



Mechanical Properties and Material Requirements for Externally Threaded Fasteners

1 Scope

This specification defines the mechanical and material requirements for externally threaded fasteners sized M39 and smaller. This specification is based on ISO 898-1. However, only Property Class described in this document shall be used.

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. The fasteners applicable to this specification are formed from steel wire or bar and heat treated by quench and tempering, as required by the property class. The chemical composition, internal cleanliness of the steel, mechanical properties, microstructure, and other physical properties are described in this document.

1.2 Symbols. Not applicable.

1.3 Applicability. This specification applies to bolts, screws, SEMS (bolts with washer assembly), threaded plugs, and studs.

1.3.1 This specification may be referenced partly for non-standard grades such as work-hardened and bainitic/austempered grades. See Appendix B for guidance.

1.4 Remarks.

1.4.1 GM does not allow new release of fasteners with property class 9.8. The properties listed are for reference for legacy parts only.

1.4.2 Externally threaded fasteners with strength > property class 10.9, including proposed austempered types with hardness > 39 HRc (Rockwell Hardness) (385 HV (Vickers Hardness)), shall not be used for any application that may be exposed to environmental chlorides (such as road salt), regardless of fastener coating. Fasteners > property class 10.9 shall be released only after approval from GM Fastener and Materials Engineers.

1.4.3 Special "underlined grades" (identified as 12.9 for example) per ISO 898-1 are not permitted.

1.4.4 The scope of ISO 898-1 does not include threaded plugs. For the purpose of this specification, a threaded plug can be considered a very short bolt.

2 References

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

2.1 External Standards/Specifications.

ISO 898-1	ISO 6157-1	ISO 16047	SAE/USCAR-8
ISO 898-2	ISO 6157-3	SAE J422	

2.2 GM Standards/Specifications.

GMW3059

2.3 Additional References.

- GM Part Drawing 24502102

3 Requirements

This specification is based on ISO 898-1. Fasteners manufactured to this specification shall conform to the requirements of ISO 898-1 unless otherwise specified in this document. The supplier may be requested to provide records and test data showing conformance to ISO 898-1 requirements not explicitly described in this document.

3.1 Test Reporting. Appendix A, Table A3 lists the tests required to be performed and reported for Production Part Approval Process (PPAP) and for each production lot. Other requirements described in this standard shall be produced by the fastener supplier when requested.

3.2 Steel Chemistry. Fasteners to this standard shall be made of steel conforming to the chemical composition requirements specified in Appendix A, Table A1.

3.2.1 In addition to the chemistry requirements, the supplier must ensure that the selected grade of steel has sufficient hardenability to produce a heat treated microstructure of minimum 90% martensite before tempering.

3.3 Steel Inclusions. The inclusion rating of steel shall not exceed 3-O (oxide) or 4-S (silicate) as per SAE J422.

Note: This requirement is for referee purpose only.

3.4 Mechanical Properties. Parts shall meet the mechanical requirements specified in Appendix A, Table A2 when tested per ISO 898-1.

Note: In the case of special bolts and screws with alternative configurations, such as drilled heads, which make the heads weaker than the threaded section, tensile strength requirements may not be met. Supplier is required to run tensile test of the special head fasteners for information purposes. This test result, including the failure mode, shall be included in PPAP submission. Short bolts/screws (length < 2.5 diameters) are excluded from tensile test.

3.4.1 In the case of property class 8.8 SEMS where the washer and bolt is heat treated as an assembly, the maximum surface and core hardness of the bolt may reach a maximum of 36 HRc (354 HV).

3.5 Microstructure. For fasteners with property class 8.8 and higher, the microstructure shall consist of minimum 90% tempered martensite.

3.6 Decarburization. Fasteners of property class ≥ 8.8 shall meet the decarburization limits described in ISO 898-1.

3.7 Surface Discontinuities.

3.7.1 Fasteners of property class ≤ 6.8 shall meet the requirements of ISO 6157-1.

3.7.2 Fasteners of property class ≥ 8.8 shall meet the requirements of ISO 6157-3.

3.7.3 Discontinuities at thread root caused by usage of serrated thread forming dies are permissible if the depth does not exceed 0.5% of the fastener's nominal diameter. These discontinuities are in the form of scallops at the root and follow contour of thread root.

3.7.4 For threaded plugs sized M20 and larger, conformance to ISO 6157-3, Section 3.7 shall be met, except the maximum torque value allowed for screwing on a GO-ring gauge is 7 Nm.

Note: The surface discontinuity test is applied to parts before any finishing/coating processes.

3.8 Grain flow. Grain flow at the head-shank junction of a bolt must follow the contour of the fillet. No end grain exposure is allowed at the filler or adjacent shank area. Grain flow must conform to SAE/USCAR-8.

3.9 Dephosphating. For fasteners with property class ≥ 10.9 , any phosphate coating must be removed prior to heat treatment. A metallographically detectable (400x magnification) white phosphorous enriched layer is not permitted.

Note: The metallographic test is for referee purpose only.

3.10 Retempering Test. To test the effectiveness and stability of the tempering operation, take three (3) hardness measurements on parts before and after retempering at 415 °C (tolerance of +5/-0 °C) for 30 minutes. The mean average hardness after retempering shall not be more than 20 HV lower.

Note: This requirement is for referee purpose only.

3.11 Torsional Yield Test. This test procedure is only applicable to parts drawings specifying a torsional yield requirement.

This procedure may be used in place of the requirements on GM part drawing 24502102.

3.11.1 The following characteristics will be determined and reported:

- Torsional yield load
- Ultimate strength
- Angular ductility

3.11.2 The test equipment and fixtures shall meet the following requirements:

- Load cell with 0.3% (full scale) accuracy and minimum capacity 130% of the average peak load of fastener to be tested.
- Torque transducer with 0.3% (full scale) accuracy and minimum capacity 130% peak torque of fastener to be tested.
- Angle transducer accurate to 1 degree of angular rotation.
- Data acquisition system (DAS) capable of recording load versus angle and load versus torque measurements.
- Plain Hardness Low (HL) washer and plain test nut per ISO 16047 or other suitable part as agreed to by GM fastening engineer. The washer and nut shall be degreased in solvent within 2 h of performing this test.
- Torque chatter and thread stripping will invalidate the test.

3.11.3 Test Procedure.

- a. Test a minimum of 12 parts randomly selected from each production lot.
- b. Install test bolt onto test fixture, shimming as necessary to duplicate the clamp length from actual application (obtained from fastener engineer). The head of the bolt shall bear against the test washer. The test washer shall be restrained from turning during tightening. Finger assemble the bolt approximately two (2) threads into the test nut.
- c. Using the electric tool, tighten at 20 rpm to 100 rpm spindle speed until bolt reaches ultimate strength.
- d. During tightening, load, torque, and angle of the bolt is recorded continuously a minimum of one (1) data point per degree rotation.

3.11.4 Calculations.

- a. Ultimate Strength: The highest load measured during the test.
- b. Torsional Yield Point (load): Determine the slope of the elastic (linear) portion of the Load-angle plot between 80% and 30% of ultimate strength. Draw a line with the same slope, except offset 30 degrees to the right. The intersection of this line with the load-angle plot is the Torsional Yield Point.
- c. Angular Ductility: The angle of turn from the Torsional Yield Point to the Ultimate Strength.

See Appendix A, Figure A1 for an illustration of the calculations.

3.11.5 For parts with torsional yield requirements, the tensile and hardness test results can deviate from the values in Appendix A, Table A2. However, the supplier shall maintain a tensile strength range of 110 MPa and hardness range of 4 points HRc. For example: Hardness (36.0 to 40.0) HRc ((354 to 394) HV).

Note: Fasteners with modified material or mechanical properties outside of specified range for the base property class shall not have the property class identified on the head of the fastener.

3.12 Head soundness test per ISO 898-1, Section 9.8 shall apply to fasteners size M6 or larger meeting the following criteria:

- Head diameter to head height ratio $\geq 5:1$, or
- Head diameter to shank diameter ratio $\geq 3:1$, or
- Head with recess drive, or
- Weight saving head designs with depression $> 33\%$ of the overall head height

Note: Head soundness test shall be performed on samples before heat treatment during PPAP and production run. However, this test may also apply to finished parts for quality problem resolution.

3.13 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.