

AES Recommended Practice Specification of Loudspeaker Components Used in Professional Audio and Sound Reinforcement

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Abstract

This document is a recommended practice for describing and specifying loudspeaker components used in professional audio and sound-reinforcement systems. These components include high- frequency drivers, high- and mid-frequency horns, low-frequency drivers, and low-frequency enclosures. For drivers, specifications are given for describing frequency response, impedance, distortion, and power handling. For horns and enclosures, specifications are given for describing directional characteristics and additional pertinent performance data. For all components, specifications are given for describing necessary physical and mechanical characteristics, such as hardware, mounting data, size, and weight. Appendices supporting the text give guidelines for making proper free-field measurements, sizing of baffles for low-frequency driver measurements, a method for producing the specified noise signal used in power testing, and a summary of required information.

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[This foreword is not a part of the AES recommended practice for specification of loudspeaker components used in professional audio and sound reinforcement, AES2-1984.]

Foreword

The purpose of this document is to recommend methods of specifying the performance of loudspeaker components used in music, speech, and fixed-signal (such as siren alert) systems. It is needed so that these components may be compared on an equal basis, by methods which directly relate to their specific real use. Previously, no such practice or standard existed for this class of acoustical product. Tests and nomenclature used in this document are compatible with IEC Standard, Publication 268-5 (1972) and Supplement 268-5A (1980).

The document presented here is a complete recommendation.

This committee was suggested and formed by John Eargle in 1975 November, and the following members have contributed to the processing and approval of this Recommended Practice:

CLIFFORD HENRICKSEN, *Chairman*

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The American National Standards Institute version of this standard has not been reprinted and remains available as ANSI S4.26-1984.

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AES Recommended Practice Specification of Loudspeaker Components Used in Professional Audio and Sound Reinforcement

1 General

1.1 Purpose.

This Recommended Practice establishes a set of primary specifications to be followed by manufacturers in describing loudspeaker components used in professional audio and sound-reinforcement system design.

1.2 Units.

SI units shall be used in all specifications with U.S. customary units in parentheses where applicable.

1.3 Tolerance.

Tolerances for all constants and characteristics shall be stated where applicable.

1.4 Free-Field Measurements.

All swept sine-wave amplitude frequency response (referred to throughout this document as response) measurements [except those high-frequency (hf) driver measurements made on plane-wave tubes] shall be made in the free field. Ideally, this implies that the measurement distance from the acoustic center of the device must be large with respect to: (1) the largest dimension of the radiator, and (2) the square of the largest dimension of the radiator divided by the wavelength of the highest measurement frequency.

NOTE: In practice, these requirements may be difficult to meet. As a guide to good engineering practice, it is suggested that the measuring distance be at least *four times* the largest dimension of the effective radiating surface, or *two times* the square of the largest dimension of the radiator divided by the shortest wavelength to be measured, whichever is larger. In any event, the manufacturer shall specify the actual distance at which the measurements were made as well as identify clearly the centers of rotation in measurements of polar data. (See Appendix A for details of method for determining the acoustical center of a radiator.)

1.5 Referred Measurement Distance.

Free-field response curves shall be referred to a distance of 1 m, that is adjusted by $20 \log (d_{\text{meas.}}/1)$.

1.6 Nominal Input Power Level.

The nominal power level used for response tests shall be stated, and the plotted response curves shall be adjusted to that pressure produced by 1 W (a voice-coil voltage numerically equal to $Z_{\text{min}}^{1/2}$).

1.7 Minimum Impedance.

The minimum impedance (Z_{min}) is defined as the lowest value of the modulus of impedance which a driver presents over its rated operating frequency range. (Because of the critical nature of this measurement, the manufacturer shall specify Z_{min} to a stated tolerance and the voice-coil temperature at which the measurement was made.) Normal practice is for this measurement to be made at 25 ± 5 °C.

1.8 Distortion.

Distortion measurements shall present values of both second- and third-harmonic components versus fundamental frequency. The levels of distortion shall be expressed in decibels to the same scale as the fundamental.

1.9 Plotting Scales.

Scales shall be plotted in accordance with IEC Standard Scales and Sizes for Plotting Frequency Characteristics and Polar Diagrams, Publication 263 (1975).

1.10 Tolerances.

Applicable tolerances shall be stated with all physical dimensions.

1.11 Measurements.

Measurements with random noise shall use equal energy per percentage bandwidth (pink) noise.

1.12

This document details the minimum information which shall be required in order to comply with this Recommended Practice. Manufacturers are encouraged to provide additional information.

2 High-Frequency Drivers

2.1 Physical and Mounting Information.

Specifications shall include the following.

- (1) Pertinent external physical dimensions and weight, including the sound channel outlet dimensions.
- (2) Line drawings with dimensions.
- (3) Mounting information, including pertinent hole, thread, and screw sizes. Tolerances and screw types (U.S. or metric) shall be clearly stated.
- (4) A list of accessories normally used with the device, including mounting data.
- (5) A description of electrical connections, color coding, and polarity of the device. Standard practice is that terminals be red and black; a positive voltage at the red terminal should cause a positive pressure at the output of the device.
- (6) Additional information concerning materials and finishes, especially if of an environmental nature. Any special safety agency approvals shall be stated here.
- (7) A description of the diaphragm and compliance construction, including the effective diaphragm diameter and voice-coil diameter.

2.2 Performance Characteristics

2.2.1 Amplitude Frequency Response.

The response shall be measured with the driver mounted on a plane-wave tube having a termination producing a standing-wave ratio not exceeding 2 dB over the measurement range and of small enough diameter for the first radial mode to be above the measurement range ($f_{\max} < 1.22 c/d$, where c is the velocity of sound in air and d is the diameter of the plane-wave tube). The diameter of the plane-wave tube shall be stated, and the measurement shall be referred to a *standard* plane-wave tube diameter of 25.4 mm.

NOTE: This is a simplified and “minimum” recommended practice for plane-wave tube measurement. It is known that axial, radial and circumferential placement of the microphone in the tube are all sources of data error, especially at high frequencies. Some manufacturers may wish to provide hf data for drivers with relatively large throat diameters. Apparatus for this requires an area-reducing connector between the driver and the tube entrance. The need for a more complete plane-wave tube measurement recommended practice is clear; an expanded section of considerable depth is presently under consideration. Nevertheless, the committee felt that this “minimum” recommendation would be practical, expedient, and valuable even as it is presented here.

2.2.2 Distortion.

Plots of second- and third-harmonic distortion shall be presented for 0.1 rated power input with a plane-wave tube termination.

2.2.3 Impedance.

Using a plane-wave tube termination, a plot of impedance modulus shall be given. The ordinate shall be a logarithmic scale, labeled in $20 \log_{10} (Z/1)$ ohms, that is, 20 times the common logarithm of the modulus referred to 1.0 Ω . The scales shall be the same as those used for response.

2.2.4 Voice-Coil Resistance.

The dc voice-coil resistance shall be given at a standard temperature of 25 ± 5 °C.

2.3 Power-Handling**2.3.1 Test Conditions and Equipment.**

The driver shall be mounted on an appropriate constant- or expanding-area acoustical load whose initial area is no smaller than that of the driver throat. The manufacturer shall specify the method of loading. The driver shall be excited with a band of pink noise extending one decade upward from the manufacturer's stated low-frequency (f_l) limit of the device. The noise shall be bandpass filtered at 12 dB per octave, with Butterworth filter response characteristics, and the peak-to-rms voltage ratio of the noise signal supplied to the f_l driver shall be 2:1 (6 dB). Refer to Appendix C for recommended method. The manufacturer shall state the upper and lower cutoff frequencies (-3 dB) of the noise signal.

2.3.2 Test Procedure.

The device under test shall be subjected to successively higher powers and allowed to reach thermal equilibrium at each increment (approximately 2 h). Power shall be determined as the square of applied rms voltage, as measured with a "true rms" voltmeter, divided by Z_{min} . The rated power of the device shall be that power the device can withstand for 2 h without permanent change in acoustical, mechanical, or electrical characteristics, greater than 10%.

2.3.3 Displacement Limit.

The manufacturer shall specify the maximum excursion of the device which, when exceeded, results in permanent mechanical damage to the device. The manufacturer shall state the cause of damage (for example, elastic limit of suspension, diaphragm striking a mechanical stop, etc.).

2.3.4 Thermal Test Information.

The temperature rise of the voice-coil and magnet assembly at the end of the 2-h power-handling test shall be stated. The manufacturer shall state the method of temperature measurement.

2.3.5 Statistical Study.

The manufacturer shall assure himself that he has made sufficient statistical study of a given class of product to establish a rated power under this specification.

3 High-Frequency Horns**3.1 Physical and Mounting Information.**

Specifications shall include the following.

- (1) Pertinent external physical dimensions and weight.
- (2) Line drawings with dimensions.
- (3) Mounting information, including pertinent hole, thread, and screw sizes.
- (4) Accessories, including mounting brackets, hardware, and coupling fixtures.
- (5) A listing of hf drivers recommended for use with the horn. Data should specify the necessary mounting hardware and coupling devices.

3.2 Acoustical Parameters**3.2.1 Frequency Response and Polar Data.**

Separate on-axis response measurements shall be provided for the hf horn for each driver the manufacturer recommends for use with that horn. Polar plots shall be shown for each hf horn in both vertical and horizontal planes using one-third octave pink-noise bands according to American National Standard Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets, Publ. S1.11 (1966) or IEC Standard Octave, Half-Octave, and Third-Octave Band Filters Intended for the Analysis of Sound and Vibration, Publication 225 (1966).

Additional polar information data shall include response curves made in increments of 15° up to and including one half the nominal design angle of the device. The data shall be presented for both horizontal and vertical performance. The data may be normalized to the on-axis response of the horn/driver combination.

3.2.2 Distortion.

Plots of second- and third-harmonic distortions versus frequency shall be presented for an input of 0.1 rated power for all drivers the manufacturer recommends for use with a given hf horn. These measurements shall cover the useful frequency range of the horn and shall be made on axis under free-field conditions.

3.2.3 Additional Power-Handling Information.

Rated power for each horn/driver combination shall be stated if it is different from that observed when the driver is loaded per 2.2.5.1. The manufacturer shall specify the lowest useful frequency of recommended filter cutoff frequency and slope for all horn/driver combinations.

4 Low-Frequency Drivers**4.1 Physical and Mounting Information.**

Specifications shall include the following.

- (1) Pertinent external physical dimensions and weight.
- (2) Line drawings and dimensions.
- (3) Mounting information, including pertinent hole, thread, and screw sizes.
- (4) A list of accessories normally used with the device.
- (5) A description of electrical connections, color coding, and polarity of the device. Standard practice is that terminals be red and black; a positive voltage at the red terminal should cause a positive pressure at the output of the device.
- (6) Additional information concerning materials and finishes, especially if of an environmental nature.

4.2 Physical Constants

- (1) Effective piston diameter, millimeters.
- (2) Effective moving mass (cone + voice coil + effective spider and surround masses + air load), grams.
- (3) Voice-coil winding depth and diameter, millimeters.
- (4) Voice-coil wire length, meters.
- (5) Thickness of top plate adjacent to voice coil, millimeters.
- (6) Minimum impedance Z_{\min} , ohms.
- (7) Transduction coefficient [3] (“B1 product”) newtons per ampere.

4.3 Thiele-Small Parameters.

Definitions of these parameters shall be found in [1], [2].

4.3.1 Small-Signal Parameters

- (1) Resonance frequency of driver in free air, f_s .
- (2) Total Q of driver at f_s , including all driver loss mechanisms, Q_{TS} .
- (3) Q of driver at f_s , considering electromagnetic damping only, Q_{ES} .
- (4) Q of driver at f_s , considering mechanical loss mechanisms only (nonelectromagnetic), Q_{MS} .
- (5) Reference efficiency (half-space acoustic load), η_0 .
- (6) Volume of air having same acoustic compliance as driver suspension V_{AS} .
- (7) Resistance of driver voice coil, R_E .
- (8) Effective projected surface area of driver diaphragm, S_D .

4.3.2 Large-Signal Parameters

- (1) Nominal electrical input power, $P_E(\max)$.
- (2) Voice-coil peak displacement at which the “linearity” of the motor deviates by 10%, X_{\max} . Linearity may be measured by percent distortion of the input current or by percent deviation of displacement versus input current. Manufacturer shall state method used. The measurement shall be made in free air at f_s .
- (3) Peak displacement volume of driver diaphragm, ($= S_D X_{\max}$).

4.4 Performance Characteristics.

The measurements called for in 4.4.1 and 4.4.2 shall be made with the lf driver mounted on a standard baffle (or larger baffle), as described in Appendix B. (Normal 2π steradians measurement conditions with sufficient volume behind the lf device will satisfy this condition. Sufficient volume implies at least $5V_{AS}$.)

4.4.1 Amplitude Frequency Response.

The response shall be stated on axis and at 45° off axis. (The purpose of this single off-axis measurement is to give some indication of the frequency region where secondary modes come into play in the vibration of the lf device.)

4.4.2 Distortion.

Second- and third-harmonic distortion shall be stated on axis for 0.1 rated power input.

4.4.3 Impedance.

A plot of the free-air impedance modulus versus frequency shall be provided. The ordinate shall be a logarithmic scale, labeled in $20 \log_{10} (Z/1)$ ohms, that is, 20 times the common logarithm of the modulus referred to 1.0 Ω . The scales shall be the same as those used for response.

4.5 Power-Handling**4.5.1 Test Conditions and Equipment.**

The lf driver shall be mounted in free air so that the direction of motion of the diaphragm is in a horizontal plane and so that there is no appreciable air loading from adjacent structures. The driver shall be excited with a band of pink noise extending one decade upward from the manufacturer's stated lf limit of the device. The noise shall be bandpass filtered at 12dB per octave with Butterworth filter response characteristics, and the peak-to-rms voltage ratio of the noise signal supplied to the lf driver shall be 2:1 (6 dB). Refer to Appendix C for recommended method. The manufacturer shall state the upper and lower cutoff frequencies (-3 dB) of the noise signal.

NOTE: The committee adopted this free-air power-handling test only after *many* hours of intense deliberation. We recognize that such a test will not always produce results that reflect the intended use of the loudspeaker. However, the free-air test is more practical than an "infinite baffle" ($5V_{AS}$) test. It avoids the issue of which enclosure to use and has the same net effect on diaphragm excursions on an infinite baffle. The free-air test requires a dramatically smaller test facility, produces much lower sound-pressure levels, and is easily duplicated, with simple test equipment and in the field. This test method allows similar loudspeakers from different manufacturers to be compared on an equal basis.

4.5.2 Test Procedure.

The device under test shall be subjected to successively higher powers and allowed to reach thermal equilibrium at each increment (approximately 2 h). Power shall be determined as the square of applied rms voltage, as measured with a "true rms" voltmeter, divided by Z_{min} . The rated power of the device shall be that power the device can withstand for 2 h without permanent change in acoustical, mechanical, or electrical characteristics greater than 10%.

4.5.3 Displacement Limit.

The manufacturer shall specify the maximum excursion of the device which, when exceeded, results in permanent mechanical damage to the device. The manufacturer shall state the cause of damage (for example, elastic limit of suspension, diaphragm striking a mechanical stop, etc.).

4.5.4 Thermal Test Information.

Temperature rise of the voice-coil and magnet assembly shall be provided at the end of the 2-h power-handling test. The manufacturer shall state the method of temperature measurement.

4.5.5 Statistical Study.

The manufacturer shall assure himself that he has made sufficient statistical study of a given class of product to establish a rated power under this specification.

4.6 Enclosure Specifications.

The manufacturer shall specify for a given lf driver the recommended enclosures or enclosure types. The manufacturer shall also note any differences in the rated power of an lf device if its performance in a given enclosure is significantly different from that observed with the unit mounted on the standard baffle to radiate into 2π steradians.

5 Low-Frequency Enclosures

5.1 Physical and Mounting Information.

Specifications shall include the following.

- (1) Pertinent and external physical dimensions and weight.
- (2) Line drawings with dimensions.
- (3) Specific information relative to mounting of the lf enclosure, including location of the center of gravity for the enclosure when loaded with the recommended components.
- (4) A listing of accessories normally used with the lf enclosure.
- (5) A listing of lf drivers recommended for use in the enclosure.

5.2 Acoustical Parameters

5.2.1 Response.

On-axis frequency response measurements for each lf driver recommended for use with the lf enclosure shall be provided. In addition, the manufacturer shall provide typical horizontal and vertical polar graphs using lf drivers of his choice. The signal source used shall be one-third-octave bands according to American National Standard S1.11 or IEC Standard 225.

5.2.2 Distortion.

Plots of second- and third-harmonic distortion versus frequency shall be provided for an input of 0.1 rated power for all drivers the manufacturer recommends for use with a given lf enclosure. These measurements shall cover the useful frequency range of the lf enclosure and shall be made on axis.

5.2.3 Impedance.

A plot of the modulus of impedance over the useful frequency range for all drivers recommended for a given lf enclosure shall be provided. The ordinate shall be a logarithmic scale labeled in $20 \log_{10} (Z/1)$ ohms, that is, 20 times the common logarithm of the modulus referred to 1.0Ω . The scales shall be the same as those used for response.

5.2.4 Additional Power-Handling Information.

If the rated power for a given lf driver/enclosure combination is different from that observed when the driver is mounted on the standard baffle to radiate into 2π steradians, the manufacturer shall so state.

6 References to Other Existing Standards

The following standards are referred to in this Recommended Practice:

- Scales and Sizes for Plotting Frequency Characteristics and Polar Diagrams, IEC Publication 263 (1975)
- Octave, Half-Octave, and Third-Octave Band Filter Sets, ANSI Publication S1.11 (1966) or Octave, Half-Octave, and Third-Octave Band Filters Intended for the Analysis of Sound and Vibration, IEC Publication 225 (1966).

7 References

- [1] Thiele, A.N., "Loudspeakers in Vented Boxes," *Proc. IREE (Australia)*, vol. 22, p. 487 (1961 Aug.); also *J. Audio Eng. Soc.*, vol. 19, pp. 382-392 (1971 May) and pp. 471-483 (1971 June).
- [2] Small, R.H., "Direct-Radiator Loudspeaker System Analysis," *J. Audio Eng. Soc.*, vol. 20, pp. 383-395 (1972 June).
- [3] Hunt, F., *Electroacoustics* (American Institute of Physics, New York, 1982), p. 92.

(The following Appendixes are not a part of the AES Recommended Practice for Specification of Loudspeaker Components Used in Professional Audio and Sound Reinforcement, AES2-1984. They are included for information purposes only.)

Appendix A Free-Field Measurement Procedure

A1 General

To satisfy the requirement for free-field conditions, the loudspeaker must appear to be a point source at the measurement microphone. This requirement leads to two criteria: (1) The measurement distance should be large compared to the diameter of the source. (2) The measurement distance must be large compared to the quotient of source diameter squared, divided by the wavelength of sound at the measurement frequency. Since the second condition is often difficult to fulfill, it is necessary to verify experimentally the range over which the $1/r$ dependence of sound pressure with distance is satisfied. The determination requires an accurate knowledge of the acoustic center of the loudspeaker over the frequency range of measurement. Its location may be determined as follows.

A2 Theory

Let

r = Distance from the acoustic center of a sound source to the microphone

x = Distance from a convenient measuring point on the sound source to the microphone

d_r = Distance from the measuring point to the acoustic center

p = Sound pressure

k = Constant

In the free field

$$p = k/r \quad (1)$$

where

$$r = x + d_r \quad (2)$$

so that

$$x = k/p - d_r \quad (3)$$

Hence if $1/p$ is plotted as a function of x on linear coordinate paper, the intercept on the x axis at $1/p = 0$, d_r , the straight line giving the best fit to the data will yield d_r . Positive values of the intercept indicate that the acoustic center is in front of the measuring point.

A3 Procedure

Since it is more convenient to measure sound-pressure level rather than pressure, it is convenient to choose as a reference level the sound-pressure level at the nearest measurement point. The value of $1/p$ for this point will then be less, and $1/p$ will be accordingly greater and can be obtained from the following equation:

$$1/p = \text{antilog}_{10} [(L_{p\text{ref}} - L_p)/20]$$

Having determined the location of the acoustical center, the values of r for the respective sound-pressure level readings should be computed.

The values of sound-pressure level should then be plotted as a function of r on semilog paper, and the distance over which the sound-pressure level varies as $1/r$ within the required tolerance determined by observing the deviation of the data from a straight line.

Appendix B

Standard Baffle for LF Driver Measurements

The preferred baffle is of the dimensions given in Fig. B1 and Table B1. The dimensions for the 200-mm (8-in) size are identical to those of the standard baffle in IEC Standard, Publication 268-5 (1972). The dimensions for the larger sizes have been increased approximately in proportion to the loudspeaker diameter. Smaller drivers may be tested on larger baffles, as stated in 4.4.

Manufacturers are encouraged to modify the basic IEC baffle construction to allow front mounting of drivers.

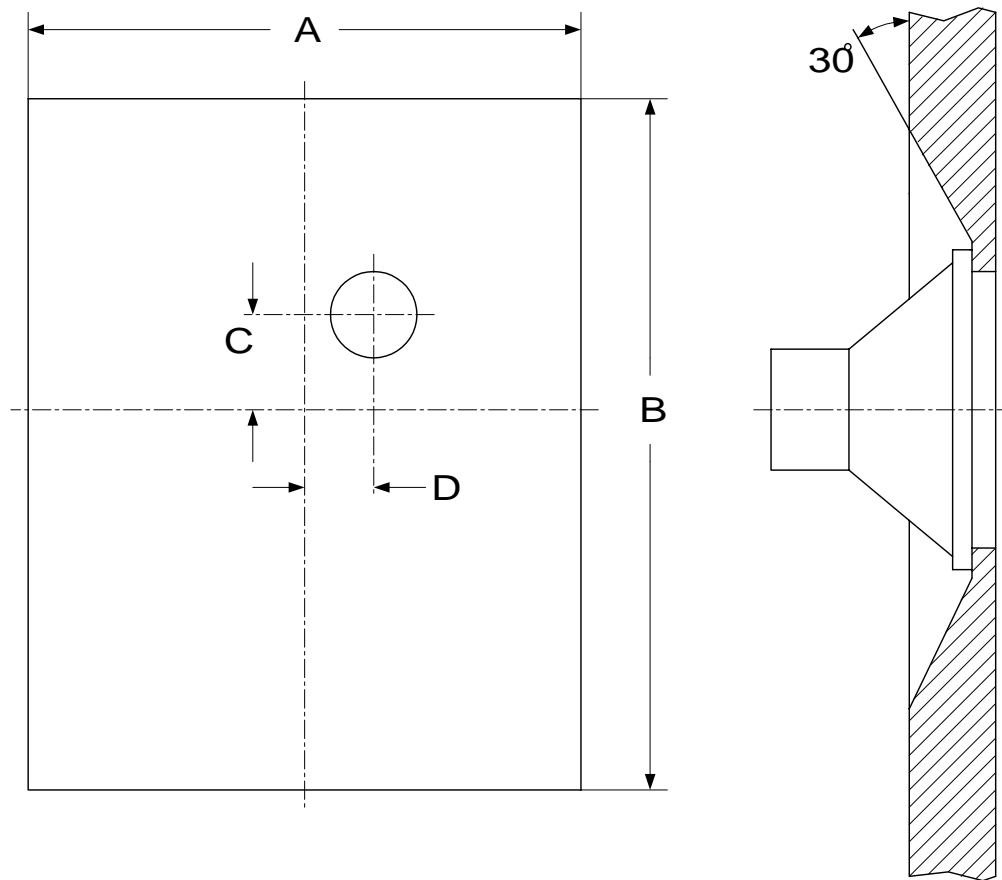


Fig. B1. Standard baffle dimensions for low-frequency driver measurements.

Table B 1. Preferred baffle dimensions for lf loudspeaker

Nominal Loudspeaker Size ¹	Baffle Dimensions ²			
	A	B	C	D
200 mm (8 in)	1350 mm	1650 mm	225 mm	150 mm
250 mm (10 in)	1690 mm	2065 mm	280 mm	190 mm
315 mm (12 in)	2025 mm	2475 mm	340 mm	225 mm
400 mm (15 in)	2530 mm	3090 mm	420 mm	280 mm

¹ The nominal loudspeaker size is defined as the outer diameter of the frame, and the metric equivalent is given in the nearest preferred number according to IEC Standard, Publication 268-14 (1980).

² Baffle dimensions have been calculated from the IEC dimensions by multiplying them by the ratio of the nominal size in inches to 8 inches, and rounding the resulting dimensions to the nearest 5 mm.

500 mm (18 in)	3040 mm	3715 mm	505 mm	340 mm
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Appendix C Method for Producing Noise Signal Used in Power Testing

Two methods of setting peak-to-rms voltage ratio to 2:1 are:

- (1) Adjust output of the pink-noise source so that the rms voltage across the diodes is 0.32 V (Fig. C1). The diodes must be maintained at a case temperature of 25 ± 5 °C.
- (2) Read the amplifier rms output voltage with a “true rms” meter. Read the amplifier peak output voltage with a calibrated oscilloscope. Adjust the pink-noise output so that the peak-to-rms ratio of voltages is 2:1, or 6dB.

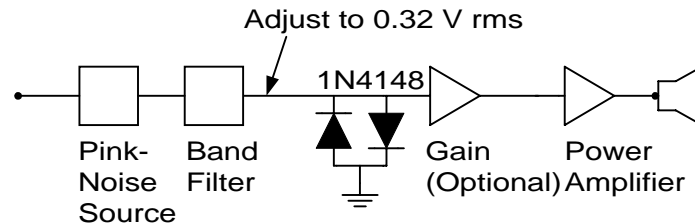


Fig. C1. Suggested circuit for obtaining 6-dB peak-to-average pink noise. Note temperature dependence of diodes.

Appendix D Summary of Required Information

D1 High-Frequency Drivers

- (1) Dimensions and weight
- (2) Dimensioned line drawing
- (3) List of accessories
- (4) Description of electrical connections
- (5) Additional descriptive information
- (6) Description of diaphragm and diaphragm construction
- (7) Frequency response on plane-wave tube (PWT)
- (8) Distortion on PWT; swept second and third harmonics at 10% rated power.
- (9) Impedance on PWT; swept
- (10) DC voice-coil resistance
- (11) Power handling on appropriate acoustic load
- (12) Displacement limit of diaphragm
- (13) Thermal rise after power test

D2 High-Frequency Horns

- (1) Dimensions and weight
- (2) Dimensioned line drawings
- (3) Mounting information
- (4) List of accessories
- (5) Recommended hf drivers
- (6) On-axis frequency response using recommended driver(s)
- (7) One-third octave polar plots (vertical and horizontal)
- (8) Distortion using recommended drivers at 10% rated power
- (9) Impedance of recommended driver mounted on horn
- (10) Additional power-handling data and information using recommended drivers

D3 Low-Frequency Drivers

- (1) Dimensions and weight
- (2) Dimensioned line drawings
- (3) Mounting information
- (4) List of accessories
- (5) Description of electrical connections
- (6) Additional descriptive information
- (7) Physical constants; piston diameter, moving mass, voice-coil winding depth and length, top-plate thickness at voice coil, minimum impedance Z_{\min} , and transduction coefficient.
- (8) Thiele-Small parameters: f_s , Q_{TS} , η_0 , V_{AS} , Q_{ES} , Q_{MS} , R_E , S_D
- (9) Large-signal parameters: $P_E(\max)$, X_{\max} , V_D
- (10) Frequency response (0° , 45°) in standard baffle
- (11) Distortion (second and third harmonic), swept, at 10% rated power
- (12) Impedance response, free air
- (13) Power handling in free air, 2 h
- (14) Displacement limit
- (15) Thermal rise after power test
- (16) Recommended enclosures

D4 Low-Frequency Enclosures

- (1) Sizes and weight
- (2) Dimensioned line drawings
- (3) List of accessories
- (4) Recommended driver list
- (5) On-axis frequency response using recommended driver(s)
- (6) One-third-octave polar plots
- (7) Distortion, using recommended driver at 10% rated power
- (8) Impedance response of recommended driver mounted in enclosure
- (9) Additional power-handling information