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AMERICAN NATIONAL STANDARD
Guide to the Experimental Determination of Rotational Mobility Properties and the Complete Mobility Matrix

This Guide is the fourth part of a set of five documents covering the experimental determination of the mechanical mobility of structures by a variety of methods appropriate for different test situations. The present Part IV of the set offers guidance in situations where it is necessary to measure not only translational motion responses to a translational exciting force but also the rotational and combination terms of the 6×6 mobility matrix required to fully describe each point of a structure. This part of the set is published as an ANSI Guide rather than as a Standard because the state of the art of rotational motion and force measurement is still in flux. Several methods are described, all requiring attached exciters.

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AMERICAN NATIONAL STANDARDS ON ACOUSTICS

The Acoustical Society of America is the Secretariat for Accredited Standards Committees S1 on Acoustics, S2 on Mechanical Shock and Vibration, S3 on Bioacoustics, and S12 on Noise. Standards developed by these committees, which have wide representation for the technical community (manufacturers, consumers, and general-interest representatives), are published by the Acoustical Society of America as American National Standards after approval by their respective standards committees.

These standards are developed as a public service to provide standards useful to the public, industry, and consumers, and to Federal, State, and local governments.

This guide was approved by the American National Standards Institute as ANSI S2.34-1984 on 6 July 1984.

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FOREWORD

[This Foreword is not a part of American National Standard Guide S2.34-1984 (ASA Catalog No. 34-1984).]

This standard Guide has been developed under the jurisdiction of Accredited Standards Committee S2 using the American National Standards Institute (ANSI) Committee Procedure. The Acoustical Society of America holds the Secretariat for Committee S2. This guide has been approved for publication by S2 and by the Acoustical Society of America Committee on Standards (ASACOS).

The scope of Standards Committee S2 on Mechanical Shock and Vibration under whose jurisdiction this standard was prepared is as follows:

> Standards, specifications, methods of measurement and test, and terminology in the fields of mechanical shock and vibration, but excluding those aspects which pertain to safety, tolerance, and comfort.

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Suggestions for improvement of this standard Guide will be welcomed. They should be sent to the Standards Secretariat, Acoustical Society of America, 335 East 45th Street, New York, NY 10017.

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0 INTRODUCTION

0.1 Introduction to the Set of ANSI Mobility Measurement Documents

Dynamic characteristics of structures can be determined as a function of frequency from measurements of mobility or of the related frequency response functions called accelerance and dynamic compliance. Each of these frequency response functions is a ratio of the motion response of a structure to the excitation force or moment at a single point. The magnitude and the phase of these ratios are functions of frequency.

Accelerance and dynamic compliance differ from mobility only in that the motion response is expressed in terms of acceleration or displacement, respectively, instead of in terms of velocity. To simplify the standards, only the term "mobility" will be used. It is understood that all test procedures and requirements described are applicable also to the determination of accelerance and dynamic compliance.

Mobility measurements are typically used for:

(1) Predicting the dynamic response of structures to known or assumed input excitation;
(2) Determining the modal properties of a structure (natural frequencies, mode shapes, and damping ratios);
(3) Predicting the dynamic interaction of interconnected structures;
(4) Determining dynamic properties (i.e., the complex modulus of elasticity) of materials in pure or composite forms;
(5) Checking the validity and improving the accuracy of mathematical models of structures.

For some applications, a *complete* description of the dynamic characteristics may be required considering translational forces and motions along three mutually perpendicular axes, as well as moments and rotational motions about these three axes. This results in a 6×6 mobility matrix for each location of interest. For N locations on a structure, the system thus has an overall mobility matrix of size $6N \times 6N$.

For most practical applications, it is not necessary to know the *entire* $6N \times 6N$ matrix. Often, it is sufficient to measure the driving-point mobility and a few transfer mobilities by exciting with a force at a single point in a single direction and measuring the translational response motions at key points on the structure. In other applications, only rotational response to moment excitation around a single axis may be of interest.

In order to simplify the use of standards for the varied mobility measurement tasks encountered in practice, a set of ANSI documents on mobility measurement will be published in five separate parts:

Part I (ANSI S2.31-1979) covers basic definitions and transducers. The information in Part I is common to most mobility measurement tasks.

Part II (ANSI S2.32-1982) covers mobility measurements using single-point translational excitation with an attached exciter.

Part III will cover mobility measurements using single-point rotational excitation with an attached exciter. This information is primarily intended for rotor system torsional resonance predictions.

Part IV (the present Guide) covers measurements of the entire mobility matrix using attached exciters. This includes the translational, rotational, and combination terms required for the 6×6 matrix for each location on the structure.

Part V will cover mobility measurements using impact excitation with an exciter which is not attached to the structure.

NOTE: At the time when Part IV was published, Parts III and V were in preparation. Part IV is published as an ANSI Guide, whereas Parts I and II are ANSI standards.

Mechanical mobility is defined as the frequency response function formed by the ratio of the phasor of the translational or rotational response velocity to the phasor of the applied force or moment excitation. If the response is measured with an accelerometer, conversion to velocity is required to obtain the mobility. Alternatively, the ratio of acceleration to force or moment, called accelerance, may be used to characterize a structure. In still other cases, dynamic compliance, the ratio of displacement to force or moment, may be used.