American National Standard for motion pictures— B chain electro-acoustic response— control rooms and indoor theaters

Approved August 7, 1984 Secretariat: Society of Motion Picture and Television Engineers

1. Scope

This standard specifies the measurement and characteristics of the B chain electro-acoustic response of motion-picture control rooms and indoor theaters whose volume exceeds 150 m^3 (5297 ft^3). It is intended to assist in standardization of reproduction of motion-picture sound in control rooms and indoor theaters. It does not apply where the recorded sound is intended for reproduction under domestic listening conditions, i.e., radio broadcasting, television broadcasting, tape, or disc. This standard does not cover that part of the motion-picture sound system from the transducer to the input terminals of the main fader, nor does it cover the electro-acoustic response characteristic of motion-picture theater surround or effects loudspeakers or sub-bass loudspeakers (sub-woofers).

2. Reference Standards

The following American National Standards are intended to be used in conjunction with this standard:

ANSI S1.11-1966 (R1976), Specifications for Octave, Half-Octave, and Third Octave Band Filter Sets

ANSI S1.13-1971 (R1976), Methods for the Measurement of Sound Pressure Levels

3. Definitions

3.1 Complete Sound Reproduction System: Represented diagrammatically in Fig. 1 and used in studio dubbing theaters, laboratory review rooms, and indoor theaters, generally considered to consist of an A chain and a B chain.

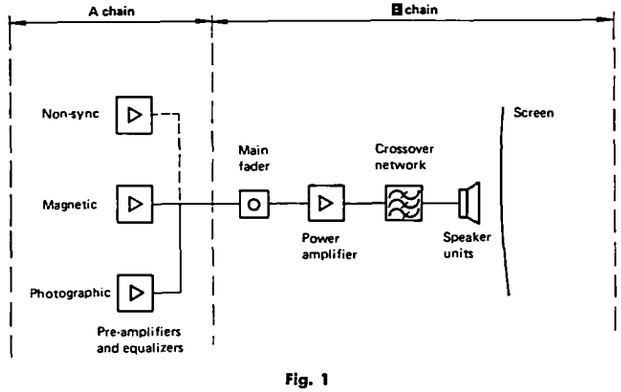

Fig. 1
Complete Theatrical Sound Reproducing System

3.2 Pre-emphasized Audio Track: An audio record, either magnetic or photographic, which is intended for playback over normally de-emphasized theater playback systems.

3.3 Wide-Range Audio Track: An audio record, either magnetic or photographic, which has not been pre-emphasized and is intended for playback over theater playback systems without de-emphasis.

3.4 A Chain (Transducer System): That part of a motion-picture audio system, as shown in Fig. 1, extending from the transducer to the input terminals of the main fader.

3.5 B Chain (Final Chain): That part of a motion-picture sound reproduction system, as shown in Fig. 1, commencing at the input terminals of the main fader and terminating at any position in the listening area of the room or auditorium at which sound pressure measurements are taken.

3.6 Electro-Acoustic Response: The electro-acoustic response of the final chain is the sound pressure level expressed in decibels with respect to an arbitrary reference pressure (see Sec. 5) over a given frequency range measured at a given position in the listening area when pink noise of constant electromotive force (emf) is applied to the input terminals of the main fader, preceding the power amplifier. (See Fig. 1.) This response is calculated for each frequency band as ten times the common logarithm of the average of the squares of the rms sound pressures measured at each position in a given area. (If the variations among the sound pressure levels at the different measuring positions are small, not exceeding 4 dB, the arithmetic mean of these individual sound pressure levels in decibels can be used.)

3.7 Pink Noise: A continuous spectrum noise having constant energy per constant percentage bandwidth and Gaussian probability distribution of instantaneous values. (See 4.4.)

3.8 Wide-Band Pink Noise: Pink noise having a bandwidth exceeding the frequency range of interest, typically extending from 31.5 Hz to at least 12.5 kHz.

4. Method of Measurement

4.1 The electro-acoustic response shall be measured with the equipment and instruments arranged in accordance with Figs. 2, 3, and 4. (See Appendix.)

4.2 Sound pressure level measurements (See Appendix) shall be made as follows:

(a) In dubbing theaters, at each of the principal listening areas

(b) In review rooms and review theaters, at a sufficient number of positions to cover the listening area

(c) In indoor theaters, at position S as shown in Fig. 3 and position R as shown in Fig. 4 and at other representative positions within the shaded area

4.3 It is recommended that measurements be made at a normal seated head height between 1 and 1.5 m (3.3 and 4.9 ft), and not closer than 1.5 m (4.9 ft) to any wall and 5 m (16.4 ft) to the loudspeakers.

American National Standards Institute, 1430 Broadway, New York, N.Y. 10018

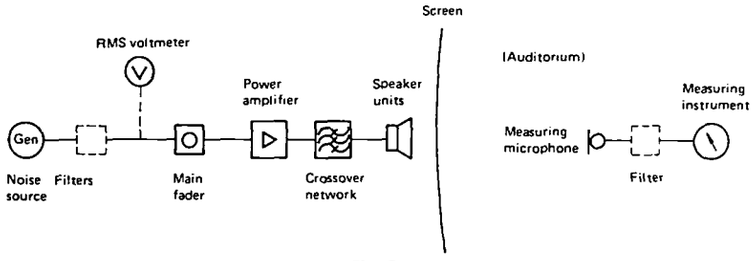

Fig. 2
Method of Measurement of B Chain
(Optional Equipment shown with Dotted Lines)
(See Appendix A3)

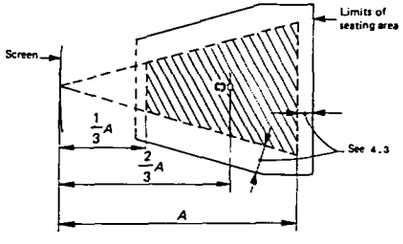

Fig. 3
Theater Auditorium

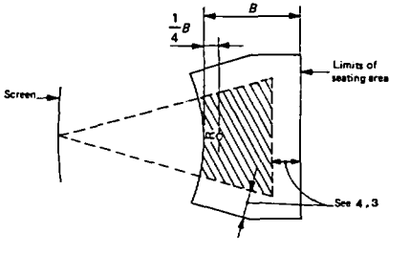

Fig. 4
Theater Balcony

4.4 A suitable single loudspeaker auditorium sound pressure level with wide-band pink noise is 85 dBC. The spectral level in any third-octave band shall exceed the background noise in the band by at least 10 dB, or by 4 dB if adjusted according to Table 4 in ANSI S1.13-1971.

Table 1
B Chain Characteristics

Central Frequencies of One-Third Octave Bands Hz	Characteristics Normal dB	Wide Range dB	Tolerances + dB —	
50	—6	—1	3	6
63	—3	0	3	5
80	—1	0	3	4
100	0	0	3	3
125	0	0	3	3
160	0	0	3	3
200	0	0	3	3
250	0	0	3	3
315	0	0	3	3
400	0	0	3	3
500	0	0	3	3
630	0	0	3	3
800	0	0	3	3
1000	0	0	3	3
1250	0	0	3	3
1600	0	0	3	3
2000	0	0	3	3
2500	—1	—1	3	3
3150	—2	—2	3	3
4000	—3	—3	3	3
5000	—5	—4	3	3
6300	—8	—5	3	3
8000	—11	—6	3	3
10 000	—14	—7	3	3

5. Characteristics

The electro-acoustic response of the B chain shall be within the tolerance of curve N in Table 1 and Fig. 5. This response is satisfactory for record monitoring and playback of conventional pre-emphasized audio tracks. Curve X, as shown in Fig. 6 with its tolerance (within 4 to 10 KHz), is required for record monitoring and playback of wide-range audio tracks.

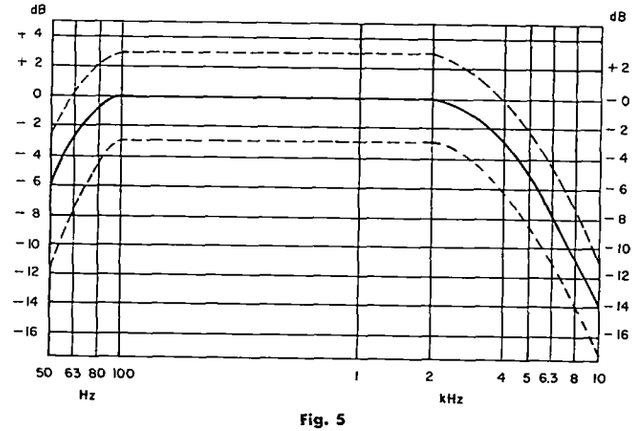

Fig. 5
Curve N of B Chain Characteristic

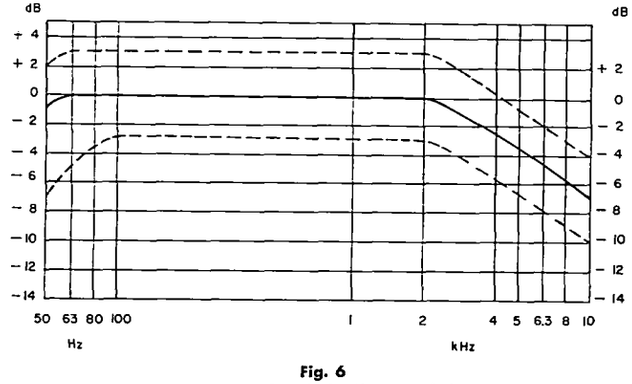

Fig. 6
Curve X of B Chain Characteristic

NOTE: Tolerances are based upon 1/3 octave measurements. If 1/1 octave measurements are used, reduce tolerance by 1 dB.

Appendix

(The Appendix is not a part of this American National Standard, but is included for information purposes only.)

A1. This standard refers to the B chain (final chain) which includes the reproduction equipment as shown in Fig. 1 and the listening area or auditorium.

It should be emphasized that, in practice, satisfactory reproduction of sound in a listening room or auditorium is also dependent upon the alignment and performance of the A chain (see Fig. 1) of the installation. It is, therefore, essential that the A chain be correctly aligned within the tolerances of existing or proposed standards by the use of the appropriate photographic or magnetic test film and, in the case of reproducing photographic film, that relevant de-emphasis be applied. For record monitoring, where magnetic masters are prepared with pre-emphasis for making photographic negatives, it is necessary to include both the photographic A chain and the B chain de-emphasis in the monitoring chain.

A2. If a theater wishes to change to curve X, it is necessary to make suitable adjustments to the photographic A chain in order to reproduce conventionally recorded audio records. A noise reduction system must be used for recording and reproducing photographic tracks when using curve X.

A3. Preliminary checks for gross acoustic errors should be made prior to measuring the electro-acoustic response as described in this standard. Typical checks include verification that the loudspeaker being measured is close enough to the screen to avoid any behind-screen echoes, and a quick verification that the loudspeaker distribution is moderately smooth throughout the listening room or auditorium. This latter test can easily be performed by ear if wide-band pink noise is available as a test signal.

A4. At least five methods of measurement are recognized as providing appropriate data for the evaluation of the electro-acoustic response of the B chain. The methods depend upon the generation of pink noise from 31.5 Hz to 10 kHz or beyond, and are as follows:

(a) Generate wide-band pink noise. Measure the acoustic output with a calibrated microphone intended for use in the diffuse field and an audio-frequency spectrum analyzer, covering the spectrum in 1/3-octave bands.

(b) Generate pink noise in 1/3-octave bandwidth conforming to the requirements for class II third-octave band filters specified in ANSI S1.11-1966. Measure the output sound pressure levels with a microphone and true rms voltmeter calibrated in decibels with an accuracy of ± 0.1 dB over the bandwidth 315 Hz to 16 kHz. Measure the signal at the B chain input with a true rms voltmeter having a crest factor similar to that of the sound level meter.

(c) Generate wide-band pink noise. Measure the acoustic output with an rms voltmeter as in (b) above, reading acoustic output through a series of 1/3-octave bandpass filters.

(d) Generate pink noise in octave bands, the center frequencies of which shall be altered in either 1/1- or 1/3-octave steps. Measure the acoustic output with a sound level meter as described in (b). This procedure, using full-octave bands, requires that tolerances on the B chain electro-acoustic response curve be reduced as noted in Fig. 5.

(e) Generate pink noise by one of the methods described above and, with a calibrated microphone intended for use in the diffuse field and a precision tape recorder, record the microphone output level as a function of both frequency sweep and position analysis in the theater. Reproduce and analyze the results by one of the methods described above at a subsequent time in an appropriate laboratory.

The pink noise test signal should be at such a level in the auditorium as to be clearly louder than any ambient noise (air conditioning, traffic rumble, etc.). The level should not be so loud as to risk loudspeaker damage, or to reach power amplifier saturation.

Care should be taken that none of the microphone placements chosen are extraordinary. Positions should be avoided which are exactly on lateral or transverse theater centerlines, or are under the lip of a balcony.

To obtain a valid representation of the acoustic response throughout the listening area, it is suggested that at least three positions be averaged when employing whole-octave bands, and at least five positions when employing 1/3-octave bands. In balcony houses, representative measurements should also be made in the balcony.

Averaging shall be done by the sum of the squares of the sound pressure levels as follows:

$$L = 10 \log_{10} \left[\frac{1}{N} \sum_{k=1}^{N} \text{antilog}_{10}(L_k/10) \right]$$

where N is the number of positions and L_k is the sound pressure level at each position. If the range of sound pressure levels is within 4 dB, simple averaging may be used. Large ranges may indicate a fault in the system.

A5. The perceived electro-acoustic response resulting from a loudspeaker situated behind a motion-picture screen is affected by various factors before the sound is heard by a listener. These include:

(a) Attenuation of high frequencies caused by the screen. With conventional theater loudspeakers and screens, the attenuation will be approximately 3 dB at 8 kHz.

(b) A room gain reverberation component added to the direct signal. This component will have a frequency response proportional to the reverberation time versus frequency characteristic. It should be noted that as the reverberation takes a finite time to build up, this component will only be measurable with quasi steady-state signals, such as pink noise, or sustained music chords. The reverberation component builds too slowly to be added to signals of short duration, such as many speech sounds, but will, instead, be perceived as interference with the speech.

(c) High-frequency attenuation in the air, proportional to the signal path length.

To take account of (b) and (c) above, the measured characteristic to maintain subjectively identical response will differ slightly according to auditorium size. The measured response should have a slightly attenuated high-frequency characteristic in a large theater when compared with Table 1 and Fig. 3. In the same way, there should be a slightly elevated high-frequency response in a small theater. Table 2 below gives approximately suitable correction factors which should be added numerically to the characteristic given in Table 1 and Fig. 3.

Table 2
Approximate Correction Factors for Auditorium Size, dB

	Number of Seats					
	30	150	500	1000	1500	2000
Frequency kHz						
2.0	0	0	0	0	0	0
4.0	1.0	0.5	0	—0.5	—1.0	—1.5
8.0	2.0	1.0	0	—1.0	—2.0	—3.0

Corrections for auditorium size are not normally required below 2 kHz, as a result of a more linear reverberation/frequency dependency at mid-frequencies, and the longer integration time of the ear at low frequencies. More accurate determination of the above correction factors for a particular auditorium can be deduced from measurement of the reverberation/frequency characteristic.

Wherever possible, the electro-acoustic response should be measured with the auditorium's typical operational humidity. If abnormal humidity conditions are present, than corrections can be applied based on the following data: With respect to 1 kHz, the high-frequency loss at 10 kHz per 20 meters is approximately 4 dB at 20% humidity, 3 dB at 45% humidity, and 2 dB at 80% humidity.

A6. It is recommended that not only should the overall response fall within the tolerances specified in Sec. 5, but that each individual response also fall within those tolerances.

Provided that the final chain meets the tolerances specified, the electro-acoustic frequency response for sound reproduction should be satisfactory for both photographic and magnetic recordings.

With unequalized loudspeakers, the response should conform to the normal characteristic and tolerances given in Table 1 and Fig. 3.

Care should be taken that deviations from the curve, although within the tolerance area, do not cause a tonal imbalance. For example, a situation where bass responses are all positive and treble responses negative should be avoided.

If there is a radical deviation from the characteristic, it may be caused by one of the following faults:

(a) faulty power amplifier
(b) incorrect or faulty loudspeaker performance
(c) incorrect location, orientation, or directivity of the loudspeaker
(d) severe acoustical room defects
(e) incorrect adjustment of the loudspeaker crossover network (relative level of the bass and treble loudspeaker units), or crossover wiring polarity reversal

Some high-frequency loudspeaker units exhibit more distortion components than others; this may cause a subjective change in high-frequency response which will not be evident from the test procedures described in this standard.

If the electro-acoustic response remains unacceptable, suitable corrections should be made to the B part of the installation.

Because the measurements deal only with the steady-state properties of the auditorium, acoustical defects such as backstage overhang, harmful echoes, etc., do not show up. Attempts to use measurement results as a basis for major equipment redesign in a theater found defective have to be preceded by ascertaining that no grave acoustical faults are present. Methods for finding or eliminating such faults are not covered in this standard.

As the sound pressure level of band-limited random noise in rooms fluctuates strongly with time, it is recommended that measurements be time-averaged over a period of not less than 60 s for the lowest frequency band and not less than 5 s in the highest frequency band; for intermediate bands, averaging times may be approximately interpolated between these extremes.

A7. Adjustment of the electro-acoustic response to curve X for record monitoring and playback of wide-range sound tracks will normally require some electrical equalization, typically 1/3 octave. The following points should be noted:

(a) The crossover network should be adjusted to the smoothest response before equalization is attempted.

(b) Equalization at and above 8 kHz should not be attempted with normal theater loudspeakers.

(c) Equalization of room node aberrations below approximately 100 Hz should be avoided; these specific room resonances cannot be corrected with 1/3-octave filters without attenuation or amplification of other frequencies within the same 1/3-octave band pass.

A8. In multiple-loudspeaker auditoriums, each stage loudspeaker should be individually checked for electro-acoustic response. After measurement and, if applicable, equalization, a wide-bandwidth pink noise test signal can be sent to combinations of loudspeakers (L and C, L and R, C and R) as a simple verification of consistent loudspeaker polarity. Applying the same level of wide-band pink noise to each loudspeaker assembly separately should yield an equal sound pressure level in the auditorium within ± 1 dB.

A9. *Compliance with this standard is a necessary but insufficient condition for the achievement of high-quality sound reproduction in review rooms and theaters. Subjective judgments of sound quality are influenced not only by the frequency respose of the B chain which is the subject of this standard, but also by the amplitude of distortion products generated in the power amplifier, the level of electrical background noise heard during quiet passages, the reverberation time of the review room or theater, the placement of the loudspeaker systems with respect to the listeners, and many other factors. This standard was prepared in the belief that, for many review rooms and theaters in current use, an extended and uniform frequency response will go a long way toward providing an improved listening environment.*

American National Standard
for motion-picture film (35-mm)—recorded characteristic—magnetic audio records

Approved August 7, 1984

Secretariat: Society of Motion Picture and Television Engineers

1. Scope

This standard specifies for studio use the recorded characteristic of magnetic audio records on 35-mm motion-picture magnetic film when reproduced at the nominal speed of 24 frames (457 mm or 18 in) per second.

2. Recorded Characteristic

The recorded relative short circuit magnetic flux level versus frequency shall be as given by the following equation:

$$L_\phi \text{ re } 92.50\,\text{nWb/m} = 0.20511 - 10\log_{10}[1+(2\pi\tau)^2 f^2]\ \text{dB}$$

where L_ϕ is the recorded relative short circuit magnetic flux level in decibels, f is the frequency in hertz, τ is a time constant of 35 μs, and 0.20511 is a constant calculated to make $L_\phi = 0$ at the reference frequency of 1000 Hz.

The appropriate numerical values of the recorded relative short circuit magnetic flux level, L_ϕ, are given in Table 1. The shape of the resulting curve is defined by the single time constant indicated. It is only a convenience in defining the desired response curve and is never intended as a recommended electrical circuit.

3. Tolerances

Magnetic audio records on the film shall be recorded to the characteristic specified in Sec. 2 within the tolerances given in Fig. 1.

Table 1
Relative Flux Level (L_ϕ) Versus Frequency

Hz	dB
40	0.20
50	0.20
63	0.20
80	0.20
100	0.20
125	0.20
160	0.20
200	0.20
250	0.19
315	0.18
400	0.17
500	0.15
630	0.12
800	0.07
1000	0.00
1250	— 0.11
1600	— 0.30
2000	— 0.56
2500	— 0.94
3150	— 1.50
4000	— 2.28
5000	— 3.24
6300	— 4.45
8000	— 5.92
10 000	— 7.46
12 500	— 9.12
16 000	—11.06

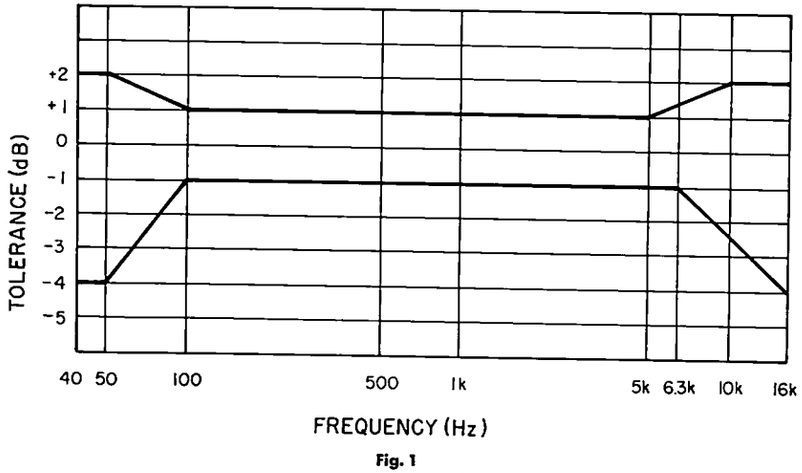

Fig. 1
Tolerances on Recorded Levels

American National Standard
for motion-picture film (8-mm type S)—recorded characteristic—magnetic audio records

Approved August 7, 1984 Secretariat: Society of Motion Picture and Television Engineers

1. Scope

This standard specifies the recorded characteristic of magnetic audio records on 8-mm Type S motion-picture prints and on full-coat motion-picture magnetic film conforming to ANSI PH22.149-1981, running at the nominal speed of 24 frames (102 mm [4.0 in]) per second or 25 frames (106 mm [4.2 in]) per second.

2. Reference Standard

The following American National Standard is intended to be used in conjunction with this standard:

ANSI PH22.149-1981, Dimensions for 8-mm Motion-Picture Film Perforated 8-mm Type S, 1R

3. Recorded Characteristics

The recorded relative short circuit magnetic flux level versus frequency shall be as given by the following equation:

$$L_\phi = 0.02738 - 10\log_{10}\left(\frac{1+(2\pi\tau_h)^2f^2}{1+1/(2\pi\tau_\ell)^2f^2}\right)\text{dB}$$

where L_ϕ is the recorded relative short circuit magnetic flux level in decibels, f is the frequency in hertz, τ_ℓ is the low-frequency time constant of

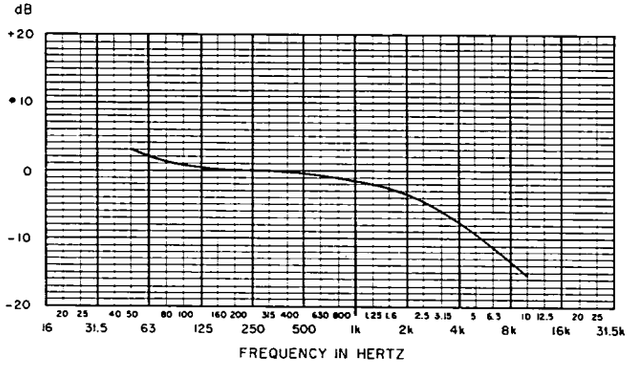

Fig. 1
Recorded Relative Magnetic Flux Level Versus Frequency

3180 μs, τ_h is the high-frequency time constant of 90 μs, and 0.02738 is a constant calculated to make $L_\phi = 0$ at the reference frequency of 315 Hz. (See Fig. 1.)

The appropriate numerical values of the recorded relative short circuit magnetic flux levels, L_ϕ, for a series of preferred 1/3-octave frequencies in hertz are given in Table I. The resulting curve (Fig. 1) is defined by the two time constants indicated. They are only a convenience in defining the desired response curve and are never intended as a recommended electrical circuit.

4. Tolerances

Magnetic audio records on the film shall be recorded to the characteristic specified in Sec. 3 within the tolerances given in Fig. 2.

Table 1
Relative Flux Level (L_ϕ) Versus Frequency

Hz	dB
50	3.04
63	2.15
80	1.45
100	0.98
125	0.65
160	0.40
200	0.24
250	0.11
315	0.00
400	— 0.12
500	— 0.26
630	— 0.46
800	— 0.76
1000	— 1.17
1250	— 1.73
1600	— 2.57
2000	— 3.55
2500	— 4.74
3150	— 6.18
4000	— 7.84
5000	— 9.51
6300	—11.34
8000	—13.29
10 000	—15.15

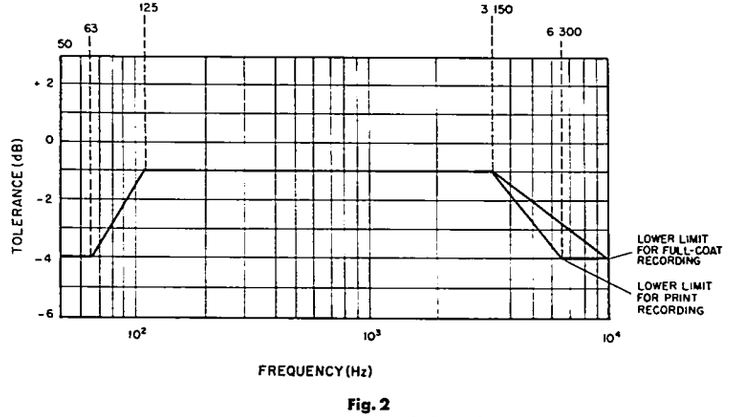

Fig. 2
Tolerances on Recorded Levels

SMPTE RECOMMENDED PRACTICE

RP 62–1984

Specifications for Flutter Test Film for 8-mm Type S Audio Reproducers, Magnetic Type

1. *Scope*

This practice specifies two test films for determining the presence of flutter in 8-mm Type S motion-picture magnetic audio reproducers, one operating at approximately 20 ft (6.1 m) and another at approximately 15 ft (4.6 m) per minute.

2. *Test Film Signal*

2.1 Frequency

2.1.1 Type 24 Film. The audio record on Type 24 film shall be an original recording which will reproduce at a frequency of 3150 ± 25 Hz when the linear velocity of the film is 24 frames per second or approximately 20 ft (6.1 m) per minute (4 in or 102 mm per second).

2.1.2 Type 18 Film. The audio record on Type 18 film shall be an original recording which will reproduce at a frequency of 3150 ± 25 Hz when the linear velocity of the film is 18 frames per second or approximately 15 ft (4.6 m) per minute (3 in or 76 mm per second).

2.2 Distortion. The total harmonic distortion of the recorded signals shall not exceed 0.5 percent.

2.3 Audio Record. The location and dimensions of the audio record shall be in accordance with American National Standard Position, Dimensions and Reproducing Speed of Magnetic Sound Record on 8-mm Type S Motion-Picture Film, ANSI PH22.164-1982. The audio record may also be recorded so that it extends from one edge of the film to the other.

2.4 Recorded Level. The flutter test tone shall be not more than 10 dB down from the equivalent reference level of 3150 Hz at 185 nanowebers per meter after correct equilization of 90 μs.

2.5 Flutter. The weighted peak flutter of the audio record shall not exceed 0.10 percent when measured in accordance with American National Standard Method for Measurement of Weighted Peak Flutter of Sound Recording and Reproducing Equipment, ANSI/IEEE 193-1982.

2.6 Azimuth. The azimuth of the audio record shall be 90° ± 5′ to the reference edge of the film.

3. *Film Stock*

3.1 The film stock shall be magnetic full-coat, splice-free, of the polyester, safety type in compliance with American National Standard Specifications for Motion-Picture Safety Film, ANSI PH22.31M-1980, and cut and perforated in accordance with American National Standard Dimensions for 8-mm Motion-Picture Film Perforated 8-mm Type S, 1R, ANSI PH22.149-1981.

3.2 The film stock shall be conditioned for 10 days at 20°C ± 3° (68°F ± 5.4°) at a relative humidity of 50 ± 10 percent prior to recording.

3.3 The film shall be recorded and packaged within the temperature and humidity limits specified in 3.2. The recorded film shall be packaged in a metal can and sealed either with a low-moisture permeability plastic tape or a fabric tape having a moisture barrier.

4. *Identification*

Each test film shall be identified by a suitable identification marking.

5. *Calibration*

5.1 Flux. The short circuit flux shall be determined by means of the calibrated short-gap ferromagnetic core reproducer technique. This technique is described in American National Standard Method of Measuring Recorded Flux of Magnetic Sound Records at Medium Wavelengths, ANSI/IEEE 347-1982.

5.2 Level. The signal level specified in 2.4 shall be measured with an rms voltmeter calibrated in decibels with an accuracy of ± 0.1 dB over the bandwidth 31.5 Hz to 16 kHz.

5.3 Reproducing Head. The test film shall be calibrated on a reproducing head made in accordance with ANSI PH22.164-1982.

NOTE: Test films made in accordance with this practice are available from the Society of Motion Picture and Television Engineers.

Revision of RP 62-1975
Approved 4 April 1984