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AppNote

ASSESSING MUSICIANS by Marshall Chasin, M.Sc., Reg. CASLPO, Aud (C), FAAA

The Audioscan RM500 can be used as a sound level meter and as a spectrum analyzer to:

(1) measure the spectral output of the musician's own instrument at different intensity levels

(2) compare the spectral output of different musical notes

(3) measure the spectral output with and without hearing protection

(4) measure the effects of hearing protection

Clients in the performing arts pose a fascinating problem for hearing healthcare professionals. They can be subjected to music levels in excess of even the most stringent of noise regulations, or find themselves in relative quiet. Other than being on-site during an actual performance with an array of sound level meters, there is no definitive way to determine the musician's amount of noise/music exposure. However, fairly good estimates can be obtained from assessing the spectral output of: (1) their own instruments and (2) those around them.

The Audioscan® RM500, like most real ear measurement systems, can be used as a sound level meter and as a spectrum analyzer. It is an ideal device for the purposes of measuring the spectral output from the musician's instrument.

MEASURING THE SPECTRAL OUTPUT OF THE MUSICIAN'S OWN INSTRUMENT

To determine the range of intensities possible from a specific instrument:

1. Calibrate the RM500 real ear system.
2. Seat the client at a distance 18"– 24" directly in front of, and facing the loud-speaker. With the probe tube in the calibrate position (between the retainer posts, directly in front of the reference microphone inlet), hang the probe module on the musician's ear. Adjust the blue cord until the probe module is located just below the ear lobe, with the reference microphone facing outwards. Securely attach the probe module by clipping it to the clothing on the non-test ear side of the body.
3. Press TEST <UNAIDED> to start the Quikscan® stimulus and leave the stimulus level set to the default of 55 dB.
4. Press TEST <UNAIDED> a second time to 'freeze' the active measurement curve on-screen. The measurement curve obtained should be a flat line.
5. Press DISPLAY <UNAIDED> to 'hide' this curve, so that it is not visible in subsequent measurements.
6. Leave the probe tube in the calibrate position on the test ear. Press TEST <AIDED 1> to start the Quikscan® stimulus and scroll (⇦⇨) to 0 dB. Have the musician play and sustain a note at average (mezzo forte) level for the duration of time it takes the 1/12 octave measurement to be obtained once the <CONTINUE> key has been pressed. Alternatively, a lower resolution curve at 1/3 octave intervals can be obtained by pressing the <AIDED 1> key a second time. The displayed curve shows the spectral output of the musician's own instrument at an 'average' input level measured at ear level position.
7. The spectral output measurements can be repeated using the TEST <AIDED 2> and TEST <AIDED 3> keys at loud (forte) and soft (piano) input levels. Remember to scroll to 0 dB stimulus level for these measurements.

Results will vary according to the individual's playing style; their reed, bow or mouth-piece; and construction of their own instrument. The above-described measurement technique therefore provides exact information based on that individual with his or her instrument.

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Figure 1

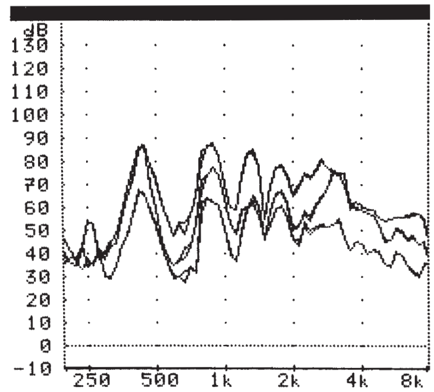

Figure 1 shows measured output (dB SPL) as a function of frequency for a violinist playing the note "A" (at 440 Hz) for three different playing levels. Note the gradual increase in the spectral output as the violinist increases the playing intensity from soft (bottom) to loud (top).

COMPARING/CONTRASTING THE SPECTRAL OUTPUT OF DIFFERENT MUSICAL NOTES

It is possible that one range of notes appears to be bothersome to the musician. To compare the spectral output of different musical notes:

1. Follow set-up steps 1-5 shown in the preceding section: **measuring the spectral output of the musician's own instrument.**
2. Press TEST <AIDED 1> to start the Quikscan® stimulus and scroll (◁▷) to 0 dB. Have the musician play and sustain a note in the lower part of the instrument's frequency range for the duration of time it takes the measurement to be obtained once the <CONTINUE> key has been pressed.
3. Repeat step #2, using mid-frequency and high frequency notes, and the TEST <AIDED 2> and TEST <AIDED 3> keys.

The procedure described in this AppNote measures the spectrum of sound in 1/7th octave bands near the ear. The spectrum at the eardrum can be measured using the same procedures but with the probe tube inserted to within 1/4" (6 mm) of the eardrum.

ESTIMATING THE NOISE/MUSIC EXPOSURE FROM OTHER MUSICIANS' INSTRUMENTS

Table 1 shows a summary of the peak levels of various musical instruments. It can be seen that some instruments are quite capable of generating sound levels that can be potentially damaging. This table can be used to estimate the exposure from the other musical instruments around the performer.

Instrument	Peak Level (dB SPL)
French Horn	107
Bassoon	102
Trombone	108
Tuba	110
Trumpet	111
Violin	109
Clarinet	108
Cello	100
Amplified Guitar	>115
Drums	>120

Table 1: Peak levels (dB SPL) from various musical instruments

AppNote

MEASURING THE EFFECTS OF EAR PROTECTION

To prevent a slit leak between the ear protection and the ear canal when performing real-ear measures try using a little Otoferm™ or Otoease™ lubricant on the ear protection before inserting. This will aid in achieving a good seal.

To measure the effects of ear protection:

1. Calibrate the RM500 real ear system.
2. Seat the client at a distance of 18”– 24” directly in front of, and facing the loudspeaker. Hang the probe module on the test ear, and insert the probe tube into the client’s ear canal to within 1/4” of the eardrum. Adjust the blue cord until the probe module is located just below the ear lobe, with the reference microphone facing outwards. Securely attach the probe module by clipping it to the clothing on the non-test ear side of the body.
3. Press <AGRAM> and enter 0 dB HL threshold values at all frequencies (250 – 6000 Hz). Press <HL/SPL> key to ensure that you are working in HL mode.
4. Press TEST <UNAIDED> to start the Quikscan® stimulus and scroll (⇦⇨) to 55 or 60 dB. Press TEST <UNAIDED> a second time to ‘freeze’ the active measurement curve obtained at 1/3 octave frequencies on-screen. Alternatively, the <CONTINUE> key can be pressed to run a more detailed measurement (at 1/12 octave frequencies). To reduce the amount of data displayed on-screen, press DISPLAY <UNAIDED> to ‘hide’ the measured unaided ear response.
5. Fit the ear protection to the client being careful not to move the probe-tube in the ear.
6. Press TEST <AIDED 1> to start the Quikscan® stimulus and scroll (⇦⇨) to 80 dB. A higher stimulus level is chosen in order to ensure that the signal is sufficiently above the internal noise floor of the RM500. Erroneously low attenuation measurements in the high-frequency region may be obtained if a low stimulus level is used. Press TEST <AIDED 1> a second time to ‘freeze’ the measurement curve on-screen. The curve displayed on-screen in the HL mode is the true attenuation obtained from the fitted ear protection.

Depending on the study, between 52% and 90% of all musicians have “noise notches” in their audiograms.

According to statistics from Etymotic Research Inc., approximately 100,000 pairs of ER-15 and ER-25 earplugs have been fit since 1988.

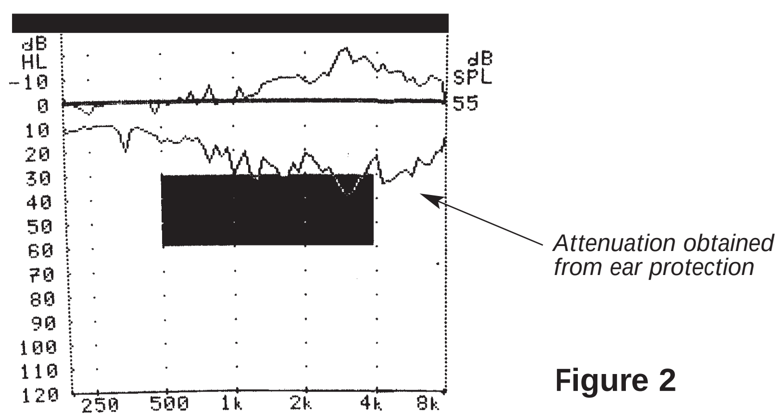

Figure 2

Figure 2 shows an attenuation measurement (using an 80 dB SPL stimulus) for a non-custom foam earplug similar to those used in industry

All stringed (violin, viola, cello, bass, etc.) and brass (trumpet, French horn, trombone, etc.) instruments perform like the violin – steady overall increase in output as playing level increases. However, all reeded woodwinds (clarinet, saxophone, oboe, bassoon, etc.) have an interesting characteristic where the high-frequency output increases faster than the lower frequency output as playing intensity is increased.

MEASURING THE SPECTRAL OUTPUT OF THE MUSICIAN'S OWN INSTRUMENT WITH AND WITHOUT HEARING PROTECTION

If ear protection is available (e.g., ER-15™, ER-25™, vented/tuned earplugs), the RM500 can be used to measure the spectral output with and without the ear protection in place. The procedure outlined above which uses <UNAIDED> and <AIDED> measurements can be utilized for this purpose. However, because the measurement of interest is the level of the musician's own instrument, scroll (◁▷) to 0 dB as a stimulus level when obtaining the unaided and aided measurements. It is important that the musician plays his instrument at the same intensity level across measurements. Typically an inexpensive sound level meter (e.g., Radio Shack $50) can be used to verify that the musician is playing at the same level. Table 2 shows the optimal ear protection for musicians with various instruments.

Instrument	Auditory Damage	Earplugs
Reeded woodwinds	Brass section to rear	ER-15 vented/tuned
Flutes	Flutes (>105 dB SPL)	ER-15 vented/tuned
Small strings	Small strings (>110 dB SPL)	ER-15
Large strings	Brass section to rear	Vented/tuned
Brass	Brass	Vented/tuned
Percussion	Percussion (high hats)	ER-25
Vocalists:		
Solo	Soprano (>115 dB SPL)	Vented/tuned
Nonsolo	Other instruments	ER-15
Amplified instruments	Speakers/monitors	ER-15

Table 2: Optimal hearing protection for musicians

Treble musical instruments such as the trumpet and flute tend to have greater energy in the higher frequencies than fundamental energy for the lower frequencies.

To help relate musical note to frequency, recall that middle C on the piano (just below the treble clef) is around 250 Hz, and the top note on a piano is around 4000 Hz.

Figure 3

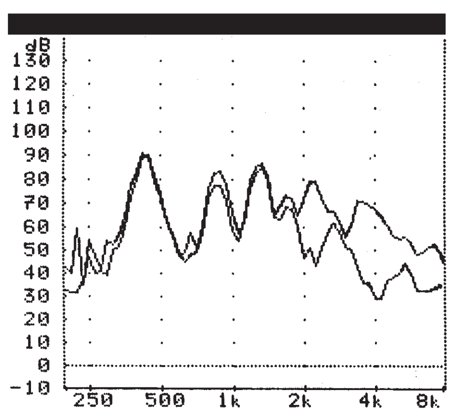

Figure 3 shows the case of a clarinet played in the same fashion as the violin in Figure 1 (but only for medium and loud playing intensities). Note that as the playing intensity increases, the higher frequency spectral energy grows faster than the lower frequency sounds. This is in contrast to the violinist's case.

An in-depth explanation of the procedure described in this AppNote, and clinical strategies to reduce the potential for hearing loss with musicians can be found in "Musicians and the Prevention of Hearing Loss" by Marshall Chasin (Singular Publishing Group, Inc., 1996).