



Cast Aluminum Wheel Metallurgical Requirements

1 Scope

This standard covers metallurgical requirements for cast aluminum wheels made from permanent mold castings using the low pressure or gravity casting process.

1.1 Material Description. GMW5M-AL-C-P-Si7Mg-T6 for Cast Aluminum Wheels.

1.2 Symbols. Not applicable.

1.3 Applicability. Cast aluminum alloy wheels for passenger cars, sport utility vehicles, and light duty pick-up trucks which have been manufactured with cast disc and Cast Rim (coded as class "CR") or manufactured with cast disc and Flow-Formed Rim (coded as class "FFR").

1.4 Remarks. This standard details the requirements for the materials, real time radioscapy inspection, dye penetrant inspection of flow-formed rims, and conical seat steel bushings. See Appendix A for Aluminum Wheel Inspection Requirements by real time radioscapy imaging.

2 References

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

2.1 External Standards/Specifications.

ASTM B557M	ASTM E1316	EN 462-5	ISO 6506-1
ASTM E155	ASTM E2002	EN 473	ISO 6892-1
ASTM E165-95	ASTM E2736	EN 10263-2	ISO 9712
ASTM E1000	ASTM E2737	EN 10277-3	ISO 9916
ASTM E1025	Edict INMETRO 445/10	GB/T 9445	SNT-TC-1A

2.2 GM Standards/Specifications.

GMW5	GMW3059	GMW16436	GMW16705
GMW3044			

2.3 Additional References.

CG1152 Wheel and Wheel Trim Statement of Requirements (SOR), Appendix B.

TMC003 Material Safety Data Sheet guidance documents (available at www.gmsupplypower.com).

3 Requirements

3.1 Chemical and Micro-Structure Requirements.

3.1.1 Chemistry. Cast Aluminum Chemistry per GMW5M-AL-C-P-Si7Mg-T6.

3.1.2 Micro-Structure. Micro-Structure of the final wheel shall have a well modified silicon Eutectic phase (typically strontium modified). The level of modification shall be demonstrated by submission of micro-structure images during validation at Production Part Approval Process (PPAP). The images shall clearly demonstrate the morphology of the Silicon Eutectic phase. Modification levels in production wheels shall be equivalent to those used for validation at PPAP and shall be verified during production based on the sampling plan in the part control plan.

The final wheel shall have a fine grain structure (typically achieved through use of grain refiners such as Titanium Boron (TiB)). The grain size shall be demonstrated by Secondary Dendrite Arm Spacing (SDAS) measurement submissions during validation at PPAP. Grain size in production wheels shall be equivalent to

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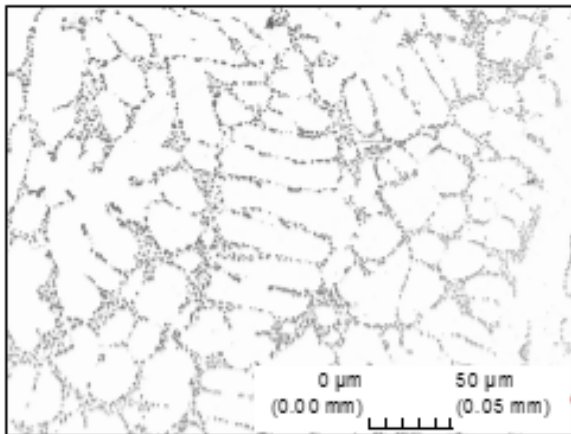
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those used for validation at PPAP and shall be verified during production based on the sampling plan in the part control plan. SDAS shall be measured as per GMW16436.

Refer to Figure 1 and Figure 2 for respective examples of well modified and insufficiently modified Silicon Eutectic on non-flow-formed cast aluminum rims.

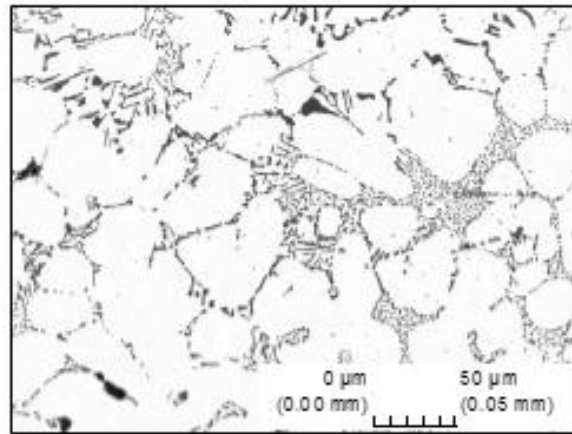
Refer to Figure 3 and Figure 4 for respective examples of well elongated and insufficiently elongated dendrites for flow-formed cast aluminum rims.

Figure 1: Well Modified Silicon Eutectic



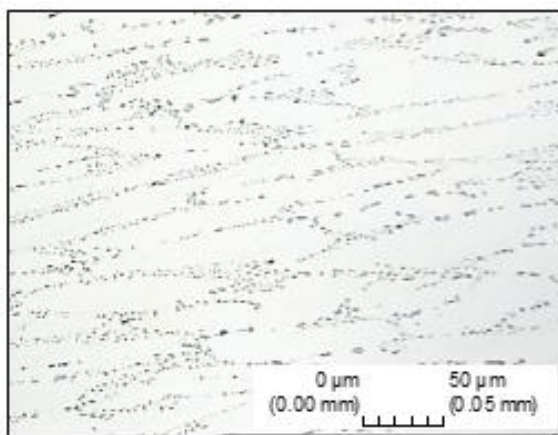
Note: An Aluminum alloy micrograph displaying a well modified Silicon Eutectic (darker phase) at 200x magnification.

Figure 2: Insufficiently Modified Silicon Eutectic



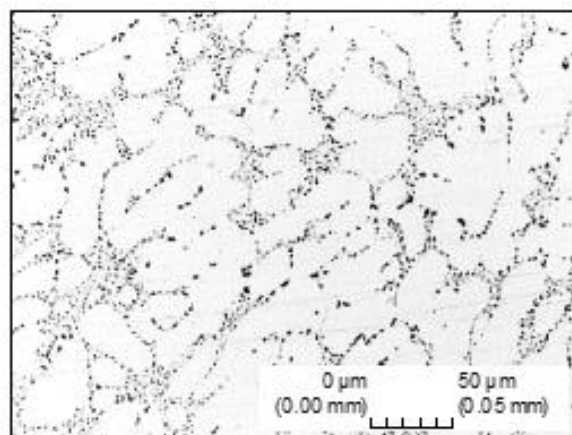
Note: An Aluminum alloy micrograph displaying an insufficiently modified Silicon Eutectic (darker phase) at 200x magnification.

Figure 3: Well Elongated Dendrites



Note: An Aluminum alloy micrograph displaying well elongated dendrites and well modified Silicon Eutectic (darker phase) after Flow-Forming at 200x magnification.

Figure 4: Insufficiently Elongated Dendrites



Note: An Aluminum alloy micrograph displaying insufficiently elongated dendrites but well modified Silicon Eutectic (darker phase) after Flow-Forming at 200x magnification.

3.1.3 All micrograph images and SDAS measurements shall be from fully processed wheels (after heat treatment, aging, and paint bake cycles). The micrograph images and SDAS measurements supplied shall be taken and documented from the outboard rim flange, hub, spoke, and inboard rim flange (plus middle of rim for flow-formed rims) from a minimum of two (2) finished wheels that are representative of the wheels used for validation tests. Refer to Figure 5 and Figure 6 for micrograph locations. Refer to Table 1 and Table 2 for sample sizes. For flow-formed rims, micrograph images and SDAS measurements shall be provided at time of delivery of validation wheels to GM. The first mold and all subsequent mold micrograph images and SDAS measurements shall be measured at PPAP.

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The images provided should contain a micron bar and show the as-polished microstructure per the following:

- A 50x image should show approximately 2 mm² of the structure (typically taken with a 5x objective lens) and labeled as 50x.
- A 200x image should show approximately 0.5 mm² of the structure (typically taken using a 20x objective lens) and labeled as 200x.

Castings shall be free from cold laps, mis-runs, hot tears, cracks, macro-porosity (porosity), shrinkage, dross, mold material and lubricants, entrapped air and any other discontinuities, all to an extent that would be detrimental to machinability, or performance.

3.1.4 The melt shall contain a minimum of 40% primary material (ingots or sows). The total melt shall contain no more than 60% returns. Returns are defined as foundry charge material that consists of reusing previously cast material such as scrapped whole wheels, sprues, runners, gates, and risers. Turnings, dross, and other forms of scrap which carry foreign material shall not be directly charged into the holding and/or cast furnace for wheel castings.

Figure 5: Schematic Cross Section of a Wheel Indicating the Approximate Location and Orientation for Mechanical Property Specimens and Micrographs

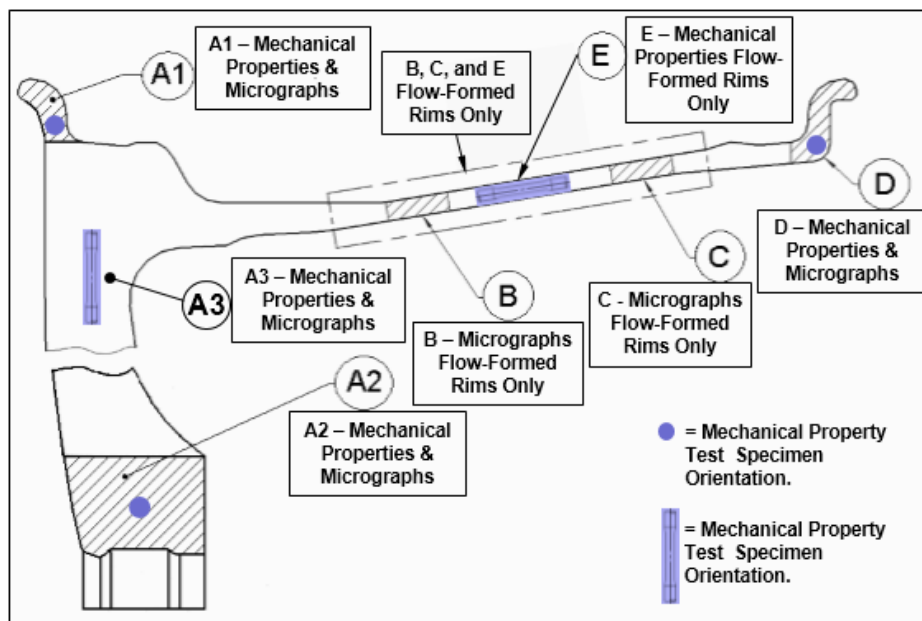


Figure 5 Legend for Wheel Areas:

- A1:** Outboard rim flange (Mechanical Properties & Micrographs).
A2: Hub (Mechanical Properties & Micrographs).
A3: Spoke (Mechanical Properties & Micrographs).
B: Rim near dropwell of rim, Flow-Formed Rims Only (Micrographs Only). Note Micrographs for Wheel Area B to be fully in Flow-Formed Zone.
C: Rim near inboard bead hump of rim, Flow-Formed Rims Only (Micrographs Only).
D: Inboard rim flange (Mechanical Properties & Micrographs).
E: Middle of rim, Flow-Formed Rims Only (Mechanical Properties Only).

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Figure 6: Schematic Front View of a Wheel Indicating the Approximate Location and Orientation for Mechanical Property Specimens and Micrographs

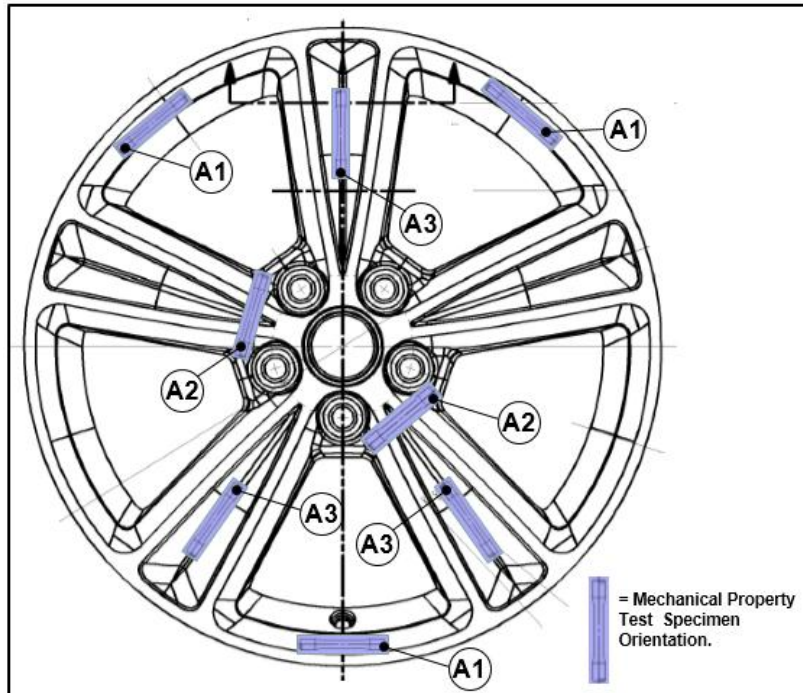


Figure 6 Legend for Wheel Areas:

A1: Outboard rim flange (Mechanical Properties & Micrographs)

A2: Hub (Mechanical Properties & Micrographs).

A3: Spoke (Mechanical Properties & Micrographs).

Table 1: Cast Rim (CR) Wheels (Class "CR")

Property	Unit	Outboard Rim Flange A1 (Note 1)	Hub A2 (Note 1)	Spoke A3 (Note 1)	Inboard Rim Flange D (Note 1)
Ultimate Tensile Strength (UTS)	N/mm ²	230 minimum	Measure and Document Only	Measure and Document Only	Measure and Document Only
Yield Strength (YS) (Note 2)	N/mm ²	150 minimum	Measure and Document Only	Measure and Document Only	Measure and Document Only
% Elongation (EL) after Fracture (Note 3)	%	7 minimum	Measure and Document Only	Measure and Document Only	Measure and Document Only
Brinell Hardness	HBW (Note 5)	Not applicable	70 minimum/80 minimum (Note 4)	Not applicable	Not applicable
Number of Bars per Wheel	Not applicable	Three (3) Bars approximately 120 degrees apart (Each of the three (3) Bars between spokes, at middle of vent window, where feasible)	Two (2) Bars between bolt holes	Three (3) Bars on three (3) different spokes	Three (3) Bars approximately 120 degrees apart
Number of Micrographs per Wheel	Not applicable	One (1) image at 50x and one (1) image at 200x	One (1) image at 50x and one (1) image at 200x	One (1) image at 50x and one (1) image at 200x	One (1) image at 50x and one (1) image at 200x

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Property	Unit	Outboard Rim Flange A1 ^(Note 1)	Hub A2 ^(Note 1)	Spoke A3 ^(Note 1)	Inboard Rim Flange D ^(Note 1)
Number of Wheels to take Bars and Micrographs from	Not applicable	2	2	2	2

Note 1: See Figure 5 and Figure 6.

Note 2: Use 0.2% offset method for YS.

Note 3: EL shall be measured using an extensometer.

Note 4: Core hardness for aluminum wheels without steel bushings is 80 in conical seat area.

Note 5: HBW = Brinell Hardness Number.

Table 2: Flow-Formed Rim (FFR) Wheels (Class “FFR”)

Property	Unit	Outboard Rim Flange A1 ^(Note 1)	Hub A2 ^(Note 1)	Spoke A3 ^(Note 1)	Inboard Rim Flange D ^(Note 1)	Middle of Rim B, C, E ^(Note 1)
UTS	N/mm ²	230 minimum	Measure and Document Only	Measure and Document Only	280 minimum	At E only: 280 minimum
YS ^(Note 2)	N/mm ²	150 minimum	Measure and Document Only	Measure and Document Only	190 minimum	At E only: 190 minimum
% EL after Fracture ^(Note 3)	%	7 minimum	Measure and Document Only	Measure and Document Only	8 minimum	At E only: 8 minimum
Brinell Hardness	HBW ^(Note 5)	Not applicable	70 minimum/80 minimum ^(Note 4)	Not applicable	Not applicable	Not applicable
Number of Bars per Wheel	Not applicable	Three (3) Bars approximately 120 degrees apart (Each of the three (3) Bars between spokes, at middle of vent window, where feasible)	Two (2) Bars between bolt holes	Three (3) Bars on three (3) different spokes	Three (3) Bars approximately 120 degrees apart	At E only: Three (3) Bars approximately 120 degrees apart
Number of Micrographs per Wheel	Not applicable	One (1) image at 50x and one (1) image at 200x	One (1) image at 50x and one (1) image at 200x	One (1) image at 50x and one (1) image at 200x	One (1) image at 50x and one (1) image at 200x	At B and C only: One (1) image at 50x and one (1) image at 200x at middle of rim
Number of Wheels to take Bars and Micrographs from	Not applicable	2	2	2	2	2

Note 1: See Figure 5 and Figure 6.

Note 2: Use 0.2% offset method for YS.

Note 3: EL shall be measured using an extensometer.

Note 4: Core hardness for aluminum wheels without steel bushings is 80 in conical seat area.

Note 5: HBW = Brinell Hardness Number.

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