SURFACE VEHICLE RECOMMENDED PRACTICE

J1390™	APR2026

Issued 1982-04
Revised 2022-02
Stabilized 2026-04

Superseding J1390 FEB2022

Engine Cooling Fan Structural Analysis

RATIONALE

Stabilizing this document.

STABILIZED NOTICE

This document has been declared “STABILIZED” by SAE Cooling Systems Standards Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

SAE Executive Standards Committee Rules provide that: “This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user.”

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2026 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, or used for text and data mining, AI training, or similar technologies, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: **Tel: 1-877-606-7323 (U.S. and Canada only)**
Tel: 1-724-776-4970 (outside U.S. and Canada)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

For more information on this standard, visit
https://www.sae.org/standards/content/J1390_202604/

Documents Document Sharing Hub
Full document details: SAE J1390-2026 Engine Cooling Fan Structural Analysis

FOREWORD

This SAE Recommended Practice is intended as a guide toward standard practice but may be subject to frequent change to keep pace with experience and technical advances, and this should be kept in mind when considering its use.

1. SCOPE

Three levels of fan structural analysis are included in this practice:

a. Initial structural integrity.

b. In-vehicle testing.

c. Durability (laboratory) test methods.

The initial structural integrity section describes analytical and test methods used to predict potential resonance and, therefore, possible fatigue accumulation.

The in-vehicle (or machine) section enumerates the general procedure used to conduct a fan strain gage test. Various considerations that may affect the outcome of strain gage data have been described for the user of this procedure to adapt/discard depending on the particular application.

The durability test methods section describes the detailed test procedures for a laboratory environment that may be used depending on type of fan, equipment availability, and end objective.

The second and third levels build upon information derived from the previous level. Engineering judgment is required as to the applicability of each level to a different vehicle environment or a new fan design.

This SAE Recommended Practice is applicable to any engine cooling fan application including medium and heavy-duty trucks, buses, construction equipment, industrial, and agricultural equipment. Some sections are more applicable to engine-driven fans than to hydraulic-driven or electric-motor-driven fans, especially with respect to speed control. Fan failure modes, however, are generally the same regardless of driving modes.

The usage of non-metallic construction necessitates areas of evaluation not required by metallic designs. Chief among

Documents
Document Sharing Hub

Full document details: SAE J1390-2026 Engine Cooling Fan Structural Analysis

these are temperature extremes, moisture content, impact resistance, chemical attack, material purity/homogeneity, and aging/weathering. Areas of evaluation affecting both metallic and non-metallic fans, but requiring somewhat different approaches with non-metallic parts, include natural frequency determination and durability testing.

1.1 Purpose

The purpose of this document is to identify the general methodology for the structural analysis of engine cooling fans, and to provide expanded information on subset practices within the general methodology, such that a user of this practice can adapt specific subsets related to a vehicle[1] class.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1099 Technical Report on Low Cycle Fatigue Properties, Ferrous and Non-Ferrous Materials

SAE J1116 Categories of Off-Road Self-Propelled Work Machines

SAE J1234 Specification Definitions - Off-Road Work Machines

SAE J/ISO 6165 Earthmoving Machinery - Basic Types - Vocabulary

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D618 Standard Practice for Conditioning Plastics for Testing

3. DEFINITIONS

3.1 NON-METALLIC FANS

Non-metallic fans can be constructed from a variety of thermoplastic and thermosetting resins, with or without any of the following: reinforcing fibers, fillers, stabilizers, modifiers, and pigments. Non-metallic fan materials in common use include but are not limited to polypropylene, nylon, polyester, and vinyl ester.

3.2 WELD-LINE or KNIT-LINE

The area of a molded non-metallic part formed by the union of two or more streams of thermoplastic flowing together during an injection molding process.

3.3 STRESS WHITENING

An effect noted in non-metallic materials under stress loading occurring as a result of molecular orientation, visible as a white area due to the change in the refraction index of the material.

4. INITIAL STRUCTURAL INTEGRITY

[1] The term "vehicle" as used in this practice is defined as an all-inclusive term.

Documents
Document Sharing Hub
Full document details: SAE J1390-2026 Engine Cooling Fan Structural Analysis

4.1 Scope

It is necessary to identify and attempt to evaluate the characteristics of an application which can have an effect on fan durability. Failures almost always occur in fatigue, so careful attention should be paid to avoid resonance or forced vibration of the fan. This section considers vibrational inputs, fan natural frequencies, and operating speed as part of the initial structural integrity analysis. A fan application fact sheet (Figure 1) is recommended as a form to communicate between user and fan supplier.

4.1.1 A resonant condition may occur when the natural frequencies of the fan as determined from 4.3 is coincident with either of the vibrational input frequencies or their harmonics, as calculated in 4.2, or with the effects of airflow obstructions near the fan.

4.1.2 It is desirable to separate these frequencies, including the upper and lower harmonics, whenever possible. In addition, torsional vibrations, auxiliary equipment, driveline vibrations, etc., may cause vibratory inputs to the fan which cannot be predicted in equation form.

4.1.3 Vibratory inputs to the fan caused by the fan tips rubbing against a shroud should be avoided. Such rubbing is generally accompanied by much noise but can also be easily identified by visual inspection of the fan and shroud. Engine movement and vehicle frame flexure are two conditions that can cause rubbing.

Documents
Document Sharing Hub
Full document details: SAE J1390-2026 Engine Cooling Fan Structural Analysis

PART ONE - FAN USER INFORMATION

Customer: _____ Location: _____

Contact Person: _____

Phone Number: _____ E-mail Address: _____

Performance Required Air Density: _____

Volumetric Flow Rate: _____ Static Resistance Pressure: _____

Speed: _____ RPM Max Fan Power: _____

Limitations

Max Fan Diameter: _____ Max Over-Speed: _____ RPM

Max Projected Width: _____ Max Fan Power: _____

Other: _____

_____

Application (Vehicle) Description

Model Number: _____ Engine: _____

Rated Power: _____ at Engine Speed: _____ RPM

Fan Drive Type: _____

Fan/Engine Speed Ratio: _____ Fan Mounting Location: _____

Fan Rotation: _____ Belt Tension: _____

Pilot and Bolt Circle: _____ Maximum Run-Out: _____

System

Shroud (& Type): _____ Shroud Diameter: _____

Fan Position: _____

Clearance to Obstructions: Front: _____ Rear: _____

Required Testing

Airflow: _____ Spin Burst: _____ Shaker Scan: _____ Impact: _____

Strain Gage: _____ Endurance (Bench Test): _____ Dimensional Check: _____

Material Properties: _____ Other: _____

PART TWO - FAN SUPPLIER INFORMATION

Manufacturer: _____ Location: _____

Contact Person: _____

Phone Number: _____ E-mail Address: _____

Proposal

Manufacturer's Part Number: _____

Drawing and/or Model File Attached: _____

Fan Weight: _____ Max Fan Imbalance: _____

Fan Rotational Inertia: _____ Fan Transverse Inertia: _____

Other: _____

Test Results Attached

Airflow: _____ Spin Burst: _____ Shaker Scan: _____ Impact: _____

Strain Gage: _____ Endurance (Bench Test): _____ Dimensional Check: _____

Material Properties: _____ Other: _____

Figure 1 - Fan application fact sheet

Documents
Document Sharing Hub

Full document details: SAE J1390-2026 Engine Cooling Fan Structural Analysis

4.2 Vibrational Inputs

4.2.1 Frequency Prediction

Without verification by in-vehicle testing, the potential critical speeds and frequencies that can affect the fan can only be predicted. Two potential frequencies of vibration are the harmonics of the piston firing frequency Equation 1 and the harmonics of the fan rotational frequency associated with obstructions that cause a non-uniform or pulsating flow as the fan rotates (Equation 2). Both full-order and half-order harmonic frequencies should be considered.

$$\text{Piston Firing Frequency} = \frac{(\text{No. of Cylinders})(\text{Engine rpm})}{(30)(\text{No. of Cycles})} \qquad \text{(Eq. 1)}$$

where:

number of cycles refers to two or four stroke engine

$$\text{Fan Rotational Harmonic Frequencies} = \frac{(n)(\text{Fan rpm})}{60} \qquad \text{(Eq. 2)}$$

where:

n = 1,2,3, ... obstructions encountered per revolution

4.2.2 Air Pressure

The cooling fan operates with a working pressure gradient across the fan swept area. Local obstructions, side-members, and core (or stacked core) air restrictions all affect fan blade deflections and strain levels.

4.3 Fan Natural Frequencies

4.3.1 The resonant frequencies and location of the node lines of the fan should be measured for each mode of vibration. This can be done by using a shaker table, accelerometers, strain gages, or by observation. The resonant frequencies may be for both rectilinear and torsional modes of vibration. Each resonant frequency of a fan can be affected by the following:

4.3.1.1 The shape of the fan mounting surface, which may affect the relative spring constant of the system and should be duplicated as closely as possible.

4.3.1.2 The torque of the mounting bolts may also affect the relative spring constant.

4.3.1.3 Dimensional variations from fan to fan, including material tolerances, may affect both the relative spring constant and the vibrating mass.

4.3.1.4 When using means other than the actual installation for driving the vibrating mass, caution should be exercised with the excitation level as the natural resonant frequencies can be masked by the high excitation levels of an over-driven forced vibration.

4.3.1.5 Temperature and moisture content of a non-metallic fan, since tensile modulus and flexural modulus vary with both temperature and moisture content.

4.3.1.6 Orientation of reinforcing fibers of a non-metallic fan (if present).

4.3.1.7 Material homogeneity of a non-metallic fan due to molding process variations.

4.3.2 The maximum stress may not occur at the resonant frequency. It may occur at a frequency between the resonant frequencies of two different modes of vibration, i.e., a combination of rectilinear and torsional excitation.

AVA Documents
Document Sharing Hub

Full document details: SAE J1390-2026 Engine Cooling Fan Structural Analysis