



Front and Rear Knuckles

1 Introduction

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. This specification defines the general Material performance and requirements for Cast or Forged knuckles.

1.2 Applicability. Requirements in this specification are applicable to all aluminum, iron, and steel steering knuckles for all vehicle platforms.

1.2.1 Additional conditions that augment or supercede GMW16718 requirements may be specified.

1.3 Remarks. This document describes the material related knuckle component specifications. It includes requirements that are to guarantee the quality of both the material and the knuckle design. It serves as an acceptance standard for the inspection of internal and surface anomalies and discontinuities.

2 References

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

2.1 External Standards/Specifications.

ASNT SNT-TC-1A	ASTM B594	ASTM E446	ISO 6506
ASTM A275	ASTM E10	ASTM E1025	SAE 1541
ASTM A897	ASTM E155	ASTM E1417	
ASTM A909	ASTM E165	ASTM E2422	

2.2 GM Standards/Specifications.

GMW5	GMW15181	GMW15536	GMW16705
GMW10	GMW15182	GMW15657	
GMW3059	GMW15183	GMW16436	
GMW14988	GMW15426	GMW16704	

3 Test Preparation and Evaluation

3.1 Resources.

3.1.1 Facilities. The evaluation of porosity on machined surfaces, and handling damage will be visually checked. Optical magnifying equipment may be used in visual inspection.

The evaluation of internal casting porosity, will be performed on all castings by real time/digital x-ray.

The evaluation of surface cracking where required will be evaluated via fluorescent die penetrant (aluminum) and magnetic particle (iron) on all knuckles.

3.1.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.2 Equipment. Visual evaluation systems, real time x-ray system, testing equipment for cracks, Microstructure evaluation and Nondestructive Test (NDT) equipment.

3.1.3 Test Vehicle/Test Piece. Test parts shall be selected per GMW16704. Mechanical testing samples excised from parts shall be of sufficient size to provide standard test specimens per GMW16705 requirements.

3.1.4 Test Time. Not applicable – required test procedures are based on GMW16704 and GMW16705 and are not time dependent. Test frequency is defined later in this specification.

3.1.5 Test Required Information. As stated in Appendix A.

3.1.6 Personnel/Skills. Personnel making accept/reject decisions based on the results of nondestructive testing performed shall be fully trained and certified in appropriate disciplines per American Society for Nondestructive Testing Recommended Practice No. SNT TC 1A (ASNT SNT-TC-1A).

3.2 Preparation. A detailed test matrix shall be prepared prior to all tests. All sample preparation shall be carried out with due care to eliminate any effects (stress, deformation, heating, corrosion, etc..) on the material or part that may cause erroneous results.

3.2.1 Test Samples for Material Strength. Test Samples shall be excised from unmachined knuckles in the finished form (i.e., after any heat treatment or thermal processing). If heat treated Aluminium knuckles are painted with a baked paint process, then this baking treatment shall be performed prior to test samples being taken.

3.3 Conditions. The finished surfaces shall be dry and free of dirt, dust and rust.

3.3.1 Environmental Conditions. Parts and specimens shall be allowed to stabilize to room temperature prior to test.

3.3.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

3.4 Instructions. As per section 4 and GMW16705.

3.5 Data. As per Appendix A and GMW16705.

3.6 Safety. This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

3.7 Documentation. Samples of components or material released to this standard shall be tested for conformity with the requirements of this standard and approved by the responsible GM Department prior to the start of delivery of production level components or materials.

Any change to the component or material, e.g., design, function, properties, manufacturing process and/or location of manufacture requires a new release of the product. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product. In some cases, a shorter test can be agreed to between the responsible GM department and the supplier.

3.7.1 Test Results. As per Appendix A.

4 Requirements and Procedure

The supplier is responsible to furnish part specific drawings with all agreed upon material, quality and other requirements prior to Production Part Approval Process (PPAP).

A matrix summarizing some of the knuckle testing requirements is listed in Appendix A.

4.1 Material Specification. The material specification shall be listed on the Math model and should fall within a material group listed in Table 1. The specific grades of materials listed in Table 1 are not exhaustive and alternative materials may be used after agreement between Supplier and GM Engineering. When an alternative material is used, then the requirements of the relative category are still required to be fulfilled.

Table 1: Material Groupings of Some Common Knuckle Materials

Material Group	Typical Material Specifications for Each Group	
Aluminium Casting	GMW5M-Al-C-P-Si7Mg-T6	-
Nodular Iron Casting	GMW10M-IR-C-N450-xx	ADI to ASTM A897 Grade 900/650/09
Aluminium Forging	GMW15657M-AL-F-Mg1SiCu(AA 6061)-T6	GMW15657M-AL-F-Si1MgMn(AA 6082)-T6
Steel Forging	ASTM A909 Grade 5	SAE 1541 Modified

ADI = Austempered Ductile Iron

4.1.1 Mechanical Properties. Mechanical Properties shall be tested on samples machined from knuckles as per Appendix B.

Mechanical Properties shall be per:

- GMW16704 – Class 1, with limits set as per Table 2.

If the exact material grade is not listed in Table 2 then the mechanical properties must be per:

- GMW16704 – Class 1, with the specific properties listed in the Math Model.

A component level fatigue testing may be used in lieu of material fatigue testing if agreed upon by the responsible GM department and the supplier.

4.1.1.1 Hardness. Hardness measurements shall be taken from samples that are evenly distributed throughout the heat treatment (HT) batches or continuous cycles for heat treated parts. For non-heat treated parts, hardness measurements shall be taken from samples that are evenly distributed throughout the casting batch.

4.1.1.2 Fatigue. Fatigue testing shall be performed on samples from same heat/batch as tensile testing.

4.1.2 Chemical Composition. The Material Specification shall be listed on the Math Model, along with any deviations. GMW5 for Aluminium Castings, GMW15657 for Aluminium Forgings and GMW10 for Nodular Iron are applicable GM standards. For Austempered Ductile Iron Castings and Steel forgings, ASTM standards are applicable.

4.1.2.1 Nodular Iron Castings. Silicon composition shall be below 2.80% for optimum low temperature properties.

4.1.2.2 Aluminium Castings. It is recommended that at least 50% of the charge is to be made up of virgin Aluminium. It is also recommended to restrict Iron composition to a maximum of 0.12% to meet the required mechanical properties.

4.1.2.3 Aluminium Forgings. No additional chemical requirements.

4.1.2.4 Steel Forgings. No additional chemical requirements.

4.1.3 Ultrasonic Testing of Aluminium Forging Base Material. Forging base stock shall be tested for flaws ultrasonically on 100% of logs. Testing shall be performed in 2 directions, at right angles to each other.

4.1.4 Microstructure. Microstructures shall be regularly monitored at sampling rates that meet or exceed those specified in Appendix A.

4.1.4.1 Aluminium Castings. The microstructure shall consist of a fine-grained, well rounded, Al-Si-Eutectic in an aluminum α -Matrix (Continuous Phase).

Dendrite Arm Spacing (DAS) to be < 70 μm within 10 mm of the surface. Dendrite Arm Spacing (DAS) measurement per GMW16436.

4.1.4.2 Nodular Iron Castings (Including ADI). Nodularity should be checked at the thickest section of the casting. Automated sonic or ultrasonic methods shall be used to verify nodularity on 100% of parts.

Chills should be checked in thinnest sections.

Pearlite and Carbide levels shall be regularly monitored at sampling rates that meet or exceed those specified in Appendix A.

4.1.4.3 Aluminium Forging. The microstructure shall be primarily fibrous with minimum recrystallized grains.

4.1.4.4 Steel Forging. No additional microstructural requirements.

Table 2: Mechanical Properties as per GMW16704-Class 1

Material Grade	Hardness (HBW) Per ISO 6506/ ASTM E10		B1 YS (MPa)	Min. YS (MPa)	B1 UTS (MPa)	Min. UTS (MPa)	Min. EI (%)	Fatigue/OSP 100% STP B1 (MPa) Note 1
GMW5M-AI-C-P-Si7Mg-T6-210	≥ 90 Note 2	≥ 85 Note 3	210	210	290	290	8	100
GMW5M-AI-C-P-Si7Mg-T6 ^a -190	≥ 85 Note 2	≥ 80 Note 3	190	190	270	270	7	95
GMW15657M-AL-F-Mg1SiCu-T6 (AA 6061-T6)	≥ 100 Note 2	≥ 95 Note 3	270	270	310	310	10	125
GMW15657M-AL-F-Si1MgMn(AA 6082)-T6	≥ 100 Note 2	≥ 95 Note 3	310	310	340	340	10	135
GMW10M-IR-C-N450-12	156 to 197 Note 4		310	310	450	450	12	N/A
GMW10M-IR-C-N450-10	156 to 197 Note 4		290	290	450	450	10	N/A
ADI ASTM A897 Grade 900/650/09	269 to 341 Note 4		650	650	900	900	9	N/A
SAE 1541 Modified	262 to 302 Note 4		-	685	-	830	18	N/A
ASTM A909 Grade 5	229 to 285 Note 4		-	550	-	690	15	N/A

Min. = Minimum, N/A = Not applicable, UTS = Ultimate Tensile Strength, YS = Yield Strength

Note 1: Overstress Probe (OSP) testing is based on 100 MPa for 1 000 000 cycles.

Note 2: 10 mm diameter ball, 1000 kg force, 10 s to 15 s (or equivalent).

Note 3: 10 mm diameter ball, 500 kg force, 10 s to 15 s (or equivalent).

Note 4: 10 mm diameter ball, 3000 kg force, 10 s to 15 s (or equivalent).

4.1.5 Heat Treatment. All heat treatment equipment shall be well maintained and have regular calibration checks. Due care shall be taken to fully account for any thermal gradients present in the equipment. Rack design and part configuration shall be optimized to ensure uniform heat treatment through each load.

No heat treatment reprocessing may be performed without approval of GM Materials Engineering. Approval may require increased sampling rates and additional validation testing.

4.2 Inspection Requirements.

4.2.1 Visual Inspection by Casting/Forging Supplier. A 100% visual inspection will be performed by the supplier for any surface anomalies or discontinuities including (but not limited to) cracks, blisters, laminations, die coating concerns, pin holes, handling damage and locator issues on all surfaces. Section 4.2.7 details some minimum acceptance standards.

4.2.2 Inspection of Machined Surfaces. The machinist will inspect the knuckles after machining for any anomalies or discontinuities (especially porosity). Section 4.2.7 details some minimum acceptance standards.

4.2.3 Real Time X-ray Inspection of Castings.

4.2.3.1 Real Time X-ray Testing Equipment Capability. The x-ray equipment shall be capable of inspecting to a 2-3T (2% of 3 times the thickness) penetrometer referenced in ASTM E1025. The supplier will assure equipment capability to detect discontinuities > 4% of material thickness across the view axis. The detection limit of inspection system will assure discontinuities > 6% are identified and evaluated to the specification limits, an example of regional breakdowns is shown in Appendix C.

The equipment must be capable of capturing images and the image retention period must be agreed by GM Engineering.

4.2.3.2 Cast Knuckle Development. Hard film X-rays or digitally recorded x-rays must be taken of all cast knuckles used in durability tests. Whenever possible, Knuckles should be selected for these tests that contain the worst case anomalies expected during production. Different maximum levels of anomalies may be allocated into different zones through testing and analysis as per Section 4.2.7.

The final allowable anomaly levels and zones will be based on what was validated in component durability testing and shall be agreed upon by GM Engineering and the supplier and recorded in the GM part drawing.

Unless otherwise agreed upon, the maximum anomaly level that should be agreed upon and validated is shown in Table 3.

Table 3: Maximum Internal Discontinuity Size

If no anomaly was present in validation samples, then no anomaly is allowed in production.

Material Group	Maximum Permissible Size (or Level)	
	Red Zone	Blue Zone
Cast Aluminium	ASTM E155/E2422, Porosity and Shrinkage Level 1	ASTM E155/E2422, Porosity and Shrinkage Level 2
Nodular Iron	ASTM E446, Porosity and Shrinkage Level 1	ASTM E446, Porosity and Shrinkage Level 2

4.2.3.2.1 Knuckle Casting Porosity Level Designations. Appendix D provides additional porosity design guidelines based on CAE modeling and test simulation. Maximum allowable porosity levels are defined based on CAE load cases for specific component level tests (i.e., steering arm fatigue, panic brake, etc.) The appendix defines each porosity level based on a cycle count from each CAE component test load case and CAE model condition associated with the specific test.

4.2.3.3 Cast Knuckle Production. The level of porosity (shrinkage or gas types) shall not exceed the agreed upon levels based on durability tested samples.

The evaluation of internal porosity shall be performed on 100% of all Aluminium castings using X-ray imaging or fluoroscopy.

4.2.4 Magnetic Particle or Fluorescent Dye Penetrant Inspection. Fluorescent dye penetrant inspection of the knuckle surfaces for absence of harmful discontinuities such as cracks will be performed by the supplier. The evaluation will be performed on all casting shipped up to and including PPAP submission. It is expected that capability will be confirmed during PPAP submission, at that time, 100% inspection for surface cracks may be reduced to an audit basis based on Statistical Process Control (SPC) if agreed to by the relevant GM department. The minimum audit will be eight knuckles per heat treat batch, or in the case of continuous heat treat operation, eight knuckles per similar amount to the total quantity produced by a batch operation. Furthermore, the number of knuckles to be audited can be reduced to one given capability has been demonstrated for the following 6 months.

The use of SPC may be agreed upon by Customer and Supplier after process capability is exhibited. The implementation of SPC requires the approval of GM Product Development and Quality Assurance and should include analysis tools such as Process Failure Mode and Effects Analysis (PFMEA).

4.2.5 Eddy Current Testing (Electrical Conductivity). For series testing of heat treatment a 100% Eddy current testing may be performed. A typical test location is from the brake caliper attachment to the opposite arm/boss. If the measured value is below minimum value, then an individual inspection (visual test on blisters and surface cracks) shall be performed. If required, then test parameters should be recorded on the part specific drawing.

4.2.6 Inspection Zones. For surface inspection purposes, the surface of the knuckle is divided into four zones as listed in Table 4. For internal inspection purposes the bulk of the knuckle is divided into two zones as listed in Table 4. Typical inspection zones are illustrated in Appendix E.

Table 4: Knuckle Inspection Zones

	Red Zone	Yellow Zone	Orange Zone	Blue Zone
Surface Area Description	Critical Areas with a Machined Finish	Other Machined Surfaces	Critical Areas with an as-cast or as-forged Finish	All other surfaces
Surface Area Covered	Within 2 mm of all seal contact surfaces	Machined clearance surfaces	Locator/clamp positions	-
	Within 2 mm of edges between multiple machined features	-	Identification Marking Areas	-
	Within 2 mm of fastener load bearing areas	-	Regions subject to high localized stresses	-
	First five threads of all threaded features	Remainder of all threaded features	-	-
	Regions subject to high localized stresses	-	-	-
Bulk Description	Critical zones subject to higher stresses	-	-	Other zones

Regions of relatively high stresses should be determined through program development and should be documented on part specific drawings.

4.2.7 Acceptance levels for Anomalies and Discontinuities. All knuckles shall conform to the maximum discontinuity size ratings for each zone (Section 4.2.6) as listed in Table 5. Any deviations to these values shall be listed in the part specific GM Math Model or drawing. Definitions of the defects and discontinuities are as per Appendix F.

Table 5: Permissible Discontinuity Sizes

	Maximum Permissible Size (or Level)			
	Red Zone	Yellow Zone	Orange Zone	Blue Zone
Cold Shut/Cold Lap/Interrupted Pour	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
Cracks/Tears	Not Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
Blisters/Pimples	-	-	Not Acceptable	A 16 mm ² H 3 mm 2 per surface
Burn In/Burn On	-	-	Not Acceptable	A 50 mm ² H 5 mm 2 per knuckle
Laminations	-	-	A 100 mm ² D 1 mm 1 per knuckle	A 100 mm ² D 2 mm 1 per knuckle
Cold Shot/Inclusions	None Visible	A 5 mm ² 1 per surface	A 2 mm ² 1 per surface	A 5 mm ² 2 per surface
Excess Die Coat	-	-	300 per GAR C-9	560 per GAR C-9
Heat Checking	-	-	300 per GAR C-9	560 per GAR C-9
Drags/Galling	-	-	A 100 mm ² D 1 mm 1 per knuckle	A 150 mm ² D 1 mm 2 per knuckle
Excess Metal	-	-	Not Acceptable	A 50 mm ² H 5 mm 2 per knuckle

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	Maximum Permissible Size (or Level)						
	Red Zone	Yellow Zone		Orange Zone		Blue Zone	
Pin Holes	Not Acceptable	A 2 mm ²	D 0.5 mm	A 2 mm ²	D 0.5 mm	A 5 mm ²	D 0.5 mm
				5 per knuckle		15 per knuckle	
Exposed Porosity	Not Acceptable	A 14 mm ²	D 2 mm	A 2 mm ²	D 0.5 mm	A 14 mm ²	D 2 mm
		1 per surface		1 per Surface		2 per surface	
NCU (Non Cleanup)	Not Acceptable	A 25 mm ²	D 1 mm	-		-	
		1 per surface					
Handling Damage/Witness Marks	Not Acceptable	A 25 mm ²	H 0 mm	A 16 mm ²	H 0 mm	A 25 mm ²	D 2 mm
		D 1 mm		D 1 mm			
Surface Sink	-	-		Not Acceptable		A 200 mm ²	D 1 mm
Flash/Fin	-	-		Not Acceptable		H 1.5 mm	D 0.5 mm
Gate Height	-	-		Not Acceptable		H 1.5 mm	NA

A = Area; measured as the intended surface area of the knuckle.

H = Height; perpendicular height of the discontinuity from the original surface to the highest point of the discontinuity.

D = Depth; perpendicular depth of the discontinuity from the original surface to the lowest point of the discontinuity. Discontinuities where the bottom of the discontinuity is not visible are not permitted.

L = Length; Serpentine Length.

4.3 Traceability. All knuckles shall have clear traceability/identification markings that enable traceability of critical processes for the life of the part. Table 6 outlines the identifiers that are expected of knuckles from each material group. The position of the identifying markings is to be clearly shown on the part drawing, including an explanation of any abbreviations or coding used. Appendix G, Figure G1 provides an example of the identification numbering required. All identification markings shall be clearly discernable (without visual aid) at a distance of 400 mm. Additional traceability requirements may be specified in the SOR.

Table 6: Identification Markings

Identifier Required	Material Group			
	Aluminium Casting	Nodular Iron Casting	Aluminium Forging	Steel Forging
Part Number	X	X	X	X
Manufacture Date	X	X	X	X
Tool/Cavity Number	X	X	X	X
Heat Treatment Date/Batch	X	If applicable	X	X
Rework Identifier	If applicable	If applicable	If applicable	If applicable
Alternative Identification Marking Position	X	X	X	X
Machining Identifier	Optional	Optional	Optional	Optional

X = Required

4.4 Additional Requirements.

4.4.1 Casting and Forging Requirements. The Castings and Forgings shall conform to the dimensions and tolerances specified on the part drawing. Harmful discontinuities, e.g., cracks, inclusions, cold laps, scabs, porosity, etc., that may be detrimental to subsequent processing or to the service for which the parts are intended are not permitted. Casting and Forging surfaces shall be smooth and free from scale. No repairing, plugging or welding of any kind shall be permitted, unless specific permission as to location and procedure to be used has been requested by the supplier and granted by GM Engineering. The repair of defects shall not impair machinability and/or serviceability. The repaired areas shall be permanently marked.

Any repaired areas, excessive dye penetrant or other inspection markings that may impair the aesthetics of finished vehicle are not permitted.

5 Provisions for Shipping

Not applicable.

6 Notes

6.1 Glossary.

Acicular: Sharp, or needle like.

Blasting or Blast Cleaning: A process for cleaning or finishing metal objects by use of an air blast or centrifugal wheel that throws abrasive particles against the surfaces of the work pieces. Small irregular particles of metal are used as the abrasive in grit blasting; sand in sand blasting; and steel balls in shot blasting.

Blue Zone: Raw surfaces other than those deemed as part of the Orange Zone.

Cavity: The portion of a pattern/die which forms the external shape of the knuckle.

Chaplet: A small metal insert or spacer used in molds to provide core support during the casting process.

Charge: A given weight of metal introduced into the casting furnace.

Cleaning: Removal of runners, risers, flash, surplus metal and sand from a casting.

Core: A sand or metal insert in a mold to shape the interior of the casting or that part of the casting that cannot be shaped by the mold pattern. The portion of the cast which forms the internal shape.

Core Wash: A liquid suspension of a refractory material applied to cores and dried (intended to improve surface of casting).

Dendrite Arm Spacing: Also known as Secondary Dendrite Arm Spacing. The average center to center measurement between adjacent dendrite arms.

Draft: Taper on the vertical sides of a pattern or core box that permits the mold to be withdrawn without distortion or tearing.

Each Lot: A definitive batch of components manufactured from the same batch of material up to a maximum of 4 h production

Each Run: A group of components from an uninterrupted manufacturing process up to a maximum of 8 h or 1 shift production. May incorporate one or more lots.

Ejector Pins: Movable pins in the pattern die that “push” to remove cast pattern from the dies.

Feeder/Riser: Part of the gating system that forms the reservoir of molten metal necessary to compensate for losses due to shrinkage as the metal solidifies.

Fluoroscopy: Real time moving images obtained by radiography (X-ray).

GAR C-9: A series of casting surface roughness comparison samples by GAR Electroforming Division of Electroformers, Inc.

GP12: Controlled shipping where increased inspection frequencies are implemented to ensure a process capability is achieved. GP12 inspection is also known as Safe Launch period.

Mold: The form, made of sand, metal or refractory material, which contains the cavity into which molten metal is poured to produce a casting of desire shape.

Mold Wash: A slurry of refractory material, such as graphite and silica, used in coating the surface of the mold cavity to provide an improved casting surface.

Orange Zone: Critical raw surfaces or areas of high stress identified through engineering analysis. Additional Orange Zones may be specified on engineering part drawings.

Parting Line: A mark or line produced on the knuckle, formed at the junction of the parting dies.

Percentage Elongation (%EL): Equal to the total Elongation (%) minus the elastic strain at fracture. $\%EL = \text{Total Elongation (\%)} - 100\% \times (\text{Breaking Stress/Elastic Modulus})$.

Raw Surface: Unmachined surfaces of components, i.e., as-cast Surface of a casting, or as-forged surface of a Forging.

Red Zone: Critical machined surfaces or areas of high stress identified through engineering analysis. Additional Red Zones may be specified on engineering part drawings.

Region of Interest (ROI): A specified area of the casting inspected during x-ray examination.

Returns: Metal charge material in the form of gates, sprues, runners, risers and scraped castings returned to the furnace for re-melting.

Runner System: The portion of the casting mold that does not form part of the finished part, including runners, down gates, sprues, ingates, risers, shrink bobs, flow offs and vents.

Yellow Zone: Machined surfaces other than those deemed as part of the Red Zone.

6.2 Acronyms, Abbreviations, and Symbols.

%EI	Percentage Elongation
ADI	Austempered Ductile Iron
DAS	Dendrite Arm Spacing
DRE	Design Responsible Engineer
DV	Design Validation
FEA	Finite Element Analysis
GD&T	Geometric Dimensioning and Tolerancing
GSSLT	Global Subsystem Leadership Team
HBW	Brinell Hardness with Tungsten Carbide ball
HT	Heat Treatment
LH	Left Hand
NCU	Non Cleanup
NDT	Nondestructive Test
OSP	Overstress Probe
PFMEA	Process Failure Mode and Effects Analysis
PPAP	Production Part Approval Process
PV	Product Validation
RH	Right Hand
SOR	Statement of requirements
SPC	Statistical Process Control
UTS	Ultimate Tensile Strength
YS	Yield Strength of a material, determined by the 0.2% proof method

7 Additional Paragraphs

7.1 All parts or systems supplied to this standard must comply with the requirements of GMW3059, **Restricted and Reportable Substances**.

7.2 General Cast Tolerances. See relevant part drawing for cast tolerances.

8 Coding System

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

GMW16718

9 Release and Revisions

This standard was originated in October 2011. It was first approved by the Non-ferrous Metals and Castings GSSLT in June 2012. It was first published in June 2012.

Issue	Publication Date	Description (Organization)
1	JUN 2012	Initial publication.
2	OCT 2017	Minor changes to section 1.1 Purpose and 1.2 Applicability. Added Appendix D which provides porosity level designation guidelines for CAE design load cases. (Materials – Nonferrous and Castings Global Subsystem Leadership Team (GSSLT))

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