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INSTRUMENT REQUIREMENTS FOR PERSONAL SOUND EXPOSURE (DOSE) METERS

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INTRODUCTION

Recent developments have generated new requirements for instruments to measure personal sound exposure. The relationship between exposure and hearing damage is the subject of continuing research. Regulatory agencies must select hearing damage models from an ambiguous matrix of candidates. In such a milieu, formulation of instrument standards is difficult but indispensible.

DISCUSSION

Currently emphasis is being placed on protection against exposure to impulsive noise. In October of 1981, a Workshop on Impulsive Noise was held at the Institute of Sound and Vibration Research of the University of Southampton, Reference [1]. The report of the workshop specified a number of quantities that should be measured, including L_{Aeq}; L_{EX}; $_{day}$; L_{AX}; and peak sound pressure (unweighted) for individual impulses. It was recommended that such measurements be made with accuracies "corresponding to IEC specification 651 for sound level meters of type 1 or better...". It was further recommended that the stated accuracy requirements be "also adopted for personal sound exposure measurements...".

In the United States, the Hearing Conservation Amendment of the Occupational Safety & Health Administration Regulations was promulgated in August of 1981 with certain portions held in abeyance. The final version was issued in March of 1983 and included exposure to impulsive noise in the determination of worker noise dose.

Models describing the human hearing mechanism and its susceptibility to damage by noise are not simple analogs of linear physical systems. Yet there is a strong propensity on the part of physicists and engineers not versed in the life sciences to apply indiscriminately measures and analytic techniques that are appropriate only for linear systems. An example is given by the attempts to challenge the validity of 5dB exchange dose computation on the grounds that the principles of superposition are violated. Once the true nature of the pertinent damage model is recognized, arguments of such orientation are recognized as exercises in sophistry.

In formulating instrument standards it must be recognized that there is no presently existing universal theory of hearing damage to unify the many special theories and models in use. Of necessity, regulatory practices are based on selected special models. Requirements of research programs seeking to develop broadly based models are not likely to be currently compatible with those of regulatory agencies. In the opinion of the writer, two types of standard are needed. To meet the needs of users of broadly based models, ones satisfying the objectives of the Workshop on Impulsive Noise are appropriate. One that is close to adoption is the International Technical Commission, document 29C (Secretariat) 37, "Integrating Sound Level Meters". For regulatory agencies, standards of narrower scope are indicated and must be compatible with the individually chosen special models for hearing damage. A standard of the latter type was developed in the U.S., ANSI S1.25 Specification for Personal Noise Dosimeters. Its origin, scope and purpose are much misunderstood, thus its background should be reviewed.

Current OSHA regulations trace back to the Walsh-Healy Act which in turn encompassed the guidelines for hearing protection published by ACGIH (American Conference of Government Industrial Hygienists). These set forth the concept of a Permissible Exposure Level (P.E.L. also called Criterion Level) stated in decibels (A weighting being used). The time weighted average level to which a subject is exposed must be gaged against the P.E.L. and is computed from readings obtained with a traditional SLM having "slow" response. The computing algorithm is based on a 5dB exchange rate.

It is crucial to note that the implicit OSHA model for hearing damage is based on the ACGIH guidelines. With technical advancements it became possible to automate the process of data reduction as well as eliminate the need for following a worker with an SLM. The resulting instrument is now commonly called a personal dosimeter. This instrument is similar to but is not identical to an integrating/averaging SLM. It intentionally retains the exponential averaging device characteristic of an SLM. Figure 1.

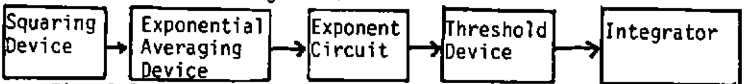

Fig. 1 Partial Block Diagram, ANSI S1.25 Dosimeters

Only under special circumstances can the two types of instruments be theoretically identical. These are that: the exponential averaging device employs a first order low pass filter having identical rise and decay time constants, the exponent circuit corresponds only to 3dB exchange and the threshold circuit is bypassed.

Questions raised about interpretation of results obtained with dosimeters for OSHA regulatory purposes have always been interpreted in terms of measurements that could be obtained with sound level meters whose readings are subsequently processed to generate dose or time weighted average levels. Recent developments indicate that this regulatory agency is extending this philosophy also to impulsive exposure.

Traditional sound level meters were never intended for measurement of brief transient wave forms. Instead they were applied to measuring steady state signals having modest time variability. In the absence of pertinent standards, such instruments have been applied to transient measurement with varying degrees of success. It is not surprising then that S1.25 as originally issued stipulated that it is not suitable for measurements of noise that is predominantly impulsive. An excellent review of the characteristics of sound level meters and interpretation of their response to transient signals is given in Reference [2].

In addition it is shown that a dosimeter is an SLM with a superposed automatic data processor. Moreover it is concluded that dosimeters can be designed to accomodate short transients by incorporating impulse response capabilities specified for modern SLM's in IEC 651 and S1.4 - 1982.

The ANSI S1 Committee has appointed a Working Group S1-7 to amend S1.25 to remove constraints on measurement of impulsive noise. The charge is limited in scope and defers extensive revision to a future task or perhaps even to the formulation of a new standard.

The following discussion describes some proposed changes or additions submitted to the working group as interpreted by the writer. In no way do they represent at this time the consensus view of the working group nor those of the governing S1 committee. Because the subject standard as amended is aimed at being responsive to regulatory needs, the views and comments of all interested parties are solicited.

Dosimeters are intended to be worn on the body of persons potentially exposed to hazardous noise. Such applications will subject the instrument to rigorous environmental stress. It has been proposed that a type 1 Class be defined. It does not appear practical to do so despite the fact that the state of the art of circuit performance is very promising. Unfortunately the limiting factor is the microphone. Type 1 microphones are at present only available in condenser or electret types. Neither can be reasonably expected to survive or retain their accuracy under extreme work environments.

Crest factor and associated performance tests are inadequate for predicting random impulse response but should be retained for defining response to repeated transient sounds such as produced by riveting hammers. Candidate crest factors of 20 and 25 dB have been proposed.

Dosimeters should be able to respond correctly to random impulses. Durations for such impulses have been proposed to range from 10 milliseconds upward. Alternate proposals have been advanced to extend the duration down to 1 millisecond and below. Choice of minimum duration will be influenced by economic feasibility and by interpretation of the damage model.

Outer bounds for dynamic span for steady state signals have been proposed between 80 and 144 dB. Within that range random impulses having amplitudes of at least 30 dB above local average level should be accomodated. Test procedures for evaluating impulse integrating capabilities have been proposed to be based on the pulse range concept using 4 killohertz isolated tone bursts.

Presently defined threshold tolerances are too broad and consideration will be given to reducing them to a 1 dB window.

CONCLUSIONS

The dosimeter standard, ANSI S1.25 is narrowly based to meet the requirements of the damage model implicit in the U.S. OSHA regulations. Amendment of this standard should reflect the amended regulations.

Formulation and possible adoption of a more broadly based standard should be guided by the recommendations of reference [1] and developments in future regulatory practices.

REFERENCES

[1] H.E. von Gierke, D. Robinson, and S.J. Karmy, "Results of the Workshop on Impulse Noise", 1st/2nd October, 1981, University of Southampton, ISVR Memorandum 618.

[2] W.R. Kundert, "Dosimeters, Impulsive Noise and the OSHA Hearing Conservation Amendment", Noise Control Engineering, Vol.19, no. 3, Nov./Dec. (1982).