MSHA Test Procedures and Acceptability Criteria for Noise Dosimeters

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CONTENTS

TABLES

MSHA TEST PROCEDURES AND ACCEPTABILITY CRITERIA FOR NOISE DOSIMETERS

by

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INTRODUCTION

The Mine Safety and Health Administration (MSHA) is currently proposing amendments to 30 CFR, Parts 70 and 71, which would allow the use of noise, dosimeters in the performance of noise surveys in coal mines. To complement these amendments, a test procedure and criteria were needed by MSHA to evaluate commercially available noise dosimeters. Since there are no recognized standard test procedures and criteria for the noise dosimeter, it was necessary for MSHA to adopt its own. The adopted test procedures were developed jointly between the U.S. Bureau of Mines and MSHA, while the adopted criteria was developed solely by MSHA. A full presentation of the procedures and initial test results may be found in the U.S. Bureau of Mines Information Circular 8754 titled, "Noise Dosimeter Performance--A Second Evaluation," by Timothy Y. Yen and Kenneth C. Stewart.

TEST PROCEDURE

1. General

Three dosimeters of a given model designation under consideration for MSHA acceptance shall be randomly selected from stock for testing. The method of selection shall have the prior approval of MSHA. Prior to and during the course of testing, the calibration of each dosimeter shall be verified according to the manufacturer's instructions to insure that it remains in good working order. If a unit fails to function or calibrate during the test, the manufacturer has the option of continuing with the remaining instruments or may begin the entire test program over again with the selection of three new instruments according to the previously established procedures. A manufacturer, whose brand of noise dosimeter fails to meet the MSHA criteria, may at a later date, request a repeat of the tests on new instruments provided they have been selected according to the previously established procedure.

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All testing shall be conducted in an anechoic chamber that will cover the frequency range of interest (100 to 8,000 Hz). The anechoic chamber shall be of sufficient size to permit the placement of the dosimeter microphones in the farfield[4] of the sound source. Farfield placement of the microphones shall be conducted for each test unless it is specified otherwise. No more than three dosimeters may be tested at one time and the spacing between any two dosimeter microphones must be at least 6 inches.

2. Frequency Response

The frequency response of a dosimeter shall be determined at the preferred l/3 octave band center frequencies from 100 to 8,000 Hz, inclusive, Each of the acoustic test sounds shall be pure tone at a constant sound level of 100 dBA and having a total harmonic distortion of less than 1 percent. The test tone may be incident upon the dosimeter microphone either parallel or perpendicular to the axis of the microphone. The level of the sound field at each position to be occupied by a dosimeter microphone must be established with a monitor microphone and an appropriate readout device. The spatial deviation of the acoustic field among the microphone positions shall not exceed 21 dB. The actual sound level established with the monitoring system is to be used in calculating each dosimeter response. The calibration of the monitor system must be established and be directly traceable to the National Bureau of Standards. For each test tone, the dosage readout (starting from zero) shall be recorded after one-half hour of exposure. Throughout each test period, the sound field in the chamber must be monitored continuously to verify that the sound field is constantly maintained.

Since the current ANSI Standard S1.4-1971, "Specifications for Sound Level Meters," specifically deals with the random incidence response of sound level meters, it is appropriate for the response of a dosimeter to be specified in terms of its random incidence response. Knowing the relationship between the random incidence response and the response at the selected angle of incidence, it is possible to reduce the data to that corresponding to random incidence. If that relationship is not known, then such a relationship must be established according to the procedure given in appendix A of the ANSI Standard S1.4-1971 and must be reported for the dosimeter microphone in question. Each dosimeter microphone must be placed in the farfield of the sound source except at frequencies of 100, 125, and 160 Hz where nearfield placement is permissible.

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[4]The farfield of a sound source is the region in which the sound pressure is inversely proportional to the distance from the source. A deviation of ±0.5 dB from the theoretically projected sound pressure level is permissible.

3. Time-Level Exchange Rate

It suffices to determine the dosimeter exchange characteristics at a single frequency of 1,000 Hz. The test tone shall be presented to each dosimeter at the levels and for durations specified below:

1,000 Hz tone sound level, dBA.....	92	95	100	105	110	113	115
Duration of exposure, hours.....	2.0	1.5	0.5	0.5	0.3	0.2	0.2

The total harmonic distortion of the test tone at any level must be less than 1 percent. The actual levels to which each dosimeter microphone is exposed must be determined with the monitor system. The spatial deviation of the acoustic field among the microphone positions shall not exceed 51 dB. The actual level of exposure established with the monitoring system is to be used in evaluating the exchange rate.

4. The Dosimeter Threshold

To bracket the cutoff threshold of each dosimeter, it is sufficient to use a test tone of 1,000 Hz at levels of 88 and 92 dBA and for durations of 1 and 2 hours, respectively. The dosage readout for each dosimeter at the two levels shall be-reported.

5. The Limit Level Indicator

The limit level indicator shall be verified with a 1,000 Hz tone at levels of 113, 115, and 117 dBA for a duration of two-tenths of an hour at each level. The status of the indicator at the end of each test level shall be reported. Nearfield microphone placement at 117 dBA is permissible.

6. Crest Factor Handling Capability

The ability of dosimeters to handle test signals with crest factor values larger than that for a pure tone shall be determined with tone bursts and with a broadband noise stimulus.

6.a. Tone Burst

A 1,000 Hz continuous waveform passing through a gating device shall be used as the test signal.- The continuous waveform shall produce a level of 115 dBA at each test position as established by the monitoring system. The spatial deviation of the acoustic field among the microphone positions shall not exceed +l dB. The tests shall be run at a duty period of 250 milliseconds, with on times of 150, 100, 50, and 25 milliseconds (containing 5 milliseconds of rise time and 5 milliseconds of decay time). The actual sound level at each of the microphone positions shall be measured with an indicating device possessing an ANSI Type I A-weighting function and slow response. The indicating system must be capable of measuring waveforms with a crest factor of at least 10. The test duration for each tone burst shall be two-tenths of an hour.

6.b. Broadband Noise

A random noise source shall be used as the electrical input to a loudspeaker. The sound level produced by the loudspeaker shall be 115 dBA at each dosimeter microphone position. The spatial deviation of the acoustic field among the microphone positions shall not exceed +l dB. The spectrum of the sound field produced by the loudspeaker shall have a frequency distribution such that the deviation in sound pressure level for the 1,000 Hz through the 8,000 Hz octave bands does not exceed ±3 dB. Below 1,000 Hz, a rolloff of approximately 10 dB per octave is permissible. The spectrums of the test sound must be measured with an octave or l/3 octave band sound analyzer at each microphone location. The exposure duration for this test shall be two-tenths of an hour.

DATA ANALYSIS

The raw data, generated in the process of evaluating the characteristics of noise dosimeters according to the previously established testing procedure, shall be sent to MSHA[5] at the conclusion of the tests. Upon receipt, the data will be analyzed by the method described in the document, "Noise Dosimeter Performance--A Second Evaluation," by Timothy Y. Yen and Kenneth C. Stewart, BuMines IC 8754. Appendix A presents the format that MSHA will use for the reduced data.

MESA ACCEPTANCE CRITERIA

The criteria are to be applied only to the reduced data and not to the raw data. At least two instruments of the three instruments submitted by the manufacturer for testing must pass all seven of the criteria. The acceptance by MSHA of a model noise dosimeter will be published in a separate notice in the Federal Register and the model will be added to MSHA's list of acceptable dosimeters.

1. Maximum Dosage Readout Capability

Acceptable dosimeters must be capable of accumulating and reading out a dosage of up to and including 999 percent.

2. Crest Factor

2.a. Pure Tone (tone burst)

The deviation in equivalent sound, 6, as derived from the dosage readings from test 6.a. must be within ±1.5 dB in the pure tone crest factor range of 1.4 to 3.2.

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2.b. Broadband Noise

The deviation in equivalent sound level, δ, as derived from the dosage readings from test 6.b. must be within ±1.0 dB.

3. Exchange Rate Linearity

The exchange or trade-off rate linearity error, β, of a dosimeter must be such that the deviation in equivalent sound level as derived from the dosage readings from test 3 must be within ±0.5 dB in the sound level range of 95 to 115 dBA.

4. A-weighting Response

The A-weighting error, ∝, as derived from the dosage readings from test 2 must be within the A-weighting tolerances shown in table 1. These tolerances are identical to those specified in ANSI Standard S1.4-1971 for Type II A-weighting.

Frequency, Hz	Tolerance limits, dB	Frequency, Hz	Tolerance limits, dB
100	±2.5	1,000	±2.0
125	±2.5	1,250	±2.0
160	±2.5	1,600	±2.5
200	±2.5	2,000	±3.0
250	±2.5	2,500	+4.0, -3.5
315	±2.0	3,150	+5.0 -4.0
400	±2.0	4,000	+5.5, -4.5
500	±2.0	5,000	+6.0, -5.0

5. Pink Noise

This criterion applies to the overall response of the dosimeter. The A-weighting error, a, from test 1, the linearity error, β, for a 105 dBA sound level from test 3, and the broadband crest factor error, δ, from test 6.b., are used together with an assumed pink noise spectrum as input data to the computational procedure shown in appendix B. For an instrument to meet this criterion, the computed overall error must be within ±2 dB which corresponds to a dosage tolerance of 76 to 132 percent.

6. Field Calibration

An acoustical calibrator, designed to be used with the noise dosimeter, must be commercially available. Additionally, a calibration verification procedure must be specified in the

7. Threshold

The dosage readout as determined from the dosimeter threshold test 4 at 88 dBA must be 1.0 percent or less.

APPENDIX A.--DATA FORMAT

Table A-l is an example of the format that will be used by MSHA for the reduced data.

Where

α = A-weighting error in dB (used in criterion 4)

β = linearity error in dB (used in criterion 3)

γ = calibration error in dB

δ = crest factor error in dB (used in criteria 2.a. and 2.b.)

and where

$$C = 2^{\gamma/5}$$

$$F = 2^{\alpha/5}$$

$$G = 2^{\beta/5}$$

$$R/R_o = 2^{\delta/5}$$

TABLE A-l. - Example of format for reduced dosimeter data

Frequency in Hertz	Sample 1		Sample 2		Sample 3		Sample Mean	
	F	α	F	α	F	α	F	a
100	0.966	-0.2	0.728	-2.3	0.920	-0.6	0.871	-1.0
125	0.902	-0.7	0.805	-1.6	0.939	-0.5	0.882	-0.9
160	0.901	-0.8	0.885	-0.9	0.965	-0.3	0.917	-0.6
200	0.874	-1.0	0.885	-0.9	0.943	-0.4	0.900	-0.8
250	0.902	-0.7	0.920	-0.6	0.979	-0.2	0.934	-0.5
315	0.875	-0.8	0.885	-0.9	0.948	-0.4	0.903	-0.7
400	0.865	-1.0	0.897	-0.8	0.945	-0.4	0.902	-0.7
500	0.865	-1.0	0.910	-0.7	0.964	-0.3	0.913	-0.7
630	0.828	-1.4	0.917	-0.6	0.931	-0.5	0.892	-0.8
800	0.916	-0.6	0.884	-0.9	0.920	-0.6	0.907	-0.7
1,000	0.914	-0.6	0.923	-0.6	0.964	-0.3	0.934	-0.5
1,250	0.871	-1.0	0.962	-0.3	0.946	-0.4	0.926	-0.6
1,600	1.015	0.1	0.989	-0.1	1.053	0.4	1.019	0.1
2,000	0.986	-0.1	1.238	1.5	1.096	0.7	1.107	0.7
2,500	1.296	1.9	1.310	1.9	1.196	1.3	1.267	1.7
3,150	1.351	2.2	1.028	0.2	0.844	-1.2	1.074	0.5
4,000	1.162	1.1	1.016	0 . 1	0.892	-0.8	1.023	0.2
5,000	0.960	-0.3	1.116	0.8	1.074	0.5	1.050	0.4
6,300	1.157	1.1	1.310	1.9	1.197	1.3	1.221	1.4
8,000	1.385	2.3	1.394	2.4	1.281	1.8	1.353	2.2

TABLE A-l. - Example of format for reduced dosimeter data--Continued

Sound Level in dBA	Sample 1		Sample 2		Sample 3		Sample Mean	
	G	β	G	β	G	β	G	β
92	0.973	-0.2	0.978	-0.2	1.020	0.1	0.990	-0.1
95	1.054	0.4	1.008	0.1	0.990	-0.1	1.017	0.1
100	1.041	0.3	0.968	-0.2	0.990	-0.1	1.000	0
105	0.986	-0.1	1.030	0.2	1.016	0.1	1.011	0.1
110	0.978	-0.2	1.008	0.1	0.983	-0.1	0.990	-0.1
113	0.996	0.0	1.014	0.1	0.998	0	1.003	0
115	0.975	-0.2	0.996	0	1.003	0	0.991	-0.1
Calibration Factor	C	Y	C	Y	C	Y	$\bar{C}$	4
	1.051	0.4	1.075	0.5	1.048	0.3	1.058	0.4
R at 88 dBA for 1 hour	0%		1%		0%			
115 dBA light activated at	115 dBA		117 dBA		117 dBA			

TABLE A-l. - Example of format for reduced dosimeter data--Continued

Factor	Time	R/R_0	δ	R/R,	δ	R/R,	δ	R/R,	δ
1,000 Hz Tone Bursts									
2.0	60%	1.150	1.0	1.146	1.0	1.138	0.9	1.145	1.0
2.4	40%	1.202	1.3	1.235	1.5	1.112	0.8	1.183	1.2
3.5	20%	1.224	1.5	1.234	1.5	1.254	1.6	1.237	1.5
5.0	10%	1.175	1.2	1.172	1.1	1.172	1.1	1.173	1.2
Broadband Noise		1.006	0	0.961	-0.3	0.987	-0.1	0.985	-0.1

Crest Factor = 4.3

APPENDIX B.--PINK NOISE RESPONSE COMPUTATION

The pink noise criterion applies to a computed result. The computation is based on a spectrum with a sound pressure level of 93.44 dB in each 1/3 octave band from 100 Hz to 8,000 Hz, inclusive. These levels result in an overall A-weighted sound level L_a equal to 105 dBA.

In performing the computation, the spectrum is weighted with the ANSI A-weighting values and the α values for each 1/3 octave band for the dosimeter under consideration. The resultant 1/3 octave levels are combined to yield an overall sound level. The δ value obtained from the broadband noise test and the β value from the linearity test for a sound level of 105 dBA are then added to this overall sound level. The resultant sound level, La is the equivalent level that the dosimeter records. The error is then determined by subtracting L_a from L'_a.