



Extruded Aluminum Mechanical Tubing and Hydroformed Components

1 Scope

1.1 Material Description. This specification covers round extruded aluminum mechanical tubing and hydroformed components for vehicle body structure and chassis applications. For straight, hollow and semi-hollow aluminum extruded profiles produced from welding chamber (i.e., spider, porthole, or bridge) dies, solid aluminum extruded profiles, solid aluminum extruded round bars, and narrow flat aluminum extruded sheets, refer to GMW15665.

1.2 Symbols. Not applicable.

1.3 Applicability. Typical applications include, but not limited to, aluminum body structure side rails, aluminum body structure roof bows, chassis engine cradles, and chassis rear suspension cradles.

2 References

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

2.1 External Standards/Specifications.

ASTM B221M	ASTM E34	ASTM E607	ISO 8493
ASTM B241	ASTM E101	ASTM E1251	SAE J911

2.2 GM Standards/Specifications.

GMW3011	GMW3335	GMW16170	GMW16721
GMW3059	GMW15665	GMW16549	

2.3 Additional References.

- Aluminum Association Aluminum Standards and Data Manual - Metric SI
- Aluminum Association publication QCA-2, "Visual Quality Characteristics of Aluminum Extrusions"
- General Motors Material Property Database
- Safety and Industrial Hygiene (S&IH) Technical Standard (TS), S&IH TS 3.4-160-02

3 Requirements

3.1 Requirements on Test Specimens.

3.1.1 Chemical Requirements. Tubing and hydroformed components furnished shall conform to the chemical composition (percentage by weight) in Table A1 in Appendix A. Chemical composition shall be determined per ASTM E34, ASTM E101, or ASTM E1251. In cases of dispute, referee method shall be ASTM E34.

3.1.2 Mechanical Requirements.

3.1.2.1 Mechanical Property Requirements. Tubing and hydroformed components including longitudinal weld seams shall meet the mechanical property requirements shown in Table A2 in Appendix A. The extrusion process at the tube supplier shall be adjusted to compensate for excess mechanical property variation if the mechanical properties of a single tube sample measured at the standard tensile sampling locations (see Figure A1 in Appendix A) varies by more than 10% from the average value. Additionally, the longitudinal weld seams must have mechanical properties within 10% of the average value. Mechanical properties shall be determined per GMW3335.

3.1.2.2 Post-Paint Bake Mechanical Properties. Aluminum hydroformed components may show significant tensile mechanical properties changes following E-coat and paint (i.e., primer surfacer, basecoat, topcoat) bake processing. Supplier may be required to modify aluminum hydroformed component artificial aging practice in

order to assure that component exceeds minimum tensile mechanical property requirements after GM assembly plant E-coat and paint bake processing.

3.1.2.3 Mechanical Properties After Simulated Elevated Temperature Exposure. Suppliers of aluminum hydroformed components to be used in elevated temperature vehicle locations such as the motor compartment, and near the exhaust system shall submit mechanical property data following simulated elevated temperature exposure. Supplier shall submit yield strength, ultimate tensile strength and total elongation measurements on hydroformed component samples following 205 °C (302 °F) exposure for 1 h, and 150 °C (401 °F) exposure for 1000 h. Upon request, aluminum hydroformed component supplier shall submit elevated temperature exposure samples to GM materials engineer.

3.1.3 Surface Requirements.

3.1.3.1 Surface Preparation. Aluminum tubing and hydroformed components shall be free of white (aluminum oxide) corrosion and pitting. Refer to Aluminum Association publication QCA-2, "Visual Quality Characteristics of Aluminum Extrusions" for photographs and definitions of pitting and water stain corrosion. It is preferable that tubes being prepared for shipment are washed, rinsed, and then coated with a GM approved corrosion preventative compound. If a washing process is used, it must not leave insoluble residue that interferes with proper operation of bending and hydroforming equipment, welding, phosphating, or painting. Processing compounds (lubricants, cutting fluids, marking inks, etc.) and corrosion preventative compounds applied to hydroformed components that will be processed through GM assembly plants shall be capable of being removed during paint system cleaning operation. Delivery of corrosion free hydroformed components may require packaging and/or use of corrosion preventative compounds.

3.1.3.2 Cleanliness. Tubing shall be clean and free of any contamination, including stringers, chips, solids, or excessive residues of any type on the outer diameter, inner diameter, and ends.

3.1.3.3 Surface Quality. The inside and outside surfaces of the tubing shall be free of surface discontinuities > 5% of wall thickness. Surface discontinuities 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 discontinuities. Upon request, supplier shall provide boundary samples of worst case surface discontinuities to GM materials engineer for documentation of location and severity. Supplier shall also retain of duplicate worst case surface discontinuities boundary samples.

3.1.3.4 Pre-lube Application. If pre-lubricated tubing are to be supplied, the lubricant must conform to GMW3059.

3.1.3.5 Surface Roughness. The surface roughness shall not exceed $R_A = 20 \mu\text{m}$ and $R_{\text{max}} = 70 \mu\text{m}$. Note that surface discontinuities described in 3.1.3.3 shall not be included in the surface roughness measurement. Surface roughness shall be measured in the longitudinal direction according to SAE J911.

3.1.4 Product Integrity.

3.1.4.1 Longitudinal Weld Seam Integrity. If a porthole extrusion process is used to manufacture tubing, longitudinal weld seams shall be of sufficient strength such that structural integrity is not compromised. Weld seam integrity shall be demonstrated by subjecting extruded tube samples to drift/flare testing. Refer to ISO 8493 for drift/flare testing general guidelines. Tube samples shall be subjected to constant axial load until fracture occurs. See Appendix C for drift/flare test procedure and pass/fail criteria. Supplier shall submit a schematic diagram showing location of longitudinal weld seams around the tube circumference. Refer to Figure B1 for an example of a longitudinal weld seam location diagram.

3.1.4.2 Transverse Weld Seams. Aluminum mechanical tubing supplied to this specification shall not contain transverse weld seams. Transverse weld seams shall be removed during extrusion process.

3.1.4.3 Internal Integrity. Aluminum mechanical tubing supplied to this specification shall be free of internal discontinuities that may compromise the structural integrity. Internal discontinuities 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 discontinuities.

3.1.4.4 Back End Condition. Aluminum mechanical tubing 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 aluminum mechanical tubing.

3.1.5 Microstructure Requirements. The microstructure shall be homogeneous along the length and circumference of the aluminum mechanical tubing. Tubes supplied to this specification shall contain minimal large recrystallized grains at outer surfaces commonly known as periphery coarse grain, or coarse grained recrystallized outer band. Supplier shall provide reference photomicrographs with grain size measurements to document periphery coarse grain or coarse grained recrystallized outer band grain size.

3.2 Processing Requirements.

3.2.1 Chemical Requirements.

3.2.1.1 Zinc Phosphate and/or Nano Ceramic Conversion Coating Analysis. For aluminum hydroformed components that will be processed through GM assembly plant paint systems, supplier shall have zinc phosphate and/or nano ceramic conversion coating analysis performed on production representative 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. Supplier shall have analysis performed by GMW3011 zinc phosphate supplier and/or GMW16170 nano ceramic conversion coating supplier, or a GM approved independent testing laboratory.

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

3.2.2 Physical Requirements.

3.2.2.1 End Finish. Tubing ends must be burr-free and pinch-free. No sharp edges allowed at tube ends. Outside condition of as-received tubes is not to interfere with clamping or sealing ability.

3.2.2.2 Labeling and Traceability. Tubing blanks must have an ink stamp for "lot" identification. The ink used must survive any subsequent thermal treatment, should be insoluble in water, and should be applied at three locations (lead end, middle, and tail end) along the length of the tube (Refer to Figure A2 in Appendix A).

3.2.2.3 Dimensional Tolerances. Unless otherwise specified in electronic math data files, or on engineering drawings, Tubing dimensional tolerances shall conform to Table A3 in Appendix A.

3.2.3 Additional Requirements.

3.2.3.1 Joining. When applicable, aluminum hydroformed components supplied to this specification shall be suitable for welding and mechanical clinching by standard GM methods.

3.2.3.2 GM Material Property Database Sample. Upon request, hydroformed component supplier shall submit sample to GM materials engineer to generate data for the GM Material Property Database. Samples shall be at least 200 mm (8 in) in length.

3.3 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

Aluminum mechanical tubing can be manufactured by seamless, or porthole die extrusion processes. Seamless extruded tubes, as defined in ASTM B241, is an extrusion which does not contain any longitudinal weld seams resulting from method of manufacture. If a porthole die extrusion process is used, as defined in ASTM B221M, longitudinal weld seams must be of sufficient quality to not fracture or split during hydroforming.

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.

Prototype, PPAP, GP-12/Launch, and Production data submission requirements are shown in Appendix B and Table B1.

7 Notes

7.1 Glossary.

T4: Solution heat treated or press quenched, and naturally aged to a substantially stable condition.

T6: Solution heat treated or press quenched and then artificial aging.

T7: Solution heat treated or press quenched and overaged/stabilized.

7.2 Acronyms, Abbreviations, and Symbols.

AA	Aluminum Association
ASTM	ASTM International
CTS	Component Technical Specification
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
GMNA	General Motors North America
GPSC	Global Purchasing and Supply Chain
GSSLT	Global Subsystem Leadership Team
ID	Inner Diameter
IMDS	International Material Data System
ISO	International Organization for Standardization
Max.	Maximum
MPS	Material Part Specification
MSDS	Material Safety Data Sheet
PPAP	Production Part Approval Process
S&IH	Safety and Industrial Hygiene
SDS	Safety Data Sheet
TS	Technical Standard
VTs	Vehicle Technical Specification

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

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, and temper designation.

Example of tubing coding system for electronic math data file or engineering part drawing:

GMW16866M-AL-E-6063-T4

Where:

GMW	=	GM Worldwide
16866	=	GMW Standard No.
M	=	Metal
AL	=	Aluminum
E	=	Extrusion
6063	=	Alloy Designation
T4	=	Temper Designation

Example of hydroformed component coding system for electronic math data file or engineering part drawing:

GMW16866M-AL-E-6063-T6

Where:

GMW	=	GM Worldwide
16866	=	GMW Standard No.
M	=	Metal
AL	=	Aluminum
E	=	Extrusion
6063	=	Alloy Designation
T6	=	Temper Designation

9 Release and Revisions

This standard was originated in October 2012. It was first approved by the Non-ferrous Metallic Materials GSSLT in February 2013. It was first published in March 2013.

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1	MAR 2013	Initial publication.
2	MAR 2018	5 year refresh. Updated template and references. (Materials – Nonferrous and Casting Global Subsystem Leadership Team (GSSLT))