Hearing Solutions Indianapolis

To: Users of the 3M™ E-A-Rfit™ Dual-Ear Validation System

From: Elliott H. Berger

Date: April 17, 2015

Re: Presentation of uncertainty/variability values

This memo details the presentation of uncertainty values in the E-A-Rfit Dual-Ear Validation System.

The uncertainty, also called variability, of a personal attenuation rating (PAR), is the result of three factors:

1. Measurement uncertainty – how closely do an E-A-Rfit validation system measurement and a corresponding real-ear attenuation at threshold (REAT) measurement agree? This is tricky to answer since both the E-A-Rfit validation system and the REAT measurement have variability inherent in their respective measurement processes. This variability is in fact somewhat larger for REAT since it is a subjective measurement, whereas E-A-Rfit validation system data are based on objective results (no subject response required).
2. Fit variability – regardless of how one measures a PAR there is an uncertainty in the fact that the next time the person fits the hearing protector s/he may do it differently. The PAR provides an estimate of attenuation for a given hearing protector and for a given fit, but the prediction for the next fit has an associated uncertainty. The E-A-Rfit validation system estimates this value based on experience in our lab-based compensation-factor studies in which we create calibration factors for our various probed products. As part of these studies we develop a measure of fit variability. The laboratory-based fit variability component is included in the E-A-Rfit validation system uncertainty.
3. Spectrum uncertainty – whenever a single number rating is used to estimate protection there is an "error" or uncertainty as compared to the more accurate approach that would utilize all of the available spectral data for both the noise measurement and the hearing protector's attenuation. Most users wish to employ a single number, ideally one that can be subtracted from the A-weighted noise measurement, and this is what the PAR provides. As a result of this simplified approach, the E-A-Rfit validation system PAR, or the A-weighted PAR from any other fit-test system, will have an amount of uncertainty related to the hearing protector's spectral attenuation characteristics. Devices with a more uniform attenuation across frequency will have less spectral uncertainty than those for which attenuation falls off substantially as frequency decreases.

The total uncertainty is the combination of the measurement, fit, and spectral uncertainties.[1] Including it in computations allows estimates of the protection achieved by most users, i.e., a prediction of the effective protected exposure when the hearing protectors are worn. On the first three tabs of the display of Test Results (Quick View, Protection, and Attenuation Graph), the total uncertainty has been accounted for in the median PAR that is presented (i.e., the uncertainty has already been subtracted from the measured PAR), and it is also included in the "You Are Here" computation shown on the Safety Guide. However,

[1] Since the spectral uncertainty is influenced by the shape of the attenuation curve as a function of frequency, and since the attenuation curve may differ between the ears, the spectral uncertainty may also differ between ears, by approximately one dB. Since spectral uncertainty is part of the overall uncertainty, the total uncertainty may also differ between the two ears. This is accounted for in the computation of the overall uncertainty of the binaural PAR.

the mean octave-band data points on the Attenuation Graph do not include uncertainty since the average attenuation values are the best estimate of what that person actually achieved for that fit of the device.

The top portion of the Detail View tab presents the median PAR with the uncertainty shown explicitly (i.e., separately) for the binaural estimate and for each ear separately. This allows the user to appreciate the uncertainty contributions. However, in the computation of the protected and maximum exposures at the lower part of the tab, total uncertainty is included so that the estimates are more protective.

Of the three uncertainties, only the measurement uncertainty is a function of the 3M™ E-A-Rfit™ Dual-Ear Validation System process per se. The fit uncertainty is related to the skill of an average person fitting the product. The spectral uncertainty is a function of the mathematics of the single-number computation. The method used in the E-A-Rfit validation system is based upon the NRS_A as defined in ANSI S12.68-2007 (R2012).

An example of the magnitudes of the uncertainties appears below. The actual values of uncertainty for each of the components will vary depending on the probed product, the wearer, and the shape of the measured attenuation curve.

Measurement uncertainty	(system related)	3.8 dB
Fit uncertainty	(user related)	3.6 dB
Spectral uncertainty	(related to the computation of PAR)	4.1 dB
Combined uncertainty	(square root of sum of squares of the above rows)	6.6 dB