



Aluminum Extrusions for Structural Applications

1 Scope

1.1 Material Description. This specification covers the chemical composition, mechanical properties, surface quality, and structural integrity requirements of aluminum alloy hollow and semi-hollow extruded profiles produced from welding chamber (i.e., spider, porthole, or bridge) dies, solid profiles, solid round bars, and flat sheets. Refer to the Aluminum Association Aluminum Standards and Data Manual - Metric International System of Units (SI) and/or EN 755-1 for definitions of hollow, semi-hollow and solid aluminum extrusions.

1.1.1 Aluminum extrusions may be supplied in straight as-extruded lengths, or bent to meet desired part shape. Secondary forming operations (i.e., formation of crush initiators, flats, flanges) shall be performed before artificial aging heat treatment. For round aluminum alloy extruded tubing intended for hydroformed components, refer to GMW16866 "Hydroformed Extruded Aluminum Mechanical Tubing and Components".

1.1.2 The aluminum extrusion alloy and temper designations contained in this specification shall include aluminum alloys with temper mechanical property limits documented in a regional national standard - Aluminum Association (AA), European Standard (EN), ASTM International (ASTM), Japanese Industrial Standards (JIS). In this specification, aluminum extrusion alloy and temper designations that conform to regional national standards shall be designated as standard grades.

1.1.2.1 Aluminum extrusions with modified alloys and/or tempers that deviate from regional national standards shall be designated as non-standard grades. Aluminum extrusion alloys with chemical composition limits that do not conform to regional national standard chemical composition limits shall be designated as proprietary chemical composition grades. Non-standard and proprietary composition grades are divided into two categories: minimum yield strength based grades and nominal yield strength based grades. Nominal yield strength based grades are applicable to bumper system components known as crush cans, crash boxes or danner boxes.

1.1.3 Material Identification. This specification shall be referenced in engineering math data files or engineering drawing material specifications. The material specification shall consist of the General Motors Worldwide (GMW) specification number, the materials type, non-ferrous metal type, alloy designation, the temper designation and minimum or nominal yield strength. See Section 8 "Coding System" for further explanation.

1.2 Symbols. A_{50} , 5D, $5.65(S_0)^{0.5}$, A, A5, $\pm$.

1.3 Applicability. Typical applications include body, closure, exterior and chassis structural applications. Refer to GM Materials Engineering or the Global Preferred Materials Catalog for selection of appropriate extrusion materials for specific applications.

2 References

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

2.1 External Standards/Specifications.

ASTM B557M	ASTM E101	EN 755-1	EN 10002-1
ASTM E34	ASTM E1251	EN 755-9	ISO 8493

2.2 GM Standards/Specifications.

GMW3011	GMW16170	GMW16705	GMW16866
GMW3059	GMW16549	GMW16721	

2.3 Additional References.

- Aluminum Association Aluminum Standards and Data Manual – Metric International System of Units (SI).
- Aluminum Association Publication QCA-2, "Visual Quality Characteristics of Aluminum Extrusions".

- General Motors Material Property Database (GMMPD).
- Global Preferred Materials Catalog.
- GP-12/Safe Launch
- Safety and Industrial Hygiene (S&IH) Technical Standard (TS), S&IH TS 3.4-160-02

3 Requirements

3.1 Chemical Composition. Base metal composition shall conform to the requirements in Table A1 in Appendix A. The base metal chemical composition shall be determined per ASTM E34, ASTM E101 or ASTM E1251. In cases of dispute, referee method shall be ASTM E34. Suppliers of proprietary chemical composition grades shall report chemical composition limits for Integration Vehicle Build, Production Part Approval Process (PPAP), GP-12/Safe Launch and Production data submissions.

3.2 Mechanical Properties.

3.2.1 As-Received Mechanical Properties. Specimen sampling shall be conducted per Aluminum Association Aluminum Standards and Data Manual Metric SI, or EN 755-1. The 0.2% offset yield strength, ultimate tensile strength, and percent total elongation in 50 mm or 5D/5.65(S_0)^{0.5} gauge length shall be determined per ASTM B557M or EN 10002-1, respectively.

3.2.1.1 Standard Grade. Standard grades are identified by alloy designation (i.e., 6063, 6061, etc.) or alloy designation followed by a capital letter suffix (i.e., 6005A, 6005C, etc.) temper designation (i.e., T4, T5, T6), followed by minimum yield strength value. Standard grades furnished to this specification shall conform to the mechanical property values shown in Table A2 in Appendix A.

3.2.1.2 Non-standard and Proprietary Chemical Composition Grades. Non-standard grades are identified with a capital letter suffix after the alloy designation (i.e., 7003A, 7003B, etc.) and/or temper designation (i.e., T5A, T6A, T7A) followed by minimum, or nominal yield strength value. Proprietary chemical composition grades are identified by the specific numerals "6000" or "7000" with a capital letter suffix after these numerals (i.e., 6000A, 7000A), and temper designations (i.e., T5A, T6A, T7A), followed by minimum or nominal yield strength value. Non-standard and proprietary chemical composition minimum yield strength grades are shown in Table A3 in Appendix A. Non-standard nominal yield strength grades are shown in Table A4 in Appendix A.

3.2.2 Post – GM Assembly Plant Paint Bake/Supplier E-coat Bake Mechanical Properties. Aluminum Extrusions may show significant tensile mechanical properties changes following GM assembly plant paint bake (i.e., E-coat, primer surfacer, basecoat) ovens exposure, or supplier E-coat bake oven exposure. Minimum yield strength and minimum ultimate tensile strength values shall be determined using Weibull B1C50 statistical analysis of at least of fifteen (15) tensile test specimens taken from multiple component samples subjected to GM assembly plant paint bake ovens, or supplier E-coat bake oven exposure. Component samples shall be submitted to GM materials engineer for tensile testing and Weibull B1C50 statistical analysis. Refer to GMW16705 Appendix A for Weibull B1C50 statistical analysis. Weibull B1C50 minimum yield strength and minimum ultimate tensile strength values shall be documented in component math data file, or engineering drawing. Supplier may be required to modify extruded aluminum profile as-received mechanical properties to assure that aluminum extrusions exceed minimum tensile mechanical property requirements after GM assembly plant paint bake ovens, or supplier E-coat bake oven exposure.

3.2.3 Allowed Alloy Substitutions. If necessitated by global availability or commercial restrictions, it is permissible to substitute 6060 alloy with 6063 alloy or substitute 6063 alloy with 6060. If an alloy substitution is made, the final extruded component must meet the mechanical property requirements of the originally specified material grade. When material and part qualifications are granted based on extrusions produced from a particular alloy (6060 or 6063), re-qualification will be required prior to substitution of the alternate alloy (6063 or 6060).

3.3 Surface Requirements.

3.3.1 Surface Quality. Aluminum extrusions supplied to this specification shall be free of surface imperfections that may compromise the structural integrity of extrusions. Surface imperfections include, but are not limited to blisters, corrosion pits, blowholes, orange peel, stretcher jaw marks, and speed tears. Refer to Aluminum Association publication QCA-2, "Visual Quality Characteristics of Aluminum Extrusions" for photographs and definitions of imperfections. Surface imperfections that are judged to be cosmetic and do not compromise the structural integrity may be acceptable provided that boundary samples are provided to GM Materials Engineering to document location and severity. Suppliers may be required to prove cosmetic imperfections do not compromise structural integrity. Boundary samples shall be established on a part number by part number basis.

3.3.2 Surface Preparation. Aluminum extrusions shall be free of white corrosion (aluminum oxide) and pitting. Processing compounds (lubricants, cutting fluids, marking inks, etc.) and corrosion preventative compounds applied to aluminum extrusions that will be processed through GM assembly plants shall be capable of being removed during paint system cleaning operation.

3.3.3 Conversion Coating Pretreatment. If conversion coating pretreatment is required, the GMW15665 materials specification shall end with the "P". Conversion pretreatment requirements are outlined in GMW16721.

3.4 Product Integrity.

3.4.1 Internal Integrity. Aluminum extrusion supplied to this specification shall be free of internal imperfections that may compromise the structural integrity. Internal imperfections include, but are not limited to laminations, unhealed billet cracks, porosity, and stringer inclusions. Refer to Aluminum Association publication QCA-2, "Visual Quality Characteristics of Aluminum Extrusions" for photographs and definitions of imperfections. Supplier process control plan shall show manufacturing procedures used to assure aluminum extrusion internal integrity.

3.4.2 Back End Condition. Aluminum extrusions supplied to this specification shall be free of oxides and inclusions commonly known as "Back End Condition". Suppliers shall process billets such that butt ends are sheared in such a way to avoid the presence of this condition in extruded profiles.

3.4.3 Transverse Weld Seams. Aluminum extrusions supplied to this specification shall not contain transverse weld seams. Suppliers shall process extrusions such that transverse weld seams are removed from extruded profiles.

3.4.4 Longitudinal Weld Seams. Longitudinal weld seam integrity shall be demonstrated by subjecting hollow aluminum extrusions to a drift expansion test per ISO 8493. Profiles shall be subjected to increasing load until fracture occurs. Satisfactory fracture surfaces shall exhibit 100% ductile fracture (i.e., dimple rupture, micro void coalescence) characteristics. Fracture surfaces exhibiting any smooth, featureless surfaces characteristics shall be judged to be unsatisfactory. If necessary, examine fracture surfaces with scanning electron microscope for confirmation. See Figure B1 in Appendix B for schematic diagram showing longitudinal weld seam evaluation by drift test method. For specific details refer to ISO 8493 - Metallic Materials—Tube—Drift Expanding Test.

3.4.5 Stress-Corrosion Resistance. Stress Corrosion Cracking (SCC) can be caused by the combination of sustained tensile stress and a corrosive service environment resulting in premature failure of parts along grain boundaries. Varying amounts of copper in the alloy influence SCC differently. Hence, alloy percentages in materials, fabricating methodologies, heat treatment methods, loading paths, etc., shall be carefully selected to minimize SCC so as to meet the durability requirements of components.

3.5 Processing Requirements.

3.5.1 Zinc Phosphate and/or Nano Ceramic Conversion Coating Analysis. For aluminum extrusions that will be painted, aluminum extrusion supplier shall have zinc phosphate and/or nano ceramic conversion coating analysis performed on production representative aluminum extrusion samples. Zinc phosphate shall meet GMW3011 crystal size, coating thickness and coating weight requirements. Nano ceramic conversion coatings shall meet GMW16170 coating thickness and coating weight requirements. Aluminum extrusion supplier shall provide sample to GM materials engineer for analysis performed by GMW3011 zinc phosphate supplier and/or GMW16170 nano ceramic conversion coating supplier, or a GM approved independent testing laboratory.

3.5.2 Adhesive Compatibility. When applicable, aluminum extrusions supplied to this specification shall meet the adhesive compatibility requirements of GMW16549. Testing shall be performed on an aluminum extrusion sample which has been subjected to production representative processing compounds (lubricants, cutting fluids, marking inks, etc.) and/or corrosion preventative compounds. Aluminum extrusions may require pre-treatment (i.e., conversion coating) processing per GMW16721 prior to adhesive bonding.

3.5.3 Joining. When applicable, aluminum extrusions supplied to this specification shall be suitable for welding and mechanical clinching by standard methods.

3.6 Additional Requirements.

3.6.1 Dimensions and Dimension Tolerances. Unless specified on the engineering drawings or math data files, aluminum extrusions dimensions and dimension tolerances shall conform to the Aluminum Association Aluminum Standards and Data Manual – Metric International System of Units (SI) and/or EN 755-9. Depending on supplier capability and component performance requirements, more restrictive dimension tolerances may be required.

3.6.2 GM Material Property Database Sample and Data Submission. Upon request, aluminum extrusion supplier shall submit samples to GM Material Engineering representative to generate data for the GM Material Property Database. Samples shall be at least 200 mm (8 in) in length. Supplier shall also be prepared to provide physical properties (i.e., Elastic Modulus, Density), and thermal properties (i.e., Coefficient of Linear Thermal Expansion, Thermal Conductivity, Specific Heat) upon request.

3.6.3 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. In addition, product MSDS/SDS submissions must be in compliance with specific country General Motors S&IH TS 3.4-160-02 where available.

6 Approved Sources

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

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.

GMW15665 aluminum extrusion supplier Integration Vehicle Build, PPAP, GP-12/Safe Launch, and Production data submission requirements are shown in Appendix B and Table B1.

7 Notes

7.1 Glossary.

5D: EN 10002-1 tensile test specimen gage length to diameter ratio.

5.65(S₀)^{0.5}: EN 10002-1 tensile test specimen gage length dimension.

A: Percentage elongation after fracture in 5.65(S₀)^{0.5} mm gauge length (where S₀ is the initial cross-sectional area of the test piece).

A5: Percentage elongation after fracture in 5.65(S₀)^{0.5} mm gauge length (where S₀ is the initial cross-sectional area of the test piece).

A₅₀: Percentage elongation after fracture in 50 mm gauge length.

S₀: EN 10002-1 tensile test specimen initial cross sectional area.

7.2 Acronyms, Abbreviations, and Symbols.

AA	Aluminum Association
CTS	Component Technical Specification
EN	European Standard
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
GMAP	General Motors Asia Pacific
GMLAAM	General Motors Latin America, Africa, and Middle East
GMMPD	General Motors Material Property Database
GMNA	General Motors North America
GMW	General Motors Worldwide
GPSC	Global Purchasing and Supply Chain
IMDS	International Material Data System
JIS	Japanese Industrial Standards
ME	Manufacturing Engineering
MSDS	Material Safety Data Sheet
NOM	Nominal
PPAP	Production Part Approval Process
S&IH	Safety and Industrial Hygiene
SCC	Stress Corrosion Cracking
SDS	Safety Data Sheet
SI	International System of Units
VTs	Vehicle Technical Specification Coding System

8 Coding System

The coding system for GMW aluminum extrusions on engineering part drawings/electronic math files, manufacturing engineering documents and other documents (VTS, CTS, etc.) shall use a nomenclature consisting of the GMW base metal specification number, aluminum alloy designation, temper designation, and minimum or nominal with plus/minus tolerance as-received yield strength.

8.1 Example of Coding for a Standard Aluminum Extrusion Grade.

GMW15665M-AL-E-6063-T4-70

GMW15665	= GMW specification number
M	= Metal
AL	= Aluminum
E	= Extrusion
6063	= Alloy designation
T4	= Temper designation
70	= Minimum as-received yield strength (MPa)

8.2 Example of Coding for a Non-standard Minimum Yield Strength Aluminum Extrusion Grade.

GMW15665M-AL-E-6082-T6A-270

GMW15665	= GMW specification number
M	= Metal
AL	= Aluminum
E	= Extrusion
6082	= Alloy designation
T6	= Temper designation
A	= Non-standard temper designation