GM	WORLDWIDE ENGINEERING STANDARDS	Material Specification	GMW15192

Aluminum Sheet for Body and Closure Panel Applications

1 Scope

This standard covers the requirements for wrought aluminum alloy sheet for exposed and unexposed body and closure panel applications. This specification is applicable to two types of wrought aluminum alloys; age hardenable and non-age hardenable. Age hardenable (e.g., 6000 series) aluminum alloys can be used for exposed and unexposed applications. Due to surface characteristics, non-age hardenable (e.g., 5000 series) alloys may not be suitable for exposed applications.

Age hardenable aluminum alloys attain an increase in strength due to strain hardening and accelerated aging (precipitation hardening) when subjected to the assembly plant paint bake cycle or other post-forming heat treatments. Non-age hardenable aluminum alloys increase in strength due to strain hardening only, and will show some decrease in strength following the paint bake cycle or other post-forming heat treatment.

Additional requirements or agreements shall be specified by each region (e.g., General Motors North America (GMNA), General Motors Brasil (GMB), General Motors International Operations (GMIO), General Motors Shanghai (SGM), General Motors Korea (GMK), General Motors Holden (GMH), etc.)

1.1 Material Description. The material designation is defined by the General Motors Worldwide (GMW) base metal specification number, basic aluminum alloy concept (5000 or 6000), special processing category, minimum as received yield strength, finish type, and coil pretreatment.

For specific material call-outs see Section 8. Examples of Aluminum Association (AA) alloys, European Standard Aluminum Wrought (EN AW) alloys and Japanese Industrial Standards (JIS) alloys are shown in Table 1.

1.2 Symbols. Not applicable.

1.3 Applicability. Typical applications include body and closure panel applications such as hoods, doors, fenders, liftgates, body sides, roofs, and underbody components.

2 References

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

2.1 External Standards/Specifications.

ASTM E34	ASTM E607	IATF 16949	ISO 10275
ASTM E101	ASTM E1251	ISO 6892	JIS H4000
ASTM E517	DIN EN 14726	ISO 10113	VDA 239-200

2.2 GM Standards/Specifications.

GMW3011	GMW14019	GMW16170	GMW16823
GMW3059	GMW15420	GMW16549	
GMW3335	GMW15421	GMW16721	

2.3 Additional References.

- GMNA Stamping Plant Requirements for Sheet Metal Coils and Blanks (North American Coil and Blank (NACB))

© Copyright 2019 General Motors Company All Rights Reserved

AVA Documents Document Sharing Hub

Full document details: GMW GMW15192 2019

3 Requirements

3.1 Requirements on Test Specimens. Reference GMW15420.

3.1.1 Special Processing Requirements.

- **S** Standard
- **IBR** Improved Bake Response
- **IF** Improved Formability
- **IH** Improved Hemming
- **HS** High Strength
- **SST** Soft Structural Applications
- **RSS** Reduce Stretcher Strain
- **ST** Structural Application
- **R** Reinforcement Parts

3.2 Requirements on Delivery. The following section defines specific requirements for material on delivery, processing, performance and other stages during life cycle. Deviations required for regional GM business units are listed in the Deviations Section at the end of this specification. In case of dispute, the GMW15192 specification shall take precedence.

3.2.1 Chemical Requirements.

3.2.1.1 Base Metal. Base metal composition shall conform to the requirements of Table 2 and Table 3. Additional demands and restrictions may be imposed by regional Materials Engineering organizations depending upon the application. The base metal chemical composition shall be determined per ASTM E34, ASTM E101, ASTM E607, ASTM E1251 or DIN EN 14726. In cases of dispute, referee method shall be ASTM E34.

3.2.1.2 Lubrication Approval. All aluminum sheet should have a mill applied corrosion preventative lubricant. All lubricants or fluids (mill oils, prelubes, hot melts, etc.) applied to the material by the aluminum producer or processor must be removable in the purchaser's paint line cleaning system. Mill-applied products must be approved to GMW14019, and/or approved by the region receiving the material. Approved lubricants are specified by the region receiving the material, and must be documented in the qualification package.

Specific lubrication requirements for material delivered to GM North America are outlined in the GMNA Stamping Plant Requirements for Sheet Metal Coils and Blanks (NACB) document.

3.2.2 Mechanical Requirements. The mechanical property requirements are applicable to the final delivered form (e.g., Coil or Blank) to the GM designated facility.

3.2.2.1 Tensile Mechanical Property Requirements. The aluminum products shall meet the mechanical properties as specified in Table 4 through Table 6. The 0.2% Offset Yield Strength, ($R_{p0.2}$), Ultimate Tensile Strength (R_m), percentage plastic elongation at maximum force (A_g), and percentage elongation after fracture (A *or* E_l) shall be determined in the transverse direction per GMW3335. For flat products with widths ≤ 300 mm, test samples in rolling direction are allowed.

Tests shall be performed according to GMW3335 using samples per ISO 6892 Type I (50 mm gage length ASTM International (ASTM) type sample or JIS No. 13B) or ISO 6892 Type II (80 mm gage length Deutsches Institut für Normung (DIN) type sample or JIS No. 13A). The strain hardening exponent n-value shall be determined per ISO 10275. The specific strain level shall be reported with all test results. The strain hardening exponent n-value shall be determined at 10% to 20% strain or from 10% to the end of plastic elongation at maximum force (A_g). The plastic strain ratio, r-value, shall be determined at 10% strain per ISO 10113 or ASTM E517.

The mechanical property requirements shown in Table 6 shall be guaranteed for material that has been through a simulated paint bake cycle of 185 °C for 20 minutes.

3.2.2.2 Hemming Requirements. All 6000 grade aluminum products for exposed applications shall meet the hemming requirements as specified in Table 7 in both the longitudinal 0 degrees and transverse 90 degrees directions.

The hemming factor is defined as:

$$f = \frac{r_i}{t}$$

© Copyright 2019 General Motors Company All Rights Reserved

AVA Documents Document Sharing Hub

Full document details: GMW GMW15192 2019

Where:

r_i = punch radius

t = sheet thickness, as seen in Figure 1

The hemming factor shall be determined using GMW15421, and represents the minimum radius above which the hem surface has good quality as defined by GMW15421, with no cracks or micro cracks.

3.2.2.3 Aging of 6000 Grades.

3.2.2.3.1 6000-IH. For 6000-IH, the mechanical property and hemming requirements shall represent material that has naturally aged a minimum of (3) days following Solution Heat Treatment (SHT), and shall be guaranteed for 6 months after SHT in its final delivered form. Final delivered form (e.g., Coil or Blank) shall be delivered to the GM designated location within 4 months following SHT date.

3.2.2.3.2 All other 6000 Series Grades. For all other 6000 grades, the mechanical property requirements shall represent material that has naturally aged a minimum of (3) days following SHT, and shall be guaranteed for a minimum of 6 months after SHT in its final delivered form. Material older than 3 months after SHT must be retested prior to delivery to the GM designated location. Test results must show that the material is expected to meet mechanical property requirements for a minimum of three months after delivery to the GM designated location in the final delivered form (e.g., Coil or Blank). Retesting may be waived by the final customer.

Any deviation to the delivery or aging requirements must be approved by Materials Engineering.

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. The preferred nominal thickness should follow the increments in Table 8 The sheet thickness tolerance requirements are listed in Table 9 The tolerance requirements shall be referenced as follows:

- Thickness Tolerance: Per GMW15192.

3.2.3.2 Surface Requirements.

3.2.3.2.1 Surface Condition. Specific surface condition requirements are outlined in GMW16823.

3.2.3.2.2 Surface Quality. Surface quality requirements are outlined in GMW16823. 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 a quality paint coating or a cathodic electrodeposition primer (E-coat, ELPO, Electro coat, or an electrolytic coating). The other surface shall conform at least to unexposed (U) surface quality. Certain applications may require both surfaces of the aluminum sheet to conform to exposed (E) surface quality.

3.2.3.2.3 Coil Pretreatment. If coil pretreatment is required, the GMW15192 callout will end with “-P”. Coil pretreatment requirements are outlined in GMW16721.

3.2.3.2.4 Surface Appearance after Straining Tension Perpendicular to Rolling Direction. Age hardenable aluminum alloy sheet approved to this specification for exposed (E) applications shall be free from surface irregularities commonly known as “paint brush” or “roping” lines which form on the surface of the sheet upon application of tensile strain perpendicular to the sheet rolling direction. The evaluation method is defined in GMW15420. Supplier shall submit test samples to show proof of conformance.

3.2.3.2.5 Paint System Pretreatment Compatibility. For painted applications, the surface shall be capable of achieving a high quality zinc phosphate conversion coating according to GMW3011 (for crystal size and coating weight) and also capable of meeting coating thickness and coating weight requirements in GMW16170 for nano-ceramic pretreatment. Material qualification requirements for paint system pretreatment compatibility are given in GMW15420.

3.2.3.2.6 Adhesive Compatibility. The aluminum alloy sheet approved to this specification shall be tested according to GMW16549. For bonded applications, the surface of the flat products furnished to this specification shall be capable of adhering to surfaces bonded with GM qualified adhesives and approved by the regional business unit. Test requirements for material qualification are outlined in GMW15420. The qualification champion has the responsibility to determine the extensiveness of testing.

3.2.3.2.7 Reduced Stretcher Strain Alloys. Reduced Stretcher Strain (RSS) alloys shall be free from surface irregularities commonly known as “stretcher strain marks” or “Lüders lines”.

© Copyright 2019 General Motors Company All Rights Reserved

AVA Documents Document Sharing Hub

Full document details: GMW GMW15192 2019

Yield Point Elongation (A_e or YPE) shall be measured using the sample geometry defined in GMW3335. Tensile testing shall be in both the longitudinal 0 degrees and transverse 90 degrees directions on samples from three (3) different coils for material qualification per GMW15420.

After tensile testing, enlarge the tensile curve graphically so that the strain path between 0% and 1.5% and the full YPE domain are clearly visible. The YPE plateau is defined as the area between the first peak on the stress strain curve and the end of the plateau. Measure the YPE and express it as a percentage with two decimal places. The YPE must be < 0.60% for the alloy to be classified as a reduced stretcher strain.

3.2.3.2.8 Base Metal Density Values. For theoretical calculation of product and part mass, the base metal densities shown in Table A1 shall be used. Note that information in Appendix A is for GM Engineering Information Only. The information in Appendix A is not guaranteed by the supplier.

3.2.3.2.9 Base Metal Thermal Expansion Coefficient Values. For thermal calculations, the thermal expansion coefficients shown in Table A2 shall be used. Note that information in Appendix A is for GM Engineering Information Only. The information in Appendix A is not guaranteed by the supplier.

3.2.4 Additional Requirements.

3.2.4.1 Lot Identification. All shipments must include documentation indicating GMW grade, supplier name, name of production site, coil number or batch number, surface quality (E or U) and surface texture (Electric Discharge Texture (EDT) or Mill Finish (MF)). In addition, material delivered to GM North American facilities should include the documentation outlined in the GMNA Stamping Plant Requirements for Sheet Metal Coils and Blanks (NACB).

All shipments of production age-hardenable aluminum alloy sheet, blanks or coils shall show date (month, day and year) of SHT and quenching at supplier's production facility on the supplier's material certification warrant. All shipments of production non-age hardenable aluminum alloy shall show the production date on the supplier's material certification warrant.

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

All shipments to GMNA manufacturing facilities shall meet the requirements in the GMNA Stamping Plant Requirements for Sheet Metal Coils and Blanks (NACB) document.

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.

3.3 Joining. The aluminum sheet products supplied to this standard shall be suitable for mechanical clinching and welding by standard methods. Specific test requirements for material qualification are outlined in GMW15420.

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 5.3) from scrap or other materials used in the manufacturing process which would impair the recyclability of the finished components.

3.5.2 Mechanical Requirements. Not applicable.

3.5.3 Physical Requirements. Not applicable.

3.5.4 Additional Requirements. Not applicable.

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.

© Copyright 2019 General Motors Company All Rights Reserved

AVA Documents Document Sharing Hub

Full document details: GMW GMW15192 2019

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 representative initial production samples have been approved by the appropriate Engineering department(s) as meeting the requirements of this specification.

No shipments shall be made by any supplier until Level 1 approval has been obtained per GMW15420. Level 2 approval must be obtained before supply of regular serial production material. Requirements for Level 1 and Level 2 approval may be found in GMW15420.

5.6 Quality Requirements. The supplier shall have quality process control procedures compliant with IATF16949 or as required by GM Supplier Quality Engineering 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.

Coil Pretreatment (P): Modification or finishing of the sheet surface in the form of a thin layer applied or converted through chemical reactions. Also called passivation or conversion coating.

High Strength (HS): Typical applications include roof panels, where high strength is required to minimize distortion in the paint bake ovens. This alloy should not be used in a hemmed panel application or in a highly corrosive environment.

Improved Bake Response (IBR): Typical applications include hood and liftgate outers requiring improved strength.

Improved Formability (IF): Typical applications include body side outers and fenders.

Improved Hemming (IH): Typical applications include hood and liftgate outers requiring hems with small radii or flat hems.

Reduced Stretcher Strain (RSS): Typical applications include visible inner panels. This grade shall not be used for outer panels or for applications which may experience stress corrosion cracking. Exposing work hardened 5000 aluminum alloys containing more than 3% magnesium to temperatures above 66 °C (150 °F) may result in susceptibility to Stress Corrosion Cracking.

Reinforcement Parts (R): Typical applications include closure reinforcements or body structure parts.

Soft Structural Applications (SST): Typical applications include hood inners.

Standard Grades (S): Typical applications include hood inners and outers with no special requirements regarding strength, formability, or hemming.

© Copyright 2019 General Motors Company All Rights Reserved

AVA Documents Document Sharing Hub

Full document details: GMW GMW15192 2019

Structural Application (ST): Typical applications include body structure parts.

7.2 Acronyms, Abbreviations, and Symbols.

A,	Percentage elongation after fracture (without elastic strain)
AA	Aluminum Association
Ae, YPE	Yield point elongation
Ag,	Percentage plastic extension at maximum force (without elastic strain)
ASTM	ASTM International
CTS	Component Technical Specification
DIN	Deutsches Institut fur Normung
E	Exposed
EDT	Electric Discharge Texture
ELPO	E-coat or Electro coat or an Electrolytic Coating
EN AW	European Standard Aluminum Wrought
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
GMB	General Motors Brasil
GMH	General Motors Holden
GMIO	General Motors International Operations
GMK	General Motors Korea
GMNA	General Motors North America
GMW	General Motors Worldwide
GPSC	Global Purchasing and Supply Chain
GSSLT	Global Subsystem Leadership Team
HS	High Strength
IATF	International Automotive Task Force
IBR	Improved Bake Response
IF	Improved Formability
IH	Improved Hemming
IMDS	International Material Data System
ISO	International Organization for Standardization
JIS	Japanese Industrial Standards
max.	Maximum
ME	Manufacturing Engineering
MF	Mill Finish
Mg	Magnesium
min	Minimum
MPa	Megapascal
MPS	Material Part Specification
MSDS	Material Safety Data Sheet
NACB	North American Coil and Blank
n-value	Strain Hardening Exponent
P	Coil Pretreatment, including passivation or conversion coating
PATAC	Pan Asian Technical Automotive Center
PPAP	Production Part Approval Process
R	Reinforcement
RD	Rolling direction

© Copyright 2019 General Motors Company All Rights Reserved

AVA Documents Document Sharing Hub

Full document details: GMW GMW15192 2019