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# **AES–ALMA Standard test method for audio engineering — Measurement of the lowest resonance frequency of loudspeaker cones**

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## **Abstract**

This standard test method is intended to determine the frequency of lowest resonance of a loudspeaker cone. Such information is used for engineering design and for quality control. The method has been developed to improve correlation of measurement between cone manufacturers and loudspeaker manufacturers.

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## Foreword

[This foreword is not a part of the *AES–ALMA Standard test method for audio engineering — Measurement of the lowest resonance frequency of loudspeaker cones*, AES19-1992 (ALMA TM-100).]

This document has been prepared by the Committee of Cone Suppliers of the American Loudspeaker Manufacturers Association, acting as a working group for the Audio Engineering Society Standards Committee. The following individuals have contributed to the preparation of this document: R. Brennan, C. Caldwell, D. J. Field, G. C. Johnston, G. R. Pariza, P. B. Williams, and T. Yocum.

GEORGE C. JOHNSTON, *Chairman*  
Committee of Cone Suppliers  
1990 December

At the time of approval of this document for publication, the AES Standards Committee had the following membership: Yoshi-Haru Abe, R. Ajemian, James S. Brawley, Richard C. Cabot, M. Cundiff, Peter D’Antonio, Donald Eger (Chair), Robert A. Finger, D. Gray, Irving Joel, William Hogan, Tomlinson F. Holman, Mike Klasco, David L. Klepper, Bart N. Locanthi, J. P. Nunn, T. Owen, Daniel Queen (Secretary), Tom Roseberry, W. T. Shelton, William D. Storm, Ted Telesky, Han Tendeloo, Floyd E. Toole, and D. Wickstrom.

The American National Standards Institute version of this standard has not been reprinted and remains available as ANSI S4.30-1992.

*Note: Historically, this standard was published jointly by the AES and by ALMA.. In 2003, AESSC Subcommittee SC-04 proposed that it be withdrawn as an AES document in the understanding that ALMA International, Princeton Junction, NJ, US., will continue to publish and maintain this standard as ALMA TM-100*

# AES–ALMA Standard test method for audio engineering — Measurement of the lowest resonance frequency of loudspeaker cones

## 1 Scope

This standard test method shall be applied to determine the frequency of lowest resonance of a loudspeaker cone before assembly into a loudspeaker. The test results shall be used for engineering design purposes and for quality control. The method is intended to improve correlation of measurement between cone manufacturers and loudspeaker manufacturers. It shall not be used for finished loudspeaker assemblies. This standard applies to cones up to 380 mm (15 in) in diameter. The effects of gravity are beyond the scope of this standard.

## 2 Introduction

Loudspeakers are limited-bandwidth devices. They are limited at the low frequency in direct relation to the resonance of the loudspeaker assembly. This assembly resonance is a function of the mass and spring elements that make up the moving components of a loudspeaker. These elements include the mass of the diaphragm, the mass of the voice coil, the mass of the air load; the stiffness of the surround, the stiffness of the spider, and, if applicable, the stiffness of the air in the loudspeaker enclosure.

NOTE – Because cone resonance is a function of two of these parameters (cone mass and surround stiffness), the accuracy of the test for resonance has particular importance.

The cone resonance  $F_0$  is given by

$$F_0 = (S_S/M_D)^{1/2} \quad (1)$$

and the loudspeaker resonance  $F_S$  is given by

$$F_S = [(S_S+S_P+S_A)/(M_D+M_C+M_A)]^{1/2} \quad (2)$$

where

$M_D$  = mass of diaphragm (or cone)

$M_C$  = mass of coil and adhesive

$M_A$  = mass of air load

$S_S$  = stiffness of surround

$S_P$  = stiffness of spider

$S_A$  = stiffness of air load

As can be seen from Eqs. (1) and (2), the cone resonance value is mathematically related to the loudspeaker resonance. It is thus important to control cone resonance as a partial control on loudspeaker resonance.

### 3 Definitions

**3.1** The frequency of lowest resonance (or concisely, resonance) shall be that frequency of vibration of a column of air which excites the greatest displacement of the test cone suspended in the column when the vibration is produced by a loudspeaker driven by an amplified variable-frequency oscillator.

NOTE – Maximum excursion is the means by which the frequency of resonance is detected, that is, when the frequency of an oscillator driving a loudspeaker through an amplifier is slowly increased, the frequency at which the maximum excursion is observed in the test cone is recorded as the resonance of that cone.

**3.2** The clamp dimension shall be the minimum dimension at which the cone is normally restrained by adhesion to the basket (or frame) and to the pad ring (or gasket). This dimension usually becomes the clamp dimension for cone measurement, which is the inner diameter (ID) on  $B_1$  and  $B_2$  in Fig. 1. For non-circular cones, the clamp dimension should be specified in sufficient detail.

NOTE – The clamp dimension details are highly critical for proper correlation in cone resonance measurements. Differing dimensions on two pairs of clamp rings can result in greatly different resonance readings. Be sure that the rings you will be using are within 0.05 mm (0.002 in) of the rings of the correlating parts.

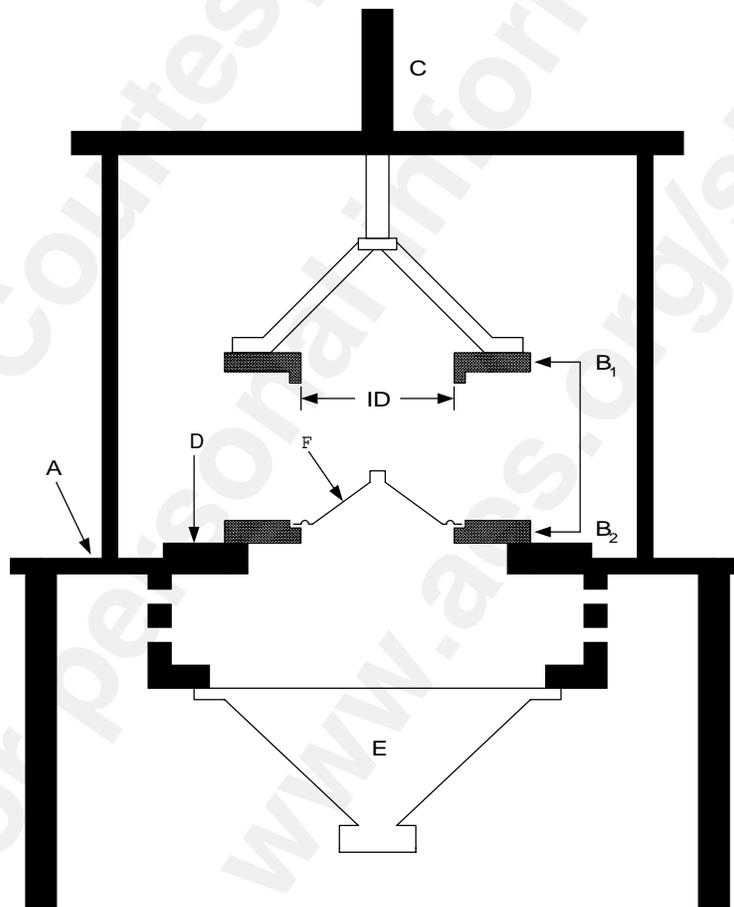


Figure 1. Test fixture showing test table A, top clamp ring  $B_1$ , bottom clamp ring  $B_2$ , top clamp ring holder and pressure applicator C, bottom clamp ring holder D, driving loudspeaker E, and cone under test F.

**3.3** The trim dimension (TD) shall be the maximum dimension of clamping that is a reference useful for orientation of the clamp rings as they fit together, that is, the outside diameter (OD) on B<sub>1</sub> and TD on B<sub>2</sub> in Fig. 2. For non-circular cones, the trim dimension should be specified in similar detail to the clamp dimension.

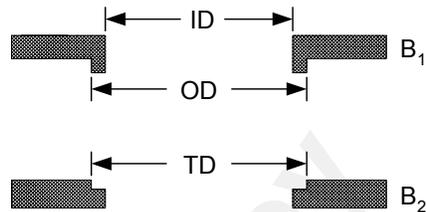


Figure 2. Top clamp ring B<sub>1</sub> and bottom clamp ring B<sub>2</sub>.

#### 4 Test equipment

The essential elements of test equipment needed are as follows:

- 1) A sine wave generator and frequency counter
- 2) An amplifier
- 3) A driving loudspeaker (usually a large woofer)
- 4) A set of matched clamp rings
- 5) A mounting apparatus that facilitates quick and repeatable setup and test sequences.

#### 5 Test configuration

**5.1** The cone shall be mounted securely about the clamp dimension specified. If the clamp rings are of sufficient self-weight (i.e., steel construction) and completely free of warpage, additional pressure may not be needed. If the clamp rings are wood or plastic, then additional means of applying pressure may be warranted.

**5.2** The clamp rings (upper and lower) shall be on the same centers and axes for proper clamping of the test cone. This is usually accomplished via orientation detail in the mating clamps.

**5.3** The cone shall also be at the same center and axes as the clamp ring, oriented such that the cone apex is up, opposite to the orientation of the driving loudspeaker-cone. The cone shall fit entirely within the orientation ridge, so that no mechanical interference between any part of the cone and the ring is observed.

**5.4** The driving loudspeaker shall be mounted on a 0.38-m (15-in) square solid plate parallel to the lower clamp ring surface such that the face of the mounting plate is 0.09 to 0.1 m (3 1/2 to 4 in) from the test cone mounting surface. The area between the driving loudspeaker mounting plate and the lower clamp ring shall be open on each side to prevent undesirable loading of the driving loudspeaker. This amounts to testing within the driving loudspeaker's un baffled near field.

NOTE – The driving loudspeaker is a relatively large loudspeaker with a free air resonance well below the resonance of the cone to be tested. There should be no abnormal response or distortion characteristics from the loudspeaker as measured in an anechoic chamber, and the loudspeaker should be as stable in the long term as possible.

The lower clamp shall completely seal around the periphery of the cone to complete a solid base at least 0.38-m (15-in) square. Thus there are in this test two parallel surfaces, each about 0.154 m<sup>2</sup> (225 in<sup>2</sup>), with a loudspeaker mounted in one plate and a test cone in the other.

**5.5** Several detection schemes have and can be used successfully to determine maximum excursion. Among these are visual detection, optical detection, and acoustical detection. Visual detection is subjective, although usually repeatable. Optical detection (using series of light-emitting diodes and photodetectors) can be the most reliable, although it is also the most complex. Acoustical detection is practical only if ambient noise and system non-linearities can be minimized.

In visual detection, marking the cone with a white chalk at the apex and reading excursion against a linear scale or optical comparator can be very helpful. In optical and acoustical detection, feedback into computers can help determine resonance automatically. These details are left to the user to determine use and suitability.

## 6 Test procedure and reporting

### 6.1 Procedure

- 1) Place the test cone in properly matched clamp rings in the fixture described in 5.4.
- 2) Turn on the amplifier and set the oscillator for an amplifier output sufficient to produce a sound pressure level of 100 dB at the outer edge of the cone mounting plate surface, at a frequency 20% below the expected resonance of the cone (e.g., if the cone specification is 80 Hz, then set the oscillator for 64 Hz).
- 3) Slowly raise the oscillator frequency until the maximum excursion is observed. This will require tuning beyond the frequency of maximum excursion, and then backing down until the excursion is apparently at maximum again.
- 4) Record the frequency of the oscillator setting as read from the frequency counter.
- 5) To confirm the reading, tune the oscillator to a frequency 20% above resonance and repeat the process in reverse, tuning downward through maximum excursion and then backing up to maximum excursion again.
- 6) Record this second frequency from the counter.

### 6.2 Reporting

**6.2.1** If the two resulting numbers are close (within 1% of each other), the test is considered accurate, and the first reading shall be adopted.

**6.2.2** If the numbers are relatively far apart, the accuracy of the measurement is suspect. Repeat steps 2) through 6), if possible, using the fine-tuning control on the oscillator. If the numbers are repeatable, though still far apart, then the average of the two readings shall be adopted.

**6.2.3** If more than 12 pieces are measured, then the mean and the unbiased standard deviation (“sigma  $n-1$ ”) should be reported with the data.

**6.2.4** Temperature and humidity can have rather large effects on resonance readings of some cones, particularly where tight controls of resonance and of mass are needed. Where critical conditions exist, it is appropriate to record the temperature and humidity readings at the time of measurement. Then, if so desired, a correlation factor, compensating for the temperature and humidity differences, could be calculated and applied. The need and suitability of these data and corrections are at the joint discretion of the supplier and the user. Barometric pressure may also be reported.