Predicted Impairment and Handicap from Exposure to Steady-State Broad-Band Industrial Noise

Chagok, N.M.D.,* Fom, T.P., Izam, M.M., Domtau, D.L., Jwanbot, D.I.
Department of Physics, University of Jos, Nigeria
* E-mail of the corresponding author: nchagok@yahoo.com

Abstract

In this work, the empirical formula derived by Chagok and Gyang (2012)in conjunction to the AAO-1979 rule was used to predict values for the monaural impairment and the hearing handicap for exposure to steady-state broad-band industrial noise. The predicted values for the monaural impairment and the hearing handicap increase with exposure levels and therefore support the Equal Energy Hypothesis (EEH). The values of the hearing handicap are always higher than the corresponding values of the monaural impairment. The values of the monaural impairment and the hearing handicap show that all the values increase with sound pressure level, exposure time and age and that values of the impairment and handicap could be obtained for sound pressure level of 70dBA if the table is expanded to consider entries for higher ages and more exposures.

Keywords: Monaural impairment, hearing handicap, noise, hearing loss, industries.

1. Introduction

Noise is a common occupational hazard that leads to one of the most common complaints in industrial workers. Although noise-induced hearing loss (NIHL) is not amendable to medical or surgical therapy, it is entirely preventable. That prolonged exposure to noise can result in a persistent shift in the threshold of hearing has been demonstrated in so many studies (Coles et al., 1968;Passchier-Vermeer, 1974; Ward, 1975; Berger et al., 1978; Stevin, 1982; Alberti, 1998; Nash, 2000; Chagok, 2010).The greater the intensity of the noise the greater the probable threshold shift is intuitively reasonable and factually demonstrable from the results of a few investigations where different noise-exposed groups were studied under common audiometric and test protocol. From the systematic studies of Chagok and Gyang (2012), it has been possible to establish a definite relationship between threshold shift and duration of exposure, the level and pattern of noise being invariant (on a cyclic daily basis) throughout the duration for a wide range of exposure. The relations so established permit the calculations of statistical distributions of noise-induced pure-tone threshold shift at various audiometric frequencies for a population exposed for a specified time to a specified noise level, including allowance for age.

For normal hearing, the threshold of audibility is within the range of -10dB to 25dB.Hearing loss is classified into various degrees ranging from mild to profound. They are:

26dB to 40dB	Mild hearing loss
41dB to 55dB	Moderate hearing loss
56dB to 70dB	moderately severe hearing loss
71dB to 90dB	severe hearing loss
Over 90dB	profound hearing loss

Hearing loss could be unilateral (hearing loss in one ear) or bilateral (hearing loss in both ears).

Hearing impairment and handicap are terms that are frequently, though incorrectly used synonymously. Hearing impairment refers to “a change for the worse in either structure or function, outside the range of normal”. A hearing handicap is “the disadvantage imposed by impairment sufficient to affect a person’s efficiency in the activities of daily living”.

2. Methods and Materials

In this work, pure tone audiometry was used to establish hearing thresholds at 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz and 8000Hz for exposure to noise levels and for specified time. A-weighted Sound Pressure Levels and

Sound Spectrum Levels, at machine-operator positions in the companies/industries included in the research were measured using Brüel & Kjaer Impulse Precision Sound Level Meter Type 2209 in conjunction with ⅓-Octave Filter set, Type 1616 and the audiometric tests were carried out using Beltone 112 Audiometer as reported in Chagok and Gyang (2012) and Chagok *et al.* (2013). The background noise levels during all tests satisfied the octave band level requirements of ANSI S3.1-1977. Five hundred and twenty four (524) workers were tested out of a total of seven hundred and ninety one (791) workers interviewed.

3. Results and Discussion

Chagok and Gyang (2012) obtained values of the coefficients a and b as shown in table 1 which were used for the regression equation of $L_{50\%}$ on L_E

$$L_{50\%} = a + bL_E \quad (1)$$

$$L_E = L_A + 10\log T \quad (2)$$

From the regression equation of $L_{50\%}$ on L_E i.e. $L_{50\%} = a + bL_E$ with a and b given in Table 1, it is possible to assess at each test frequency, the risk of noise-induced hearing loss $L_{50\%}$ caused by exposure to a certain level of broad-band noise for a known duration.

Generally the hearing level of an individual of known age and exposure to a certain level of broadband noise, for a known period of time, can be estimated at each test frequency using Equation(1) with a and b given in Table 1 together with presbycusic/sociocusic loss calculated using regression equation

$$J = c + dy \quad (3)$$

J is the presbycusic/sociocusic loss, c and d given in Table 2 and y the age in years. The hearing level, also called the permanent threshold of audibility, (PTA) of a person who has worked in a noisy environment can be estimated using the expression

$$PTA = L_{50\%} + J = a + bL_E + c + dy \quad (4)$$

The most commonly accepted formula for calculating impairment and handicap is the AAO-1979 rule. In this formula, pure tone audiometry is used to establish hearing thresholds at 500Hz, 1000Hz, 2000Hz and 4000Hz for each ear and the average monaural thresholds are calculated using these values. Then, using the assumptions that hearing handicap begins when PTA thresholds exceed 25dB and increases by 1.5% for each decibel loss above 25dB, (Noise-Induced Hearing Loss, 2008) and that noise-induced hearing loss is bilateral, having a maximum difference of 10dB, the monaural percent impairment is calculated as

$$MI = 1.5(PTA - 25) \quad (5)$$

$$= 1.5[(L50 + J) - 25]$$

$$= 1.5\{[(a + bL_E) + (c + dy)] - 25\} \quad (6)$$

The hearing handicap (HH) is calculated by applying a 5:1 weight favoring the better hearing ear. The hearing handicap is

$$HH = \frac{[5(MI_b) + (MI_W)]}{6} \quad (7)$$

Table 3 shows the calculated values of the Monaural Impairment (MI) in percent obtained by the use of equation (8) with all the parameters in tables 1 and 2. The corresponding values of the Hearing Handicap (HH) are computed using equation (7). It may be noted that generally, the monaural impairment (MI) and the hearing handicap (HH) increase with increase in exposure level and age. Monaural impairment and handicap begin to show when the permanent threshold of audibility (PTA) is above 25dBA. However, noise-induced hearing loss begins to show when the SPL is 70dBA as shown in the work of Chagok and Gyang (2013) and Chagok et al. (2013). Sound

pressure level, years of exposure and age are the factors upon which the monaural impairment and hearing handicap depend with noise-induced hearing loss depending on the sound pressure level and the exposure time whereas the presbycusic loss depends on age. The values of the hearing handicap are always higher than the corresponding values of the monaural impairment. The values of the monaural impairment and the hearing handicap show that all the values increase with sound pressure level, exposure time and age and that values of the impairment and handicap could be obtained for sound pressure level of 70dBA if the table is expanded to consider entries for higher ages and more exposures.

4. Conclusion and Recommendations

The empirical expressions for noise-induced hearing loss and presbycusic/sociocusic loss derived by Chagok and Gyang (2012) in conjunction to the constants as shown in tables 1 and 2 were used to compute the permanent threshold of audibility (PTA). The AAO-1979 rule for calculating the monaural impairment and the hearing handicap was used. Results show that noise causes monaural impairment and hearing handicap; the impairment and the handicap depend on the exposure level, thus supporting the Equal Energy Hypothesis (EEH).The authors suggest that noise assessment of workplaces should be carried out regularly, employers should provide hearing protection and employees should develop the habit of using the hearing protection provided. From this work, the following recommendations are made:

(i) An investigation into industrial noise levels of companies and industries.

(ii) An investigation into the establishment of disability from monaural impairment and hearing handicap from exposure to noise and the compensation of the affected individuals.

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Table 1. Values of the Coefficients a and b

Frequency Hz	a		b	
	M	F	M	F
250	-21.24	-17.82	0.30	0.24
500	-29.55	-20.18	0.39	0.26
1000	-44.96	-30.47	0.55	0.37
2000	-21.89	-37.08	0.36	0.45
4000	-51.43	-36.23	0.64	0.45
8000	-50.21	-20.26	0.60	0.27

Table 2. Values of the Coefficients c and d for Presbycusic/Sociocusic Loss

Freq	Age	c		d	
		M	F	M	F
250	20-45	-1.32	-0.95	0.097	0.08
	50-75	-16.48	-11.14	0.39	0.27
500	20-45	-1.30	-0.95	0.097	0.08
	50-75	-20.14	-7.95	0.47	0.23
1000	20-45	-1.32	-1.32	0.10	0.10
	50-75	-21.38	-13.38	0.49	0.33
2000	20-45	-3.61	-2.09	0.18	0.13
	50-75	-36.38	-22.10	0.85	0.54
3000	20-45	-4.93	-4.16	0.28	0.23
	50-75	-38.00	-34.00	1.00	0.84
4000	20-45	-5.50	-4.17	0.35	0.25
	50-75	-41.10	-31.14	1.14	0.87
6000	20-45	-9.75	-9.52	0.53	0.46
	50-75	-47.14	-33.76	1.31	0.98
8000	20-45	-10.10	-9.54	0.53	0.46
	50-75	-66.86	-56.71	1.69	1.41

Table 3. Values for Monaural Impairment (MI) and Hearing Handicap (HH)

SPL			70	75	80	85	90	95	100	105	110	115	120
	AGE (years)	EXPOSURE (years)	MI:HH	MI:HH	MI:HH	MI:HH	MI:HH	MI:HH	MI:HH	MI:HH	MI:HH	MI:HH	MI:HH
	20	5											
	25	5											
		10											
	30	5											3.23:5.73
		10										1.79:4.29	3.54:6.04
		15										3.06:5.56	4.52:7.02
	35	5										0.96:3.46	4.61:7.11
		10										3.15:5.65	6.78:9.28
		15									0.80:3.30	4.46:6.96	8.07:10.57
		20									1.70:3.27	5.34:7.84	8.97:11.47
	40	10									0.68:3.18	1.79:4.29	7.89:10.39
		15									2.16:4.66	3.11:5.61	9.17:11.67
		20									3.06:5.56	3.98:6.48	10.47:12.97
		25								0.12:2.62	3.77:6.27	7.41:9.91	10.85:13.35
	45	10									2.24:4.74	7.38:9.88	9.44:11.94
		15									3.53:6.03	7.19:9.69	10.73:13.23
		20								0.80:3.30	4.43:6.93	8.07:10.57	11.63:14.13
		25								0.90:3.40	5.13:7.63	8.76:11.26	10.91:13.41
		30								2.06:4.56	5.72:8.22	9.35:11.85	12.98:15.48
	50	15								3.00:5.50	6.33:8.83	9.98:12.65	13.61:16.11
		20								3.60:6.10	7.25:9.75	10.85:13.35	14.52:17.02
		25							0.68:3.18	4.31:6.81	7.95:10.45	11.58:14.08	15.23:17.73
		30							1.25:3.75	4.88:7.38	8.52:11.02	12.17:14.67	15.80:18.30
		35							1.73:4.23	5.37:7.87	9.02:11.52	12.65:15.15	16.29:18.79
	55	20						1.86:4.36	5.88:8.38	9.12:11.62	12.78:15.28	14.28:16.78	19.19:21.69
		25						2.34:4.48	6.21:8.71	9.84:12.34	13.46:15.96	17.12:19.62	20.06:22.65
		30						3.14:5.64	6.78:9.28	10.41:12.91	14.06:16.56	17.81:20.31	21.33:23.83
		35						3.63:6.13	7.26:9.76	10.91:13.41	14.54:17.04	18.18:20.68	21.81:24.31