GM	WORLDWIDE ENGINEERING STANDARDS	Material Specification	GMW17627

Retained Austenite Bearing Advanced High Strength Sheet Steel

1 Scope

This specification covers the requirements for continuous cast, cold rolled, retained austenite bearing sheet steel with specified minimum tensile strengths from 690 MPa to 1180 MPa.

1.1 Material Description. This specification applies to uncoated and coated retained austenite bearing advanced high strength steels that rely on one or more induced plasticity mechanisms to achieve enhanced combinations of strength and ductility relative to high strength steels. Common references to these steel types include transformation induced plasticity (TRIP) steel, TRIP-aided bainitic ferrite (TBF) or carbide-free bainite (CFB), quench and partition (Q&P) steel, and medium manganese TRIP steel. All products shall contain significant fractions of retained austenite and one or more of the following phases/microsconstituents: primary ferrite, bainite, bainitic ferrite, martensite, and tempered martensite. The presence of the following phases might also be expected: cementite, transition carbides, alloy carbides/nitrides/carbonitrides. The product phase/microconstituent composition, steel chemistry, and process path/annealing practice shall determine the common steel type designation according to accepted industry terminology and nomenclature. These products shall be supplied as coils or sheets. Cold rolled 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, and reinforcements for enhanced strength and vehicle impact performance.

2 References

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

2.1 External Standards/Specifications.

ASTM A751	IATF 16949	ISO 12004-2	SAE/USCAR-5
ASTM E45	ISO 6892	ISO/TS 16630	SAE/USCAR-7
ASTM E646	ISO 7438	JIS Z 2241	
ASTM E2218	ISO 10275	JIS Z 2256	

2.2 GM Standards/Specifications.

GMW8	GMW3335	GMW14829	GMW16546
GMW11	GMW14057	GMW14872	GMW16549
GMW3011	GMW14058	GMW15056	GMW16656
GMW3059	GMW14699	GMW15282	GMW16823
GMW3221	GMW14704	GMW15425	GMW17508
GMW3224	GMW14729	GMW16170	

2.3 Additional References.

- Engineering Part Drawing or Electronic Math File
- GWS-5A
- Safety and Industrial Hygiene (S&IH) Technical Standard (TS), S&IH TS 3.4-160-02
- SEP 1970 (Available at http://www.stahleisen.de → Go to Products → Bookshop)

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3 Requirements

The following 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 grade specific requirements in Appendix A, Table A1. 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.

3.1.1.2 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, Table A2. The 0.2% Offset Yield Strength, Tensile Strength, Elongation (at or after fracture) and BH_2-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. Strain hardening exponent, *n*, and coefficient, *K*, shall be determined per ISO 10275 or ASTM E646. The specific strain level shall be reported with all test results.

Strain hardening exponent, *n***,** and coefficient, *K***,** shall be determined 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 ($n_{U.E.} = \varepsilon_{U.E.}$) The specific strain range shall be reported with all test results. Product qualification requires an additional submission of *n* as a function of strain for samples tested longitudinal and transverse to the rolling direction.

3.1.2.1 Bake Hardening Index. Some steels have the additional requirement of a bake hardening index (BHI or BH_2). Where required, the material shall attain an increase in lower yield strength as specified in Table A2 after 2% tensile strain and baking at 170 °C for 20 minutes. Figure B1 in Appendix B 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 or two low friction mounted test rollers and a former. Steels must meet the bending radii as specified in Table A2 for a bending angle of 90°. Samples shall not exhibit cracking in a minimum of three (3) tested samples as viewed at 10x to 20x magnification.

3.1.2.3 Hole Expansion Ratio Test. For material qualification, hole expansion ratio testing shall be performed on a minimum of two (2) sheet thicknesses within the intended production thickness range per ISO/TS 16630 or JIS Z 2256.

3.1.2.4 Forming Limit Diagram. For material qualification, forming limit diagrams shall be supplied from material with typical tensile properties on a minimum of two (2) sheet thicknesses within the intended production thickness range per ISO 12004-2 or ASTM E2218.

Separate diagrams shall be submitted for longitudinally and transversely oriented major strain axes with respect to the sheet rolling direction. Suppliers should also include a description of how the forming limit diagram was determined including the sample geometry.

3.1.3 Physical Requirements.

3.1.3.1 Material Thickness and Tolerance. The detailed engineering part drawing or 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. Specific requirements for the texture for each region are detailed in GMW16823.

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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) or temper rolled (T) surfaces may be specified for materials subject to GMW17627. Specification of exposed (E) surfaces is not allowed.

3.1.3.2.3 Pre-Treatment Compatibility/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. However, the following additional requirements 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. 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).

3.1.3.2.4 Adhesive Compatibility. For material qualification, uncoated or zinc-based coated steels supplied to this specification shall be tested according to GMW16549 and capable of being bonded with GM approved adhesives. Testing to this specification will evaluate bonding characteristics to the metal surface.

3.1.3.2.5 Coating Requirements. Refer to coating requirements in GMW8 for hot dipped coatings, GMW11 for electrogalvanized 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 Phase/Microconstituent Fractions. For material qualification, 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.

3.1.3.3.2 Material Inhomogeneties and Cleanliness. Inhomogeneties (e.g., martensite lines, inclusions, segregations) in the steel shall be minimized and should not affect cold forming properties. For material qualification, anisotropy indices per ASTM E1268 may be requested by the qualification champion.

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.

3.1.3.4 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, retests, 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.

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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 must 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 unexposed (U) surfaces, weld seams are not permissible unless special exceptions are made by the local organization.

3.2.1.2 Welding. 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 with and approved by the ME-Weld Department of GM Manufacturing Engineering. Contact the GM Weld Council for specific information regarding weldability at weld.council@gm.com.

Note: Modifications to these methods may be required for high strength, retained austenite bearing steels. 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.

3.3 Performance Requirements. Not applicable.

3.4 Requirements on Other Stages during Life Cycle.

3.4.1 Chemical Requirements. Provisions must be made to prevent the addition of such elements (see 5.3) from scrap or other materials used in the manufacturing process which would impair the recyclability of the finished components.

3.4.2 Mechanical Requirements. The mechanical property requirements shown in Table A2 shall be guaranteed for a minimum of 3 months after delivery to the manufacturing plant. For material qualification, required mechanical properties shall be guaranteed for a minimum of 6 months after coil finishing.

3.4.2.1 Hydrogen Embrittlement Sensitivity. During source approval/qualification of materials, the supplier must demonstrate that the retained austenite bearing steel is free of hydrogen embrittlement according to 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.

Following GM-qualified steelmaking and/or electro-coating processes, subsequent hydrogen generating processes including, but not limited to, acid cleaning, phosphating, electroplating, etc., shall not be performed without GM Materials Engineering approval for retained austenite bearing advanced high strength steels. In the case where hydrogen generating processes cannot be avoided for steel and/or part processing, suppliers shall follow the de-embrittlement requirements per SAE/USCAR-5 and be free of hydrogen embrittlement per SEP 1970 or SAE/USCAR-7 in the same manner as the preceding

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.

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