



High Strength Sheet Steel, 180 MPa through 700 MPa Yield Strengths

1 Scope

This standard covers the requirements for continuous cast sheet steel with specified minimum yield strengths from 180 MPa through 700 MPa.

1.1 Material Description. This specification applies to uncoated and coated, cold (CR) or hot rolled (HR) bake hardenable (BH) and high strength low alloy (HSLA) substrates. Continuously hot or cold rolled flat products shall be supplied as coils or sheet. Hot rolled flat products are usually supplied in thicknesses > 1.75 mm. These flat products are used for cold forming and for manufacturing of welded tubes. Cold or hot rolled flat products with the appropriate surface type and surface finish are suitable for the application of surface coatings, metallic hot dipping, electrolytic plating, hot spray painting, organic coatings, and/or other coatings. This specification does not apply to steel for case hardening and cold reduced, work hardened strips.

1.2 Symbols. Not applicable.

1.3 Applicability. Typical applications include body panels, body structure members, chassis components, reinforcements and bumpers.

2 References

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

2.1 External Standards/Specifications.

ASTM A751	ASTM E1268	ISO 7438	JIS G 3113
ASTM E45	IATF 16949	ISO 10113	JIS Z 2241
ASTM E112	ISO 6892	ISO 10275	

2.2 GM Standards/Specifications.

GMW8	GMW14057	GMW14872	GMW16546
GMW11	GMW14058	GMW15056	GMW16549
GMW3011	GMW14699	GMW15282	GMW16656
GMW3059	GMW14700	GMW15425	GMW16823
GMW3221	GMW14704	GMW16066	
GMW3224	GMW14729	GMW16086	
GMW3335	GMW14829	GMW16170	

2.3 Additional References.

- GWS-5A

3 Requirements

This section defines specific requirements for material on delivery, processing, performance and other stages during life cycle. Deviations required for individual GM business units are listed in the Deviations.

3.1 Requirements on Delivery.

3.1.1 Chemical Requirements.

3.1.1.1 Base Metal. Base metal composition based on product (coil or sheet/blanks) analysis determined per ASTM A751 shall conform to the requirements of Appendix A, Table A1 and Table A2. When end-product (coil/blank) test results are not available, heat analysis may be used. Chemical composition of the end-use product is the referee method.

3.1.1.2 Surface Treatment. Products coated with a designated lubricant (e.g., mill oil or pre-lube) shall comply with GMW16546 and GMW16656 and/or be approved by the local business unit.

3.1.2 Mechanical Requirements. All products supplied to this specification shall meet the mechanical properties as specified in Appendix A, Tables A3 through A6. The 0.2% Offset Yield Strength, Tensile Strength, Elongation (at or after fracture) and BH₂-values (bake hardening index) shall be determined in the longitudinal direction per GMW3335. Tests shall be performed using samples per ISO 6892 Type I (50 mm gage length ASTM type sample), ISO 6892 Type II (80 mm gage length DIN type sample) or ISO 6892 Type III (JIS Z 2241 no. 5 type sample). Both test methodology and results shall be reported accordingly per GMW3335. 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) < 20%, r and $\bar{r}$ shall be reported in a similar manner at strains equal to 0.8*UE. The specific strain level shall be reported with all test results. The strain hardening exponent, n , and the strength coefficient, K , shall be determined per ISO 10275 or ASTM E646 at 10% to 20% strain, or at 10% to end of uniform elongation when uniform elongation is < 20%, but > 12%. If the maximum uniform elongation is < 12%, the strain hardening exponent shall be reported as the true strain at the end of uniform elongation ($n_{U.E.} = \epsilon_{U.E.}$). The specific strain range shall be reported with all test results. For tensile tests conducted to ISO 6892, only longitudinal test samples should be used (except for $\bar{r}$ value). Conformance to the $\bar{r}$ (r -bar) requirement shall be verified at the time of approval and at the time of the initial production shipment, unless otherwise required by the local materials engineering or manufacturing department.

3.1.2.1 Bake Hardening Index. Bake hardenable steels have the additional requirement of a bake hardening index (BHI or BH₂). Where required, the material shall attain an increase in lower yield strength as specified in the appropriate table after 2% tensile strain and baking at 170 °C for 20 minutes. Figure C1 in Appendix C defines bake hardening and work hardening indices.

Note: The bake hardening index in this specification is a parameter that characterizes the general bake hardening response of steel. The actual or measured bake hardening response for production parts depends on a number of factors that must be considered. The amount of strain, the direction of strain relative to the test direction, the actual part temperature/time in the paint bake ovens, etc., may all impact the observed bake hardening response.

3.1.2.2 Bend Test Requirements. For material qualification, testing shall be performed according to ISO 7438 by utilizing a bending device consisting of a V-block and a former for high strength low alloy grades (see Tables A4 and A5) or two low friction mounted test rollers and a former for structural automotive grades (see Table A6). Specified bend radii requirements must be met to bend angles of 90° and 180° for HSLA and SA grades, respectively. Samples shall not exhibit cracking in a minimum of three (3) tested samples as viewed at 10x to 20x magnification.

3.1.3 Physical Requirements.

3.1.3.1 Material Thickness and Tolerance. The detailed engineering part drawing/electronic math file will specify the material thickness and tolerance. The tolerance requirements for various thicknesses and strength levels are listed in GMW3224.

3.1.3.2 Surface Requirements.

3.1.3.2.1 Surface Texture. All products shall be supplied to surface texture requirements per GMW16823.

3.1.3.2.2 Surface Quality. The surface condition shall meet the requirements of GMW16823. The steel shall be free from surface defects as negotiated between purchaser and supplier. Only unexposed (U), temper rolled (T) surfaces, or exposed (E) surfaces may be specified for materials subject to GMW3032. Specification of semi-exposed (Z) surfaces is not allowed.

3.1.3.2.3 Surface of Hot Rolled Products without Special Requirements on the Surface Quality. Uncoated hot rolled products shall be supplied in a pickled (de-scaled) and oiled condition to ensure adequate processability and adhesion of applied coatings as required by the appropriate coating specifications. Hot rolled steels may be temper passed at the discretion of the supplier or with agreement by General Motors.

3.1.3.2.4 Pre-Treatment/Paint Adhesion. For material qualification and 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) shall be met. Steels with thin organic pre-coatings per GMW15056 are excluded from these requirements as a pre-treatment will not be

deposited. The additional requirements in 3.2.3.2.5.1 through 3.2.3.2.5.4 must be met for thin film organic pre-coating qualification.

After application of production representative pre-treatment and paint, the steel 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 with phosphate pre-treatment.
 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).

3.1.3.2.5 Adhesive Compatibility. For material qualification, uncoated or zinc based coated steels supplied 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.

3.1.3.2.6 Coating Requirements. Refer to coating requirements in GMW8 for hot dipped coatings, GMW11 for electrogalvanized coatings, GMW16066 for aluminized coatings, and GMW15056 for thin organic pre-coatings. Coating requirements include, but are not limited to, coating composition, coating mass, and coating adhesion.

3.1.3.3 Microstructure.

3.1.3.3.1 Grain Size. By analysis, grain size when tested to ASTM E112, shall be consistent throughout the thickness of the sheet. Grain size shall be Number 6 or finer for hot rolled substrates, and Number 8 or finer for cold rolled substrates.

3.1.3.3.2 Material Inhomogeneities and Cleanliness. Inhomogeneities (e.g., martensite lines, slag inclusions, segregations) in the steel shall be minimized and should not affect cold forming properties. A "B" designation is specified for hot rolled LA "F" type grades which need to be free of microstructural banding, e.g., chassis applications. Required anisotropy indices per ASTM E1268 for banding free grades are listed in Appendix D.

3.1.3.3.3 Inclusions. For material qualification, 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.

3.1.3.3.3.1 Inclusion Control. When required by manufacturing or product engineering to improve edge stretching or bending in some applications, a designation may be added to the callout to specify inclusion control ("F" designation, see Section 8, Coding System). The supplier may limit sulfide inclusions content via ultra-low sulfur steelmaking practices and/or may utilize a calcium treatment or rare-earth element (i.e., Cerium) (Ce) addition to control inclusion shape (small globular particles are preferred). Inclusion control shall only apply to LA grades.

3.1.3.4 Marking. If required, marking shall be carried out on the unexposed surface of full finish coils for outer panels and on the outer side of the coils for inner panels. The marking must be agreed upon between the supplier and purchaser. The purchaser must release the marking ink.

3.1.3.5 Other Requirements. Requirements such as tolerances on product shape and dimensions, inspections units, number of tests, sampling, test conditions, re-tests, inspection documents, packing, and handling of disputes shall be agreed upon between supplier and the local business unit.

3.2 Processing Requirements.

3.2.1 Additional Requirements.

3.2.1.1 Weld Seams in Coils. If weld seams in cold rolled material are allowed by Global Manufacturing Engineering Department, the following restrictions shall be considered:

- For cold reduced coils, pickling weld seams from the manufacturing process of hot rolled coils is permissible without restriction.
- Punch holes may be used for cold reduced coils to detect weld seams, but must be avoided in stamped parts.
- For cold reduced coils with exposed (E) or semi-exposed (Z) surfaces, weld seams are permissible, but must be indicated by perforation.
- For cold reduced coils with unexposed (U) surfaces, weld seams are not permissible unless special exceptions are made by the local organization.
- For hot rolled coils, weld seams are not permissible.

3.2.1.2 Weldability. Sheet steel supplied to this standard shall be weldable with standard GM Weld Practices and meet spot weld, arc weld, and laser weld acceptance criteria per GMW14057, GMW14058, and GMW15425 respectively. When required for qualification, testing for spot weldability shall be performed per GWS-5A and approved by the Manufacturing Engineering (ME) - Weld Department of GM Manufacturing Engineering. Contact the GM Weld Council for specific information regarding weldability at weld.council@gm.com.

Note: The standard weld test methods are intended for **yield** strength levels up to 420 MPa. Modifications to these methods may be required for higher strength levels. Selection of the weld process parameters should be determined in consultation with the steel supplier and GM Manufacturing Engineering.

3.2.1.3 Stretcher Strains/Yield Point Elongation. All steel used for exposed (E) surfaces and secondary exposed surfaces located in Zones A, B, and C, as defined by GM Product Quality Standards, shall be free from stretcher strains for six (6) months. The zones will be identified on the manufacturing requirements document, GMNA MPS Sheet (or other regional manufacturing requirement documents) of the GM Purchase Order or in the purchased stamping Statement of Requirements (SOR). For all applications, yield point elongation shall not vary significantly from that of the originally qualified material or in a manner that significantly degrades or alters the formability of the previously qualified product.

3.2.1.4 Secondary Work Embrittlement (SWE). Secondary work embrittlement occurs in some interstitial free flat-rolled steel products. Secondary work embrittlement testing will be required for any steels that have <0.015% carbon by mass. All material supplied to this specification shall be determined to be free of secondary work embrittlement according to GMW16086 or as agreed upon between the purchaser and supplier. Conformance to this requirement shall be verified at the time of during material qualification.

3.3 Performance Requirements. Not applicable.

3.4 Requirements on Other Stages during Life Cycle.

3.4.1 Chemical Requirements. Provisions shall be made to prevent the addition of such elements (see 5.5) from scrap or other materials used in the manufacturing process which would impair the recyclability of the finished components.

3.4.2 Mechanical Requirements. Mechanical property requirements as specified in Appendix A shall be guaranteed for a minimum of three (3) months after delivery to the manufacturing plant. For materials qualification, required mechanical properties shall be guaranteed for a minimum of six (6) months after coil finishing.

3.4.3 Physical Requirements. Not applicable.

3.4.4 Additional Requirements.

3.4.4.1 Rounding Convention. When determining conformance to this specification, an observed value or a calculated value shall be rounded "to the nearest unit" for the last right-hand digit used in expressing the specification requirement. The rounding method shall be in accordance to the following:

- When the digit beyond the last digit to be retained is < 5, the last digit to be retained shall remain unchanged.
- When the digit beyond the last digit to be retained is ≥ 5, the last digit to be retained shall be increased by one (1) unit. When employing a rounding method, successive rounding for calculated values should be avoided.

3.5 Requirements on Test Specimens. Reference GMW3221.

3.6 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.

4 Manufacturing Process

Not applicable.

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.

It is the responsibility of the supplier to inform the customer in a timely manner, without solicitation, and to include documentation of all modifications of materials and/or processes and to apply for a new release.

5.4 Material Safety Data Sheets/Safety Data Sheets (MSDS/SDS). For new product submissions, or when a change in chemical composition of an existing product has occurred, a complete copy of the Material Safety Data Sheet/Safety Data Sheet must be submitted in compliance with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) requirements or other country-specific MSDS/SDS requirements.

5.5 Initial Source Approval. No shipments shall be made by any supplier until preliminary technical approval (inclusive material tests at supplier and/or GM) has been obtained. Requirements for steel qualification may be found in GMW14699.

5.6 Quality Requirements. The supplier shall have quality process control procedures compliant with IATF 16949 or as required by GM Global Purchasing and Supply Chain (GPSC) demonstrating that the product will conform to all specification requirements. The data required to be submitted for this specification for each shipment will be determined by the regional manufacturing location.

6 Approved Sources

Materials supplied to this specification must be approved by General Motors (Materials Engineering).

The appropriate GM Materials Engineering department(s) must confirm material as meeting the requirements of this specification. Any test data sheets of material submitted to General Motors for such confirmation (e.g., during Production Part Approval Process (PPAP)) under this material specification must list all properties and must apply corresponding test methods of this material specification.

7 Notes

7.1 Glossary. Not applicable.

7.2 Acronyms, Abbreviations, and Symbols.

AI	Anisotropy Index
ASTM	ASTM International
BH	Bake Hardenable
BHI	Bake Hardening Index
Ce	Cerium
CR	Cold Rolled

DIN	German Institute for Standardization
DP	Dual Phase
E	Exposed (Surfaces)
EG	Electrogalvanized (Coatings)
ELPO	Electrodeposited Primer, Cathodic E-coat
EN	European Standard
EXT	Exterior
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
GMB	GM Brazil
GMK	GM Korea
GMNA	GM North America
GMW	GM Worldwide
GPSC	Global Purchasing and Supply Chain
HAZ	Heat Affected Zone
HD	Hot-Dipped (Galvanized Coatings)
HR	Hot Rolled
HSLA	High Strength Low Alloy
IF	Interstitial Free
IMDS	International Material Data System
ISO	International Organization for Standardization
JIS	Japanese Industrial Standards
LA	Low Alloy
Max.	Maximum
ME	Manufacturing Engineering
Min.	Minimum
MPa	Megapascals
MPS	Material Parts Specification
MSDS	Material Safety Data Sheet
N/A	Not applicable
P	Re-phosphorized
PPAP	Production Part Approval Process
ppm	Parts Per Million
Ra	Roughness Average
R_{eL}	Lower Yield Stress
$\bar{r}$	r-bar
R_p	Proof Stress
RPc	Roughness Peak Count
SA	Structural Automotive
SDS	Safety Data Sheet
SOR	Statement of Requirements
SWE	Secondary Work Embrittlement
t	Thickness
T	Temper Rolled (Surfaces)
T	Tensile Strength
U	Unexposed (Surfaces)

UE	Uniform Elongation
VDA	German Association of the Automotive Industry (Verband der Automobilindustrie)
WH	Work Hardening
WHI	Work Hardening Index
YS	Yield Strength

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Material per GMW3032

The coding system for GMW sheet steel specifications on engineering part drawings and GMNA Manufacturing Engineering Metal Parts Specifications (MPS) Sheets and/or electronic math data files shall use a nomenclature consisting of the material designation, minimum yield strength and surface quality or coating designation. The engineering part drawing may also include the steel product type (HR or CR). If manufacturing and/or product engineering determines the steel requires inclusion-control, an "F" may be included following the steel type. Hot rolled HSLA grades that are inclusion controlled and need to have banding free microstructure are designated by "B" in the material designation. In addition, if the engineering part drawing does not include the steel product type (HR or CR), the manufacturing engineering group shall select the desired product type based on such factors as availability, formability and cost, and shall include this information on the appropriate engineering documents. The material designation is defined by the applicable GMW base metal material specification which follows the GMW specification number system. The minimum yield strength is specified in Megapascals (MPa) by a numerical designation.

The surface quality is designated as either E for exposed, or U for an unexposed application and T for temper rolled. For coated applications, refer to GMW8 for hot dip zinc coatings, GMW11 for electrogalvanized coatings, and GMW16066 for aluminized coatings. The GMW sheet steel specification shall be called out on engineering drawings and manufacturing engineering documents as follows:

8.1 Example of coding for uncoated high strength steel.

8.1.1 Example of engineering part drawing and manufacturing coding for uncoated high strength steel:

GMW3032M-ST-S-CR180B2-UNCOATED-E

Where:

GMW	= Validation Area (GM Worldwide)
3032	= Sequential Number
GMW3032	= Material Type (Base material specification)
M	= Material Type: Metals
ST	= Category: Steel
S	= Subcategory: Sheet
CR	= Steel Product Type: Cold rolled
180	= Minimum Yield Strength (MPa)
B2	= Steel Type (B2, LA)
UNCOATED	= Uncoated Substrate Designation
E	= Surface Quality (see 3.2.3.2.2)

8.2 Example of coding for hot dip zinc coated high strength steel.

8.2.1 Example of engineering part drawing and manufacturing coding for hot dip zinc coated high strength steel.

GMW3032M-ST-S-CR210B2-HD60G60G-U

Where:

GMW	= Validation Area (GM Worldwide)
3032	= Sequential number
GMW3032	= Material Type (Base material specifications)
M	= Material Type: Metals