



Heat-Treatable 7000 Series Aluminum Sheet

1 Scope

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.

1.1 Purpose/Material Description. This specification covers the requirements for heat-treatable 7000 series aluminum used in the manufacture of structural parts to manage very high tensile loads without significant deformation as required in safety and occupant protection. This material is heat treated, formed and simultaneously quenched in a water-cooled die in a process referred to as hot stamping.

The material designation is defined by the GMW material specification number. The aluminum grades will correspond to the chemical and mechanical requirements as shown in Appendix A, Table A1 through Table A2. Only the surface quality designation of U, representing an unexposed application, shall be used unless otherwise approved by Materials Engineering.

1.1.1 Hot Stamped Die Quenched Aluminum. Parts shall be made by solutionizing a pre-cut blank, hot stamping the heated blank and rapid cooling (quenching) the stamped part in the die.

1.1.2 Material Callouts. The list of material and coating designations shown in Table 1 are the only approved material callouts that can be released unless GM Materials Engineering and the appropriate Global Subsystem Leadership Team approves.

Table 1: Approved Material Call-Outs

Material Call-Out	Material Description
GMW18378M-AL-S-7000-HSA-475-U	Hot stamped aluminum

1.2 Symbols. Not applicable.

1.3 Applicability. Typical applications are sheet metal stampings requiring tensile strength minima ranging from 475 MPa to 550 MPa. Typical applications include door impact beams, bumper impact beams and structural reinforcements for side impact, roof strength, and impact energy management.

2 References

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

2.1 External Standards/Specifications.

AIAG CQI-9	ASTM E607	ISO 6892	JIS No. 13B
ASTM E34	ASTM E1251	ISO 10113	VDA 238-100
ASTM E101	DIN EN 14726	ISO 10275	
ASTM E517	IATF 16949	JIS No. 13A	

2.2 GM Standards/Specifications.

GMW3011		GMW16170	GMW16967
GMW3059	GMW15192	GMW16549	GMW18377
GMW3335	GMW15420	GMW16823	

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 at the end of this document.

Parts supplied according to this specification shall undergo successful trials that fully meet end product requirements. In the event of any changes to the tools, heat treatment and/or manufacturing process to which the part was successfully validated, the appropriate engineering group must be notified, and the part must be tested and requalified to the proper Production Part Approval Process (PPAP) level as determined by GM.

Hot stampers are required to maintain a consistent source of aluminum supply and to use GM approved suppliers listed in GM's Approve Source List.

3.1 Sample Requirements for Qualification. For initial aluminum supplier qualification, test samples shall be removed from production representative coils and heat treated in a production representative manner.

3.2 Engineering Requirements.

3.2.1 Chemistry. Base metal composition shall conform to the requirements of Table A1. 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.

3.2.2 Applied Process Coatings.

3.2.2.1 Corrosion Preventatives. Temporary/transit corrosion protection, such as oils, paper, or containerization, etc., may be used to protect the coils or blanks from in-transit corrosion that may result in detrimental impact to subsequent manufacturing processes. White rust preventatives applied to finished parts shall be chosen to prevent contamination to paint systems or negative effects to subsequent manufacturing operations.

3.2.2.2 Forming Lubricants. If coil or blank lubricants are applied, supplier shall ensure that all downstream operations, manufacturing processes and part performance requirements are not negatively affected. Any lubricant applied must pass all qualification tests outlined in this specification. Lubricants will be selected for their ability to facilitate heating of the blanks and their ability to be removed post treatment process.

3.2.3 Mechanical Property Requirements. The aluminum products shall meet the mechanical properties as specified in Table A1. 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 El) 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.

3.2.3.1 Base Metal Temper Requirements. Aluminum supplied to this specification for direct hot stamping operations shall be in the annealed (O) or as rolled (F) condition.

3.2.3.2 Finished Part Mechanical Property Requirements. All finished parts shall meet the mechanical property requirements shown in Tables A2. Suppliers are responsible to ensure that the method used to cut and prepare tensile specimens for evaluation shall be appropriate for the strength of the material.

3.2.3.2.1 Additional Requirements for Aluminum for Hot Stamping. The following requirements shall be met by aluminum suppliers and stampers of 7000 series aluminum used in hot-stamping applications. These requirements are in addition to the chemical and mechanical requirements in Table A1 and Table A2.

3.2.3.2.2 Post-Stamping Heat Treatment. Parts produced to GMW18378M-AL-S-7000-HSA-475-U require a post-stamping bake 121 °C for 6 h and a simulated paint bake at 185 °C for 20 minutes; baking must be performed prior to determining specification conformance.

3.2.4 Bend Test Requirements. Bend testing is required for aluminum supplier qualification. Samples shall be taken from production representative coils and heat treated in a production representative process.

Bend testing shall be performed according to VDA 238-100. The material shall be capable of being bent without pre-strain, both longitudinally and transverse to the rolling direction, through the bend angle, α , as shown in Table A3 in Appendix A on a three-point free bend with the ends unrestricted with the specified bending radii.

3.2.4.1 Bend Test for Heat Treated Parts. Heat treated parts shall meet the bend test requirements as described in 3.2.4 as part of the prototype part validation and initial part production verification by saleable PPAP. Samples shall be removed from finished parts using laser, water jet cutting, or electrical discharge machining (EDM). If a suitably sized sample for bend testing per VDA 238-100 cannot be removed from the part, flat samples from the production material may be heat treated and die quenched in the production representative process according to the supplier's process control plan or waived by GM Engineering or GM Supplier Quality.

3.2.5 Material Thickness and Tolerances. The detailed engineering part drawing or electronic math data file will specify the material thickness. Thickness tolerances shall be per GMW15192.

3.3 Manufacturing Requirements.

3.3.1 Pre-Treatment/Paint Adhesion of Heat Treated Parts. 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.

3.3.2 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.

3.3.3 Surface Requirements. Surface defects such as slivers, laminations, scratches in the substrate that may be detrimental to the finished part performance are not allowed.

3.3.3.1 Surface Quality. The surface condition shall meet the requirements of GMW16823. The aluminum shall be free from surface defects as negotiated between purchaser and supplier. Only unexposed (U) surfaces may be specified for materials subject to GMW18378.

3.3.3.2 Surface Cleanliness.

- After hot stamping, the aluminum surface shall be cleaned such that subsequent operations such as phosphating/painting, bonding and welding are not adversely affected.
- The application of a corrosion preventative oil may be required to ensure parts do not develop surface oxides during shipment and storage. Any applied oils must meet the requirements shown in 3.2.2.1.
- Surfaces that have been cleaned shall consist of a uniform, homogeneous appearance.

3.3.4 Quality. Suppliers are responsible to develop a comprehensive quality control plan for all aspects of material procurement, blanking, heat treatment, stamping, trimming and hole piercing/cutting, cleaning and dimensional tolerancing, the basis of which is described in GMW18377. Through the quality control plan and generation of data, suppliers will demonstrate they have developed a process that will consistently produce parts that meet requirements of GMW18378. The process control plan will also detail the steps that will be taken to ensure any process related excursions from established requirements does not result in discrepant material being shipped to GM.

Suppliers shall qualify their furnaces to AIAG CQI-9 standards and show certification of their furnaces as such. A PH workbook detailing sample sites, die hot spots at steady state run and part form post stamping shall be included. Any deviations from CQI-9 and PH workbook shall have to be approved by GM SQE representative.

3.3.5 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.

3.3.5.1 Welding. Aluminum substrates supplied to this standard in a properly solutionized, quenched, heat treated, and cleaned condition shall meet the requirements of GMW16967 for resistance spot welding.

3.4 Life Cycle Requirements.

3.4.1 Chemical Requirements. The processes used in manufacturing these parts shall not add any material, coating or contamination (see 5.5 and 5.6) from scrap or other materials applied or used in manufacturing that would affect or impair the recyclability of the finished components.