is suspected. Reference GMW17083 for instructions on running the acetic acid stress test (for ABS) and the organic dye test (for ABS/PC).

3.3 Coating.

3.3.1 Plating Thickness. Minimum plate thickness as specified in Table 2 (for copper and nickel) and Table 3 (for chrome) applies to all significant surfaces. Significant surfaces are those normally visible, directly or by reflection, on the finished part when assembled in vehicle position or which can be the source of corrosion deposits that deface visible surfaces on the assembled vehicles. Class A surfaces are always significant surfaces. The use of auxiliary anodes and advanced plating analysis is recommended. See Appendix B, Figure B2 for an example of plating layer construction.

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3.3.1.1 Computer Aided Engineering (CAE) plating thickness simulations are recommended when there is uncertainty of meeting minimum plating thicknesses due to part design features. Concerns for meeting minimum plating thicknesses should be reported to Materials Engineering for evaluation. If corrosion products are visible anywhere on a finished and dressed component in vehicle position after testing, this specification requirement is not met. For initial study of a new part, a mapping of the metal thickness of the part will be made on significant surfaces.

3.3.2 In the case of nickel satin finishes: All bright nickel replacement of the satin nickel is to be a 1:1 substitution of metal thickness. No "skim coating" of the bright nickel with satin is allowed to provide long term corrosion and appearance assurance. Proof of ability to color match satin and other specialty finishes to the required construction type must be provided to GM Design Appearance Quality, (DAQ), and GM Materials Engineering prior to any production usages.

3.3.3 Prior to Production Part Approval Process:

- Map the production rack to show high, mid, and low, current density areas. Provide this map as part of PPAP submission.
- Select a high and low current density part from the production rack.
- For large parts, apply a 10 cm × 10 cm grid for the entire part. For long, thin areas, check every 10 cm. If the grid area has contour, measure the thickness in the high and low current density areas within each grid. If the grid area is flat, one (1) measured point is sufficient.
- For small parts less than 10 cm × 10 cm, one (1) representative point tested is sufficient unless the part drawing indicates more points, or the part has a recess over 15 mm or a length/diameter ratio < 2.0.

3.3.4. This exercise is intended to demonstrate that minimum metal thickness is obtained for the entire part or to alert GM to metal thickness issues that may require attention. Plating thickness should be optimized so there are no exceptions to plating thickness requirements. In the event of an exception to the plating thickness requirement, there must be an approval by GM Engineering and the exception shown as a detail on the part drawing by either designating plating checkpoint(s), or by indicating in an appropriate view, the area(s) with deviated thickness allowed. These exceptions must still meet the specified number of corrosion test hours. In other cases, the part drawing may include zones. When zones are specified, deviations to the copper and nickel plating thickness requirements in Table 2 are allowed, according to Dev 3.1 in the Deviations Section, located at the end of this specification.

3.3.4.1 For PPAP, report the thickness mapping and quality assurance plating thickness points. These points are also referred to as P-points. If not otherwise designated, at least four (4) thickness measurements shall be made per part. After PPAP, the supplier is encouraged to show correlations in P-Points to each other and petition GM Supplier Quality Engineer (SQE) to reduce the total number of points measured per part based on their daily or weekly testing intervals.

3.3.4.2 GM Engineering and Supplier Quality reserve the right to change the locations and number of selected P-Points if not consulted or as any need should arise. Minimum thickness and corrosion resistance performance requirements for textured finishes (matte, vapor blast, brush, etc.,) apply after texturing. The use of microporous nickel is required to minimize fingerprint marks or stains when specified.

Table 2: Copper and Nickel Thickness Requirements

Application		Plating Thickness (µm) Note 1		
		Total Minimum	Copper Minimum	Nickel Minimum
Interior Code A	Type 1 and Type 3	18	10	8
	Type 2	33	25	8
Exterior Code B	Type 1, Type 2, Type 3, and Type 4	40	20	20

Note 1: Plating thickness exceptions may be listed on part drawings.

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Table 3: Chrome Thickness Requirements

Chrome Type	Thickness (µm) Note 1	Applicable Types
Trivalent	(r) 0.15 Minimum	All interior
	(mp) 0.15 to 0.40	All interior, exterior
Hexavalent	(r) 0.25 Minimum Note 3	All interior
	(mp) 0.25 to 0.50 Note 3	All interior, exterior
	(mc) 0.8 Minimum	All interior, exterior Note 2

Note 1: **mc** = microcracked chrome, **mp** = microporous chrome **r** = regular chrome.
Note 2: The use of microcracked chrome must be approved by GM Materials Engineering.
Note 3: Minimum thickness 0.15 µm permissible in zones "B" and "C" according to GMW16882.

3.3.5 Copper Layer Thickness. In special cases, the minimum thickness must be increased to meet performance requirements (e.g., interior door handles).

3.3.6 Nickel Layer Thickness. For systems with a total nickel layer ≥ 20 µm, multiple layer nickel thickness consisting of at least two (2) layers of electro-deposited nickel shall be as indicated in Table 4. In the case of interior Code A, parts where < 20 µm of nickel is required, a single, bright nickel layer may be used. Exterior parts must have three (3) or four (4) primary layers of nickel. A sample calculation for percent (%) semi bright nickel is below:

$$\frac{\text{Semi Bright Nickel}}{\text{Total Nickel}} \times 100 = \text{percent (\%) Semi Bright}$$

Table 4: Nickel Thickness Requirements

Type of Nickel Layer	Interior Note 1	Exterior	
		Triple Layer	Quad Layer
1 Semi Bright	Optional if thickness < 20 µm	50% to 80%	50% to 70%
2 High-Sulfur	Not required	Not applicable	Required
3 Bright or Satin	50% minimum Note 2	20% to 50%	≥ 30%
4 Microporous/Microcracked	Not Required	Required	Required

Note 1: Dual, triple, or quad layer nickel systems are allowed for interior. If dual layer system is utilized, at least 50%, semi bright (SB) is required and the balance of bright nickel will be required to meet minimum nickel overall thickness and appearance as specified.
Note 2: For Interior < 20 µm of total nickel, a single, bright nickel or satin layer may be used.

3.3.7 Nickel Electrochemical Potential (Multiple-layer Nickel Systems Only). Nickel electrochemical potential shall follow Table 5. Electrochemical potential is only a binding requirement for exterior (Code B) parts. Use the determination of electrochemical potential difference following ASTM B764. See Appendix B, Figure B1 for an example chart. The supplier must demonstrate the conformance to this requirement by using appropriate statistical charting techniques on a routine quality control basis.

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Table 5: Nickel Electrochemical Potential

Layers	Potential Range Note 3
Microporous to Bright or Satin	20 mV to 90 mV
Microporous to Bright or Satin (Exterior Code B Type 4 only) Note 2	50 mV to 90 mV
Bright or Satin to Semi Bright	100 mV to 200 mV
High-sulfur to Bright or Satin Note 1	15 mV to 40 mV

Note 1: If applicable to construction selected.
Note 2: Certain trivalent chrome systems are not optimized within this range. When recommended by the chemical supplier and approved by GM Materials Engineering, potential ranges outside of the values listed in Table 5 may be used. The allowed electrochemical potential ranges shall be documented in the supplier's control plan.
Note 3: The microporous layer shall be cathodic to the bright or satin nickel layer. The semi bright nickel layer shall be cathodic to the bright or satin layer. The bright or satin layer shall be cathodic to the high sulfur layer. See Appendix B, Figure B1 for an example.

3.3.8 Discontinuous Chromium. Microporous chromium is the preferred method for corrosion resistance of plated plastic parts. Plating sources are required to maintain microporous active sites as stated in Table 6. Usage of microcracked chromium should be limited and released by GM Materials Engineering. The use of discontinuous chromium is required for exterior parts and optional for interior parts.

Table 6: Discontinuous Chromium Requirements

Chromium	Requirements
Microporous (mp)	Dubpernell: Minimum of 10 000 pores/cm^2
	Active Sites: Minimum 5000 pores/cm^2
Microcracked (mc)	250 cracks/cm to 800 cracks/cm (closed homogenous network in all directions)

3.3.9 Trivalent Chromium. For all trivalent chromium, both interior and exterior, the corresponding chemical companies electroplating grade hexavalent (or equivalent performance) sealant/passivate is required after the chromium application unless otherwise specified. Approved trivalent chromium grades are listed in MATSPC.

3.3.10 Bond between Plating and Substrate. In general, all chrome plated components are expected to exhibit strong adhesion characteristics. This is accomplished through design, tooling, resin characteristics, and plating process parameters. A 2.54 cm width specimen will typically yield up to 60 N peel strength. For smaller parts or those with difficult geometries, a narrower width can be selected. For ABS, it is recommended a mean value on peel strength be achieved > 30 N per 2.54 cm width (> 12 N/cm). If strong adhesion characteristics are not met for any reason, Materials Engineering is to be contacted so that steps can be taken to remedy these limitations. It is the plating companies' responsibility to bring attention to any part geometry limitations leading to poor adhesion.

3.4 Test Requirements.

3.4.1 Plating Thickness. The plating thickness shall be determined by the microscopic method per ISO 1463 or the electrochemical method per ISO 2177. In case of disagreements between purchaser and supplier, the microscopic method shall be the preferred method for nickel and copper layers.

Note: X-Ray (ISO 3497) may be used, but usage may be limited to chrome layer thickness if copper and nickel layer thickness is too high.

3.4.2 Nickel Electrochemical Potential (Multiple-layer Nickel Systems Only). The electrochemical potential difference between nickel layers shall be determined to ASTM B764. See Appendix B, Figure B1 for an example chart. This test is also known as the Simultaneous Thickness and Electrochemical Potential (STEP) test.

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3.4.3 Determination of Crack Number/Pore Number. Discontinuous chromium (microporous) measurement shall be performed by either the copper deposition (Dubpernell) method or by the determination of active corrosion sites after Copper-Accelerated Acetic Acid Salt Spray (CASS) testing. Both methods are described in ASTM B604. Typically, active sites are measured after 48 h of CASS testing. Some systems (i.e., satin nickel) may require CASS testing for up to 60 h in order to distinguish active sites from other features. In the case of an active site's determination, compare the viewed sample at 100x to the pore density charts shown in Appendix A, Figure A1 of this specification to determine pore count. Photomicrographs should be taken to demonstrate effective pore size and distribution. Other analytical measures for determining total active sites may also apply. Stripping of chrome after CASS exposure and prior to active site determination is required. Active sites are the preferred method for both hexavalent and trivalent chromium.

For microcracked chrome, evaluation and count of microcracks may be done directly by adding a straight line of a certain length to the part and use of a microscope.

3.4.4 Peel-Off Test. Peel test per ASTM B533 or equivalent on a flat area of the part. Use a test speed of 100 mm/minute. Test the part by taking it through the plating process through acid copper. Remove part from the line, cut out a section for peel testing, reactivate the copper and deposit two (2) additional layers of copper in a hull cell. As an alternative, the peel strength may also be obtained after full plating is completed. See Table 7 for peel strength requirements.

If part size or geometry does not allow for a minimum peel width of 1.25 cm, test and report the peel and sample width for the maximum width possible or follow the procedure detailed below.

- To ensure a stable plating system performance, run plaques or surrogate parts of the same material, during the same time frame plating the parts in question. Plating through copper on the plating line and use of a hull cell is recommended. Test peel adhesion on the plaques to GMW14668. Achieving minimum results per GMW14668 constitutes a pass.
- Additional verification is required to ensure the molding system performance is optimum (see 3.2.3), Substrate Surface Stress Test.

Report the peel strength in Newtons per centimeter (N/cm). Peel sites are to be selected at the weakest adhesion sites of the part. These are typically located at or near gates and at the end of flow lengths. The lowest peel strength areas of the part are to be used in all quality tests reports. In reporting peel values, omit beginning (breakaway) and end of test load readings. Use the average of the remaining values within the load curve to determine the average peel strength. Refer to Appendix B, Figure B4. Provide or retain peel test graphs with any laboratory records or submissions to General Motors.

Table 7: Peel Strength – Continuous Load Requirements

Substrate	Minimum Requirement (N/cm)
ABS	9.0
ABS+PC, PA	4.5

ABS = Acrylonitrile Butadiene Styrene, **PA** = Polyamide (Nylon), **PC** = Polycarbonate.

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