



Electric Cooling Fans

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 describes the quality, reliability, durability and performance requirements for all Electric Cooling Fans (ECF), including all the sub components such as motor, blade assemblies, shroud, resistors, etc. A portion of this standard is focused at testing powertrain cooling systems consisting of the Electric Cooling Fan and shroud, herein referred to as the cooling fan. This standard is a supplement to GM authorized ECF component drawings.

1.2 Applicability. This standard applies to all ECF using ambient air to charge air heat transfer. Some requirements of this standard may be validated on the exact technology, regardless of configuration, or in lieu of application specific parts.

1.3 Remarks. The engineering test schedule contained within this standard defines the minimum performance and durability criteria necessary for design and production validation. In addition, the minimum requirements for in-process testing of ongoing production are outlined. The schedule is intended as a supplement to normal material standards, dimensional checking and in-process controls, and should in no way adversely influence adherence to other inspections operations.

All requirements of this standard must be met in order to demonstrate robust design and production validation.

This standard replaces various regional standards with one worldwide standard for ECF assemblies. Any common cooling fan requirements are contained in this standard. All component specific requirements are on the ECF component drawing.

2 References

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

2.1 External Standards/Specifications.

EN 10204	ISO 5167-1	ISO 21940-21
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2.2 GM Standards/Specifications.

GMW3059	GMW3172	GMW15272	GMW17010
GMW3091	GMW14204	GMW15442 (ID)	
GMW3097	GMW14478	GMW16044	
GMW3103	GMW14872	GMW16449	

Note: (ID) = This standard is limited to internal distribution within General Motors and shall not be distributed outside this company. Contact the GM Lead Engineer for further instructions.

2.3 Additional References.

- ECF component drawing.
- ECF CTS.
- GM packaging and identification requirements for productions parts in the SOR.
- HVAC/PTC Integration SSTs.

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- Powertrain Electrical Interface (PPEI) Cooling Fan Control Test Procedures located at the following site: (https://gmweb.gm.com/sites/PTI_GSSLT/Pages/PPEI.aspx).
- SOR C1 Condenser Radiator Fan Module (CRFM) document.
- Supplier Analysis Development and Validation Plan and Report (ADVP&R).
- Vehicle Technical Specification.

3 Test Preparation and Evaluation

3.1 Resources.

3.1.1 Facilities.

Test facilities according to the test specifications and standards listed and:

- Semi-Anechoic chamber.
- Hot - Cold chambers.

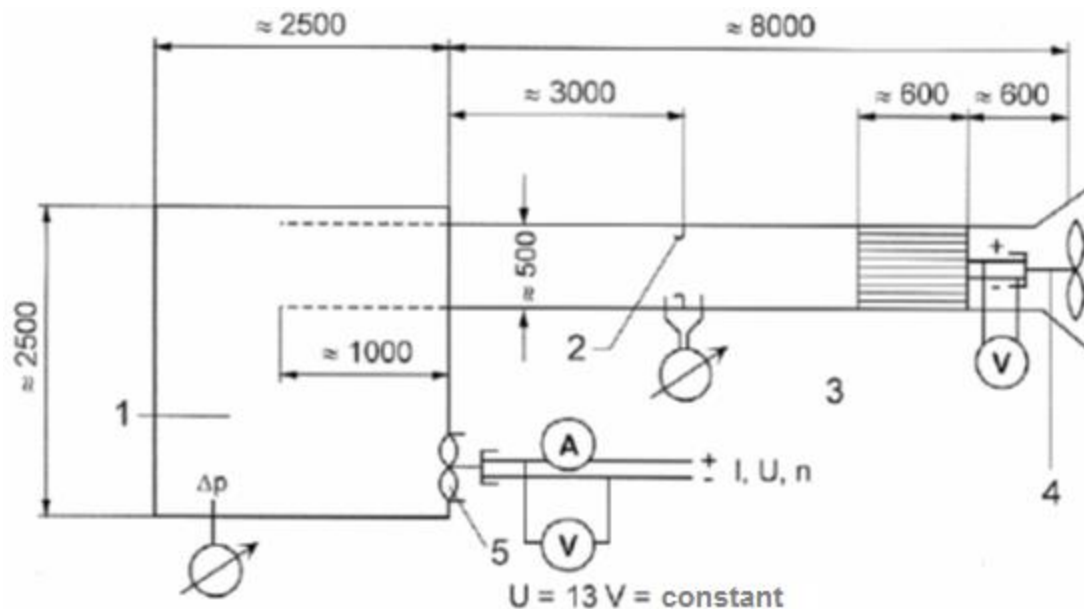
3.1.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

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.

3.1.2.1 Test equipment for measuring the output curve, see Figure 1, comprising 3.1.2.1.1 through 3.1.2.1.9.

Figure 1: Test Equipment for Measuring the Output Curve (Sketch)



Note: All dimensions are in millimeters.

Key:

Smoothing chamber
Standard nozzle
Smoothing grid
Auxiliary fan
Sample

I Current
U Voltage
n Frequency
 ΔP Differential Pressure
 $\approx$ Approximately

(A) Amp Meter
(V) Volt Meter
 Pressure Meter

3.1.2.1.1 Intake tube, 8 m long, internal diameter 300 mm, with smooth internal wall and smoothing piece behind the inlet.

3.1.2.1.2 Standard nozzle to ISO 5167-1.

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3.1.2.1.3 Differential pressure meter to measure the differential pressure occurring at the pressure release openings of the standard nozzle with error limit of 0.5%.

3.1.2.1.4 Smoothing chamber, dimensions approximately ($\approx$) 2500 mm x 2500 mm x 2500 mm.

3.1.2.1.5 Pressure measuring device, measurement range 0 Pa to 200 Pa, error limit 0.5%.

3.1.2.1.6 Current measurement device, measurement range 0 A to 100 A, accuracy class 0.5.

3.1.2.1.7 Voltage measurement device, measurement range from 0 V to 16 V, accuracy class 0.5.

3.1.2.1.8 Rotational speed measurement device.

3.1.2.1.9 Electrical power supply: 30 V, 100 A with adjustable voltage and current (constantly).

3.1.2.2 Temperature cabinet with circulating air, test space 0.5 m³.

- Temperature range: -40 °C to +120 °C.
- Temperature accuracy: ± 3 °C.

3.1.2.3 Fatigue test equipment, comprising:

- Temperature cabinet.
- Test space.
- Temperature range: -30 °C to +120 °C (the heat emitted by the test objects shall be taken into account) with pass-through.
- Time controlled power supply to perform the durability test.

3.1.2.4 Equipment for testing vibration resistance.

3.1.2.5 Measurement equipment for determining dynamic unbalance.

3.1.3 Test Vehicle/Test Piece.

3.1.3.1 ECF Test.

3.1.3.1.1 Test Samples. If not otherwise specified for initial sample approval and release tests, a minimum of 50 ECF assemblies/parts for Design Validation and 50 ECF assemblies/parts for Production Validation shall be required supplied. Document the assemblies/parts with inspection reports per EN 10204.

It shall be expected that, in the samples presented, the values of all required parameters shall give the tolerance range of the production spread. If the test samples do not meet this condition, the tolerance range of the production spread shall be given in the works certificate for all required parameters, irrespective of the individual values.

3.1.3.1.2 Conditioning. Unless otherwise specified in the individual tests, the tests shall be performed without pretreatment, in the as-received condition at +23 °C $\pm$ 5 °C and 60% relative humidity.

3.1.3.2 Dryness/Cleanliness. The assembly shall be thoroughly dry internally and externally prior to shipment. The assembly shall be free of oil, grease or any contaminants that may interfere with proper coating, cause plugging, or have a detrimental effect on material properties or fan function.

3.1.3.3 Finish/Appearance. Unless otherwise specified on the component drawing, the fan assembly shall be smooth, free from burrs and sharp edges.

3.1.3.4 Packaging. All assemblies shall be packed per GM packaging and identification requirements for productions parts.

3.1.3.5 Storage. Service parts shall be adequately protected to ensure satisfactory performance after a storage period of five (5) years beyond the date of shipment from the manufacturer's plant.

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3.1.4 Test Time.

Calendar time: 136 days, 273 days, 364 days, 1546 days
Depends on ECF Type

Test hours: 3000 h, 6000 h, 8000 h, 34 000 h
Depends on ECF Type

Coordination hours: Depends on ECF Type

3.1.5 Test Required Information. The performance measurements and durability test results shall be summarized and reported to GM on the Supplier Analysis Development and Validation Plan and Report (ADVP&R) plan. Full test reports will be available for viewing by GM personnel on request.

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

3.2 Preparation.

3.2.1 General. Detailed design and process Failure Mode and Effects Analysis (FMEA), shall be submitted to the Design Engineer and Validation Engineer upon request and shall be maintained as part of the vendor records of the Design Validation (DV) and Process Validation (PV). The FMEAs shall be updated each time a change occurs.

Design Validation testing and Production Validation may be changed by the use of the analysis tool, Design Review Based on Failure Mode (DRBFM). Results of this DRBFM shall be a report as part of the ADVP&R for this requirement if sample size and testing at DV or PV is changed from approved ADVP&R.

3.2.2 Fan Assembly Performance. The requirements shall be satisfied as partial fulfillment of the requirements for prototype and production part submission. Any common cooling fan requirements are contained in this standard, all component specific requirements are on the ECF component drawing.

3.3 Conditions.

3.3.1 Environmental Conditions. Unless other conditions are specified for a procedure, these tests shall be run at +17 °C to +25 °C and that temperature is to be recorded.

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. ECF tests are a set of tests that will measure characteristics like: airflow, Noise and Vibration (N&V), Electromagnetic Compatibility (EMC), stall protection, structural and electrical durability.

3.5 Data. Not applicable.

3.6 Safety. This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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.

3.7.1.1 All test report shall be provided according with the Production Part Approval Process (PPAP).

3.7.1.2 A Design Review Based on Test Results (DRBTR) report shall be provided after finishing the test using GMW16044 format.

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4 Requirements and Procedure

4.1 Standard Plenum Air Flow.

Supplier shall correlate the airflow measurement method with the method used by GM in the Air Movement and Control Association (AMCA) Labs. Before performing the airflow test, the supplier shall contact the AMCA GM Engineer and agree on a single procedure, so both labs are correlated and results can be used for analysis without issue.

The minimum air flow requirements shall be noted on the ECF component drawing as a function of static pressure head and air volume flow rate. The air handler system used for all air flow tests must be Air Movement and Control Association (AMCA) or American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) certified. In addition, a review of all fan test procedures must be conducted by GM personnel. Prior to measurement, the cooling fan assembly is to be run for 15 minutes at a minimum. GM will use the GMW15442 as the internal test process.

These tests shall be run at room temperature and that temperature is to be recorded.

4.2 Free Air Flow Performance. All assemblies will be tested for free flow fan performance (cubic meters per minute (m^3/minute)) at specific rotation speed in revolutions per minute (rpm) and current. Use the procedure explained in 4.2.1. The free air flow value shall exceed the free air flow requirement, and the free air flow current value shall be less than the free air flow current requirement. Both requirements will be shown on the ECF component drawing.

4.2.1 Air Flow Test.

4.2.1.1 Mount the assembly with the shaft horizontal.

4.2.1.2 Supply the motor with $12.0 \text{ V} \pm 0.1 \text{ V}$.

4.2.1.3 Measure the stable free air flow when speed is within ($\pm 10 \text{ rpm}$) and current ($\pm 0.1 \text{ A}$) and record the results reporting the plus/minus airflow performance.

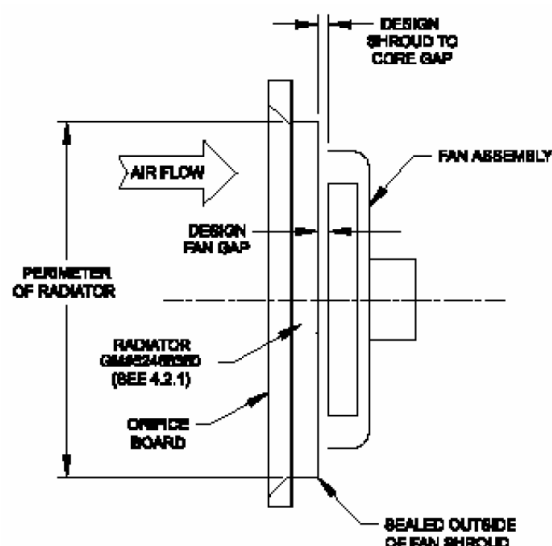
4.3 Radiator Mounted Tests.

The cooling fan assembly shall be mounted downstream of a 16 mm thick, 2.5 fin constant radiator with dimensions of 774 mm wide x 438 mm high. A radiator of similar dimensions with the same thickness and fin constant is also acceptable as long as the radiator is at least as large as the fan/fan shroud being tested.

It is preferred to use the heat exchangers that represent design intent of the specific platform. The fan assembly mounting configuration is shown in Figure 2 and Figure 3.

This test has the objective of confirming that the analysis performed by GM and supplier are correct and airflow performance targets are met.

Figure 2: Shrouded ECF Mounted



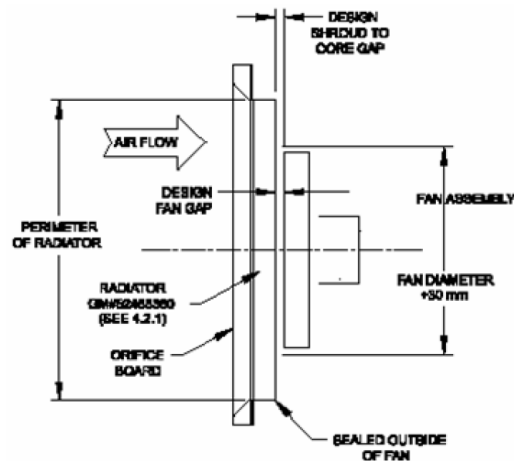
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Figure 3: Unshrouded ECF Mounted



4.3.1 Board Mounted Tests. The fan assembly mounting configuration is shown in Figure 4 and Figure 5. The objective of this test is to collect data to demonstrate the ECF performance only and compare this with the calculated airflow performance by the GM Aero Group.

Figure 4: Unshrouded ECF Mounted

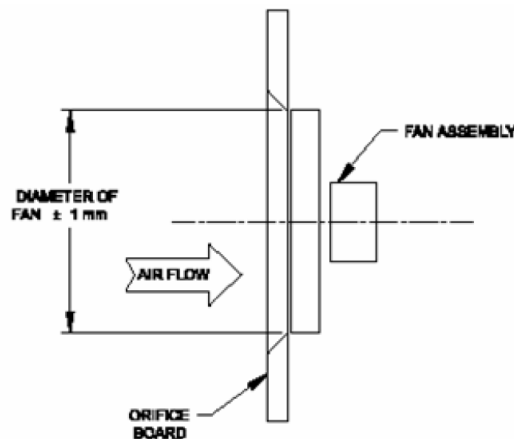
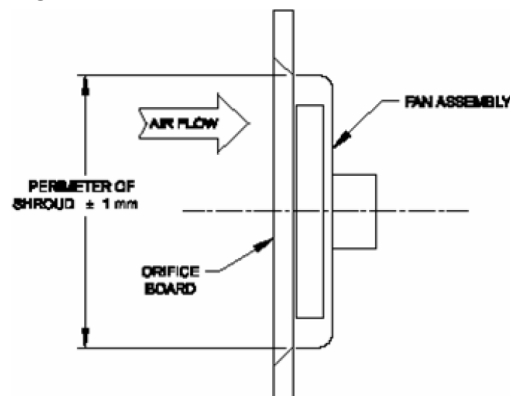


Figure 5: Shrouded ECF Board Mounted



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4.4 Electric Cooling Fan Noise and Vibration.

4.4.1 Fan Balance Characteristics.

4.4.1.1 Static Unbalance. The maximum static unbalance shall be specified in the SOR C1 Condenser Radiator Fan Module (CRFM) document and on the ECF component drawing. If no unbalance is specified, a value of 0.025 kg mm shall be used. Static balance tests shall be performed on GM approved equipment per ISO 21940-21 (7 samples).

4.4.1.2 Dynamic Unbalance The maximum couple dynamic unbalance shall also be specified in the CRFM Integration SSTS and noted on the ECF component drawing. If no value is specified, use a value as follows according to the SOR C1 CRFM document.

- 12 kg mm for fans < 325 mm in diameter.
- 22 kg mm for fans that are ≥ 325 mm and ≤ 500 mm in diameter.
- 50 kg mm for fans > 500 mm in diameter.

Verify those values on the ADVP&R document. Dynamic balance tests shall be run on GM approved equipment per ISO 21940-21 (7 samples).

4.4.1.3 Thermal Cycling Balance Stability. The balance requirements of 4.4.1.1 and 4.4.1.2 shall also be met after high ambient thermal cycling of the fans per the following high ambient thermal cycling test procedure for non-metal materials:

- a. Mount the cooling fan assembly with the motor shaft(s) horizontal including fan shroud, all exceptions shall be approved by the GM Validation Engineer or Design Release Engineer or Fan Bill of Material (BOM) Family Owner (BFO) and documented on the ADVP&R.
- b. Supply each motor 12.0 V $\pm$ 0.5 V with amperage to meet demand.
- c. Test the assembly in a +105 °C $\pm$ 5 °C ambient environment.
- d. Perform cycles of 10 minutes $\pm$ 5 s with motor(s) OFF followed by 5 minutes $\pm$ 5 s with motor(s) ON.
- e. Perform two (2) cycles of "d" and then cool entire assembly to +20 °C.
- f. Repeat "e" three (3) times.

The preceding procedure results in three (3), 30 minute sessions of high ambient exposure for an approximate total of 90 minutes.

This is a test conducted for PV that would prove that the injection molding of the fan blade was correctly done. If this was not correctly done or the incorrect material was selected, the dimensional stability of the blade would not be maintained and, therefore, the balance would be lost.

4.4.1.4 Balance Capability Demonstration. The capability of meeting the unbalance requirements must be demonstrated using a statistical model, such as a Variation Simulation Model (VSM) or any other equivalent model used by the supplier, accounting for variation of all components, processes, and dimensions influencing balance.

4.4.2 Electric Cooling Fan Noise. Cooling fan noise levels shall be specified in the SOR C1 Condenser Radiator Fan Module (CRFM) document, ECF CTS and on the ECF component drawing for maximum noise level and tonal content as the maximum limit. The A-weighted sound levels shall conform to the requirements when tested according to GMW14478 and the following setup. The fan shall be tested in the complete program specific CRFM. If the program specific CRFM heat exchangers are not yet available, the setup shown in Figure 6 may be used.

The fan assembly is to be tested according to GMW14478 mounted to a heat exchanger package (as shown in Figure 6) while meeting the following restrictions:

- It is preferred to use the heat exchangers that represent design program specific intent. In case they are not available, heat exchangers with a flow resistance of two 16 mm thick x 2.5 fin constant radiators in series with a 25 mm separation gap shall be used, see 4.3 for dimensions.
- Radiator exit must cover entire fan assembly inlet area.
- Heat Exchanger Isothermal Pressure Drop.
- Uniform inlet flow distribution.
- +25 °C $\pm$ 5 °C.

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