# NAB STANDARD

## *Cartridge Tape Recording and Reproducing*


*Engineering Department*

*October, 1964*

**NATIONAL ASSOCIATION OF BROADCASTERS**

*1771 N Street, N.W. • Washington, D.C. 20036*

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# NAB AUDIO

# RECORDING AND REPRODUCING

# STANDARDS AND GLOSSARY

# FOR MAGNETIC TAPE CARTRIDGE SYSTEMS

The NAB Recording and Reproducing Standards Committee was originally organized in 1941. Standards proposals issuing from the Committee have been adopted by the Board of Directors in 1942, 1949, 1950, and 1953. The Standards contained herein were adopted by the Board on August 17, 1964.

These standards and recommended good engineering practices are for the guidance of the broadcasting industry, and represent the contributions of many of the nation's authorities on the various phases of recording as used by the industry. The NAB Recording and Reproducing Standards Committee has also benefited by contributions made by several international organizations. The committee was open to participation by any interested individual or organization and consisted of representatives from the manufacturers, broadcasters and producers. Close liaison was maintained with other organizations (as well as foreign countries) to insure the maximum degree of coordinated understanding and recommended standardization, to permit interchangeability and, at the same time, to embrace the latest technological advances of the art.

Nothing in these standards prohibits or discourages continued progress or advancement of the art. On the contrary, the standards are intended to provide stimulus for continued scientific exploration in the field of recording. It is anticipated that when new techniques and developments are evident the NAB Recording and Reproducing Standards Committee may request submissions thereon looking toward any needed amendments and additions to keep pace with the art as it effects all forms of AM, FM and TV broadcasting.

THE NATIONAL ASSOCIATION OF BROADCASTERS
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The following organizations contributed to the formulation of these standards:

Amerline Corporation, Chicago, Ill.
Ampex Audio Div., Sunnyvale, Calif.
Automatic Tape Control, Bloomington, Ill.
Broadcast Electronics, Inc., Silver Spring, Md.
Collins Radio Co., Cedar Rapids, Iowa
Columbia Broadcasting System, New York, N. Y.
Conley Electronics Corp., Cherry Hill, N. J.
Gates Radio Co., Quincy, Ill.
Minnesota Mining & Mfg. Co., St. Paul, Minn.
Norton Associates, Hicksville, N. Y.
Radio Corporation of America, Camden, N. J.
RCA Victor Record Division, Indianapolis, Ind.
Reeves Soundcraft, Danbury, Conn.
TelePrompter Corp., New York, N. Y.
Unireel, Inc., Boonton, N. J.
WSVA, Harrisonburg, Va.
WWDC, Washington, D. C.

The Standards were reviewed by the following organizations:

American Broadcasting Company, New York
Columbia Broadcasting System, New York
National Broadcasting Company, New York
Station WSVA, Harrisonburg, Virginia
Station WWDC, Washington, D. C.
Audio Devices, Inc., New York
Capitol Records, Los Angeles, California
Collins Radio Company, Dallas, Texas



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# NAB MAGNETIC TAPE CARTRIDGE SYSTEM
# RECORDING AND REPRODUCING STANDARDS

## I. MECHANICAL SPECIFICATIONS

### Cartridge Sizes

1.05 It shall be standard that there shall be three cartridge sizes physically identified and designated as NAB-A, NAB-B, and NAB-C. Pertinent dimensions are shown in Chart B, Table 1.

### Tape Thickness

1.10 It shall be standard that the thickness of magnetic tape for use in tape cartridges shall not exceed 0.0016 inches.

### Tape Width

1.15 It shall be standard that the width of magnetic tape be 0.246 inches ± 0.002 inches.

### Tape Speed

1.20 It shall be standard that the cartridge tape speed shall be 7½ inches per second with a speed accuracy of ±0.4% as measured over a 150 foot ± 1.0 inches loop of one mil (base film thickness) lubricated tape loaded in an NAB type A cartridge.

### Flutter [1]

1.25 It shall be standard that the flutter shall not exceed 0.2% RMS.

### Machine Tape Pulling Force [2]

1.30 It shall be standard that the machine shall be capable of a minimum tape pulling force of one-and-one-half pounds (1½) using clear (no-oxide) unlubricated ¼ inch one mil (base film thickness) polyester tape.

### Cartridge Loading

1.35 It shall be standard that a loaded NAB cartridge shall have the tape length in playing time clearly marked on the heel of the cartridge (see Chart B).

1.35.01 It shall be standard that a loaded cartridge shall contain no less tape than that required to provide the indicated playing time marked on the cartridge and that excess tape footage shall be in accordance with the following table:

| LENGTH | EXCESS TAPE |
|---|---|
| up to 63 feet | 3 seconds maximum (22½ inches) |
| Over 63 feet | 6 seconds maximum (45 inches) |

### Head and Track Configuration—Monophonic [3]

1.40 It shall be standard that:

a. The system shall be a two track system consisting of one program track and one cue track.

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[1] The measurement shall be made within the band from 0.5 to 200 cps by playing an NAB standard flutter tape containing a 3 kc recording. The flutter meter shall have no frequency weighting. The meter shall have the dynamics of the Standard Volume Indicator (ASA C16.5-1961). When making flutter measurements it is recommended that the meter be read for ten seconds, recording peak readings but excluding peaks which do not occur more often than three times in a ten-second period.

[2] This measurement shall be made by securing a length of ¼ inch non-lubricated one mil polyester recording tape to a suitable tension scale. The tape is then threaded between the capstan and pressure roller and the machine set in motion. An indication of at least 1½ lbs. on the scale should then be observed before tape slippage occurs.



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b. The upper track recorded by head B shall be the program channel; the lower track recorded by head B shall be the cue channel; the upper section of head A shall be the program reproducing channel; the lower section of head A shall be the cue reproducing channel.
c. The standard tape track dimensions shall conform to Chart A.

**Head and Track Configuration—Stereophonic** [3]

1.45 It shall be standard that:

a. The system shall be a three track system consisting of two program tracks and one cue track.
b. The upper track shall be the left program channel; the center track shall be the right program channel; the lower track shall be the cue channel.
c. The standard track dimensions shall conform to Chart C.

## II. ELECTRICAL SPECIFICATIONS

**Standard Reference Level** [4]

2.05 It shall be standard that the NAB Standard Reference Level shall be that 400 cps level which is equal to the recorded level on the NAB Primary Reference Tape.

**Recorded Program Level** [5]

2.10 It shall be standard that the recorded program level shall produce the same reference deflection on a Standard Volume Indicator (ASA Standard C16.5-1961) as that produced by a 400 cps tone recorded at the Standard Reference Level.

**Cue Tone Recorded Level**

2.15 It shall be standard that primary and tertiary cue tones be recorded at a level that produces an output 8 db, ± 3 db, above that produced by the NAB Standard Reference Level at the open-circuit terminals of an ideal head. The secondary cue tone shall be recorded at a level that produces an output 2 db, ± 3 db, below that produced by the NAB Standard Reference Level at the open-circuit terminals of an ideal head. (See Annex C)

**Frequency Response—Reproduce** [6]

2.20 It shall be standard that the frequency response of a reproducing system, when reproducing an NAB cartridge frequency test tape, shall fall within the limits shown in Figure 2(A) between the frequencies of 50 and 12,000 cps.

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[3] It is recognized that during the recording process there may be partial erasing of the cue tone and program material within the first one-quarter second of a recording. This possibility exists due to the arrangement of the recording and reproducing heads, the spacing between them and the fact that recording bias current may be present in the recording heads during the primary cue process after a recording has been completed. Some over-running of the tape is also to be expected at the stop (primary) cue. Audible degradation of the program material will usually not be noted in so short a period of time but to prevent this possibility it is recommended that the recording of program material be delayed by one-quarter second after the beginning of the primary cue tone.

[4] The NAB Primary Reference Tape is a tape of the normal general purpose type which has been selected for average characteristics of output, sensitivity and distortion. The 400 cps recording on it was made at 7½ ips with bias adjusted for maximum output, at an output level 8 db below that which produced 3% third harmonic distortion. This does not imply a failure to meet the 10 db overload margin of footnote 5. It is rather, an arbitrary but convenient method of specification and measurement which is consistent with this requirement for the magnetic recording process. Since neither the tape nor the measurement conditions can be duplicated exactly in the field, all NAB Standard Test Tapes contain a 400 cps recording at the NAB Standard Reference Level within ± 0.25 db as a means for making this level available.

[5] It is well established that at least a 10 db margin is required between the sine wave load handling capacity of a system and the level of program material measured by a Standard Volume Indicator. This is believed to be approximately the maximum level which can be recorded on available tapes without excessive distortion. This specification of level is believed to represent the optimum compromise between distortion and signal-to-noise ratio for the magnetic recording process at audio bandwidths suitable for broadcasting.

[6] See Annex A-2.



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**Frequency Response—Record** [7]

2.25 It shall be standard that the recorded response and level shall be the same as the NAB frequency test tape, within the limits shown in Figure 2(B) when such recorded tape is reproduced through the same reproducing system.

**System Distortion** [8]

2.30 It shall be standard that the total record-reproduce system harmonic distortion shall be less than 3% for a 400 cps tone recorded so as to produce a level 6 db above the standard NAB Reference Level.

**System Signal-to-Noise Ratio**

2.35 It shall be standard that the unweighted signal-to-noise ratio shall be not less than the following:

| Monophonic [9] | Stereophonic |
|---|---|
| 45 db | 42 db |

2.35.01 Unweighted noise shall be measured over the frequency range of 20 cps to 20 kc. The noise measurement shall be made using a tape previously recorded with bias but with no signal. The reference signal level shall be the 400 cps NAB Standard Reference Level and the indicating meter shall have the dynamics of the Standard Volume Indicator (ASA Standard C16.5-1961). The measuring system shall have the characteristics of a full-wave rectified average measurement law.

**System Crosstalk—Monophonic**

2.40 It shall be standard that the cue tone (normal level) to program channel system crosstalk at the NAB Standard Reference Level shall not be less than the following:

| | |
|---|---|
| 150 cps | 50 db |
| 1000 cps | 55 db |
| 8000 cps | 50 db |

**System Crosstalk—Stereophonic**

2.45 It shall be standard that the cue tone (normal level) to program channel system crosstalk shall not be less than 50 db for stereophonic systems referenced to the NAB Standard Reference Level.

**Channel Phasing—Stereophonic**

2.50 It shall be standard that for stereophonic recordings the two program tracks shall be recorded with head gaps in line and phased for reproduction on equipment so connected that when a full track tape is reproduced it produces in phase signals in the two channel outputs.

**Tape Erasure**

2.55 It shall be standard that no erasing function shall be provided as a machine capability. Bulk erasing of tape cartridges is required.

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[7] The response measurement shall be made at the same recorded level as that of the NAB Test Tape.

[8] The recording amplifier should not overload with high frequency input signals equal in level to the maximum expected 400 cps level. In practice this means that the recording equalization places an additional demand on the undistorted amplifier output. Furthermore, bias leakage into the amplifier output may produce additional distortion. High frequency distortion products may not be detected by harmonic distortion measurements.

[9] This measurement is intended to give a measure of noise in terms of a fixed reference. In this way it becomes a measure of merit. It does not, however, take into account the program level which may be recorded on a particular tape nor the dynamic range of the program material. Heretofore, by common practice, the signal-to-noise ratio was determined by using peak recording level (3% THD) as a reference. When determined in this manner, the signal-to-noise ratio is improved by approximately 8 db resulting in an effective signal-to-noise ratio of 53 db. (Rev. 12/64)



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**Cue Tones**

**2.60** It shall be standard that the primary standard cue tone frequency shall be 1000 cps ± 75 cps.

**2.60.01** The primary cue tone shall be the stop cue.
**2.65** It shall be standard that the secondary cue tone shall be 150 cps ± 30 cps.
**2.65.01** The secondary cue tone shall be the end of message cue.
**2.70** It shall be standard that the tertiary cue tone shall be 8 kc ± 1 kc.
**2.70.01** The tertiary cue tone shall be an auxiliary tone to be used as desired.

**Cue Tone Burst Duration**

**2.75** It shall be standard that the cue tone burst duration shall be 500 milliseconds ± 250 milliseconds.

## III. TEST TAPE SPECIFICATIONS

The NAB Test Tapes shall consist of four standard test tapes in NAB-A cartridges, each loaded with approximately 150 feet of tape.

3.05 *Test Tape #1—Azimuth.* The azimuth adjustment tone shall be 15 kc recorded full track 10 db below the NAB Standard Reference Level and the recorded azimuth shall be 90 degrees, ± 1 minute, with respect to the length of the tape. The tone shall be recorded over the full length of the tape.

3.10 *Test Tape #2—Flutter.* The flutter test tone shall be 3 kc recorded full track at the NAB Standard Reference Level. The flutter content of the flutter test tape shall be no greater than 0.05%, measured in the same manner as described in footnote 1 under Section 1.25. The test tone shall be recorded over the full length of the tape.

3.15 *Test Tape #3—Frequency Response, Monophonic.* Test tones shall be recorded on the program track in accordance with the following table:

| | |
|---|---|
| 400 cps—10 seconds | Standard Reference Level ± 0.25 db |
| 400 cps—10 seconds | Calibration Level (10 db below Standard Reference Level) |
| 15 kc —20 seconds | |
| 12 kc — 5 seconds | |
| 10 kc — 5 seconds | |
| 8 kc — 5 seconds | |
| 5 kc — 5 seconds | |
| 2.5 kc — 5 seconds | |
| 1 kc — 5 seconds | |
| 600 cps— 5 seconds | |
| 300 cps— 5 seconds | |
| 150 cps— 5 seconds | |
| 75 cps— 5 seconds | |
| 50 cps— 5 seconds | |
| 30 cps— 5 seconds | |

Each test tone shall be identified by voice announcement preceding the tone. All test tones, with the exception of the Standard Reference Level Tone, shall be recorded so as to produce a uniform response ±½ db, when the test tape is reproduced through an ideal reproducing system (See Annex A & B). The recording level shall be 10 db below the NAB Standard Reference Level.[10]

Test tones shall be recorded on the cue track in the following manner: 1000 cps to coincide with the beginning of the program track test tones, 1000 cps stop cue between the first and second 400 cps tones, 150 cps at the end of the program track test followed by 8000 cps, with addi-

[10] In lieu of the ± ½ db tolerance specification, a ± 3 db tolerance specification may be used provided that the deviation from uniform response when the test tape is reproduced on an ideal reproducing system is supplied for each test frequency.



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tional 150, 1000, and 8000 cps tones of 4 seconds duration each added for calibration of cue circuitry. Unless otherwise specified, the cue test tones shall be recorded so as to comply with Sections 2.15 and 2.75 of these Standards.

3.20 *Test Tape #4—Frequency Response, Stereophonic.*[11] Test tones shall be recorded on the stereophonic program tracks in accordance with the following table:

| | |
|---|---|
| 400 cps—10 seconds | Standard Reference Level ± 0.25 db |
| 400 cps—10 seconds | Calibration Level (10 db below Standard Reference Level) |
| 15 kc —20 seconds | |
| 12 kc — 5 seconds | |
| 10 kc — 5 seconds | |
| 8 kc — 5 seconds | |
| 5 kc — 5 seconds | |
| 2.5 kc — 5 seconds | |
| 1 kc — 5 seconds | |
| 600 cps— 5 seconds | |
| 300 cps— 5 seconds | |
| 150 cps— 5 seconds | |
| 75 cps— 5 seconds | |
| 50 cps— 5 seconds | |
| 30 cps— 5 seconds | |

Each test tone shall be identified by voice announcement preceding the tone. All test tones, with the exception of the Standard Reference Level tone, shall be recorded so as to produce a uniform response ± ½ db when the test tape is reproduced through an ideal reproducing system (see Annex A & B). The recording level shall be 10 db below the NAB Standard Reference Level.[12]

Test tones shall be recorded on the cue track in the following manner: 1000 cps to coincide with the beginning of the program track test tones, 1000 cps stop cue between the first and second 400 cps tones, 150 cps at the end of the program track test tones followed by 8000 cps, with additional 150, 1000, and 8000 cps tones of 4 seconds duration each added for calibration of cue circuitry. Unless otherwise specified, the cue test tones shall be recorded so as to comply with Sections 2.15 and 2.75 of the Standards.

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[11] The test frequencies shall be recorded with a phase additive relationship. Channels shall be identified as "left" or "right" as applicable by voice announcement.

[12] In lieu of the ± ½ db tolerance specification, a ± 3 db tolerance specification may be used provided that the deviation from uniform response when the test tape is reproduced on an ideal reproducing system is supplied for each test frequency.



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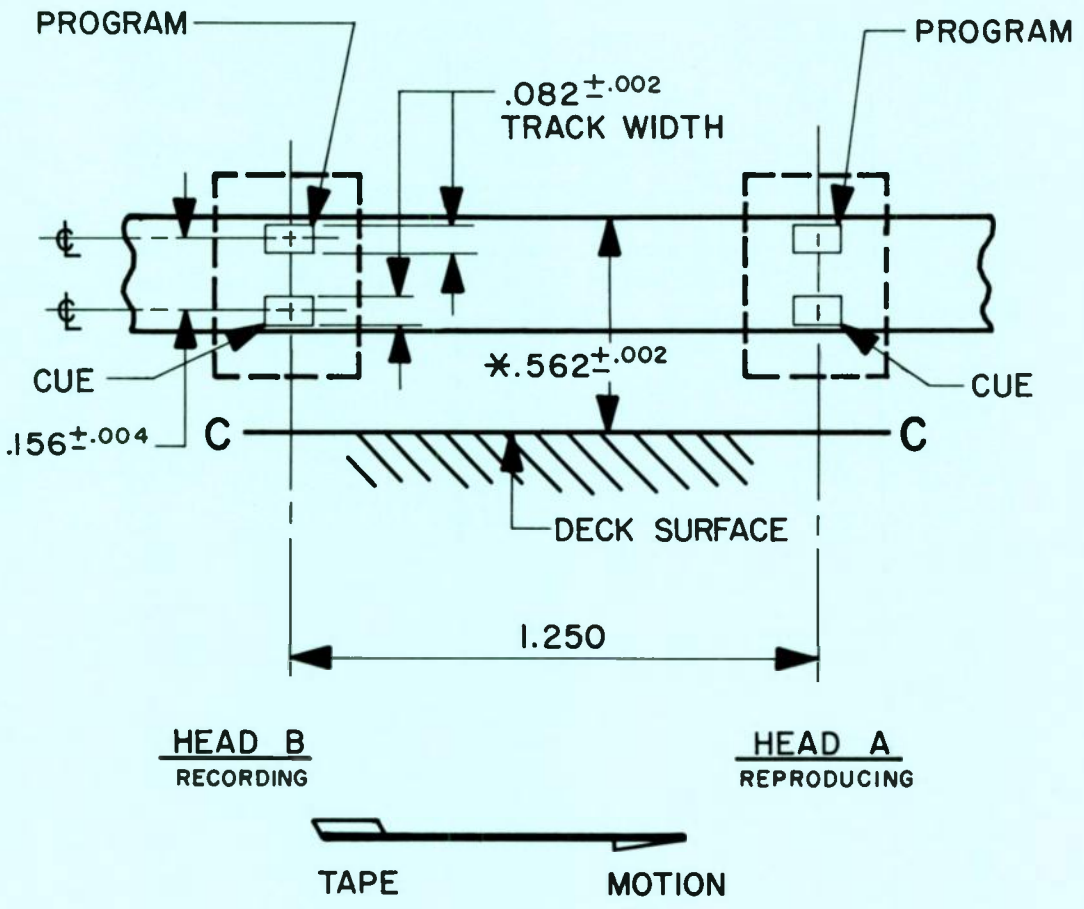
# CHART A

## MONOPHONIC TWO-TRACK
## RECORDED TRACK DIMENSIONS




* REFER TO FIG 4, CHART B, FOR MEANING OF THIS DIMENSION



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THE SPRING ACTION DEVICE MUST NOT PROTRUDE MORE THAN 1/4" INTO CUT-OUT FROM REFERENCE B-B, NOR MORE THAN 3/16" ABOVE DECK SURFACE C-C.

FORCE REQUIRED TO DEFLECT SPRING FULLY SHALL BE 4 TO 8 OZ. MEASURED ALONG A-A, PARALLEL TO BASE.

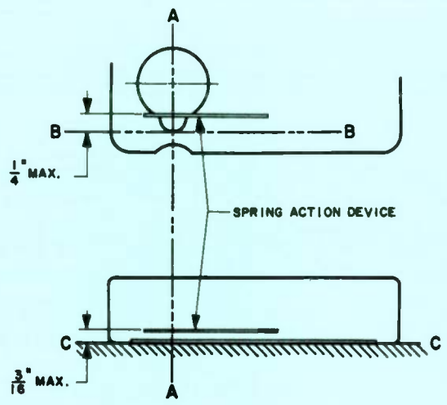


FIG. 1 REQUIRED SPRING ACTION DEVICE LIMITATIONS

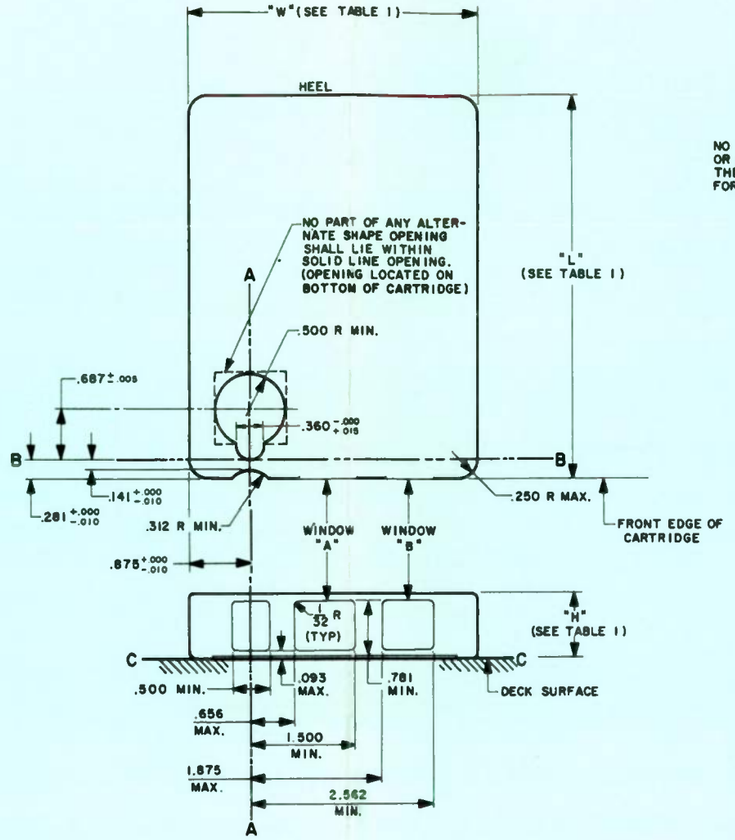


FIG. 3 CARTRIDGE DIMENSIONS

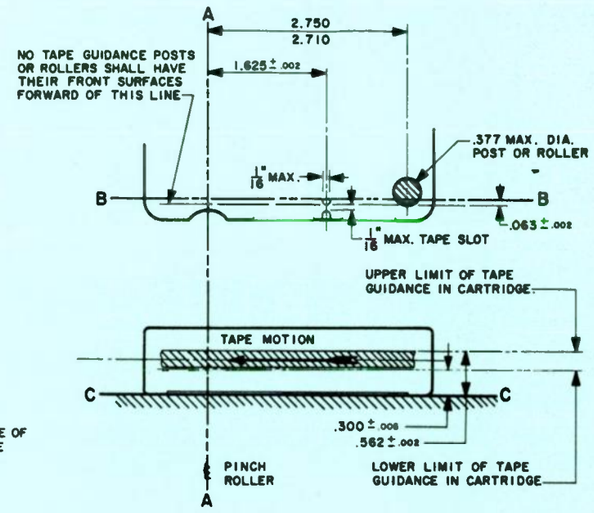


FIG. 4 TAPE GUIDANCE LIMITS

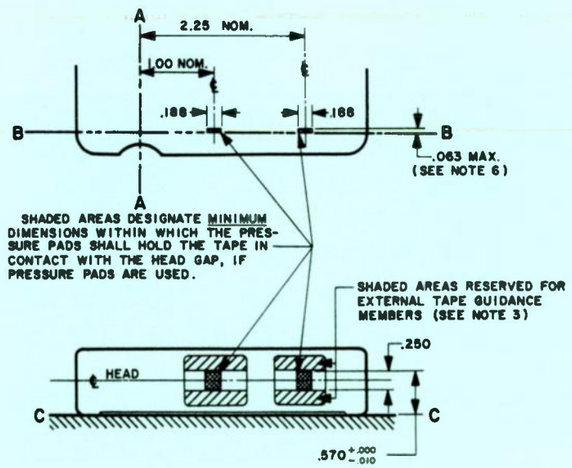


FIG. 2 PRESSURE PAD PROVISION (IF USED)

TABLE 1

| CARTRIDGE NAB TYPE | WIDTH "W" ± 1/64" | LENGTH "L" MAX. | HEIGHT "H" MAX. |
|---|---|---|---|
| A | 4" | 5 1/4" | .9375 |
| B | 6" | 7" | .9375 |
| C | 7 5/8" | 8 1/2" | .9375 |

NOTES

1. DIMENSIONS:
   ALL IMPORTANT OPERATING DIMENSIONS ARE REFERENCED FROM TWO IMAGINARY MUTUALLY PERPENDICULAR, VERTICAL PLANES MARKED A-A & B-B, AND A THIRD HORIZONTAL PLANE C-C, REPRESENTING THE DECK SURFACE OF THE CARTRIDGE TAPE PLAYER.

   WHERE APPLICABLE, DIMENSIONS INCLUDE DRAFT ALLOWANCES.

2. MATERIALS:
   ALL MATERIALS USED IN THE CARTRIDGE CONSTRUCTION SHALL BE NON-MAGNETIC.

3. TAPE GUIDANCE:
   PRECISE TAPE GUIDANCE SHALL BE PROVIDED BY TAPE GUIDE, OR GUIDES, EXTERNAL TO THE CARTRIDGE. INTERNAL GUIDANCE, AS SPECIFIED, IS TOLERANCED AND DIMENSIONED SO AS NOT TO INTERFERE WITH EXTERNAL HEAD GUIDES, PROPERLY SET, AND USING ST'D 1/4" TAPE (.246±.002)

   ROLLERS, POSTS, OR OTHER TAPE GUIDING SURFACES MUST BE SMOOTH AND PROVIDE A VERTICAL TAPE PLANE IN THAT PORTION OF TAPE WHICH PASSES ACROSS THE FRONT OF THE CARTRIDGE.

   THE MINIMUM WINDOW AREA, EXCEPT FOR THE AREA COVERED BY THE TAPE PATH, SHALL BE KEPT CLEAR FOR A DISTANCE OF .187 TO THE REAR OF B-B TO PROVIDE FOR EXTERNAL TAPE GUIDES.

4. TAPE TENSION:
   TAPE TENSION SHALL NOT EXCEED 6 OZ. AT CAPSTAN.

5. TAPE LENGTH:
   TAPE LENGTH IN PLAYING TIME SHALL BE LEGIBLY MARKED ON THE HEEL OF CARTRIDGE BASE.

6. HEAD PENETRATION:
   HEAD PENETRATION SHALL CONFORM TO CROSS-HATCHED AREA SHOWN IN FIG. 2.

# CHART B
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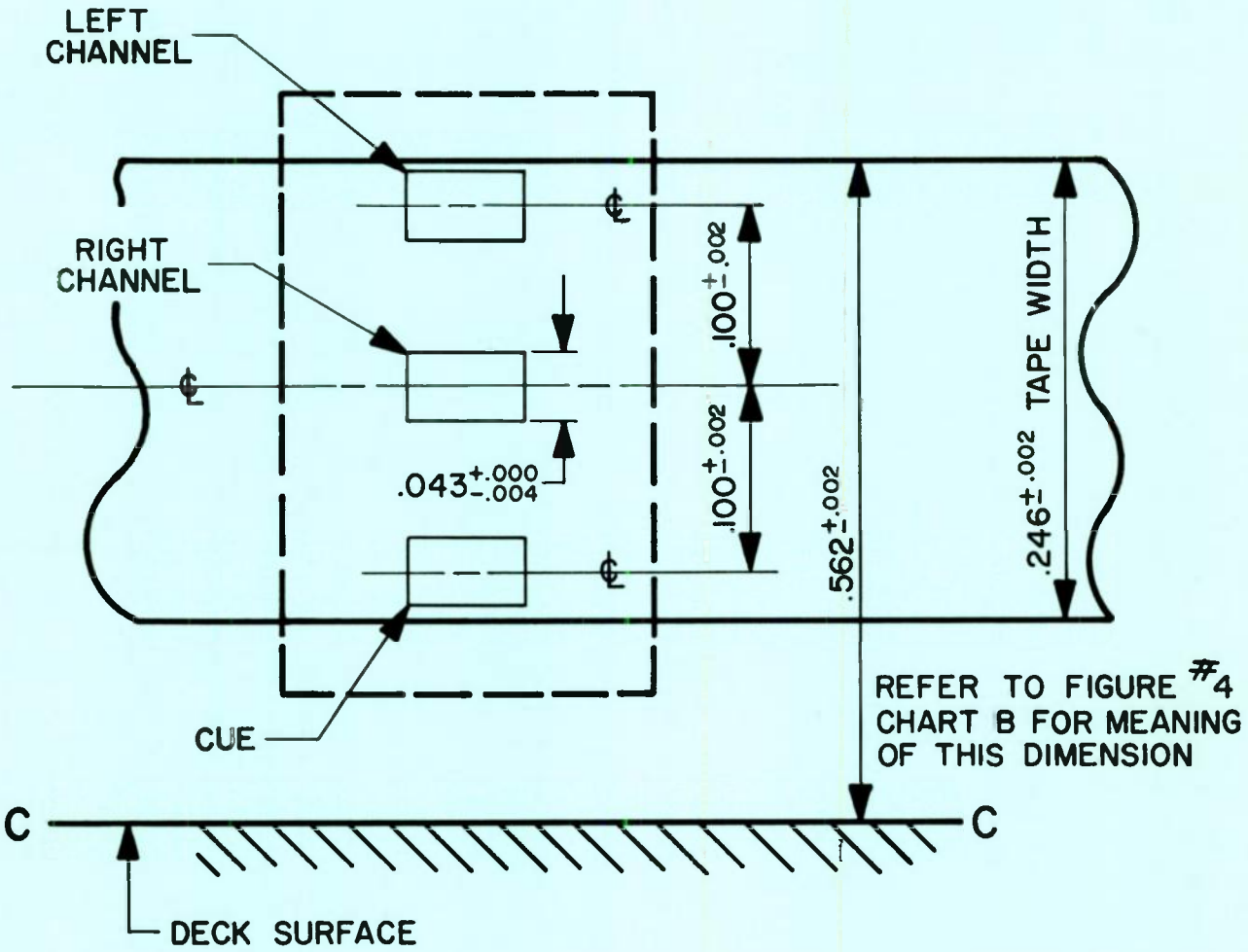
# CHART C

## STEREO 3-TRACK
### RECORDED TAPE TRACK DIMENSIONS




NOTES:

1. IF SECOND STEREO HEAD IS USED IT SHOULD BE PLACED 1.250 FROM FIRST HEAD.

2. TRACK WIDTH: ALL TRACKS SHALL BE $.043^{+.000}_{-.004}$



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# ANNEX A

## 1. Ideal Reproducing System

It shall be standard that the NAB Ideal Reproducing System is a theoretical reproducing system. It consists of an "ideal" reproducing head[1] and an amplifier the output voltage of which shall conform to the voltage-frequency curve of Figure 1 with constant flux vs frequency in the core of the head.[2]

The curve of voltage amplification vs frequency shall be uniform with frequency except where modified by the following equalizations:

(a) The voltage attenuation of a single resistance—capacitance high pass filter having an RC time constant $t_1$.

(b) The inverse of the voltage attenuation of a single resistance capacitance low pass filter having an RC time constant $t_2$. The curve expressed in decibels is represented by the following expression:

$$N_{db} = 20 \log_{10} \omega t_1 \sqrt{\frac{1 + (\omega t_2)^2}{1 + (\omega t_1)^2}}$$

$\omega = 2\pi$ times frequency

For 7½ inches per second tape speed $t_1 = 3180$ microscends, and $t_2 = 50$ microseconds.

## 2. Standard Reproducing System [3] [4]

It shall be standard that an NAB Standard Reproducing System shall consist of a suitable tape transport, reproduce head and amplifier equalized to compensate for head losses insofar as possible and to produce a reproduce response from an NAB Standard Test Tape, within the limits specified in Figure 2. It shall also meet the specifications for distortion, signal-to-noise ratio and other applicable parts of this Standard.

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[1] An "ideal" reproducing head is defined as a ferromagnetic head, the losses of which are negligible. This means that the gap is short and straight, the long wave-length flux paths are controlled so that no low frequency contour effects are present, and the losses in the head materials are negligibly small.

[2] It is recognized that the flux in the core of an "ideal" head is not necessarily the same as the surface flux on a tape in space for various reasons. Since most of these effects are not readily measured it has been decided to base this standard on "ideal" head core flux rather than surface induction.

[3] The practical method of measuring a reproduce system response characteristic is with an NAB Test Tape. More precise methods of measuring and calibrating a reproduce system are discussed in Annex B of this Standard. A reproducer calibrated by these methods and meeting the recommendations set forth in Annex B is considered suitable for measuring and calibrating test tapes.

[4] It is recommended that the Reproducing System response roll off at the rate of at least 6 db per octave beyond the frequency limits shown in Figure 2.



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# ANNEX B

## PRIMARY CALIBRATED REPRODUCING SYSTEM [1]

It shall be standard that a Primary Calibrated Reproducing System shall meet the following specifications:

A. The total net system response shall not deviate more than ± 3 db from the ideal over the frequency range of interest.

B. Electrical—Eddy current loss at the highest frequency of interest shall not exceed 3 db, undamped head resonance shall not exceed 3 db and amplifier deviation from the ideal shall not exceed ±3 db.

C. Magnetic—Head gap losses shall not exceed 3 db at the highest frequency of interest and the head contour effect curve shall not deviate more than ±2 db from the average.

Electrical losses shall be determined from measurements of the amplifier response frequency characteristic and the reproduce system output voltage characteristic with constant flux vs frequency in the head core.

Magnetic losses shall be determined from calculations of gap loss and measurements of head contour effects.

The following paragraphs specify the methods by which these characteristics shall be measured and the reproduce system calibrated. The procedure is to determine the various losses independently and apply them as corrections to the theoretical "Ideal Reproducing System."

### Electrical Measurements

Three response frequency curves shall be made. First the amplifier response alone with voltage proportional (voltage doubles for each octave frequency increase) to frequency, measured by conventional methods, second, the head and amplifier response measured by applying a small voltage proportional to frequency across a low resistance connected in series with the head, and finally the head and amplifier response measured with a constant flux vs frequency induced into the core of the reproduce head. The third measurement can be made by placing a fine wire over the head gap, securing it firmly in place, and feeding constant current through the wire. Although the resultant flux distribution is not identical to that from a tape, it is considered to be satisfactory for the purposes of this measurement. Ideally the third curve would follow the Ideal Reproducing Characteristic as shown in Figure 1. However, in practice the curve may vary from the ideal because of head resonance effects, and apparent core losses. Resonance effects are determined by comparing curves 1 and 2 while eddy current losses are identified by comparing curves 2 and 3.

### Magnetic Measurements

A curve of approximate gap loss vs. frequency shall be calculated from the following expression:

$$\text{Gap loss} = -20 \log_{10} \frac{\sin \frac{d}{\lambda} 180 \text{ degrees}}{\pi \frac{d}{\lambda}}$$

where $d$ = null wavelength

$\lambda$ = wavelength at which the gap loss is calculated.

The null wavelength is determined by finding the recorded wavelength at which the reproducing head output reaches a distinct minimum of at least 20 db below maximum output. It is desirable to make this measurement at ½ or ¼ normal speed and with a tuned voltmeter with no greater than one-third octave band width. In order to reach the 20 db null the head gap edges must be sharp, straight and parallel.

In order to determine that a gap meets these requirements visual examination of the gap at about 1000x magnification is necessary. This may be accomplished with a toolmaker's microscope or with suitable photomicrographs taken at several locations along the gap. It has been shown that the null wavelength will be 1.14 times the optical gap length for a perfectly constructed head.[2] In

[1] It is recognized that commercial production recorders may deviate from the stated system losses and response, however, this does not invalidate the calibration procedure for such machines.

[2] W. K. Westmijze, "Studies on Magnetic Recording" Philips Research Reports, Vol. 8, No. 3, pp-161-183, 1953.



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practice it is usually greater. However, it is recommended that the null wavelength not be greater than 1.25 times the optical gap length for this application.

A curve of the low frequency reproducing response shall be made using a constant current vs frequency recording made with normal bias and the result compared to the curve of reproduce system response with constant flux vs frequency induced into the head core (curve 3 above), in order to determine contour effects. This reproducing response curve ideally should follow the Standard Reproducing Characteristic at frequencies below approximately 750 cps at 7½ inches per second. In practice it is known that all of the flux from a tape at long wavelengths does not enter the head core. The amount that does enter varies with wavelength depending upon the length of tape to head contact, the shields in and around the head and the shape of the pole pieces.

It is important to accurately measure frequency when making the recording so that slight frequency errors are not interpreted as response errors. It is recommended that the slope of the contour effects curve not exceed 10 db per octave so that a frequency error of ½% will result in a response error of not more than 0.07 db.

### Calibrated System Response

Having determined the various losses or deviations from the Ideal System Response a calibration of the actual system is obtained as follows: To the system response curve, (curve 3 under Electrical Measurements,) subtract the gap loss curve at high frequencies and algebraically add the low frequency portion by the contour effect curve. The resulting curve is the reproducing system response for constant available flux from a tape. The difference between this curve and the Standard Reproducing System Characteristic represents the variation from the ideal response.



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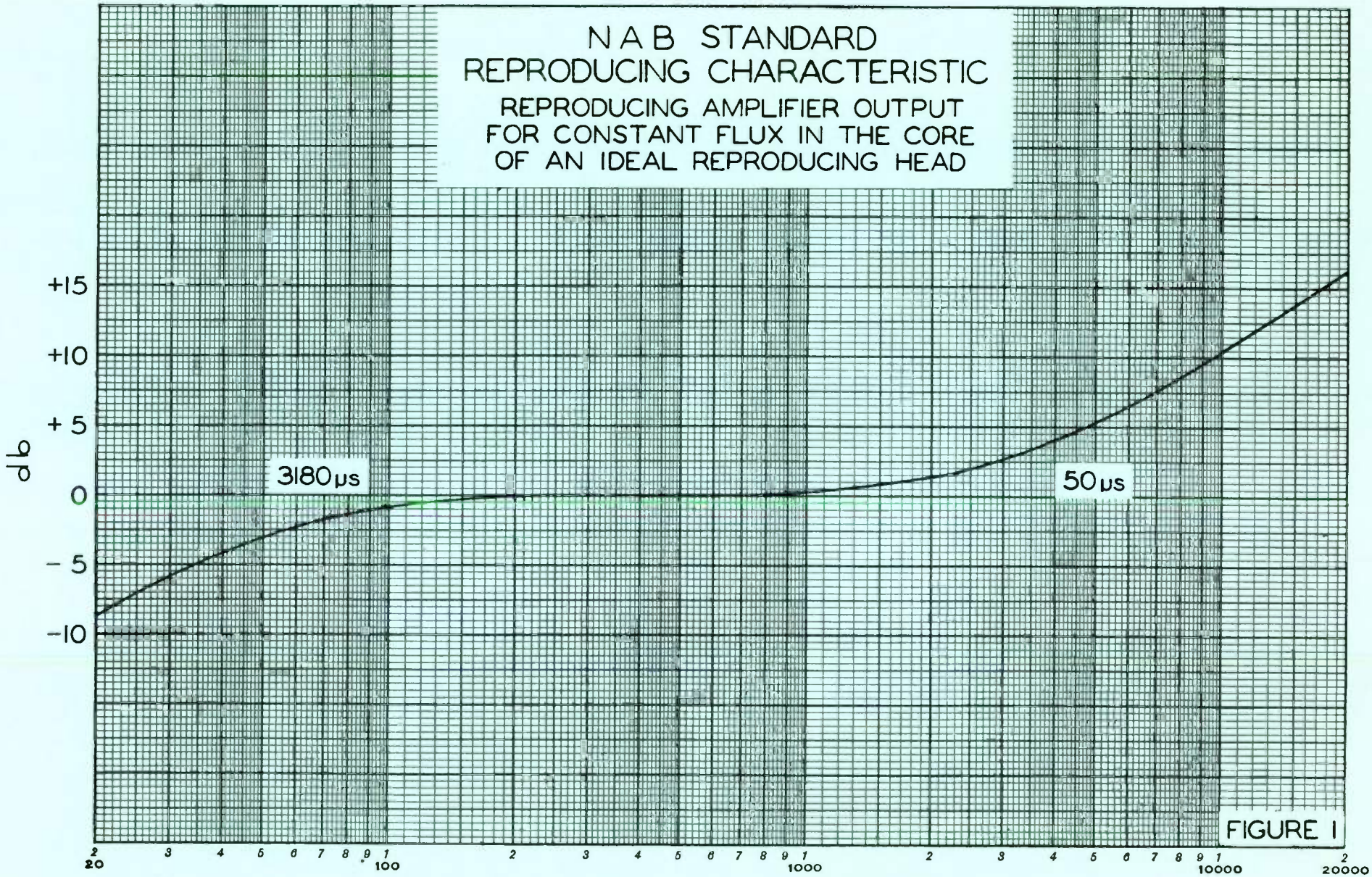




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## TABLE I

### RESPONSE OF IDEAL REPRODUCING SYSTEM

| *Frequency* | *Response* | *Frequency* | *Response* |
|---|---|---|---|
| 20 cps | –8.6 db | 1.5 kc | +0.9 db |
| 25 cps | 7.0 db | 2 kc | 1.4 db |
| 30 cps | 5.8 db | 2.5 kc | 2.1 db |
| 40 cps | 4.1 db | 3 kc | 2.7 db |
| 50 cps | 3.0 db | 4 kc | 4.1 db |
| 60 cps | 2.3 db | 5 kc | 5.4 db |
| 70 cps | 1.8 db | 6 kc | 6.6 db |
| 75 cps | 1.6 db | 7 kc | 7.6 db |
| 80 cps | 1.4 db | 7.5 kc | 8.2 db |
| 90 cps | 1.2 db | 8 kc | 8.6 db |
| 100 cps | 1.0 db | 9 kc | 9.5 db |
| 150 cps | 0.4 db | 10 kc | 10.3 db |
| 200 cps | 0.2 db | 11 kc | 11.1 db |
| 250 cps | 0.1 db | 12 kc | 11.8 db |
| 300 cps | –0.1 db | 13 kc | 12.5 db |
| 400 cps | ±0 db | 14 kc | 13.1 db |
| 500 cps | +0.1 db | 15 kc | 13.6 db |
| 600 cps | 0.1 db | 16 kc | 14.2 db |
| 700 cps | 0.2 db | 17 kc | 14.7 db |
| 750 cps | 0.2 db | 18 kc | 15.2 db |
| 800 cps | 0.2 db | 19 kc | 15.6 db |
| 900 cps | 0.3 db | 20 kc | +16.1 db |
| 1 kc | +0.4 db | | |



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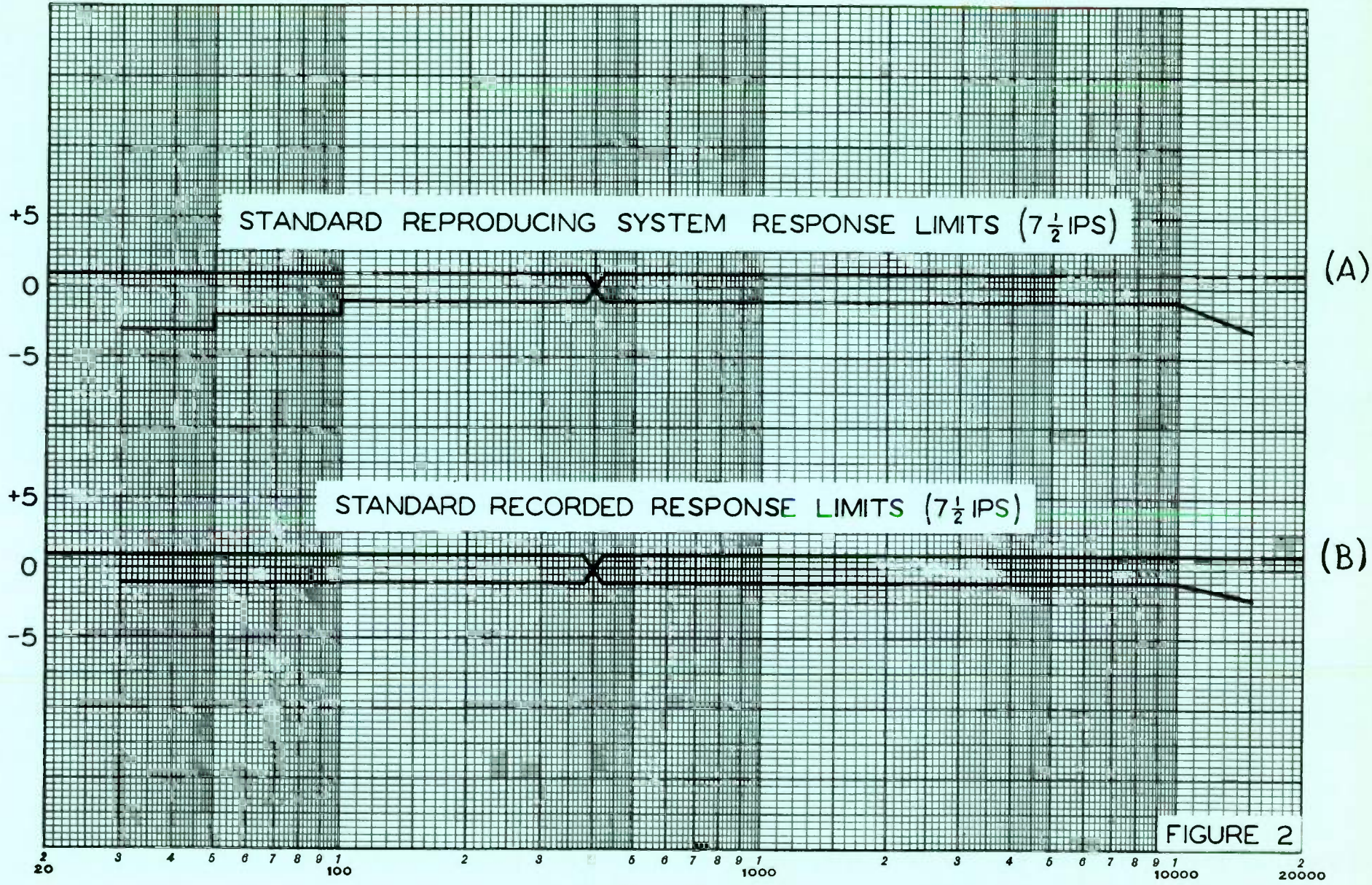


FIGURE 2



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# ANNEX C

**Cue Tone Recorded Levels**

1. The choice of the recorded level for the three cueing tones is based on two primary considerations. The first is the signal to noise ratio of the cue track. Maximum reliability of the cue system requires a high signal to noise ratio. Assuming that the cue system is well designed and is operating at a minimum noise level, it then remains that any improvement in the signal to noise ratio will be the result of recording the cueing tones at the highest practical level.

   The second consideration is crosstalk of the cueing tones into the program channel. The crosstalk level can be kept to a minimum by recording the cueing tones at a low level. Since these two considerations aim in opposite directions, a compromise becomes necessary.

2. On the basis of experience, it was felt that the primary cueing tone (1000 cps) could be recorded at the same level on the tape as the NAB Standard Reference Level, i.e., at normal program level. At 1000 cps most systems exhibit good signal to noise and crosstalk ratios. Further, it was felt that the secondary cueing tone (150 cps) should be recorded about 6 db above program level in order to overcome possible interference from fundamental or harmonics of the power line frequency. The resulting slight increase in crosstalk should not be annoying because the ear is relatively insensitive to low level low frequency tones.

   Finally, the tertiary cueing tone (8 kc) posed a special problem because it may be recorded several times during a recording and the crosstalk could be annoying if at a high level. Accordingly, a level about 10 db below program level was adopted. This level is still high enough for a good signal to noise ratio in the cue channel.

3. The recorded level of each of the three cueing tones is referenced to the NAB Standard Reference Level at 400 cps. A direct comparison may then be made by means of an "ideal" head and a suitable voltmeter. Although the standard is written in terms of an "ideal" head, a practical head can be used if its losses are known.

   The procedure for converting the original estimated tone levels from a "program level" reference to a voltage output of a head is as follows: the original tone levels are converted to relative flux by means of a correction factor. The correction factor is the inverse of the NAB equalization given in Table 1, Annex B. These relative fluxes are converted into "ideal" head voltages by applying the response of an "ideal" head. Such a head has an ouptut which rises 6 db per octave with increasing frequency.

   This procedure is shown in Table 1a, which converts to relative fluxes, and Table 1b, which converts to the output of the "ideal" head. The last column lists the adopted values, which are rounded off to whole numbers. The 8 kc tone was rounded off to equal the 1000 cps tone.

4. A practical method for measuring the recorded cue tone levels is to reproduce the recorded tape cue track through an NAB equalized playback channel. The output levels observed may then be compared with the Standard NAB Reference Level. Table 2 shows the correct relationship of the various cueing tones to the standard levels when measured in this manner.

## Table 1a

CONVERTING FROM PROGRAM LEVEL TO FLUX

| *Frequency* | *Recording Level (ref. pgm level)* | *Conversion Factor (–NAB Equalization)* | *Relative Flux* |
|---|---|---|---|
| 400 cps | 0 db | 0 db | 0 db |
| 1000 cps | 0 | –0.4 | –0.4 |
| 150 cps | +6 | +0.4 | +6.4 |
| 8 kc | –10 | –8.6 | –18.6 |



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## Table 1b

CONVERTING FROM FLUX TO IDEAL HEAD OUTPUT

| *Frequency* | *Relative Flux* | *Response of Ideal Head* | *Output of Ideal Head* | *Adopted Level* |
|---|---|---|---|---|
| 400 cps | 0 db | 0 db | 0 db | 0 db |
| 1000 cps | –0.4 | +8.0 | +7.6 | +8 |
| 150 cps | +6.4 | –8.5 | –2.1 | –2 |
| 8 kc | –18.6 | +26.0 | +7.4 | +8 |

## Table 2

NAB CUE TONE OUTPUT LEVELS AS REPRODUCED THROUGH AN NAB EQUALIZED PLAYBACK CHANNEL

| *Frequency* | *Output* |
|---|---|
| 400 cps | 0 db (NAB Standard Reference Level) |
| 1000 cps | +0.4 |
| 150 cps | +6.1 |
| 8 kc | –9.4 |



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# GLOSSARY OF MAGNETIC CARTRIDGE TAPE

## RECORDING AND REPRODUCING TERMS AND DEFINITIONS

**AZIMUTH LOSS.** The signal loss due to misalignment of the playback head with respect to the recorded signal.

**BACKGROUND NOISE.** Background noise is the total system noise independent of the signal. The signal is not included as part of the noise.

**BIAS.** See Magnetic Biasing.

**CAPSTAN.** The spindle or shaft—often the motor shaft itself—which drives the pressure roller and tape.

**CARTRIDGE.** A plastic or metal enclosure containing an endless loop of lubricated magnetic tape, wound on a rotatable hub in such a fashion as to allow continuous tape motion.

**CONTOUR EFFECT.** The alteration of the voltage output from a magnetic reproducing head at long wavelengths.

**CROSSTALK.** The presence of an undesirable signal in a system channel from external sources.

**CUE TONE.** A recorded audio frequency of specified duration arranged in a physical fashion on the recorded tape so as to provide a signalling system available for positioning the tape at the start of message, end of same, and such auxiliary functions as may be necessary and desirable.

**CUE TRACK.** That portion of recorded tape which is used to actuate tape motion or auxiliary functions within or external to the recorder/playback device.

**DBM.** 1 MW of power (usually 600 ohms). The standard reference level used in broadcast work.

**DISTORTION.** An undesired change in waveform.

**DISTORTION, NONLINEAR.** (Amplitude) Distortion caused by a deviation from a linear relationship between the input and output of a system or component.

**DISTORTION, HARMONIC.** Nonlinear Distortion characterized by the appearance, in the output, of harmonics of the fundamental input frequency.

**DISTORTION, PER CENT HARMONIC.** A measure of the Harmonic Distortion in a system or component, numerically equal to 100 times the ratio of the root-mean-square voltages (or currents) of each of the individual harmonic frequencies, to the root-mean-square voltage (or current) of the fundamental.

**DISTORTION, INTERMODULATION.** Nonlinear Distortion characterized by the appearance of frequencies in the output, equal to the sums and differences of the component frequencies present in the input wave.

**EQUALIZATION.** The process of modifying the frequency response characteristics in a recording and reproducing system.

**EQUALIZER.** A device designed to modify the frequency response of a system or component.

**ERASING HEAD.** A device which is used to produce the magnetic field necessary for erasing a magnetic recording.

NOTE: AC erasing is achieved by subjecting the medium to a frequency modulated magnetic field of decreasing magnitude. The medium is then essentially left in a demagnetized condition.

**ERASURE.** Neutralizing the magnetic pattern on tape by placing it in a strong magnetic field, thereby removing any recorded signal from the tape. An "erase" head on a tape recorder does this automatically to any signal previously recorded on the tape just before the tape reaches the "record" head. A permanent magnet can also be used to erase magnetic tape, but with a resultant increase in background noise compared to ac erasure.



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**FLUTTER (WOW) (DRIFT).** The deviation of frequency which results in general from irregular motion during recording, or reproduction.

NOTE: The term "flutter" usually refers to cyclic deviations occurring at a relatively high rate, as for example 10 cycles per second. The term "wow" usually refers to cyclic deviations occurring at a relatively low rate, as for example, a once-per-revolution speed variation of a phonograph turntable. The term "drift" usually refers to a gradual average variation over an extended period of time.

**FLUTTER RATE.** The number of cyclical variations per second of the flutter.

**FREQUENCY RESPONSE.** The relative output vs frequency of a recording or reproducing system usually presented in the form of a curve plotted with frequency as the ordinate and db as the abscissa.

**FREQUENCY TAPE.** A recording of various test frequencies at known amplitudes, usually for the purposes of testing and measuring reproducing equipment.

**GAP LENGTH.** The physical distance between adjacent surfaces of the pole tips or a magnetic head measured in the direction of tape travel.

NOTE: The effective gap length is usually greater than the physical length.

**GAP LENGTH, EFFECTIVE.** The recorded wavelength at which the output of a magnetic head goes through the first null point.

NOTE: The effective gap length is usually about 1.14 times the physical length.

**HEAD ALIGNMENT.** Positioning of the record and reproduce head on a tape recorder so that their gaps are mutually parallel and perpendicular to the path of travel of the tape.

**LEVEL, RECORDED.** The level measured by a reproducing system with respect to the NAB Standard Level, expressed in decibels.

**MAGNETIC BIASING.** The simultaneous conditioning of the magnetic recording medium during recording by superposing an additional magnetic field upon the signal magnetic field.

NOTE: In general, magnetic biasing is used to obtain a substantially linear relationship between the amplitude of the signal and the remanent flux density in the recording medium.

**MAGNETING BIASING, AC.** Magnetic biasing accomplished by the use of an alternating current which is usually well above the highest signal frequency.

**MAGNETIC HEAD.** A transducer for converting electrical signal currents into magnetic signals for storage on magnetic media, for converting stored magnetic signals into electrical signals, or for erasing stored magnetic signals.

NOTE: A ferromagnetic head is one in which the permeability of the material is much greater than one (1) being most often several thousand.

**MAGNETIC HEAD CORE.** The high permeability (usually laminated) structure which forms the head gap and supports the head windings.

**MAGNETIC-COATED TAPE.** A tape consisting of a coating of uniformly dispersed, ferromagnetic material on a non-magnetic base.

**MAGNETIC PRINTING.** The permanent transfer of a recorded signal from a section of a magnetic recording medium to another section of the same or a different medium when these sections are brought in proximity.

**MAGNETIC RECORDER.** Equipment incorporating an electromagnetic transducer and means for moving a ferromagnetic recording medium relative to the transducer for recording electric signals as magnetic variations in the medium.

NOTE: The generic term "magnetic recorder" can also be applied to an instrument which has not only facilities for recording electric signals as magnetic variations, but also for converting such magnetic variations back into electric variations.



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**MAGNETIC RECORDING HEAD.** A magnetic head for transforming electric signals into magnetic signals for storage on magnetic media.

**MAGNETIC RECORDING MEDIUM.** A magnetizable material used with a magnetic recorder for retaining the magnetic signals imparted during the recording process.

**MAGNETIC RECORDING REPRODUCER.** Equipment for converting magnetic signals on magnetic recording media into electric signals.

**MAGNETIC REPRODUCING HEAD.** A transducer for converting magnetic signals on magnetic media into electric signals.

**MODULATION NOISE.** The noise caused by the signal. The signal is not included as part of the noise.

**MULTITRACK MAGNETIC RECORDING SYSTEM.** A recording system which provides, on a medium such as magnetic tape, two or more recording paths which are parallel to each other, and which may carry either related or unrelated program material in common time relationship.

**NOISE.** (Audio Frequency). Any electrical disturbance introduced from a source extraneous to the signal.

**NOISE, UNWEIGHTED.** The noise measured within the audio frequency pass band using a measuring instrument which is uniform in output with respect to frequency.

**NOISE, WEIGHTED.** The noise measured within the audio frequency pass band using a measuring instrument which has a frequency selective characteristic. The sensitivity is usually greatest in the frequency range where noise is most objectionable subjectively.

**PLAYBACK.** An expression used to denote reproduction of a recording.

**POST-EMPHASIS.** That portion of the equalization which is applied in the reproducer.

**PRE-EMPHASIS.** (Pre-equalization). That portion of the equalization which is applied in the recorder.

**PRESSURE ROLLER.** Also called "capstan idler" or "puck." A rubber-tired roller which holds the magnetic tape tightly against the capstan.

**RECORDING CHANNEL.** The term "recording channel" refers to one of a number of independent recorders in a recording system or to independent recording tracks on a recording medium.
NOTE: Two or more channels are used at the same time for stereophonic recording or for multichannel monophonic recording.

**RECORDING LOSS.** The loss in recorded level whereby the amplitude of the wave in the recorded medium differs from the amplitude of the recording current.

**RING HEAD.** A magnetic head in which the magnetic core material forms an enclosure with one or more gaps. The magnetic recording medium bridges one of these gaps and is contacted by the pole pieces on one side only.

**SOUND RECORDING SYSTEM.** A combination of transducing devices and associated equipment suitable for storing sound in a form capable of subsequent reproduction.

**SOUND REPRODUCING SYSTEM.** A combination of transducing devices and associated equipment for reproducing recorded sound.

**STROBOTRON.** A gas filled electron tube with a cold cathode used especially as a source of stroboscopic light.

**SURFACE INDUCTION.** The flux density at right angles to the surface of the tape in a medium of unity permeability and not in contact with a reproducing device.

**TACHOMETER.** A device for measuring or indicating the rotational speed of a shaft or associated moving part.



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**TRACK CONFIGURATION.** The relative position of the active recording area referenced to the entire cross-sectioned surface of the magnetic recording medium.

**WEIGHTING CHARACTERISTIC.** The response-frequency characteristic of a measuring device used to measure Weighted Noise.

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