Status of Sound Field Audiometry among Audiologists in the United States

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Abstract

Results of a national survey on sound field usage and sound field calibration are presented. Respondents to the survey were 418 ASHA certified audiologists, who answered questions on demographic variables, sound field testing conditions, and sound field calibration procedures. Demographic characteristics of the respondents indicate that they were representative of ASHA certified audiologists. Eighty-one percent of the respondents use sound field audiometry as part of their audiologic practice. Electroacoustic calibration of the sound field stimuli is done most often by an equipment technician, and only a small percentage of the respondents knew how the calibration was done. Results show a lack of standardization among sound field test rooms, great diversity in the stimuli used for sound field testing, and inconsistent calibration methods. Results indicate the need for standards and improved pre-service and in-service training in sound field calibration techniques.

Key Words: Calibration, loudspeakers, sound field testing

Sound field audiometry, in which the test stimuli are delivered through a loudspeaker instead of earphones, is commonly used in the clinical evaluation of difficult to test clients, such as infants, young children, and persons with developmental disabilities, as well as in the assessment of hearing aid benefit for adults and children.

When calibrated earphones are not being used, the interactions between test stimuli, room acoustics, and psychoacoustic perceptions in the listener become critical. Although the results of sound field testing are used routinely for making decisions about the magnitude of hearing loss and commensurate auditory expectations, as well as the need for and benefit from hearing aids, the current standard for audiometers (ANSI 3.6-1989) does not include recommendations for the calibration of stimuli used in sound field testing. The complexity of establishing a standard when there is so much variability among sound field environments has made standardization difficult. Instead, sound field calibration is only addressed in an Appendix, not as part of the official standard. Suggestions are made regarding the acoustic characteristics of the room, the location of the loudspeaker(s), the appropriate reference level for a speech signal in sound field, and the frequency response of the sound field, but there is no mention of calibration method nor standard reference levels for either warble tones or narrow bands of noise. These two signals are most commonly used during sound field measurement.

The American Speech-Language-Hearing Association (1991) recently published a tutorial on sound field measurement that discusses some of the issues encountered with sound field measurements, and offers suggestions to reduce or eliminate the problems.

The lack of standards is of particular concern because current research indicates that differences in speaker placement, sound field stimuli, and calibration methods can significantly affect threshold measurement (Stream and Dirks, 1974; Barry and Resnick, 1978; Orchik and Rintelmann, 1978; Stephens and Rintelmann, 1978; Morgan et al, 1979; Wilber, 1979, 1985; Dillon and Walker, 1980, 1981, 1982a, b; Walker and Dillon, 1983; Walker et al, 1984; Cox and McCormick, 1987).

Although the literature on sound field stimuli and calibration is incomplete and occasionally conflicting about best practice, the trend among researchers, supported by suggestions...
from the ASHA tutorial (1991), is to recommend the following for sound field testing.

1. Warbled pure tones, or secondarily, narrow bands of noise, but not unmodulated pure tones, should be used when stimuli are delivered through loudspeakers instead of earphones.
2. Characteristics of the warble tones should include sinusoidal or triangular waveforms, small frequency deviations, and large modulation rates.
3. Position of the listener in sound field should be carefully established and maintained, with the patient's chair always an equal distance from the loudspeaker, so the sound pressure level of the test signal at the patient's pinna is a known constant. The azimuth between the loudspeaker and the listener's ear should be kept at one of the recommended angles of 0, 45, or 90 degrees.
4. Calibration of the warble tones in sound field should be completed regularly through electroacoustic measurements, with the observed values compared to one of the sets of published normative values. The normative values most commonly discussed in the literature are those proposed by Wilber (1979, 1985), Morgan et al (1979), and Walker et al (1984).

The purposes of this study were: (1) to describe and analyze sound field stimuli, sound field test conditions, and sound field calibration procedures currently employed by audiologists nationwide and (2) to investigate the extent of agreement between current practice and recommended practice.

METHOD

To assess the current status of sound field use and calibration procedure in the United States, a questionnaire was sent to 942 ASHA certified audiologists selected by a random sample (every eighth name alphabetically, starting with a random chosen number).

The survey instrument instructed the respondents who use sound field testing in their clinical practice to answer questions in the areas of demographic variables, use of sound field testing, and calibration methods. Questions on the survey were derived from topics in the literature and from common practice in clinical audiology. Survey questions consisted of multiple choice answers for the respondents. The survey questionnaire appears as Appendix A.

Of the 942 surveys mailed in November, 1989, 5 were returned as not deliverable. A total of 418 surveys were returned (45%), which exceeds the value of 368 needed to be statistically representative (with 95% confidence that differences are not attributable to chance) of the 9000 ASHA certified audiologists (Krejcie and Morgan, 1970).

RESULTS

Analysis of the data shows that a majority of the 418 respondents (338 audiologists, 81%) use sound field testing in their clinical practice, and data from those respondents are summarized below. Although the survey instrument did not contain a request for more information, some of those who did not use sound field testing offered explanations, such as no longer in active practice or currently working in administrative positions. It is important to note, however, that over half of the audiologists surveyed did not return the questionnaire, so the respondents may be biased towards those who use sound field testing.

Respondents' Demographic Characteristics

Analyses of data from questions in Part 1 of the survey, General Information, were used to determine the representativeness of the sampled group of respondents to the larger population of ASHA certified audiologists.

Of the 338 responding audiologists who use sound field testing, most are female (71%), with Master's degrees (90%) and 1 to 10 years of experience (59%). Forty-eight of the 50 states were represented by the respondents, with only Delaware and Vermont not represented. Additionally, three respondents were from the District of Columbia, and one lived overseas. Using the U.S. census regions, the distribution of respondents was within 5 percent of the national population's regional distribution (U.S. Bureau of the Census, 1990).

Respondents work in a variety of settings, with the largest groups employed in a hospital or clinic (30%) or in a private practice setting (37%). Employment settings aggregated into the "other" category include a research laboratory, interdisciplinary clinic, industrial clinic, early intervention center, state health department, psychiatric center, and institutions for the developmentally disabled.

The age groups of clientele served varied among clinics. One third of the respondents reported that their facility serves adults most of...
Sound Field Test Usage and Test Conditions among Respondents

In the second section of the survey, respondents were asked to describe the sound field stimuli and sound field test conditions they used. Responses to the nine questions from Part 2 of the survey, Use of Sound Field Testing, were analyzed to determine if patterns exist in the sound field stimuli and sound field test conditions currently used by ASHA certified audiologists.

| Table 1 Characteristics of Respondents Who Use Sound Field Testing |
|--------------------------|--------------------------|
| **Percentage** | **n** |
| Gender | | |
| Male | 29 | 96 |
| Female | 71 | 240 |
| Highest earned degree | | |
| Master's | 90 | 303 |
| Doctorate | 9 | 30 |
| Other | 1 | 4 |
| No response | <1 | 1 |
| Years of employment in audiology | | |
| Less than 1 | <1 | 1 |
| 1 to 10 | 59 | 197 |
| 11 to 20 | 33 | 112 |
| Over 20 | 8 | 27 |
| No response | <1 | 1 |
| Type of employment setting | | |
| School | 11 | 36 |
| College or university | 7 | 23 |
| Hospital or clinic | 30 | 101 |
| Rehab or Sp/Hng facility | 8 | 26 |
| Private office | 37 | 126 |
| Other | 7 | 25 |
| No response | <1 | 1 |
| Age of clientele served at facility | | |
| Infant-preschool mostly (>75%) | 4 | 14 |
| School age mostly (>75%) | 6 | 19 |
| Adults mostly (>75%) | 34 | 116 |
| Infant-school mostly (>75%) | 8 | 26 |
| School-adults mostly (>75%) | 20 | 67 |
| All ages (no predominance) | 28 | 96 |

N = 338.

As shown in Table 3, sound field testing is used by over 70 percent of the respondents for testing infants, toddlers, and uncooperative clients who refuse earphones, as well as for performing hearing aid evaluations. Other purposes, such as the confirmation of earphone results and presurgical and postsurgical comparisons were reported by fewer than one of five respondents. Write-in responses showed that additional purposes for using sound field testing include: testing speech discrimination in noise, measuring the functional gain of hearing aids after fitting, measuring the thresholds of developmentally disabled clients of all ages, evaluating central auditory processing difficulties, conditioning groups of children for testing, verifying earplug attenuation, checking thresholds when collapsing ear canals are a problem, evaluating cochlear implant patients, evaluating auditory trainers, meeting the report requirements of an agency, demonstrating hearing loss and educating family members, and research.

Respondents administer sound field evaluations from under 5 to over 20 times per week, and nearly all use two loudspeakers for sound field testing (93%). The patient is most often placed at a 90 degree azimuth to the speakers (43%) or at an azimuth that depends on the type of testing being done (23%). Most respondents use warble tones (93%) and/or narrow bands of noise (66%) to obtain thresholds across frequencies. Surprisingly, some respondents (16%) re-
Table 4 Make and Model of Audiometers Used

<table>
<thead>
<tr>
<th>Make and Model</th>
<th>Percentage</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grason-Stadler GSI16</td>
<td>28</td>
<td>94</td>
</tr>
<tr>
<td>Grason-Stadler GSI10</td>
<td>16</td>
<td>54</td>
</tr>
<tr>
<td>Madsen OB822</td>
<td>14</td>
<td>46</td>
</tr>
<tr>
<td>All other models (39 models, each less than 5%)</td>
<td>42</td>
<td>139</td>
</tr>
</tbody>
</table>

N = 333.

port using pure tones in a sound field, despite the known problems of standing waves in sound field. Twenty-one audiologists reported using some other type of stimuli, including calibrated noisemakers and toys, filtered speech or noise, the Ling 5 Sound Test, filtered environmental sound tapes, or music to obtain frequency-related thresholds in sound field.

Forty-two different models of audiometers are used by the respondents, with three models (Grason-Stadler GSI16 and GSI10, Madsen OB822) accounting for over one half of the audiometers, as shown in Table 4. The other 39 models were each used by fewer than 5 percent of the respondents. As noted by Staab and Rintelmann (1972), different manufacturers vary widely in the frequency deviations, modulation rates, and waveforms of their warble tones.

Sound Field Calibration Techniques, Used by Respondents

The third section of the survey looked at the sound field calibration methods used by audiologists. Most respondents (74%) report that an equipment repair person is responsible for performing the sound field calibration. Included in this group are calibration technicians, specialists, or instrumentation and calibration service providers. It would be of great interest to know the calibration techniques of the equipment repair persons who frequently provide calibration service to audiologists. Only 10 percent of the audiologists are responsible for the calibration of their sound field system (Table 5). The group of “other” responsible persons included acoustical or staff engineers, biomedical personnel, vendors, former employees, or a rotation among audiologic staff.

Nearly all respondents (97%) report that their sound field stimuli are calibrated at least once a year, and 42 percent calibrate at least twice a year.

The most frequently reported method for performing the sound field calibration (Table 6) was with the use of electroacoustic normative values (58%), although the second most frequent answer was “Don’t know” (18%). The “other” category included several respondents who indicated that a sound level meter was used, but did not specify the method.

Of the subgroup of 240 respondents who use the electroacoustic calibration method, either alone or in combination with another method, over 60 percent were unable to give the source for the normative values used in their clinics, as shown in Table 7.

Of the other 40 percent who cited values, those proposed by Morgan et al (1979) were used most often, followed distantly by those proposed by Wilber (1979), and Walker et al (1984). A number of respondents also gave normative values that were not consistent with any proposed in the research literature. In other words, less than one third of the respondents who calibrate electroacoustically know and use normative values substantiated in the literature. When viewed as a percentage of all respondents who use loudspeakers, only 20 percent claim to

Table 5 Responsibility for Sound Field Calibration

<table>
<thead>
<tr>
<th>Responsibility for Sound Field Calibration</th>
<th>Percentage</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respondent</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>Another audiologist</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Equipment repair person</td>
<td>74</td>
<td>250</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>38</td>
</tr>
</tbody>
</table>

N = 337.

Table 6 Method of Sound Field Calibration

<table>
<thead>
<tr>
<th>Method of Sound Field Calibration</th>
<th>Percentage</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biologic calibration</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Electroacoustic calibration</td>
<td>58</td>
<td>197</td>
</tr>
<tr>
<td>No calibration of loudspeaker</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Combination of methods</td>
<td>13</td>
<td>43</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Don’t know</td>
<td>18</td>
<td>60</td>
</tr>
</tbody>
</table>

N = 337.

Table 7 Reference Values Used for Electroacoustic Calibration

<table>
<thead>
<tr>
<th>Reference Values Used for Electroacoustic Calibration</th>
<th>Percentage</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morgan, Dirks, and Bower (1979)</td>
<td>28</td>
<td>68</td>
</tr>
<tr>
<td>Walker, Dillon, and Byrne (1984)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Wilber (1979)</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>ANSI S3.6-1969</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ANSI S3.6-1989</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Self-generated norms</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Don’t know</td>
<td>62</td>
<td>149</td>
</tr>
</tbody>
</table>

N = 240.
use recommended normative values for calibration, in spite of the fact that sound field test results are used frequently for important diagnostic decisions.

Even the respondents who used the biologic or real ear method for calibrating were not consistent in their methodology. Most (42 of 54, or 78%) used less than 10 normal hearing subjects. Slightly over one half (28 of 54, or 55%) corrected the subjects' measured sound field thresholds by their earphone thresholds. Thirty percent of the respondents who used a biologic calibration method (16 of 54) occluded the nontest ear while obtaining thresholds. Since binaural free field listening is known to improve discrete frequency hearing acuity by an average of 6 dB over monaural earphone listening (Sivian and White, 1933; Dirks et al, 1972), failure to occlude the nontest ear in sound field (for both calibration and testing) would result in nonequivalent thresholds between earphones and loudspeakers.

When the respondents were asked where they learned about sound field calibration, most (91%) indicated that they got their information from their university training programs. However, the questionnaire did not ascertain if the university coursework on calibration included issues that are unique to sound field measurement. Some audiologists have solicited or received additional knowledge through on-the-job training (48%), independent reading (28%), and workshops (11%).

Sound Field Usage and Calibration Compared to Acceptable Standards of Practice

One additional question that arose as a result of this investigation was “To what extent does the respondents’ practice in sound field audiometry match acceptable practice?” For the purpose of this study, the author designated a standard of acceptable practice to include the following four criteria.

1. Stimuli delivered through loudspeakers to obtain frequency dependent thresholds should be warble tones or narrow bands of noise, but not pure tones (Morgan et al, 1979; Wilber, 1979, 1985; Byrne and Dillon, 1981; Goldberg, 1981; Dillon and Walker, 1982b; Walker and Dillon, 1983; Walker et al, 1984; Arlinger and Jerlvall, 1987; ASHA, 1991).

2. The method for calibration of sound field stimuli should include electroacoustic measurements, either as the sole method or in combination with biologic calibration (Stream and Dirks, 1974; Morgan et al, 1979; Walker et al, 1984; Wilber, 1985; Cox and McCormick, 1987; ASHA, 1991).

3. Electroacoustic measurements obtained should be compared to one of the sets of normative values reported in the literature (Stream and Dirks, 1974; Morgan et al, 1979; Wilber, 1979; Walker et al, 1984; Cox and McCormick, 1987; ASHA, 1991).

4. Calibration of sound field stimuli intensities should be done at least four times a year (ASHA, 1978, revised in 1989 to a standard that does not specify any time period for recalibration; Wilber, 1985).

When the respondents’ data were analyzed, only 7 percent of the audiologists (23 of 338) met all four of the criteria for a standard of acceptable practice. As shown in Table 8, 27 percent of the respondents met at least three criteria, 71 percent met at least two criteria, and almost all (99%) met at least one criterion.

CONCLUSIONS

The most basic assumption in sound field testing is that the thresholds obtained through loudspeakers correlate with those obtained under earphones. Research shows that the position of the loudspeakers, the characteristics of the stimuli used for testing, and the calibration of the sound field signals all affect the measured thresholds of the listener. In contrast, the results of this survey show a distinct lack of standardization among sound field test rooms, a variety of stimuli used for sound field testing, and inconsistent calibration methods. Even without consensus about “best practice” in sound field audiometry, the validity of test results obtained via loudspeakers in many test situations must be reconsidered carefully. Uniformity among audiologists and the validity of sound field test results are critical, especially since PL 99-457, Education of the Handicapped Act Amendments of 1986, now mandates the identification and habilitation of handicapped and at-risk preschool children. As a result, there will be more evaluations of infants and toddlers, and therefore more frequent use of sound field test techniques.

More specifically, audiologists may be making incorrect assumptions about the extent of hearing loss, need for amplification, improvement from a hearing aid, improvement or decrease in hearing over time, improvement in hearing after surgery, or eligibility for special education. Although the measured sound field
Table 8 Number and Percentage of Respondents who Meet Standards of Acceptable Practice in Sound Field Testing

<table>
<thead>
<tr>
<th>Criteria met</th>
<th>n</th>
<th>Percentage</th>
<th>Cumulative n</th>
<th>Cumulative Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Criteria met</td>
<td>23</td>
<td>7</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td>3 Criteria met</td>
<td>68</td>
<td>20</td>
<td>91</td>
<td>27</td>
</tr>
<tr>
<td>2 Criteria met</td>
<td>150</td>
<td>44</td>
<td>241</td>
<td>71</td>
</tr>
<tr>
<td>1 Criterion met</td>
<td>94</td>
<td>28</td>
<td>335</td>
<td>99</td>
</tr>
</tbody>
</table>

N = 338.

thresholds indicate a certain audiologic conclusion and recommendation for the patient, instrumentation factors related to calibration may compromise the validity of the results obtained.

Results of this survey indicate a need for improvement in graduate training programs and postgraduate professional development in the area of sound field testing and calibration, and a prerequisite for improved training may be the development of standards. Currently, ANSI S3.6-1989 contains an Appendix on sound field speech testing that recommends a standard reference sound pressure level of 13 dB for binaural listening for spondee speech words delivered at a 40 to 60 degree azimuth, consistent with the findings of Dirks et al (1972). Although a reference value for speech delivered via a loudspeaker exists, no standards for frequency dependent stimuli are included. In the interim, practitioners should use one of the published sets of equivalent sound pressure levels as references to calibrate their warble tone signals in sound field.

The ASHA tutorial on sound field measurement (1991) recommends a different set of values for each of the three most common loudspeaker/listener azimuths: Walker et al's (1984) values for 0 and 90 degree azimuths and Morgan et al's (1979) values for 45 degree azimuth. The results of this study would support use of the levels recommended by Morgan et al (1979) as the most logical selection for an interim standard, because values are included in a single reference for three different azimuths, and they are the values currently used by most audiologists who report knowledge of a source.

REFERENCES


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APPENDIX A
Survey Questionnaire

The purpose of this survey is to obtain information about sound field audiometry and calibration procedures used by audiologists. Your cooperation in completing this survey is appreciated. A postage-paid envelope has been included for your convenience in returning the survey.

Do you use sound field testing (through loudspeakers) as part of your audiological practice?

___ No. Please return the questionnaire unanswered.
___ Yes. Please continue with the questionnaire. If you work in more than one facility, please answer the questions as they pertain to the setting and sound booth where sound field audiometry is used most frequently. There are three sections to the questionnaire, with a total of 23 questions.

General Information (6 Questions)

1. In what state do you practice audiology? 

2. What is your gender?
   ___ Male
   ___ Female

3. What is your highest earned academic degree?
   ___ B.S. or B.A.
   ___ M.A. or M.S.
   ___ Ph.D. or Ed.D.
   ___ Other (__________________________________________ )

4. How many years have you worked in audiology?
   ___ less than 1
   ___ 1 to 10
   ___ 11 to 20
   ___ over 20
5. In what type of employment setting do you most often use sound field testing?
   - school (incl. preschool or special school)
   - college or university
   - hospital or clinic
   - rehabilitation or speech-hearing facility
   - private office (incl. physician's office)
   - hearing aid dispensary
   - other (describe: ____________________________)

6. Please estimate the percentage of your clientele by age group:
   - % preschool (under 5 years old)
   - % school age (5–21 years)
   - % adult (over 21 years old)
   100% Total

Use of Sound Field Testing (9 Questions)

1. For what purpose(s) do you use sound field testing? (CHECK ALL THAT APPLY)
   - testing infants and toddlers
   - testing uncooperative clients who refuse earphones
   - hearing aid evaluations
   - confirmation of earphone results
   - pre-surgical and post-surgical audiograms
   - other (describe: ____________________________)

2. Approximately how many times per week do you use sound field testing?
   - less than 5
   - 6 to 10
   - 11 to 20
   - over 20

3. How many operational loudspeakers do you use in your most frequently used sound booth?
   - 1
   - 2
   - 3
   - 4
   - more than 4

4. Please draw the location of the loudspeaker(s) and the position of the patient in the booth you use most frequently:

5. When doing sound field testing, how do you seat the patient in the room?
   - 0° azimuth (nose facing loudspeaker)
   - 90° azimuth (ear facing loudspeaker)
   - 45° azimuth (loudspeaker at angle between nose and ear)
   - other (describe: ____________________________)

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6. What stimuli do you use to obtain thresholds across frequency in sound field? (CHECK ALL THAT APPLY)
   - pure tones
   - warble tones
   - narrow band noise
   - other (describe: ______________________)

7. What is the make and model of the audiometer you use for sound field testing?
   Make ______________________
   Model ______________________

8. What are the maximum output levels (in dB HL) for warble tones in your sound field for each of the following frequencies?
   250 Hz ______
   500 Hz ______
   1000 Hz ______
   1500 Hz ______
   2000 Hz ______
   4000 Hz ______
   6000 Hz ______

9. What are the maximum output levels (in dB HL) for narrow band noise in your sound field for each of the following frequencies?
   250 Hz ______
   500 Hz ______
   1000 Hz ______
   1500 Hz ______
   2000 Hz ______
   4000 Hz ______
   6000 Hz ______

Calibration of Sound Field Stimuli (8 Questions)

1. Who is responsible for performing the sound field calibration?
   - I am
   - another audiologist in this facility
   - another audiologist in another facility
   - an equipment repairperson
   - I don't know
   - other (describe: ______________________)

2. On the average, how often is your sound field output calibrated?
   - more often than once a month
   - every three months
   - every six months
   - once a year
   - less than once a year

3. By what method do you calibrate your sound field output?
   - biological calibration using normal subjects
   - substitution calibration using sound pressure level measurements of normal subjects' thresholds
   - electroacoustic calibration using normative data
   - no calibration of loudspeaker output, only earphone output
   - a combination of methods (describe: ______________________)
   - other (describe: ______________________)
   - don't know
4. If you use the biological calibration method, please answer the following questions. If not, go on to Question #5.
   a. How many normal hearing subjects do you use? _________________
   b. Do you occlude one ear while testing? _________________
   c. Do you correct each subject’s sound field thresholds by their earphone thresholds?

5. If you use the calibration by substitution method, please answer the following questions. If not, go on to Question #6.
   a. How many normal hearing subjects do you use? _________________
   b. Do you occlude one ear while testing? _________________
   c. How do you position the substitution microphone in the test room?

6. If you use the electroacoustic calibration method, please answer the following questions. If not, go on to Question #7.
   a. What are the normative values you use at each frequency?
      - dB @ 250 Hz
      - dB @ 500 Hz
      - dB @ 1000 Hz
      - dB @ 2000 Hz
      - dB @ 4000 Hz
      - dB @ 6000 Hz
   b. Are these values in dB SPL or dB HL? (CIRCLE ONE)
   c. Where did you get these normative values?
      - Morgan, Dirks, and Bower (1979)
      - Walker, Dillon, and Byrne (1984)
      - Wilber (1979)
      - ISO R266 (1961)
      - ANSI S3.6-1969
      - ANSI S3.6-1989
      - self-generated norms
      - uncertain of source
      - other (describe: __________________________)