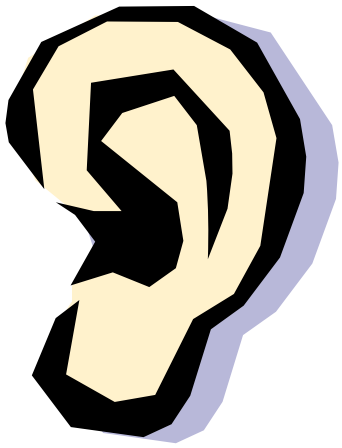
Guidelines:

Hearing and Middle-Ear Screening



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These materials have been prepared to serve as a guide for individuals performing hearing and middle-ear screening. Clinicians providing screening should receive formal training prior to operating the various screening devices described in the document.

Audiologists, speech-language pathologists, public health nurses, pediatric nurse consultants, and child development specialists have assisted in preparing this document. Screening pass/not pass criteria are based on the American Speech-Language-Hearing Association guidelines for screening hearing and on the Oklahoma State Department of Health hearing screening/middle-ear screening protocols. The Oklahoma State Department of Health assumes no responsibility for the use of these guidelines and screening criteria.

CONTENTS

HEARING AND MIDDLE-EAR SCREENING

OVERVIEW:

Hearing loss is often an "invisible" condition, the consequence of which can be devastating. In a child with hearing loss, speech and language development may be delayed, since good hearing is crucial to speech/language development. Educationally, the child with hearing loss may be considered to be a slow learner, inattentive and/or disruptive. Adults with hearing loss may experience social isolation, vocational dilemmas and difficulty communicating. The need for early identification of hearing loss along with appropriate follow-up treatment and/or habilitation is of utmost importance.

Hearing losses are described as one of three types: conductive, sensorineural or mixed. The type and extent of a hearing loss can be diagnosed only after a complete audiological and/or medical evaluation.

Conductive hearing loss results from deformity, disease, or injury to the outer and/or middle ear. A conductive loss is characterized by a decrease in the loudness of sound. Typically, conductive losses respond to medical intervention. Causes of conductive hearing loss include, but are not limited to: anatomic malformations (e.g. absence of external canal or ossicles); impacted cerumen or foreign bodies in the external canal; tympanic membrane perforation or rupture; acute otitis media; serous otitis; ossicular chain disruption (often from head injury); and otosclerosis. In the United States, otitis media is the third most frequently diagnosed illness in children surpassing all other ailments except the common cold and sore throat. A child with otitis media may continue to have significant middle ear fluid for an extended time period although discomfort has subsided and the tympanic membrane is no longer inflamed. Temporary or long-standing conductive hearing loss may occur in these children even when no symptoms are present. More than 80% of the hearing loss found in children is of the conductive type.

Sensorineural or "nerve" losses result from impairment of the cochlea or auditory nerve. This type of loss is characterized by a decrease in the loudness of sound and also a decrease in the clarity of sound. Speech may be described as sounding muddled or distorted; loud speech may not be understood. Factors causing sensorineural loss in children may include heredity, maternal complications during pregnancy and/or delivery and serious illness such as meningitis. Factors causing this type of loss in adults may include heredity, illness, noise exposure and aging. In most cases, sensorineural losses do not respond to medical treatment. After a thorough medical and audiologic assessment, hearing aids may be recommended.

Mixed hearing losses are those which exhibit combined conductive and sensorineural components. This type of loss may be seen in both children and adults.

Prevention and early identification of hearing disabilities are integral components of a hearing conservation program. Hearing conservation efforts must include a systematic implementation of a hearing/middle-ear screening program.
Hearing/middle-ear screening is a <u>screening</u> <u>only</u> and not a complete assessment of hearing sensitivity. Not passing a screening does not necessarily indicate a hearing loss but rather is an indication of the need for an in-depth audiologic evaluation. Further, because of the

limited scope of a screening, certain audiologic or otologic problems cannot be ruled out even if the screening is passed.

Children and Adolescents

Hearing/middle-ear screening programs must be systematic to best identify children with potential hearing problems. Teacher or parent referral for screening only specific children is not adequate. A systematic program for screening all children at certain ages and grades and for screening at-risk children should be implemented.

Hearing/middle-ear screening prior to age three begins with an assessment of the child's risk for hearing loss. Through interviewing the caretaker and observation of the child's behavior, the health care professional should attempt to identify those children with risk for hearing difficulties. Infants and children under age three may be screened with the ABR (six months and younger) and OAE screeners, a tympanometer and when available the "Colorado" Visual Reinforcement Audiometer (provided that the person screening has been trained to use this equipment). Children age three through adolescence typically are screened with a pure tone audiometer and a tympanometer. Whenever there is a question regarding the hearing ability of any age child, consultation and referral to an audiologist or physician should occur.

Adults

Personnel sometimes are requested to screen the hearing and/or middle-ear status of adults. Screening procedures using audiometers and tympanometers as described in this manual are appropriate for adults when such individuals express concern regarding hearing. Hearing screening/conservation programs for industry only can be provided by audiologists or by individuals who have completed the training requirements established by the Occupational Safety and Health Administration (OSHA).

Hearing screening is not appropriate for monitoring clients who are being administered ototoxic drugs. Because of the possibility of legal and medical complications, these clients must be referred to an audiologist for a baseline assessment prior to the start of the drug therapy program. Their hearing sensitivity must be monitored at prescribed intervals by an audiologist during the course of drug therapy.

RECOMMENDED SCREENING SCHEDULE

1. Infants and toddlers being examined for the early intervention program must be screened for hearing and middle-ear function prior to or at the time of the arena assessment. All infants and toddlers age 0 to 3 years should be screened for hearing and middle-ear function at each well child visit.

2. Children functioning at a developmental level of 3 years through grade three should be screened annually.

3. Children in grade four and above should be screened minimally at three-year intervals.

4. Children under 3 who are "at risk" should be re-screened at least every 6 months. Older "at risk" children should be re-screened annually

   Risk conditions include:

   a. identified as at-risk for hearing loss by the Newborn Hearing Screening Program
   b. enrolled in the early intervention program
   c. recurrent otitis media (2 episodes within 6 months or 1 episode of serous otitis lasting longer than 4 weeks)
   d. history of frequent colds, adenoiditis, tonsillitis, or allergies
   e. cleft lip and/or palate
   f. Down Syndrome
   g. suspected hearing loss
   h. speech/language problems or obvious communication difficulties
   i. difficulty following oral directions
   j. inconsistent inattentive auditory behavior
   k. ear pain, ear fullness, dizziness and/or ringing (tinnitus)
   l. repeating a grade
   m. special education students
   n. failing hearing/middle-ear screening during the previous year
   o. participation in activities associated with noise exposure (i.e. woodworking, auto mechanics, band, etc.)
   p. Native Americans

HEARING SCREENING EQUIPMENT AND PROCEDURES

EQUIPMENT

Hearing may be screened with a number of different devices. The most typical is the pure tone audiometer. Other screening equipment includes physiologic devices (ABR and OAE screeners) and visual reinforcement audiometers (VRA). Nurses, audiologists, speech-language pathologists, and other personnel are or may be trained to operate the equipment and to interpret screening results.

ENVIRONMENT

For successful use of hearing screening devices, the choice of the screening environment is very important. The area must be reasonably quiet. The screening site should be selected during business or school hours so that noise problems can be identified. The site should be away from stairs, windows, street noise, hall traffic, heating/cooling vents and equipment, bathrooms, play areas and machine rooms, etc. Sound treated areas or rooms sometimes are available in health departments, in school libraries and in band or music rooms. These areas should be utilized when available. Screening also can be conducted in the client's home. Again, care must be taken that noise levels from TVs, stereos, family members, dishwashers, traffic, etc. do not influence screening results.

Noise levels in the test environment **must** be checked prior to any hearing screening procedure. The person performing the check must have normal hearing sensitivity. When using the VRA equipment, the person performing the screening must be able to hear the soft tones at the same levels used to screen the infant or toddler. ABR and OAE screeners automatically pause screening when noise levels become to high, however, high noise levels greatly slow the screening process. When performing pure tone testing, the noise level check is conducted using the audiometer. Wearing the audiometer earphones, the screening frequency pure tones (1000 Hz, 2000 Hz and 4000 Hz) should be heard at a level of 10 dB (screening level for children is 20 dB and for adults is 25 dB). If the tones cannot be heard at 10 dB at each screening frequency, do not screen in that environment.

If an appropriately quiet test environment cannot be found, the screening procedure should not be implemented. If noise levels become too high during screening, testing should be discontinued. **Do not increase tone levels to compensate for background noise** when using VRA and pure tone equipment.

PHYSIOLOGIC HEARING SCREENING (ABR/OAE)

(Used to screen hearing of individuals from birth through adulthood except as noted)

There are two basic electro-physiologic screening devices available to health department clinicians. They are auditory brainstem response (ABR) screeners and Otoacoustic emission (OAE) screeners. Birthing facilities use both of these devices to screen the hearing of newborns prior to hospital discharge and they are the most appropriate pieces of equipment to use to screen the hearing of infants and toddlers. **ABR** screeners (***Age range for Health Department ABR screeners is 0 to six months)*** measure hearing using computer averaged electrical responses produced by the auditory nerve and the brainstem when stimulated by an auditory signal. To screening hearing with this device, earphones are placed over the infant's ears and sensors are placed on the baby's head. The sensors are connected to a computer which monitors brainwaves to see if the sounds are heard normally. **OAE's** are sounds generated by a normal functioning cochlea in response to external acoustic stimulation. To screen hearing with this device, a probe which includes a tiny microphone is placed in the ear canal. The micorphone picks up the faint signals and sends them to a special computer which displays hearing status results. While using either of the above technoligies to screen hearing is uncomplicated, clinicians must receive formal instruction prior to using the equipment. Training in using either of these devices is available upon request from health department audiologists or speech-language pathologists.

ABR and/or OAE Results and Referrals

Both ABR and OAE screeners display results for each ear as "pass" or "refer" and a "pass" for both ears is necessary to pass the screening. **Not passing the screening on two occasions indicates that an audiologist should evaluate the individual's hearing status.** Record screening results in the appropriate area on the screening form.

VISUAL REINFORCEMENT AUDIOMETER (VRA) "The Colorado"

(Used to screen hearing of individuals age 6 months and up)

Visual reinforcement audiometers are used to screen hearing of infants age 6 months to 3 years, children who are unable or unwilling to wear earphones and developmentally delayed individuals. The instrument is capable of producing visual reinforcement to a calibrated tone presented through a loudspeaker. Speech/language pathologists, audiologists and other care providers are trained to operate this instrument and interpret screening results. Training in using the unit is available upon request from health department audiologists or speech-language pathologists. The instruction manual included with the instrument describes screening techniques well.

VRA Screening Results and Referrals

To pass a screening with VRA equipment, consistent responses must be observed to the low frequency signal and to at least one of the two high frequency signals. **Not passing the screening on two occasions indicates that an audiologist and/or physician should evaluate the individual's hearing status.** Record screening results in the appropriate area on the screening form.

THE AUDIOMETER

(Used to screen hearing of individuals age 3 and up)

A pure tone audiometer is an electronic device used for assessing hearing. This instrument is capable of generating discrete tones of varying frequency (pitch) and intensity (loudness). Many makes and models of audiometers are available, and all have certain features and controls in common. Some of these are described below.

1. Earphones: The earphones included with the audiometer are color-coded with the red one for the right ear and the blue one for the left ear. Earphones are rather fragile equipment and care must be taken that they are not dropped or otherwise damaged. They are matched and calibrated to a particular audiometer and therefore **cannot** be switched to another instrument.

2. Power On-Off: This switch controls the electrical power to the audiometer and should be left "on" for the entire day's testing.

3. Frequency Selector: This control selects the test frequency in Hz. It may have a range from 125 Hz to 8000 Hz in discrete steps, or it may have a more limited range (e.g. 250 Hz - 6000 Hz).

4. Attenuator: This control is calibrated in decibels (dB) and is used to vary the intensity of the test tone. Its settings may range from 0 dB HL to 110 dB HL. Attenuators usually are calibrated in 5 dB steps or in smaller increments.

5. Output Selector: This switch allows the tone to be presented individually to either the right or left earphone. Some audiometers may have settings for "bone" or "group." These selections are not used for individual pure tone screening.

6. Tone Presentation Switch: This control presents the test signal when it is pressed. It may be a button, a bar or a lever and, typically, little pressure is needed to activate it.

7. Tone Mode Switch: This switch controls the method of tone presentation. Usual position choices are NORM OFF, NORM ON or PULSED. Hearing screening is performed with this switch in the NORM OFF or PULSED position.

8. Signal Selector: Some audiometers may provide a switch allowing for tone and speech testing. This control is typically labeled "tone", "mic" and "tape". The switch must be placed in the "tone" position for hearing screening.

9. Masking Control: This control may be found on some audiometers used for screening. It should be left OFF during hearing screening.

An audiometer is an expensive and complex instrument. It may be damaged by excessive temperatures, by rough handling, or by being dropped.

Each audiometer must be serviced and calibrated yearly. Recalibration dates can be found on the instrument or its case. The health department maintains a service contract for this procedure. Return all audiometers to Screening, Special Services and SoonerStart, Room 709, Oklahoma State Department of Health, 1000 NE 10th Street, Oklahoma City for yearly service. Reminders regarding the need for service are mailed to county health departments the month before re-calibration is due.

Listening Checks

Prior to providing hearing screenings, a listening check of the audiometer should be performed by the examiner. The recommended procedure is as follows:

1. Plug in the audiometer. Turn the power "on" and leave the unit "on" for the day.

2. Examine the earphones. Check the cushions for cracks or splits. Wipe the headband pads and earphone cushions with an approved antiseptic solution (if possible, avoid using alcohol on the cushions). Do not allow the solution to enter the opening in the center of the earphone. The cleaning procedure should be repeated after each client).

3. Examine the earphone cords for breaks. Gently untwist the cords if they are tangled.

4. Examine the audiometer controls and be certain that all of them operate smoothly. Check that the tone presentation control works properly.

5. Perform a listening check while wearing the earphones:

    a. Set attenuator at 50 dB, frequency selector to 1000 Hz, output selector to right ear and press tone presentation switch. Tone should be clear. Check other screening frequencies in a similar manner. Repeat for left ear.

    b. Set attenuator at 50 dB and output selector to right ear. Without pressing the tone presentation control, listen for "hum". None should be present. Check for "hum" at 30 dB and at 0 dB. Repeat for left ear.

    c. Set frequency selector to 1000 Hz and output selector to right ear. While pressing the tone presentation control, slowly rotate the attenuator from 0 dB to 50 dB. Listen for abrupt increases in loudness or "dead spots". If either of these conditions is present, the instrument must be serviced before further use.

    d. Set attenuator at 0 dB and output selector to right ear. Press and release tone presentation control. No audible click should be heard upon depressing and/or releasing this switch.

Hearing Screening Procedures Using a Pure-tone Audiometer

Preparation of the child for hearing screening is EXTREMELY IMPORTANT. Individual instruction should be given to the child face-to-face and prior to placing the earphones on him. Stress the importance of responding quickly to the tone even if it is very faint. The child should be asked to respond to the tone by raising his/her hand or by saying "yes". Instructions for screening should be simple. For older children or adolescents, standard instructions can be as follows:

"You are going to hear some tones (beeps, whistles, bells, etc.)."

"Every time you hear one, raise your hand."

"Raise your hand as soon as you hear the tone, even if it is very soft."

"Do you understand?"

Instructions often must be modified for younger children and individuals with developmental delay. Pantomime, where the examiner illustrates listening, then hearing the tone and finally responding as directed may help train the individual to the task. Sometimes these children are reluctant to wear the earphones. Also, hand raising or verbal response cannot always be elicited from this population. When this happens, a "play" technique is implemented. First, to encourage the child to wear the earphones, call the

headset a hat or an airplane pilot's hat. Try comparing the headset to the earphones that come with a Walkman. Next, a supply of 1" X 1" blocks and a container or pegs and a peg-board is needed. Small toy dinosaurs or farm animals and a bucket also will work. Instructions could be:

"I want you to wear my hat. You will look just like an airplane pilot!"

"You will hear a tiny little 'beep' ('birdie, whistle')."

Place a block in the child's hand.

"When you hear the beep, drop the block into the basket!"

"Ready? Let's try it!"

This conditioning is accomplished by example and practice with the child. Pantomime again may assist in helping him understand the required task. Place a block in the child's hand, present a signal at sufficient loudness (50 dB HL) for the child to easily hear it and then assist him in dropping the block into the container. Repeat several times. Then allow the child to drop the block on his own volition when he hears the tone. Proceed with the hearing screening sequence as described below. **If after two attempts a child cannot be conditioned to respond, refer him to an audiologist for evaluation**.

Screening Protocol

The recommended hearing screening procedure that follows is based on the American-Speech-Language-Hearing Association guidelines for identification audiometry. Pure tone screening utilizes three frequencies: 1000 Hz, 2000 Hz and 4000 Hz. The intensity level used for screening is 20 dB (25 dB for age 18 and above). Each tone should be presented for a duration of 1 to 3 seconds. It is recommended that three presentations of each frequency be given per ear (i.e. 3 at 1000 Hz, 3 at 2000 Hz and 3 at 4000 Hz for each ear). The child is given credit for a frequency if he responds to 2 out of 3 presentations. Results are recorded on the Pediatric Middle-Ear/Hearing Screening Form, ODH Form No. 331-I (see appendix) or a suitable alternative form. The screening form is marked appropriately using "+" for a response and "-" for no response. Not responding at the recommended screening level at any frequency in either ear shall constitute a "does not pass."

Cautions

Several cautions are in order when performing hearing screening:

1. Make certain that the child does not have draining ears. If this is observed, **do not screen** the child. Make the appropriate medical referral if the child is not already receiving treatment.
2. Avoid exaggerated, noisy depression of the tone presentation switch; the child may see or hear this and respond to the movement or sound rather than the tone. A minimum of pressure and movement is required to operate the switch.

3. Avoid establishing a rhythm of tone presentation. Vary the length of the tones and the interval between tones.

4. Avoid looking down at the audiometer and then up at the child every time a tone is presented.

5. Do not ask the child during the screening, "Did you hear it?"

6. Expect the child to respond to the tone with the specified response (i.e. raise hand, drop block). Be **very cautious** about accepting changes in facial expression or "smiles" as responses to the tones. Re-instruct the child as to the required response. If the lack of reliable responses persists, discontinue screening. If this is the child's first screening, schedule him for a re-screening. If this is the child's second screening, refer him to an audiologist for assessment.

7. Do not allow the child to chew gum during the screening.

8. **Do not increase tone presentation levels to compensate for background noise**. If room noise levels become too great, discontinue screening or move to another location.

Screening Sequence

Seat the child so that his face is visible to the person performing the screening, but so that he faces **away** from the tester and the audiometer. Seeing the child's eyes and facial expressions is helpful in determining the accuracy of responses. It is important that the child not see the tester's hands nor the screening record form. After giving instructions, the earphones should be placed on the child by the individual who is performing the screening. The **red earphone** covers the **right ear** and the **blue earphone** covers the **left ear**. The earphones should be placed over bare ears (remove glasses, earrings, move hair out of way). The headband should be adjusted so that each earphone fits snugly against the ear. **Have a screening record form available**.

1. Start screening with the right ear (if the child reports greater hearing problems in right ear, begin with left ear).

2. Present 1000 Hz at 40 dB.
   a. If there is no response, re-instruct.
   b. If the child continues not responding, re-screen at a later time. If again he does not respond, he is considered to have not passed the screening. Mark the screening form appropriately.
   c. If there is a response, proceed as described below.

3. Move attenuator to 20 dB (25 dB for age 18 and above).
   a. Present tone three times at this level noting child's response or lack of such. Two responses out of three is considered a pass.
   b. Mark the screening form appropriately for the right (left) ear at 1000 Hz. **"+" for pass or "-" for does not pass.**

4. Change frequency selector to 2000 Hz and present tone at 20 dB (25 dB). Follow procedure used for 1000 Hz and record results.

5. Change frequency selector to 4000 Hz and again present tone at 20 dB (25 dB) as described above. Record results.

6. Switch audiometer output to left (right) ear and then repeat steps 3 through 5. Be certain to record results using **"+"** for pass and **"-"** for does not pass.

Pure Tone Screening Results and Referrals

Following completion of the screening, results must be evaluated on a "pass" or "does not pass" basis. This decision must be based on systematic standardized criterion. As stated previously: **Not responding at the recommended screening level at any frequency in either ear shall constitute a "does not pass."** Record hearing screening results in the appropriate area on the Pediatric Middle-Ear/Hearing Screening Form or other form.

If the client does not pass the screening, he should be re-screened prior to referral. Ideally, re-screening should be performed within the same screening session, but at least within a two week period. Removing and repositioning the earphones along with careful re-instruction usually reduces the does not pass rate. If a second screening is not passed, the client should be referred for further evaluation. This may be an audiologic or medical referral depending on the service available in the community. Follow-up and referral are essential to the effectiveness of the hearing screening program.

If a client displays obvious symptoms of ear pathology, such as ear pain, discharge or bleeding, he immediately should be referred to a physician and the hearing screening should be scheduled at a later date. Clients displaying disequilibrium or vertigo also should be referred to a physician.

MIDDLE-EAR SCREENING EQUIPMENT AND PROCEDURES

Middle-ear screening quickly assesses the status of the middle-ear system by measuring its mobility and the pressure within the system. The instrument that performs the screening is called a tympanometer. The screening procedure is known by several different names. It may be called tympanometry, acoustic impedance screening or acoustic immittance screening. Most county health departments have at least one tympanometer. Many have several instruments. They usually are located in nursing, child guidance and/or early intervention areas. Nurses, audiologists and speech-language pathologists other caregivers may be trained to operate tympanometers and to interpret screening results.

THE TYMPANOMETER

A tympanometer is an electronic device used to assess middle-ear status. To perform middle-ear screening, a small tip at the end of a probe is held against the outer ear canal opening sealing the ear. The tympanometer automatically varies air pressure from positive to negative in the sealed canal. At the same time, a low frequency tone is presented to the

ear. The device measures the intensity of this tone as the air pressure changes. The result of this intensity change with pressure change is plotted as a tympanogram.

Various brands and models of tympanometers are available. All instruments have certain features, accessories and controls in common. Some of these are described below. Some tympanometers do not have all of the controls listed. It may be necessary to refer to a particular instrument's instruction manual for specific details regarding its controls and its operation.

1. Power On-Off: This switch controls the electric power to the tympanometer. It should be turned "on" and left "on" for the entire day's testing. Some health department tympanometers have no power switch. Except when these units are being stored, they should remain connected to an electrical outlet at all times. After several months' storage, these tympanometers will need to be connected to an electrical outlet for 12 hours before use to recharge the battery.

2. Probe: Most probes are thick pencil-shaped appendages attached to the tympanometer with long cords. Some probes are considerably larger than those described above and are cordless. The probe, fitted with an eartip (described next), connects the tympanometer to the ear. The probe may or may not have a light or visual display indicating test status. **The probe is the most fragile part of a tympanometer**. Be careful about closing the case on the probe or cord. Avoid twisting or kinking this cord. Do not allow the probe to fall on a hard surface or to be stepped on. Information about cleaning the probe can be found in the appendix.

3. Eartips or Ear Cuffs: Eartips or cuffs are slipped over the tip of the probe and are available in various sizes. They range from approximately 8 mm (for infants) to 19 mm (for adults). **An eartip must be cleaned after use with a client**. Remove the tip or cuff from the probe before cleaning it. Thoroughly wiping the removed eartip with an alcohol swab is acceptable. Placing used tips in an approved antiseptic solution or washing them with surgical soap also is an acceptable cleansing method. **Do not leave eartips submerged in alcohol for long periods of time. Do not place them in an autoclave. Be certain that eartips and cuffs are thoroughly dry before placing them on the probe.** Replacement eartips are available from the manufacturer or supplier of the tympanometer. Call Screening, Special Services and SoonerStart, OSDH for ordering information.

4. Printers and Printer Controls: Most health department tympanometers have printers associated with them. Many instruments automatically print the tympanogram when the screening is complete. Some tympanometers require the probe to be returned to the base unit and the PRINT control depressed to activate the printer. The REPRINT control provides additional copies of the tympanogram(s) currently in the unit's memory. The CHART ADVANCE/PAPER ADVANCE/PAPER FEEDER control advances the printer paper when depressed. This assists in loading paper into the

tympanometer. On some instruments, this control has other functions. Check the unit's instruction manual for further information.

5. Printer Paper and Printer Pens: Most tympanometers use special paper. Some use thermal paper. Additional rolls of paper are available from the manufacturer or supplier of the tympanometer. Call Screening, Special Services and SoonerStart, OSDH for ordering information. Please be certain to specify the brand and model of the tympanometer when ordering paper. For the tympanometer to function properly, the paper must be loaded correctly. Carefully follow the loading directions found in the instruction manual. Tympanometers employing non-thermal paper use special pens to produce the printout. These also are available from the manufacturer or supplier. Please use care when removing and replacing pens. Follow the directions in the instrument's instruction manual.

6. Reflex: This switch controls the tympanometer's reflex screening circuit. Reflex findings are not included in most middle-ear screening protocols. If the unit is so equipped, the switch should be left in the "off" position or if inadvertently left "on", reflex results should be ignored. Some tympanometers do not have reflex screening capabilities.

7. Test Cavity/Calibration Cavity: This accessory included with the tympanometer is used for a calibration check of the instrument. The probe tip (without an eartip or cuff) should be placed in each of the labeled test cavities at start of each clinic day. The resulting canal volume (ECV, PV) shown on the printout or display should be within ±20% of the volume printed on the cavity. The actual volume measure observed may vary from day to day because of changes in barometric pressure.

A tympanometer is an expensive and complex instrument. Although it is designed for rigorous use, it may be damaged by excessive temperatures, by rough handling, or by being dropped. The instrument must be transported in the case provided.

Each tympanometer must be serviced and calibrated yearly. Recalibration dates can be found on the instrument or its case. Return the instruments for service as described for the audiometers.

Middle-Ear Screening Procedures Using a Tympanometer

Middle-ear screening can be performed on clients aged nine months or older with screening tympanometers. ***Special tympanometers that use a high frequency probe tone must be employed when screening infants from birth to nine months of age***.

1. Examine the ear and canal with a good light or with an otoscope.

2. Note size and shape of ear canal opening. Determine the direction the ear canal runs. Visual inspection revealing abnormalities such as structural defects, ear canal abnormalities and eardrum abnormalities should result in immediate medical referral. Otorrhea, otalgia, otitis externa, and presence of a foreign body in the canal, presence of a foul odor and/or history of recent tympanoplasty preclude tympanometry and should result in referral for appropriate medical care.

3. Select an eartip or cuff of a size that will seal the ear canal. Place it on the probe.

4. Position yourself at eye level with the ear. Move any hair away from the ear.

5. For infants and children to age three, gently pull down and back on the pinna to straighten the ear canal. For children age three through adulthood, pull up and back on the pinna to straighten the ear canal. Keep the pinna in either of these positions throughout the screening procedure.

6. Press the probe fitted with the appropriate eartip gently but firmly against ear canal opening. Remember that an airtight seal is necessary for screening to proceed.

7. Observe the tympanometer's signaling system regarding operating status. All brands indicate whether a seal has been obtained and whether testing is proceeding. Some devices use a series of lights; others use visual displays and/or auditory signals.

8. If a seal is obtained, the tympanometer will automatically proceed with the screening. Try to keep the probe as steady as possible during the 3 to 5 second test procedure.

9. If the device indicates that a seal was not obtained or maintained, momentarily remove the probe/eartip form the canal entrance and try again.

10. Remove the probe/eartip from the canal entrance when the instrument indicates testing is complete. Some tympanometers will automatically print out screening results when the probe is removed; other devices will store the information until the second ear has been tested. Some tympanometers have no printer and results will have to be hand recorded on the screening form (see appendix).

11. Repeat the above procedure for the other ear.

12. Be certain to mark each printout as to which ear it represents.

13. Transfer data from the tympanometer display or printout to the appropriate screening form.

Tympanometry can be performed easily on most individuals age 3 years through adulthood because of the cooperative nature of this population. Special techniques may need to be employed when screening infants, toddlers and some young children. It is important to keep the individual being tested relatively quiet during the several seconds it takes to run the screen. Infants and toddlers are more easily tested when held or when seated in the parent's lap. A visual distraction such as a toy the child can hold may help. Sucking on a bottle or pacifier is acceptable, however, the tympanogram will not look as smooth due to movement artifacts. Performing tympanometry on the mom or dad also may calm the child and will assure the anxious parent that the procedure causes no discomfort.

Middle-Ear Screening Results and Referral

WITHOUT OTOSCOPIC EXAMINATION

PASS

1. Ear canal volume of 0.2 mmho through 1.8 mmho.
2. Admittance peak of 0.3 mmho through 1.8 mmho.
3. Pressure peak of +100 daPa through -190 daPa.
4. Gradient: ≤200 daPa
5. Pass hearing screening.

IMMEDIATE REFERRAL TO PNP OR MD/DO

1. Ear canal volume less than 0.2 mmho.
2. Ear canal volume greater than 1.8mmho and no history of tympanostomy (ventilation) tubes.
3. Admittance peak less than 0.3 mmho and fail pure tone, visual reinforcement audiometry screening or physiologic screening. n.b.: Any child who is too young to test using pure tone screening and visual reinforcement audiometry is not available, the combination of an admittance peak of less than 0.2 mmho and a history of a middle-ear episode in the last six months is the basis for an immediate referral to a PNP or a physician.
4. Presence of drainage or blood.

RE-SCREEN IN 4 TO 6 WEEKS

All conditions present that are not specifically noted in the PASS or in the IMMEDIATE REFERRAL TO PNP OR MD/DO categories. This includes a gradient measure of greater than 200 daPa in children. These conditions indicate an "at-risk ear". n.b.: *A negative pressure peak (outside normal range) on three consecutive occasions warrants medical consultation.*

Following completion of the middle-ear screening, results must be evaluated on a "**PASS**," "**REFER**" or "**RE-SCREEN**" basis. Record the middle-ear screening results in the appropriate area on the Pediatric Middle-Ear/Hearing Screening Form (ODH Form No. 331-I).

Hearing/Middle-Ear Screening Referral Criteria

1. Not passing the hearing screening and/or middle-ear screening should result in a consultation with or referral to an audiologist or physician.

2. Passing the hearing/middle screening but observed delayed speech/language development in a child of any age should result in an automatic consultation with or referral to a speech-language pathologist and/or an audiologist.

3. A caregiver's concern about the child's speech and language skills or hearing ability should result in an automatic consultation with or referral to a speech-language pathologist or an audiologist.

In reporting results and keeping records, clients are often described as either having passed or failed the screening. **This terminology should be avoided** when discussing the results with the client, the caregiver and/or the teacher. **Because a hearing or middle-ear screening is not a diagnostic test, no statement regarding "hearing loss" should be made**. When a client does not pass a screening, it should be stated that the results indicate "possible hearing problems" and that further testing is necessary.

Additionally, due to the limited scope of the above screening procedures, certain audiologic or otologic problems may not be ruled out even if the screening is passed. If, after passing a screening, the client or those associated with him/her still feel there is a hearing problem, refer the client to an audiologist for in-depth assessment.

When a client is referred for audiologic assessment, the evaluation usually includes determining thresholds for an expanded range of pure tones. When the individual is old enough, thresholds for speech are recorded and speech discrimination ability (understanding) is assessed. Diagnostic middle-ear evaluations including reflex studies may be performed. For older children who present with auditory processing difficulties, the audiologist has special test batteries. For infants and children who are too young or are unable to be evaluated using behavioral methods, auditory brainstem response (ABR) testing or otoacoustic emissions (OAE) assessment may be performed by an audiologist. Both of these measures give definitive information regarding the child's auditory system.

HEARING AND MIDDLE-EAR TERMINOLOGY

ABR - see auditory brainstem response audiometry.

Acoustic reflex - the contraction of the stapedial and tensor tympani muscles in response to loud sounds. The presence or absence of a reflex noted during tympanometry is not recorded on health department middle-ear screening forms.

Admittance peak (compliance peak, COMP PEAK, Peak Y) - the highest vertical point on a tympanogram. It is the point of maximum mobility in a tympanogram that indicates the degree of mobility present in the middle-ear system. Measured in mmho, cm^3 or mmho.

Attenuator - the control on an audiometer that increases and decreases the intensity (loudness) of the presented tone.

Audiogram - a graphic representation of a pure tone hearing evaluation.

Audiometer - an electronic instrument that produces calibrated tones used to assess hearing sensitivity.

Auditory brainstem response audiometry (ABR) - measurement of hearing using computer averaged electrical responses produced by the auditory nerve and the brainstem when stimulated by an auditory signal. Often used to evaluate hearing of infants and young children who cannot be assessed easily by behavioral techniques.

BSER audiometry - brainstem evoked response audiometry (see auditory brainstem response audiometry.

Compliance peak - see admittance peak.

Decapascal (daPa) - a unit of measure for pressure. Used to measure air pressure in tympanometry. 1.0 daPa = 1.02 mm H_20.

Decibel (dB) - a unit of measure used to express the relative intensity of a sound on a scale from zero for the average least perceptible sound to 130 for the average pain level loudness.

Ear canal volume (ECV, physical volume, PV, VOLUME) - an estimate of the volume of air in the ear canal between the probe tip and the tympanic membrane. Measured in mmho or cm^3.

Gradient (GR, tympanometric width, TW) - an indication of the shape of the tympanogram by measuring its width at one-half its peak height. Measured in daPa.

Hertz (Hz) [cycles per second, cps, c/s] - a unit of measure of frequency (pitch).

Immittance screening - see tympanometry

Impedance screening - see tympanometry

OAE - otoacoustic emission (see below)

Otoacoustic emissions (OAEs) - sound generated by a normal functioning cochlea in response to external acoustic stimulation. Employing special equipment, OAE measures are used to evaluate hearing of infants and children who cannot be easily assessed by behavioral techniques.

Pressure peak (tymp. peak, middle ear pressure, MEP, tympanometric pressure peak, TPP) - the point along the horizontal axis of a tympanogram where the admittance peak is recorded. It is the pressure value where maximum mobility occurs in a tympanogram. The pressure peak approximates the pressure within the middle-ear space. Measured in daPa.

Probe tone - the low pitch tone (usually 226 Hz) that is audible when the probe fit with an eartip is introduced to the ear canal. Monitoring of the tone's intensity variation with pressure change measures middle-ear mobility.

Tympanogram - a tracing or graph produced by a tympanometer depicting the results of middle-ear assessment. It may be displayed electronically or as a printout.

Tympanometer - an electronic device used to assess middle-ear status.

Tympanometry - an objective measurement of middle-ear mobility and middle-ear pressure. Tympanometry is accomplished by varying air pressure in a sealed ear canal while monitoring the intensity of a low frequency tone.

Tympanostomy tube (pressure equalization tube, PE tube, ventilation tube) a small tube surgically inserted through the tympanic membrane to allow air to enter the middle-ear space.

Appendix

TYMPANOMETER MAINTENANCE

CLEANING THE PROBE
GSI 27, 27 A, 28 and 28 A TYMPANOMETERS

With use, cerumen will work its way up inside the tympanometer probe tip. During the warm-up period and throughout the day, inspect the probe to make sure it is clean and free of cerumen. If any cerumen is detected, remove the cone portion of the probe as follows:

1. Hold the body of the probe in one hand and grasp the cone of the probe in the other hand.

2. Rotate the cone portion of the probe until the grooves on the cone line up with the line along the body of the probe.

3. Pull the cone away from the body of the probe.

4. Place the probe body section securely on a table. Inspect the probe cone for cerumen. Use a pipe cleaner to remove any cerumen. Insert the pipe cleaner through the back portion of the cone and pull it through the front opening. It may be necessary to repeat this several times to remove all the cerumen.

5. Carefully remove the from the metal tube of the probe body. This will pull any accumulated cerumen out of the metal tube. Examine the wire for cerumen . Clean with a tissue if necessary. Re-insert the wire into the metal tube so that it is in as far as it can go.

6. Once clean, re-assemble the probe cone to the probe body by aligning the grooves of the probe cone with the line along the probe body. Push the cone as far as it will go and rotate the probe cone to lock it in place.

NOTE: The wire must be inserted into the metal tube and the probe cone must be locked into place for the tympanometer to function properly.

CLEANING THE PROBE
GSI 37 AND 38 TYMPANOMETERS

With use, cerumen will work its way up inside the probe tip. During the warm-up period each day and throughout the day, inspect the probe to make sure it is clean and free of cerumen. If any cerumen is detected, remove the cone portion of the probe as follows:

1. Hold the probe firmly in one hand. Unscrew (counterclockwise) the cone portion of the probe with the other hand. Continue until the cone is completely separated from the probe body.

2. Place the probe body section securely on a table or return it to the storage cradle. Inspect the cone for cerumen or other foreign matter. Use a pipe cleaner to remove any accumulated debris. Insert the pipe cleaner through the back portion of the cone and pull it through the front opening. Repeat as often as necessary to remove accumulated debris.

3. Carefully remove the wire from the metal tube in the tip of the probe. This will pull any accumulated cerumen out of the metal tube. Examine the wire for cerumen. Clean with a tissue if necessary. Re-insert the wire into the metal tube. Push it in as far as it will go.

4. After cleaning, re-assemble the cone to the probe body by screwing the cone back onto the probe. Take care to align the threads of the two pieces. Screw the cone on the probe body until it is finger tight. Gently squeeze the two sides of the probe body together while screwing the cone on the last few turns.

NOTE: The wire must be inserted in the metal tube for the GSI 37 and 38 tympanometers to function properly. The probe cone must be screwed firmly in place to prevent any air leaks.

CLEANING THE PROBE
EARSCAN TYMPANOMETERS

With use, cerumen may work its way into the white probe tip. While the Earscan is warming up and throughout the day, check to be certain that the probe tip remains free of cerumen. If the tympanometer will not start or if the display indicates a blocked probe, check for cerumen blocking the probe tip. When debris is noted, remove the probe tip as follows:

1. Unscrew white probe tip counterclockwise. If the tip is very tight, use a hex wrench or a rubber grip to loosen. **Do not** use pliers as they will mar the surface. **CAUTION: Always remove the white probe tip before cleaning to avoid pushing debris into hypo tube described below.**

2. Use a pipe cleaner or similar object to push the debris from probe tip. The tip may be washed in a mild soap solution. Dry thoroughly before re-assembly.

3. **Do not** attempt removal of hypodermic tube protruding from probe housing. This only should be done by an authorized service center technician.

4. Lubricate threads of probe tip with petroleum jelly before screwing tip back onto probe housing. This insures an air tight seal. Remove Teflon tape from threads if present. **CAUTION: Do not over tighten.**

5. Proper reassembly can be verified by performing an impedance test with the supplied 2.0 mmho calibration cavity.

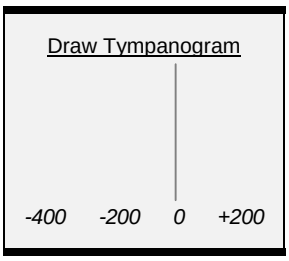
PEDIATRIC MIDDLE-EAR/HEARING SCREENING FORM

NAME _____ SEX _____ BIRTHDATE _____ DATE _____

SCREENER _____ TITLE _____ SITE _____

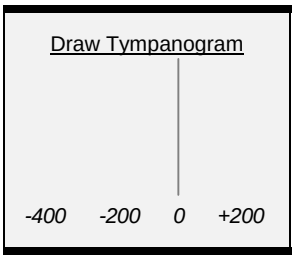
INSTRUCTIONS FOR MIDDLE-EAR SCREENING: For each ear, draw the tympanogram and record the canal volume, admittance peak, pressure peak and gradient (when available) in the appropriate boxes according to screening results. See flowchart on reverse of this page.

RIGHT EAR



Canal Volume	
Admittance Peak	
Pressure Peak	
Gradient	

LEFT EAR



INSTRUCTIONS FOR PURE TONE SCREENING: Present a 20dB HL signal to each ear at each screening frequency. Not responding to the 20 dB tone at any frequency in either ear shall constitute a does not pass. Record a "+" (plus) for "pass" or "-" (minus) for "does not pass" in the appropriate boxes.

RIGHT EAR	1000 Hz	2000 Hz	4000 Hz

LEFT EAR	1000 Hz	2000 Hz	4000 Hz

INSTRUCTIONS FOR VISUAL REINFORCEMENT AUDIOMETRY (COLORADO) SCREENING: Observe the child's response to the recorded tones presented through the right speaker and the left speaker. To pass the screening, a response must be observed to the low frequency signal and to one of the high frequency signals on each side when presented at a 25 dB level. Record a "+" (plus) for "pass" or "-" (minus) for "does not pass" in the appropriate boxes.

RIGHT SIDE	500 Hz	2700 Hz OR 3000 Hz

LEFT SIDE	500 Hz	2700 Hz OR 3000 Hz

INSTRUCTIONS FOR PHYSIOLOGIC SCREENING: Refer to the specific OSDH protocol for the technology used. Indicate screening results for each ear. Record a "+" (plus) for "pass" or "-" (minus) for "does not pass" in the appropriate box. Check the box for the type of physiologic screening used.

RIGHT EAR ☐ LEFT EAR ☐ Type of screening: AABR ☐ OAE ☐

SCREENING RESULTS: ☐ Pass ☐ Does Not Pass

RECOMMENDATIONS: ☐ Audiologic Referral ☐ Physician Referral ☐ PNP Referral

☐ Re-Check in 4-6 Weeks ☐ Other (specify) _____

COMMENTS: _____

_____

_____

NOTE TO PARENTS: Passing the screening says that middle-ear function and hearing appear to be okay. Not passing calls for more in-depth testing but does not always mean that a problem is present. Screening is a limited procedure. Some medical and hearing conditions are not ruled out even if the screening is passed. When you have concern about your child's hearing or speech and language, have hearing re-screened.

HEARING SCREENING

NAME_____ BIRTHDATE_____ SEX____

FACILITY_____ DATE_____

EXAMINER_____ TITLE_____

(Screening levels-- Age 3-17: 20dB HL; Age 18 and above: 25dB HL)

PURE TONE SCREEN

	1000 Hz	2000 Hz	4000 Hz
RIGHT	☐	☐	☐
LEFT	☐	☐	☐

FINDINGS: ☐ Pass ☐ Does not pass

Comments/Recommendations: _____

_____

_____

Pure tone hearing screening is used to check the hearing of individuals age three and up. The person being screened wears earphones and is asked to listen for very soft tones or "beeps" of different pitches or frequencies. When the sound is heard, the individual is asked to respond verbally or to raise a hand. The result of the pure tone screening is either pass or does not pass. Not responding to any one of the tones in either ear indicates the possibility of a hearing loss. A consultation with an audiologist and/or physician is recommended when an individual does not pass the screening.

PLEASE NOTE: *A SCREENING IS NOT A COMPLETE EVALUATION. It is a method used to check for possible hearing problems. Not passing the screening does not necessarily indicate a disorder, but rather is an indication of the need for more in-depth testing. Due to the limited nature of screenings, certain middle-ear and/or hearing problems may not be entirely ruled out even if the screening is passed*.

HEARING SCREENING FORM

NAME _____ BIRTHDATE _____ SEX ____

FACILITY _____ DATE _____

EXAMINER _____ TITLE _____

		1000	2000	4000
Initial Screen	RIGHT	☐	☐	☐
	LEFT	☐	☐	☐
Re-screen (if necessary)	RIGHT	☐	☐	☐
	LEFT	☐	☐	☐

INSTRUCTIONS: Record a **"+"** in the appropriate box for each ear at each screening frequency when the individual being tested responds to the tone. Use a **"-"** when the client does not respond. The absence of a response to a tone at the recommended screening level at each screening frequency constitutes a "does not pass." Individuals not passing the first screening should be re-screened on the day of the initial hearing check. A "does not pass" after the second screening results in a referral for further assessment.

Screening levels --

AGE	LEVEL
3 through 17	20 dB HL
18 and above	25 dB HL