



Anti-Friction Finish - Phosphate Type

1 Scope

This specification covers manganese-iron phosphate coating on ferrous metal. The coating may be impregnated with oil or another supplemental coating.

1.1 Material Description. A friable manganese-iron phosphate layer on a ferrous substrate is produced by a chemical process. Subsequent treatments can be added to enhance various other properties. A code system is provided in Table 1 for designation of these treatments.

1.2 Symbols. Not applicable.

1.3 Applicability. The primary purpose of this coating is for promoting rapid break-in of moving parts without scoring or scuffing, and provides minor corrosion resistance. Typical usage is on small moving parts with low corrosion requirements, such as certain powertrain components. This coating is also used on fasteners bearing against powdered metal components.

1.4 Remarks.

1.4.1 Use of this coating system on threaded surfaces and/or bearing surfaces of joints could affect the torque-tension relationship. It is recommended that a torque-tension study of the fastener joint be performed before releasing this finish on any new application.

1.4.2 This coating process generates a small amount of hydrogen in both the acid pickling and phosphating process. See 3.2 for precautions against hydrogen embrittlement.

1.4.3 The performance specified in this standard may not be met at elevated temperatures. Proper validation of material and process shall be performed before usage.

1.4.4 This coating process exposes parts to acids and may generate surface pits on metal surfaces. Generally, the higher the material hardness, the more severe the pitting. Ensure the coating process selected is not detrimental to the function or durability of the component.

2 References

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

2.1 External Standards/Specifications.

ISO 4014	SAE/USCAR-5
ISO 9227	SAE/USCAR-7
ISO 16047	
ISO 17025	

2.2 GM Standards/Specifications.

GMW25	GMW3059
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2.3 Additional References.

- 11570102 - GM Part Number.
- 11611954 - GM Part Number.
- 11612005 – GM Part Number.
- Approved Finishers List file (available at www.gmsupplypower.com).
- Automotive Industry Action Group Special Process Coating System Assessment Standard CQI-12 (AIAG CQI-12).
- TMC003 Material Safety Data Sheet guidance documents (available at www.gmsupplypower.com).

3 Requirements

The parts coated to this specification shall meet the following technical requirements and demonstrated by the test methods described. The appropriate tests for different situations: New chemical approval, new applicator approval, Production Part Approval Process (PPAP), and regular process control testing, are described in Appendix A, Table A1. Procedures and requirements for new chemical and applicator approval are described in Appendix B.

3.1 Appearance and Roughness. The coating shall be dark grey to black in color. The coating shall be continuous and uniform in thickness and crystalline texture. The roughness of the coating shall not be higher than the uncoated part.

3.2 Hydrogen Embrittlement.

3.2.1 All coated parts with surface or core hardness > 320 HV (32 HRC) shall be processed per SAE/USCAR-5. The referee method for detection of embrittlement shall be per SAE/USCAR-7.

3.2.2 The maximum material hardness in the drawing or relevant specification shall be used to determine if de-embrittlement treatment is required. If a part is heavily cold worked or heat treated to high strength/hardness, but is without a specified maximum hardness limit in the drawing or specification, then the applicator shall obtain the hardness data from their customer in order to determine if de-embrittlement treatment is required.

Note: Treatment is determined by the maximum measured hardness of the lot, not the average.

3.3 Coating Thickness and Coating Weight.

When applied to threaded products, the coating shall not have an adverse effect on normal installation and removal practices. At the same time, coating thickness shall be adequate to provide corrosion resistance and performance requirements.

3.3.1 The maximum thickness of coating which may be applied to threads on threaded products is limited by the basic thread size (tolerance h or H). After coating, parts must gage with appropriate basic size GO thread gages. Threads may be produced undersize/oversize (before coating) to accommodate the coating thickness, provided the finished product (after coating) meets all specified mechanical properties. Where mechanical properties are not specified, undersizing/oversizing is subject to approval by the pertinent engineer and all undersize/oversize shall be within permissible limits as agreed upon. Fastener supplier will consult with the coating applicator to determine the appropriate thread size before coating.

3.3.2 The Mn-phosphate coating weight is specified in Table 1. The process control range for coating weight shall be ± 4 g/m². The entire control range must be within the specified limit. Once production parts have been approved by the Production Part Approval Process (PPAP), the Mn-phosphate coating material and process must remain the same. Any change will require a new PPAP. Phosphate coating weight shall be determined by either the caustic soda method or standard chromic acid method on actual parts.

3.4 Corrosion Resistance.

3.4.1 When exposed to neutral salt spray (NSS) per ISO 9227, significant surfaces on coated parts shall show no base metal corrosion (red rust) after the minimum hours specified in Table 1. See 3.4.3 and 3.4.4 for the definition of significant surfaces.

Note: The salt spray test is only used to test the integrity of the finish for quality control. The hours to red rust in a salt spray test do not correlate to the actual service life of the part.

3.4.2 Applicator in-house NSS testing shall be performed on a regular basis to maintain statistical process control.

3.4.3 Significant surfaces for test evaluation of fasteners shall be all exposed surfaces of the fastener when installed including, but not limited to, fastener heads, socket recess, SEMS washers and external surface of nuts. Fastener threads and point are excluded unless otherwise specified on the drawing.

3.4.4 Significant surfaces on parts other than threaded fasteners shall be all surfaces. Deep recesses, such as blind holes and the interior of tubes, are excluded unless otherwise specified on the drawing.

3.5 Coefficient of Friction. For fasteners with supplemental coating to Codes G, the coefficient of total friction shall be 0.13 ± 0.03 as tested per 3.5.1.

3.5.1 Test per ISO 16047 with the following additional requirements:

3.5.1.1 For studs and bolts with non-rotating heads, or bolts with effective length (from head to first full thread) less than or equal to three (3) times the diameter ($\leq 3d$), a surrogate bolt GM part number (P/N 11570102) can be used for friction testing. The surrogate bolt must be coated simultaneously together with the production parts.

3.5.1.2 Test washer shall be according to ISO 16047, Type HL, except with surface roughness of 0.2 Ra to 0.8 Ra and plain (uncoated) surface (GM P/N 11611954). Stamped identification is not allowed on the washer bearing surface. Test washers must be ultrasonically cleaned and degreased within 2 h prior to test.

3.5.1.3 Test nuts shall be according to ISO 16047 with plain (uncoated) surface, (GM P/N 11612005 or P/N 11611987). Test nuts must be ultrasonically cleaned and degreased within 2 h prior to test.

3.5.1.4 When testing coated internally threaded parts (nuts), use test bolt according to ISO 16047 with plain (uncoated) surface as the mating component. Test bolts must be ultrasonically cleaned and degreased within 2 h prior to test.

3.5.1.5 For testing of all fasteners, the length of the protrusion of the bolt shall be two (2) threads to seven (7) threads, when the nut is seated against the test washer or test device. There shall be a minimum of two (2) full threads within the clamp length after tightening.

3.5.1.6 When testing bolt-washer or nut washer assemblies, the production part washer shall not be fixed against rotation.

3.5.1.7 The dimension D_0 is the minimum outer diameter of the bearing surface of the driven fastener as defined in the drawing, not as measured after test. In the case of bolt-washer or nut-washer assemblies, D_0 is of the bolt or nut minimum bearing surface and not the washer.

3.5.1.8 Tightening speed shall be 30 rpm $\pm$ 3 rpm.

3.5.1.9 Do not wash or pre-condition the coated fastener to be tested, as this may change the frictional characteristics of the coating and affect the test result.

3.5.2 Requirements for Chemical and Applicator Approval (for Codes G). Process test bolts using production equipment with regular production loading weights and other parameters. This includes pre-treatment, coating, post-treatments, and parts handling. The coefficient of friction test shall be performed by an ISO 17025 accredited laboratory unless otherwise agreed upon by responsible GM Materials Engineer.

3.5.2.1 Apply coating to M10 $\times$ 1.5 $\times$ 60 mm property class 10.9 hex head bolt per ISO 4014 Grade A. Thread tolerance shall be 6h after coating. Perform test according to 3.5.1. The bolt is the driven part. The coefficient of friction ± 3 sigma values based on 30 samples is required to be within the specification. For new applicator approval, the coefficient of friction test shall be performed by the applicator.

3.5.3 Requirement for PPAP. Test production fastener according to 3.5.1. The friction values for 30 samples shall be within the specification.

Note: When torsional yield testing is required per GMW25 on the fastener, friction testing per 3.5.3 is not required.

Note: When thread adhesive or sealant is specified for the fastener, frictional requirements apply to the fastener before application of those patch materials.

3.5.4 Requirement for Quality Control. Applicator coating fasteners to Codes G shall have in-house friction testing equipment capable of running test per 3.5.1. A regular test schedule shall be included in the applicator's process control plan with test data showing statistical capability. This requirement may be exempted if the fastener maker agrees to undertake the required friction testing. In this case, the applicator is still responsible for collecting, reviewing, and reacting to the test results.

4 Manufacturing Process

4.1 Manufacturing Process. The process, including pre-treatment (cleaning), coating, and post-treatment, shall be performed by one (1) company in one (1) facility. The equipment, process controls, chemicals, and location used, must remain the same for regular production. This includes pre-treatment (such as cleaning) and post-treatment. These operations cannot deviate without prior approval by GM. The only allowable exception is for applications where there is an additional thread coating (sealant, adhesive, etc.) that must be applied before the coded supplemental coating.

For each production lot of coated parts, the applicator shall supply a certificate to their customer with the following information:

- This specification number
- Applicator name and address
- Coating system used
- GM Part number
- Date(s) the parts were coated
- Coefficient of Friction test results at PPAP (for code G only)
- Coefficient of friction test results as per most recent process control test (for code G only)

Note: Coefficient of friction test is not applicable for non-threaded fasteners. The applicator shall keep the certificates for a minimum of five (5) years.

5 Rules and Regulations

5.1 Legal Regulations. All materials must satisfy applicable laws, rules, regulations and recommendations valid in the country of usage.

5.2 Language. In the event of conflict between the English and domestic language, the English language shall take precedence.

5.3 Inspection and Rejection. Samples of components or materials released to a GM material specification shall be tested for conformity with the requirements of this material specification and approved by the responsible Engineering department prior to commencement of delivery of bulk supplies.

A new approval must be received for any changes, e.g., properties, manufacturing process, location of manufacture, etc. If not otherwise agreed, all testing and documentation normally required for initial release must be completed.