



Minimum Plating Structure and Performance Requirements for Decorative Chromium Plated Metallic Parts

1 Scope

This specification covers basic requirements for copper-nickel-chromium electroplated metallic parts, including assemblies.

1.1 Material Description. Plating to this specification is subdivided into three performance classes:

- **Class A:** Exterior components with severe service conditions, likely to include damage from denting, scratching, and abrasive wear, such as those encountered by automotive bumpers and assist steps.
- **Class B:** Exterior components without stone-chipping exposure or other mechanical abuse, such as door handles or emblems (not on the front of the vehicle).
- **Class C:** Interior components.

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

For interior applications, a continuous chrome layer (r) is permissible. The use of discontinuous chromium or multiple-layer nickel systems is not required for interior components.

Plating per this specification is intended for use over metallic substrates; plating on plastics is specified in GMW14668. For plating of stainless substrates, see GMW15613.

1.2 Symbols. Not applicable.

1.3 Applicability. This type of finish shall be principally used for decorative purpose, including bright and other (e.g., satin, brushed, grained) appearances for interior and exterior 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 B456	ASTM F1470	ISO 3497	ISO/TS 16949
ASTM B571	ISO 1463	ISO 4516	SAE/USCAR-5
ASTM B764	ISO 2177	ISO/IEC 17025	SAE/USCAR-7

2.2 GM Standards/Specifications.

GMW3059	GMW14668	GMW15613
GMW14264	GMW14829	GMW16193
GMW14458	GMW14872	GMW16882

2.3 Additional References.

- GM1927-3: Supplier Quality Statement of Requirements (SOR)
- GP-12 GM1920: Early Production Containment

3 Requirements

3.1 Substrate Structure. Parts shall demonstrate no defects such as cracks, shrink holes, or surface porosity. Parts shall be free of internal stress which may influence adhesion or appearance of the plating.

3.2 Relief from Hydrogen Embrittlement. All parts heat treated or highly cold worked to the specified core hardness greater than HV 320 or surface hardness HV 353, which are processed through the hydrogen

generating processes, shall be processed per SAE/USCAR-5 and tested for de-embrittlement per SAE/USCAR-7. The sample size for the SAE/USCAR-7 test shall be per ASTM F1470.

3.3 Coating.

3.3.1 Plating Thickness. Minimum plate thickness as specified in Table 1 (copper and nickel) and Table 4 (chromium) is intended to apply to all low current density and high current density areas of significant surfaces as specified on appropriate part drawings or as otherwise agreed upon between purchaser and supplier (written statement). 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.

Plating thickness measurements shall include a mapping of specific areas of the part. Locations and key dimensions agreed upon with the GM Design Engineer and Materials Engineer. It is the supplier's responsibility to ensure that General Motors Design and Materials Engineering have been consulted on thickness mapping and quality assurance plating thickness points. These points are also referred to as P-points. If not otherwise designated, at least four thickness measurements shall be made per part which will be selected to represent low to high current density regions of the part.

Minimum thickness and corrosion resistance performance requirements for textured finishes (e.g., brushed) apply after texturing. Deviations from the minimum coating thickness must be approved by Materials Engineering. If corrosion products are visible anywhere on a finished and dressed component in vehicle position, this specification is not met.

Table 1: Copper and Nickel Thickness Requirements

Plating Class	Base Substrate Material (Part)	Minimum Thickness Significant Surface		
		Total	Copper	Nickel
		µm	µm	µm
A	Steel	45	20	25
		30	N/A	30
	Zinc	40	10	30
	Copper	30 ^{Note 1}	Optional	30
	Aluminum ^{Note 2, Note 3}	50	10	40
B	Steel	45	20	25
		30	N/A	30
	Zinc	35	10	25
	Copper	25 ^{Note 1}	Optional	25
	Aluminum ^{Note 2, Note 3}	50	10	40
C ^{Note 4, Note 5}	Steel	13	5	8
		13	N/A	13
	Zinc	13	5	8
	Copper	8	Optional	8
	Aluminum ^{Note 2}	13	5	8
	Magnesium	13	5	8

Note 1: For cloisonné type substrates, copper is optional. If copper is not used, then nickel thickness is the minimum total thickness.

Note 2: Copper plating is optional for tubular aluminum products. If copper is not used, then nickel thickness is the minimum total thickness.

Note 3: All plated components must receive an aluminized wax or other corrosion-resistant coating on insignificant surfaces unless otherwise specified on the drawing.

Note 4: For non-wear interior parts, minimum chromium thickness may be 0.13 µm, if authorized by purchaser. Approval is indicated by note on part drawing.

Note 5: Tin cobalt alloy may be used in lieu of chromium when symbol (K) is added to the specification number, e.g., "GMW14672 Class C (K)."

3.3.2 Nickel Layer Thickness. For systems with a total nickel layer thickness $\geq 20 \mu\text{m}$, multiple layer nickel thickness consisting of at least three layers of electrodeposited nickel shall be as follows in Table 2:

Note: If the total nickel layer thickness is $< 20 \mu\text{m}$, the semi-bright thickness shall be 50% minimum.

Table 2: Nickel Thickness Requirement

Type of Nickel Layer	Thickness Relative to Total Nickel Thickness		
	Single Layer (Class C)	Triple Layer (Class B)	Quad Layer ^{Note 1} (Class A or Class B)
Bottom (semi-bright)	Optional	50% to 80%	50% to 80%
Middle (high-Sulfur)	Optional	Optional	Required
Top (bright or satin)	50% minimum	20% to 50%	20% to 50%
Surface (mp)	Optional	Required	Required

Note 1: For ferrous Class A parts, a quad layer nickel system shall be used unless otherwise specified.

3.3.3 Nickel Electrochemical Potential (Multiple-layer Nickel Systems Only). Determination of electrochemical potential difference between plating layers shall follow ASTM B764 Simultaneous Thickness and Electrochemical Potential (STEP) test. A schematic view of a typical STEP chart is shown in Appendix A, Figure A1. The supplier must demonstrate conformance to this requirement by using appropriate statistical charting techniques on a routine quality control basis. Table 3 lists required STEP ranges for various plating layers.

Table 3: Nickel Electrochemical Potential

Layers	Potential Range
Microporous to Bright	20 mV to 90 mV ^{Note 1}
Bright to Semi-Bright	100 mV to 200 mV ^{Note 2}
High Sulfur to Bright ^{Note 3}	$\geq 15 \text{ mV}$ ^{Note 4}

Note 1: Microporous electrochemical potential minus Bright electrochemical potential.

Note 2: Bright electrochemical potential minus Semi-Bright electrochemical potential.

Note 3: If applicable.

Note 4: High sulfur electrochemical potential minus Bright electrochemical potential.

3.3.4 Nickel Hardness (Class A). Semi-bright nickel hardness shall be $\leq 460 \text{ HK}$ (ISO 4516, 0.025 HK). Bright nickel hardness $\leq 550 \text{ HK}$ is preferred. Use of 0.01 kgf HK for the thinner bright layer is allowed.

3.3.5 Discontinuous Chromium. Table 5 shows discontinuous chromium requirements for Class A and B.

Table 4: Chromium Thickness Requirements

Chrome Type	Thickness (μm) ^{Note 1}	Applicable Types
Trivalent	(r) 0.15 Minimum	Type C
	(mp) 0.15 to 0.40	Type A, B, or C
Hexavalent	(r) 0.25 Minimum ^{Note 2}	Type C
	(mp) 0.25 to 0.50 ^{Note 2}	Type A, B, or C
	(mc) 0.8 Minimum	Type A, B, or C ^{Note 3}

Note 1: mc = microcracked chrome, mp = microporous chrome r = regular chrome.

Note 2: Minimum thickness 0.15 μm permissible in zones "B" and "C" according to GMW16882.

Note 3: The use of microcracked chrome must be approved by GM Materials Engineering.

Table 5: Discontinuous Chromium (Measured per ASTM B456)

Chromium	Requirements (Class A and B)
Microporous (mp)	Active Sites: Minimum 5000 pores/cm ²
Microcracked (mc)	250 cracks/cm to 800 cracks/cm (closed homogenous network in all directions)

3.3.6 Plating of Aluminum and Magnesium. Suitable pretreatment processes must be developed for each type of alloy and process of manufacture of the alloy. All pretreatment of aluminum or magnesium processes must pass all visual adhesion and corrosion resistance properties as specified prior to production on each type of alloy and each type of manufacturing process of aluminum or magnesium.

3.4 Test Requirements.

3.4.1 Plating Thickness. The plating thickness shall be determined by the microscopic method (ISO 1463) or the electrochemical method (ISO 2177), or by x-ray method (ISO 3497). In case of disagreements between purchaser and supplier, the microscopic method shall be the preferred method. Generally, x-ray or electrochemical methods are preferred for measurement of the chromium layer.

3.4.2 Nickel Electrochemical Potential (Class A and B). The electrochemical potential between the different nickel layers shall be determined to ASTM B764. See Figure A1 for an example chart. This test is also known as the STEP test.

3.4.3 Semi-bright and Bright Nickel Hardnesses (Class A). The nickel hardness shall be determined to ISO 4516.

3.4.4 Determination of Crack Number/Pore Number. Discontinuous chromium (microporous) measurement shall be performed by the determination of active corrosion sites after corrosion testing, as described in Appendix X5 of ASTM B456. In the case of microporous active sites determination, compare the viewed sample at 100x to the pore density charts shown in Figure A2 of this specification to determine pore count. Photomicrographs shall be taken to demonstrate effective pore size and distribution.

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.

The surface pores or cracks shall be invisible to the unaided eye.

3.4.5 Saw Grind Adhesion Test. Plated components shall be subjected to the ASTM B571 Saw Grind Test with no evidence of lifting or peeling between plated layers or between plating and substrate.

Place pressure-sensitive adhesion tape, as described in GMW14829, approximately 10 mm to 20 mm wide over the cut edge, leaving sufficient length of tape to grasp between fingers for quick removal. Quickly pull tape at approximately 90 degrees to the surface of part to remove entire strip. Examine for evidence of lifting of electroplate.

3.4.6 Thermal Shock Test. The temperature depends on the type of substrate (see Table 6). Parts shall be heated to the temperature listed for 1 h ± 15 minutes and immersed in water at room temperature (23 °C ± 3 °C) within 20 s. The requirement is no blistering or flaking of the coating after immersion.

Table 6: Thermal Shock Test

Substrate	Temperature
Steel	300 °C ± 10 °C
Zinc	150 °C ± 10 °C
Copper	250 °C ± 10 °C
Aluminum or Magnesium	150 °C ± 10 °C

Parts which are exceptionally large may be cut/sectioned to fit in the oven.

3.4.7 Corrosion Resistance Test. Corrosion resistance shall be determined by the Copper Accelerated Acetic Acid Salt Spray (CASS) test, GMW14458, according to the number of hours specified in Table 7.

Plated components shall be free of any surface defects and free of corrosion on all significant surfaces when examined at normal reading distance with the unaided eye and uniform diffused light. This includes pitting, blistering, spotting, etc., whether or not accompanied by substrate corrosion.

Table 7: Minimum Corrosion Resistance

Application	Minimum Corrosion Resistance (hours)
	CASS
Exterior (Class A)	66
Exterior (Class B)	44
Interior (Class C)	8

CASS = Copper Accelerated Acetic Acid Salt Spray

3.4.8 Exhaust Gas Condensate Corrosion Test (only required if suffix –EXH is specified). For Class A component validation, 33 cycles of cyclic corrosion with exhaust gas condensate (GMW14872, Option 5) shall be performed. A GMW14264 rating of 9 (one or two small rust spots) or 10 (no red rust) on the entire part is required. This test is not mandatory unless specified on the part drawing (e.g., GMW14672 Class A-EXH).

3.4.9 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 the GM Approved Materials Source List.

3.5 Test Category and Frequency. Table 8 shows the required test frequencies for plated parts within a plating facility.

3.5.1 Production Part Approval Process (PPAP) Testing. An initial approval for the plating facility must be completed per GMW16193. Examples of test data forms are shown in Tables B1 thru B5. Electronic copies of Tables B1 thru B5 are available from Materials Engineering. Parts shall be tested according to the PPAP test definition in Table 8. For each test, a minimum of six (6) parts representing three (3) low and three (3) high current density rack locations is required. The plating thickness (paragraph 3.4.1) and the nickel electrochemical potential (paragraph 3.4.2) shall be measured on all P-points. All testing shall be performed in an accredited laboratory. Laboratory accreditations to ISO/IEC 17025 are acceptable. If another laboratory that is not ISO/IEC 17025 approved is planned to be used, it is the responsibility of the supplier submitting the technology to receive approval to use the laboratory. Approval must be received from the GM Engineer responsible for approving the specific technology and before any testing is done. Using an unaccredited lab may also require testing in two different labs, whereby one lab must be independent. Generally, the unaccredited laboratory must be in a facility that has a Quality System approval to ISO/TS 16949. Include a scope of accreditation or a scope of activity from the auditor with the test data.

3.5.2 Quality Control Testing. Table 8 shows the minimum test frequencies for quality control testing within a plating facility. Each test must be completed on a low current density part from the same rack location unless otherwise defined by Supplier Quality.

The quality control testing is divided into two levels.

3.5.2.1 Level 1. For product development, Level 1 testing frequency shall be performed on all plating runs during the GP-12 GM1920 Early Production Containment period. For later containment purposes or for high-risk parts, Level 1 testing may also be required by Supplier Quality at any time.

3.5.2.2 Level 2. After the GP-12 period, a formal request to reduce testing frequency to Level 2 will have to be approved by Supplier Quality. If testing frequency according to Table 8 cannot be done because parts are not produced on a regular basis, the Supplier should establish a sampling plan with GM Supplier Quality for testing all parts periodically. The sample plan is to be documented in the Control Plan. For part-specific quality control testing, consider also the part-specific Supplier Quality SOR GM1927-3 if available.