



Nonmetallic Engine Cooling Fan Blade

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 standard shall define the Design Validation (DV), Production Validation (PV), Post-validation Audit (PVA), In-Process (IP) testing, measurement conditions, performance requirements and the minimum durability specification requirements for engine-driven engine cooling fans fabricated from nonmetallic materials.

1.2 Applicability. This test applies to engine-driven engine cooling fans made of nonmetallic materials for use in GM vehicles. The operating conditions referred to are defined for typical gasoline powered vehicles.

1.3 Remarks. Not applicable.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW3059	GMW14555	GMW15758
GMW3600	GMW14872	GMW15920

2.3 Additional References.

- CG2059 Viscous Fan Clutch ADVP&R. The supplier shall work with the GM Design Responsible Engineer to comprehend this requirement.
- CG2060 Nonmetallic Engine Cooling Fan Blade ADVP&R. The supplier shall work with the GM Design Responsible Engineer to comprehend this requirement.
- Component Technical Specification (CTS)
- Statement of Requirements (SOR) Appendix B, C2, G2, and/or G3

3 Requirements

3.1 System/Subsystem/Component/Part Definition. All requirements of this specification shall be met in order to demonstrate compliance with Design Validation (DV), Product Validation (PV), Product Validation Audit (PVA) evaluations, and IP testing.

3.1.1 Appearance. All appearance variations shall be cosmetic-only in nature and shall not result in the non-conformance of the part to the requirements in this standard.

3.1.2 Content. Not applicable.

3.1.2.1 Physical Content. Not applicable.

3.1.2.2 Functional Content. The fan clutch receives mechanical energy from the engine's pulley. This energy is transmitted through a fluid to spin a fan blade. A mechanical or electric signal may be used to moderate the rate at which the mechanical energy is transmitted to the fan blade.

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3.1.3 Ambient Environment. Unless otherwise specified, the standard ambient testing temperature environment is defined as 23 °C ± 5 °C.

3.1.4 Interfaces. All subcomponents and interfaces that build up the fan clutch including the upper assembly level (if required) must be documented in a block diagram supporting the Design Failure Mode and Effects Analysis (DFMEA), Process Failure Mode and Effects Analysis (PFMEA) and Design Review Based on Failure Mode (DRBFM) as required.

3.1.5 Usage Definition. The passing of these test procedures permit the use of the part globally. If more than one material supplier, or more than one toolset produce the same part in different regions, then a separate round of validation testing shall occur. The supplier shall coordinate this activity with GM Engineering to determine the level of testing required and any other opportunity to combine testing.

3.1.6 Test Vehicle/Test Piece. The testing setup shall be approved by the GM Validation Engineer. The specified sample quantity shall be agreed prior to testing in the Analysis/Development/Validation Plan and Report (ADVP&R) plan. All subsystem components not produced by the supplier required for validation shall be provided by GM.

3.1.6.1 Master Fan Preparation.

- a. Determine locations for strain gauges by brittle lacquer coating analysis of the fan assembly or Finite Element Analysis (FEA) analysis methods approved by GM Design Responsible Engineer (DRE) or GM Validation Engineer.
- b. Designate one of the test fans in Dry as Molded (DAM) condition as the master fan.
- c. To crack the brittle lacquer, the fan is subjected to one of the following conditions:
 1. Operation in a rotational test stand equipped with appropriate obstructions and vibrational excitation at all frequencies the fan may encounter in the vehicle environment.
 2. Alternate methods of determining maximum stress areas such as finite element analysis and mathematical modeling are acceptable, provided prior correlation with similar fans has been proven. Use of any alternate method must be approved by the GM DRE and GM Validation Engineer.
 3. In-vehicle operation throughout engine speed range in all fan clutch conditions.
- d. Apply strain gauges at the determined maximum strain locations on the fan. Other necessary strain gauge locations may become apparent by subsequent cracking of test samples in areas not previously strain gauged. If this occurs, the master fan is to be strain gauged at the crack initiation location and rerun in the test stand and in the test vehicle. This will determine if the appropriate durability test strain levels have been achieved.

It is recommended that the strain gauges on the plastic master fan shall be evaluated periodically for replication of the values observed and replaced as required.

3.1.7 Test Time. Total testing time shall be considered when planning delivery of parts to meet GM key dates contained in the GM Global Vehicle Development Process (GVDP) schedule. It is highly required to leave a buffer of at least four weeks between test completion and the GM milestone when planning, due to an unexpected failure where re-validation would be required. Following is an estimated plan of how long it takes to validate and test one fan blade product or part number. Times may vary based on test cell availability and capacity.

Calendar time: 72 d

Test time: 1750 h

Coordination time: 360 h

3.1.8 Test Required Information. The performance measurements and durability test results are to be summarized and reported to GM on the supplier ADVP&R plan, CG2060 (the supplier shall work with the GM Validation Engineer to comprehend this requirement). Full test reports shall be available for viewing by GM personnel per GMW15920.

3.1.9 Personnel/Skills. The personnel and skill requirements are the responsibility of the supplier.

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3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Test Load Determination.

The determination of durability test strain levels is achieved by review of the results obtained from the in vehicle and rotational test stand strain measurements, mean and the highest observed resonant frequency. At least two strain levels shall be determined (i.e., dynamic and mean).

The resonant frequencies should be determined across a range of vehicle operation (upshifts and downshifts), including across transmission shifts at high engine speeds. Alternative methods may be used if permission is granted the GM DRE and GM Validation Engineer.

3.2.1.1.1 Infinite Life.

- For clutched fans, strain level determined at the maximum engine speed. For vehicles with gasoline engines, this shall be the Fuel Cutoff Speed indicated in the Statement of Requirements (SOR) Appendix C2. For vehicles with diesel engines, this shall be the Engine Braking Speed.
- For direct drive fans, the load factor shall be 125% of the dynamic strain and 100% of the mean strain.

3.2.1.1.1.1 Infinite Life Load Factor. The load factor for the infinite life durability test shall be established based on the criteria described as follows (a through c) and the test duration in 3.2.1.2, or as specified in the Component Technical Specification (CTS).

- If the highest strain level was observed with the clutch in the disengaged clutch (Minimum Coupling) mode, then the fan may be sensitive to drive system vibrational input and should not be considered for further testing. Deviation may be granted by the GM DRE and Test Engineers if strain levels are low; in this case, the load factor shall be 200% of dynamic strain and 100% of mean strain.
- If the highest strains were observed with the clutch in the engaged clutch (Maximum Coupling) mode, the load factor shall be 125% of dynamic strain and 100% of mean strain.
- If the highest strains were observed with the clutch in the locked clutch (Solid Coupling) mode, the load factor shall be 100% of dynamic strain and 100% of mean strain.

3.2.1.1.2 Finite Life.

- For clutched fans, strain level determined at engine speed with maximum N/V ratio in direct drive between the infinite life (3.2.1.1.1) and maximum engine speed.
- For direct drive fans, the load factor shall be 100% of the dynamic strain and 100% of the mean strain.

3.2.1.2 Test Duration Determination.

3.2.1.2.1 Infinite Life. With the loading criteria from 3.2.1.1, the fan shall demonstrate an infinite life. Test duration may be calculated using the following formula:

$$\text{Test hours} = (\text{Cycles for infinite life for the selected fan material}) / (\text{Observed frequency (Hz)} \times 3600)$$

For example, infinite life for a 33% glass reinforced nylon 6-6 fan is approximately 10 million (10^7) cycles (or as specified in the Material Data Sheet (MDS)). If this fan went into resonance at 150 Hz, the test time shall be:

$$\text{Test hours} = \frac{\text{Cycles for infinite life}}{\text{Observed resonance frequency (Hz)} \times 3600}$$

$$\text{Test hours} = \frac{10^7}{150(\text{Hz}) \times 3600}$$

$$= 18.5 \text{ h}$$

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In certain instances, the observed strain will not result from a resonant condition. In these cases, the test time shall be 25 h.

3.2.1.2.2 Finite Life. With the loading criteria from 3.2.1.1, the fan shall demonstrate a finite life of 2 h.

3.2.1.3 Cycling at Temperature. Test per 4.3.2.1. A crack that is visible to the naked eye shall constitute a test incident. The fan assembly may need to be disassembled at the end of the test to inspect hidden areas for cracks. After inspection, test per 4.3.2.2. A crack that is visible to the naked eye shall constitute a test incident. The fan assembly may need to be disassembled at the end of the test to inspect hidden areas for cracks.

3.2.1.4 Cold Impact Test. Test per 4.3.3. No cracks visible to the naked eye allowed. Using the same sample, test per 4.3.5.

3.2.1.5 Thermal Cycle Test. Test per 4.3.4. No cracks visible to the naked eye allowed. Using the same sample, test per 4.3.5.

3.2.1.6 Corrosion Test. Test per 4.3.6. No red rust allowed.

4 Validation

4.1 General.

4.1.1 Validation Phase Definitions. Reference GMW15758 (ADV Process Development and Validation Terminology) for the definitions of Design Validation, Product Validation, and Post Validation Audit.

4.1.2 Test Samples. Reference GMW15758 for explanations of how parts for Design Validation, Product Validation, and Post Validation Audit shall be produced and selected. Test samples' dimensions and materials must be within specification.

In-vehicle strain measurements and resonant durability tests are performed on Dry as Molded (DAM) fans. If, over a period of time, weight gain due to moisture absorption exceeds 0.4% by weight, then the DAM fan must dry at 80 °C for at least 72 h or a new DAM fan shall be used.

All other tests are performed on moisture conditioned fans if the fans are made from hygroscopic (i.e., moisture absorbing) materials, e.g., nylon.

4.1.2.1 Performance Evaluation.

4.1.2.1.1 In-Vehicle Data Acquisition. Test results from the in-vehicle strain tests shall be recorded in the Vehicle and Fan Identification data sheets or equivalent documents. See CG2060. The supplier shall work with the GM Design Responsible Engineer to comprehend this requirement.

- a. To monitor air temperature, locate the thermocouple in the airflow path midway between the radiator and the fan, approximately at the center of the blade portion of the fan assembly.
- b. Install the strain gauged master fan and instrumentation in the test vehicle. The maximum combined radial and/or axial runout is to be set for the combination of parts (fan, clutch, spacer, water pump, etc.) being evaluated. The GM Design Engineer shall determine the maximum runout based on the fan system component tolerances. Note: For all fans, the design intent fan to radiator dimension, fan to shroud engagement, fan to shroud tip clearance, and fan drive ratio shall be maintained.
- c. In-vehicle strain tests shall be conducted throughout the operating range of the fan. The tests shall be conducted in still air, and on the road or on a chassis dynamometer.
 - In still air, the engine is accelerated in neutral at a controlled, slow speed sweep not to exceed 500 rpm per second from idle speed to the maximum obtainable engine speed. In addition, a speed sweep is made from idle to maximum engine speed at the maximum engine acceleration rate.
 - On the road, the vehicle is driven through the Wide Open Throttle (WOT) upshift points, and in the case of automatic transmissions, through the maximum speed 2-1 forced downshift.
 - On the chassis dynamometer, the vehicle is driven through the WOT upshift points and forced downshift points (automatic transmission) with the ram air velocity to match the vehicle speed.
- d. For viscous clutch fans, the fan strains shall be determined for the following fan clutch operating conditions:
 - Disengaged clutch (Minimum Coupling) mode.
 - Engaged clutch (Maximum Coupling) mode.
 - Locked clutch (Solid Coupling) mode.

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