



Global Qualification Process for Uncoated and Coated, Low Carbon and High Strength Sheet Steel

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

This procedure defines the process and requirements a steel producer or processor (uncoated, electrogalvanized (EG), hot dip (HD) galvanized, or aluminized coating supplier) shall meet to qualify their steel products and processing lines at General Motors. This procedure applies to General Motors Worldwide (GMW) material grades and coatings that are currently in use. This includes GMW grades from new suppliers or grades that have undergone a significant change in process route. This procedure does not apply to the development of new materials or coatings. Steel sheet products supplied to GM production facilities must have Engineering and manufacturing approval as defined by this procedure.

1.1 Purpose. The intent of this specification is to create a common, global process for qualification of sheet steels that are used by GM worldwide.

1.2 Applicability. Requirements for qualification of uncoated and coated steels for specifications GMW2, GMW3032, GMW3399, GMW16056, and GMW17627 with exposed, semi-exposed, temper-rolled, and for unexposed surface quality from a specific production path are defined in this procedure. Coating requirements for these specifications are detailed in GMW8, GMW11, and GMW16066. Suppliers must also be capable of meeting the requirements in GMW3224, Sheet Steel Thickness and Tolerances before approval will be granted.

Testing requirements are summarized in Appendix A, Tables A1 through A3. These tables define testing requirements for unapproved lines, as well as approved processing lines supplying previously unapproved base metals or higher strength grades, as well as new combinations of approved processing lines and approved base metals. New steel grades or coatings under development are not the scope of this specification.

Release of specific parts and applications are not within the scope of this specification.

1.3 Remarks. This procedure is intended to evaluate a supplier's ability to produce and supply steel that meets GM's requirements. Emphasis is placed on the steel producer's ability to supply a uniform and consistent product. Some material characteristics and attribute data are requested for qualification purposes even though they are not requirements of GM Standards related to the base substrate or coating. In these instances, the data is required for informational purposes.

While this specification details the requirements for initiating global qualification, additional information and/or testing may be requested by the Qualification Champion. The data required to be submitted for each shipment will be determined by the regional manufacturing location.

2 References

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

2.1 External Standards/Specifications.

ASTM A751	IATF 16949	ISO 10113	JIS Z 2256
ASTM E45	ISO 3497	ISO 10275	SAE/USCAR-7
ASTM E112	ISO 7438	ISO 12004-2	
ASTM E517	ISO 7500-1	ISO 17025	
ASTM E646	ISO 9513	ISO/TS 16630	

2.2 GM Standards/Specifications.

GMW2	GMW3399	GMW14872	GMW16170
GMW8	GMW14019	GMW15056	GMW16549
GMW11	GMW14057	GMW15200	GMW16823
GMW3011	GMW14058	GMW15282	GMW17508
GMW3032	GMW14700	GMW15425	GMW17627
GMW3059	GMW14704	GMW16056	
GMW3224	GMW14729	GMW16066	
GMW3335	GMW14829	GMW16086	

2.3 Additional References.

- GWS-5A Weld Test Procedures for Resistance Spot Weldability: <http://gmsupplypower.com>
- SEP 1970 (available at <http://www.stahleisen.de> → Go to Products → Bookshop)

3 Test Preparation and Evaluation

3.1 Resources.

3.1.1 Facilities. All testing must be performed at an International Laboratory Accreditation Cooperation (ILAC) member accredited laboratory (see www.ilac.org for a list of national accreditation bodies) that has been certified to ISO 17025 or approved to the latest version of IATF 16949. If the lab is not approved by a signatory of the ILAC mutual recognition agreement, the laboratory must be approved for technical competence for the required testing as agreed upon by the Qualification Champion and supplier.

3.1.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label. Calibration in accordance to ISO 7500-1 and ISO 9513 is required.

3.1.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.2 Equipment. Not applicable.

3.1.3 Test Vehicle/Test Piece. Not applicable.

3.1.4 Test Time.

Calendar time: Approximately 8 months

3.1.5 Test Required Information. Not applicable.

3.1.6 Personnel/Skills. Not applicable.

3.2 Preparation. Suppliers are required to supply any test samples to General Motors or outside testing sources as required by this engineering standard and any referenced tests. Additional requirements for material may be identified at the start of testing or may be necessary if tests are repeated. The Qualification Champion shall inform the supplier if any additional samples are necessary as part of a retest.

3.3 Conditions.

3.3.1 Environmental Conditions. Not applicable.

3.3.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

Testing requirements in this procedure are determined by the type of base metal substrate, type of coating or coating alloy, surface quality and the qualification status of the processing line.

The steel producer must furnish information for each grade, coating designation and processing line combination desired for qualification. GM also requires that all suppliers adhere to the fundamental quality systems requirements of IATF 16949. Suppliers choosing other approaches must be able to show that their quality systems meet the intent of IATF 16949 as determined by GM Supplier Quality - Global Product Integrity.

3.3.3 Supplier Quality Audit. General Motors, at its discretion, may perform a supplier assessment and review of its suppliers at any time prior to or following steel qualification.

A re-assessment of the steel supplier to produce a given grade may be required if material has not been used by GM in a production environment for a period of three years from the initial date of approval or if substantial

quality issues arises which requires the supplier to re-establish conformance capability of meeting GM requirements.

3.4 Instructions. See Section 4 Requirements and Procedure.

3.5 Data.

3.5.1 Calculations. Not applicable.

3.5.2 Interpretation of Results. Test results performed in accordance to this specification shall be reviewed by the GM Champion and by the Global Sheet Metal Specialist Team (GSMST).

3.5.3 Test Documentation.

3.5.3.1 Global Engineering Requirements. Global Engineering Requirements are summarized in Appendix A, Tables A1 and A2. A material cannot be "approved" for use in any region until the Regional Manufacturing Requirements have also been met (see Appendix A, Table A3).

3.5.3.1.1 Restricted and Reportable Substances (GMW3059). All materials supplied to this specification must comply with the requirements of GMW3059, Restricted and Reportable Substances for Parts. Compliance with the requirements of GMW3059 must be documented with the GMW3059 form, located in the GMW Engineering Materials and Process Standards, and included in the Supplier Global Engineering Qualification Package.

3.5.3.1.2 Chemical Analysis of Base Steel. Base metal composition based on product (coil or sheet/blanks) analysis determined per ASTM A751 must conform to the requirements in the base metal specification. The following elements shall be reported (in weight %): C, Mn, P, S, Si, Al, N, Nb, Ti, V, B, Mo, Cu, Ni, Cr, Sn, Ca, and Zr. Any other intentional alloy additions shall be reported. The carbon equivalence, shall be reported for each grade based on a typical chemistry defined by the following:

- $CE1 = \%C + \%Mn/20 + \%Si/30 + 2(\%P) + 4(\%S)$ and
- $CE2 = \%C + \%Mn/6 + \%Si/30 + (\%Cr + \%Mo + \%V)/5 + (\%Cu + \%Ni)/15$

Additional demands and restrictions may be given by the GSMST.

In addition, the melt specification from the qualifying mill (maximum and minimum allowable for each element), as well as each alloy element and residual elements, shall be reported. The supplier must adhere to their melt chemistry ranges that were provided during qualification for all production material, and any changes shall be reported to their GM Champion for approval.

3.5.3.1.3 Mechanical Properties. Products approved by this specification shall be tested and approved to the mechanical properties as specified in the base metal specification. The mechanical test methods to be used are defined in GMW3335 using the appropriate tensile test sample geometry required by the specific region.

Mechanical properties shall include 0.2% offset yield strength, ultimate tensile strength, uniform elongation, total elongation, yield point elongation (if applicable), strain hardening exponent, and plastic strain ratio. The strain hardening exponent, n , and the strength coefficient, K , shall be determined per ISO 10275 or ASTM E646 over a strain range indicated in the base metal specification. The plastic strain ratio, r , shall be reported per ISO 10113 or ASTM E517 in the longitudinal, transverse, and diagonal directions at 20% strain along with the corresponding r -bar ($\bar{r}$) value. For steels with uniform elongations (UE) less than 20%, r and $\bar{r}$ shall be reported in a similar manner at strains equal to $0.8 \cdot UE$. True fracture strain following uniaxial tensile testing shall be reported by physical or optical measurement of gauge section reduction in area for a minimum of 10 samples for all GMW3399 and GMW17627 grades or as required by the base metal specification. Hole-expansion testing shall be performed per ISO/TS 16630 or JIS Z 2256 for all GMW3399 and GMW17627 grades or as required by the base metal specification. Bend testing shall be performed per ISO 7438 in the longitudinal and transverse directions for all GMW3399 and GMW17627 grades or as required by the base metal specification. Forming limit diagrams (FLD) shall also be performed per ISO 12004-2 or ASTM E2218 for all GMW17627 grades or as required by the base metal specification.

Data shall be supplied from uniaxial tensile testing of samples taken from the head, center, and tail locations along the body of one coil. Edge-center-edge tests shall be performed at each sampling location in the test direction specified by the appropriate GMW base metal specification; however, testing along the centerline must be performed in the longitudinal, transverse, and diagonal (LTD) directions. At least one representative, digitized stress/strain curve in the transverse, diagonal, longitudinal test directions must be provided. The data shall be in either American Standard Code for Information Interchange (ASCII) (tab or comma delimited) or Excel format and contain 50 data points minimum. Any additional requirements for mechanical properties and/or testing direction will be specified in the manufacturing qualification section.

Data shall also be supplied from uniaxial tensile testing of samples taken from the center width of the head and tail locations of ten coils. Tests shall be performed from each sampling location in the transverse, transverse, and diagonal test directions.

3.5.3.1.3.1 Bake Hardenability. When required by the base metal specification, paint bake hardenability shall be evaluated as described in the base metal specification.

3.5.3.1.3.2 Secondary Work Embrittlement (SWE). Secondary work embrittlement testing per GMW16086 is required for all new substrates when the lower mill limit for carbon content is less than 0.015 wt%. In all cases, SWE testing shall be done on samples with less than 0.015 wt% carbon.

3.5.3.1.4 Microstructure. For GMW2, GMW3032, GMW3399, and GMW16056 materials, microstructural analysis of the base steel is required in one location in both longitudinal and transverse directions, 100x, 500x and 1000x magnification. The microstructure in the transverse direction, 500x and 1000x magnification, showing the coated edge of the galvanized or aluminized sheet shall be provided.

For GMW17627 materials, microstructural analysis of the base steel via optical or electron microscopy is required in three locations (surface, through-thickness quarterline, and through-thickness centerline) in both longitudinal and transverse directions at a minimum of 1000x magnification. The microstructure in the transverse direction at 1000x magnification showing the coated edge of galvanized sheet shall also be provided. The grain size, inclusion ratings, and microstructural banding shall be tested and reported according to the base metal specification requirements.

3.5.3.1.4.1 Grain Size/Microstructural Feature Size. For GMW2, GMW3032, GMW3399, and GMW16056 materials, grain size shall be tested to ASTM E112 and shall be consistent throughout the thickness of the sheet at the head, center, and tail of the qualification coil.

For GMW17627 materials, sufficient characterization of the phase/microconstituent fractions and effective feature sizes shall be reported for cross-sectional (optical or electron) micrographs taken from the surface, through-thickness quarterline, and through-thickness centerline. A minimum of three (3) fields of view shall be analyzed and reported from each location.

3.5.3.1.4.2 Inclusions. Non-metallic inclusions in the steel substrate shall be quantified according to ASTM E45 Method D, Plate I-r, by analysis at 100x. Inclusion content shall not exceed a rating of 2.0 for thin and 2.0 for heavy.

3.5.3.1.4.3 Microstructural Banding. Microstructural banding in the steel substrate shall be quantified by the anisotropy index (AI) outlined in ASTM E1268. Banding requirements are listed within the base metal specifications.

3.5.3.1.5 Sheet Thickness Characteristics. Sheet thickness of the finished product shall be measured at the centerline and at 40 mm from each trimmed edge. Sheet thickness at these three locations across the width shall be recorded at the head and tail of the coil. The thickness measurements shall be reported along with the width of the trimmed sheet and the location of the coil where the measurements were taken. Data shall consist of thickness measurements from at least 10 coils.

3.5.3.1.6 Coating Mass and Coating Thickness. The coating mass shall be determined according to requirements in GMW11 for electro-galvanized coatings, GMW8 for hot dip galvanized coatings, and GMW16066 for aluminized coatings.

During qualification, data from on-line x-ray fluorescence techniques may also be included in the qualification package, as described in ISO 3497.

3.5.3.1.7 Coating Mass Variability. Coating mass variability data shall be provided (edge, center-edge, and top and bottom) to determine coil to coil variation of the coating line and shall meet the requirements of the appropriate coating specification (GMW8, GMW11, or GMW16066). The coating mass variation shall be provided for 20 coils using on-line x-ray fluorescence techniques in accordance with ISO 3497. Data shall be furnished for individual coils, as well as summarized in histogram form including mean, range, and standard deviation. Data submitted to this requirement shall consist of products similar to, or representative of, the type of product being submitted for qualification. When qualifying a new line, coating variability data from 20 coils shall be submitted as soon as possible after initial technical qualification is granted in order to complete requirements for full qualification of the coating line. Submission of coating variability data is expected within three months from the time of technical qualification of the line.

3.5.3.1.8 Coating Adhesion. Coating adhesion shall meet requirements stated in GMW11 for EG coatings, GMW8 for hot dip coatings, or GMW16066 for aluminized coatings. Coating adhesion shall be tested and meet

the requirements for each side of the coated sheet in both the longitudinal and transverse directions to the rolling direction. Testing shall be performed at the edge-center-edge locations. See additional requirements for General Motors Europe (GME) in the Deviations section.

3.5.3.1.9 Coating Analysis. The coating chemistry shall meet the requirements shown in the appropriate coating specification, GMW11, GMW8, or GMW16066. Coating investigation shall consist of photomicrographs depicting a representative cross section showing the coating/substrate interface at 1000x and 2000x utilizing Scanning Electron Microscopy (SEM). Additionally, SEM photomicrographs of the coating at 1000x and 2000x magnification shall be provided depicting representative surface morphology.

A coating chemical analysis shall also be submitted, and shall consist of a bulk analysis of the coating as deposited on the sheet and the chemical composition of the melting pot at the time of coating. The operating limits for the pot chemical composition shall also be provided. Reported elements shall include, but not be limited to the following: aluminum, iron, lead, antimony, cadmium, and zinc in addition to iron for galvanized (GA), nickel for zinc-nickel, and silicon for aluminized coatings. Other elements intentionally added to the coating shall also be reported. Chemical analysis of the coating on the sheet shall be performed by dissolution of the coating and analysis by Inductively Coupled Plasma (ICP) Spectroscopy and shall, at a minimum, include those elements documented.

For hot-dipped coatings specified according to GMW8 or GMW16066, a microprobe scan, Glow Discharge Optical Emission Spectroscopy (GDOES), or Energy Dispersive Spectroscopy (EDS) scan of the elements (Zn, Al, Fe, and Si (aluminized coatings)) through the coating to the base substrate shall be provided. The microprobe/spectroscopy scan shall include surface chemistry, chemistry at one-half thickness of the coating, and at the coating/steel interface as measured on a cross section of the coated sample.

3.5.3.1.10 Electrogalvanized Zinc Crystal Morphology/Orientation. When required, perform scanning electron microscopy on the as-coated zinc surface at 2000x to document coating morphology. Examples are shown in Appendix B, Figures B1 and B2.

3.5.3.1.11 Hydrogen Embrittlement Sensitivity. During source approval/qualification of steels with a tensile strength level ≥ 980 MPa, the supplier must demonstrate the steel shall be delivered free of hydrogen embrittlement via testing per SEP 1970. (u-bend or tensile specimen with notched hole loaded to 100% Yield Strength (YS)) or SAE/USCAR-7 (standard tensile specimen loaded to 80% Ultimate Tensile Strength (UTS)) under typical steel processing conditions. Additionally and where applicable, the supplier must demonstrate a sufficient resistance to hydrogen embrittlement during product service by testing according to GMW17508.

At the discretion of the GM Qualification Champion, additional testing may be requested.

3.5.3.1.12 Process Flow Diagram. A process flow diagram that represents the material being qualified is required. The flow diagram must include the location and identification of all major production steps. These steps may include the hot mill, cold mill, annealing line (including type), galvanizing line, and temper line.

3.5.3.2 Regional Manufacturing Requirements. Regional Manufacturing Requirements are summarized in Appendix A, Table A3. The Qualification Champion will provide test details for the Regional Manufacturing Requirements. Additional requirements may be specified by the Qualification Champion.

3.5.3.2.1 Mechanical Properties. Mechanical properties shall be submitted as detailed in 3.5.3.1.3 and shall meet the requirements of the specification and specific grade being submitted for approval. Mechanical properties data must be submitted by testing after the final steel finishing process or after the processing stage at which production material certifications are generated.

3.5.3.2.2 Surface Texture. When a surface texture evaluation is required according to this specification, surface roughness average (Ra) and peak count (PC_{cm}) shall be determined at top and bottom of the sheet at edge-center-edge according to GMW16823.

3.5.3.2.3 Adhesive Compatibility. Surfaces of the pre-coated and uncoated flat products and/or finished parts furnished to this specification shall be capable of being bonded with GM-approved adhesives when tested according to GMW16549. Testing to this specification will evaluate bonding characteristics to the metal surface.

3.5.3.2.4 Zinc-Iron Alloy Coating Powdering. Zinc-iron alloy (galvanized) coating powdering shall be evaluated according to requirements stated in GMW8 for hot dip coatings.

3.5.3.2.5 Zinc Blister Requirement. Zinc blister testing requirements are detailed GMW11.

3.5.3.2.6 Lubricant Approval. All lubricants or fluids applied to the surface of the steel sheet by the steel producer or processor shall meet the surface treatment requirements of the appropriate base metal specification

for the region the material is being used as specified in GMW14019. Approved lubricants are specified by the region receiving the material, but must be documented in the qualification package.

3.5.3.2.7 Pre-treatment and Paint Compatibility (Not Applicable for Aluminized Coatings). When tested with approved phosphate systems, uncoated or zinc-based coated steels shall be capable of achieving a high quality zinc phosphate conversion coating according to GMW3011 (crystal size and coating weight). When tested with approved thin film pre-treatments, the requirements of GMW16170 (coating weight and thickness) must be fulfilled. Steels with thin organic pre-coatings per GMW15056 are excluded from these requirements; as a pre-treatment will not be deposited. However, the additional requirements below must be met for thin film organic pre-coating qualification.

After application of production representative pre-treatment and paint, the steel considered for qualification shall meet the following requirements:

- a. Adhesion of the E-coat shall fulfill test requirements of the crosshatch test according to GMW14829:
 1. For samples that are phosphated: Rating 0 as-received and after 120 h humidity exposure per GMW14729.
 2. For samples with thin film pre-treatment, requirements according to GMW16170 must be met.
- b. Pretreated (zinc phosphate or thin film) and E-coated samples must meet delamination test requirements according to GMW14704 (rating 0 or 1 after 48 h test duration).
- c. For fully painted applications on exposed (E) surfaces, the material shall also meet the requirements of the stone chip resistance test according to GMW14700, Method A (or B) and Method C, with a minimum stone impact rating of 8.
- d. Creep back resistance shall be inspected on E-coated samples. The samples shall be scribed per GMW15282 and tested according to GMW14872, EXT, All, 4 salt spray per cycle, Method 1/2, Exposure C. The creep back shall be evaluated per GMW15282 and meet the requirements stated in the following specifications:
 1. GMW3011 for samples that are phosphated.
 2. GMW16170 for samples with thin film pre-treatment.
 3. GMW15056 for samples with thin organic pre-coating (applicable to thin film organic coating qualification only).
- e. Appearance evaluation requirements for exposed (E) quality steel shall be determined by the regional materials and/or Manufacturing Engineering department.

Details regarding the phosphating system (cleaning/phosphate chemicals, etc.,) and thin film pretreatment must be reported in the qualification package. Other requirements or exceptions regarding phosphate and paint compatibility may be found in the base metal specification.

The test lab that generates this data will be determined by the region doing the approval and will be communicated to the supplier at the beginning of the qualification.

3.5.3.2.8 Weldability/Joining. Sheet steel supplied to this standard shall be weldable with standard GM Weld Practices and meet spot weld, arc weld, or laser fillet weld acceptance criteria per GMW14057, GMW14058, or GMW15425, respectively. When required for qualification, testing for spot weldability shall be performed per GWS-5A or modified in consultation the ME-Weld Department of GM Manufacturing Engineering and approved by the ME-Weld Department of GM Manufacturing Engineering. When required by the GM qualification champion, testing per selected sections of SEP 1220 shall be performed and provided. Contact the GM Weld Council for specific information regarding weldability at weld.council@gm.com.

Note: Modifications to these methods may be required for GMW17627 grades. Due to unique properties of advanced high strength steels, selection of the weld process parameters should be determined in consultation with the steel supplier and GM Manufacturing Engineering.

At the discretion of the Qualification Champion and/or the ME-Weld Department of GM Manufacturing Engineering in the region considering Regional Manufacturing Qualification, test material for further evaluation may be required.

3.5.3.2.9 Plant Tryout. A plant tryout may be required at the discretion of the Qualification Champion to assure steel compatibility with the plant manufacturing and assembly environment. The steel supplier shall work with the local manufacturing engineering and/or supplier quality engineering department to arrange the necessary engineering trial run. Upon completion of the trial, the involved plant(s) are responsible to submit a letter to the