National Health and Nutrition Examination Survey (NHANES)

Audiometry Procedures Manual

January 2016

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Introduction 1

1.1 History and Overview of Hearing Examinations in NHANES

Hearing is important. It is the sensory channel by which we are connected to other people, warned of impending dangers, and entertained by music and laughter. Good hearing enables us to perceive the laughter of friends, the cries of a baby, and the breeze rustling through the trees. Without it, we feel isolated from the world around us and frustrated by our inability to fully understand the flurry of activity that surrounds us. Man is a social creature, and hearing is critical to his ability to function as such.

Our sense of hearing is truly remarkable. The smallest bones and the smallest muscles in the human body are contained within the ear. The ear can perceive vibrations which move barely the distance of an atom. It can also withstand the vibrations of much louder sounds, though sounds which are too intense can rip apart the tiny auditory structures. Our ears never rest—even when we are sleeping, our ears continue to respond to sounds (though our brains generally take a break from processing the auditory signals). Perhaps because of its delicate nature and constant function, hearing is the easiest of our five senses to lose.

Hearing loss is a widespread problem. Recent statistics indicate that nearly 40 million people in the United States have some degree of hearing impairment (CDC, 2012; Hoffman et al., 2012). In fact, more people have hearing loss than any other disability (Huntington & Swanson, 2012). While the prevalence of hearing loss increases with age, it is not merely a problem of the elderly. Two or three out of every 1,000 children born in the U.S. are deaf or hard of hearing. Approximately 17 out of every 1,000 children under age 18 have a hearing loss. Among adults, disabling hearing loss occurs in about 2 percent of those aged 45 to 54, 8.5 percent of those aged 55 to 64, nearly 25 percent of those aged 65 to 74, and in half of those who are 75 and older. For reasons which are not fully understood, hearing loss is more prevalent and more severe on average in men than in women. Less than 30 percent of adults who could benefit from a hearing aid actually use one (http://www.nidcd.nih.gov/health/statistics/quick.htm).

Furthermore, approximately 50 million Americans report tinnitus (ringing in the ears), a condition which can be as disabling as hearing loss. Over sixteen million of these individuals suffer frequent tinnitus and about 2 million experience tinnitus so severe that it interferes with their daily life (Heller, 2003; Shagorodsky et al., 2010; ATA, 2012).

Hearing loss can be caused by a myriad of factors—age, noise exposure (occupational or recreational), developmental syndromes, infectious disease, physical trauma, ototoxic drugs, and chemicals—all of which are further influenced by genetic susceptibility. Hearing loss is an "invisible" impairment; that is, there are usually no obvious external signs of the damage that is done. In children, it often goes undetected for some time while parents, educators, or health professionals mistake the signs of hearing difficulty for behavior problems or learning disabilities. In older individuals, hearing loss usually develops gradually and insidiously over time. Because of this, hearing loss is frequently misinterpreted by the individual as "mumbling" by others or "getting used to" sounds. Others often misinterpret someone's hearing difficulty as inattentiveness or dementia. Often, extensive and irreparable damage has been done to the auditory system before it is noticed.

The National Center for Health Statistics (NCHS) has regularly included evaluations of the auditory system in its health examination surveys. These evaluations have included one or more of the following: a brief medical examination of the ear (otoscopy), interview questions regarding hearing ability and ear diseases, immittance (a test of middle ear function), pure tone air conduction audiometry, pure tone bone conduction audiometry, and/or speech discrimination testing. Sometimes these evaluations have been done on all NHANES examinees, and some surveys included hearing evaluations on only a subset of examinees (such as children or adults). Table 1-1 summarizes the audiometric procedures included in each of the health examination surveys since 1960:

As the table indicates, the general adult population of the United States has received audiometric testing as part of these national surveys during four cycles: 1960-1962, 1971-1974, and 1999-2004, and 2011-2012. Shifts in national demographics, diversification of the workforce and changing occupational exposures, increases in environmental noise, emergence of new illnesses, advances in clinical medicine, and development of new pharmaceuticals over the course of the fifty years between the initial assessment of adults in 1960 and now make it necessary to periodically reexamine the prevalence of hearing disorders in the U.S. adult population. For this reason, the audiometric testing that will be conducted in the current NHANES cycle is very important.

A special emphasis of the NHANES hearing component will be collection of data to aid in studies of hearing loss induced by noise and/or other ototraumatic agents (such as lead, solvents, and carbon monoxide). It is estimated that 22 million U.S. workers are exposed to potentially hazardous noise (Tak et al., 2009) and an additional 9 million are exposed to ototoxic materials in their occupation (National Institute for Occupational Safety and Health (NIOSH), 1996). Many more are similarly exposed through recreational or environmental sources. As many as 26 million U.S. adults have developed a hearing loss as the result of their noise exposure—hearing losses which are nearly all preventable. The NHANES questionnaires include items about noise exposures on- and off-the-job so that cohorts of exposed and unexposed individuals can be compared. This data will also be available as a comparison data set in future studies of hearing loss, and as a baseline to monitor progress in prevention.

Table 1-1. Review of NHANES audiometric procedures

				Pure tone testing									
Survey	Years	Age	Immittance	250	500	1000	2000	3000	4000	6000	8000	Bone	Speech
NHES I*	1960-1962	18-74	✓		✓	✓	✓	✓	✓	✓			
NHES II	1963-1965	6-11		✓	✓	✓	✓	✓	✓	✓	✓		
NHES III	1966-1970	12-17		✓	✓	✓	✓	✓	✓	✓	✓		
NHANES I	1971-1974	25-74			✓	✓	✓		✓			✓	
Augmented	1974-1975	25-74			✓	✓	✓		✓				✓
NHANES II	1976-1980	4-19			✓	✓	✓		✓				
HHANES**	1982-1984	6-74	✓		✓	✓	✓		✓				
NHANES III	1988-1994	6-19	✓		✓	✓	✓	✓	✓	✓	✓		
NHANES 99-04	1999-2004	20-69	✓		✓	✓	✓	✓	✓	✓	✓		
NHANES 05-06	2005-2006	12-19, 70+	✓		✓	✓	✓	✓	✓	✓	✓		
NHANES 07-08	2007-2008	12-19	✓		✓	✓	✓	✓	✓	✓	✓		
NHANES 09-10	2009-2010	12-19, 70+	✓		✓	✓	✓	✓	✓	✓	✓		
NHANES 11-12	2011-2012	20-69	✓		✓	✓	✓	✓	✓	✓	✓		

* National Health Examination Survey.

**Hispanic Health and Nutrition Examination Survey.

Although in the past, NHANES has been a periodic survey, it is currently authorized to run continuously. This has made it possible to use NHANES to collect data to monitor progress toward health objectives outlined in Healthy People 2020—the prevention agenda for the Nation http://www.healthypeople.gov/ Healthy People is a national health promotion and disease prevention initiative created by the Federal Government to provide a framework for monitoring progress toward identifying and reducing significant, preventable health problems, increasing the quality and years of healthy life, and eliminating health disparities. The current Healthy People program includes eleven hearing-related objectives, at least five of which rely on data collected through NHANES for baseline measurements or monitoring progress. These objectives include:

- ENT-VSL-3: Increase the proportion of persons with hearing impairments who have ever used a hearing aid or assistive listening devices or who have cochlear implants;
- ENT-VSL-4: Increase the proportion of persons who have had a hearing examination on schedule;
- ENT-VSL-6: Increase the use of hearing protection devices;
- ENT-VSL-7: Reduce the proportion of adolescents who have elevated hearing thresholds, or audiometric notches, in high frequencies (3, 4, or 6 kHz) in both ears, signifying noise-induced hearing loss; and
- ENT-VSL-8: Reduce the proportion of adults who have elevated hearing thresholds, or audiometric notches, in high frequencies (3, 4, or 6 kHz) in both ears, signifying noise-induced hearing loss.

(See http://www.healthypeople.gov/2020/topics-objectives/topic/hearing-and-other-sensory-or-communication-disorders/objectives.)

The current protocol for the hearing examination component of the NHANES was developed by NCHS in collaboration with NIOSH and the National Institute on Deafness and Other Communication Disorders (NIDCD) in 1999. The examination includes several parts:

- Questionnaire items—hearing-related questions included on both the household questionnaire (self-reported hearing ability; use of hearing aids and hearing protective devices; relevant medical history; noise exposure history) and in the mobile examination center questionnaire (current conditions that could affect the results of audiometric testing);
- Otoscopy—a cursory physical examination of the outer ear;
- Acoustic immittance—an objective evaluation of middle ear function; and
- Pure tone air conduction audiometry—a basic evaluation of hearing sensitivity.

Information obtained through the audiometric examinations conducted in the NHANES will provide data for which there is ever a need. Researchers throughout the United States will utilize these data as a reference population for studies of hearing ability in particular subpopulations. The data will also provide a baseline from which to measure future progress in preventing hearing loss from noise, ototoxic exposures, medical conditions, and the like. Specifically, the goals of the current NHANES hearing component are to:

1. Establish technically valid and statistically representative threshold data describing the hearing sensitivity of the U.S. population aged 20-69 years stratified by gender, race, socioeconomic status, geographic region, and other variables;

2. Define the prevalence of hearing impairment among U.S. adults aged 20-69 years, and quantify the association between prevalence and factors such as noise exposure, medical conditions, ototoxicity from chemical exposures or pharmaceuticals, etc.; and

3. Monitor progress toward Healthy People 2020 hearing-related goals.

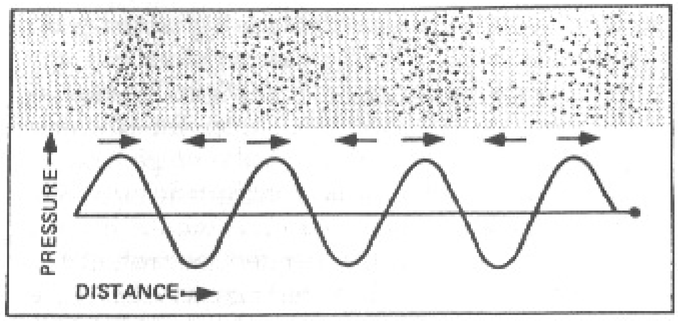
You, as a health technologist for the NHANES, play a crucial role in collecting these important data. You will be responsible for conducting the examinations, monitoring the equipment calibration and test environment, maintaining the equipment and troubleshooting difficulties, and keeping relevant records. You will not be expected to interpret the test results or provide feedback to the study participants (SPs). You will receive extensive training to ensure that you understand and are able to carry out these protocols. Nationally representative surveys such as NHANES are expensive and require significant planning and oversight to ensure technically accurate information. Please always follow the standardized procedures that have been developed for the hearing component, which are outlined in this manual. While some of the procedures may appear to be simple, it is critical that you follow them exactly, so that data on each examinee are obtained in a uniform manner. If you are ever uncertain about any procedure or examinee, always ask your supervisor.

Before discussing the specific protocol for the NHANES hearing component, it is important to cover some basic information about sound and audition. A rudimentary knowledge of the physiology of hearing is essential to understanding how to test hearing.

1.2 Basic Principles of Sound

Sound can be defined in the physical sense as a series of pressure waves caused by a vibrating object and propagated through an elastic medium (see Figure 1-1). In other words, sound is initiated when an object begins to vibrate. As the object moves back and forth, it “bumps into” molecules in the surrounding area, forcing them to move also. These displaced molecules in turn put pressure on other molecules, and thus the sound wave is propagated. Because the molecules return to their original resting position following displacement, sound is said to occur in an “elastic” medium.

Figure 1-1. Schematic representation of sound propagation



The small dots in the top of the diagram represent air molecules moving back and forth from their resting position, creating pressure "waves." The lower part of the diagram depicts the pressure wave graphically. (From Suter A.H. *Hearing Conservation Manual*, 3rd Edition. Council for Accreditation in Occupational Hearing Conservation, Milwaukee, 1993.)

In the physiological sense, sound can be defined as the sensation evoked in the auditory system by these pressure changes. This will be discussed further in Section 1.3.

Sound may be characterized along three main parameters: frequency, intensity, and complexity. Frequency is the rate of the sound pressure waves, or how often the molecules are displaced in a given period of time. Frequency is measured in Hertz (Hz), or cycles per second, and is perceived as pitch. Lower pitched sounds (such as the rumble of traffic or a man's speaking voice) are lower in frequency; higher pitched sounds (such as a whistle or a baby's cry) have higher frequencies.

Intensity refers to the amplitude of the pressure waves, or how far the molecules are displaced from their original position. Amplitude is measured in decibels and is perceived as volume, or loudness. Low amplitude sounds (in which the molecules are displaced only a little bit) are perceived as "quiet" and high amplitude sounds (in which the displacements are larger) are perceived as "loud."

Complexity refers to the interaction of the various frequencies and intensities that make up a sound. For example, a pure tone is a sound that is made up of only one frequency and one intensity. Most sounds are made up of many frequencies at different intensities combined to make a very complex signal. Complexity is perceived as sound quality or timbre. If a flute and violin are playing the same note at the same volume, complexity is the parameter of sound that allows us to distinguish between the two instruments.

Within the context of NHANES, we will be concerned primarily with the frequency and intensity of signals. The human ear is responsive to frequencies from about 20 to 20,000 Hz, but not equally so. It is most sensitive from about 1000 to 3000 Hz; and the frequencies most necessary for the understanding of speech are 500 to 4000 Hz. Audiometry conducted as part of the current NHANES will include test frequencies from 500 to 8000 Hz.

Test frequencies in audiometry are derived from the musical scale, and are generally octave intervals. An octave is a tone with a frequency that is exactly twice that of a reference tone. Therefore, the basic audiometric test frequencies are 500, 1000, 2000, 4000, and 8000 Hz. In addition, testing is often done at 3000 and 6000 Hz (sometimes called the inter-octave frequencies) because these frequencies are useful in identifying hearing losses due to noise exposure.

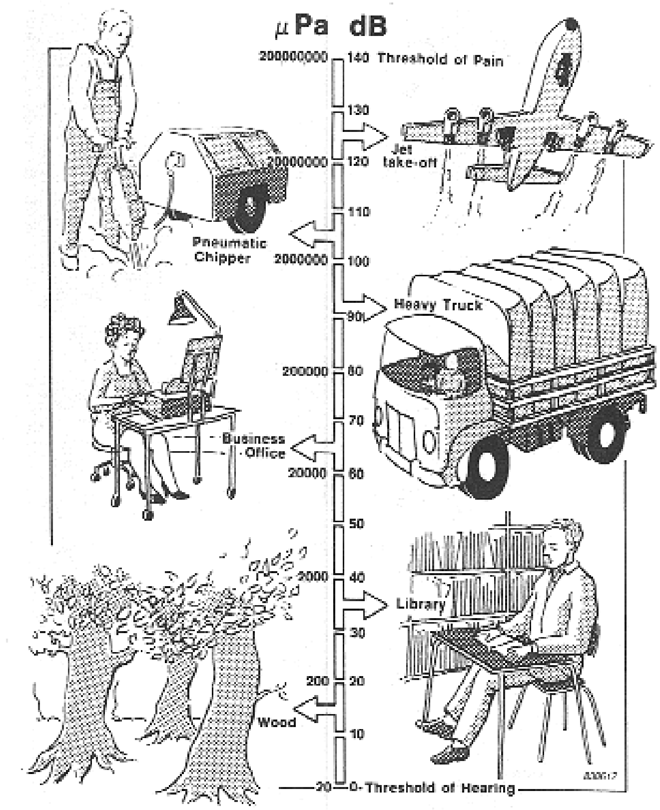
Intensity is a little more complicated. Remember that intensity refers to amplitude, or how far the molecules are displaced from their resting position by the vibrating object that is creating the sound. The farther the molecules are displaced, the greater pressure they place on neighboring molecules. Thus, intensity is measured in units of pressure; the higher the pressure, the louder the sound.

However, the difficulty is that the human ear is responsive to a very wide range of pressures. The pressure of a sound that is just barely audible to a young, normal-hearing listener is approximately 20 µPa (the µPa—micropascal—is a unit for measuring pressure). The pressure of a sound that is painfully loud could be about 200,000,000 µPa. Because it is a bit cumbersome to use such a large range to quantify intensity, we convert the pressure measurements to decibels. In decibels, the human ear is responsive to intensities from 0 dB to 140 dB—a much more manageable range. Figure 1-2 illustrates the sound levels of some common activities and shows the relationship between sound pressure in micropascals and sound level in decibels.

The decibel scale is logarithmic rather than linear; this means that the difference in actual sound pressure from one decibel to the next increases as the decibel level increases. For example, the increase in pressure from 20 to 40 dB is not the same as the increase in pressure from 40 to 60 dB. As you can see from the scale in Figure 1-2, pressure increases by 1800 µPa from 20 to 40 dB, but pressure increases by 18,000 µPa from 40 to 60 dB. Because of the logarithmic nature of the scale, decibels cannot be added and subtracted in the usual way. Two independent 90 dB sound sources produce a sound level of about 93 dB when they are put together, not 180 dB.

There are several different decibel scales used in measuring sound and hearing. When measuring sound levels at different frequencies in the environment (for example, when you measure the background noise levels in the test room as described in Section 2.5.2), the **sound pressure level** scale is used; results are recorded in **dB SPL.** When measuring an individual's hearing thresholds (for example, when doing pure tone audiometry as described in Section 3.5.3), the **hearing level** scale is used; results are recorded in **dB HL.** A measurement of 30 dB SPL is not the same as a measurement of 30 dB HL.

Figure 1-2. Sound levels of various activities



The intensity of the sound is shown in micropascals on the left and decibels on the right. (From Suter, A.H. *Hearing Conservation Manual*, 3rd Edition. Council for Accreditation in Occupational Hearing Conservation, Milwaukee, 1993).

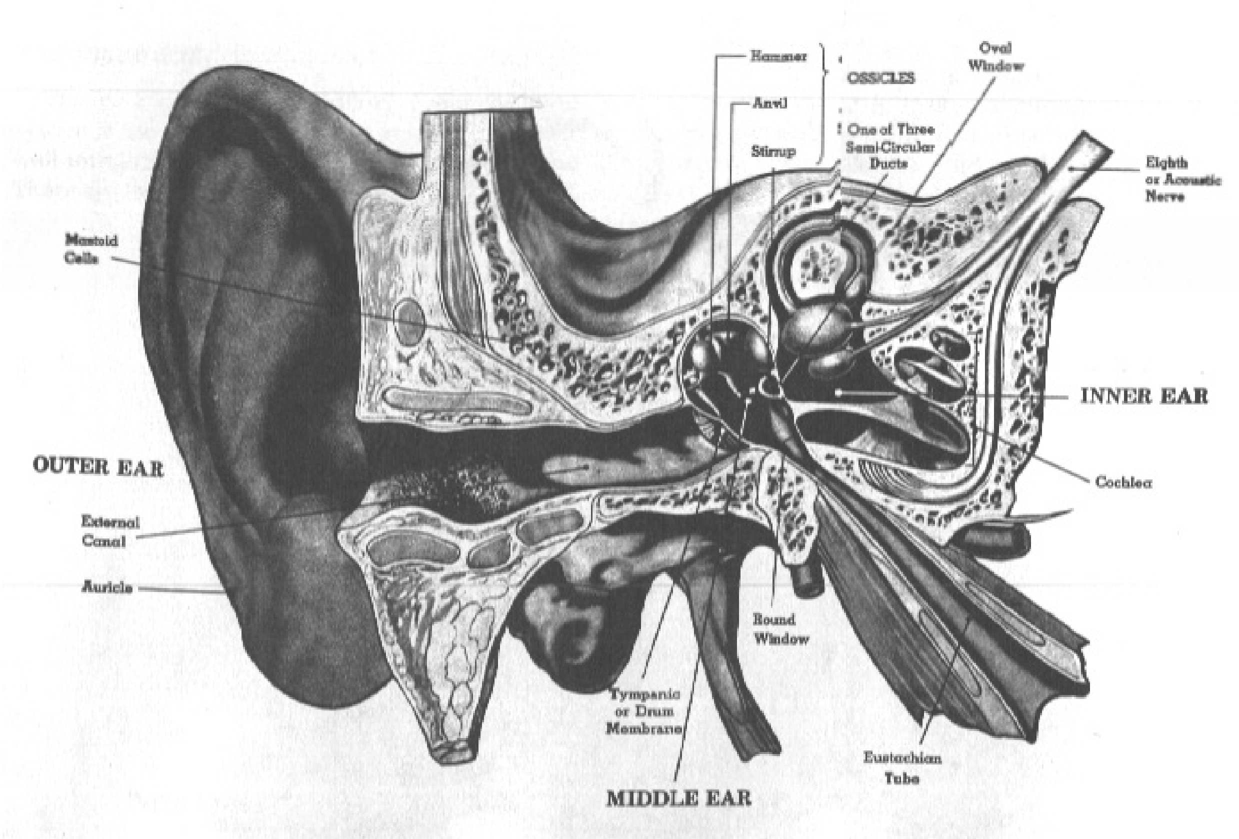
Finally, it is important to note that a measurement of 0 dB does not mean that there is no sound at all—just like a temperature of 0°F does not mean that there is no heat at all. There are sounds that are quieter than 0 dB, and these sounds are measured in negative decibels in the same way that temperatures colder than 0° are measured in negative degrees.

1.3 Basic Principles of Audition

When you think of the ear, you probably think primarily of the two most visible portions of the auditory system that are located on either side of the head. However, the ear is much more than this.

The ear actually has four main parts: the outer ear, the middle ear, the inner ear, and the auditory neural system (see Figure 1-3).

Figure 1-3. Schematic diagram of the ear



(From Suter A.H. *Hearing Conservation Manual*, 3rd Edition. Council for Accreditation in Occupational Hearing Conservation, Milwaukee, 1993).

The outer ear consists of the auricle (sometimes called the pinna) and the ear canal (also called the external auditory meatus). The outer ear functions primarily to funnel sound into the ear, and to modify, to some extent, the acoustic signal. The shape and size of the ear canal cause it to amplify signals with frequencies of approximately 2000-3000 Hz; this is the main reason that human hearing is most sensitive in this frequency range.

The middle ear consists of the eardrum (or the tympanic membrane); three tiny bones (or ossicles) called the malleus, the incus, and the stapes; and two small muscles. The primary function of the middle ear is to transform the acoustic signal into mechanical vibration. The middle ear muscles form part of a reflex arc (known as the acoustic reflex), which provides some small amount of protection against loud sounds. The middle ear also houses an opening to the eustachian tube, which connects this part of the ear to the back of the throat. The eustachian tube permits ventilation of the middle ear space, which maintains a balance in air pressure on either side of the eardrum; this balance is necessary in order for the eardrum to respond to sound most efficiently.

The inner ear consists of the cochlea, which is contained within a spiral opening in the temporal bone of the skull. The cochlea is divided into three parallel, fluid-filled ducts. The upper and lower ducts are connected at one end; and a wave is set up in them as the ossicles vibrate in response to sound. The middle duct contains rows of tiny hair cells. These hair cells are bent as the wave comes to a peak; the bending of the hair cells stimulates the auditory nerve. The inner ear therefore serves to transform the mechanical vibrations from the middle ear into neural impulses.

Finally, the auditory neural system consists of the auditory nerve and the auditory areas of the cortex. This system carries the neural impulses to the brain and interprets them.

The auditory system is complete and possesses normal adult sensory function approximately halfway through prenatal development. Auditory sensitivity reaches its peak at adolescence and then begins a very gradual decline. Barring any insult that would accelerate the decline (such as noise or disease), the reduction in sensitivity is not generally clinically measurable until at least the third decade of life. After about age 60, hearing sensitivity decreases by an average of about 10 dB per decade. The decrease in hearing sensitivity begins at the highest frequencies and gradually progresses to include the middle and low frequencies. Hearing loss due to age-related changes is called presbycusis.

There are a number of other age-related changes that occur in the ear. The cartilage in the outer ear and the ear canal begins to deteriorate, causing the auricle and canal opening to become very soft; this can cause a condition known as "canal collapse," which can affect hearing test results (see Section 3.3.3). Additionally, the auricle gets larger and the ear canal narrows, potentially shifting the resonant characteristics of the outer ear. Cerumen becomes drier, which—in combination with narrower ear canals—can impede the natural expulsion of wax from the ear. Cerumen becomes more easily trapped, potentially partially or completely blocking the ear canal and causing a temporary loss of hearing. The tympanic membrane may become less flexible and there can be slight degenerative changes in the joints between the bones in the middle ear. However, none of these issues are typically significant enough to affect hearing sensitivity (Chisolm et al., 2003).

1.4 Basic Principles of Hearing Loss

Dysfunctions anywhere along the auditory pathway can cause hearing loss. Most hearing losses (such as age- and noise-related hearing losses) occur gradually over time, although sudden hearing losses (such as from infection or trauma) are possible. Many sudden hearing losses are idiopathic—meaning the cause remains unknown. Hearing losses can be stable (not changing over time), progressive (getting worse over time), or fluctuating (getting sometimes better and sometimes worse). Hearing losses may be divided into several categories based on where in the ear the impairment is located (the type of hearing loss), how severely the impairment affects a person's hearing sensitivity (the **degree** of hearing loss), and which ears are affected (the **laterality** of the hearing loss).

Hearing losses that are caused by a problem in the external or middle ear are called conductive hearing losses, because the difficulty lies in the conduction of sound to the cochlea. For example, excessive wax in the ear canal, fluid in the middle ear brought on by an infection, or a discontinuity between the ossicles would prevent sounds from reaching the inner ear efficiently. These types of hearing losses are often medically or surgically correctable.

Hearing losses that are caused by a problem in the inner ear or along the auditory nerve are called sensorineural hearing losses, because the difficulty lies in the ability of the cochlea to sense the sound or the ability of the nerve to carry the signal to the brain. Damage to the cochlear hair cells due to age-related deterioration, repeated noise exposure, or a tumor on the auditory nerve are examples of etiologies that would lead to sensorineural hearing impairment. These types of hearing losses are not usually medically correctable. Often, sensorineural hearing loss can be remediated to a certain extent with hearing aids. However, while hearing aid technology has improved immensely over the past few years, hearing aids do not restore normal hearing in the same sense that eyeglasses restore normal vision.

A hearing loss can also be "mixed"—that is, partly conductive and partly sensorineural. For example, if a person has a noise-induced hearing loss and then develops an ear infection, he would have a mixed hearing loss. The conductive part of the hearing loss may resolve when the infection clears up, but the sensorineural portion of a mixed hearing loss is generally permanent.

Classifying degree of hearing loss is much more complex. The severity of the handicap due to abnormal hearing thresholds depends on a number of interrelated factors, such as the age of the individual, the age at which the impairment was first sustained, the point of damage within the auditory system, the individual's communicative environment and needs, the presence or absence of other illnesses or sensory deficits, etc. For example, a person who has had significant hearing loss since birth is affected differently than someone who acquires a similar hearing loss after reaching adulthood. A person with a conductive hearing loss (which causes simply a reduction in the audibility of sounds) is affected differently than someone with a sensorineural hearing loss (which often causes a reduction in the intelligibility as well as the audibility of sounds), even if their thresholds are the same. And a person whose only sensory impairment is hearing loss is affected differently than someone with the same hearing thresholds but who also has significant visual or mobility impairments.

Nevertheless, some basic scheme for classifying severity of hearing loss is necessary. Although there is no one universally accepted method of defining degree of hearing loss, the following system is generally representative of the various schemes currently in use:

- 0-25 dB Normal hearing;
- 26-40 dB Mild hearing loss;
- 41-55 dB Moderate hearing loss;
- 56-70 dB Moderately severe hearing loss;
- 71-90 dB Severe hearing loss; and
- 91+ dB Profound hearing loss.

Quite often, an individual has different degrees of hearing loss at different frequencies. For example, normal hearing in the low frequencies and gradually worsening hearing sensitivity in the high frequencies is typical of age-related and noise-related impairments. In cases such as these, the classification scheme may be applied to each test frequency individually (for example, "normal hearing sensitivity through 1000 Hz, gradually sloping to a moderately severe hearing loss at the highest test frequencies"); or thresholds at various frequencies may be averaged and an overall hearing loss rating may be assigned. Here again, however, there is little agreement as to which frequencies ought to be averaged. The American-Speech-Language-Hearing Association (1981) and NIOSH (1996) classify hearing impairment according to the average hearing threshold at 1000, 2000, 3000, and 4000 Hz. Other recommendations include average thresholds at 500, 1000, and 2000 Hz or an average of 1000, 2000, and 3000 Hz. Some schemes even involve weighting the various frequencies included in the average. Audiometric results obtained in NHANES will be reviewed by an audiologist who will determine the scheme to be used in classifying degree of hearing loss.

Finally, hearing losses may be classified as either unilateral (affecting only one ear) or bilateral (affecting both ears). Bilateral hearing losses may be symmetric (approximately the same in each ear) or asymmetric (worse in one ear than the other). Hearing losses from environmental causes (such as noise, ototoxic chemicals, and aging) are generally bilateral and symmetric. Hearing losses from medical causes (such as ear infections, mumps, and acoustic tumors) are often unilateral or asymmetric. A substantial difference in hearing sensitivity between ears can therefore be indicative of a medically significant condition.

1.5 References

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Equipment 2

2.1 Description of Exam Room in the MEC

Hearing testing is conducted in the audiometry room, located in trailer #3 of the mobile examination center (MEC). A special sound booth (manufactured by Acoustic Systems, model Delta 142) has been built into this room. This triangular-shaped booth is designed to ensure that the sound levels inside are sufficiently quiet to permit accurate hearing threshold measurements. In addition to the sound booth, the exam room has several other features designed to further reduce the sound levels in the room. These include sound dampening materials on the interior walls of the exam room and a rubber seal on the hallway door.

The area outside the sound booth includes two separate work areas for the technologist. One of the work areas is located in front of the audiometric booth just under the window and consists of a small, custom-built triangular table with the audiometer on top and the computer tower beneath. The placement of the table allows the technologist to observe the examinee during air conduction testing, yet helps ensure that the examinee is unable to observe the technologist in order to prevent any inadvertent cueing that would compromise the test results. The second work area is located to the side of the booth and includes a desk area and upper and lower storage cabinets for supplies and spare equipment. There is an additional work area inside the sound booth that holds the remaining audiometric equipment as well as supplies needed during the examination. The computer display and keyboard are also located in this work area to facilitate data entry during the exam.

The entire audiometric exam is conducted with the study participant (SP) seated inside the booth. Examinees must step over a raised threshold to enter the sound booth. The threshold is approximately 4 inches high. A portable metal wheelchair ramp is available to facilitate the movement in and out of the booth of examinees in wheelchairs or with other mobility problems. The ramp can be lifted out of the way and stored by the work area to the side of the booth when not in use.

2.2 Description of Equipment and Supplies

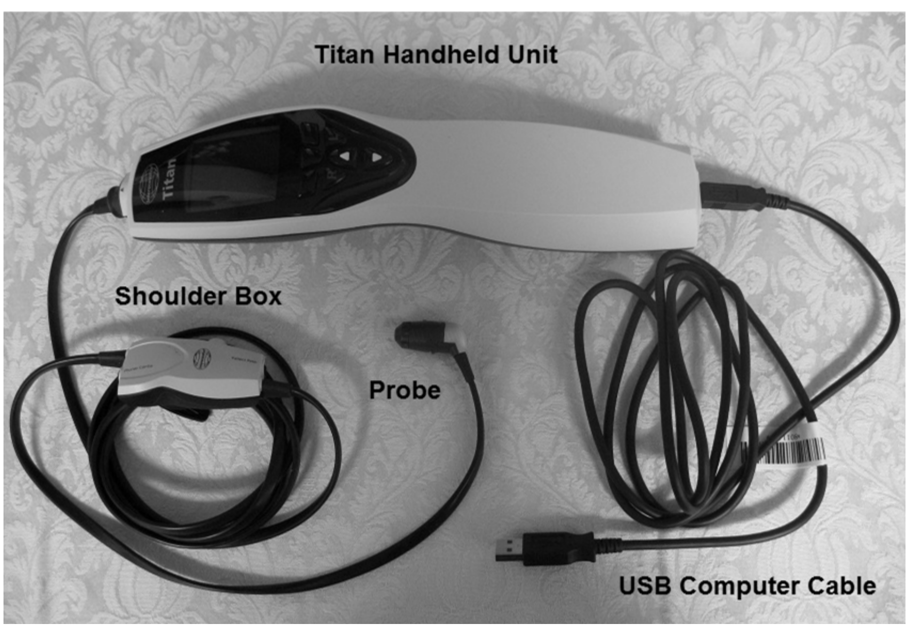
The following equipment has been supplied for the hearing component of NHANES:

- Welch-Allyn Model 25020 otoscope (Figure 2-1) with rechargeable handle and disposable specula in two sizes (2.75 mm and 4.25 mm ear tips).

Figure 2-1. Welch-Allyn Model 25020 otoscope

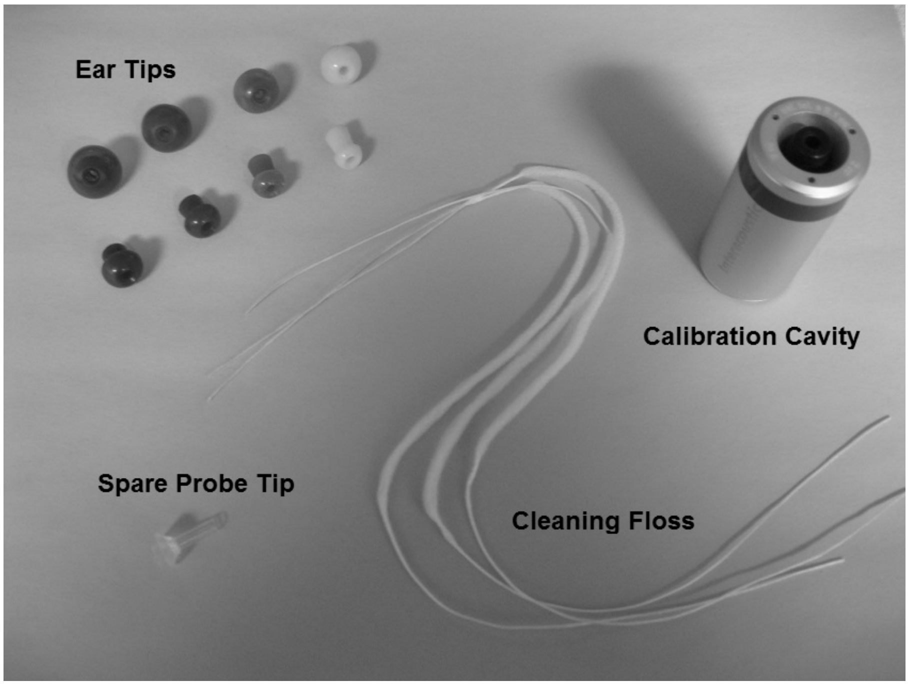
- Interacoustics Titan handheld unit with probe tip, shoulder box, and USB computer cable (Figure 2-2).

Figure 2-2. Interacoustics Titan handheld unit and cables



- Parts for the Titan: disposable ear tips in various sizes, calibration cavity, spare probe tip, cleaning floss, external wall charger, probe cleaning tool, desiccant pack, charging cradle, back plate, and steel cable holder (Figure 2-3).

Figure 2-3. Parts for the Titan



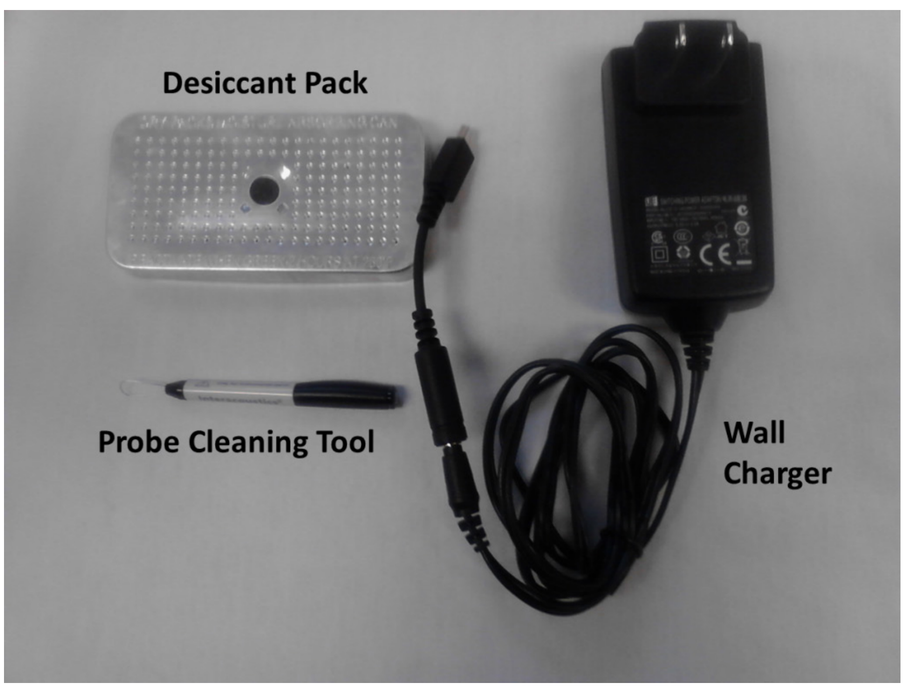
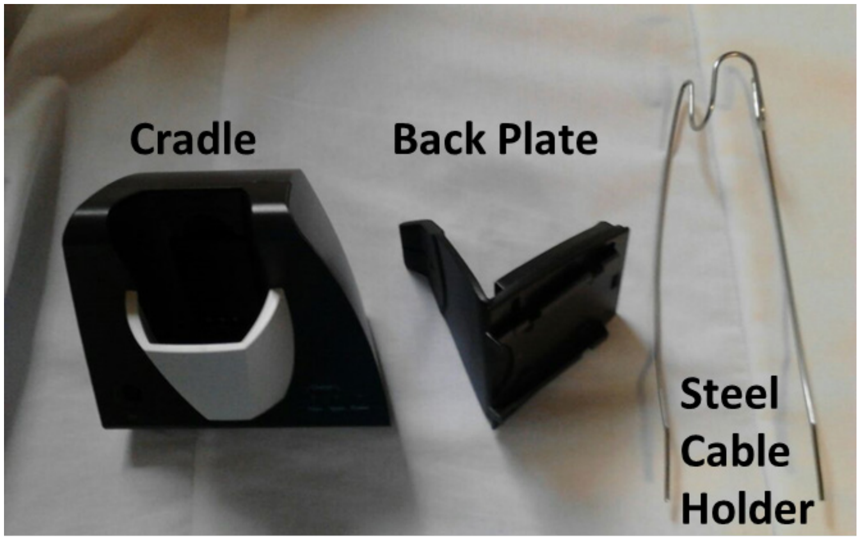
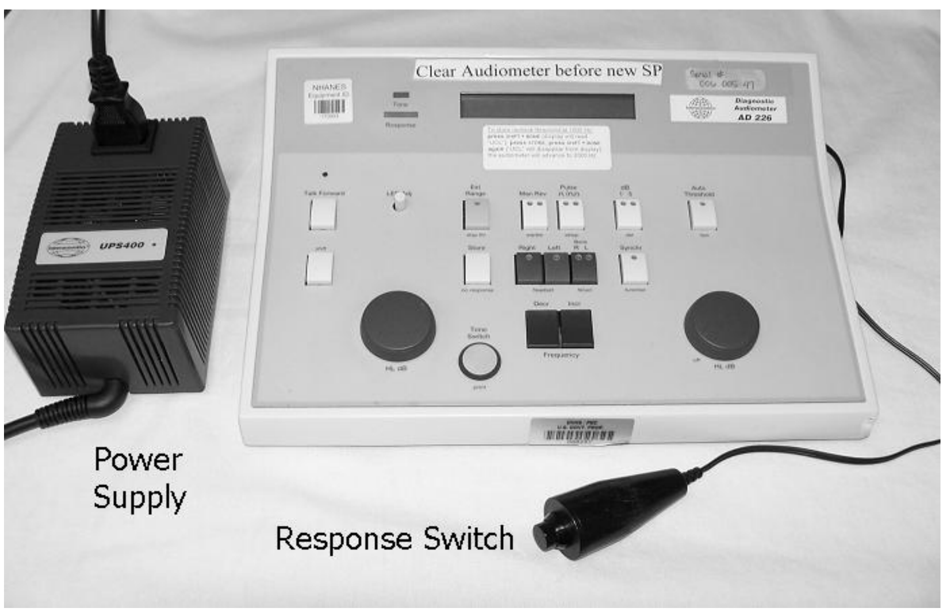


Figure 2-3. Parts for the Titan (continued)



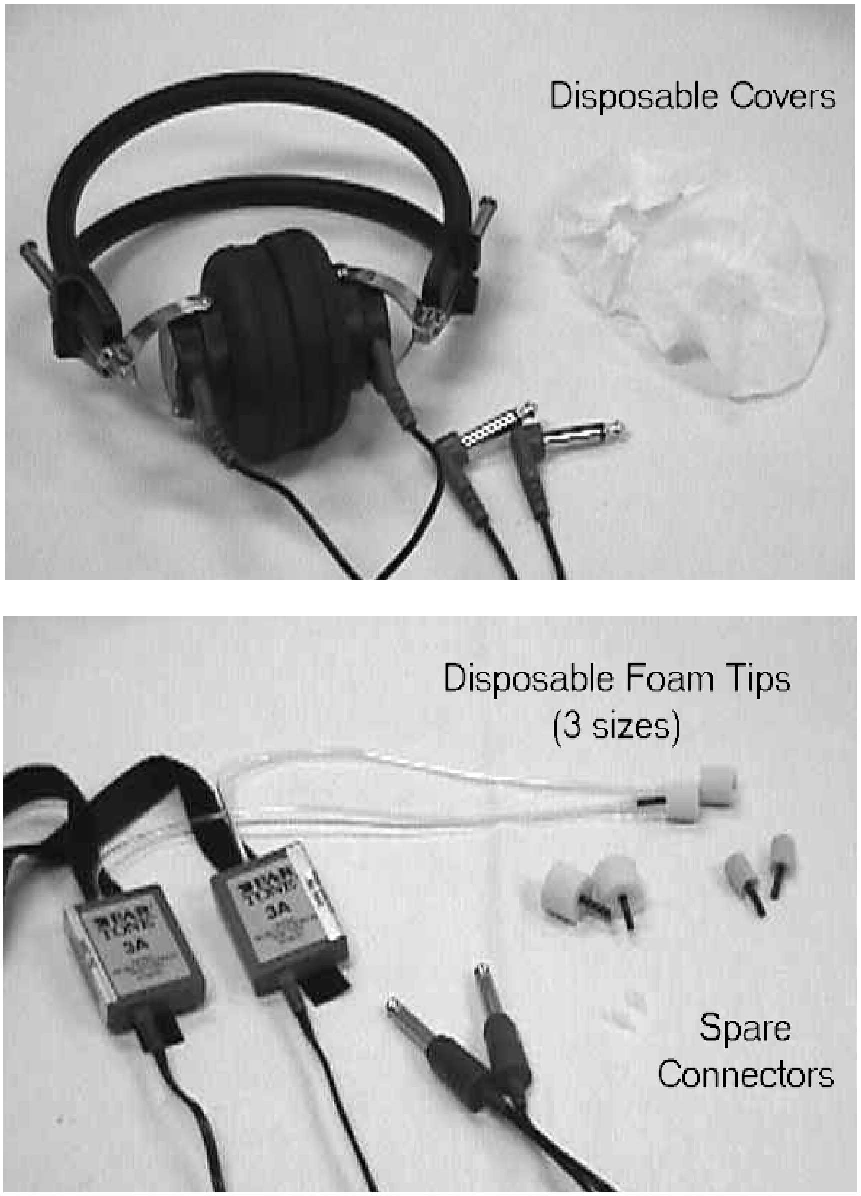
- Interacoustics Model AD226 audiometer (Figure 2-4) with power supply and response switch.

Figure 2-4. Interacoustics Model AD226 audiometer



- Standard TDH-49P headphones with Phone Guard disposable hygienic covers, and E•A•Rtone 3A insert earphones with disposable foam tips in three sizes and spare plastic connectors (Figure 2-5).

Figure 2-5. Parts for audiometer

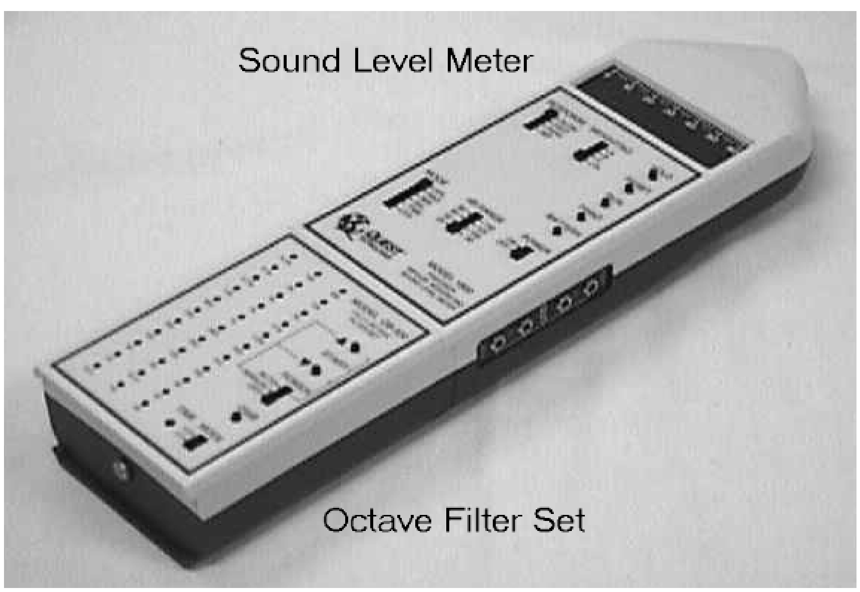


- Quest Model BA-202-27 bioacoustic simulator (Figure 2-6) and octave band monitor with microphone, pre-amp cable, response cable, and insert earphone adapters.

Figure 2-6. Quest Model BA-202-27 bioacoustic simulator and accessories

- Quest Model 1800 precision integrating sound level meter and Model OB-300 1/3—1/1 octave filter set (Figure 2-7).

Figure 2-7. Quest Model 1800 sound level meter

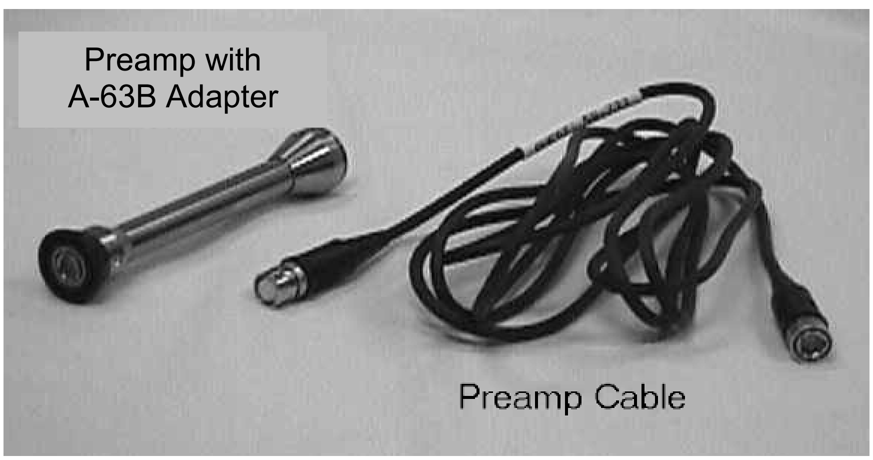


- Quest Model QE 4170 one-inch pressure microphone and microphone adapter ring (Figure 2-8).

Figure 2-8. Quest Model QE 4170 microphone and adapter ring

- Quest preamp with A-63B preamp adapter and 59-733 preamp cable (Figure 2-9).

Figure 2-9. Quest preamp with adapter and cable

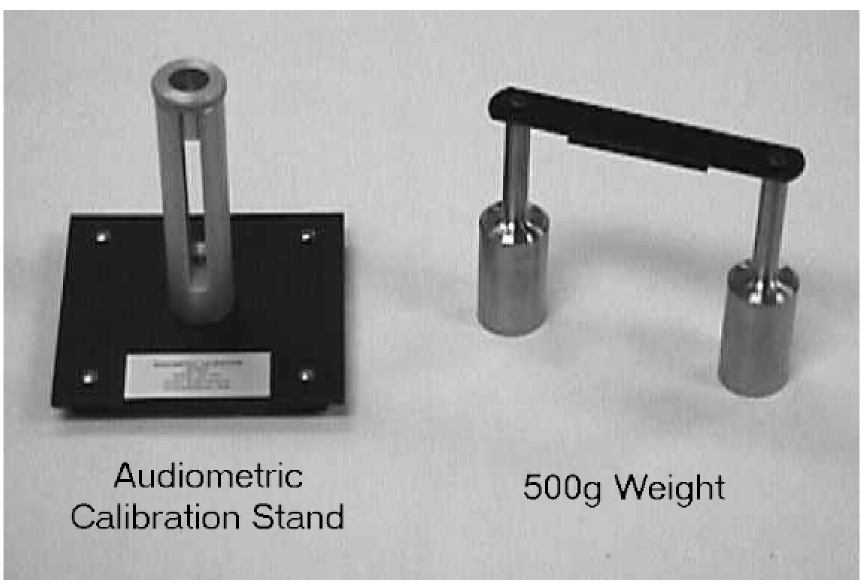


- Quest Model QC-20 calibrator with adapter for ½-inch microphone (Figure 2-10).

Figure 2-10. Quest Model QC-20 calibrator with adapter

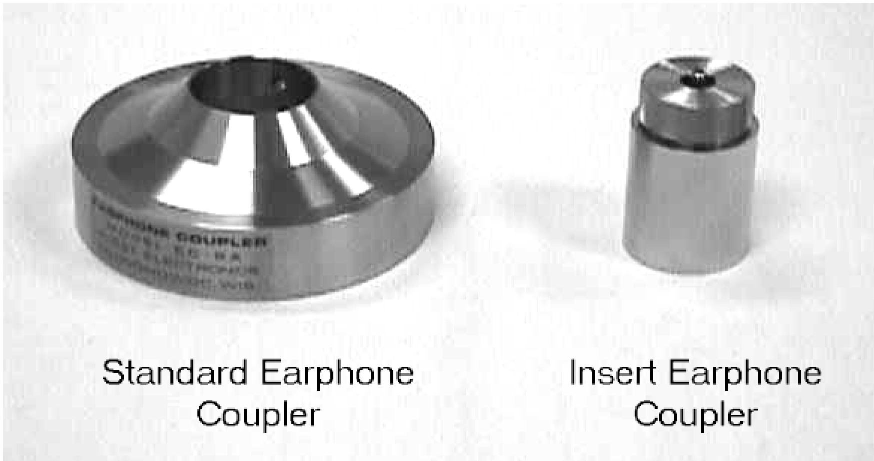
- Quest Model AS-1550 audiometric calibration stand and 500g weight (Figure 2-11).

Figure 2-11. Quest Model AS-1550 audiometric calibration stand and weight



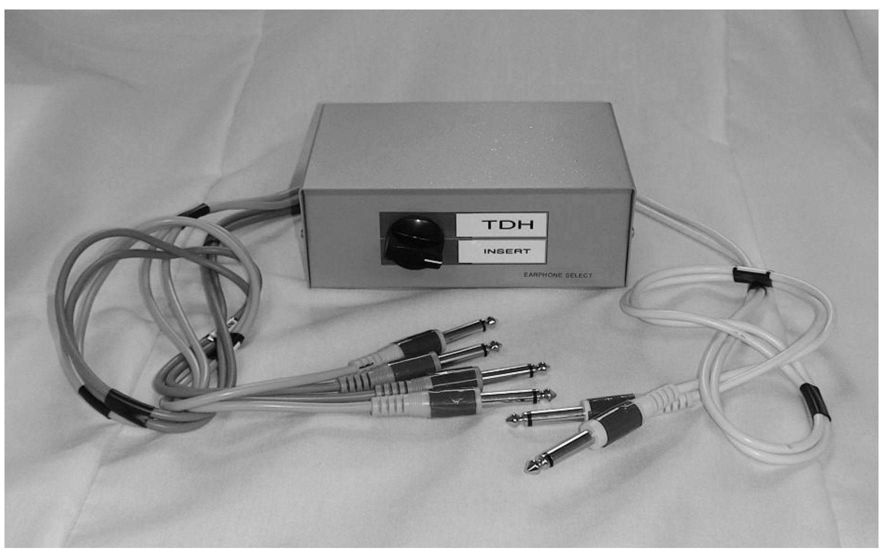
- Quest Model EC-9A 6cc earphone coupler and Bruel & Kjaer Model DB 0138 2cc earphone coupler (Figure 2-12).

Figure 2-12. **Earphones couplers**



- Headphone selector box (Figure 2-13).

Figure 2-13. **Headphone selector box**



- Audiometer patch cords (Figure 2-14).

Figure 2-14. Audiometer patch cords

- Standard photographic tripod with quick-release platform
- Large and small flathead screwdrivers; small Philips screwdriver
- Hex wrench
- Hex key set
- Audiowipes
- Alcohol prep pads

2.2.1 Otoscope

The Welch-Allyn 25020 otoscope is a small, hand-held instrument with a light that is directed through a funnel-like tip to illuminate the ear canal for examination. The funnel-like tip is called a "speculum." The specula are disposable and come in two sizes (2.75 mm for very small ear canals and 4.25 mm for average adult ear canals). The otoscope is powered by a rechargeable battery in the handle; the handle detaches and can be plugged into a standard wall outlet for recharging. There is a spare otoscope on each MEC.

2.2.2 Middle Ear Analyzer

The Interacoustics Titan is a device used to evaluate the functional health of the middle ear system. Known as an "immittance unit" or "middle ear analyzer," it conducts traditional tympanometry, wideband reflectance, and a variety of acoustic reflex tests through a probe with a soft rubber tip that is used to seal off the entrance to the ear canal. During tympanometry, the Titan checks the mobility of the eardrum by measuring the transmission of a single frequency (226 Hz) across a range of air pressures within the ear canal. During wideband reflectance testing, the Titan delivers a series of clicks through the probe and measures the transmission of sound through the eardrum across a range of frequencies while ear canal pressure remains constant. Finally, while the probe is still in place, the Titan delivers a series of six brief, loud signals to evaluate the acoustic reflex (see Section 3.4). The Titan unit comes with a supply of disposable rubber ear tips in different sizes, a cylindrical cavity that is used for calibration, and tools and floss for cleaning the probe tip. Two Titans on each MEC are rotated between stands and provide a backup unit in the event one malfunctions during a stand.

2.2.3 Audiometer

The Interacoustics Model AD226 audiometer is used to obtain air conduction thresholds on all examinees. The AD226 is capable of performing the audiometric threshold test automatically (which will be the general protocol) or allowing you to perform the test manually (which will be the protocol under special circumstances as described in Section 3.5.3.3). The audiometer is supplied with both standard audiometric headphones and insert earphones, which are used in cases where ear canal collapse is suspected or when there is a large difference in hearing thresholds between ears (see Sections 3.3.4 and 3.5.5). The standard headphones should be covered with disposable Phone Guard fabric earphone covers (which are acoustically transparent) for hygienic purposes; the insert earphones come with disposable tips in three sizes to prevent contamination between examinees. There are two audiometers on each MEC that are rotated between stands and provide a backup in case one malfunctions during a stand.

2.2.4 Bioacoustic Simulator

The Quest Model BA-202-27 performs two functions. First, as a bioacoustic simulator, it is a kind of "dummy" ear that is used to check the calibration of the audiometer on a daily basis. The simulator is programmed with 60 dB HL thresholds at each test frequency and its "hearing" should be tested every day to verify that the calibration of the audiometer has not shifted. Special adapters are provided to allow the simulator to be used with insert earphones as well as with standard headphones. Second, as an octave band monitor, it continuously measures the background noise levels in the audiometric test room. Whenever the noise levels in the test room exceed the standards, which have been programmed into the unit, a light comes on to alert the tester to the problem. Audiometric testing cannot be accomplished when the monitor indicates that background noise levels are too high (see Section 2.5.1).

There are two simulators on each MEC which should be rotated between stands and provide a backup in case one stops functioning during a stand.

2.2.5 Sound Level Meter and Accessories

The Quest Model 1800 sound level meter and its accessories are used to measure the intensity, or loudness, of sounds. These instruments will be used throughout the NHANES to measure the background noise levels in the exam room and to periodically verify the calibration of the audiometer.

The sound level meter uses a 1-inch microphone attached to a preamp, sometimes via the preamp cable. The Quest Model OB-300 octave filter set is attached to the sound level meter to limit the instrument to measuring sound levels in a certain frequency range, rather than the overall sound level. The calibration stand and earphone couplers are used when checking the calibration levels of the audiometer. The sound level meter is mounted on the photographic tripod using a "quick-release platform" which screws into the back of the meter when measuring the background noise levels in the audiometric test room.

Before the sound level meter is used to make any measurement, it must be calibrated with a known signal to verify that the meter is reading accurately; the Quest Model QC-20 calibrator provides this known signal.

There is only one sound level meter kit on each MEC. An additional sound level meter kit is kept in storage at the Westat home office and will be shipped out on request.

2.2.6 Inventory Procedures

An inventory of the audiometric equipment and supplies will be conducted at the beginning and the end of each stand, using the form illustrated on pages A-1 and A-2. Please note the following when conducting the inventory:

- Supply counts refer to unused (i.e., spare) items only. Supplies currently in use (for example, batteries currently in equipment, light bulbs currently in the otoscope, headbands currently attached to headphones) are not to be counted on the inventory sheet.
- The "Quick Release Platform" refers to the attachment on top of the tripod that screws into the back of the sound level meter.

Supplies will be sent to a MEC prior to its next stand opening. Malfunctioning or missing equipment should be reported to the MEC manager and health technologist assigned to Audio for the stand.

2.3 Start of Stand Procedures

2.3.1 Room Setup

Unpack the Quest BA-202-27 bioacoustic simulator and insert a 9-volt battery into the battery compartment (see Section 2.8.2.1). Slide the simulator over the screws in the wall mount, making sure it is secure on both screws. Insert the pre-amp cable into the MIC jack at the bottom left of the unit, lining up the pins and notches, and screw the cable securely in place. Unpack the microphone from its case and remove the white plastic cover. Gently screw the microphone onto the other end of the preamp cable. Run the microphone cable up the wall and across the ceiling through the magnetic hooks and suspend it above the subject chair. Use a twist-tie to secure the extra cord length; the microphone should be as close to the ceiling as possible. Insert the black connecting cable for the audiometer into the RESPONSE jack.

Unpack the otoscope and rechargeable handle and plug the handle into a wall outlet. The handle should be charged for 8 hours before examinations begin at each stand.

Check the Serial Number Register and unpack the Titan unit that was NOT used at the previous stand. Place it on the table inside the sound booth. Hang the extension cable with the probe and shoulder box on a hook on the booth wall. Follow the steps below to assemble the cradle.

1. Insert the wall charger cable (without the short USB adaptor piece) into the port on the back of the cradle labeled "power." Insert the USB computer cable into the port labeled "USB." The connections are shown in the photos in Figure 2-15.

Figure 2-15. Charging cradle connections

2. Slide the back plate in place (Figure 2-16).

Figure 2-16. Charging cradle back plate

3. Stand the cradle up, and then slide the steel cable holder completely into the two openings on the back plate (Figure 2-17).

Figure 2-17. Steel cable holder inserted into back plate

4. Insert the spare Titan battery into the cradle holder (Figure 2-18). ***Make sure the gold plates on the bottom of the battery line up with the gold pins in the cradle***. Don't rely on the printing on the battery to know which way to place it—some of them are printed on the front and some on the back. Installing it incorrectly will break the pins.

Figure 2-18. Spare Titan battery in cradle holder

5. Slide the handheld unit into the cradle as shown below. You can loop the probe cable over the steel holder (Figure 2-19) or hang the cable on a hook on the booth wall. It is important that this cable be kept looped up and out of the way as it contains an airline and microphone and speaker wires that can be easily damaged by stepping on or rolling over the cable with a chair.

Figure 2-19. Titan Cords Looped Around Steel Holder

6. Plug the wall charger into an outlet and the USB cable into the computer. The "Power" light in the bottom right corner of the cradle should light up and remain on. The "Charge" lights to the left of the power indicator will flash whenever the handheld unit or spare battery is charging.

NOTE: A wall charger has also been supplied for charging the Titan separately if for any reason the cradle is not working and it does not maintain a sufficient charge from the computer (see Section 2.8.4.4).

Check the Serial Number Register and unpack the Interacoustics AD226 audiometer that was NOT used at the previous stand. Place it on the table outside the sound booth. Insert the black cable from the power supply into the POWER jack on the back of the audiometer; then plug the power cord into the power supply and into the wall outlet under the table on the wall of the booth. Connect the computer cable to the RS232 jack on the back of the audiometer (connections to the computer itself will have been completed by the ISIS staff).

Unpack the headphone selector box and affix it to the Velcro strips near the jack panel outside the sound booth. Plug the white cables labeled "AUDIO" into the jacks labeled "RIGHT" and "LEFT" on the back of the audiometer; the cable with the red tip goes into the "RIGHT" jack and the cable with the blue tip goes into the "LEFT" jack (the audiometer jacks are also color coded red and blue). Plug the yellow cables from the headphone selector box labeled "TDH" into jack 5 (blue-tipped cable) and jack 6 (red-tipped cable) on the sound booth jack panel. Plug the gray cables from the headphone selector box labeled "INSERT" into jack 9 (blue-tipped cable) and jack 10 (red-tipped cable) on the sound booth jack panel.

Unpack the standard headphones and plug the cable with the blue tip into jack 5 and the cable with the red tip into jack 6 on the jack panel **inside** the sound booth.

Unpack the insert earphones and plug the blue-tipped cable into jack 9 and the red-tipped cable into jack 10 on the panel inside the booth. Plug the patient response switch into jack 3 **inside** the sound booth; plug one end of the black patch cord into jack 3 **outside** the sound booth and the other end into the "PAT. RESP." jack on the back of the audiometer. Cover the unused audio input jacks both inside and outside the sound booth with the protective blue covers.

NOTE: Actual jack numbers have been assigned arbitrarily. If a jack is broken or if the equipment will fit more conveniently into a different jack, it is acceptable to use jacks other than those indicated here. However, **each component MUST be plugged into the same numbered jack both inside and outside the booth**. For example, if you decide to use jack 1 for the left standard headphone cable outside the booth, be sure to plug the left standard headphone (i.e., TDH) cable into jack 1 inside the booth.

Mount the specula dispenser on the wall and fill it as needed. Unpack the tympanometer ear tips and insert earphone tips and place them in containers on the table inside the sound booth. Fill the headphone cover dispenser with Phone Guard covers.

2.3.2 Start of Stand Calibrations

Conduct calibration checks of the following equipment in the order indicated (directions for calibration checks are in Section 2.4, which follows):

- Bioacoustic simulator;

- Audiometer (acoustic check, bioacoustic check, listening check); and
- Middle ear analyzer.

At the start of a stand, one audiometer and one middle ear analyzer should undergo complete calibration checks. Should one of the units not pass calibration checks, take out the backup unit and complete the calibration checks on it. Notify the MEC manager of the nonfunctioning unit, so that arrangements can be made for its repair.

Measure the environmental noise in the audiometric test booth according to the directions in Section 2.5.2.

Record the results of start of stand calibrations in the Start of Stand tab in the Integrated Survey Information System (ISIS) QC application, as explained in the individual calibration instructions in Section 2.4. The 10 subtabs correspond to the following results:

QC 1: Equipment Serial Numbers

QC 2: Bioacoustic Simulator Calibration Check

QC 3: Audiometer Acoustic Calibration Check (Standard Headphones)

QC 4: Audiometer Acoustic Calibration Check (Insert Headphones)

QC 5: Audiometer Bioacoustic Reference Values (Standard Headphones)

QC 6: Audiometer Bioacoustic Reference Values (Insert Headphones)

QC 7: Audiometer Listening Check (Standard Headphones)

QC 8: Audiometer Listening Check (Insert Headphones)

QC 9: Environmental Noise Survey

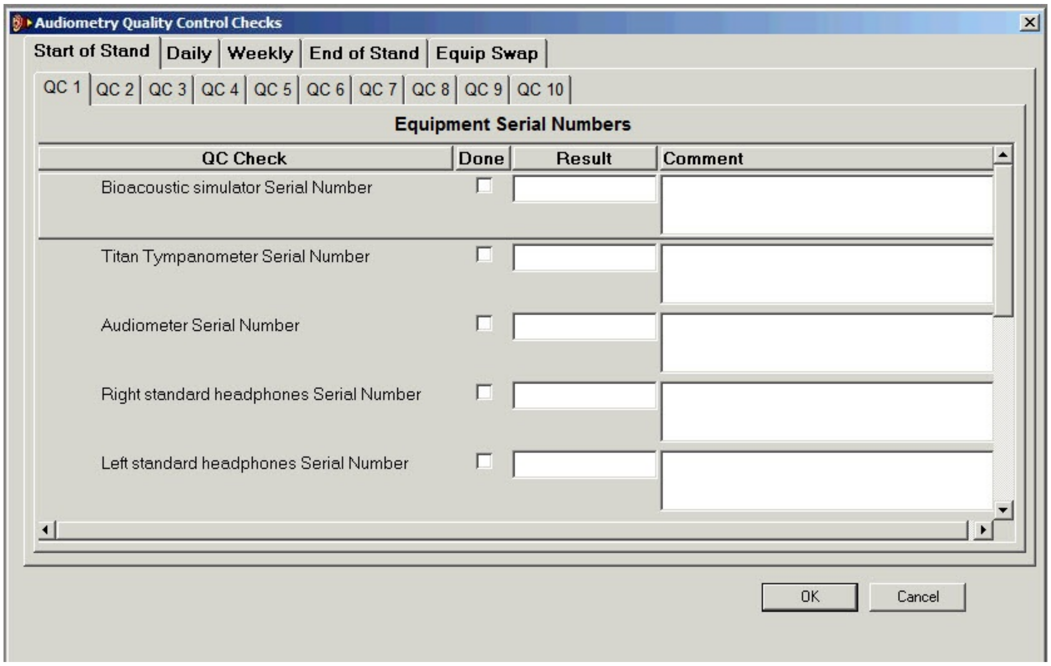
QC 10: Titan Calibration Check

2.3.3 Recording Serial Numbers

Serial numbers of the equipment used at each stand must be recorded on the Serial Number Register (a hard-copy log) and in ISIS. The Serial Number Register should be kept in the audio room in the MEC. If there is no hard copy available, it can be obtained from the “blank forms” folder on the computer in the staff lounge.

To enter the serial numbers in ISIS, open the QC application on the computer in the audiometry room and go to the Start of Stand tab. Click on the QC1 tab (Exhibit 2-1) and enter the serial number for each piece of equipment in the “Results” column. Click the “Done” box next to each piece of equipment as you enter each serial number. Use the scroll bars to move up and down the screen and enter numbers for all the equipment listed.

Exhibit 2-1. Entering equipment serial numbers in ISIS



NOTE: Be sure to enter the manufacturer’s serial number for each piece of equipment. Do NOT enter the DHHS/PHS bar code number or the NHANES equipment identification number. You will know you are recording the correct number if it has exactly the same number of characters as there are spaces for that item number on the hard-copy serial number log. **ANOTHER NOTE**: Be certain to enter the serial numbers in the “Result” field and NOT the “Comment” field.

2.4 Calibration Checks

In order for audiometric test results to have any validity, it is necessary to know that all the equipment associated with the tests was properly calibrated. Calibration checks will therefore be conducted as the audiometric equipment is set up at the start of each stand, periodically throughout the stand, and again at the end of each stand to ensure that the accuracy has not shifted.

2.4.1 Bioacoustic Simulator Calibration Check

Before the Quest BA-202-27 bioacoustic simulator can be used to verify the calibration of the audiometer, its own accuracy must be verified. This is done by testing the same headphone on both the right and left "ears" of the simulator. Because the test circuits on each side are identical, testing each of them with the same headphone should result in the same threshold values. The calibration of the bioacoustic simulator is checked at the beginning and end of each stand. It must be checked **before** it is used to check the calibration of the audiometer.

Conduct the calibration check of the bioacoustic simulator in the following way:

- Turn on the audiometer and allow it to warm up for at least 3 minutes.
- Press the ON button on the Quest BA-202-27 bioacoustic simulator and check the power indicator to verify that the light is flashing "brightly" (if the light is flashing dimly or does not flash at all, replace the battery as described in Section 2.8.2.1). Unplug the response switch for the audiometer from jack 3 inside the sound booth, and plug the simulator response cable into this jack. Place the standard headphones on the simulator, with the **right** earphone over the simulator coupler marked **right** and the **left** earphone over the simulator coupler marked **left**.
- Verify that the audiometer is set as follows:
  - MAN REV button set to REV
  - 1 5 DB button set to 5
  - RIGHT ear selected
  - Standard HEADSET selected (on the audiometer <u>and</u> the headphone switchbox)

NOTE: Pulsing should be off (i.e., both lights off on the PULSE button) during this calibration.

- Set the frequency to 500 Hz and the intensity level to 30 dB.
- Close the doors to the sound booth and the audiometric test room.
- Slowly turn the left DB HL knob on the audiometer to increase the intensity in 5 dB steps. Pause a few seconds at each new intensity level and check to see if the right light on the simulator becomes illuminated (the response light on the audiometer should light up at the same time). Once the right light is lit, stop increasing the intensity and press STORE to record this level in the audiometer.

- The audiometer will automatically advance to the next frequency (1,000 Hz). Reduce the intensity to 30 dB and repeat the slow increase in level until the right light on the simulator becomes lit again. Press STORE to record this value. The audiometer will again advance to the next frequency. Continue this procedure (slowly increasing intensity from 30 dB until the right light on the simulator becomes lit) for the remaining test frequencies in the right ear only, storing the values in the audiometer.

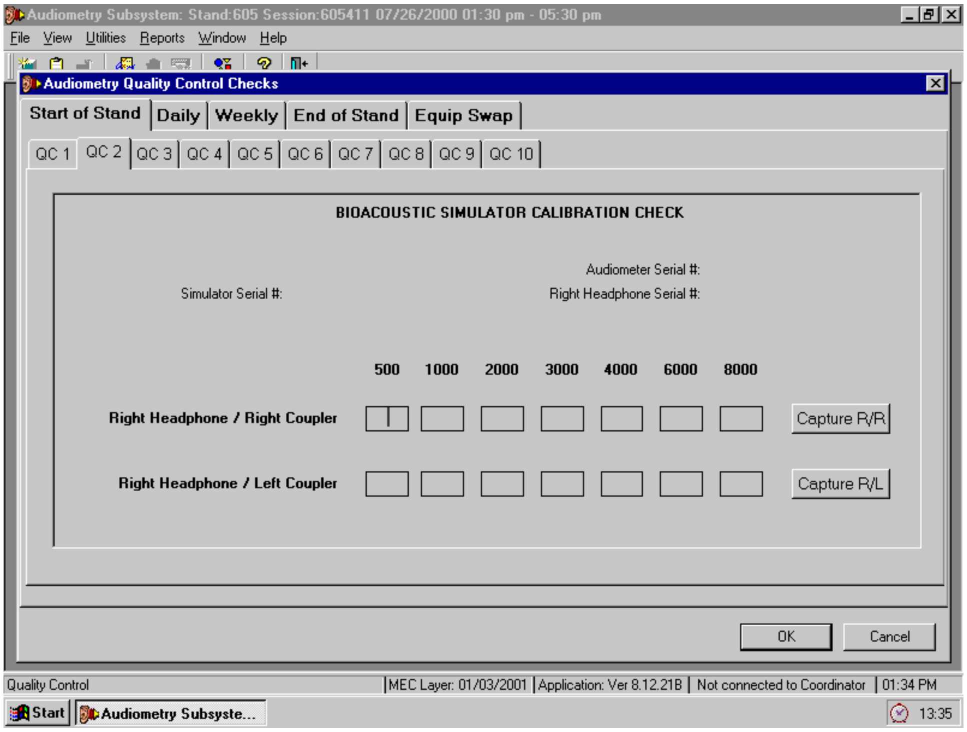
- When all frequencies have been tested in the right earphone, capture the data in ISIS (Exhibit 2-2). Go to the QC2 tab (under Start of Stand QC) and click on the "Capture R/R" button to capture the QC data for the right coupler.

NOTE: If you would like to display the data on the audiometer, press SHIFT/EXT range to display threshold results. The display should appear as shown below:

PH-R	***	***	65	***	65
***	65	65	65	65	65

- Reverse the headphones on the simulator, such that the **left** earphone is over the simulator coupler marked **right** and the **right** earphone is on the simulator coupler marked **left**. Press SHIFT/DEL on the audiometer and hold the buttons down until the display reads that "All thresholds are del." Verify that the other audiometer settings are still as noted above, and repeat the procedure. The audiometer should still be set to test the **right** ear; however, this time you will be observing the **left** light on the simulator. When all frequencies have again been tested and stored in the audiometer, click on the "Capture R/L" button to capture the QC data for the left coupler.

Exhibit 2-2. Bioacoustic Simulator Calibration Check



ISIS will automatically compare both sets of threshold values (i.e., obtained from the same earphone over the right versus the left couplers on the simulator). The thresholds must agree within ±5 dB. If the thresholds at any frequency differ by more than 5 dB, ISIS will display an error message. Notify the MEC manager and health technologist assigned to Audio for the stand before continuing with any further calibration checks.

2.4.2 Audiometer Calibration Checks

There are three levels of checks on the audiometer calibration. An acoustic calibration check involves using a sound level meter to measure the test signals produced by the audiometer and verifying that these signals meet standard specifications. A bioacoustic check involves using a bioacoustic simulator to monitor the output of the audiometric headphones in order to verify that the output remains stable over time. A functional check involves listening to the output through the headphones to ensure that the signals are being routed properly and that there are no extraneous sounds. In addition to these calibration checks, all audiometers will be sent to a laboratory for an exhaustive calibration once a year, or whenever unresolvable problems are discovered during the calibration checks.

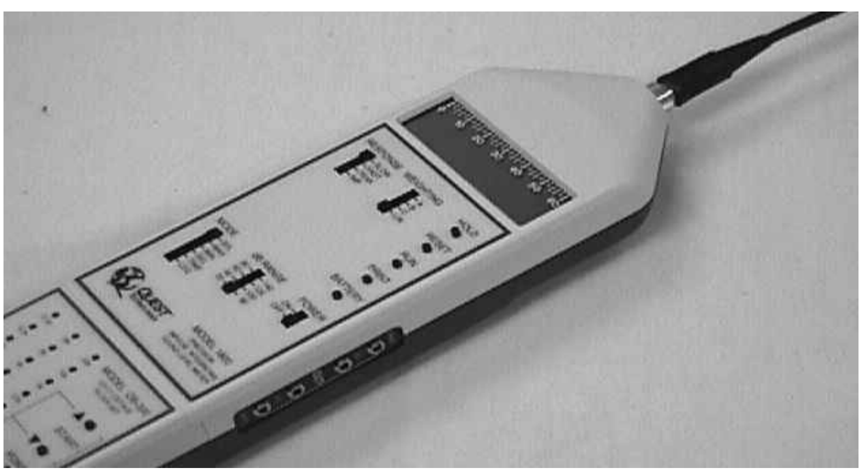
2.4.2.1 Acoustic Calibration Check

There are two components to an acoustic calibration check—verifying output (which involves measuring each test frequency at one intensity level) and verifying linearity (which involves measuring multiple intensity levels at one frequency). To check the output, the audiometer is set to produce a 70 dB tone at each frequency, and the sound level meter is used to make sure the output is actually 70 dB. To check the linearity, the hearing level dial is adjusted in 10 dB steps, and the sound level meter is used to verify that the output actually changes by 10 dB. The right and left earphones of both the standard and insert headphones must be checked individually. This must be accomplished at the beginning and end of each stand.

An acoustic calibration check is a very exact procedure and must be done thoroughly and carefully to ensure valid results. Conduct the calibration check in the following way:

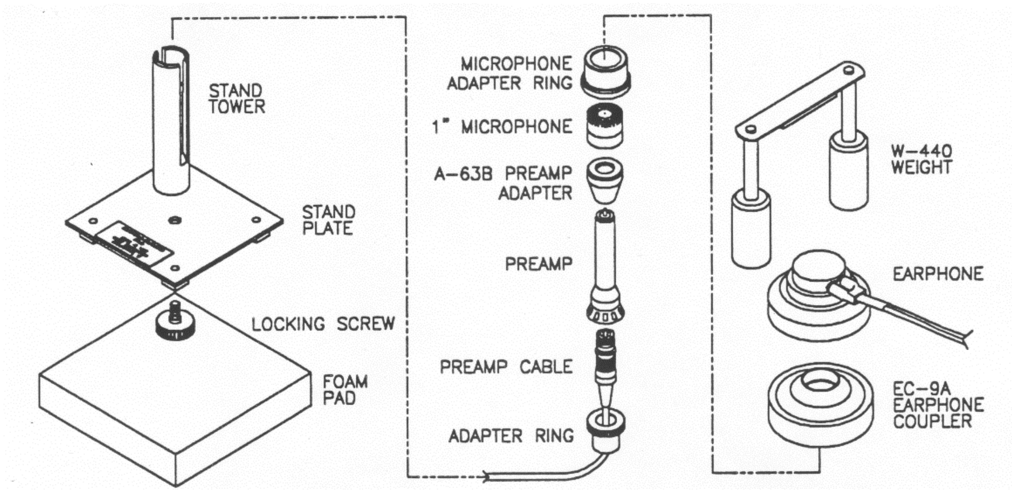
- Turn on the audiometer and let it warm up for at least 3 minutes.
- Set up the sound level meter and octave band filter.
  - Insert batteries (if necessary) into the sound level meter and the octave filter set, as described in Section 2.8.1.2.
  - Connect one end of the preamp cable to the top of the sound level meter and tighten the silver screw. The meter should appear as shown below in Figure 2-20.

Figure 2-20. Sound level meter connected to pre-amp cable



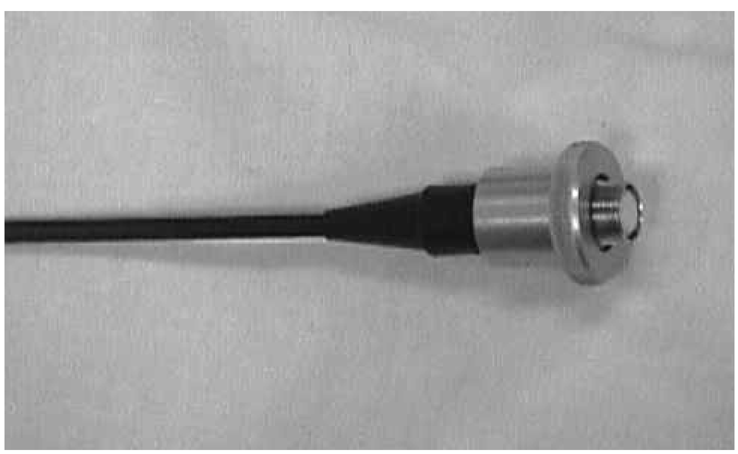
- Assemble the audiometer calibration system (Figure 2-21). Refer to the diagram below and step-by-step instructions and photographs that follow.

Figure 2-21. Assembling the audiometer calibration system



- Connect the stand tower to the stand plate with the locking screw.
- Verify that the other end of the preamp cable is attached to the adapter ring. The assembly should appear as shown below in Figure 2-22.

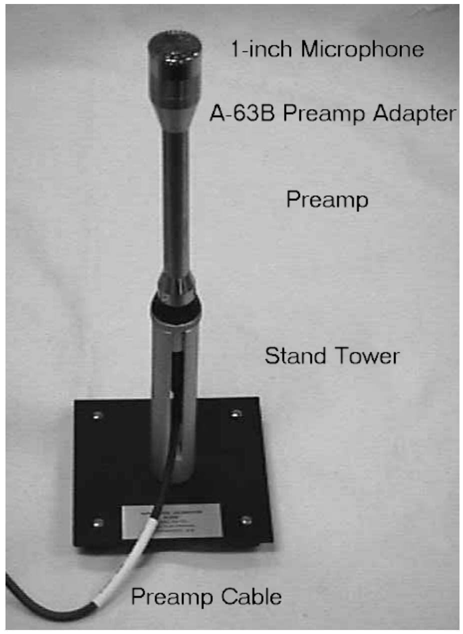
Figure 2-22. Assembly of preamp cable



- Connect the preamp to the preamp cable just above the adapter ring. Gently screw the one-inch microphone onto the top of the preamp and A-63B adapter.

- Firmly press the adapter ring into the stand tower, allowing the preamp cable to exit one of the tower slots. The calibration system should now appear as shown below in Figure 2-23.

Figure 2-23. Assembled calibration tower



- Slide the POWER switch in the lower right of the meter to on.
- Press the battery button on the sound level meter to check the batteries. Good batteries are indicated by a bar extending to the right well beyond the BAT arrow (5 on the numeric scale). If the bar falls near or below the indicating arrow, both batteries must be replaced before proceeding (see Section 2.8.1.2).
- Calibrate the sound level meter:
  - Set the sound level meter controls as follows:
    1. Response: Slow
    2. Weighting: Lin
    3. Mode: SPL
    4. Range: 60-120

NOTE: Be sure that the POWER switch on the OB-300 filter set is off.

- Make sure the calibrator is set to 1 KHz and 94 dB. Slide the calibrator over the microphone so that it fits snugly. Turn on the calibrator.

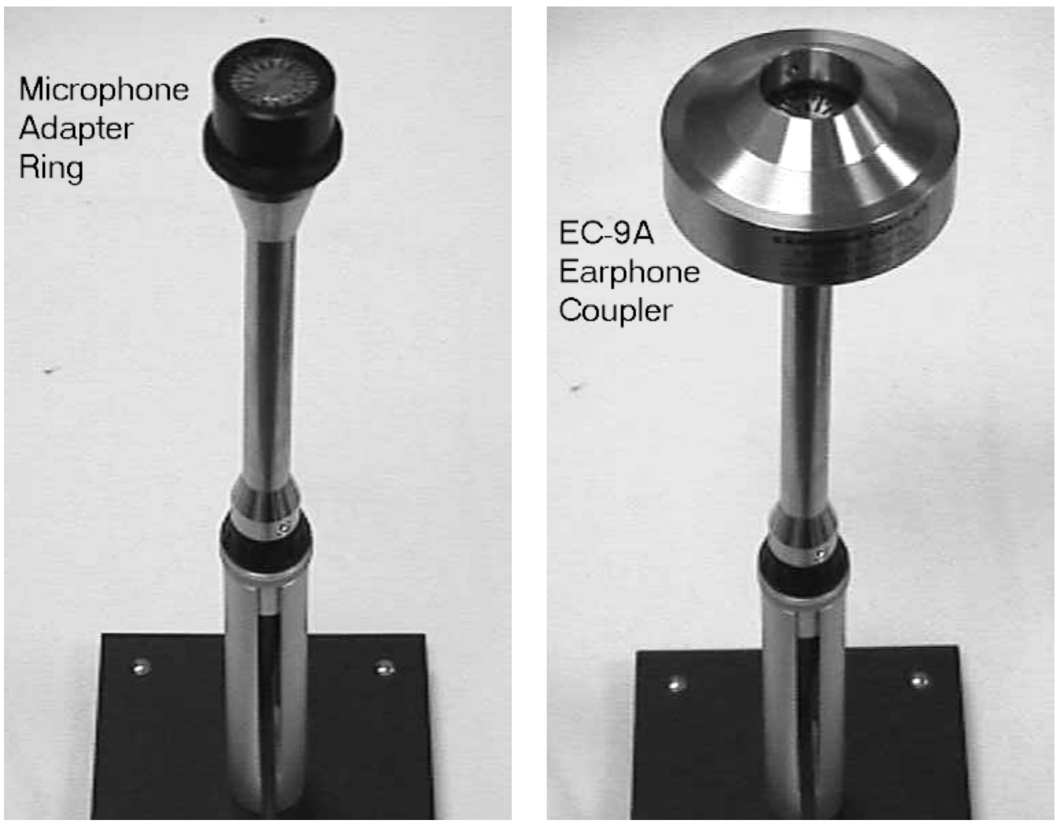
- Check the meter display. It should read 94.0 dB. If it does not, use the small flathead screwdriver to adjust the small control on the left side of the meter until the proper value is displayed (see photograph in Figure 2-24).

Figure 2-24. Adjusting the sound level meter

NOTE: Turn the screwdriver up (i.e., away from you) to adjust the meter down; turn the screwdriver down (i.e., toward you) to adjust the meter higher.

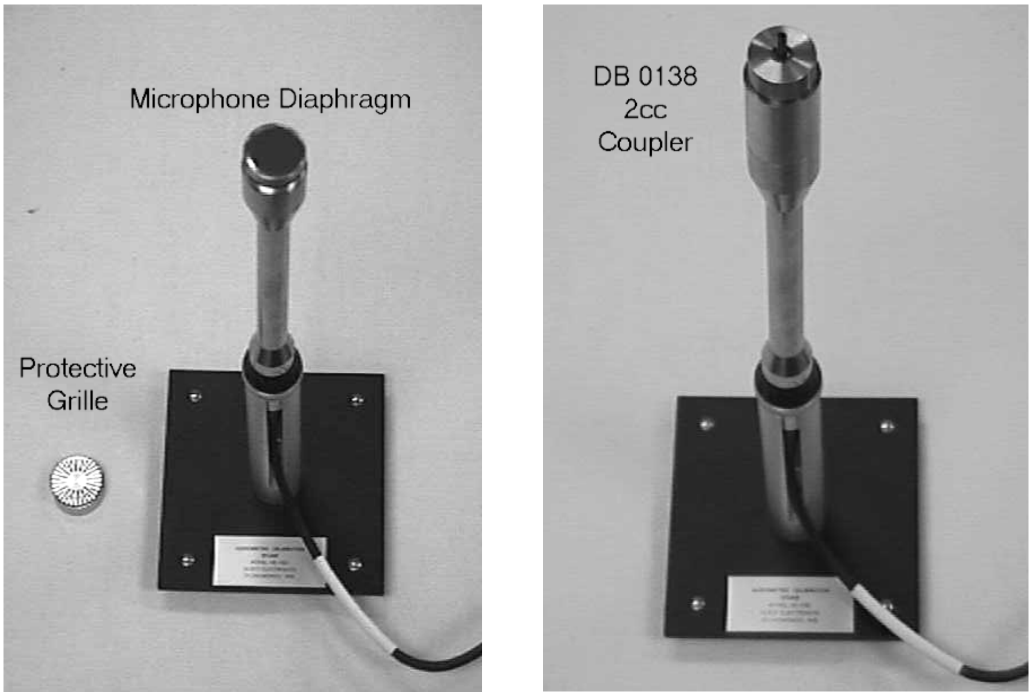
- Remove the calibrator and turn it off.
- Attach the appropriate coupler to the calibration assembly.
  - **For standard headphones:** Pull the black microphone adapter ring over the microphone until it is fully seated. **DO <u>NOT</u> PUSH THE ADAPTER ONTO THE MICROPHONE WITH THE PALM OF YOUR HAND BECAUSE THE PRESSURE BUILDUP WILL DAMAGE THE MICROPHONE.** Slide the EC-9A coupler over the adapter. See pictures below for reference (Figure 2-25).

Figure 2-25. Adapter ring (left) and earphone coupler (right)



- For **insert earphones:** Carefully unscrew the metal grille on top of the microphone and remove it. Very carefully slide the DB 0138 (HA-2) 2cc coupler over the bare microphone and screw it in place. **Be very careful not to touch the top (i.e., the diaphragm) of the microphone!** Refer to the photographs below (Figure 2-26) for guidance.

Figure 2-26. Microphone with grille removed (left) and coupler attached (right)



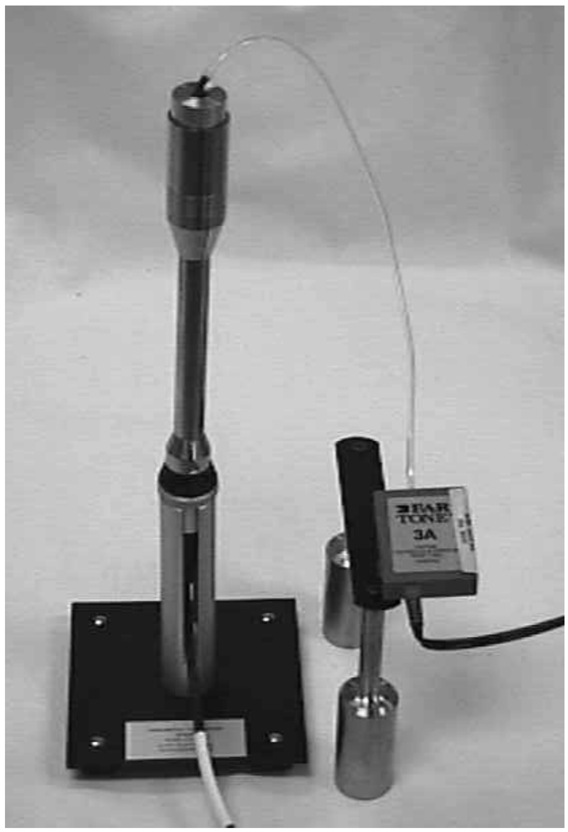
- Mount the earphone to be tested onto the coupler:
- **For standard headphones:** Remove the earphones from the headband (use a large flathead screwdriver to gently lift the silver clip off each earphone). Place the earphone squarely over the top of the coupler. Place the W-440 weight on top of the earphone to hold it in place. Both the weight and the earphone should be centered as accurately as possible on the coupler. In addition, the two sides of the weight should be in direct contact with the sides of the coupler. See illustration in Figure 2-27.

Figure 2-27. Earphone mounted on coupler

- **For insert earphones:** Slide the white plastic tip at the end of the sound tube into the black plastic tubing on the tip of the coupler (a foam eartip is not used during this calibration check).

- Make certain that the tip is inserted all the way to the nub (Figure 2-28). Hang the earphones in such a way that there are no kinks in the sound tubing (e.g., upside down from the headphone hook in the sound booth).

Figure 2-28. Insert earphones in coupler



- Check the pure tone output levels of the audiometer at each frequency through the earphone under test:

  – Set the DB RANGE on the sound level meter to 40-100.

  – Set the POWER switch on the OB-300 octave filter set to MANUAL and set the MODE switch to 1/1.

  – Set the audiometer controls as follows:

    1. MAN REV button set to REV

    2. 1 5 DB button set to 5

3. RIGHT or LEFT ear selected, as appropriate

4. Appropriate HEADSET selected (on the audiometer **and** switchbox)

5. Left attenuator (i.e., the left DB HL knob) adjusted to 70 dB HL

NOTE: Pulsing should be off (i.e., both lights off on the PULSE button) during the acoustic calibration check.

– Set the test frequency on the audiometer to 500 Hz (using the FREQUENCY DECR button) and use the ∇ button on the octave filter to select 500.

– Press the RESET button, then the RUN button on the sound level meter. Allow the meter to measure for about 5 seconds (the reading should become very stable), then record the measurement on the calibration log sheet in the section labeled "Output Check." This measure will be copied into ISIS from the calibration log sheet.

– Set the test frequency on the audiometer to 1,000 Hz (using the FREQUENCY INCR button) and press the Δ button on the octave filter to set it to 1k. Press RESET (do NOT press RUN), repeat the measurement process, and record the result on the calibration log.

– Continue measuring the audiometer output at all test frequencies. Refer to the table below for appropriate frequency settings on the audiometer (AD226) and the octave filter (Oct Fil). **Remember to press RESET before making the measurement at a new frequency!** Record the calibration values on the log sheet. Calibration values measured on the sound level meter should match the reference values in Table 2-1, within the tolerances shown:

Table 2-1. Reference calibration levels for pure tones

Frequency setting		Standard headphones			Insert earphones		
AD226	Oct Fil	Reference Level	Tolerance		Reference Level	Tolerance	
500	500	83.5	80.5	86.5	75.5	72.5	78.5
1000	1k	77.5	74.5	80.5	70.0	67.0	73.0
2000	2k	81.0	78.0	84.0	73.0	70.0	76.0
3000	4k	78.8	75.8	81.8	72.8	69.8	75.8
4000	4k	80.5	77.5	83.5	75.5	72.5	78.5
6000	8k	82.8	77.8	87.8	71.3	66.3	76.3
8000	8k	83.0	78.0	88.0	70.0	65.0	75.0

- Check the linearity of the pure tone attenuator (i.e., the left DB HL knob) through the earphone under test:

  – With the earphone still in place, reset the test frequency on the audiometer to 1,000 Hz and reset the octave filter to 1k.

  – Adjust the left attenuator on the audiometer to 70 dB HL.

  – Press RESET and verify that the sound level meter display still reads "RUN." Allow the sound level meter to measure for a few seconds (the reading should become very stable). Enter the measurement onto the calibration log in the section labeled "Linearity Check."

  – Reduce the attenuator to 60 dB HL. Press RESET and allow the meter to measure as before. Record the value on the calibration log.

  – Repeat again with the attenuator set to 50 dB HL.

  – Set the DB RANGE selector on the sound level meter to 20-80. Continue making measurements in 10 dB decrements through 10 dB HL (or until the sound level meter no longer responds) and record the values on the calibration log. **Remember to press RESET before making the measurement at a new intensity!** Calibration values measured on the sound level meter should shift between 9 and 11 dB with each 10-dB reduction in intensity.

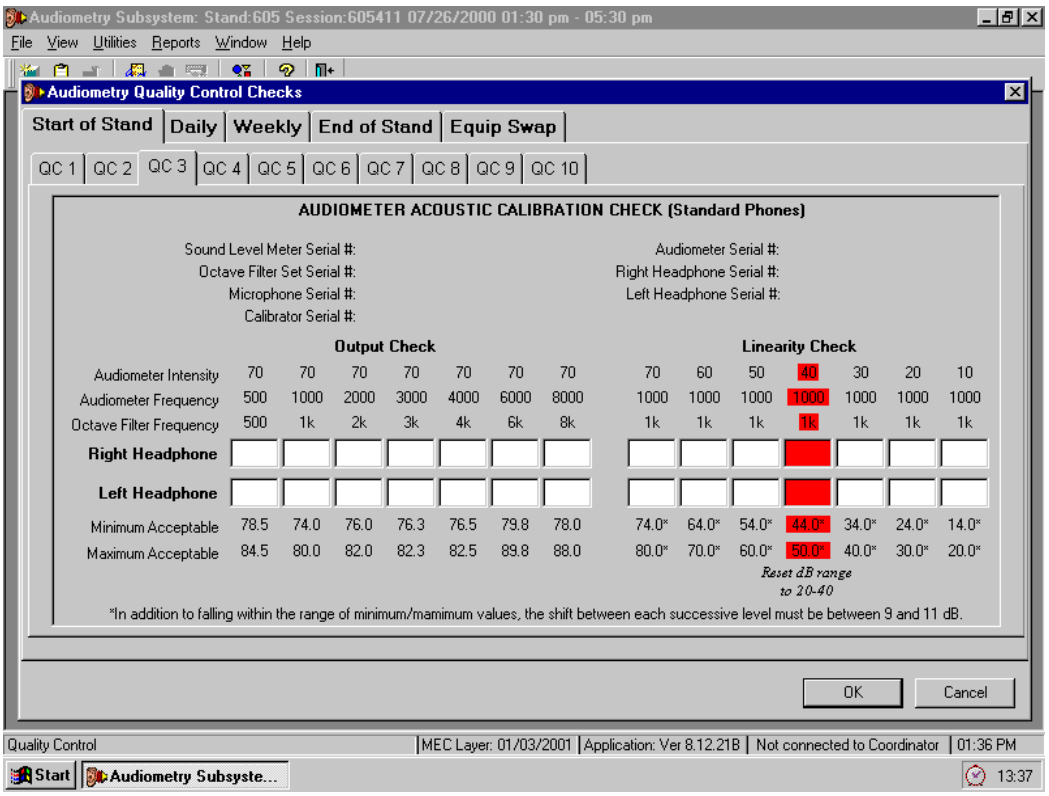
NOTE: It may not be possible to obtain an accurate sound level at 10 dB HL due to the noise floor of the equipment and surrounding environment. Do not be concerned if the sound level meter reading at 10 dB HL is not within calibration limits.

  – Press MAN REV on the audiometer to turn off the pure tone signal.

  – Repeat the output and linearity checks for each ear of each headphone.

Enter the results of the acoustic calibration check into ISIS (Exhibit 2-3). To enter the standard headphone data, go to the QC3 tab under the Start of Stand tab (the insert headphone data will be entered under the QC4 tab). Type the data from the log sheet for the output checks into the corresponding frequency boxes. Do the same for the linearity check data, and enter the numbers into the corresponding intensity boxes. **Be sure to use the correct ISIS tab for each headphone (standard or insert).**

Exhibit 2-3. Entering results of acoustic calibration check



If any results are out of range, ISIS will display a notification message. Repeat the measurements. If results remain out of range, notify the MEC manager and health technologist assigned to Audio for the stand before proceeding with further calibration checks.

NOTE: Audiometers and headphones are calibrated **as a unit.** If a set of headphones falls out of range at any point during the stand, the entire audiometer (audiometer, standard headphones, and insert earphones) must be replaced. The acoustic calibration must be repeated and new bioacoustic simulator reference values must be obtained.

2.4.2.2 Audiometer Bioacoustic Check

The bioacoustic check serves to confirm that the audiometer is remaining within the limits of calibration. This is done by testing someone (or something) with known hearing thresholds and verifying that the thresholds remain constant across time. The bioacoustic simulator serves as that "something" with known hearing levels. The simulator is programmed with a reference audiogram, which should remain unchanged as long as the calibration of the audiometer does not shift. The "hearing" of the simulator is tested at the beginning of each stand (following the acoustic calibration check) to obtain the reference thresholds. Then, the simulator is retested each day throughout the stand and again at the end of the stand. The results of these retests are compared with the reference thresholds to verify that there has been no shift.

The Quest BA-202-27 bioacoustic simulator is used to monitor the calibration of the right and left earphones of both the standard and insert headsets.

At the beginning of the stand, determine the reference values for each ear of each headphone in the following way:

- Press SHIFT/DEL on the audiometer and hold the buttons down until the display reads that "All thresholds are del."
- Make sure the bioacoustic simulator is turned on and verify that the power is flashing brightly, indicating that the battery voltage is sufficient. (If the power light does not flash or flashes dimly, change the battery as explained in Section 2.8.2.1.)
- If necessary, unplug the audiometer response switch from jack 3 inside the test room, and plug the response cable from the simulator into this jack.
- Verify that the headphone selection box is set to "TDH" to select the standard headphones.
- Place the standard headphones squarely on the simulator with the headband height fully extended; make certain that the right earphone is on the right coupler and the left earphone is on the left coupler.
- Set the following controls on the audiometer:
  - MAN REV button set to REV
  - 1 5 DB button set to 5
  - RIGHT ear selected

– Standard HEADSET selected

– Frequency set to 500 Hz and the intensity level to 30 dB.

NOTE: Pulsing should be off (i.e., both lights off on the PULSE button) when conducting calibration checks using the bioacoustic simulator.

- Close the doors to the sound booth and the audiometric test room.

- Slowly turn the left DB HL knob on the audiometer to increase the intensity in 5 dB steps. Pause a few seconds at each new intensity level and check to see if the right light on the simulator becomes illuminated (the response light on the audiometer should light up at the same time). Once the right light is lit, stop increasing the intensity and press STORE to record this level in the audiometer.

- The audiometer will automatically advance to the next frequency (1,000 Hz). Reduce the intensity to 30 dB and repeat the slow increase in level until the right light on the simulator becomes lit again. Press STORE to record this value. The audiometer will again advance to the next frequency. Continue this procedure (slowly increasing intensity from 30 dB until the right light on the simulator becomes lit) for the remaining test frequencies, storing the values in the audiometer.

- Repeat the procedure for the left headphone.

- When all frequencies have been tested in both ears, press SHIFT/EXT RANGE to display threshold results. The display should appear as shown below:

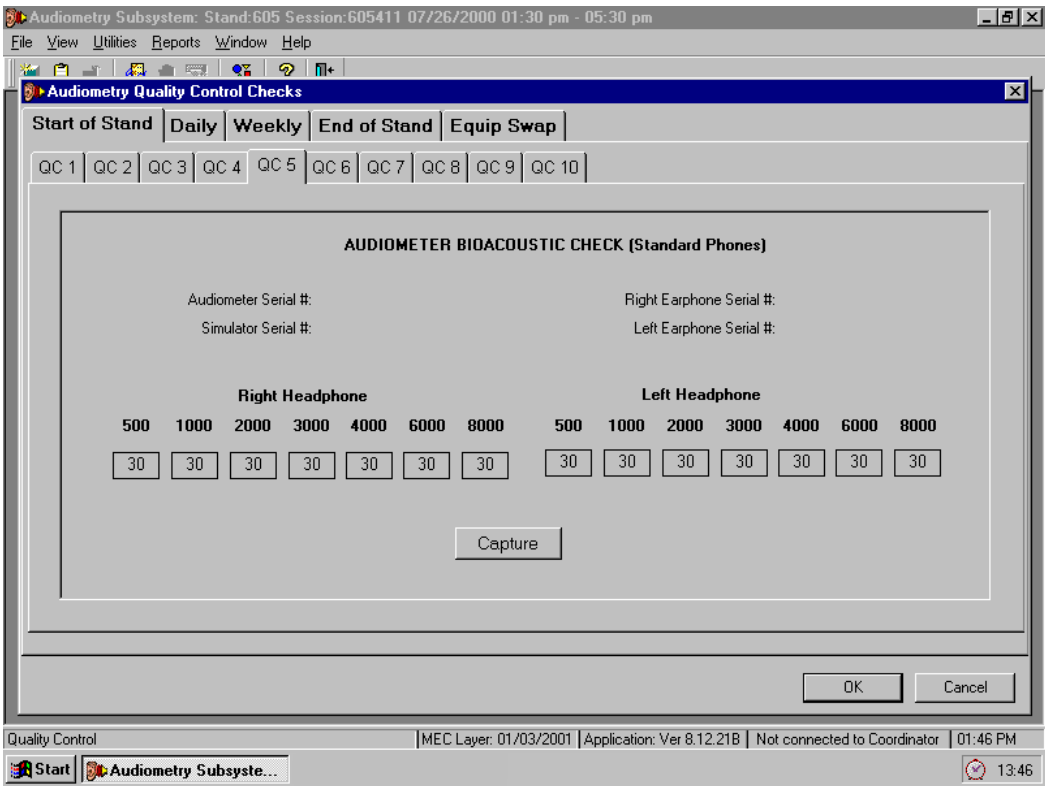
PH-R	***	***	65	***	65
***	65	65	65	65	65

– The first value displayed is the 500 Hz threshold; the second value is the 1,000 Hz threshold, and so on. (Ignore the asterisks; these represent frequencies of 125, 250, 750, and 1500 Hz, which are not being tested in NHANES.) Press RIGHT or LEFT to toggle between results for the right and left headphone as necessary. These thresholds will be the reference thresholds for the daily bioacoustic simulator calibration of the standard headphones throughout the stand.

- Copy the results into the reference values section of the Daily Audiometer Bioacoustic Check log form labeled “Standard Headphones.” Even though these results will also be stored in ISIS, it is convenient to have a hard copy for easy reference should there be difficulties encountered during daily calibration checks during the stand.

- Enter the standard headphone QC data into ISIS (Exhibit 2-4). Go to the QC5 tab under the Start of Stand tab and click on the "Capture" button to bring the data from the audiometer into ISIS.
  - Data that are entered during the daily QC checks will be automatically compared to these reference values established at the start of the stand.

Exhibit 2-4. Standard headphone bioacoustic check data



- Remove the standard headphones from the simulator. Gently press the black insert earphone adapters into the couplers on each side of the simulator.

- Place E-A-RLink 3A eartips (the standard or middle size) onto the ends of the insert earphones. Firmly roll each tip between your fingers to compress the foam and slide the tip into the opening on the adapters. Hold the tip in place until the foam expands. (Drape the Velcro strip across the top of the simulator to prevent the weight of the earphones from pulling the tips out of the adapters.)

- Press SHIFT/RIGHT on the audiometer to change the headphone selection to "Inserts." Switch the headphone selector box to "INSERT".

- Press SHIFT/DEL on the audiometer until the display reads that "All thresholds are del." Verify that the other audiometer settings are still as noted above.

- Conduct the threshold search in each ear at each frequency as before, storing the thresholds in the audiometer.

- When the test is complete, press SHIFT/EXT RANGE to display threshold results. Copy the results into the reference values section of the Daily Audiometer Bioacoustic Check log form labeled "Insert Earphones."

- Enter the results into ISIS by going to the QC6 tab and clicking the "Capture" button. These thresholds will be the reference thresholds for the daily bioacoustic simulator calibration of the insert earphones throughout the stand.

- Unplug the simulator response cable from jack 3 inside the test room, and plug the cable for the audiometer response switch back into this jack.

The daily calibration check is conducted in the same way. Standard and insert headphones will be checked on alternate days; ISIS will prompt you regarding which headphones to check on a particular day. Enter the results into ISIS under the Daily section; tab "Audio Bioacoustic Check." ISIS will compare the results of the Daily QC to the reference values obtained at the Start of Stand QC. If the daily results differ from the start of stand reference values by more than +/- 5dB, ISIS will display a notification message. The MEC manager and the health technologist assigned to Audio for the stand must be notified of the problem before any more exams are conducted.

At the end of the stand, conduct a final bioacoustic calibration check of both sets of headphones. Enter the QC data from the end of the stand in the End of Stand section, tab QC5 for standard headphones, and tab QC6 for inserts. ISIS will compare the results with the reference values and display a notification message if the values differ by more than +/-5 dB. If the end of stand calibration is off, notify the MEC manager and the health technologist assigned to Audio for the stand.

2.4.2.3 Audiometer Listening Check

The object of the listening check (also called a functional check) of the audiometer is to verify that the unit is functioning properly and that the test signals are being generated and routed to the appropriate earphone without distortion, extraneous sounds (such as clicks or hum), or loss of signal. A listening check is conducted at the beginning of each stand for both standard and insert headphones. Throughout the stand, standard and insert headphones are checked on alternate days following the same schedule as for the bioacoustic check. ISIS will prompt you regarding which headphones to check on a particular day. A listening check of both sets of headphones is conducted again at the end of each stand.

NOTE: Technologists must have normal hearing (i.e., thresholds better than or equal to 25 dB HL from 500-8000 Hz bilaterally) to conduct the audiometer listening check.

There are five components to the functional check—listening to the quality of the test tones; verifying the adjustment of the attenuator; checking the integrity of the earphone cords; checking the function of the response switch; and ensuring the proper routing of signals between the right and left earphones. The listening check is conducted as described below.

- Make sure the audiometer is on and has warmed up for at least 3 minutes.
- Verify that the appropriate headphones are selected on the headphone selector box ("TDH" for standard headphones and "INSERT" for insert earphones).
- Set the following controls on the audiometer:
  - MAN REV button set to REV
  - PULSE button set to _∏_∏_
  - 1 5 DB button set to 5
  - RIGHT ear selected
  - Appropriate HEADSET selected
- Check tonal quality:
  - Set the frequency to 500 Hz and adjust the left attenuator (i.e., the left HL DB knob) to a level of 50 dB HL. Listen to the tone pulses; verify that the tones are clear and that there is no noticeable click at the beginning or end of each pulse.
  - Cycle through all test frequencies by pressing the FREQUENCY INCR button, listening briefly (about three pulses) to each to verify that the tones are not distorted and that there are no extraneous sounds.
  - Select the LEFT headphone, readjust the left attenuator to a level of 50 dB HL, and repeat the procedure.
- Check the accuracy of the attenuator control:
  - Select a test frequency of 1,000 Hz and adjust the left attenuator to 0 dB.

– Adjust the left attenuator slowly in 5 dB steps up to 70 dB HL, stopping briefly at each level to verify the intensity change and listening for any extraneous sounds (clicks, scratches, etc.) as the level is changed.

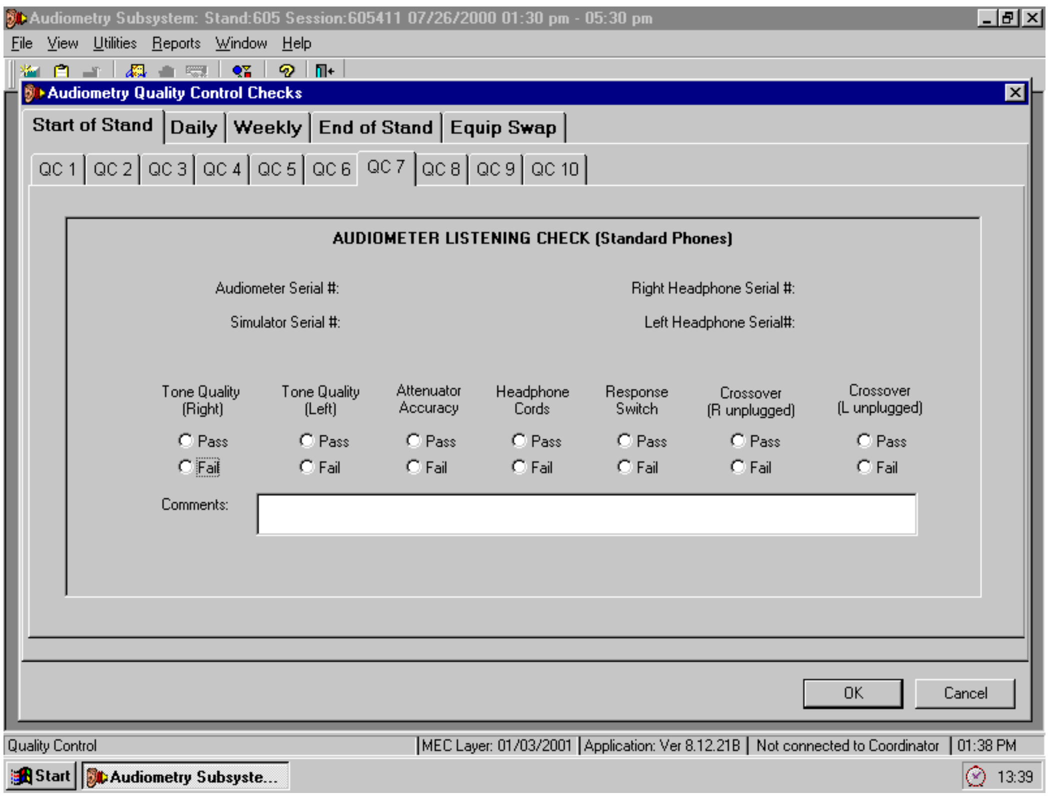
NOTE: It is only necessary to conduct the attenuator check in one ear.

- Check the earphone cords:
  - Select a test frequency of 1,000 Hz and adjust the left attenuator to 50 dB HL. Press the PULSE button once to turn off the pulsing (there should now be a steady tone).
  - Wiggle the earphone cords, especially where they enter the headphones and where they are plugged into the jacks inside the test room. Also wiggle the cables between the headphone box and the audiometer or sound booth. Listen for any interruption in the test signal, changes in the signal level or static or other noise in the headphones as the cords are flexed.
  - Select the LEFT headphone, readjust the intensity to 50 dB HL, and repeat the procedure.
- Check the response switch:
  - Press MAN REV once to turn off the test signal.
  - Press the response button. Verify that the response light on the audiometer is activated as the button is pressed and that pressing the response switch does not produce any sound in the earphones.
- Check for crossover:
  - Press MAN REV to turn on the test signal.
  - Select the RIGHT headphone, adjust the left attenuator dial to 70 dB HL, and set the test frequency to 1,000 Hz; you should hear a loud signal in the right headphone.
  - Unplug the right earphone jack from the back of the audiometer. Listen through the headphones; there should be no signal in either ear.
  - Plug the right earphone jack back into the audiometer.
  - Select the LEFT headphone and readjust the left attenuator dial to 70 dB HL. There should be a loud signal in the left ear.
  - Unplug the left headphone jack from the back of the audiometer. Listen through the headphones; there should be no signal in either ear.
  - Plug the left earphone jack back into the audiometer.

– Press MAN REV to turn off the test tone.

Enter the results of the Audiometer Listening Check in ISIS (Exhibit 2-5) as either "Pass" or "Fail" under tab QC7 for standard headphones and tab QC8 for inserts in the Start of Stand section. If any problems are noted, explain the problems in the "Comments" box and notify the MEC manager and the health technologist assigned to Audio for the stand. A sample of the Audiometer Listening Check screen for Standard Phones is below:

Exhibit 2-5. Results of audiometer listening check



2.4.3 Middle Ear Analyzer (Titan) Calibration Check

A simple check of the Titan's physical volume calibration must be conducted daily, including the beginning and end of stand as well as each day throughout the stand. The calibration will be affected by changes in temperature, so make sure that the temperature of the unit has stabilized prior to turning on the unit. In addition, a sample test should be run each day to evaluate the overall function of the Titan system and ensure that the unit is producing clear, normal graphs.

NOTE: If there is a loss of power during a session, or if the Titan is turned completely off between sessions, the physical volume calibration should be rechecked once the unit is powered up again. It is not possible to capture the repeat check in the ISIS QC system; the result should simply be recorded on the hard copy log, with a note explaining the purpose of the recheck.

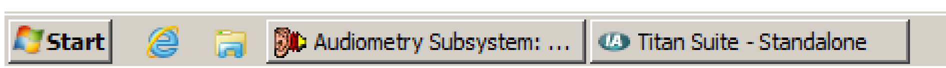
2.4.3.1 Titan Physical Volume Check

Physical volume must be calibrated on the Titan system each day. This is accomplished by running a test in a hard-walled cavity which has a known volume and verifying that the volume measurement (V) reported by the Titan matches the known volume of the cavity.

Conduct the Titan physical volume check in the following way:

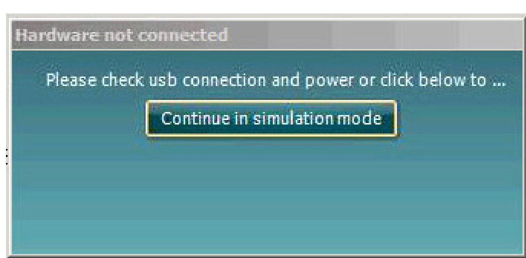
- Turn on the Titan handheld unit by pressing the R or L button on the handheld unit (the unit can remain in the storage cradle).
- The Titan Suite automatically launched when the ISIS quality control utility was first opened. When you are ready to conduct the Titan physical volume check, toggle to Titan Suite by clicking on the Titan Suite icon in the task bar at the bottom of the screen (Exhibit 2-6).

Exhibit 2-6. Task bar with Audiometry application and Titan Suite open



NOTE: If the unit is off or "sleeping," you will get a message that the hardware is not connected (Exhibit 2-7). Turn the unit on to make the message go away.

Exhibit 2-7. Hardware not connected message



- Select the IMP tab in the upper right corner of the Titan Suite window.

NOTE: It does not matter whether the Titan is set to test the left or the right ear for the physical volume calibration check.

Insert the Titan probe (without an ear tip) into the 2.0 cc calibration cavity (the side marked with green tape) until the black probe cap touches the black rubber gasket on the cavity (see Figure 2-29). The probe light should turn green, indicating that the Titan is able to test.

NOTE: The lower left corner of the cradle contains a built-in 2cc calibration cavity, which you can use for the daily volume check in lieu of the cylindrical calibration cavity. You can use whichever you prefer for conducting this check; however, it may be easier to see how fully the Titan tip is inserted if you use the silver cylinder to do the check rather than the calibration cavity built into the charging cradle.

Figure 2-29. Probe tip inserted in calibration cavity

Press the laptop space bar or shoulder box button to start the test. The Titan will run through both the entire test sequence (tympanometry, wideband reflectance, and acoustic reflexes); however, only the tympanometry results are necessary for the physical volume calibration.

When the probe flashes white and the test is complete, remove the probe from the calibration cavity.

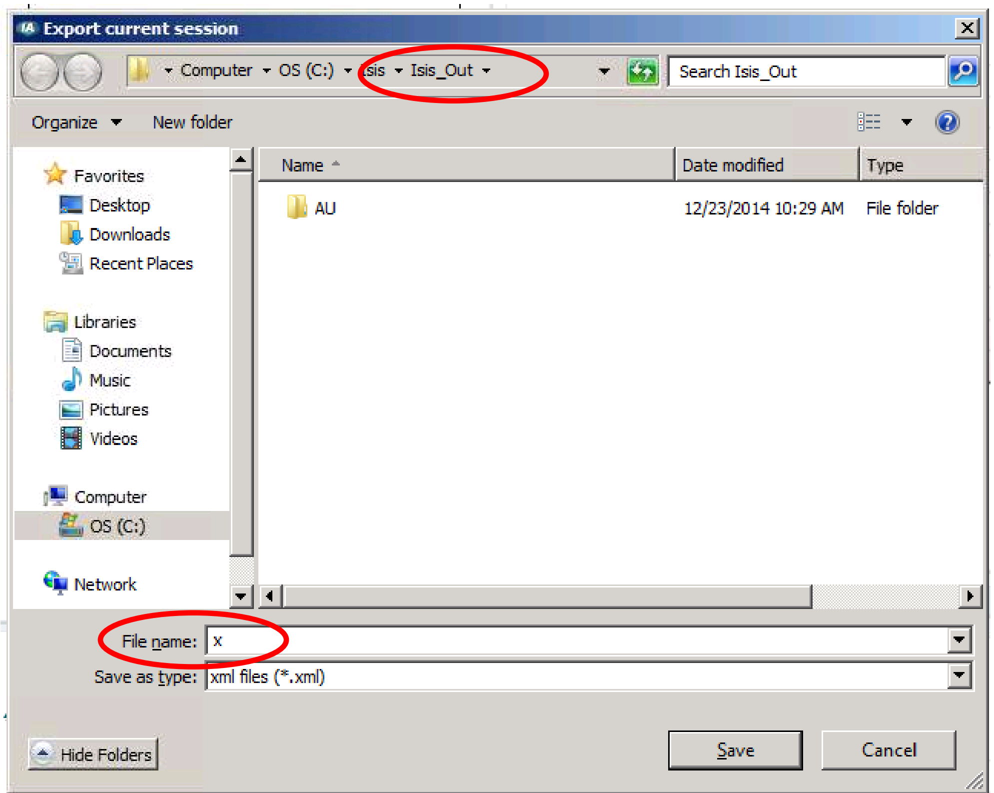
Verify that the V (volume) value reported on the Titan display is between 1.90 and 2.10 ml, as shown in Figure 2-30.

Figure 2-30. Physical volume calibration result

Press ALT-M, ALT-E, ALT-X (think "ALT-MEX") to save the Titan results to ISIS. The Titan Export window will pop up.

Confirm that the path at the top of the window indicates the ISIS_Out folder, as shown below, type "x" for the file name, and click SAVE (Exhibit 2-8):

Exhibit 2-8. ISIS_Out folder

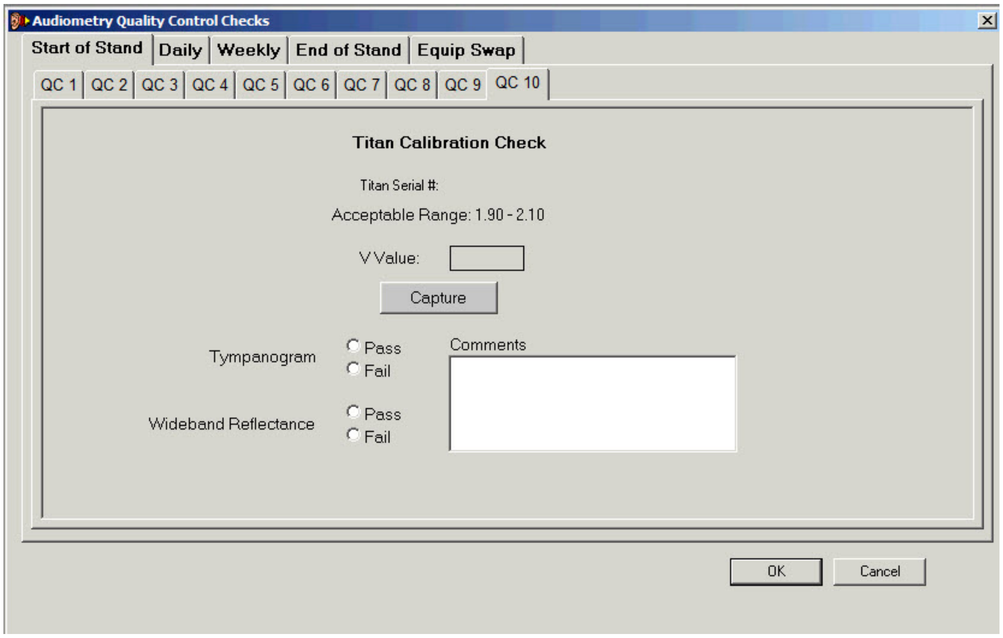


NOTE: If an x.xml file is already in the ISIS_Out folder when you try to save the calibration result, contact the MEC manager or health technologist assigned to Audio for the stand before proceeding.

Toggle back to the ISIS QC utility by clicking the audiometry icon in the task bar at the bottom of the screen.

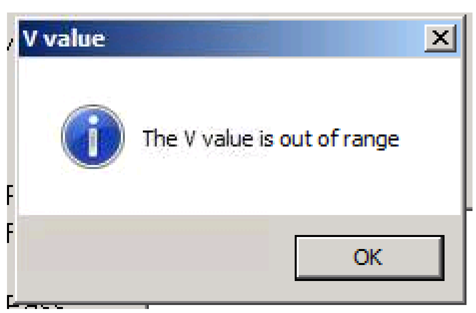
Go to the QC10 tab under the Start of Stand tab. Click the “Capture” button to capture the tympanometry QC data (Exhibit 2-9).

Exhibit 2-9. Tympanometry Calibration Check screen



If the physical volume measurement does not fall within the required range, ISIS will display a notification message (Exhibit 2-10). (The notification will not prevent you from continuing or saving.) Repeat the calibration making sure to insert the probe completely into the cavity and hold the probe very still (ambient movement results in “noisy” immittance measurements). Placing the probe on a piece of foam or other soft surface during the calibration may be helpful.

Exhibit 2-10. Out of Range Notification



If the physical volume is still out of calibration limits, clean and reseal the probe tip as described in Section 2.8.4.2. If this fails to correct the problem, notify the health tech assigned to Audio for the stand.

NOTE: Recheck the Titan volume calibration no more than three times per exam day. If the volume calibration does not fall into the 1.9-2.1 range after 3 attempts, contact the audiometry consultant (Christi Themann). Once Christi has been notified of a Titan volume issue at a particular stand, continue to use the current Titan unit unless the daily calibration falls below 1.8 or above 2.2. Notify Christi if the volume calibration either falls outside this wider range or eventually falls within the actual target range (1.9-2.0).

2.4.3.2 Titan Sample Tympanogram and Wideband Reflectance Checks

The physical volume measurement only checks the calibration of part of the middle ear measurement system. In order to evaluate the overall function of the system, you need to run a sample test on yourself to ensure that the unit is producing clear, normal graphs.

Run the Titan middle ear test sequence on yourself just as you would during a test (see Section 3.4.3.2). Make sure the Titan is set to test the same ear that the physical volume check was run on (your results will over-write the results from the physical volume check in the Titan Suite window). Run a sample middle ear test sequence on one of your ears; it does not matter which ear you test, but try to test the same ear each day. You will not be able to monitor the probe lights while testing yourself, but you will know when you have obtained a seal when you feel the pressure build up in your ear canal. You can also monitor the progress of the test by watching the Titan Suite display on the computer screen. If you do not have a seal, the pressure indicator (V) below the horizontal axis will waver back and forth; once you obtain a seal, the tympanogram will plot on the display and the WBR test will immediately follow.

Once the test is completed, evaluate the tympanogram for smoothness and symmetry, as during a hearing evaluation (See Section 3.4.3.3). Also evaluate your WBR results just as you would during a hearing evaluation (see Section 3.4.3.3). Make sure the graph crosses the vertical axis below the 40 percent point, and check that the plot looks similar to your usual WBR result. Verify that the acoustic reflexes were tested as they should be; do not worry about the specific acoustic reflex results.

You do not need to save the results from the sample test. On the ISIS QC screen, click "Pass" to indicate that you obtained normal sample tests on the ISIS screen.

If any part of the sample test does not does not look normal, follow the troubleshooting guide in Section 2.4.4 and try repeating the test (overwriting your initial results). If you cannot obtain a normal tympanogram or WBR result on your usual ear, try running the test on your other ear on another team member. If you still do not get an acceptable tympanogram or WBR result, record "Fail" on the ISIS QC screen and describe the problem and your troubleshooting efforts in the "Comments" box. Notify the MEC manager and health technologist assigned to Audio for the stand.

2.4.4 Troubleshooting Calibration Problems

The following problems may be encountered during audiometric calibration checks. Potential solutions are listed for each problem to assist in troubleshooting these difficulties.

- Titan V value outside range:
  - Repeat calibration holding probe very still or placing it on a piece of soft foam.
  - Clean or replace probe tip, as explained in Section 2.8.4.2.
  - Check the volume using the alternate cavity (i.e. the silver cylindrical cavity or the cavity on the Titan storage cradle).
- Sample tympanogram flat:
  - Repeat tympanogram in your other ear.
  - Run a tympanogram on another team member.
  - Clean probe tip as explained in Section 2.8.4.2
- Sample tympanogram "noisy":
  - Repeat tympanogram, holding the probe very still.
  - Repeat tympanogram on another team member.

- Sample WBR crosses vertical axis above 40 percent mark:
  - Repeat WBR, pressing the probe more firmly in the ear.
- Audiometer acoustic calibration values out of range:
  - Make sure audiometer is set to proper headset.
  - Make sure octave-band filter is set to the appropriate frequency.
  - Verify that you are comparing results to the appropriate set of reference values (i.e., for standard or insert headphones).
  - Check the batteries in the sound level meter.
  - Verify that all headphone jacks are plugged in completely.
  - "Clean" the audio jacks and sound booth inputs by inserting/removing the jack in and out of the panel several times, twisting it around a bit in the jack panel each time.
  - Place calibration stand on a piece of soft foam to avoid influence of low-frequency vibration.
- Sound level meter reads "– – –":
  - Verify that DB RANGE setting is correct.
  - Press RUN.
  - Check batteries.
- Audiometer bioacoustic calibration is more than 5 dB from reference values:
  - Check battery in bioacoustic simulator.
  - Verify that audiometer is set to appropriate headphones (standard or insert).
  - Make sure you are comparing results to the appropriate reference values (standard or insert).
  - (For standard headphones) make sure insert earphone adapters were removed from the simulator.

2.5 Environmental Noise Survey

2.5.1 Environmental Noise Principles

In order to obtain valid hearing threshold measurements, the background noise levels in the test environment (called the ambient noise) must be quiet enough for the examinee to hear the very low intensity test tones that will be presented to him or her. If the ambient noise is too high, then the examinee might be unable to hear signals that his auditory system is capable of sensing, simply because the test environment is inadequate.

Because the sound room used in NHANES is mobile, the ambient noise levels must be checked each time the MEC is moved to a new location. Therefore, a sound survey must be done as part of the setup procedures at the beginning of a new stand. Additionally, since the sound environment around the MEC is subject to change, the sound survey will be repeated weekly during the stand to verify that the ambient noise has not changed. Finally, if at any point you notice a change in the background environment (for example, if any of the background noise indicators on the bioacoustic simulator light up consistently or if operations using heavy equipment begin adjacent to the MEC), the survey must be repeated to check for any problems that would interfere with accurate testing.

2.5.2 Environmental Noise Survey Procedure

The background noise levels in the sound room should be measured insofar as possible under the same conditions as will exist during actual audiometric testing. Therefore, prior to conducting the ambient noise survey, set up the test environment as follows:

- Computer, audiometer, and Titan turned on;
- Lights turned on inside the booth; lights turned off outside the booth;
- Ventilation system turned on inside the test booth; and
- Sound room and hallway doors closed.

Conduct the environmental noise survey in the following way:

- Set up the sound level meter and octave filter set.
  - Connect the preamp directly to the top of the sound level meter. Gently screw the 1-inch microphone onto the top of the preamp and A-63B adapter. The meter should appear as shown below in Figure 2-31.

Figure 2-31. Sound level meter connected to preamp and microphone

  - Mount the sound level meter on the tripod and adjust it to a 45-degree angle (pointing toward the ceiling). Place the sound level meter in the test room at the approximate position the examinee's head will occupy during testing. Position the tripod so that the meter display is visible through the window in the sound booth door.
- Slide the POWER switch of the sound level meter to "on" and check the batteries, as described in Section 2.4.2.1.
- Set the sound level meter controls as follows:
  - Response: Slow
  - Weighting: Lin
  - Mode: SPL
  - Range: 60-120
- Be sure that the power switch on the OB-300 filter set is off.
- Calibrate the sound level meter as described in Section 2.4.2.1.

NOTE: Even if the sound level meter was calibrated previously in order to check the acoustic calibration of the audiometer, it must be calibrated again here because the preamp cable is no longer being used.

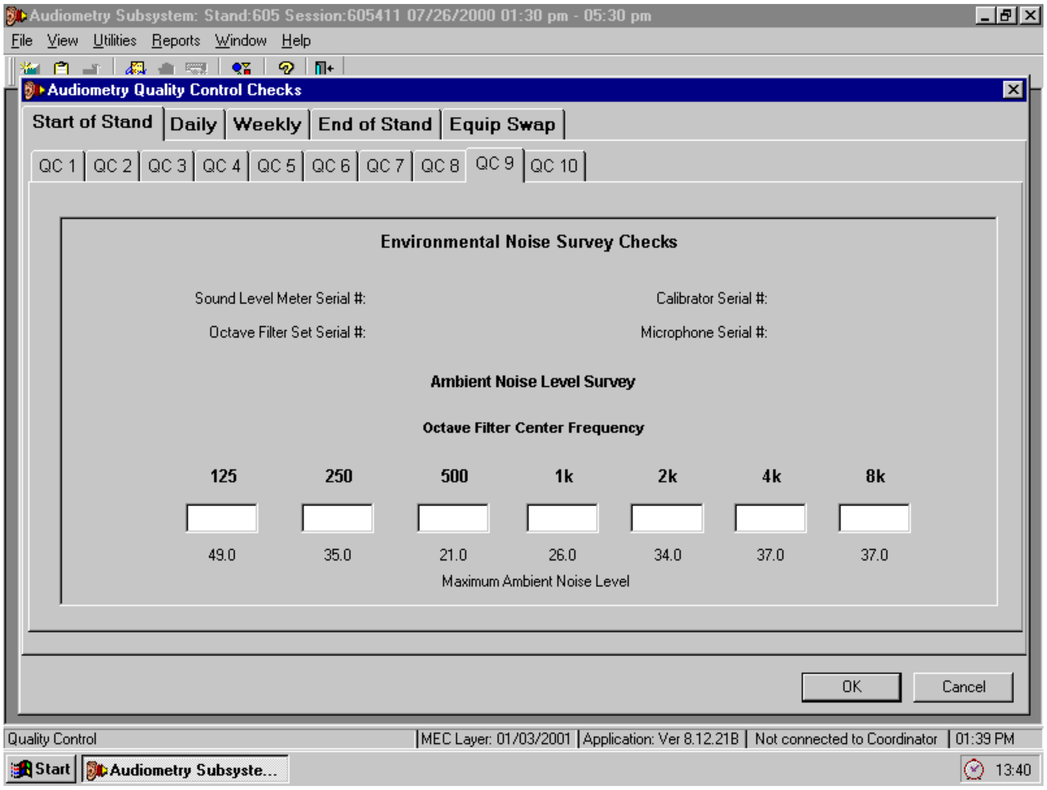
- Reset the sound level meter range to 20-80.
- Reset the sound level meter mode to LEQ.
- Set the POWER switch on the OB-300 octave filter set to manual and set the mode switch to 1/1.
- Use the ∇ button on the octave filter to select a center frequency of 63 Hz. Slide the POWER switch on the octave filter to AUTO. Press the Δ button, then RUN.
- Exit the sound booth and close the sound booth door. Wait for the octave filter to advance to a center frequency of 125 Hz. The meter will average the sound level for approximately 25 seconds before advancing to the next frequency. Record the average level on the environmental noise survey log form.

NOTE: An ambient noise measurement is not recorded at 63 Hz. The octave filter is initially set for this frequency to allow time for you to exit the room and close the door before beginning measurements at 125 Hz.

- The octave filter will automatically advance to a center frequency of 250 Hz (the display will read ——— as the frequency changes). The meter will repeat the measurement process, averaging the background noise at 250 Hz. Record the result on the calibration log.
- Continue measuring in the same way as the octave filter automatically advances to each successive frequency band. Record average background noise levels at 500, 1k, 2k, 4k, and 8k Hz.
- Open the door to the sound room. Slide the POWER switches on both the sound level meter and octave filter set to "off."

Copy the data from the environmental noise survey log into the Start of Stand QC section under tab QC9. The QC screen displays (Exhibit 2-11) the maximum limits for the ambient noise levels.

Exhibit 2-11. Environmental noise survey check screen



If the noise levels are too high at any frequency, ISIS will display a notification message. Try to determine the source of the interfering sound and correct it. If it is not possible to reduce the ambient noise to acceptable levels, inform the MEC manager immediately. **Pure tone audiometric testing can NEVER be done when the ambient noise levels in the test room exceed the levels shown on the screen above**. Thresholds obtained in high background noise are invalid and useless.

2.5.3 Daily Monitoring of Ambient Noise Levels

The Quest BA-202-27 is equipped with an octave band monitor that monitors the ambient noise in the sound room continuously. The octave band monitor is activated simply by turning on the simulator. If the background noise levels exceed the maximum levels that have been programmed into the unit, one or more of the red indicators will light up.

Whenever pure tone testing is conducted, the monitor should be observed. If the indicator lights remain on for more than a few seconds, the hearing test should be suspended until the noise problem is resolved.

2.6 Daily Procedures

2.6.1 Setup and Calibration

Turn on the audiometer and middle ear analyzer and allow them to warm up for at least 10 minutes prior to beginning the daily calibration procedures. Unplug the otoscope base from the electric outlet and screw the top portion onto it. Turn on the otoscope and verify that it works. Turn on the ventilation switch inside the sound booth and open the door. Keep the door to the booth open as often as possible to keep the temperature inside at a comfortable level.

Calibrate Titan physical volume measurement as described in Section 2.4.3.1. Remember that the calibration will be affected by changes in temperature; if a large change in temperature occurs in the test room over the course of the day, turn the power off, wait 3 seconds, and turn the unit on again. Also, if the Titan is turned completely off at any point during the day (e.g., between sessions or due to a power outage), recheck the physical volume calibration before conducting the next exam.

Conduct a sample middle ear test on yourself as described in Section 2.4.3.2.

Conduct a bioacoustic check and a listening check of the headphones, as described in Sections 2.4.2.2 and 2.4.2.3. Standard and insert headphones should be checked on alternate days, as prompted by ISIS.

2.6.2 Changing Equipment After Start of Stand

If equipment is changed for any reason during a stand, the replacement equipment must go through the start of stand calibration procedures. All calibration checks done on replacement equipment will be entered into ISIS under the Equip Swap section. The QC tabs in the Equip Swap section are identical to the tabs in the Start of Stand section. The serial number of the new piece of equipment must be entered on the hard-copy serial number log and in the QC1 tab in ISIS. Appropriate calibration checks must be conducted as indicated below.

If the bioacoustic simulator is swapped, conduct the following QC checks:

QC 1: Enter the serial number of the replacement bioacoustic simulator.

QC 2: Check the calibration of the replacement bioacoustic simulator.

QC 5: Obtain new reference values for the standard earphones.

QC 6: Obtain new reference values for the insert earphones.

If the middle ear analyzer is changed, conduct the following calibration checks:

QC 1: Enter the serial number of the replacement Titan.

QC 10: Check the volume calibration of the replacement Titan and run a sample test on yourself.

If the audiometer is swapped, conduct the following calibration checks:

QC 1: Enter the serial numbers of the replacement audiometer, right and left standard earphones, and right and left insert earphones.

QC 3: Conduct complete acoustic calibration check of the standard earphones.

QC 4: Conduct complete acoustic calibration check of the insert earphones.

QC 5: Obtain new reference values for the standard earphones.

QC 6: Obtain new reference values for the insert earphones.

QC 7: Do a listening check of the standard earphones.

QC 8: Do a listening check of the insert earphones.

If the sound level meter kit (or any part of it) is changed, record the following QC:

QC 1: Enter serial numbers of the replacement sound level meter, octave-band filter set, calibrator, and microphone.

NOTE: If equipment is changed at the beginning of a test day, you may need to enter the results into the daily QC section as well.

2.6.3 Procedures at the End of an Exam Day

At the end of each test day, turn off all of the audiometric equipment. To power down the Titan handheld unit, press both the R and L buttons until the globe appears. Recharge the otoscope as explained in Section 2.8.3.2.

NOTE: Do **not** recharge the otoscope if the MEC will be closed the following day.

2.7 Weekly Procedures

Conduct an environmental noise survey according to the procedure given in Section 2.5.2. Clean the viewing window on the otoscope as described in Section 2.8.3.3, and the Titan probe tip as described in Section 2.8.4.2.

2.8 Equipment Care and Maintenance Procedures

The equipment selected for the study was chosen in part because it is rugged and durable enough to withstand field testing conditions. Nonetheless, like all medical equipment, it must be handled with care in order to ensure that it stays in good working order and that the calibration of the instruments does not change.

The exterior housing of the sound level meter, calibrator, bioacoustic simulator, audiometer, and Titan handheld unit may be cleaned as necessary by wiping them with a damp cloth or an Audiowipe. Do not use any other cleaners or a cloth so damp that fluids could seep into the interior of the housing. Maintenance and care of the specific instruments are described in the following sections.

2.8.1 Sound Level Meter and Accessories

2.8.1.1 General Handling

Sound level meters are very precise instruments that require careful handling. Always use the following precautions when handling the sound level meter and its accessories:

- Handle the microphone very carefully. Never touch the diaphragm of the microphone; try to keep dust and other objects from touching the diaphragm as well.
- Store the microphone in its case when it is not in use. Do not leave the microphone attached to the preamp.
- Make sure the power is turned off on the sound level meter and octave filter set before assembling or disassembling the meter. Especially, **NEVER** attach the microphone to the sound level meter when the power is on.
- Attach the microphone, preamp, adapters, couplers, etc., very gently. Never try to force a connection. If something does not seem to be attaching easily, remove it and try again.
- Do not expose the sound level meter or its accessories to excessive heat, cold, or dampness. Allow the instruments to adjust to the ambient temperature of the environment before using them.
- Make sure the batteries are in good condition. If the meter will be in storage for an extended period of time (more than a week; e.g., between stands), remove the batteries from the meter and the filter set before storing them away.

2.8.1.2 Changing Batteries

The sound level meter and octave filter set together require two 9-volt alkaline batteries. The batteries go into the battery compartment underneath the instrument (Figure 2-32). Use a small Phillips head screwdriver to remove the cover plate. Snap the batteries onto the connectors inside the compartment. Replace the cover and screw it back into place. Battery life is approximately 8 hours when both the meter and the octave filter set are used.

Figure 2-32. Changing batteries in sound level meter

The QC-20 calibrator requires one 9-volt alkaline battery. When the battery is so low that it would affect calibration, the LOBAT indicator will light up and the calibrator will produce no sound. To replace the battery, gently unscrew the gray section of the calibrator from the black section and slide the gray cover off (see Figure 2-33). Unsnap the battery from its connector. Press the flat end of the new battery down on the foam pad until it fits underneath the connector; then snap the battery into place. Slide the calibrator back into the gray sleeve and screw it into place.

Figure 2-33. Changing battery in the calibrator

2.8.1.3 Annual Calibration

The sound level meter, octave filter set, and microphone should receive a comprehensive calibration annually (or sooner if problems are encountered). The calibration should be accomplished by the manufacturer (Quest Technologies) or by another laboratory whose calibrations are traceable to the National Institute of Standards and Technology (NIST).

2.8.2 Bioacoustic Simulator

2.8.2.1 Changing the Battery

The bioacoustic simulator requires one 9-volt alkaline battery. The battery compartment is located at the top of the unit. Lift the left side of the gray battery door upward. Snap the battery onto the connector, slide it into the battery compartment, and close the battery door. Battery life is approximately 24-32 hours, or 3-4 days assuming 8 hours of daily use. As the battery weakens, the power light indicator will flash less brightly. When the light flashes dimly or does not flash at all, the battery must be replaced.

Because the battery must be changed so frequently, the battery connector on the bioacoustic simulator suffers a lot of “wear and tear.” **Be particularly careful when removing and replacing the battery so that the battery connector is not damaged.**

2.8.2.2 Calibration

The bioacoustic simulator should receive a comprehensive calibration annually (or sooner if problems are encountered). The calibration should be accomplished by the manufacturer (Quest Technologies) or by another laboratory that is a member of the National Association of Special Equipment Distributors, in order to ensure that the calibrations are traceable to NIST.

2.8.3 Otoscope

2.8.3.1 Assembling the Otoscope

The otoscope consists of two parts: the head (which contains the lamp and the eyepiece) and the handle (which holds the batteries). The handle itself also contains two parts: the upper part (which connects to the head) and the lower part (which contains the battery). Assemble the two parts of the handle by screwing them together. Then slide the head over the top of the handle, lining up the notches on the head with the protrusions on the handle, and turn it clockwise until it locks in place.

2.8.3.2 Charging the Battery

The otoscope contains a rechargeable battery in its base, which can be charged simply by unscrewing the top of the handle and plugging the base into any standard wall outlet (see Figure 2-34). The otoscope should be charged for 8 hours at the start of each stand; and overnight during the stand. Do not charge the battery if the MEC will be closed the following day.

Figure 2-34. Charging the otoscope

NOTE: It is not necessary to remove the head of the scope in order to charge the handle.

2.8.3.3 Cleaning the Eyepiece

The eyepiece on the head of the otoscope slides out for easy cleaning (see Figure 2-35). Gently push the window to the right with your thumb. The window may be cleaned with alcohol or standard glass cleaner. The eyepiece should be cleaned about once a week, or as often as necessary. Do **not** clean the window without first removing it, as the cleaning solutions could damage the otoscope.

Figure 2-35. Cleaning the eyepiece

2.8.3.4 Changing the Otoscope Lamp

The light source for the otoscope is a small, fiber optic bulb located at the base of the otoscope head. To change the lamp, disconnect the otoscope head from the handle. Remove the old bulb by pulling it out gently using your fingernails or a small nail file to lift it out of place (the bulb is held in by friction only). Taking care not to touch the glass surface of the replacement bulb, gently insert it into the receptacle and push it in as far as it will go. (The base of the bulb should be slightly below the metal base of the otoscope head.) Replace the head on the handle.

2.8.4 Middle Ear Analyzer

2.8.4.1 General Handling

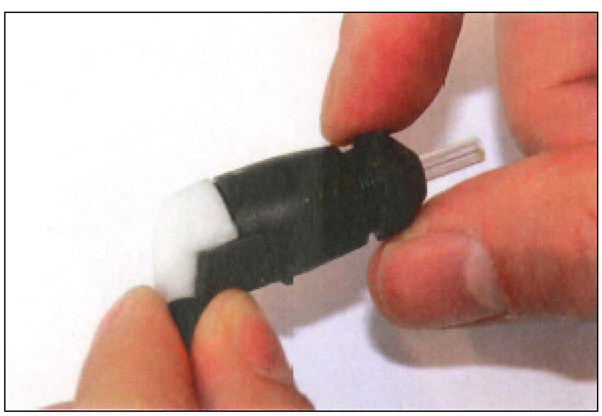
Calibration data for the Titan is stored in the probe tip and in the shoulder box. Be especially careful not to bang or drop the extension cable to which these parts are attached, as this may affect the function or calibration of the Titan. In addition, take care not to kink or step on the extension cable, as this could damage the internal airline and make it impossible to conduct the middle ear tests. Coil this cable loosely when hanging it in the exam room or when packing equipment to avoid potential damage to the air line or wires.

2.8.4.2 Cleaning the Probe Tip

The clear tip at the end of the Titan probe must be cleaned regularly to ensure proper functioning of the Titan. It should minimally be cleaned once a week and at the end of each stand, and more often if cerumen or other debris is evident, if the Titan repeatedly reports a block when attempting to conduct immittance testing, or if the physical volume measurement is repeatedly low during calibration.

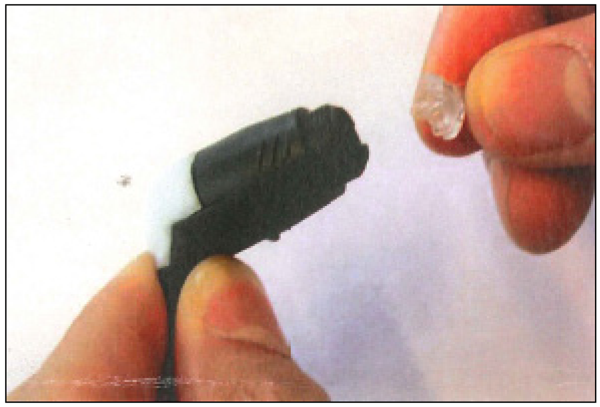
Clean the probe as follows: Unscrew the probe cap, as shown in Figure 2-36 below:

Figure 2-36. Unscrew the probe cap from the probe tip



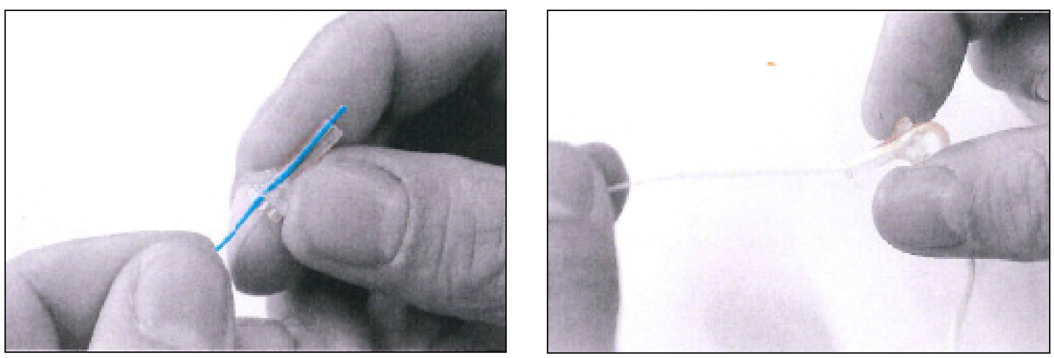
Next, take off the probe tip by pulling it gently straight out, as shown in Figure 2-37.

Figure 2-37. Pull the probe tip directly off the probe



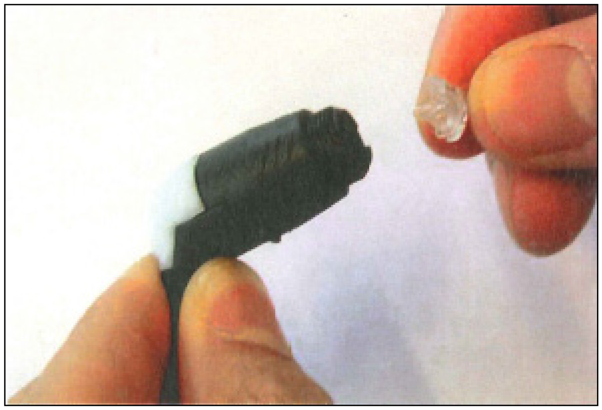
Use the probe cleaning tool to remove any debris from the probe tip. You can also use cleaning floss. Thread the stiff end of the cleaning floss through the probe tip tube and then pull the cleaning floss completely through, as shown in Figure 2-38. Discard the floss.

Figure 2-38. Cleaning the probe tip with floss



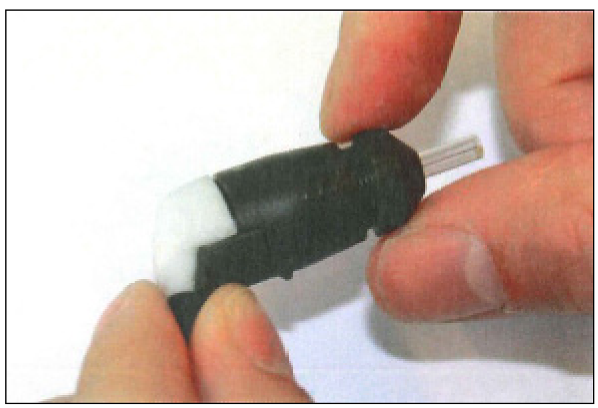
Replace the tip onto the probe by lining up the two small holes and one large whole; there is also a notch between the two small holes to guide placement (see Figure 2-39 below). Press gently until the tip snaps into place.

Figure 2-39. Snap the tip back onto the probe



Screw the cap back onto the probe, as shown in Figure 2-40.

Figure 2-40. Screw the cap back onto the probe



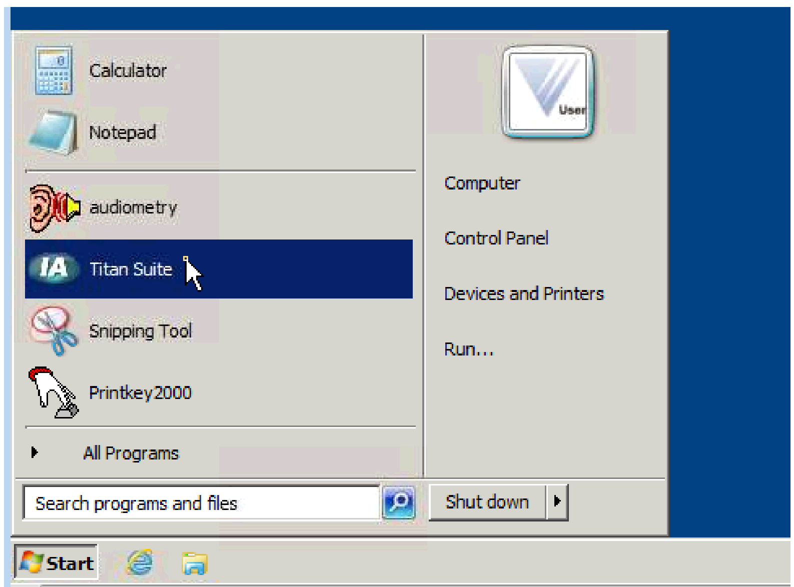
A spare probe tip is provided with your supplies, so that you can quickly swap the tip if it becomes clogged while conducting an evaluation. The clogged tip can be cleaned later when time permits.

NOTE: Do **not** attempt to clean the probe tip while still attached to the housing.

AND ANOTHER NOTE: Do **not** attempt to remove debris that may be evident on the probe itself. A block at the level of the probe itself must be cleaned by an authorized laboratory.

If it is necessary to clean the probe tip or switch the probe tip after the daily QC has been conducted, you must recalibrate the middle ear analyzer. This can be done outside of the ISIS QC utility by clicking on the start menu button in the toolbar and selecting "Titan Suite" (Figure 2-41). Check the volume calibration and run a sample test on yourself using the instructions in Section 2.4.3.1; however, you do not need to save the results.

Figure 2-41. Opening Titan Suite outside of ISIS



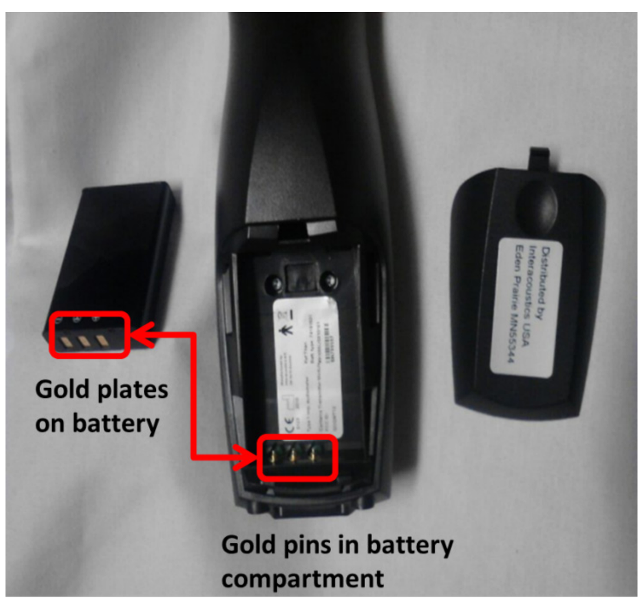
2.8.4.3 Changing the Titan Battery

The Titan operates from a rechargeable battery, which is continually charged through the Titan storage cradle. However, if for some reason the battery becomes fully discharged and must be replaced, remove the battery cover from the back of the handheld unit by pressing gently on the indentation near the bottom of the unit and gently sliding the cover downwards (see Figure 2-42).

Figure 2-42. Removing the battery cover from the Titan handheld unit

Place the new battery in the compartment, making sure that the gold plates on the bottom of the battery line up with the gold pins in the battery compartment, as shown in Figure 2-43.

Figure 2-43. Gold plates on Titan battery lined up with the gold pins in the battery compartment



NOTE: Do not rely on the printing on the battery to know which way to place it; some batteries are printed differently than others. Always double check how you are placing the battery in the unit, as installing it incorrectly will break off the pins.

Replace the battery door by sliding it up over the compartment until it clicks in place.

2.8.4.4 Charging the Titan Outside the Cradle

The Titan can be charged independently of the storage cradle in two ways. The handheld unit can be connected directly to the computer using a USB cable (with a mini USB connection on one end and regular USB connector on the other end). Insert the mini USB connector into the bottom of the handheld unit and the regular USB connector into an open USB port on the computer monitor. If the battery is fully charged, this type of connection is usually sufficient to run tests for a day.

The Titan, however, does not always maintain a sufficient charge over time when charged via a computer USB port, and it takes a long time to recharge a low battery through the computer connection. Therefore, when you are not using the Titan cradle, the handheld unit should be charged overnight using a wall outlet. Connect the mini USB end of the wall charger into the bottom of the handheld unit and plug the charger into a wall outlet. Do not charge the Titan overnight on evenings when no exams are scheduled for the following day.

2.8.4.5 Controlling Humidity

The Titan probe (the small part at the end of the cable, which lights up) contains a filter that is very sensitive to humidity. Desiccant packs are used to try to keep humidity out of this filter. There are two different types of desiccant packs—one for use when the Titan is in storage in its black case and another for when the Titan is unpacked for use during a stand.

Desiccant Pillows for Use in Storage

Desi View desiccant pillows should be used in the black Titan storage case whenever the Titan is packed in this case. This would include:

- When the Titans are packed up between stands;
- When shipping a Titan for calibration or service; and
- When storing the spare Titan during a stand.

The pillows are filled with blue and white silica gel (Figure 2-44). When the silica crystals turn from blue to pink, they have reached their absorbance capacity and should be changed.

Figure 2-44. Desiccant pillows

When packing the desiccant pillows in the black cases, try to keep them as close to the probe as possible (Figure 2-45).

Figure 2-45. Probe packed near desiccant pillows

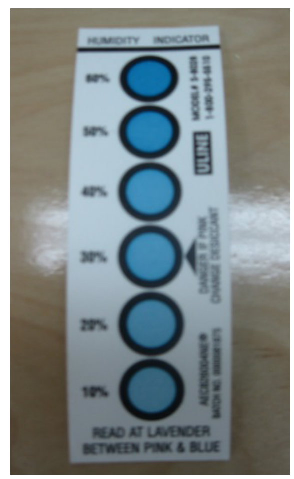
Spare desiccant pillows should be kept in a Ziploc bag to prevent them from absorbing moisture until they are needed.

Please check the desiccant pillow packed with the spare Titan at the start and end of each stand and replace it if necessary. It isn't necessary to monitor the desiccant for the spare Titan during a stand.

Desiccant Packs for Use in During a Stand

Small desiccant packs should be used during the stand to prevent humidity from affecting the probe tip of the Titan in use for that stand. These desiccant packs have silica crystals that do not change color when their moisture capacity is reached. Therefore, a humidity indicator strip is needed to monitor how much moisture has been absorbed. The humidity strips are supplied in an airtight can and have dots that will successively turn pink as more moisture is absorbed (Figure 2-46).

Figure 2-46. Humidity strips and can



At the end of each exam day, put the Titan probe tip in a Ziploc bag each evening with 5 of the small white desiccant packs and the dot strip (Figure 2-47).

Figure 2-47. Titan probe tip storage

Change the desiccants and the strip when the 30 percent dot changes from blue to pink.

Store the spare desiccant packs a Ziploc bag to prevent them from absorbing moisture until they are needed.

2.8.4.6 Annual Calibration

The Titan must receive a comprehensive calibration annually (or sooner if problems are encountered). The calibration must be accomplished by the manufacturer (Interacoustics) or a laboratory that is a member of the National Association of Special Equipment Distributors, in order to ensure that all calibrations are traceable to NIST.

2.8.5 Audiometer

2.8.5.1 General Handling

While the Interacoustics AD226 audiometer is a fairly rugged instrument designed to provide accurate and reliable service even under field testing conditions, the headphones are more susceptible to damage. Be very careful not to bang or drop the headphones or insert earphones, as this may alter the calibration. If either headphone is accidentally dropped, recheck the calibration using the bioacoustic simulator (see Section 2.4.2.2).

2.8.5.2 Annual Calibration

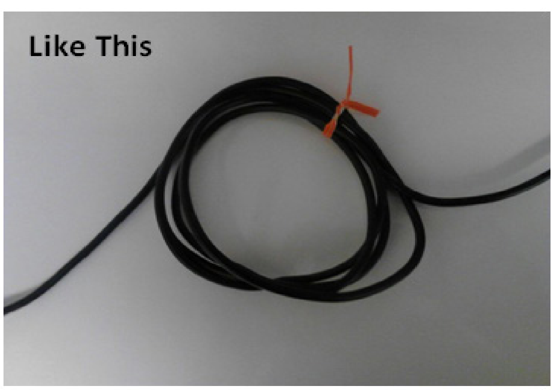
The audiometer must receive a comprehensive calibration annually (or sooner, if problems are encountered). The calibration must be accomplished by the manufacturer (Interacoustics) or a laboratory that is a member of the National Association of Special Equipment Distributors, in order to ensure that all calibrations are traceable to NIST.

2.8.6 Cable Management

As you have noticed by now, the equipment for the audiometry component involves a lot of cables. Cables are often the weakest link in electronic systems. Follow these simple precautions to avoid damage to the cables and subsequent problems with the hearing test equipment:

- Coil cables loosely when packing equipment to avoid potential damage to the internal wires. Do not pinch or crimp cables tightly. See the examples in Figure 2-48.

Figure 2-48. Correct and incorrect ways to secure cables



- Keep attachment points loose to avoid stress where the cable meets the equipment. For example, when packing up the headphones, allow a bit of the cord to hang directly down from the earpiece before coiling up the rest of the cord, as shown in Figure 2-49.

Figure 2-49. Correct and incorrect ways to protect cables at attachment points to equipment

- Use twist-ties to loop up extra length to reduce the amount of dangling cord (Figure 2-50).

Figure 2-50. Correct and incorrect ways to manage extra cable length

- Group cables together as much as possible to make it easier to avoid stepping or tripping over them.

2.9 End of Stand Procedures

2.9.1 End of Stand Calibrations

Conduct final calibration checks on the following equipment in the order indicated below. Only the equipment used during the stand needs to be rechecked at the end (it is not necessary to check the spares at the end of a stand). Refer to Section 2.4 for directions on calibration.

- Bioacoustic simulator;
- Acoustic, bioacoustic, and listening calibration check of both standard and insert earphones; and
- Middle ear analyzer.

If any equipment fails the end of stand QC check, notify the health technologist assigned to Audio for the stand or MEC manager so that arrangements can be made for repair of the equipment prior to the next stand. Conduct a final environmental noise survey, and enter the results in ISIS as described in Section 2.5.2.

Conduct an inventory of equipment and supplies, as described in Section 2.2.6.

2.9.2 Room Teardown

Make sure the bioacoustic simulator is turned off. Unscrew the microphone from the preamp, put the protective white plastic cover over it (do not cover up the hole in the cover when placing it on the microphone), and pack it in its case. Disconnect the microphone cable and the response switch cable from the bottom of the bioacoustic simulator (press the black button to remove the response cable). Check to make sure that the insert earphone adapters are in place on the simulator. Take the simulator down from the sound room wall and remove the battery. Wrap the simulator and the cables and pack everything carefully into the packing box.

Disconnect the otoscope heads from the rechargeable handles. Clean the eyepieces if necessary, as explained in Section 2.8.3.3. Check the dates on the rechargeable batteries and replace if required. Wrap each part of the otoscopes in bubble paper and pack them in the small green packing boxes. Place the boxes in the drawer inside the sound room.

Disconnect the Titan from the USB cable at the lower end of the handheld unit. Inspect and clean the probe as necessary, as described in Section 2.8.4.2. Pack the Titan extension cable, wall charger, and calibration cavity into the special zippered carrying case. **Do <u>not</u> coil the extension cable too tightly or the air line may be damaged!** Be sure to put the desiccant pack in the case near the handheld unit. Label the case with a note stating "Used at Stand ###" to facilitate setup at the next stand.

Unplug the power supply from the back of the audiometer. Disconnect the computer cable from the back of the audiometer. Unplug the cables from the headphone selector box from the back of the audiometer and from the jack panel of the sound booth. Unplug the audiometer patch cord from the back of the audiometer and the sound booth jack panel. Inside the sound room, unplug the standard headphones, the insert earphones, and the response switch from the jack panel. Cover the audio jack inputs both inside and outside the sound booth with the protective blue plastic caps. Place the headphone selector box into one of the drawers in the cabinet next to the sound booth. Pack the audiometer, both headphones, the response switch, and the patch cords into the packing box. The power supply should remain attached to the triangular worktable. Label the audiometer box with a note stating "Used at Stand ###" to facilitate setup at the next stand.

Remove the Phone Guard headphone covers from the dispenser and pack them in their original box in the upper cabinet. Remove the specula dispenser from the wall and pack it in the drawer. Place the tympanometer ear tips in a lidded plastic container and place it in the drawer. Place the foam insert earphone tips in zip closable bags and place them in the drawer. Secure other small items in the drawer also, including the hex wrench, screwdriver(s), batteries, petroleum jelly, and pipe cleaners.

Pack the equipment boxes (audiometers, middle ear analyzers, bioacoustic simulator, and sound level meter) in the lower cabinet to the right of the sound booth. Secure the cabinet with a Velcro fastener.

Secure the tripod and wheelchair ramp outside the booth. Overturn the SP chair and technologist stool inside the sound booth and close the doors to both the sound booth and the exam room tightly.

2.9.3 Guidelines for Packing Audio Equipment

When packing equipment at the end of stand, or to ship out at other times (e.g., for annual calibration), each unit must be packed up **neatly** and **carefully** in its own packing box with **all necessary components** for that piece of equipment and **no additional components**.

With the bioacoustic simulator, components should include:

- Simulator;
- Microphone;
- Pre-amp cable
- Response cable; and
- Insert earphone adapters.

With each middle ear analyzer, components should include:

- Titan handheld unit and attached probe cable;
- Calibration cavity;
- Wall charger; and
- Desiccant pack.

NOTE: Do **NOT** send Titan charging cradle with the Titan when sending the Titan away from the MEC, **unless** the charging cradle needs repair.

With each audiometer, components should include:

- Audiometer;
- Standard headphones;
- Insert earphones;
- Power supply (with one audiometer only; the other remains fixed on the table);
- Response switch and patch cord; and
- Computer cable (if there is a spare on the MEC).

NOTE: Do **NOT** send headphone switch boxes with the audiometer when sending the audiometer away from the MEC, **unless** the switch box needs repair.

With the sound level meter kit, components should include:

- Sound level meter and octave filter (attached);
- Microphone;
- Calibrator and half-inch adapter;
- Preamp, preamp adapter, and preamp cable;
- Audiometric calibration stand (black base plate and silver tower);
- 500 g weight;
- Standard earphone coupler and black adapter ring;
- Insert earphone coupler; and
- Small flathead screwdriver.

Examination Protocol 3

3.1 Eligibility Criteria

All examinees 20-69 years of age are eligible to participate in the audiometry component. Although a few screening questions are asked of the study participant (SP) prior to testing, these are designed only to ascertain whether alternate test methods are necessary and to provide information that may assist with later analysis of the data. There are no precluding conditions for any part of the audiologic exam (otoscopy, middle ear testing, or audiometry). All three tests may be performed on all eligible, consenting examinees.

3.2 Pre-Examination Procedures

3.2.1 Preliminary Activities

A few preliminary procedures should be accomplished before beginning an audiometry exam. If possible, complete these activities before bringing the SP to the audiometry room:

- Wash your hands;
- Put fresh phone guards on the audiometric headphones; and
- Verify that the ventilation system and lights are turned on inside the audiometric booth. The lights outside the sound booth should be turned off while hearing testing is conducted in order to make it easier to observe the SP during the test.

When the coordinator assigns an SP to the audiometry component, introduce yourself and ask the SP to have a seat **inside** the sound booth; warn them to watch their step as they enter the booth. Follow standard Integrated Survey Information System (ISIS) logon procedures. Click on the audiometry icon. Click on the logon SP button. Logon using your ID and password.

Each participant wears an identification bracelet with the participant's identification number bar-coded on it. Enter the participant's identification number into the ISIS system by "reading" the bar code with the wand. ISIS will automatically pull up the identification screen for that examinee. Verify that the SP information is correct. Click "OK" to proceed with the examination.

Check to see if the examinee is wearing hearing aids. If so, provide as much instruction/explanation as possible before asking the SP to remove his or her hearing aids for the examination. Be aware that the SP may need to reinsert at least one hearing aid between various portions of the exam in order to hear instructions for the next segment.

NOTE: If an SP cannot remove his or her own hearing aids (or is not accompanied by a family member or other person who can assist in removing the hearing aids), that SP will skip audiometry. Close the exam and enter "Physical Limitation" as the reason the exam was not done.

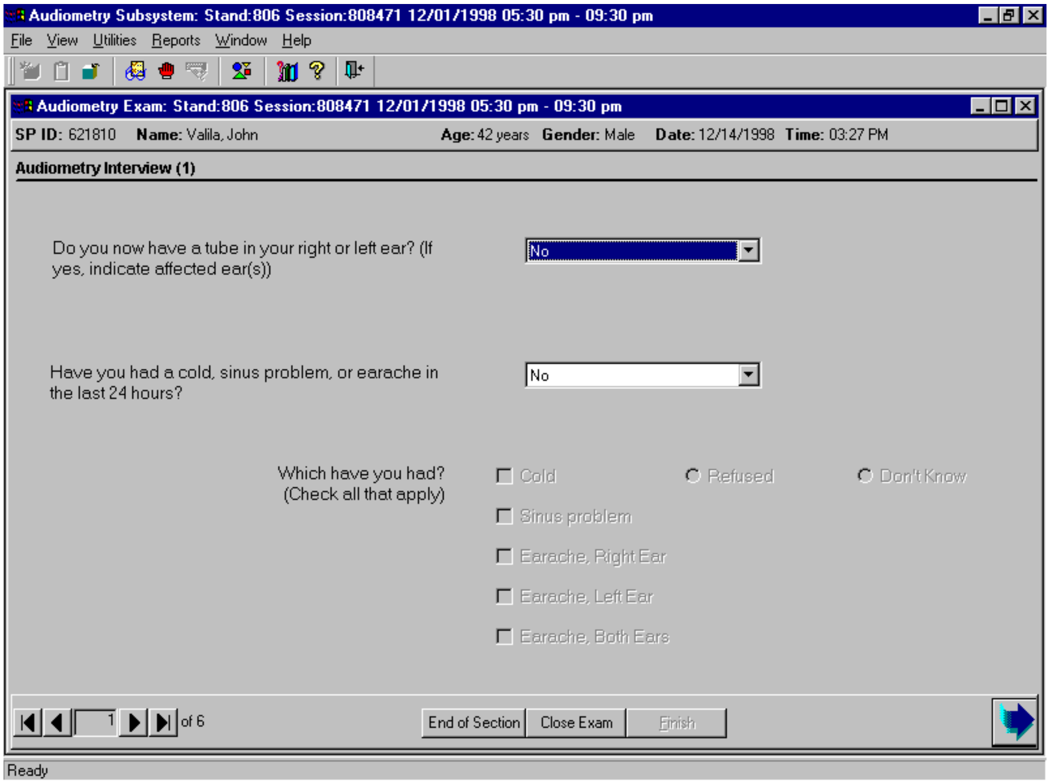
Have the examinee remove eyeglasses, chewing gum, earrings, hair ornaments, hats, or anything else that may interfere with your ability to manipulate the ear and/or properly place the audiometric headphones on the subject. These items may be placed on the table inside the sound booth during the test.

3.2.2 Pre-Exam Questionnaire

Prior to beginning the hearing examination procedures, the study participant is asked a series of questions to identify conditions that may affect either how the test will be conducted or how the results will be interpreted. ISIS will prompt you to ask the following questions; responses are entered directly into the computer (Exhibit 3-1). In most cases, responses are entered from drop-down menus.

Be certain to ask the questions **exactly** as they appear on the screen. Do not omit or add anything. If the SP is unsure how to answer, use the explanations below each question to help the SP determine the answer. Listen carefully to the SP's responses, and make certain he is providing the information the question is seeking. If you think the SP has misunderstood the question, probe to clarify by repeating the question with a preface such as "Just to make sure I have this correct…"

Exhibit 3-1. Audiometry Interview (1) screen



1. Do you now have a tube in your right or left ear (if yes, indicate affected ear[s])?

Yes, right ear	No
Yes, left ear	Refused
Yes, both ears	Don't know

Pressure equalization (p.e.) tubes are frequently placed in the eardrums of persons who are prone to chronic ear infections. Although more common in children, they are also used in the adult population. If a study participant reports the presence of a p.e. tube in one or both ears, you should expect to visualize it during otoscopy. It should appear as a round, plastic disk with an opening in the center. Additionally, you should expect a flat, high volume tympanogram and unusual wideband reflectance results during middle ear testing (see Section 3.4.3).

2. Have you had a cold, sinus problem, or earache in the last 24 hours?

Yes Refused
No Don't know

(If Yes) Which have you had (check all that apply)?

Cold Refused
Sinus problem Don't know
Earache, right ear
Earache, left ear
Earache, both ears

A cold refers to a disorder of the upper respiratory tract. A sinus problem refers to an inflammation of the sinuses. Allergies are included if they have resulted in a reaction within the upper respiratory system or sinuses. If the SP is unsure if he or she has had either of these, probe for any of the following conditions: runny nose, stuffy head, slight temperature, chills, sinus headache. **Focus on symptoms from the neck up.** If the SP has had any of these symptoms in the past 24 hours, record a positive answer.

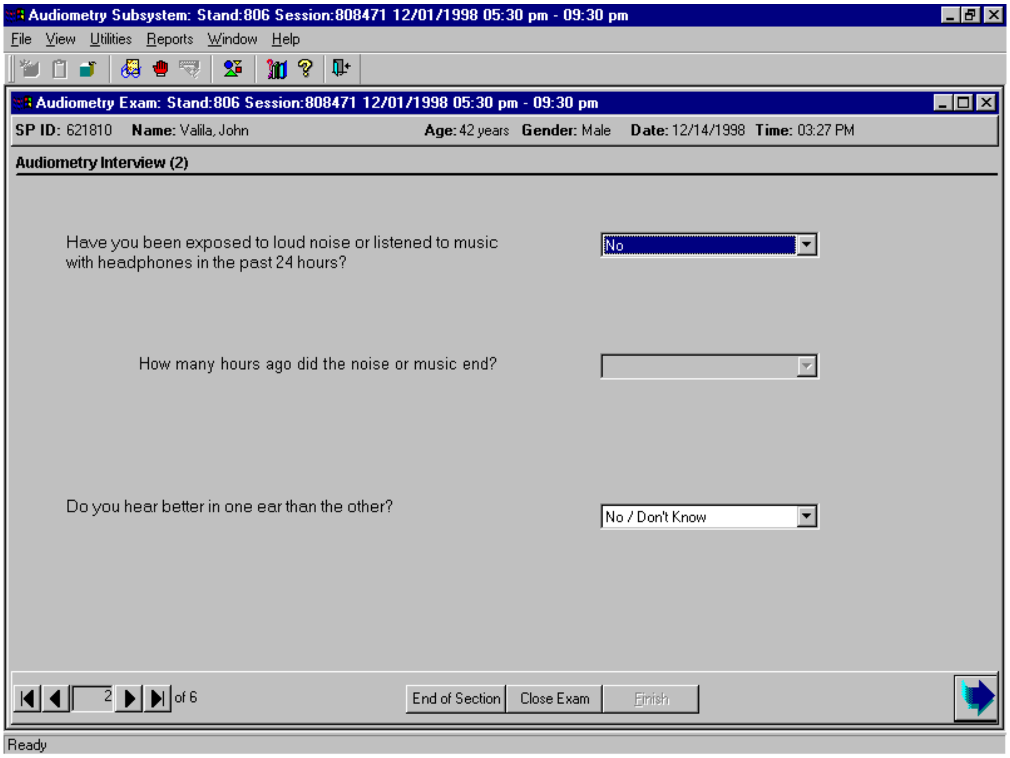
An earache refers to any pain **within** the ear, regardless of severity. It does **not** include pain on the external ear.

3. Have you been exposed to loud noise or listened to music with headphones in the past 24 hours?

Yes Refused
No Don't know
(If Yes) How many hours ago did the noise or music end?
Number of hours Refused
Don't know

Noise is defined as "loud" if (1) someone would have had to raise their voice in order to be heard 3 feet away; **or** if (2) ringing in the ear was noticed after the noise ended. If the SP indicates that he or she was exposed to loud noise or did listen to music with headphones, inquire how long ago the noise or music ended. Enter the response to the nearest hour; round up partial quantities of 30 minutes or more. If the SP cannot remember, encourage him or her to make the best estimate possible; only enter "DON'T KNOW" if the SP cannot make a guess after you have encouraged him or her to do so (Exhibit 3-2).

Exhibit 3-2. Audiometry Interview (2) screen



4. Do you hear better in one ear than the other?

Yes, right ear	Refused
Yes, left ear	No/Don't know

When an SP responds affirmatively to this question, follow up by inquiring specifically which ear is **better**. There seems to be a tendency for people to report the ear that they think has trouble rather than the ear that they think is better. **Therefore, it is important to always verify that the SP is telling you which is the better ear.**

If a study participant reports better hearing in one ear than the other, air conduction testing should begin in that ear. If the subject indicates that his or her hearing is about the same in both ears or doesn't know, then the first test ear will be alternated between subjects as described in Section 3.5.3.1.

When responses to all the questions have been entered, click the forward arrow on the navigation bar to advance to the otoscopy screen.

3.3 Otoscopy

3.3.1 Purpose of Otoscopy

Otoscopy refers to the visual examination of the outer ear—including the auricle, ear canal, and eardrum. Otoscopy has two purposes in NHANES:

1. To identify abnormalities that may require alternate audiometric procedures or influence the results obtained; and

2. To identify conditions that may require medical referral.

It is important to note that otoscopy in the context of NHANES has only the two purposes noted above; it is **not** a diagnostic procedure.

3.3.2 Instrumentation for Otoscopy

As described briefly in Section 2.2.1, the otoscope is a small, hand-held instrument with a light that is directed through a funnel-like tip to illuminate the ear canal for examination. The funnel-like tip is called a "speculum." Directions for assembling the otoscope are given in Section 2.8.3.1. To turn the otoscope on, press the green button down and rotate the black ring clockwise. To turn it off, rotate the black ring counterclockwise until the green button pops back up.

3.3.3 Procedure for Otoscopy

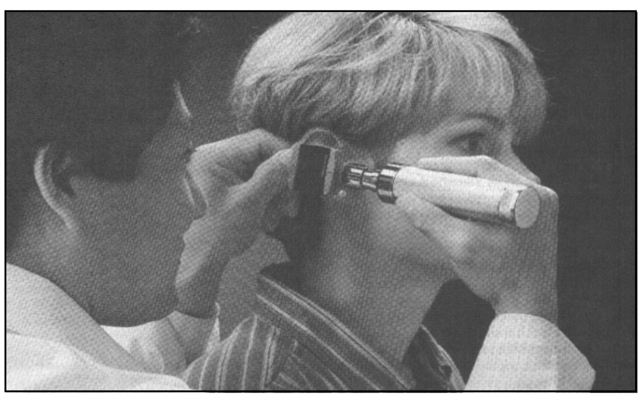
Explain to the participant that you are "just going to take a quick look in his or her ear." Then, generally inspect the auricle for skin changes or other gross abnormalities. While these conditions should not affect the results of the hearing test (unless they prevent proper placement of the headphones or cause such discomfort that the subject cannot tolerate the hearing test), they may warrant medical referral. If such a significant abnormality is noted, send an observation to the MEC physician.

Begin with either ear. Select the proper size speculum. The adult size speculum will be appropriate for most subjects; however, in rare instances the smaller, pediatric speculum may be required. Place the speculum on the otoscope and turn it on.

Hold the otoscope like a pen, between the thumb and index/middle fingers, having the speculum end of the scope where the writing tip of the pen would be (see Figure 3-1 below). Brace the hand holding the otoscope against the cheek or mastoid bone (behind the ear) of the examinee—depending on which ear you are examining; bracing your hand will help prevent jabbing the wall of the ear canal if the participant moves suddenly. With your other hand, grasp the helix (upper portion) of the auricle and gently pull up and back to straighten the ear canal. Carefully insert the speculum about halfway into the entrance of the ear canal and direct it toward the eardrum. The eardrum should appear pearly-gray in color. Look closely for any evidence of perforation, inflammation (redness), drainage or discharge, presence of a p.e. tube, small objects in the canal, etc. Move the otoscope around slightly to examine the canal walls for any evidence of irritation or swelling.

Figure 3-1 presents the proper method of holding otoscope during otoscopy (from Suter, A.H. *Hearing Conservation Manual*, 3rd Edition. Council for Accreditation in Occupational Hearing Conservation, Milwaukee, 1993).

Figure 3-1. Proper method of holding otoscope

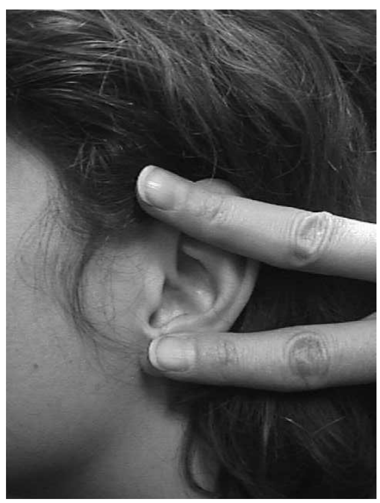


Look also for excessive cerumen (earwax). Most people have some amount of wax in their ear canals, and this is normal. Even an excessive amount of wax (such that less than half the eardrum is visible) will not have too great an effect on the audiometric thresholds; it will, however, preclude the use of insert earphones. If there is so much earwax that no part of the eardrum can be visualized at all, the ear is said to be "impacted" with cerumen; this condition can cause a significant reduction in hearing thresholds, and also precludes the use of insert earphones.

Make a mental note of the size and direction of the ear canal; this information will be important when you are conducting the middle ear tests.

Remove the otoscope from the ear. On each ear, gently press the helix of the auricle against the mastoid bone behind the ear using your index and middle fingers in the form of a "V" (see Figure 3-2 below), imitating the pressure that will be caused by the headphone when it is placed on the ear. Direct the light of the otoscope toward the opening of the ear canal and look for any sign of "canal collapse"; that is, a closing off of the entrance to the ear canal. This problem is more common among the elderly; however, canal collapse can be present in any individual. It is particularly likely in persons who have small ear canals or whose pinna feels "soft" when you pull on the outer ear. Collapsed canals can cause elevated thresholds because the test signals cannot enter the ear canal effectively. When this condition is noted, the participant should be tested with insert earphones rather than headphones, provided there are no precluding conditions for the use of inserts. (See Section 3.5.3.1 for instructions.)

Figure 3-2. Checking for collapsed ear canal



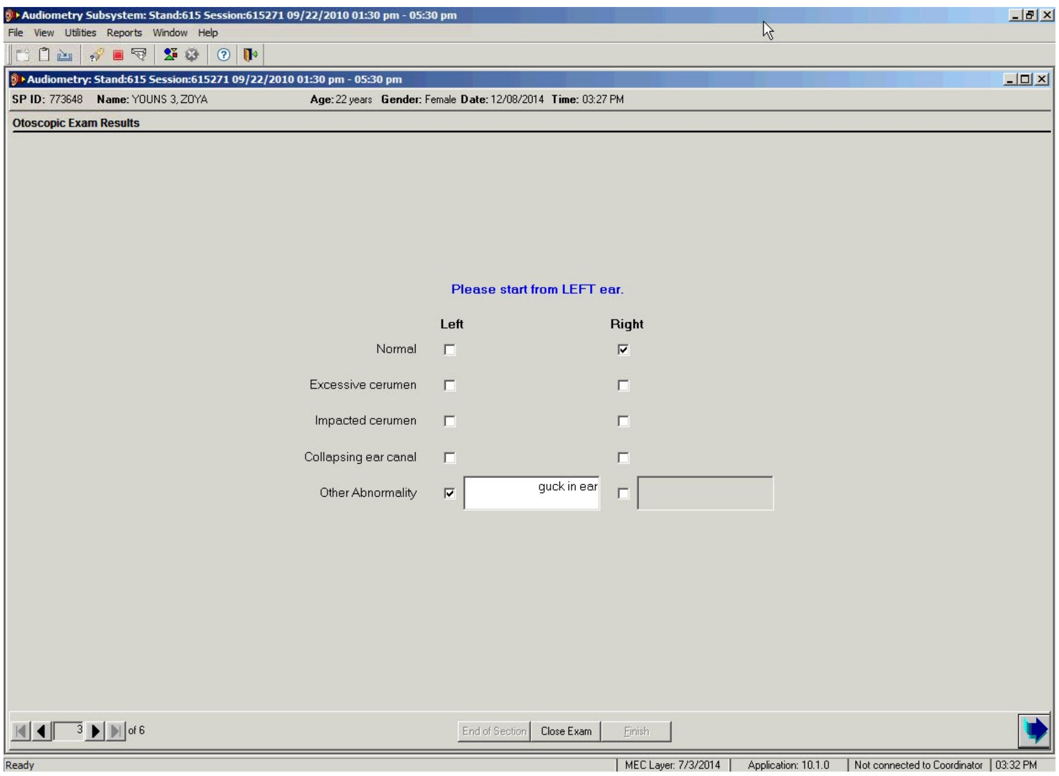
Record the results in the ISIS program as described in Section 3.3.4. Repeat the examination in the other ear and record the results in ISIS. Remove the speculum from the otoscope and throw it away.

NOTE: Be very careful not to make any mention to the SP of what you observe in otoscopy, as you are not conducting this check for diagnostic purposes. If the SP inquiries about the otoscopic results, simply say that you are only checking to see which headphones to use.

3.3.4 Recording Results of Otoscopy

The otoscopy exam results screen (Exhibit 3-3) presents a list of possible outcomes and corresponding check boxes for each ear. ISIS defaults to “normal” for both ears. If otoscopy is not normal in one or both ears, simply record the results by clicking in the appropriate box(es) as described below. A check mark will appear in the box(es) you select. If you make an error, simply click in the same box again, and the check mark will be removed.

Exhibit 3-3. Otoscopy exam results screen

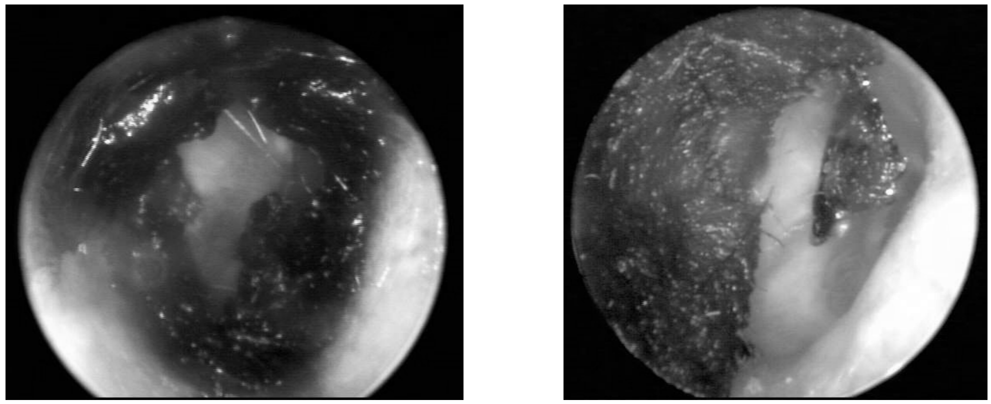


NOTE: On this screen and all subsequent screens, results for the left ear are always recorded in the left column and results for the right ear are always recorded in the right column, regardless of which ear is evaluated first.

- **Normal.** At least half the eardrum can be clearly visualized, and it appears pearly-gray in color. No other abnormalities are noted. A “normal” result excludes any other result in that ear, **except** for collapsed canals.

- **Excessive Cerumen (Figure 3-3).** Significant accumulation of earwax in canal, such that view of the eardrum is partially (but not completely) blocked. If less than half the tympanic membrane is visible due to wax, it is considered excessive. This condition precludes the use of insert earphones during audiometry.

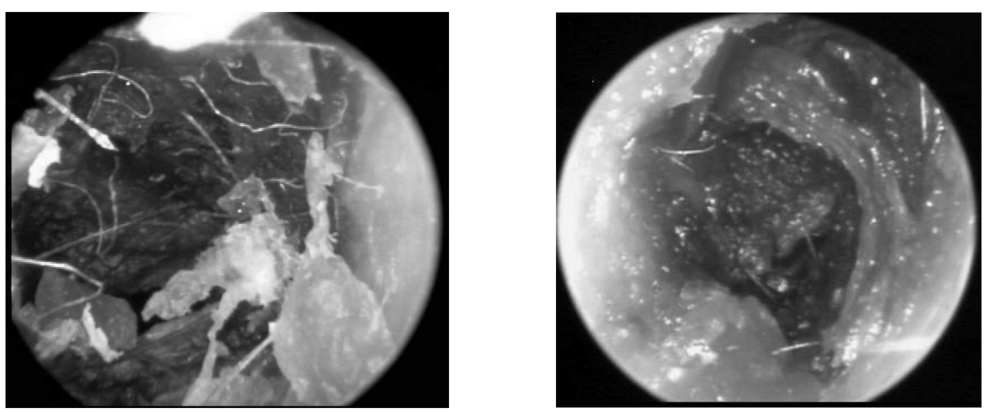
Figure 3-3. Examples of excessive cerumen during otoscopy (From Sullivan R.F. *Audiology Forum: Video Otoscopy*)



- *Impacted cerumen* (Figure 3-4)—Even greater accumulation of earwax in the ear canal, such that no part of the eardrum can be visualized. This condition precludes the use of insert earphones during audiometry.

NOTE: Excessive cerumen and impacted cerumen cannot both be recorded in the same ear. If you try to mark one after the other has already been marked, the first result will be deleted. If you **can see any** part of the eardrum, record the result as "excessive cerumen." If you **cannot see any** part of the eardrum, record "impacted cerumen" as the finding.

Figure 3-4. Examples of impacted cerumen during otoscopy (From Sullivan R.F. *Audiology Forum: Video Otoscopy*)



- **Other Abnormality (Describe).** Any other observation that does not appear normal (Figure 3-5). This could include drainage (fluid) in the ear canal, blood, a foreign body (e.g., bugs, cotton, a p.e. tube that has ejected itself from the eardrum, etc.), a perforation in the eardrum, a growth in the ear canal, significant skin abnormalities, or anything else that you feel may be cause for concern. Describe the abnormality briefly in the field provided. This finding precludes the use of insert earphones; ISIS will prompt you to send an observation to the MEC physician (see Section 3.6.2).

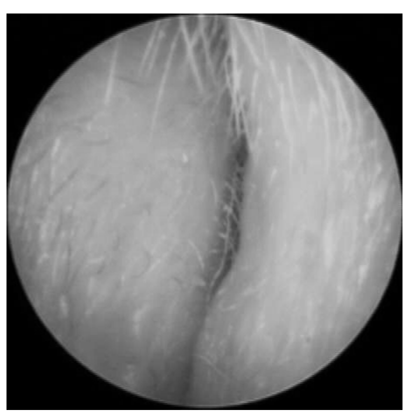
NOTE: An observation to the physician is not sent automatically. You must re-enter the finding using the standard physician observation procedures within ISIS.

Figure 3-5. Examples of other findings during otoscopy

Illustration 1 shows a p.e. tube placed in the eardrum. Illustration 2 (center) depicts a large perforation in the eardrum; the entire center portion of the membrane is missing. Illustration 3 (right) shows a small piece of glass lodged in the ear canal. (From Sullivan R.F. *Audiology Forum: Video Otoscopy.)*

- **Potential canal wall collapse (Figure 3-6).** This condition requires the use of insert earphones during audiometry, provided no other conditions preclude their use.

Figure 3-6. Example of a collapsed ear canal (From Sullivan R.F. *Audiology Forum: Video Otoscopy*)



3.4 Middle Ear Testing

3.4.1 Purpose of Middle Ear Testing

Middle ear testing, sometimes called acoustic immittance, is a collective term which refers to measurements of eardrum compliance. From such measures, we can make inferences about the health of the middle ear system—including the eardrum, the three ossicles, the Eustachian tube, and the two middle ear muscles. Note that middle ear testing evaluates the physiological status of the middle ear; that is, whether or not it is working as it should. While these tests can point out problems with how the ear is functioning—which of course may impact hearing sensitivity—they do not directly indicate how well a person can hear. A person can have normal middle ear function and yet be completely deaf.

The hearing examination in NHANES includes three middle ear tests: tympanometry, wideband reflectance (WBR), and acoustic reflex threshold screening. Both tympanometry and WBR measure the movement of the eardrum. Tympanometry measures how much sound is delivered through the middle ear system at a single frequency (226 Hz) across a range of pressures. WBR measures how much sound is transferred through the middle ear across a range of frequencies at a single pressure (ambient air pressure). Both tests are conducted by placing a probe with a rubber tip into the entrance of the ear canal, playing calibrated signals (a 226 Hz tone for tympanometry and broadband clicks for WBR) into the canal, and measuring how much sound bounces back. Because tympanometry involves varying the pressure in the ear canal, it requires that the rubber tip form an airtight seal. Because WBR makes measures just at the background room air pressure, it does not require an airtight seal. However, the rubber tip blocks out room noise and keeps a certain amount of air in the ear canal.

The acoustic reflex is an involuntary contraction of the two muscles in the middle ear—the stapedius and the tensor tympani—in response to loud sounds. When these muscles contract, the ossicles pull the eardrum slightly back; the middle ear system "stiffens up" and sound is not transmitted as efficiently. This affords the sensitive inner ear a small bit of protection against potentially damaging sounds. The acoustic reflex is tested by sending a brief tone into the middle ear loud enough to elicit the reflex, and looking for a resultant change in eardrum mobility as the muscles contract and pull back on the eardrum. Acoustic reflex test results are useful in clarifying questionable tympanograms, verifying degree of hearing loss, and distinguishing between sensorineural hearing losses caused by damage to the cochlea versus the auditory nerve.

All three middle ear tests have the advantage of being objective, in that they do not require any response or feedback from the examinee. The equipment for these tests is automated; once the probe is correctly placed in the ear, it performs the tests and records the results without any further intervention from the tester.

3.4.2 Instrumentation for Middle Ear Testing

The Interacoustics Titan, which was described briefly in Section 2.2.2, will be used to conduct middle ear testing. The Titan consists of the "hand-held" unit (though you will not be holding it in your hands to run the test) with a long cable and a probe. The probe contains three tiny openings – one of these openings sends air pressure into the ear canal, one delivers the test signals (tones or clicks) to the ear, and one contains a microphone to measure the amount of the signal that is reflected back from the eardrum. The end of the probe is fitted with rubber tips of various sizes, which are used to seal off the entrance to the ear canal in order to block out background noise and control the air pressure in the canal when needed. The Titan Suite software that runs the middle ear tests interprets the amount of sound reflected back from the eardrum and converts it to a measure of the stiffness of the eardrum.

Between the handheld unit and the probe is the "shoulder box" (see Figure 3-7 below). On the back of the shoulder box is a clip that can be clipped to the SP's clothing to help keep the probe in place. On the side of the shoulder box is a control button which can be used to send commands to the Titan system.

Figure 3-7. Titan shoulder box and control button

3.4.3 Procedure for Middle Ear Testing

3.4.3.1 Opening Titan Suite and Operating the Titan

After entering results of the otoscopic exam for both ears, advance to the tympanometry screen by clicking on the forward arrow button. ISIS will automatically launch the Titan Suite software. Titan opens in the background. You will be able to switch back and forth between ISIS and Titan Suite if necessary by clicking the appropriate buttons on the task bar.

If you have not used the Titan for a period of time, you may also receive a pop-up window on top of the opening screen with the following message (see Exhibit 3-4):

Exhibit 3-4. Hardware not connected message box

This usually indicates that the Titan is in "sleep" mode. Press the R or L button (see Figure 3-8 below) on the handheld unit to re-activate the Titan and the message window will close automatically. You will not be able to proceed in Titan Suite until this message disappears.

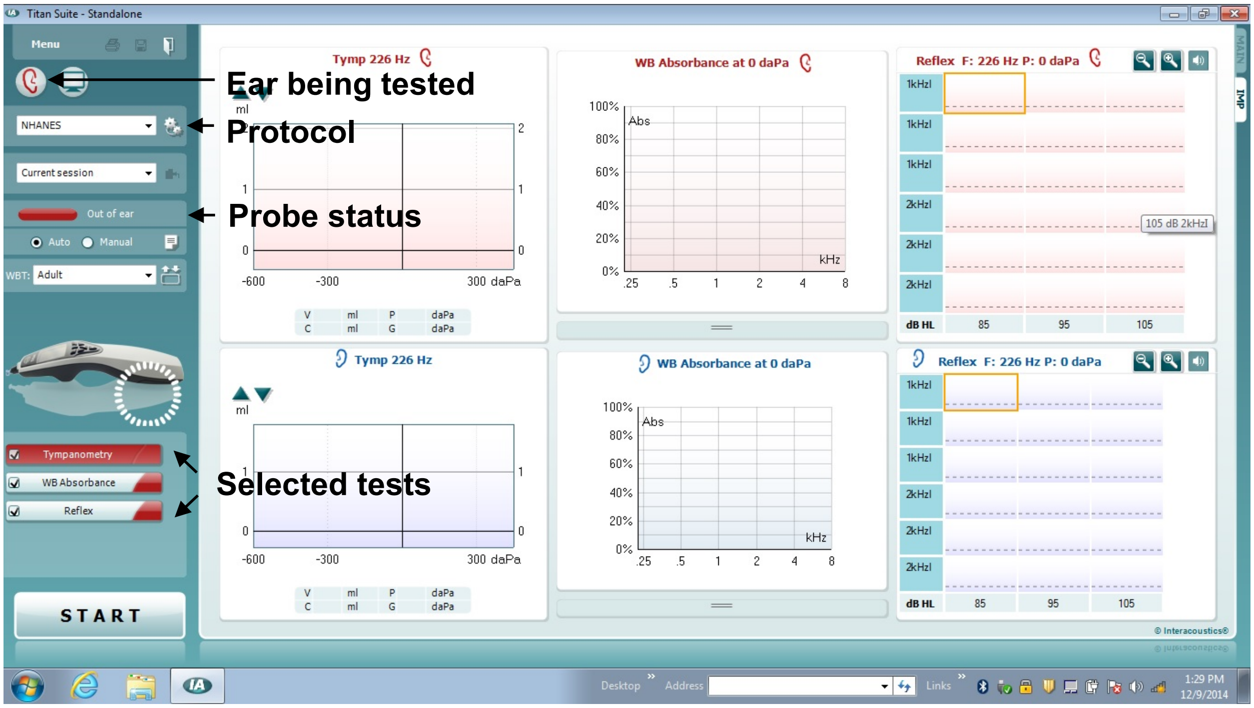
Figure 3-8. R and L buttons on the Titan handheld unit

The Titan Suite Software will open to the window shown in Exhibit 3-5 below. Click the IMP tab in the upper right corner of the Titan Suite window to open the NHANES middle ear testing screen.

Exhibit 3-5. Opening Titan Suite screen. Click IMP (as shown by the arrow) to proceed

Once you have clicked the IMP tab, Titan Suite will open the NHANES testing screen (see Exhibit 3-6 below).

Exhibit 3-6. NHANES middle ear testing screen



The left panel of the Titan Suite screen indicates the following, as shown by the captions above:

- The ear selected for testing (a red ear icon indicates the right ear; a blue ear icon indicates the left ear);
- The selected test protocol (this should always read "NHANES");
- The probe status (the probe is "out of ear" in the example above); and
- The tests in the protocol that will be run (indicated by checked boxes).

The main panel of the Titan Suite screen shows the test results for the right (top) and left (bottom) ears. (There are no results displayed on the screen shown above.)

You can begin the middle ear tests with either ear. The Titan Suite defaults to testing the right ear first. You can select a different test ear in any of the following ways:

- Press the R or L button on the handheld unit.

- Click the ear icon in the top left corner of the Titan Suite screen (the selection will toggle back and forth between the right and left ear).

- Press the control button on the shoulder box.

NOTE: This only works if the probe is out of the ear.

If everything functions normally, the Titan Suite will close between each SP, and any data for that SP will be deleted from the Titan software (it will have been saved in a separate location). Therefore, the Titan Suite should always open to a blank results screen. **If there is any data from a previous SP in the Titan Suite window when you start a new test, notify the ISIS staff before proceeding with the middle ear tests.**

3.4.3.2 Instructions and Probe Placement

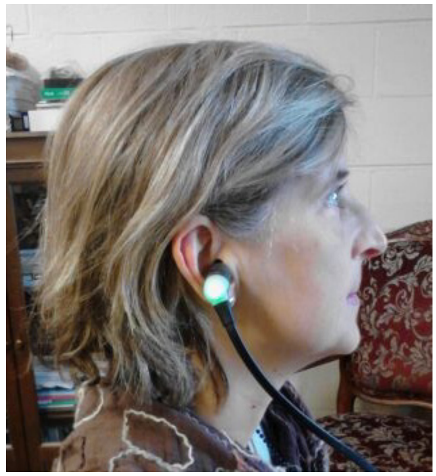
When you are reading to begin middle ear testing, explain the procedure to the SP. You may use your own words, but please include all the points in the sample instructions below:

- **Instructions.** "This is a test to measure how well your eardrum is able to move. It is a completely automatic test, so you will not need to respond in any way. I am going to place a probe snugly into the opening of your ear canal. You will hear a continuous 'hum' and feel a little pressure; then you will hear some clicks and several loud beeps. The test will only take about thirty seconds. It is important that you sit very still, and try not to move, speak, or swallow from the time I insert the probe until I tell you the test is finished. Do you have any questions?"

Select a disposable rubber Titan tip of the appropriate size to seal off the entrance to the ear canal, keeping in mind the size of the ear canal, which you noted during otoscopy. **Note that bigger is not always better!** It is just as difficult to obtain a good seal with a tip that is too large as it is with a tip that is too small. Slide the tip onto the probe, making sure that the base of the tip goes all the way down. If you like, clip the shoulder box to the SP's clothing.

Move away any hair or other items (e.g., hats, hair ornaments) from the ear. For best results, position yourself at eye level with the SP's ear canal. With your nondominant hand, gently pull the auricle up and back slightly to straighten out the ear canal. With your dominant hand, place the Titan probe gently into the entrance of the ear canal (see Figure 3-9 below). If you have an appropriately-sized tip, the probe should stay in place without having to be held there; however, it is OK to hold the probe during the test as long as you hold it very still.

Figure 3-9. Correct placement of the Titan probe



The Titan probe lights will help you know whether you have placed the probe correctly (you can also refer to the probe status indicator on the left panel of the Titan Suite screen). Whenever the handheld unit is active (i.e., the Titan has not reverted to "sleep" mode), the probe will be lit with one of the following colors:

- **Red Light.** The right ear is selected, but the probe is either out of the ear or not sufficiently inserted into the ear to conduct the test.
- **Blue Light.** The left ear is selected, but the probe is either out of the ear or not sufficiently inserted into the ear to conduct the test.
- **Green Light.** The probe is inserted into the ear canal and the Titan is ready to conduct the test. ***Note that a green light does not necessarily mean an airtight seal has been obtained.*** You may have a sufficient fit for WBR but not for tympanometry.
- **Yellow Light.** The probe tip is blocked or leaking. This could indicate that the probe is directed towards the wall of the ear canal rather than towards the eardrum; that the probe itself is blocked by cerumen or other debris, or that the seal has been lost.

  If the yellow light changes to red or blue when you remove the probe from the ear, the problem is with probe fit or direction. Re-insert the probe into the ear canal, making sure to direct it towards the eardrum; you may need to re-examine the ear with the otoscope to assist in properly directing the probe.

  If the yellow light remains lit when the probe is removed from the ear canal, the probe itself is blocked. Clean the probe tip as described in Section 2.8.4.2.
- **White Light (Solid).** The probe status is unknown.

- **White Light (Flashing).** The Titan has finished the current test. If another test is programmed to run automatically, the Titan will immediately proceed to conduct the next test. If no further tests are programmed, the probe can be removed from ear.

3.4.3.3 Running and Evaluating the Middle Ear Tests

Confirm that all three middle ear tests (tympanometry, WBR, and acoustic reflex thresholds) are selected (checked) on the left panel of the Titan Suite screen. Start the test in one of the following ways:

- Press the control button on the shoulder box;
- Press the space bar on the laptop; or
- Click the START button in the lower left corner of the Titan Suite screen.

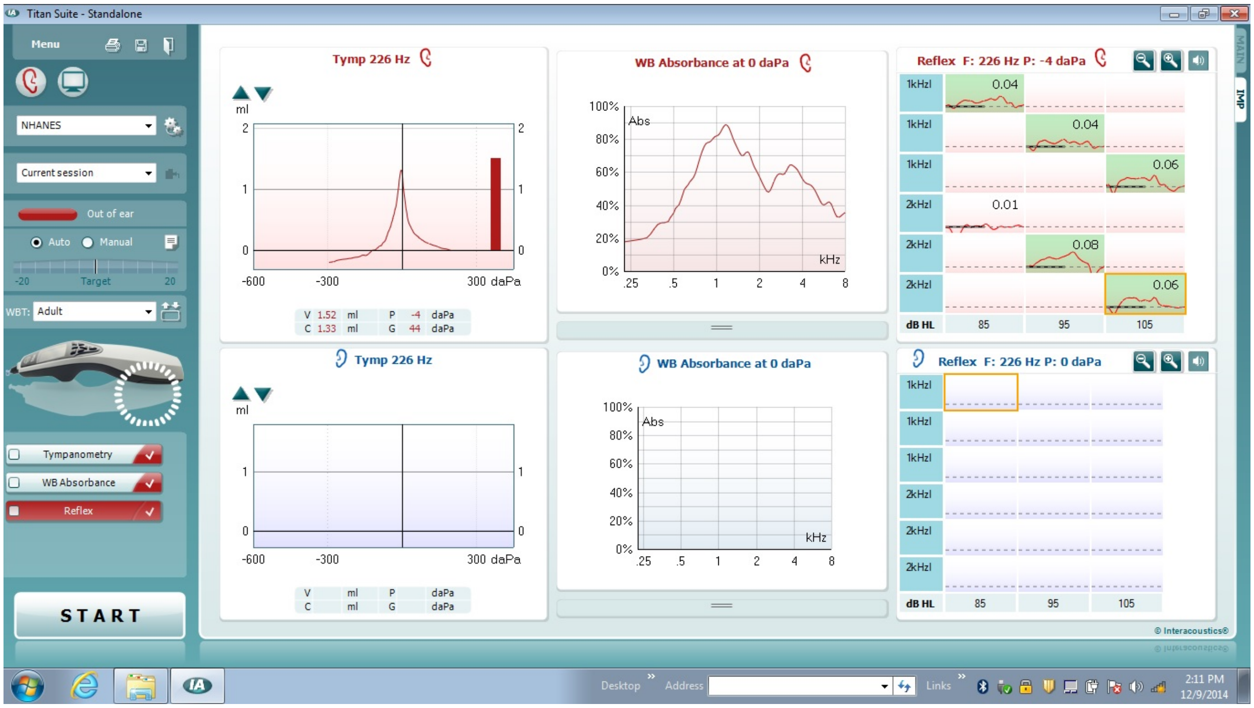
The Titan will run each test automatically. Results will be displayed on the Titan Suite screen as they are obtained. Tympanometry is conducted first. Recall that tympanometry requires an airtight seal. If the seal is sufficient, the sliding arrow at the bottom of the tympanometry display (on the Titan Suite screen) will slide all the way to the right, and then slide back to the left as the graph is traced on the screen. If the seal is not airtight, the sliding arrow will pause and hover on the way to the right, indicating that the system cannot build up sufficient pressure.

If you do not have a seal, adjust the probe. Note that – as you have started the test sequence – Titan will run the tympanogram as soon as a seal is obtained. If you are still moving the probe at that point, the result will be noisy. Alternatively, you can press the control button or space bar to stop the test while you re-seat the probe, and then begin the test again.

When tympanometry has been completed in the first test ear, the Titan will proceed automatically to WBR. As WBR does not require an airtight seal, a probe that was successfully placed for tympanometry will nearly always be appropriately placed for WBR. The WBR test involves averaging results for several seconds. You will notice the results "jump around" a bit on the Titan Suite screen while the test is running. When the WBR graph stops moving, the test is finished.

When WBR has been completed, the Titan will begin the acoustic reflex screening. The Titan will test for an acoustic reflex six times in each ear – at 85, 95, and 105 dB at 1000 Hz and 2000 Hz. As each stimulus is delivered, the Titan will display a tiny graph on the reflex grid. If the Titan believes a reflex was measured, the graph for that stimulus will have a green background. When all six frequency/intensity combinations have been tested, the middle ear test is complete. A sample results screen is shown below, in Exhibit 3-7.

Exhibit 3-7. Sample Titan Suite screen showing a completed test in the right ear



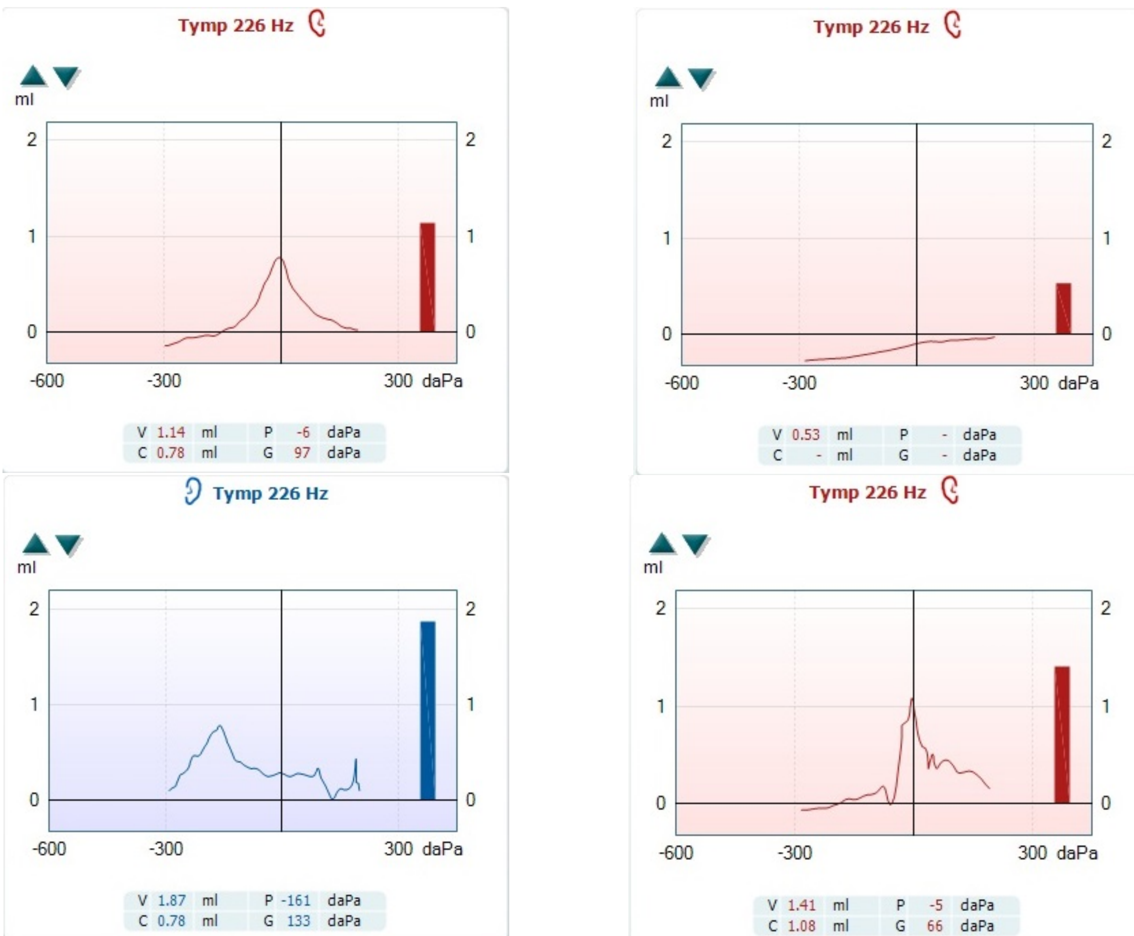
Check the results displayed on screen. Tympanometry results will include a graphed curve and numbers in four fields below the graph. The numbers indicate the following:

- V: the volume of the ear canal in milliliters (ml);
- C: the compliance, or flexibility, of the eardrum;
- P: the air pressure in the middle ear space in decaPascals (daPa); and
- G: the gradient, or width of the curve at half its height.

You do not need to evaluate the meaning of the numbers; only confirm that they are there. If the V value is missing, you should rerun the test. Do not rerun the test if any of the other values are missing.

You do need to judge the adequacy of the tympanometric curve. Tympanograms should be evaluated on the basis of smoothness and symmetry. A normal tympanogram will have a peak located near the vertical line near the center of the graph. However, the peak may occur in other places if the SP has an early or resolving infection. In some cases, the tympanogram will be flat, with no peak evident at all. Such cases include people who have impacted cerumen, perforated eardrums, or p.e. tubes. As long as the results are clear and consistent, abnormality is not a reason to reject a tympanogram. Examples of good and poor tympanograms are shown in Figure 3-10 below.

Figure 3-10. Examples of good, questionable, and poor tympanograms



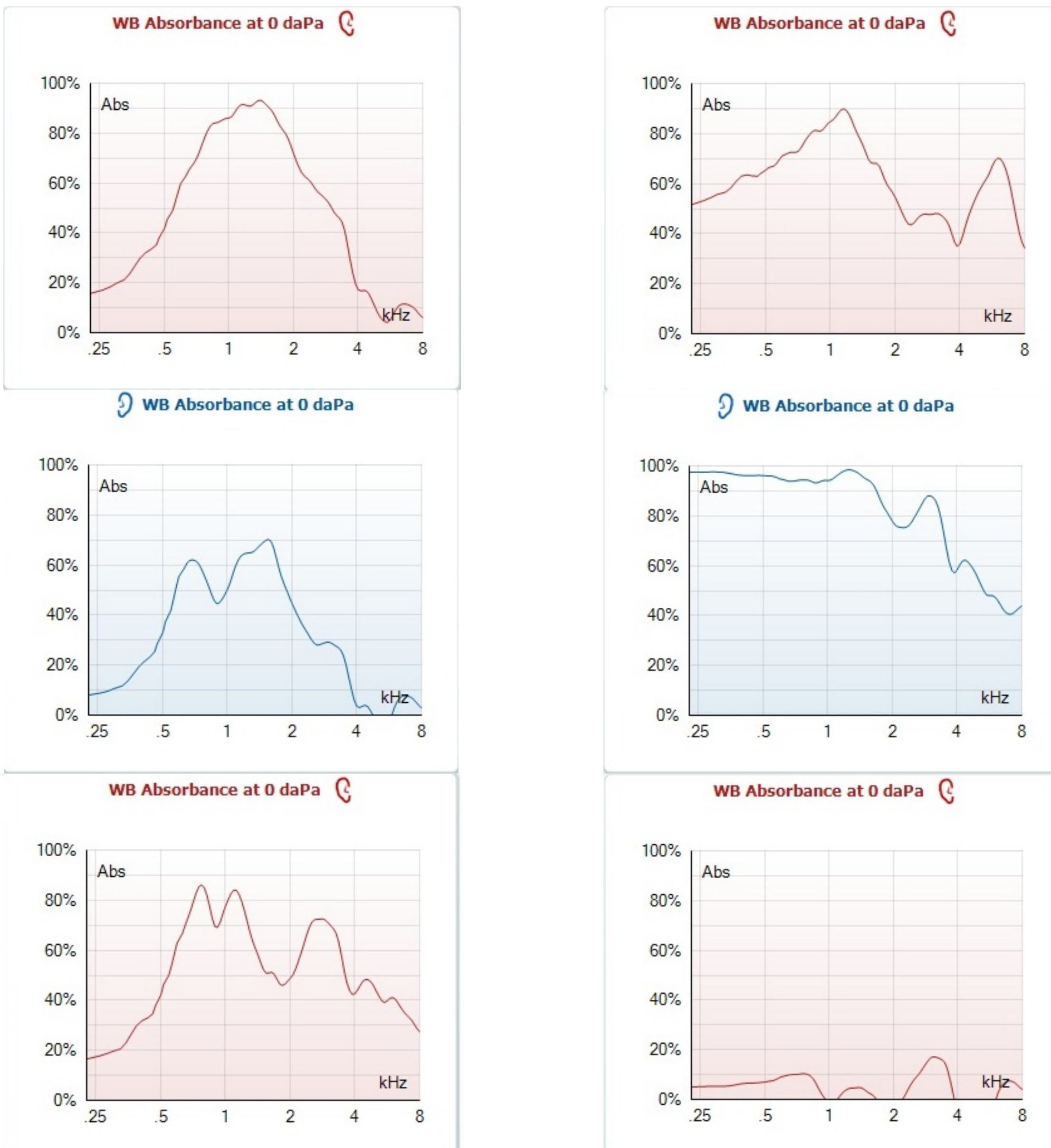
The top left tympanogram on the left is good; it is smooth and symmetrical.

The top right tympanogram in the center is questionable; it may be a valid flat tympanogram or it may be the result of a technical error; it should be rerun to verify.

The two results on the bottom are “noisy” and should be redone.

Wideband reflectance results include only a graph. It should also be evaluated for adequacy. WBR graphs may take many shapes. A good graph will have at least some part of the curve above the 60 percent point on the vertical axis and will cross this axis below 40 percent. Examples of good and poor WBR results are provided in Figure 3-11 below.

Figure 3-11. Examples of good, questionable, and poor WBR results



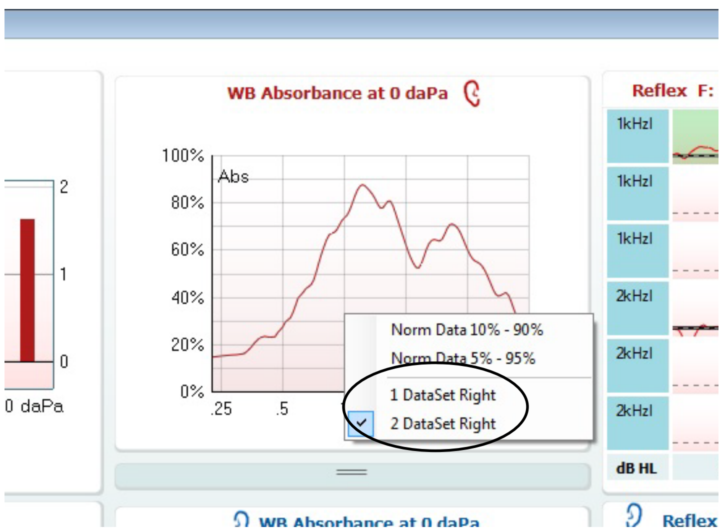
The three graphs on the left are good; each of them have part of the graph that exceeds 60 percent and they all cross the vertical axis below 40 percent.

The three graphs on the right are questionable or poor. The top and middle graphs cross the vertical axis above the 40 percent point; the bottom graph does not have any part that exceeds 60 percent.

Verify that the acoustic reflex results are displayed for each of the six test stimuli. You do not need to evaluate the acoustic reflex results in any way; simply confirm that they have been obtained.

If either the tympanogram or the WBR are unacceptable, or if all or part of the acoustic reflex results are missing, rerun that test once to try to obtain a better result (or, at least, to confirm the poor result). Check the box(es) in the lower left corner of the Titan Suite screen to select the test(s) that you want to rerun (by default, Titan only selects the last test run). Re-seat the probe in the SP's ear, then start the test as before. Titan Suite will display the second set of results, but the results of the first test are not overwritten. You can select whether to save the first or second result of each middle ear test by right-clicking on the graph of the result and selecting Data Set 1 or 2 in the pop-up window, as illustrated below in Exhibit 3-8. You can toggle back and forth between the results if needed to select the better result. Only the result that is displayed on the Titan Suite screen when you save the data will be saved.

Exhibit 3-8. Pop-up window allowing the display of the first or second test results



Regardless of the results of the second trial, move on to the next ear. In order to keep the test time within specified limits, middle ear testing will not be repeated more than once in each ear.

NOTE: If you cannot obtain an airtight seal for tympanometry for a particular ear, de-select the tympanometry test in the lower left corner of the Titan Suite screen and just run WBR on that ear.

When you have completed testing the first ear, select the next test ear as described earlier. **Note that the Titan Suite software cannot catch a mistake if you accidentally select the wrong test ear.** If you forget to select a new test ear, the Titan will overwrite your results from the first ear with the results from the second ear (you can go back and select the results for the correct ear by right-clicking each graph as described above). Also, if you are supposed to test the right ear and you correctly set the Titan for testing the right ear but inadvertently put the probe in the left ear, the software cannot catch this (and you cannot correct this in the field; if you accidentally test the ears in reverse, submit a back-end edit request to reverse the results in the data set). **Always double-check that you have selected the correct ear and that you are testing the ear you selected.**

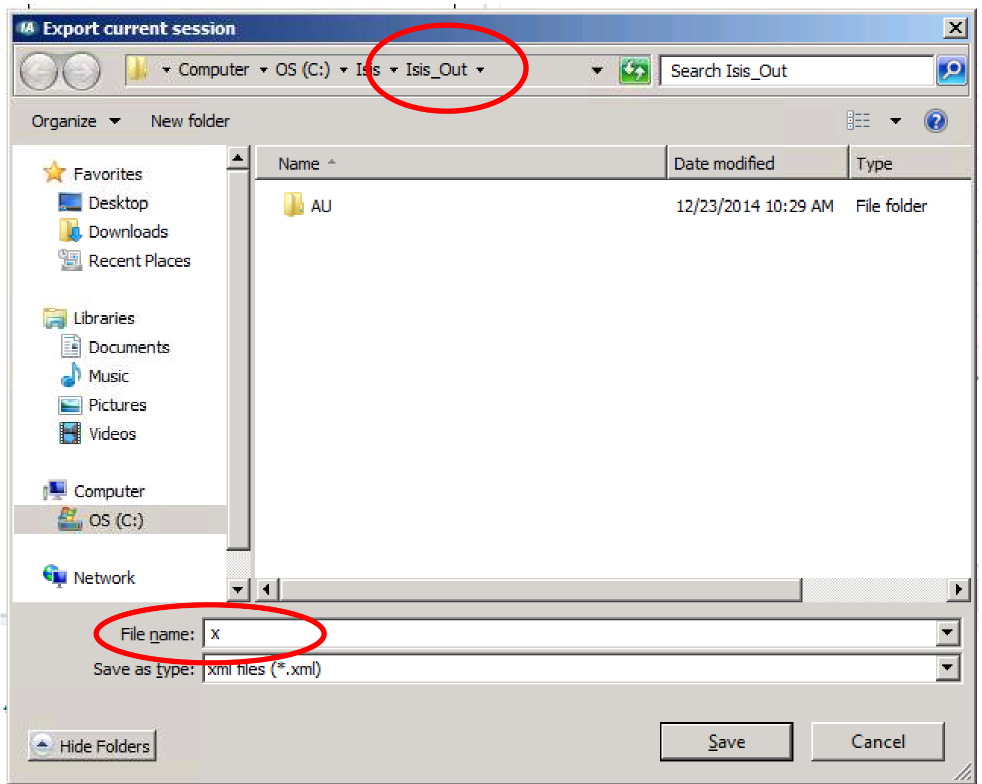
Place the probe in the other ear (you will probably need to move the shoulder box as well, if you are clipping it to the SP's clothing). Often, you will be able to use the same probe tip in both ears; however, some SPs will require a different size tip in each ear. Also, if the tip becomes contaminated with wax, drainage, or any other substance while testing the first ear, change to a clean tip before testing the next ear. Run the tests in the second ear, evaluate the graphs, and repeat any poor or questionable results once. The Titan Suite screen should now show complete results for both ears, as shown in Exhibit 3-9 below:

Exhibit 3-9. Completed middle ear test results in both ears

3.4.4 Recording Results of Middle Ear Testing

After both ears have been tested, Press ALT-M, ALT-E, ALT-X (think "ALT-MEX") to save the Titan results. The Titan Export window will pop up. Confirm that the path at the top of the window indicates the ISIS_Out folder, as shown below (Exhibit 3-10):

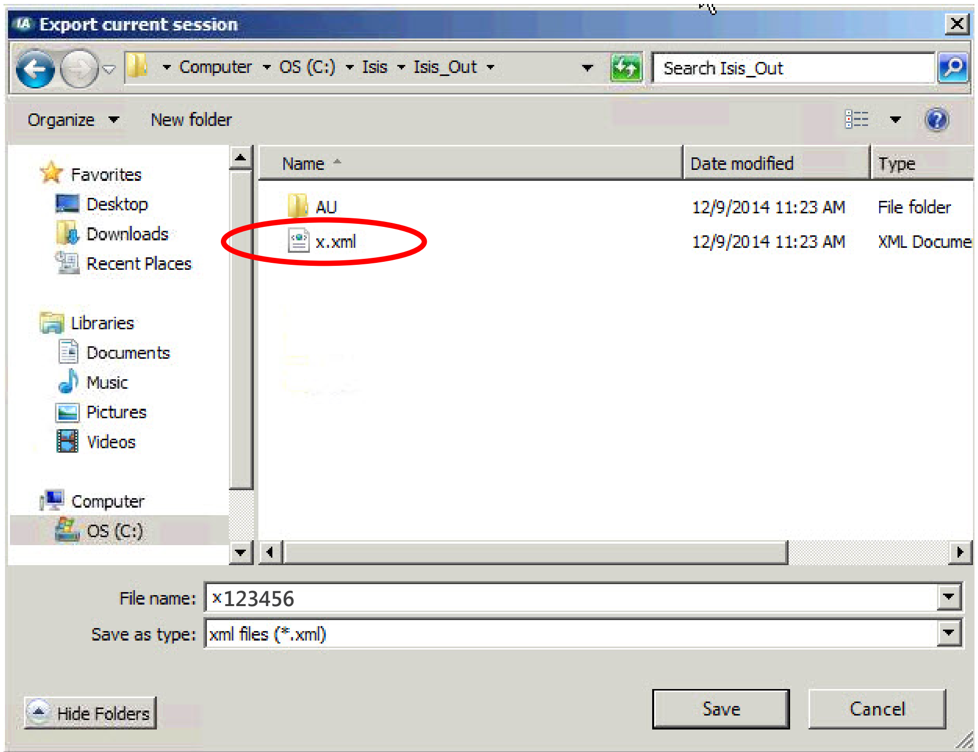
Exhibit 3-10. ISIS_Out folder



- Type "x" for the file name and click SAVE.

NOTE: When you close the ISIS application at the end of the hearing test, ISIS will find the x.xml file and move it to another location with a specific file name that identifies the result with that SP. Therefore, when you save the Titan results for the next SP, there should no longer be an x.xml file in the ISIS_Out folder. If you ever find a previous x.xml file in the ISIS_Out folder when saving an SP's results, do not over-write it! Instead, name the file you are saving with the current SP ID (for example, "123456" instead of "x", as shown in Figure 3-11 below) and notify the ISIS staff as soon as possible.

Exhibit 3-11. ISIS_Out folder when an x.xml file is already present



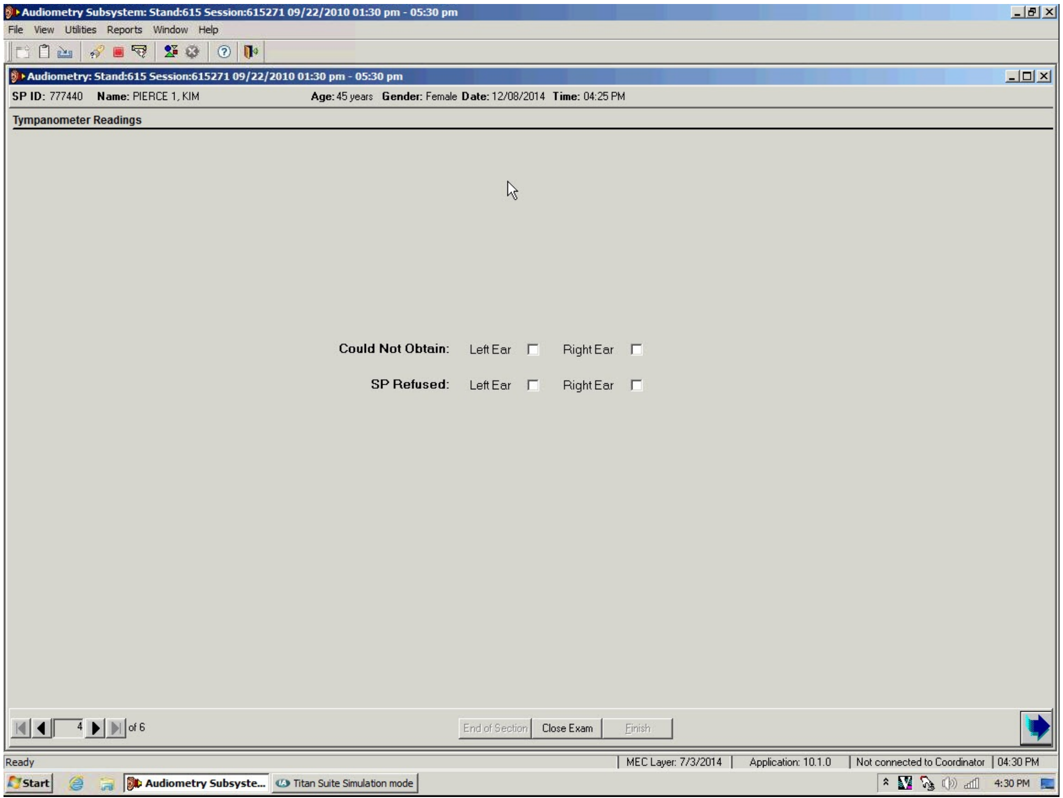
- Toggle back to the ISIS Audiometry application by clicking the audiometry icon in the task bar at the bottom of the screen.

Advance the screen and you will receive a message indicating that the data were successfully stored, or if the data could not be stored, some data are missing, etc. (Exhibit 3-12).

Exhibit 3-12. Pop-up window indicating data were successfully stored

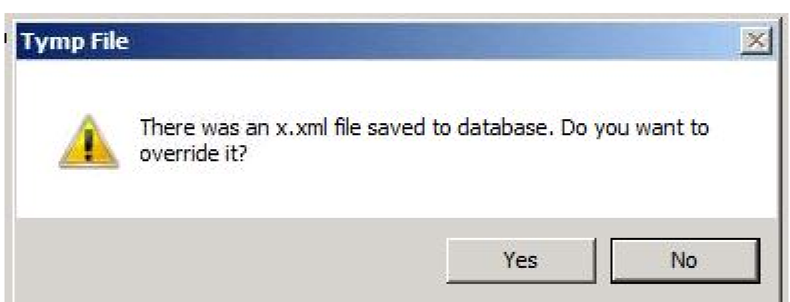
If one or both ears were not able to be tested at all, click COULD NOT OBTAIN or SP REFUSED, as appropriate (Exhibit 3-13). Titan Suite will automatically close when the screen advances.

Exhibit 3-13. ISIS middle ear test results screen



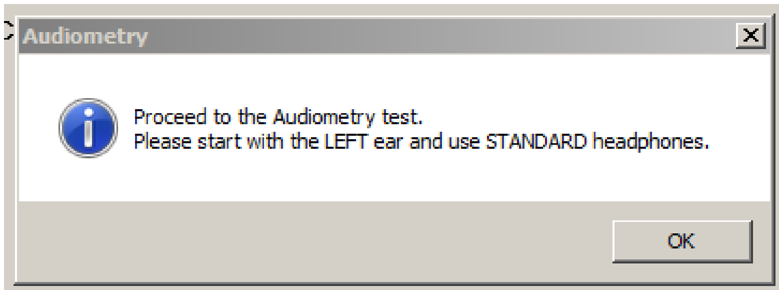
If you back up after advancing past the middle ear test result screen, you will receive a warning message (Exhibit 3-14). If you previously saved an x.xml file and do not want to save over it, click "No," and ISIS will proceed to the Audiometry slide. (If you want to save over your original x.xml file for some reason, the application will allow that if you select "Yes.")

Exhibit 3-14. Override x.xml file message



As you advance to the audiometry screen, ISIS will display a message indicating which ear to test first and which headphones to use for audiometry (Exhibit 3-15). **Pay close attention to this message.** Click OK, and then click the forward arrow to move on to audiometry.

Exhibit 3-15. Audiometry pop-up box



3.4.5 Troubleshooting Middle Ear Testing

The following are some common problems that may be encountered during middle ear testing, and a list of possible solutions that may correct the difficulty.

- Difficulty obtaining a sufficient seal to conduct the test:
  - Pull the probe completely away and reset the probe tip in the ear.
  - Pull up and back a little more on the ear to straighten the ear canal.
  - Use a different size tip.
- Probe indicates blockage when running the test (indicated by a yellow probe light):
  - Verify that the probe cuff is in the entrance to the ear canal and pointing toward the ear drum, not up against another part of the ear.
  - Check that the probe tip is not blocked by wax, etc. If necessary, replace the clear plastic probe tip.
  - Recall the direction of the ear canal noted on otoscopy and try to direct the probe appropriately.
- Titan takes an abnormally long time to begin tympanometry:
  - Typically, this means that an airtight seal has not been obtained.
  - Remove the probe and begin again.

- Results are “noisy”:
  - Try to seat the probe so that you do not have to hold it during the test. If you must hold the probe in place, hold it very still.
  - Remind the SP to be as still and quiet as possible (yawning, swallowing, talking, or chewing during the test will result in “noisy” graphs).
- ISIS will not capture data:
  - Make sure you have saved the file in the correct location (the ISIS_Out folder).

If you are ever unsure whether the Titan is malfunctioning, test it by placing your finger over the tip of the probe (the probe status indicator in the left panel of the Titan Suite screen should say “Blocked”) or by running a calibration. If the Titan can calibrate or gives the “Blocked” message, it is not malfunctioning; reseat the probe, try a different size probe cuff, etc.

3.5 Audiometry

3.5.1 Purpose of Audiometry

Audiometry is the measurement of hearing sensitivity. The NHANES hearing component includes pure tone air conduction audiometry, which tests the hearing sensitivity of the entire auditory system by presenting pure tone signals to the ear through earphones and varying the intensity of the signals until the level is identified at which the person is just able to hear the sound. This level is known as the person’s threshold; clinically, threshold is usually defined as the level at which the subject will be able to detect the signal 50 percent of the times that it is presented. Pure tones are presented at frequencies across the range of human hearing. Because the tones are presented at the external ear, and processing of those signals through the auditory nervous system is necessary in order for the subject to be aware and respond that the signal was heard, this type of testing evaluates the auditory system as a whole, and is capable of identifying hearing problems at almost any level within the auditory system.

3.5.2 Instrumentation for Audiometry

Pure tone air conduction threshold testing is done using the Interacoustics Model AD226 audiometer. The audiometer is an electronic device capable of generating pure tone signals, which can be adjusted in both frequency and level. The Interacoustics AD226 is a microprocessor audiometer, which means it has been programmed to conduct the threshold test automatically. It is capable of presenting the tones, recording the subject's responses, adjusting the level of the tone accordingly, and determining when the threshold has been found. The AD226 can also be used as a manual audiometer, which means the frequencies and the tester, who also makes the threshold determination, adjusts levels.

The AD226 is supplied with standard audiometric headphones, EARtone 3A insert earphones, a patient response switch, and an external power supply.

3.5.3 Procedure for Audiometry

3.5.3.1 Preliminary Procedures and Instructions

The examinee will remain in the sound room for pure tone audiometry. The ear to be tested first will be varied in order to prevent biasing the data. The fifth digit of the sample person identification number (SPID) will be used to identify which ear should be tested first; if the fifth digit is 5-9, the right ear will be tested first, and if the fifth digit is 0-4, the left ear will be tested first. For example, SP# 448937 will have his left ear tested first, and SP# 879592 will have her right ear tested first. However, if a subject indicated that he or she has better hearing in one ear than the other, the ear with the better sensitivity should be tested first. The ISIS program will prompt which ear is to be tested first as you move from the tympanometry screen to the audiometry screen.

Be certain that the SP has removed eyeglasses, earrings, chewing gum, hair ornaments, hats, wigs, or anything else that might interfere with proper placement of the headphones. Hair should be pushed away from the entrance to the ear canal. Also, verify that any hearing aids have been removed. If the examinee must wear his or her hearing aid in order to hear the test instructions, remember to have the examinee remove it before testing begins.

Explain the test and instruct the examinee in the following manner:

- **Instructions.** "This last test measures how well you can hear certain sounds. I am going to place these earphones on your head and you will hear a series of short beeping sounds through them. They will have various pitches, both low and high, and will gradually become softer and softer until you can't hear them anymore. Each time you think you hear the tones, no matter how quiet they seem, push down on this button. You will have to listen very carefully. The beeping sounds will come in groups of three or four – beep beep beep. You only have to push the button once for each set. Also, you do not have to wait until you have heard all three; you should press the button as soon as you think you hear them. We will be starting in your right/left ear. Do you have any questions?"

Place the appropriate headphones on the SP. **The RED earphone goes on the RIGHT ear and the BLUE earphone goes on the LEFT ear.** Proper placement of the headphones is essential to obtaining accurate hearing thresholds. Do not permit the examinee to place the headphones on herself or himself.

- Standard headphones:

  Standard headphones will be the default, unless the potential for collapsing canals was noted on the otoscopic exam.

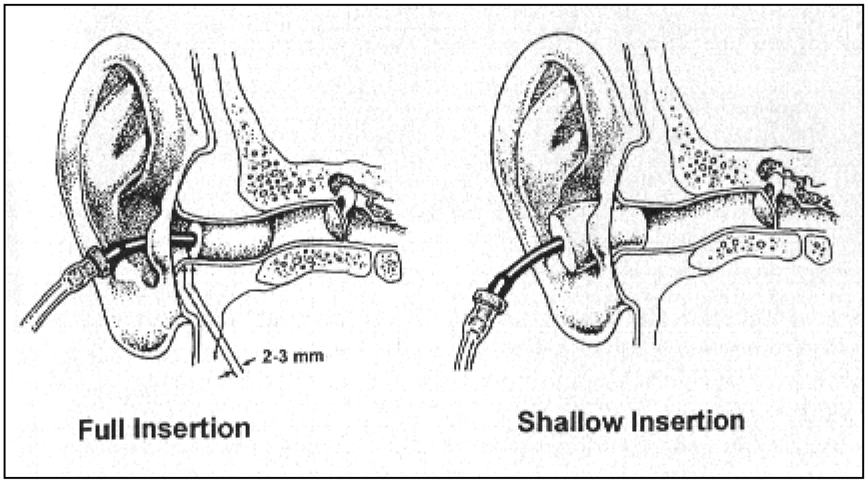
  To place these headphones on the SP, fully extend the height of the headset. Position the earphones such that the diaphragm of the earphone is aimed directly at the opening of the ear canal, pushing aside any hair from over the ear. When the earphones have been positioned, hold them in place and slide the top of the headset down so that it rests solidly on the top of the examinee's head. (This step may disarrange the examinee's hairstyle but it is important for proper use of the headphones.) Make sure that the earphones exert firm pressure on each ear and form a good seal.

- Insert earphones:

  Insert earphones will be used when the potential for collapsing canals was noted on otoscopy, and for any retests when there is a significant difference in threshold between the right and left ears at the same frequency. Insert earphones **may not** be used when excessive or impacted cerumen was noted in either ear, or when there was another abnormality noted in either ear at otoscopy.

  Particular care must be taken in proper insertion, as improper insertion will result in inaccurate threshold levels. Drape the Velcro strip behind the SP's neck to support the earphones. Slowly roll (do **not** squeeze) the foam tip into as small a diameter as possible; there should be no creases or wrinkles in the compressed foam. Pull up and back on the helix (upper part) of the outer ear to straighten the ear canal, and quickly insert the foam tip to a point such that the outer edge of the tip is flush with the entrance to the ear canal. Hold the foam plug in place with a fingertip until the foam has completely expanded (approximately 10 seconds). Correct insertion is illustrated in the first illustration in Figure 3-12 below. Incorrect (i.e., shallow) insertion is shown in the second illustration. If the foam tip is not inserted properly, remove it and try again.

Figure 3-12. Insertion of earphones



After placing the headphones on the SP, make sure the examinee is seated in such a way that you can observe him or her during the test protocol, but the examinee cannot observe what you are doing or how the equipment is being operated. Generally, it is best to have the examinee facing the back wall of the room. Explain to the examinee that you are asking him or her to face this way to prevent distraction.

Close both the door to the sound room and the exterior door to the audiometry exam room prior to the start of testing. Assure the examinee that, although the door must be closed during testing, you will be observing the test through the window and he or she should signal if anything is needed.

3.5.3.2 Automated Audiometry Procedures

Automated audiometry is the procedure in which the frequency, stimulus level, presentation of test signals, and determination of threshold are controlled by a computer program built into the audiometer. The AD226 audiometer contains such software, and is capable of conducting the hearing test in much the same way as you would conduct the test manually (as described in the next section). Automated audiometry will be the standard test procedure in NHANES, except under certain conditions (see Section 3.5.3.3).

Once the preliminary procedures have been completed and the SP is ready to begin the test, verify that the audiometer is set as follows:

- MAN REV button set to MAN;
- PULSE button set to _⊓_⊓_;
- 1 5 dB button set to 5;
- RIGHT or LEFT ear selected (whichever ISIS indicated should be tested first); and
- Appropriate HEADSET selected.

  The appropriate headset must be selected on both the audiometer and the headphone selector box.

  On the audiometer, the standard headphones are the default setting; if the audiometer is set for standard headphones, the display will read "Ph." in the lower left corner. To set the audiometer for insert earphones, press SHIFT/RIGHT or SHIFT/LEFT (depending on which ear is to be tested first; pressing SHIFT/RIGHT also selects the right ear as the test ear and pressing SHIFT/LEFT selects the left ear). **This is very important**, as it changes the internal calibration levels to those necessary for inserts. When the audiometer is set for insert earphones, the display will read "Ins." in the lower left corner. To switch back to standards, press SHIFT/RIGHT or SHIFT/LEFT again.

  Set the appropriate headset on the headphone selector box by turning the knob toward "TDH" (standards) or "Inserts."

When starting a test on a new SP, always begin by deleting any thresholds, which may be stored in the audiometer; press and hold SHIFT/1 5 dB until the display reads "All thresholds are del."

Press AUTO THRESHOLD to begin testing. Monitor the test as it is conducted. The green TONE light will flash when a test signal is being presented to the examinee; the red RESPONSE light will flash when the examinee presses the response switch to indicate that he or she heard the tone. As you are monitoring the test, watch for the following:

- SP attention:

  Periodically observe the SP to verify that everything is well and that he or she is not watching the audiometer for cues to the presentation of test signals. If you need to communicate with the SP, you can do so by pressing the TALK FORWARD button. If the SP needs to communicate with you, you must pause the test (by pressing AUTO THRESHOLD) and go into the sound booth.

- Frequent false positive responses:

  A false positive occurs when the subject responds to a signal that was not presented. False positives are indicated by a flash of the red RESPONSE light that does not immediately follow a flash of the green TONE light. In other words, the examinee indicated that he or she heard the tone, but the tone was not presented. If more than three false positives are noted at a given test frequency, press AUTO THRESHOLD to pause the test and reinstruct the participant (see Section 3.5.8 on Difficult Test Situations). Press AUTO THRESHOLD again to resume testing (the AD226 will pick up at the frequency at which the test was paused). If false positives persist, the subject should be tested manually.

- Long searches for threshold at a given frequency:

  A long search for threshold can occur when the subject has difficulty distinguishing the test signal from tinnitus, when the subject becomes fatigued, etc. If the examinee spends an inordinate amount of time at a given frequency, you may want to pause the test (by pressing AUTO THRESHOLD) and reinstruct the examinee. If the situation does not improve, the test should be completed manually (see Section 3.5.8 on Difficult Test Situations). Skip the problem frequency temporarily and try it again at a later point in the test. It is not possible to skip frequencies or test frequencies in a different order during an automated test.

- Slow response time or inability to operate the response switch:

  If the examinee has limited dexterity, he or she may be unable to operate the response switch or may not be able to respond in the time window programmed into the audiometer for a valid response. In such cases, the examinee will have to be tested manually using a different response mechanism—such as raising his or her hand or nodding his or her head (see Section 3.5.3.3 on Manual Audiometry and Section 3.5.8 on Difficult Test Situations).

- Test/retest consistency at 1000 Hz:

  The automated procedure programmed into the AD226 tests 1000 Hz twice in each ear as a measure of the reliability of the subject's responses. It is important to note both 1000 Hz thresholds in a given ear and make sure that there is no more than 10 dB difference between them. If the test/retest thresholds differ by more than 10 dB **in the same ear**, the audiometer will beep and display the message "Retest failed! Press Auto Threshold." Press AUTO THRESHOLD to stop the test and reinstruct the participant—emphasizing that he or she only press the response switch when fairly certain that the test tone is heard (remind him or her that the tones will be pulsed).

  To restart the test, press RIGHT or LEFT to select the ear that was under test (the audiometer will have automatically reset itself for the right ear when you pressed AUTO THRESHOLD). Press SHIFT/1 5 dB until the display reads "PH-R Thresholds are del." (Instead of PH-R, you may also see PH-L, IN-R, or IN-L, depending on which ear was being tested and which headphones were being used for the test). **Make sure you have**

selected the correct test ear before deleting! Do **not** continue to press SHIFT/1 5 dB or you will delete thresholds in both ears. Press AUTO THRESHOLD to continue the test.

If the test/retest at 1000 Hz fails a second time in the same ear, the test should be ended.

- Excessive ambient room noise:

  Observe the Quest bioacoustic simulator from time to time throughout the test to verify that the power light is still flashing and that the ambient room noise is within acceptable limits. If the power light is not flashing, change the battery in the simulator after you finish the examination. If the noise monitor lights remain on for more than a few seconds, press AUTO THRESHOLD to pause the test until the noise goes away; when ambient levels have quieted sufficiently, press AUTO THRESHOLD again to resume testing.

When all frequencies have been tested, the audiometer will beep and the display will read "Successfully ended. Press Auto Threshold." Press AUTO THRESHOLD to stop the test.

3.5.3.3 Manual Audiometry Procedures

Manual audiometry is the procedure in which the technologist controls the frequency, stimulus level, and presentation of test signals and makes the determination as to when threshold has been identified. It is essential that hearing tests given manually follow the same protocol as hearing tests done automatically by the audiometer in order to obtain comparable results. Therefore, it is very important that the procedures outlined in this section be followed exactly.

Manual audiometry is done in lieu of automated audiometry when any of the following circumstances exists:

- The examinee lacks the dexterity necessary to operate the response switch;
- The examinee appears confused by or unable to "keep up with" the automated test (i.e., he or she responds to the signal slowly, and therefore the response is not counted by the audiometer, which looks for a response within a specific time window following the stimulus);
- More than three false positive responses are noted at any given test frequency during the automated procedure; and
- A threshold exceeds 100 dB (90 dB at 8000 Hz).

In situations in which the automated test has already determined threshold at some test frequencies when a circumstance arises that dictates the need for manual testing, the technologist should pick up the manual procedure where the automated procedure left off. It is not necessary to go back and begin the audiometry all over. However, as soon as manual testing has begun, the remainder of the test should be done manually. At the end of the test, note on the audiometry results screen in which ear and at which frequency the manual procedure was begun.

First, verify that the audiometer is set up properly. If you are beginning a test on a new SP, PRESS SHIFT/1 5 dB until the display reads "All thresholds are del." **If you are continuing a test that was begun in automated mode, do not delete**, or the thresholds already stored in the audiometer will be lost! Set the audiometer controls as follows:

- MAN REV button set to MAN;
- PULSE button set to _∏_∏_;
- 1 5 dB button set to 5;
- RIGHT or LEFT ear selected (whichever ISIS indicated should be tested first); and
- Appropriate HEADSET selected (as described in Section 3.5.3.2).

Set the frequency to 1000 Hz and the intensity level (using the left HL dB dial) to 30 dB.

Present the tone by pressing the TONE SWITCH for about 1 second (about 3 pulses). If the examinee does not respond, increase the intensity in 15 dB steps until a response is obtained. You will be able to increase the level to 100 dB HL. **If no response is obtained by 75 dB HL** and the examinee did not indicate a lot of trouble hearing, stop the test and listen to the output of the earphone yourself to verify that the equipment is working properly.

When a positive response is obtained from the examinee, drop the level in 10 dB steps and present the signal again until no response is obtained.

When there is no response, increase the intensity in 5 dB steps and present the signal each time until the tone can again be heard by the examinee. Count this response toward threshold.

Continue to search for threshold in this manner—decreasing the stimulus in 10 dB steps following each positive response and increasing the stimulus in 5 dB steps following each nonresponse.

Count responses made following an **increase** in stimulus intensity toward threshold (these are called "ascending presentations"); do **not** count responses made following a **decrease** in stimulus intensity toward threshold (these are called "descending presentations").

Threshold is defined as the lowest intensity at which the tone has been heard by the examinee at least 50 percent of the time following a minimum of three ascending presentations at that level (e.g., at least 2 out of 3, 2 out of 4, 3 out of 5, etc.).

To summarize the procedure, once you have obtained an initial response from the SP, use the **UP 5, DOWN 10** method to search for threshold. Count responses while you are going **UP** toward threshold. Stop when the SP has responded to half the presentations at a given level (obtain at least two responses).

Record the threshold manually in the AD226 by pressing STORE. Press the FREQUENCY DECR button twice to change the test frequency to 500 Hz. Reset the intensity to 30 dB HL (or 15 dB above the threshold level at 1000 Hz, whichever is higher). Repeat the threshold search procedure and press STORE to record the threshold.

The audiometer will automatically advance again to 1000 Hz. Find the threshold again. If the new threshold is within 10 dB of the original threshold at 1000 Hz, press SHIFT/BONE (the display should read "UCL" under the test frequency), then press STORE. Press SHIFT/BONE again to exit the UCL mode (Verify that the display no longer shows "UCL.") and continue testing in the normal manner. (The audiometer will automatically advance to the next test frequency.) **You must store the second 1000 Hz threshold in UCL mode** or the audiometer will overwrite the first 1000 Hz threshold.

If the new thresholds differ from the original threshold by more than 10 dB, stop the test and reinstruct the examinee. (See Section 3.5.8 on Difficult Test Situations.) The audiometer does not check the test/retest variability automatically when testing in manual mode, so you will have to remember the initial 1000 Hz threshold and evaluate this yourself. The ISIS system will alert you at the end of the test if you fail to note the inconsistency between test and retest thresholds at 1000 Hz. However, it will not do so until the test has been completed and the thresholds have been captured. At this point, there will not be time to go back and retest. Therefore, **it is very important that you monitor the test/retest variability** as the test is underway.

Continue to test the remaining frequencies: 3000, 4000, 6000, and 8000 Hz. Always begin with an initial intensity of 30 dB HL or intensity level 15 dB above the threshold at the preceding frequency, whichever is greater.

When thresholds have been obtained at all frequencies in the first test ear, press the RIGHT or LEFT button to shift to the other ear. Conduct the test in this ear in exactly the same way, including the threshold recheck at 1000 Hz.

If the SP does not respond to the test signal at the default intensity limit of the audiometer (100 dB HL at 500-6000 Hz; 90 dB HL at 8000 Hz), it is possible to increase the intensity 20 dB further by using the Extended Range mode. **Before testing in an extended range, listen through the headphones to rule out an equipment malfunction.** To activate the extended range, press EXT RANGE; a "+" will appear to the left of the intensity level on the display (you must have the intensity set to at least 80 dB HL to enter the extended range mode). Continue searching for threshold in the same manner. (If the attenuator drops below 80 dB HL [70 dB at 8000 Hz], the audiometer will automatically exit the extended range mode, and you will have to reactivate by pressing EXT RANGE again.) If there is still no response from the SP, store "No Response" as the threshold by pressing SHIFT/STORE. No response thresholds are indicated by "NRS" on the AD226 display and when displayed by ISIS.

Exit the extended range mode by dropping the intensity level below 80 dB HL (70 dB at 8000 Hz) or by pressing EXT RANGE again.

NOTE: Extended range testing provides 20 dB additional intensity beyond the default output limit of the audiometer. The output limit of the audiometer varies by headphone and frequency. The levels noted above refer to the audiometer output for standard headphones. Table 3-1 summarizes audiometer output constraints for both standard and insert earphones.

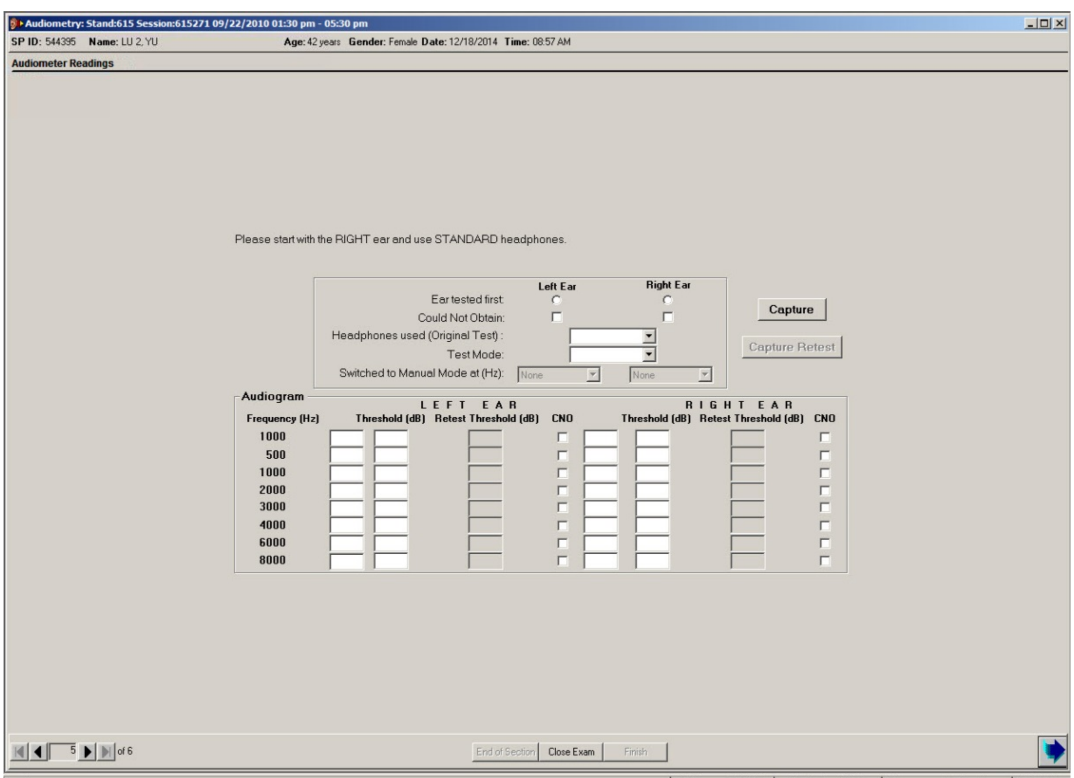
Table 3-1. Audiometer output constraints for standard and insert earphones

	Standard headphones			Insert earphones		
Frequency	Minimum level to enter ext range	Default max output: no ext range	Max output: with ext range	Minimum level to enter ext range	Default max output: no ext range	Max output: with ext range
500 Hz	80	100	120	70	90	110
1000 Hz	80	100	120	80	100	120
2000 Hz	80	100	120	80	100	120
3000 Hz	80	100	120	80	100	120
4000 Hz	80	100	120	75	95	115
6000 Hz	80	100	120	60	80	100
8000 Hz	70	90	110	55	75	95

3.5.4 Recording Audiometry Results in ISIS

When thresholds have been obtained at all frequencies in both ears, transfer the results to ISIS by clicking the “Capture” button on the audiometry results screen (Exhibit 3-16). Verify that ISIS displays results in the THRESHOLD (dB) column for each frequency in each ear.

Exhibit 3-16. Audiometer readings screen



Complete the top portion of the results screen as necessary. Record which ear was tested first and which headphones were used to conduct the test. You do not need to complete the Test Mode fields; ISIS will capture codes which indicate whether the test was conducted automatically, manually, or mixed (some thresholds obtained automatically and some manually). The test mode for each frequency will be displayed to the left of each threshold (A = automated; M = manual). If an entire ear could not be tested, click the COULD NOT OBTAIN box in the upper portion of the screen for that ear. If a particular threshold could not be obtained, click the CNO box for the appropriate ear and frequency in the lower part of the screen. A threshold, NRS, or CNO result must be recorded for each frequency or ISIS will not advance to the final exam screen.

If one or more frequencies were accidentally skipped, ISIS will permit you to go back and test those frequencies. When you have obtained the missing thresholds, click the "Capture" button again to transfer the thresholds to the results screen.

3.5.5 Retesting with Insert Earphones

3.5.5.1 Crossover Principles

There are times during audiometric testing that the signal being presented to the test ear is loud enough that it can actually be heard by the other ear (i.e., the nontest ear). When this occurs, it is difficult to determine if the threshold obtained is truly the threshold of the test ear, or an artifact of the nontest ear (which is the ear with better hearing).

How does the test signal get to the nontest ear? In basic audiometric testing, this generally occurs when the signal in the headphone is so intense that its vibration causes the bones of the skull to vibrate as well. Because the cochleas are enclosed within the skull, they can be stimulated by the vibratory motion of the head.

There is a law of physics, which states that when a vibratory source is applied to a solid mass, the vibrations set up within the mass have the same intensity throughout the object, regardless of where on the object the vibratory source is applied. For example, imagine that a vibrating tuning fork is placed on one end of a table. If you were to place your ear against the table at the end opposite the tuning fork, the sound you would hear would be just as loud as if you were to place your ear against the table at the end nearest the tuning fork. There is essentially no loss of vibratory energy across the table, and therefore no attenuation (loss) of the audible signal.

Because the human skull is essentially one solid bone, both cochleas are stimulated equally by any vibration of the bone. Therefore, if the signal being presented to the test ear is sufficiently intense to set the skull in motion, it has the potential to stimulate the cochlea of the opposite ear.

The stimulus intensity required to set the skull in motion varies across individuals and across the range of test frequencies. However, it is not possible to know in advance how loud the stimulus must be for crossover to occur in a particular individual; and it would be very difficult to remember a different intensity level for each audiometric test frequency. Therefore, in order to make things simple, clinicians choose a conservative value that represents the minimum level that might cause the skull to vibrate and the test signal to "cross over" and be heard in the nontest ear—regardless of individual differences or test frequency. The value generally chosen is 25 dB for low frequencies and 40 dB for mid-to-high frequencies when testing with standard headphones.

Whenever the threshold at any given frequency is poorer in one ear than the other by 25 dB (at 500 and 1000 Hz) **or 40 dB** (at 2000-8000 Hz) **or more** (i.e., whenever there is a 25 or 40 dB difference between ears at a given frequency), **the nontest ear could be responding to the test signal.** The threshold in the test ear is therefore questionable.

Because insert earphones are smaller, and less mass is in direct contact with the head, a louder stimulus is required before there is the potential for crossover to occur. The value generally agreed upon as the minimum level, which might cause the skull to vibrate when testing with insert earphones is 60 dB, regardless of frequency. Therefore, whenever there is the potential for crossover using standard headphones, those frequencies will be retested using insert earphones.

3.5.5.2 Procedure for Retesting with Insert Earphones

Retesting with insert earphones will be accomplished in NHANES whenever testing with standard headphones results in a difference in threshold between the right and left ears at the same frequency of 25 dB or more at 500 or 1000 Hz, or 40 dB or more at 2000 Hz up (provided, of course, that inserts are not contraindicated for that SP based on otoscopy findings). After pure tone test results are captured, the ISIS system will prompt you if retesting is necessary. The boxes in the RETEST

THRESHOLD (dB) column will be highlighted to indicate which ear must be retested, and at which frequency(s).

Remove the standard headphones from the examinee and instruct the examinee that he or she will now be listening to some tones through a different headset, but should continue to respond as before. Insert the earphone tips as explained in Section 3.5.3.1.

Delete the original test thresholds from the audiometer by pressing SHIFT/1 5 dB until the display reads "All thresholds are del." Press SHIFT/RIGHT or SHIFT/LEFT (depending on which ear is to be retested) on the AD226 to switch to insert earphone testing. (The display will read "Ins." in the lower left corner.) Turn the knob on the headphone selector box to "Inserts."

If all frequencies must be retested, conduct the test in the automated mode as usual. If only certain frequencies must be retested, conduct the test manually using the FREQUENCY INCR and DECR buttons to select the appropriate frequencies and pressing STORE to record the new thresholds in the audiometer. It is not possible to test only certain frequencies in the automated mode. When retesting with inserts, it is not necessary to obtain a second 1000 Hz threshold unless you are retesting the entire ear in automated mode.

3.5.6 Recording Retest Results in ISIS

When all required frequencies have been retested, click the CAPTURE RETEST button on the ISIS audiometry screen to transfer the retest thresholds to ISIS. If any frequencies that required retest were omitted, ISIS will prompt you to go back and obtain those thresholds. (Click CAPTURE RETEST again to transfer the missing thresholds to ISIS.) If a particular threshold could not be obtained, click the CNO box for the appropriate ear and frequency. ISIS will not advance to the final screen if results are missing at any frequency.

3.5.7 Considerations to Ensure Threshold Accuracy

Accurate pure tone testing sounds very simple, but a number of precautions are necessary in order to ensure that threshold measurements are accurate:

- Vary the interval between stimulus presentations; stimuli, which are presented too consistently, may permit the examinee to develop a response rhythm, which can lead to false positive responses.
- Keep stimulus presentations to approximately one second (or about three pulses). Longer presentations may result in false positives.
- Do not pulse the tones manually. Always use the audiometer's multiple-pulse function and press the TONE SWITCH until three or four pulses have been presented by the audiometer.
- Avoid giving visual cues that might indicate stimulus presentations (e.g., looking at the subject each time a tone is presented; using excessive arm movement in the operation of the audiometer).
- Avoid excessive activity, which may distract the examinee.
- If responses to tones at the same frequency show large inconsistencies (i.e., more than 10 dB), reinstruct the examinee and begin that frequency again.
- If difficulty is encountered in determining threshold at a particular frequency, continue with other test frequencies and return to the problem frequency later. Spending too much time on one frequency will tire and/or frustrate the examinee and exacerbate the problem.
- Make periodic checks for false positives by not presenting the tone for 8-10 seconds and verifying that the subject does not respond.
- Count only ascending presentations when determining threshold.
- Avoid being influenced by the initial threshold at 1000 Hz when performing the recheck.
- Always double-check the audiometer settings and dial readings.

In addition, keep in mind that pure tone audiometry is a **subjective** test, which means that it relies on the perception of the subject. Therefore, the accuracy of the results can be affected by a number of subject variables, including motivation, attention, familiarity with the task, etc. Your rapport with the SP can be an important factor in encouraging him or her to complete the test well.

3.5.8 Difficult Test Situations

Obtaining accurate pure tone thresholds can be a challenge under some circumstances. Listed below are some of the most common difficulties encountered in audiometric testing and suggestions for overcoming them.

- Significant pre-existing hearing loss:

  Some SPs with significant hearing loss will actually be quite experienced with audiometric testing procedures, and may not present much of a challenge at all. But others will not be familiar with the threshold testing procedure and may have difficulty hearing the test instructions. If the SP wears a hearing aid, have him or her put it back on between each test while the explanations and directions are being given. Face the person when you speak, and talk a little more slowly than usual (but don't exaggerate your facial expressions). Use motions to help augment your message. If the SP has sufficient vision and reading skills, have him or her read the test instructions from the card kept in the sound room.

- False positives/inconsistent responses:

  Responses, which continuously vary over a range of more than 10 dB, are too inconsistent to accurately determine threshold. In such cases, the best course of action is to reinstruct the examinee, indicating that he or she should only respond when fairly certain that a tone is heard. Remind the SP that the signals will be a series of three or four pulses; instructing the SP to wait until he or she has heard at least two of the pulses may also help resolve the problem.

  If the false positives/inconsistent responses are only at one frequency, try skipping that frequency and coming back to it later. Sometimes the SP just needs a break from listening to the same signal.

- Tinnitus:

  Tinnitus (the presence of ringing or other sounds in the ear) can make it difficult for the SP to distinguish the test tones from the other noises he or she hears. The pulsed tone specified by the protocol should alleviate this problem somewhat. It may be necessary to skip the frequency corresponding to the SP's tinnitus.

- Fatigue:

  Listening for signals near threshold level is a difficult and demanding task. An SP may weary of it quickly; if the SP arrives fatigued, he or she may have difficulty staying on task. Verbal reinforcement may help keep the SP alert; you can speak to the SP through the headphones by holding down the TALK FORWARD button (the AD226 defaults to a talk forward intensity of 60 dB—which is a comfortable conversational intensity for most people with normal hearing; if the SP has a hearing loss, adjust the talk forward volume using the HL DB knob).

- Poor coordination/long tone-response latency:

  Some examinees may be slow to respond when they hear the test tones, due to poor dexterity or other reasons. Reinstructing the SP to respond **as soon as** he or she hears the signal may help the situation. Otherwise, try to get a feel for the "rhythm" of the SP's response pattern so that you will better know when a response is valid and when it is random. If another method of responding is more workable (e.g., raising a hand or finger, nodding the head, etc.), use it.

- Comprehension or language difficulties:

  If an SP has difficulty understanding the test instructions, try another mode of communication. Use motions to demonstrate the test directions while you explain them. If the SP has sufficient vision and reading skills, have him or her read the test instructions from the card kept in the sound room. If a family member or friend accompanied the SP to the MEC and is available, ask him or her to help you explain the procedures to the SP. If you do not think the SP understands the directions enough to provide valid test results, skip the pure tone testing and note "Communication Problem" as the reason for the incomplete test.

- Anxiety:

  Some SPs may be anxious about the test, for various reasons. Perhaps the most common is claustrophobia. Try to put the SP at ease as much as possible. In some cases, it may be possible to conduct the test with the door to the sound room partly or completely open…but only if the octave monitor on the Quest BA-202-27 indicates that the noise levels in the sound room are still sufficiently quiet. If the ambient noise in the room is too high with the sound booth door open, and the SP is unable to complete the test with the door closed, skip pure tone testing and record "Physical Limitation" as the reason for the incomplete test.

Reinstructing the SP can sometimes help to alleviate a difficult test situation or improve the accuracy and efficiency of the threshold test. Reinstruction is helpful in situations that involve a **misunderstanding of test instructions**. For example:

- SP pushes the button for each beep in the series;
- SP waits for all beeps to play before responding; and
- SP fails test/retest at 1000 Hz once.

However, reinstructing the SP does not help when the situation involves an **inability to follow test instructions**. For example:

- SP repeatedly fails test/retest at 1000 Hz;
- SP continues to respond with more than 3 false positives per frequency; and
- SP's dexterity is too poor to press the response button in a timely manner.

When reinstructing the SP, be certain to tailor the reinstruction to the specific circumstance. Repeating the same directions initially given to the SP does not help. If the SP did not understand the first time, a verbatim recitation of the same instructions is not likely to be successful the second time. If the SP fails the test/retest at 1000 Hz or if the SP has more than 3 false positives at one frequency, emphasize that he or she should only respond when sure that tones have been heard. If the SP responds outside the time window of the audiometer, emphasize that he or she should respond as soon as tones are heard.

Finally, if for any reason you feel that the SP is unable to provide reliable thresholds, end the test. No data is preferable to poor data; and there is no mechanism for indicating reliability. Thresholds recorded in ISIS will be assumed to be valid; therefore, if you feel they are not, discontinue testing and enter the reason for the partial exam on the status screen (see Section 3.6.1).

3.5.9 Troubleshooting Audiometry

The following are some problems that may be encountered in operating the audiometer or conducting pure tone threshold testing, and a list of possible solutions that may be used for troubleshooting.

- Audiometer does not turn on:
  - Verify that cable from power supply to outlet is inserted securely. (This connection is ***very touchy***!)
- Headphones are out of calibration on daily check:
  - Check battery in bioacoustic simulator;
  - Correct headphones selected on audiometer;

- Pulsing is off (both lights off on PULSE button); and
- For standards, make sure insert earphone adaptors were removed from simulator.

■ No tones in headphone:

- Proper headphone selected on headphone box;
- All headphones plugged into appropriate booth jacks; and
- Correct ear selected.

■ "Hissing" sound in headphones:

- Turn off masking signal. (Press SHIFT and turn right DB HL knob counterclockwise.)

■ Cannot activate extended range:

- Make sure intensity is set to at least 80 dB (or at least 20 dB below the default maximum intensity of the audiometer – see table in Section 3.5.3.3); and
- Extended range can only be activated in manual mode (does not work if AUTO THRESHOLD is activated).

■ Patient response light does not come on or stays on and does not turn off:

- Check that response switch is plugged **all the way** into booth jack (not the cable from the bioacoustic simulator);
- Make sure SP is pressing button all the way down.

■ LEDs on control buttons do not light:

- Adjust LED ADJ knob.

■ Push buttons do not respond:

- Wait one second and try again. (Buttons do not work when the microprocessor is busy.)

■ Intensity changes in 1 or 2 dB steps:

- Press 1 5 DB button several times to reset to 5 dB. (Press AUTO THRESHOLD to pause test if necessary.)

- Cannot delete stored thresholds:
  - Thresholds cannot be deleted if they are displayed; press SHIFT + EXT RANGE to turn off display, then delete.

3.6 Post-Examination Procedures

3.6.1 Closing the Hearing Exam in ISIS

Click the forward arrow to advance to the audiometry component status screen. If any part of the examination was incomplete (or if the exam was not done at all), ISIS will prompt you to enter an explanation code. The codes are standardized across all exam components. Refer to the guidelines below in assigning codes for incomplete hearing examinations:

- **Safety Exclusion.** Refers to an exclusion based on precluding conditions as outlined in the protocol. As there are no precluding conditions for the hearing component, there should seldom, if ever, because to select this code;
- **SP Refusal.** Refers to circumstances in which all or part of the exam was omitted because the SP refused, was uncooperative, etc.; but was physically able to undertake the component;
- **No Time.** Indicates that the session ended and the exam could not be conducted or had to be terminated before it was completed;
- **Physical Limitation.** Refers to the physical inability of the SP to complete all or part of the exam; for example, the SP could not remove his or her hearing aids unassisted, had ear pain so great he could not tolerate the headphones, could not respond consistently to the test tones, was claustrophobic and could not sit in the sound booth; had no external ear canals, etc.;
- **Communication Problem**. Indicates that the exam could not be accomplished because the SP could not understand the test instructions for reasons other than a language barrier (e.g., a cognitive deficit or other communication impairment);
- **Language Barrier.** Indicates that the exam could not be accomplished because of language barrier; the SP did not speak English and an interpreter was not available;
- **Equipment Failure.** Problem with test equipment or the ISIS system, or high ambient noise, which precluded pure tone testing;
- **SP Ill/Emergency.** SP had to leave abruptly due to a serious, unforeseen circumstance;
- **Interrupted**;

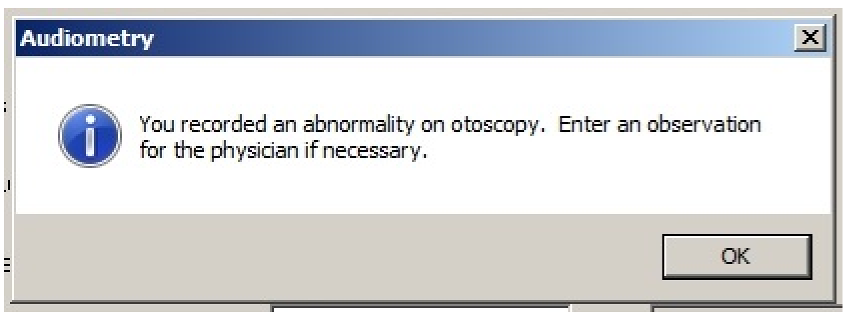
- **Other (Specify).** For use when the reason cannot be coded with any of the other categories. A brief explanation (40 characters or less) in the accompanying comment field is required. Use of this category should be limited as much as possible; and

- Click the "Finish" button to exit the component.

3.6.2 Referral

If "other abnormality" is checked for the left or right ear on the otoscopy exam screen, you will receive a pop-up reminder (Exhibit 3-17) when advancing from the otoscopy screen to the tympanometry screen.

Exhibit 3-17. Physician observation reminder message



3.6.3 Directions to Examinee

When the entire test has been completed and the SP has been closed out of the component, return any items that the examinee may have removed at the beginning of the exam (e.g., hearing aids, eyeglasses, earrings, hair ornaments, etc.). Wait a few moments for a message from the coordinator indicating to which station the SP should be directed next. Thank the examinee and direct him or her to the next station. If the examinee inquiries about the results of any of the hearing examination procedures, explain to him or her that you simply conduct the tests and that the results will be given to him or her with some explanatory materials at the end of the exam.

NEVER, NEVER, NEVER interpret the results of the hearing exam for the SP or give any indication of the test results!

3.6.4 Final Procedures

If time permits following the exam, reset the test room for the next SP. Discard the otoscope speculum, Titan ear tips, headphone covers, and foam ear tips if you have not already done so. **(Be very careful not to throw away the white plastic connectors on the insert earphones between the foam tips and earphone tubing.)** Delete the results from the audiometer by pressing SHIFT/1 5 dB until the display reads “All thresholds are del.” Reset the audiometer and switchbox to standard headphones, if applicable.

Quality Control 4

4.1 Quality Control Procedures

To ensure complete and accurate data collection and to document the data collection process, a variety of quality control procedures have been developed for this survey. Insofar as possible, checks have been programmed into the Integrated Survey Information System (ISIS) software to notify you when data are incomplete or inconsistent. It is important, however, that you also pay close attention to the completeness and accuracy of the data recorded in ISIS, particularly that:

- The correct response is marked for each item;
- No conflicting responses have been marked for the same item;
- Data from previous study participants (SPs) are deleted from the Titan and audiometer before beginning a test on a new SP; and
- Thresholds, No Response, or Could Not Obtain are entered for each test frequency.

It is particularly important that you pay close attention to calibration checks of the equipment. Follow all calibration procedures *exactly* and record them in ISIS appropriately. If problems arise, contact the consulting audiologist immediately so that the problem can be resolved without adverse effects on the data.

When keeping hard-copy logs, verify that:

- All values are recorded in the proper spaces on the proper logs; and that no required information is missing (e.g., equipment serial numbers, dates, technician ID, etc.);
- All entries are legible; and
- Values fall within the specified calibration limits.

If additional calibration checks are done mid-stand (e.g., checking audiometer output with the sound level meter when the daily bioacoustic check is out of range), be certain to record results and send them to the consulting audiologist at the end of the stand. *It is particularly important to maintain hard-*

copy records of sound level meter checks made when the daily audiometer check is out-of-range. Currently, the hard-copy record is the only evidence that the audiometer was still in calibration when the bioacoustic check indicates a problem.

4.2 Review of Data

Audiometry data will be reviewed periodically by a consulting audiologist to verify that all necessary data are being collected and saved, to evaluate the consistency of results across the tests conducted on an individual SP (i.e., otoscopy, immittance, and audiometry), and to monitor for any difficulties with test procedures. If problems are noted, the audiologist will contact the MEC team to discuss the problem and make appropriate recommendations.

Monitoring the quality of data collection will also be carried out by Westat component staff, who will generate reports from the ISIS Intraweb at the end of every stand. The number of audiometry examinations and examination times, cumulative and by technician, as well as reasons for not done and partial examinations, will be analyzed for each stand.

4.3 Field Observations

Approximately three times a year, a consulting audiologist will visit each MEC team and observe 15 to 20 examinations given by the health technologists. This visit will serve to verify that the audiometry protocol is still being implemented properly and consistently. Problems or variations in the standard procedures will be reviewed with the technologists at the end of each day. If serious issues are encountered, retraining may be scheduled.

Additionally, NCHS staff and Westat component staff will visit the MECs periodically to observe the audiometry examinations. A checklist will be used to verify that standard testing procedures are being strictly followed, including test instructions, placement of the headphones and tympanometry probe, position of the examinee during the test, manual audiometry, etc. These observations will serve to further monitor the quality of data collection and to provide constructive feedback to the MEC staff.

Appendix A

Inventory of Audiometric Equipment and Supplies

Appendix A
Inventory of Audiometric Equipment and Supplies

Audiometry
Consumable

Site ID:

Part #	Description	Par	Unit	Count
EXAM SUPPLIES				
8012972	10 mm Mushroom Style Eartip	20	each	
8012974	11 mm Mushroom Style Eartip	20	each	
8012976	12 mm Mushroom Style Eartip	100	each	
8012978	13 mm Mushroom Style Eartip	250	each	
8012980	14 mm Mushroom Style Eartip	200	each	
8012982	15 mm Mushroom Style Eartip	150	each	
8120347	19 mm Mushroom Style Eartip	20	each	
8013002	7 mm Mushroom Style Eartip	20	each	
8013004	8 mm Mushroom Style Eartip	20	each	
8012970	9 mm Mushroom Style Eartip	20	each	
58-104	Alcohol Wipes	1	box	
STO-01302	Audiowipes – 160 wipe canister	1	bottle	
2865460	Cleaning Floss 3 in1 – 200 pc box	2	box	
2860744	Cleaning Floss Bridge & Implant – 30 pc box	2	box	
SO-EPG	Ear Phone Guards, Paper	2	box	
RAS-420-2006	EarLink 3A Tips (Foam, Small)	100	each	
RAS-420-2005	EarLink 3A Tips (Foam, Standard)	120	each	
RAS-420-2028	EarLink 3A Tips (Foam, X-Large)	48	each	
9022	Gauze Pads (2 x 2)	2	pack	
GOJ-9639 12CT	Handsoap – Waterless (Purrell)	1	bottle	
52432	Otoscope Specula (Kleenspec – 2.5 mm)	6	sleeve	
52434	Otoscope Specula (Kleenspec – 4.25 mm)	10	sleeve	

Part #	Description		Par	Unit	Count
OFFICE SUPPLIES					
EVEEN22	Batteries, 9-Volt – do not count what is in equip.		15	each	
EVEEN91	Batteries, AA Cell – (spares, do not count what is in equip.)		4	each	
SPARE PARTS & TOOLS					
72300	Otoscope Battery, Rechargeable 3.5 volt		2	each	
	Lot: 2014-03	Exp DT: 06/30/2016			
	Lot: 2014-05	Exp DT: 08/31/2016			
	Lot: 2015-01	Exp DT: 05/31/2017			
03100	Otoscope Bulbs (Halogen 12v/20watt) – do not count bulbs in equip.		2	each	
COMPONENT TOOLS					
S-8028	Humidity Indicator Strips – 10 – 60% Read-Out		1	can	
S-20191	Large Desiccant Pack, 5 x 5 pack – do not count ones in use		4	each	
S-3902	Small 1 Gram Desiccant Pack		25	each	
871701	Zip-Lock Sandwich Bags – 40 ct. box		1	box	
MEC SUPPLIES					
PC720891	Tissues – Facial		2	box	

Insert * for Expired Lot.

Audiometry Mid Stand Adjustment
Nonconsumable

Site ID:

Part #	Description	Par	Unit	Count
EXAM SUPPLIES				
ER3-04	Eartip Connectors (white) – do not count tips on equip.	10	each	
SO-HB	Headband for Standard Headphones	2	each	
SUDPCB	Tripod – Lightweight Photo/Video	1	each	
SPARE PARTS & TOOLS				
41005	Hex Key Set, Standard, Buck Bros. 7 pc.	1	each	
QB-4LC	Quick Release Platform	1	each	
62-102	Screwdriver, Phillips Head	1	each	
62-104	Screwdriver, Straight Head	1	each	
5165533014	Wrench, Husky Combination 7/16	1	each	
EMERGENCY SUPPLIES				
	CPR Mask – Adult	1	each	
COMPONENT TOOLS				
Int. Manual	Asian Interpreter Manual – Audio	1	each	
9688K221	Audio Jack Cover – 1/4 Inch Plastic Cap	25	each	
LM-20	Deskbrite 200 Lighted Magnifier – Battery Powered	1	each	
	Desktop Eartip Storage Box – Infinite Divider System Box	1	each	
8011348	Probe Cleaning Tool	2	each	
8122239	Probe Tip – For Sanibel Eartip	2	each	
226207	SP Jewelry Container – 250mL Plastic Box with Lid	1	each	
6942629 250333	Storage Box – Mushroom Eartips – Locking Plastic Organizer	1	each	
226207	Storage Box – Small Eartips – 250mL Box with Lid	1	each	
226206	Storage Box – Standard Eartips – 500mL Box with Lid	1	each	
226206	Storage Box – XLarge Eartips – 500mL Box with Lid	1	each	

Insert * for Expired Lot.