



Hydrogen Embrittlement Risk Assessment and Test Procedures for Transmission and Electric Traction Motor Shafts

1 Scope

1.1 Material Description. This standard provides a specification for assessing the risk of hydrogen embrittlement in high hardness transmission and electric traction motor shafts and a test procedure to evaluate the embrittlement risk of process exposures where potentially embrittling conditions cannot be eliminated.

1.2 Symbols. Not applicable.

1.3 Applicability. Transmission and electric traction motor shafts with hardness > 35 HRC (> 32 HRC if they have threads) which are also subjected to a sustained tensile or shear stress during assembly or operation.

1.4 Remarks. Note included on drawings of applicable parts:

This part is considered susceptible to hydrogen embrittlement. Hydrogen embrittlement risk management shall be performed per GMW18184.

2 References

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

2.1 External Standards/Specifications.

ASTM E8	ASTM F519	FMVSS 114	SAE AS8879
ASTM E18	ASTM F1624	SAE AMS 2759/2	SAE/USCAR-5
ASTM E29	CMVSS 114	SAE AMS-S-4000	SAE/USCAR-7

2.2 GM Standards/Specifications.

GMW3059	GMW3399
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3 Requirements

3.1 Hydrogen Embrittlement Risk Assessment. The combination of hardness and sustained static loading is a necessary, but not sufficient condition for hydrogen embrittlement to occur. Exposure to a significant source of hydrogen during manufacturing is also required. SAE/USCAR-5 requires that the potential for hydrogen absorption from cleaning, phosphate coatings, and plating operations be considered and managed on parts susceptible to hydrogen embrittlement. If hydrogen sources are found in the process plan, then a verified method to avoid hydrogen embrittlement is required, such as baking parts after plating. (See Figure 1.)

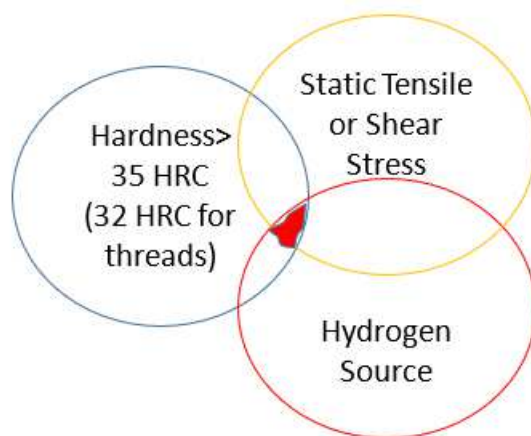


Figure 1: Conditions for Potential Hydrogen Embrittlement

3.2 Supplier Risk Assessment/Compliance Review. GM and suppliers must jointly complete the risk assessment (Data Sheet A1, Appendix A) for all part numbers susceptible to hydrogen embrittlement risk. The data sheet is intended to provide a checklist for a systematic review of all potential hydrogen sources in common manufacturing operations for high strength steel transmission parts. For each part number at risk of hydrogen charging into the part bases on the process plan, order of operations, and Product Failure Modes and Effects Analysis (PFMEA) with particular attention to the known hydrogen sources list in Table A1 and Table A2. Process controls and monitoring for the process fluids listed in Table A2 shall be affirmed by placing a “Y” in the box following Table A2. Next, complete the “Potential Hydrogen Source” assessments listed in the rows of Table A1. If no hydrogen sources listed in Table A1 are found, and the process controls are in place for the process fluids listed in Table A2, affirm that the risk of hydrogen charging has been formally assessed and none were found by entering “Y” in the box following Table A1. No further testing should be needed. If any hydrogen sources listed in Table A1 are checked yes, and or if the supplier cannot affirm process controls for process fluids listed in Table A2, then the process plan should be revised to eliminate the hydrogen source. If the hydrogen source cannot be eliminated, then the recommended risk reduction action in Column 2 of Table A1 should be implemented and testing to verify adequate elimination should be conducted per 3.3. Alternatively, a component level test approved by GM Design Responsible Engineer and Materials Engineer shall be conducted.

3.2.1 This review is to be repeated when any process change, sub-supplier change, or change to the supplier's or sub-supplier's facility occurs which could expose the parts to a source of hydrogen. If such changes occur, an updated assessment and PFMEA will be completed, submitted with the Supplier Process Change Request (SPCR), and filed in the Production Part Approval Process (PPAP) documentation.

3.2.2 If no such changes have occurred, then the review will be re-affirmed (use Data Sheet A2) as part of the annual PPAP testing, and a dated re-affirmation will be filed with the updated PPAP documentation.

3.2.3 Agreement to proceed without Embrittlement testing is not transferrable to future sources or other manufacturing locations.

3.3 Embrittlement Testing Guidelines. SAE/USCAR-7 outlines test methods and practices which can detect hydrogen embrittlement of steel parts. These methods and practices are based on experience with fastener testing, for which the parts are relatively inexpensive, and the test fixtures are simple.

In addition to SAE/USCAR-7, test methods in ASTM F519, ASTM F1624, and an obsolete specification GM3661 have been reviewed. These methods permit sustained tensile load testing of standard air melted 4340 grade steel coupons heat treated to a hardness level known to be susceptible to hydrogen embrittlement in lieu of testing full components. GM Vehicle Materials Engineering is taking a similar approach, permitting testing of standard tensile samples in GMW3399.

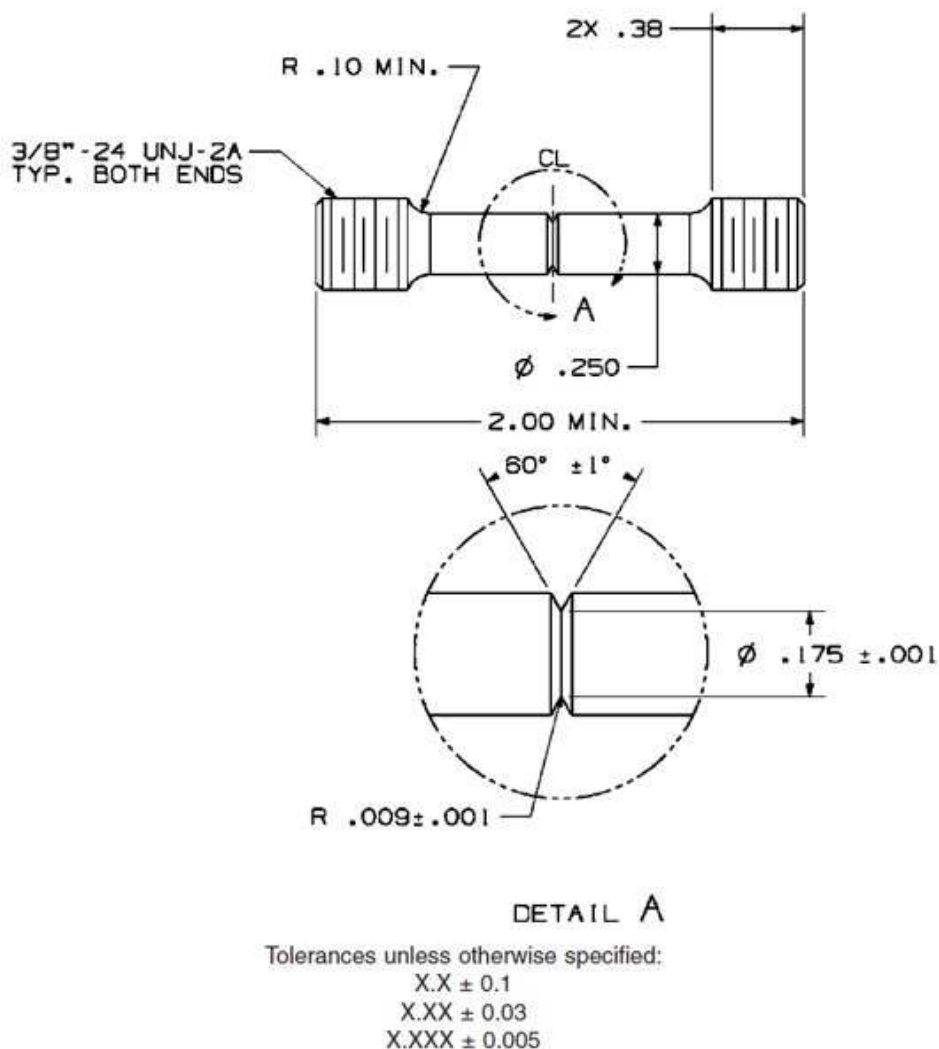
The test method for shafts is ASTM F519, when applied to exposure to service chemicals, plating baths, acid etches, and the like, as described in Annex A5.

3.3.1 Non-safety Critical Shafts.

3.3.1.1 For non-safety critical parts for which embrittlement verification testing is required, testing shall be done as part of the original PPAP when the production line is in place.

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3.3.1.1.1 Following the practice of ASTM F519, SAE AMS-S-4000 air melted 4340 bar stock will be used for test coupons. Samples will be rough machined then heat treated per SAE AMS 2759/2 Class A to a tensile strength between 260 ksi and 280 ksi (51 HRC to 53 HRC (Rockwell C Hardness Scale)) as determined according to ASTM E18. Rounding per Practice ASTM E29 permits an absolute hardness range of 50.6 HRC to 53.4 HRC of the average of three measurements. After hardening, the specimen will be finish machined to a notched tensile sample per Figure ASTM F519, Figure 2, which is reproduced for convenience.



Note: The test bar dimensions are given in inches because of the UNJ-2A thread specification requires dimensioning in inches. There is no metric equivalent per SAE AS8879, and UNJ external threads will not assemble with metric threads without interference at the minor diameter.

Figure 2: Notched Tensile Sample per ASTM F519, Type 1a.1