

Noise Exposure Metrics

(Established and Potential)

For DREAM workshop discussion

John J. Earshen, M.S., F. ASA
Principal, Angevine Acoustical Consultants, Inc.

INTRODUCTION

- To stimulate discussion of candidate direct-reading exposure assessment methods, salient metrics applied in regulatory and professional practices are reviewed.
- The metrics quantify damage risks to hearing resulting from cumulative exposures to noise.

Outline

ULTIMATE OBJECTIVE FOR DRMs:

FACILITATE PROTECTION AGAINST DAMAGE TO HEARING BY EXPOSURE TO NOISE

DRMs :

FACILITATE DETECTION OF HAZARDS

PROVIDE GUIDELINES FOR REGULATING AND ENFORCING LIMITS ON EXPOSURE

Outline

STATUS OF KNOWN DAMAGE HAZARDS

ONLY EMPIRICAL DATA RELATES PROPERTIES OF DAMAGING NOISE TO TTS AND PTS

EVALUATION OF HAZARD RISKS IN MANY AREAS ONLY FEASIBLE AFTER THE FACT

ANALYTIC MODELS-UNDER DEVELOPMENT

DESIRED END RESULTS:

CAPABILITY OF PROVIDING REAL TIME PRESENTATION OF HAZARD

GENERATING EXPLICIT FUNCTIONAL SPECIFICATIONS FOR MONITORING INSTRUMENTS

REFERENCED METRICS

- Metrics are empirically related to observed exposure effects on Temporary and Permanent Threshold Shifts.

[PTS and TTS]

- Properties of sound considered are limited to pressure, frequency content, and waveforms (energy transfers and true intensities are not addressed).
- Over the entire perceivable range of hearing damage effects start upward from approximately 75 dBA.

RELATIONS of METRICS to INSTRUMENTS

- Historically, terms incorporated in metrics have been derived from uses with Sound Level Meters and Audiometers.
- There is nothing intrinsic requiring use of decibel notation
- Adoption of terms applicable to analytic physical laws can be misleading and tend to obscure the empirical nature of what is known about hearing damage by sound exposure. (e.g. reference to equal energy properties).

NOISE DOSE CONCEPT

- References a maximum criterion level (in decibels) to which unprotected exposure is permissible for a typical shift duration.
- Reduction of exposure duration permits an increase in level;
- Increase in exposure duration requires a decrease in level
- The increase or decrease in level related to halving or doubling of duration is designated the exchange rate.
- In OSHA practice the exchange rate is 5 dB
- The dose is stated in percent by normalizing with respect to the combination of criterion level and reference shift length.

APPLICATIONS of NOISE DOSE

- Values of Criterion Level and Exchange Rate are not universally used.
- Criterion levels and exchange rates selected by different regulatory agencies include respectively [84, 85, 90 dBA] and [3, 4, 5, and 6 dB]
- “Equal Energy” concept utilizes only a 3 dB exchange rate.

IMPULSE / IMPACT EFFECTS

- It is known that transient sounds of short duration and high amplitudes have a different and more damaging effect on hearing in comparison to a slowly varying or steady sound having an average value equal to the transient sound.
- Nevertheless, the dose based metric used in many applications incorporates contributions from the transient components on an equal basis to contributions from slowly varying waveforms.

COUNTING IMPULSIVE TRANSIENTS

- Other attempts to differentiate the effects of short duration transients set up tables of impulse amplitudes in increments. For each increment exposure to permissible number of impulses was defined.
- The approach suffered from inability to accommodate transients of varying waveforms as well as development of an instrument that could compute and store exposure data on a real time basis.

CREST FACTOR DIFFERENTIATION

- Passhier-Vermeer, Henderson, Bruel, and others developed a method whereby exposure to sound waveforms having equal average levels were compared. Each was characterized by a crest factor. The waveforms with the higher crest factors were shown to produce significantly higher threshold shifts.

KURTOSIS

- Hamernick devised a metric for differentiating the impact on threshold shift based on the kurtosis properties of exposure waveforms having equal Leq levels. The approach has been extensively investigated in animal studies.
- Recently a successful pilot study demonstrated differential impact by high Kurtosis noise on threshold shifts of workers in two plants in Montreal, Quebec. The high kurtosis noise is contained in a sheet metal fabrication plant. In contrast low kurtosis noise of equal Leq level is in a plastic component manufacturing plant.
- The investigation was conducted by Marie Champagne, a doctoral candidate at the State University of New York at Buffalo with collaboration by Hamernik, Henderson, and Bertrand.

SUMMARY

Review of metrics based on empirically derived relations between cumulative exposures to sound pressures having unique frequency contents and waveforms can stimulate development of direct-reading exposure assessment methods and formulate performance requirements for monitoring instruments.