



ANSI/ASHRAE 87.1-1992
(Supersedes ANSI/ASHRAE 87.1-1983)

ASHRAE[®]

STANDARD

Method of Testing Fan Vibration— Blade Vibrations and Critical Speeds

Approved by the ASHRAE Standards Committee on January 25, 1992; by the ASHRAE Board of Directors on January 30, 1992; and by the American National Standards Institute on April 20, 1992.

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ISSN 1041-2336

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(This foreword is not part of this standard but is included for information purposes only.)

FOREWORD

This standard is classified as an ASHRAE Standard Method of Testing. It is a revision of ASHRAE Standard 87.1-1983, which was developed on the recommendation of an ad hoc study group appointed in 1972 by the ASHRAE Standards Committee to determine needs for ASHRAE standards in the field of fan vibration. The following is an excerpt from the report of this study group:

There are a significant number of failures of propeller fans in heating, refrigeration and air conditioning equipment due to an incompatibility between the dynamic characteristics of the fan and the dynamic requirements of the application. These failures are a waste, not only for the industry, but also for the consumer.

To eliminate these failures, the fan manufacturer's knowledge of the dynamic characteristics of the fan and the user's knowledge of the dynamic requirements of the application must be communicated effectively between the manufacturer and the user.

The present revision was necessitated by deficiencies in the part of the 1983 version that predicted critical speeds from the statically measured resonance frequencies.

To overcome this problem, ASHRAE conducted research program 477-RP on which this revision of the standard is based.

1. PURPOSE

The purpose of this standard is to provide a standard method of testing propeller fans for aerodynamically excited vibrations and critical speeds. The objective is to quantify those dynamic characteristics of propeller fans that are essential in the proper selection and application of such fans in order to avoid resonances that can be excited by aerodynamic forces acting on the fan blades.

2. SCOPE

2.1 This standard applies to propeller fans for use in heating, refrigerating, and air-conditioning units. The fans may be of a built-up or monolithic construction and with or without resilient hubs. The sizes typically range from 10 in. (250 mm) to 30 in. (760 mm) in diameter.

2.2 This standard covers only fans intended to be mounted directly on the shaft of the drive motor.

2.3 This test characterizes the fan by itself, independent of the specific application for which the fan is intended.

2.4 A method for predicting the critical speeds from the test data is included.

2.5 The scope of this standard does not cover

- (a) resonances in the motor/support system,
- (b) torsional resonances excited by motor torque pulsations, or

- (c) test methods for the reliability qualifications of fans in a given application; these will be covered in proposed ASHRAE Standard 87.2 currently under development.

3. DEFINITIONS AND SYMBOLS

The definitions of vibration terms used in this standard conform to those given in *ANSI S1.1-1960 (R1976)*¹ and in *ISO Standard 2041:1990*.² The most important definitions used in this standard are given below.

3.1 Definitions

accelerometer: a transducer that converts a mechanical input acceleration to an electrical output that is proportional to the input acceleration.

aerodynamic excitation: time-varying loads acting on the blades of a fan due to nonuniformities of the airflow.

Note: *Spatial nonuniformities of airflow that are steady in time give rise to harmonic excitation at frequencies that are integer multiples of the rotation rate of the fan. Turbulence of the airflow gives rise to random excitation.*

blade pitch: the angle between the chord of the propeller blade and the plane of rotation. The pitch may be constant for the length of the blade or it may be larger at the blade root than at the tip.

blade twist: the property of a propeller blade describing the variation of the pitch from the blade root to the tip.

camber: the arched curvature of the propeller blade.

camber depth: the perpendicular distance from the chord of the blade's cross section to the point of maximum camber.

chord: the straight-line distance between the leading and trailing edges of the blade.

critical speed: an operating speed at which the vibration of the fan blades is maximized.

dynamic characteristics of a fan: the resonance frequencies and mode shapes of a fan.

dynamic requirements: the operating speeds and excitation forces prevailing in a proposed application.

excitation: an external force applied to a system that causes the system to vibrate.

frequency response: the normalized motion response of a fan to a known excitation, expressed as a function of the frequency of the excitation. The frequency response is usually given graphically by curves showing the relationship of the response to the excitation (and, where applicable, phase shift or phase angle) as a function of frequency.

harmonic: a sinusoid whose frequency is an integral multiple of the fundamental frequency.

harmonic order: integer that defines the numerical value of the multiple of the fundamental frequency.

mode of vibration: in a system undergoing vibration, a mode of vibration designates the characteristic pattern of displacement assumed by the system vibrating at one of its resonance frequencies. For the purposes of this standard, the fixed-hub modes of a fan are identified in terms of their type (flapping or twisting, Figure 7-2) and in terms of the number of nodal lines (Figures 7-3 through 7-7).