



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 and is applicable to uncoated and coated, cold (CR) or hot rolled (HR) low carbon, solid solution strengthened, bake hardenable (BH), and interstitial free (IF) or high strength low alloy (HSLA) substrates with good formability. 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. Additional requirements or agreements shall be specified by regional GM business units, e.g., GM North America (GMNA), GM Europe (GME), GM Brazil (GMB), and GM Korea (GMK).

1.1 Material Description. The material designation is defined by the GM Worldwide (GMW) base metal specification number, steel product type, minimum yield strength, and finish type. The steel product type is designated by CR for cold rolled products, or HR for hot rolled products. Microstructure free of banding, which is caused by the interdendritic segregation of manganese during solidification, is specified for hot rolled HSLA inclusion-controlled grades that are used for chassis applications.

A numeral, (180, 210, 240, etc.) will designate the minimum yield strength level in MPa (Megapascals). A designation of steel type shall be added to BH₂, solid solution strengthened grades Re-phosphorized and Interstitial Free (P and IF), structural automotive (SA) and high strength low alloy (LA) steels as shown in Section 8. An "F" designation may be added on engineering and/or manufacturing documents following an LA steel type to specify the steel as inclusion-controlled. A "B" designation is specified for hot rolled LA "F" type grades which need to be free of microstructural banding. Anisotropy Index for banding free grades is listed under Appendix C. The steel grades will correspond to the chemical and mechanical requirements as shown in Table 1 through Table 5. The finish type, Pan alpha character, will designate the finish as E (exposed) or U (unexposed). In addition, products which are not coated shall have the word "Uncoated" added to the call-out after the steel type, but before the finish designation. A special requirement for temper rolling may be required and shall be specified with a "T" designation. The descriptive items in this section (1.1) are used together to form the coding system. Examples of the coding system for engineering part drawings and manufacturing engineering documents are shown in Section 8.

1.1.1 Material Identification. See Appendix A, Table A1.

1.2 Symbols. Not applicable.

1.3 Applicability. Typical applications are coated or uncoated sheet metal parts consisting of high strength sheet steel with specified minimum yield strengths from 180 MPa through 700 MPa.

2 References

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

2.1 External Standards/Specifications.

AS 1391	ASTM E112	ISO 6892	JIS Z 2201
ASTM A370	ASTM E1268	ISO 7438	
ASTM A751	EN 10049	ISO 14284	
ASTM E45	EN 10247	JIS G 3113	

2.2 GM Standards/Specifications.

GMW8	GMW14057	GMW15056	GMW16549
GMW11	GMW14058	GMW15282	GMW16656
GMW3005	GMW14700	GMW15425	GMW16823
GMW3011	GMW14704	GMW16066	
GMW3059	GMW14729	GMW16086	
GMW3224	GMW14829	GMW16170	
GMW3335	GMW14872	GMW16546	

2.3 Additional References.

- GWS-5A.
- Statement of Requirements (SOR).
- TMC003 Material Safety Data Sheet guidance documents (available at www.gmsupplypower.com).
- weld.council@gm.com.

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 Deviation Section at the end of this specification and shall be agreed between Purchasing and supplier.

3.1 Requirements on Test Specimens. Not applicable.

3.2 Requirements on Delivery.

3.2.1 Chemical Requirements.

3.2.1.1 Base Metal. Base metal composition based on product (coil or sheet/blanks) analysis determined per ASTM A751 shall conform to the requirements of Table 1 and Table 2. When end-product (coil/blank) test results are not available, heat analysis may be used. Chemical composition on the end product is the referee method.

3.2.1.2 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.

3.2.2 Mechanical Requirements. Products supplied to this specification shall meet the mechanical properties as specified in Table 3 through Table 6. The mechanical test methods to be used are defined in GMW3335 using the appropriate tensile test piece required by the specific region. Tests shall be performed using samples per ISO 6892 Type I, 50 mm gage length ASTM (ASTM International) type sample, ISO 6892 Type II (80 mm gage length) German Institute for Standardization (DIN) type sample or JIS Z 2201 (No. 5 test piece). Plastic strain ratio r_m (r-bar) shall be determined at 20% strain. When uniform elongation is <20%, plastic strain values shall be determined at the maximum of uniform elongation. The specific strain level shall be reported with all test results. Strain hardening exponent "n" and strength coefficient "K" value shall be determined at 10% to 20% strain, or at 10% to end of uniform elongation when uniform elongation is <20% unless minimum n-value is <0.12. In these cases, the strain hardening exponent must be determined at 6% to end of uniform elongation. 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 r_m value). Conformance to the r_m (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.

3.2.2.1 Mechanical Property Requirements of Solid Solution Strengthened and Bake Hardenable Grades. Mechanical property requirements of solid solution strengthened (P and IF) and (BH₂) cold reduced, uncoated and coated sheet steel grades are based on the minimum as-received yield strength (180 MPa, 210 MPa, 240 MPa, 270 MPa and 300 MPa) as shown in Table 3.

Bake hardenable steels have the additional requirement of a bake hardening index (BHI). All bake hardenable grades shall attain an increase in yield strength of 30 MPa minimum in lower yield strength (longitudinal direction and exclusive of work hardening) after 2% tensile strain and baking at +170 °C for 20 minutes. Mechanical properties for the B2 (BH₂ grades) are shown in Table 3.

Bake Hardening and Work Hardening Indices shall be determined as detailed in Appendix B, Figure B1 and Figure B2. The actual or measured bake hardening response for a production part 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.

Note: The bake hardening index in this specification is a parameter that characterizes the general bake hardening response of steel.

3.2.2.2 Bend Test Requirements for Structural Automotive Grades. Testing shall be performed to ISO 7438, bend test on two (2) low friction mounted test rollers and a punch, transverse to the rolling direction. Structural Automotive (SA) grades must meet the bending radii as specified in Table 6 for a bending angle of 180 degrees. After the test, the samples shall be free from visual cracking.

3.2.3 Physical Requirements.

3.2.3.1 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.

3.2.3.2 Surface Requirements.

3.2.3.2.1 Surface Texture. Specific requirements for the surface texture for each region are detailed in the Deviations Section at the end of this specification.

3.2.3.2.2 Surface Quality. The steel shall be free from surface defects as negotiated between purchaser and supplier. For unexposed (U) surface, defects such as pores, slight indentations, small marks, minor scratches, and slight coloring, which do not affect formability or the application of surface coatings, are allowed. Exposed (E) surfaces shall be free of defects which might affect the uniform appearance of quality paint or an electrolytic coating, electrodeposited primer, cathodic e-coat (ELPO). Certain applications require that both surfaces of the steel be of exposed surface quality. A special requirement for temper rolling may be required and shall be specified with a (T) designation. Other surfaces shall conform at least to unexposed surface quality (U). Detailed requirements will be issued by the responsible formability analysis organization (e.g., GMNA Manufacturing Engineering Material Parts Specification (MPS) sheet, GM responsible manufacturing, or metallurgical engineering document etc.

3.2.3.2.3 Roughness of Skin Passed Products. The requirements for roughness average (Ra) and roughness peak count (RPc) should be per GMW16823.

3.2.3.2.4 Surface of Hot Rolled Products without Special Requirements on the Surface Quality. Uncoated hot rolled products shall be supplied in a pickled (descaled) and oiled condition to ensure an adequate processability and a good adhesion of applied coatings.

These products are usually not skin passed, but at the supplier's choice or by agreement, the products can be supplied in a slightly skin passed condition or with agreement by GM.

3.2.3.2.5 Pre-Treatment/Paint Adhesion (Qualification Testing). 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. When tested with approved thin film pre-treatments, the requirements of GMW16170 must be fulfilled. 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:

3.2.3.2.5.1 Adhesion of the E-coat shall fulfill test requirements of the crosshatch test according to GMW14829:

- For samples that are phosphated: Rating 0 as-received and after 120 h humidity exposure per GMW14729.
- For samples with thin film pre-treatment, requirements according to GMW16170 shall be met.

3.2.3.2.5.2 Pre-treated (zinc Phosphate and thin film) and E-coated samples must meet delamination test requirements according to GMW14704 (Rating 0 or 1 after 48 h test duration).

3.2.3.2.5.3 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, B, and C, with a minimum stone impact rating of 8.

3.2.3.2.5.4 Creep back resistance shall be inspected on E-coated samples. The samples shall be scribed per GMW15282 and tested according to GMW14872, EXT, (exterior) All, 4 salt spray per cycle, Method 1/2/3, Exposure C. The creep back shall be evaluated per GMW15282 and meet the requirements stated in the following 3 (three) specifications:

- GMW3011 for samples that are phosphated.
- GMW16170 for samples with thin film pre-treatment.
- GMW15056 for samples with thin organic pre-coating (applicable to thin film organic coating qualification only).

3.2.3.2.6 Adhesive Compatibility (Qualification Testing). 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.

3.2.3.2.7 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.

3.2.3.3 Microstructure.

3.2.3.3.1 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.

3.2.3.3.2 Inclusions.

3.2.3.3.2.1 Inclusion Analysis Methods. Two (2) optional methods for analysis are available. There should be an agreement with the local business unit which of the two (2) following methods have to be performed.

- **Method A:** ASTM E45 Method D, Plate I-r, by analysis at a magnification of 100x, inclusion content shall not exceed a rating of 2.0 for thin and 2.0 for heavy.
- **Method B:** EN 10247, by analysis inclusions shall not exceed size Index 3. In case of diameters <20 mm, they shall not exceed size Index 2.

3.2.3.3.2.2 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.

3.2.3.4 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 ink used for marking must be released by the purchaser.

3.2.3.5 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.

3.3 Processing Requirements.

3.3.1 Additional Requirements.

3.3.1.1 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.

3.3.1.2 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.

3.3.1.3 Stretcher Strains. 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).

3.3.1.4 Secondary Work Embrittlement (SWE). Secondary work embrittlement occurs in some interstitial free flat 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 approval and at the time of the initial production shipment, unless otherwise required by the purchaser.

3.4 Performance Requirements. Not applicable.

3.5 Requirements on Other Stages during Life Cycle.

3.5.1 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.

3.5.2 Mechanical Requirements. Mechanical property requirements in this specification 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.

3.5.3 Physical Requirements. Not applicable.

3.5.4 Additional Requirements.

3.5.4.1 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.

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.

If not otherwise agreed, all release tests shall be repeated and documented by the supplier prior to commencement of delivery of non-conforming bulk supplies. In individual cases, a shorter test can be agreed to between the responsible Engineering department and the supplier.

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. In addition, product MSDS/SDS submissions must be in compliance with specific country General Motors TMC003 Material Safety Data Sheet/Safety Data Sheet guidance documents where available.

5.5 All materials supplied to this standard must comply with the requirements of GMW3059, Restricted and Reportable Substances for Parts.

6 Approved Sources

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

A list of approved materials can be found in the sheet metal approved source list in GM SupplyPower. (Document Library Engineering GM North America Product Design). This GM Material File is provided to third parties to reduce redundant testing of materials. If approved material already listed is used, the part supplier can use GM Material File reference for Production Part Approval Process (PPAP) material approval. If the decision is made to use a not yet approved material, contact the GM Materials Engineering for details on the approval process. The material approval process must be completed prior to PPAP start date of the part supplied to General Motors.

7 Notes

7.1 Glossary. Not applicable.

7.2 Acronyms, Abbreviations, and Symbols.

AI	Anisotropy Index
AS	Australian Standard
ASTM	ASTM International
BH	Bake Hardenable
BHI	Bake Hardening Index
Ce	Cerium

CR	Cold Rolled
DIN	German Institute for Standardization
DOI	Distinction of Image
DP	Dual Phase
E	Exposed
ELPO	Electrodeposited Primer, Cathodic E-coat
EN	European Standard
EXT	Exterior
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
GMB	GM Brazil
GME	GM Europe
GMK	GM Korea
GMNA	GM North America
GMW	GM Worldwide
GPSC	Global Purchasing and Supply Chain
HAZ	Heat Affected Zone
HR	Hot Rolled
HSLA	High Strength Low Alloy
IF	Interstitial Free
ISO	International Organization for Standardization
JIS	Japanese Industrial Standards
LA	Low Alloy
ME	Manufacturing Engineering
MPa	Megapascal
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
ReL	Lower Yield Stress
r_m	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
T	Tensile Strength
U	Unexposed
VDA	German Association of the Automotive Industry (Verband der Automobilindustrie)

WH	Work Hardening
WHI	Work Hardening Index
YS	Yield Strength
Z	Semi-Exposed

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/or electronic math data file coding for uncoated high strength steel.

GMW3032M-ST-S-CR180P-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)
P	= Steel Type (B0, B2, IF, LA, P)
UNCOATED	= Uncoated Substrate Designation
E	= Surface Quality (see 3.2.3.2.2)