NIOSH

TECHNICAL INFORMATION

LIST OF PERSONAL HEARING PROTECTORS AND ATTENUATION DATA

LIST OF PERSONAL HEARING PROTECTORS AND ATTENUATION DATA

Patricia Kroes, Ph.D.
Roy Fleming, B.S.
Barry Lempert, B.S.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
Division of Laboratories and Criteria Development
Cincinnati, Ohio 45202
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ABSTRACT

Information from manufacturers and suppliers of personal hearing protectors has been compiled into this list which is a revision and expansion of the NIOSH 1973 publication, "List of Personal Ear Protectors and Attenuation Data," TR 89. Included in this list are: manufacturer or supplier, model and type, average attenuation values and standard deviations at test frequencies 125 to 8000 Hz, test standard, and test laboratory. Also presented is a brief discussion of the factors to be considered in choosing hearing protectors, a short description of NIOSH activities related to hearing protector research, and methods (with examples) for calculating noise reduction factors for hearing protectors.

INTRODUCTION

A list of hearing protectors was published in June 1973 by the National Institute for Occupational Safety and Health (NIOSH) in response to requests for information regarding the types of hearing protectors available for use in hearing conservation programs. Since that time several letters have been received suggesting that additional information be included which would assist the user in his selection. Also, some companies have left the market, and several new companies have asked that their data be incorporated. For these reasons this revised and expanded list has been compiled.

Companies entered in the list are manufacturers or distributors of hearing protectors which have supplied their data to the Physical Agents Branch of NIOSH. These data have not been validated by NIOSH at the present time. Included in the listing are: manufacturer or supplier, model, type, average attenuation values for the test frequencies 125 to 8000 hertz, standard deviations of attenuation data, test standard, and test laboratory. Laboratories are referenced by the numbers in the "Test Lab" column, and their names and addresses are given following the data list.

The majority of suppliers have had their hearing protectors tested according to the American National Standards Institute (ANSI) standard Z24.22-1957 "Method for the Measurement of the Real-Ear Attenuation of Ear Protectors at Threshold." In certain cases different procedures were used which are explained in the footnotes at the end of the list.

Recently a new standard has been published which is a revision of the ANSI 1957 standard; however, a lack of test data by this latest standard prevented such information from appearing in this list. The new standard is ASA STD1-1975 (ANSI 3.19-1974), "Method for the Measurement of Real-Ear Protection of Hearing Protectors and Physical Attenuation of Earmuffs." The main changes which are incorporated in the ASA 1975 standard are the substitution of third-octave bands of noise instead of discrete tones as the test stimuli, the replacement of an anechoic test room by a reverberant test room, and the inclusion of an objective method for measuring physical attenuation of earmuffs.

The results from tests using the procedures specified in these standards are expressed in terms of the means and standard deviations of the attenuation data for each test frequency, which can be used to make evaluations of the noise reduction capabilities of the hearing protectors. A space has been left at the end of the row for each protector in which the user can write his own calculated values of noise reduction. Several methods of making such calculations are presented, along with examples, in the appendix following the data list. The limitations, advantages, and disadvantages are discussed for each method.

Although calculated noise reduction factors are a major consideration in selecting hearing protectors, several other aspects should be considered which can affect the actual reduction received and the acceptance of the device by a worker. Proper fit of a hearing protector is most important because it is on this basis that the attenuation data were derived. Even if proper fit is achieved, there is variation in attenuation from person to person. Fortunately, this type of variation can be accounted for by including the standard deviation data in the noise reduction calculations. Other causes of variations which usually degrade the noise reduction are improper fitting at the time of distribution, interference by hair or eyeglasses, and improper wearing by the worker. Improper fit is often a result of attempts to improve comfort, which is another factor to consider when buying; however, comfort considerations should never out-weigh attenuation considerations when insufficient protection would result. In each situation the possibility of wearer adjustment should be evaluated in terms of reliability of performance. Three additional considerations are durability (shelf life or use life), sanitation-hygienic characteristics, and cost. Many companies have found that the practices of personally fitting each worker and of offering a variety of types to the workers have greatly improved acceptance to wearing hearing protectors.

For the purpose of providing more user oriented information on hearing protectors, as well as sound level measuring devices, NIOSH has established a testing and certification program in Morgantown, West Virginia. Also, research is being conducted on the effectiveness of ear plug devices as they are actually used in industry. At the Morgantown Testing and Certification Lab (TCL), NIOSH personnel have developed facilities for testing hearing protectors according to the new ASA test standard STD1-1975 (ANSI 3.19). The logistics of the program are still being planned, but the final goal is envisioned to be a standard data sheet for each type of hearing protector. This sheet might contain attenuation values, standard deviations, dBA reduction factors, manufacturer's restrictions on use, maintenance requirements and possibly the results of evaluations of durability. Along with a certifying seal on the protector and/or its container, such a data sheet should provide the user with a certification of the protector's attenuating capabilities and with a simple means of determining if a protector meets his needs.

As was noted earlier, attenuation values are measured under proper fit (or even best fit) conditions <u>in the laboratory</u>. Thus, <u>it is necessary to maintain the same fit under actual working conditions to obtain the expected protection</u>. To investigate the differences between laboratory test attenuation data and field test data, a new field test method has been developed and verified by NIOSH. It is not to be an alternative method to the real-ear method in the new ASA standard STD1-1975; rather, it is a research tool to study the actual attenuation of ear plugs as they are worn on the job. As field research is performed using this new tool, results will be made available in the form of technical reports.

LIST OF HEARING PROTECTORS

AND ATTENUATION DATA

Submissions for corrections or additions to the list are welcomed and may be addressed to:

Physical Agents Branch B-15
DLCD/NIOSH
1014 Broadway
Cincinnati, Ohio 45202

INCLUSION OF PARTICULAR EAR PROTECTORS IN THIS LIST IN NO WAY CONSTITUTES NIOSH ENDORSEMENT OR CERTIFICATION. THE DATA WERE LISTED AS RECEIVED FROM THE MANUFACTURERS AND HAVE NOT BEEN VALIDATED BY NIOSH.

I.D. No.	Manufacturer or Supplier	Model	Type	125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
				Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB)											
1	Adcotone-Adcomold 1558 California St. Denver, Colorado 80202	Adcomold	Molded Earplug (Acrylic)	19 (5)	21 (3)	23 (4)	26 (4)	32 (3)	40 (3)	43 (3)	41 (5)	39 (4)	Yes	1	___
2		Adcosil	Molded Earplug (Silicone)	22 (4.3)	23 (4.4)	25 (3.8)	27 (3.6)	33 (4.5)	40 (3.9)	42 (4.3)	40 (4.6)	35 (4.6)	Yes	1	___
3		Adcowax	Earplug	19 (7.4)	20 (6.4)	21 (4.4)	26 (3.9)	30 (6.2)	38 (6.3)	40 (7.9)	41 (9.4)	36 (7.4)	Yes		___
4		Adcofoam Plugs	Self-molding Earplug	25 (5.2)	25 (6.3)	25 (4.8)	26 (3.1)	35 (5.6)	39 (7.0)	40 (5.7)	39 (6.1)	37 (6.2)	Yes	1	___
5		Adco V51R	Flange type Earplug	18 (6)	22 (8)	15 (6)	21 (7)	27 (5)	28 (6)	25 (6)	30 (7)	47 (8)	Yes	1	___
6		Adcowool	Earplug	13	15	18	25	31	37	40	36	35	Yes		___
7		Adcomuff	Earmuff	13 (2)	20 (2)	31 (2)	45 (2)	43 (2)	44 (3)	39 (3)	31 (3)	30 (3)	Yes	1	___
8	American Optical Safety Products 14 Mechanic Street Southbridge, Mass. 01550	A-O Hear Guards	Earplug	22 (6.2)	25 (6.6)	26 (5.8)	31 (5.2)	38 (4.0)	41 (5.0)	42 (4.5)	38 (4.9)	40 (4.4)	Yes	13	___
9		Model 1200	Earmuff	10 (2.7)	17 (2.7)	26 (3.3)	38 (3.9)	43 (3.5)	40 (3.9)	42 (5.8)	31 (6.2)	31 (4.3)	Yes	13	___
10		Model 1220 Over the Head	Earmuff	14 (1.5)	20 (2.7)	33 (4.6)	41 (3.5)	42 (5.4)	42 (5.0)	38 (3.4)	36 (5.6)	33 (4.4)	Yes	13	___
11		Behind the Head	Earmuff	14 (2.5)	21 (3.3)	33 (3.2)	42 (2.4)	42 (4.4)	42 (5.5)	37 (4.1)	35 (6.6)	31 (4.4)	Yes	13	___
12		Under the Chin	Earmuff	12 (2.0)	21 (2.3)	33 (3.3)	42 (4.1)	42 (3.3)	41 (2.6)	37 (3.4)	34 (4.2)	33 (5.1)	Yes	13	___
13		Model 1275	Earmuff	8 (3.1)	14 (3.1)	22 (3.9)	34 (3.9)	41 (3.8)	40 (4.4)	41 (5.2)	30 (6.6)	30 (6.3)	Yes	13	___
14		Model 1600A Over the Head	Earmuff	8 (2.1)	14 (2.2)	24 (2.3)	36 (2.8)	33 (2.8)	35 (3.8)	40 (3.8)	35 (2.8)	37 (4.7)	Yes	13	___
15		Behind the Head	Earmuff	7 (2.0)	10 (1.3)	23 (3.4)	30 (2.5)	34 (2.7)	37 (3.2)	39 (3.2)	34 (3.8)	35 (3.8)	Yes	13	___
16		Under the Chin	Earmuff	6 (1.9)	11 (1.2)	22 (1.6)	30 (2.9)	34 (2.8)	36 (3.0)	40 (2.9)	34 (4.6)	36 (4.0)	Yes	13	___

I.D. No.	Manufacturer or Supplier	Model	Type	125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
				Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB)											
17	American Optical Co. (cont'd)	Model 1675A Behind the Head	Earmuff	10 (3.2)	16 (2.5)	25 (2.8)	34 (5.1)	34 (2.9)	36 (5.6)	41 (5.7)	34 (6.6)	32 (5.9)	Yes	13	___
18		Model 1776K	Helmet Muff	14 (2.8)	18 (3.1)	30 (2.7)	39 (2.9)	46 (2.7)	40 (4.0)	42 (4.9)	38 (4.5)	34 (5.3)	Yes	13	___
19	Bausch & Lomb 1400 N. Goodman St. P.O. Box 450 Rochester, New York 14602	Quiet Ear Model 5N85	Earmuff	15 (2.6)	16 (2.3)	24 (4.2)	37 (4.5)	28 (5.1)	33 (5.7)	38 (3.3)	31 (7.4)	29 (6.0)	Yes	13	___
20		Model 5N86	Earmuff	16 (3.5)	15 (2.8)	26 (3.2)	37 (4.9)	27 (3.7)	34 (4.2)	37 (5.9)	33 (5.4)	29 (4.0)	Yes	13	___
21	Bilsom International, Inc. 1930 Isaac Newton Sq., East Reston, Virginia 22090	Bilsom Eardown	Glassdown Earplug	13 (4.1)	15 (3.4)	18 (3.3)	25 (3.7)	31 (3.4)	37 (3.5)	40 (3.5)	36 (4.4)	35 (3.9)	Yes[1]	6	___
22		Bilsom Propp	Preformed Glassdown Earplug	12 (3.6)	15 (3.6)	21 (3.6)	25 (4.9)	31 (3.6)	36 (3.4)	39 (3.4)	37 (4.3)	34 (3.3)	Yes[1]	6	___
23		Universal Type UF-1	Earmuff	14 (2.3)	16 (2.5)	29 (3.6)	38 (3.1)	40 (3.7)	42 (2.8)	44 (3.0)	42 (2.7)	38 (3.7)	Yes[1]	6	___
24		Universal Type UL-1	Earmuff	15 (3.4)	21 (2.8)	29 (2.6)	38 (3.2)	43 (2.7)	44 (2.9)	42 (2.8)	35 (3.6)	30 (5.4)	Yes[1]	6	___
25		Helmet Attachable Type HF-1	Earmuff	15 (3.8)	16 (3.0)	29 (3.7)	35 (4.1)	38 (3.9)	41 (4.0)	44 (3.4)	40 (3.6)	35 (3.6)	Yes[1]	6	___
26	Cesco Safety Products 100 East 16th Street Kansas City, Missouri 64108	Guardian Ear Inserts	Earplug	22 (6.1)	23 (6.1)	25 (6.5)	30 (4.5)	33 (5.8)	41 (4.5)	39 (5.7)	36 (6.5)	36 (6.0)	Yes	13	___
27	Curtis Safety Products Co. P.O. Box 61 Webster Square Station Worcester, Mass. 01603	Noise-Checks (V51R)	Earplugs	22 (6.1)	23 (6.1)	25 (6.5)	30 (4.5)	33 (5.8)	41 (4.5)	39 (5.7)	36 (6.5)	36 (6.0)	Yes	13	___

I.D. No.	Manufacturer or Supplier	Model	Type	Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB) 125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
	David Clark Co., Inc. 360 Franklin Street P.O. Box 155 Worcester, Mass. 01613	STRAIGHTAWAY													
28		Models 10A, 10AS, E105, E105S	Earmuff	15 (1.9)	22 (1.9)	33 (3.1)	44 (4.3)	43 (3.7)	48 (6.8)	48 (5.4)	39 (4.0)	32 (6.1)	Yes	18	
29		Models 9AN/2, 19A, E195	Earmuff	19 (3.4)	26 (4.0)	35 (4.0)	43 (5.5)	40 (3.9)	41 (4.8)	37 (5.3)	30 (6.2)	31 (6.6)	Yes	18	
30		Model 9AN/4	Earmuff	21 (2.0)	27 (3.7)	36 (5.3)	43 (5.5)	35 (3.9)	39 (5.1)	38 (4.3)	34 (4.1)	33 (3.5)	Yes	18	
31		Model E705 Attached to Jackson Safety Cap Model SC10	Earmuff	12 (2.5)	17 (3.0)	30 (4.6)	35 (5.6)	35 (4.5)	36 (4.3)	37 (4.2)	32 (4.1)	30 (2.9)	Yes	18	
32		Models E805, E805S	Earmuff	10 (2.0)	17 (2.6)	28 (4.3)	37 (5.4)	36 (4.5)	44 (5.6)	39 (3.8)	32 (5.4)	30 (4.9)	Yes	18	
		Models E305, E305S													
33		Overhead Position	Earmuff	13 (1.9)	19 (3.2)	29 (4.3)	39 (7.0)	36 (4.3)	42 (4.4)	36 (3.7)	33 (4.3)	31 (4.8)	Yes	18	
34		Behind Head Position	Earmuff	10 (1.9)	17 (3.0)	24 (3.5)	34 (4.7)	37 (4.5)	41 (4.5)	35 (4.1)	32 (3.5)	30 (4.7)	Yes	18	
35		Under Chin Position	Earmuff	11 (2.1)	17 (3.8)	27 (5.3)	37 (4.4)	32 (3.0)	38 (3.4)	32 (3.4)	31 (4.1)	31 (3.6)	Yes	18	
		Models E310, E310S													
36		Overhead Position	Earmuff	13 (2.2)	19 (3.3)	27 (3.8)	38 (4.6)	36 (3.9)	39 (4.7)	41 (5.5)	36 (5.2)	33 (4.3)	Yes	18	
37		Behind Head Position	Earmuff	12 (2.6)	19 (3.8)	26 (3.7)	35 (4.8)	35 (4.3)	38 (4.5)	42 (5.1)	36 (5.1)	33 (3.6)	Yes	18	
38		Under Chin Position	Earmuff	13 (2.2)	19 (2.9)	28 (4.0)	36 (4.3)	34 (3.4)	39 (3.3)	39 (4.4)	35 (4.4)	33 (4.1)	Yes	18	
		Model E320													
39		Overhead Position	Headset	12 (2.2)	17 (1.8)	25 (2.4)	36 (5.0)	37 (3.8)	41 (5.3)	40 (5.7)	38 (4.8)	35 (5.1)	Yes	18	
40		Behind Head Position	Headset	11 (2.1)	18 (1.7)	24 (2.5)	37 (5.4)	35 (3.4)	41 (4.6)	42 (5.9)	37 (4.1)	35 (4.3)	Yes	18	
41		Under Chin Position	Headset	10 (2.3)	17 (2.6)	25 (3.8)	35 (6.4)	33 (4.1)	41 (5.6)	38 (5.0)	33 (5.5)	32 (4.3)	Yes	18	

I.D. No.	Manufacturer or Supplier	Model	Type	125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
				Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB)											
42	David Clark Co., Inc. (Cont'd)	Model E150	Earmuff	7 (2.8)	6 (3.0)	11 (3.8)	21 (3.8)	27 (4.5)	31 (5.0)	40 (5.4)	33 (7.3)	33 (4.5)	Yes	18	
43		Model E850	Earmuff	8 (3.5)	7 (3.3)	12 (3.6)	24 (4.1)	28 (5.4)	38 (4.8)	39 (5.6)	33 (6.1)	29 (5.9)	Yes	18	
44		Model 7A	Earmuff	10 (6.4)	18 (9.9)	32 (9.4)	29 (7.2)	22 (9.2)	29 (8.4)	39 (9.4)	24 (8.8)	19 (9.6)	Yes	18	
45	Key to "type" of Headset: C = Carbon D = Dynamic	Model H-133C/AIC	Headset "D"	23 (1.8)	28 (1.8)	33 (2.8)	38 (3.5)	41 (4.0)	42 (5.3)	43 (3.5)	32 (4.3)	32 (4.1)	Yes	18	
46	S = Sound Powered	Model 19LB-87	Headset "D"	18 (3.0)	23 (2.5)	32 (2.4)	31 (4.4)	34 (3.8)	40 (5.6)	43 (5.5)	39 (5.6)	32 (7.6)	Yes	18	
47		Model 10BB	Headset "C"	16 (5.4)	20 (4.2)	29 (3.9)	37 (3.7)	29 (4.8)	38 (5.4)	40 (5.8)	35 (8.1)	34 (7.2)	Yes	18	
48		Model 15BM	Headset "C"	12 (3.8)	18 (4.1)	26 (4.0)	33 (3.1)	31 (4.5)	41 (4.9)	40 (4.2)	31 (7.4)	32 (8.1)	Yes	18	
49		Model C1017G-03	Headset "C"	18 (5.1)	23 (4.1)	30 (4.5)	36 (4.2)	34 (4.9)	42 (5.9)	42 (4.6)	32 (6.4)	33 (7.9)	Yes	18	
50		Model 10SB-A	Headset "S"	11 (3.8)	7 (3.1)	16 (3.7)	22 (5.4)	25 (5.8)	33 (4.6)	39 (6.8)	33 (6.5)	33 (8.0)	Yes	18	
51		Model 800SB-A	Headset "S"	6 (4.5)	10 (4.9)	16 (5.3)	24 (6.7)	27 (5.4)	36 (4.0)	39 (4.3)	41 (6.0)	38 (5.8)	Yes	18	
52		Model 800SM-A	Headset "S"	15 (4.4)	19 (3.7)	25 (4.5)	26 (4.0)	36 (5.3)	34 (4.2)	37 (5.1)	39 (8.4)	36 (7.5)	Yes	18	
53	H. E. Douglass Engineering Sales Company 2700 West Burbank Boulevard P.O. Box 7209	Sound Sentry Model 5000-B	Headband Earplug	23 (7.4)	22 (6.1)	19 (4.9)	26 (5.7)	35 (5.2)	37 (6.4)	37 (5.0)	34 (6.4)	29 (6.8)	Yes	8	
54	Burbank, California 91505	Model 5000-W	Headband Earplug	22 (8.1)	19 (5.8)	17 (4.6)	21 (6.1)	32 (6.0)	36 (6.3)	33 (5.5)	34 (7.4)	30 (6.8)	Yes	8	
55	E. I. duPont de Nemours & Co. Applied Technology Division Wilmington, Delaware 19898	Softseal	Formable Earplug	21 (3.7)	22 (3.3)	23 (3.8)	29 (4.7)	41 (3.3)	47 (4.0)	43 (2.7)	40 (6.0)	37 (6.6)	Yes	13	
56	E-A-R Corporation 376 University Avenue Westwood, Massachusetts 02090	E-A-R Plugs	Earplug	33 (4.7)	35 (4.5)	37 (5.4)	40 (3.9)	41 (3.3)	46 (4.5)	48 (4.2)	48 (4.1)	44 (3.8)	Yes	13	

I.D. No.	Manufacturer or Supplier	Model	Type	125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
				Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB)											
57	Eastern Safety Equipment Co., Inc. 45-17 Pearson St. Long Island City, N.Y. 11101	EHP-1	Earmuff	13 (1.9)	19 (3.2)	29 (4.3)	39 (7.0)	36 (4.3)	42 (4.4)	36 (3.7)	33 (4.3)	31 (4.8)	Yes	18	
58		EHP-2	Earmuff for Safety Cap	12 (2.5)	17 (3.0)	30 (4.6)	35 (5.6)	35 (4.5)	36 (4.3)	37 (4.2)	32 (4.1)	30 (2.9)	Yes	18	
59		EP1 & EP2 (EP1 with a safety cord)	Earplug	24	21	23	29	30	35	31	29	27	Yes		
60	Environmental Acoustical Research, Inc. Insta-Mold Western Headquarters P.O. Box 2146 Boulder, Colorado 80302	Insta-Mold Noiseguard	Molded Earplug	20 (3.9)	27 (4.4)	31 (6.1)	31 (4.5)	36 (3.3)	39 (5.3)	45 (4.7)	40 (5.0)	38 (5.5)	Yes	8	
61	Erb Plastics Inc. P. O. Box 156 Woodstock, Georgia 30188	Erb Earplugs	Earplug	25 (5.2)	25 (6.3)	25 (4.8)	26 (3.1)	35 (5.6)	39 (7.0)	40 (5.7)	39 (6.1)	37 (6.2)	Yes		
62		Erb Earmuffs	Earmuff	14	20	21	45	43	44	39	31	30	Yes		
63	The Fibre-Metal Products Co. Baltimore Pike at Brinton Lake Rd. Concordville, Pennsylvania 19331	Noiseguard Model 2030 Behind the Head	Earmuff	5 (2.7)	4 (3.0)	5 (5.5)	13 (6.7)	26 (6.3)	35 (5.5)	40 (6.7)	39 (6.4)	33 (9.0)	Yes	13	
64		Model 2011 Over the Head	Earmuff	12 (3.3)	13 (2.6)	19 (2.7)	28 (3.1)	39 (4.4)	39 (4.5)	38 (4.9)	35 (7.2)	31 (7.6)	Yes	13	
65		Model 2021	Earmuff	3	18	26	28	40	--	40	--	42	Yes	13	
66	Flents Products Co., Inc. 14 Orchard Street P.O. Box 2109 Belden Station Norwalk, Connecticut 06850	Anti-Noise Ear Stopples 020, 021, 025, 030, 035	Earplug (Wax-cotton)	19 (7.4)	20 (6.4)	21 (4.4)	26 (3.9)	30 (6.2)	38 (6.3)	40 (7.9)	41 (9.4)	36 (7.4)	Yes	7	
67		Quiet-Down 060	Earplug (Glass Fiber)	9 (1.4)	17 (2.6)	21 (3.0)	25 (3.7)	30 (3.1)	41 (3.5)	43 (3.7)	37 (3.6)	35 (4.9)	Yes	12	
68		Silaflex 0901, 092, 095	Earplug (Elastomer)	17 (3.8)	18 (3.5)	21 (4.2)	27 (5.5)	34 (3.4)	42 (3.1)	43 (3.6)	36 (2.7)	35 (3.9)	Yes	12	
69		Flexiplug 072, 073	Earplug (Silicone)	18 (6.2)	21 (5.3)	24 (6.5)	26 (5.5)	28 (7.2)	36 (5.1)	36 (5.0)	37 (3.7)	34 (6.4)	Yes	12	

I.D. No.	Manufacturer or Supplier	Model	Type	Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB) 125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
70	Flents Products Co. (cont'd)	Adjustoplug 076, 077	Earplug (Silicone)	21 (5.9)	24 (7.0)	30 (2.8)	31 (4.3)	34 (5.5)	38 (6.8)	36 (4.6)	41 (5.7)	40 (5.6)	Yes	12	—
71		V51R 075	Earplug (Vinyl)	22 (6.1)	23 (6.4)	25 (6.5)	30 (4.5)	33 (5.8)	41 (4.5)	39 (5.7)	36 (6.5)	36 (6.0)	Yes	13	—
72		Silenta Universal 080 U Overhead Position	Earmuff	9 (2.4)	13 (2.7)	25 (2.5)	38 (3.4)	38 (3.5)	44 (3.5)	39 (4.7)	38 (2.8)	33 (3.1)	Yes	12	—
73		Behind Head Position	Earmuff	8 (2.6)	11 (2.7)	23 (2.3)	36 (1.5)	37 (4.6)	41 (2.6)	37 (5.3)	37 (4.6)	31 (3.1)	Yes	12	—
74		Under Chin Position	Earmuff	8 (2.2)	12 (4.4)	20 (4.4)	33 (7.6)	34 (4.5)	43 (3.9)	38 (4.3)	34 (4.0)	33 (6.2)	Yes	12	—
75	Flood Safety Products Co. 1537 Walnut P.O. Box 1237	Flood Ear Insert	Earplug	22 (6.1)	23 (6.1)	25 (6.5)	30 (4.5)	33 (5.8)	41 (4.5)	39 (5.7)	36 (6.5)	36 (6.0)	Yes	13	—
76	Kansas City, Missouri 64141	Model 846000	Earmuff	8 (3.5)	7 (3.3)	12 (3.6)	24 (4.1)	28 (5.4)	38 (4.8)	39 (5.6)	33 (6.1)	29 (5.9)	Yes	18	—
77	French Laboratory 1938 Marconi Avenue Sacramento, California 95815	Soundown Personal Sound Attenuators	Earplug	21 (9)	23 (9)	26 (9)	31 (9)	35 (6)	42 (7)	39 (7)	39 (8)	34 (9)	Yes	2	—
78	Frontier Industrial Products 3521 Sunset Boulevard Los Angeles, California 90026	Model 3 Frontier Anti-Noise Earplug	Earplug	18 (8)	22 (9)	22 (7)	28 (9)	29 (7)	38 (8)	36 (6)	36 (8)	37 (9)	Yes	1	—
79	Glendale Optical Co., Inc. 130 Crossways Park Drive Woodbury, New York 11797	Quiet-Line Model GN-900	Earmuff	15 (3.1)	21 (3.1)	31 (2.7)	38 (3.4)	43 (4.6)	46 (6.0)	44 (3.5)	43 (4.6)	42 (7.2)	Yes	13	—
80		Model GN-901	Earmuff	15 (3.1)	21 (3.1)	31 (2.7)	38 (3.4)	43 (4.6)	46 (6.0)	44 (3.5)	43 (4.6)	42 (7.2)	Yes	13	—
81		Model GN-950	Earmuff	13 (4.1)	17 (4.9)	28 (3.9)	40 (6.4)	44 (5.9)	44 (5.8)	45 (4.1)	44 (4.3)	42 (7.6)	Yes	13	—

I.D. No.	Manufacturer or Supplier	Model	Type	Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB)									Tested by ANSI Z24.22-1957	Test Lab.	R
				125	250	500	1000	2000	3000	4000	6000	8000			
82	Glendale Optical Co. (cont'd)	Model GN-951	Earmuff	12 (2.6)	12 (2.4)	19 (2.9)	28 (4.5)	30 (3.7)	39 (5.5)	43 (5.3)	42 (6.4)	36 (6.0)	Yes	13	___
83		Ear Inserts	Earplug	24 (6)	21 (7)	23 (6)	29 (5)	30 (4)	35 (5)	31 (4)	29 (5)	27 (4)	Yes	13	___
84	Hearing Conservation Ltd. Amplivox House Beresford Avenue Wembley, Middlesex England HAO IRU	Auralguard III	Earmuff	14 (2.8)	16 (1.7)	24 (5.0)	34 (3.9)	37 (5.0)	42 (6.1)	44 (7.2)	38 (6.6)	37 (5.5)	Yes[2]	14	___
85		Supamuff	Earmuff	11 (3.8)	10 (3.8)	20 (3.8)	29 (4.4)	34 (3.8)	41 (4.9)	41 (4.9)	37 (5.5)	32 (8.2)	Yes[2]	14	___
86		Sonogard	Earmuff	16 (3)	22 (4)	29 (3.5)	40 (3.5)	40 (4.5)	43 (5.5)	44 (4.5)	41 (5.5)	37 (5.5)	Yes[2]	14	___
87		Gunfender	Amplitude Selective Earplug	Non-Linear; also for Impulsive Noises									No[3]	14	
88		Sonex	Earplug (Soft plastic)	8	11	13	19	27	30	25	30	32	Yes	14	___
89		Super Sonex	Earplug (Silicone)												
90	Hechler Brothers, Inc. 22-19 37th Avenue Long Island City, N.Y. 11101	Hearite Series "A" Straight	Earplug	21 (9)	25 (12)	21 (8)	23 (6)	27 (7)	32 (7)	38 (10)	43 (10)	52 (8)	Yes	1	___
91		Series "B" Curved	Earplug	17 (10)	21 (12)	19 (10)	21 (8)	27 (9)	30 (9)	35 (11)	38 (11)	49 (12)	Yes	1	___
92		Series "C" Flanged	Earplug	18 (6)	22 (8)	15 (6)	21 (7)	27 (5)	28 (6)	25 (6)	30 (7)	47 (8)	Yes	1	___
93	Hocks Laboratories 935 N.E. Couch Street Portland, Oregon 97214	Noise Braker	Earplug	Non-Linear									No[4]	9	
94	3M Company Occupational Health & Safety Products Department 3M Center St. Paul, Minnesota 55101	3M Brand Disposable Earplugs No. 8773	Earplug	19 (7.0)	20 (7.1)	22 (7.1)	28 (5.7)	31 (6.6)	39 (7.6)	40 (10.6)	39 (9.2)	39 (6.5)	Yes	13	___

I.D. No.	Manufacturer or Supplier	Model	Type	125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
				Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB)											
95	Marion Health & Safety, Inc. 9233 Ward Parkway Kansas City, Missouri 64114	Peacekeeper	Molded Earplug	18 (5.3)	16 (3.9)	18 (6.4)	20 (4.8)	36 (5.7)	41 (5.4)	44 (5.5)	40 (8.6)	35 (9.4)	Yes	13	___
96		Silent Partner	Self-Molding Earplug	21 (3.5)	23 (4.6)	26 (3.8)	31 (3.2)	40 (4.3)	44 (5.3)	43 (4.6)	45 (3.5)	39 (5.3)	Yes	13	___
97		Deci Damp	Self-Molding Disposable Earplug	33 (4.7)	35 (4.5)	37 (5.4)	40 (3.9)	41 (3.3)	46 (4.5)	48 (4.2)	48 (4.1)	44 (3.8)	Yes	13	___
98		Sound Stifler	Earmuff	14 (2.0)	20 (2.0)	31 (2.0)	45 (2.0)	42 (2.0)	44 (3.0)	39 (3.0)	31 (3.0)	30 (3.0)	Yes	1	___
99	Material Flow, Inc. 835 N. Wood St. Chicago, Illinois 60622	M-310	Earmuff	13 (2.2)	19 (3.3)	27 (3.8)	38 (4.6)	36 (3.9)	39 (4.7)	41 (5.5)	36 (5.2)	33 (4.3)	Yes	12	___
100	Mediprint Inc. 2510 Sutton Blvd. St. Louis, Missouri 63143	Noizout & Cord-a-Pair Noizouts	Earplug	22 (6.1)	23 (6.1)	25 (6.5)	30 (4.5)	33 (5.8)	41 (4.5)	39 (5.7)	36 (6.5)	36 (6.0)	Yes	13	___
101	Mine Safety Appliances Company 400 Penn Center Boulevard Pittsburgh, Pennsylvania 15235	Ear Defender	Earplug	22 (5.8)	22 (6.9)	25 (7.0)	28 (6.4)	31 (6.1)	36 (4.4)	28 (6.4)	30 (6.0)	25 (8.7)	Yes	17	___
102		Accu-Fit	Earplug	26 (5.9)	25 (6.5)	25 (7.9)	30 (5.6)	35 (5.4)	36 (5.7)	32 (6.2)	30 (10.4)	34 (8.9)	Yes	13	___
103		Noisefoe Mark II	Earmuff	19 (3.8)	25 (3.7)	35 (4.6)	42 (5.7)	37 (3.7)	34 (5.8)	36 (4.8)	36 (4.5)	35 (5.4)	Yes	13	___
104		Noisefoe Mark IV Over the Head	Earmuff	12 (2.4)	16 (1.9)	27 (4.2)	35 (2.0)	37 (3.7)	41 (4.5)	47 (5.3)	42 (5.0)	43 (6.7)	Yes	13	___
105		Behind the Head	Earmuff	17 (2.6)	18 (2.6)	29 (3.1)	36 (3.2)	38 (4.1)	44 (7.2)	44 (4.6)	43 (4.7)	43 (5.7)	Yes	13	___
106		Under the Chin	Earmuff	17 (2.6)	18 (2.6)	29 (3.1)	36 (3.2)	38 (4.1)	44 (7.2)	44 (4.6)	43 (4.7)	43 (5.7)	Yes[5]	11	___
107		Noisefoe Mark IV MC Over the Head	Earmuff	17 (3.1)	21 (2.6)	31 (3.5)	45 (4.8)	42 (6.4)	48 (6.1)	45 (7.4)	36 (6.2)	35 (8.0)	Yes	17	___
108		Behind the Head	Earmuff	17 (4.8)	21 (4.7)	31 (4.2)	41 (6.6)	40 (5.6)	44 (6.0)	44 (7.4)	34 (6.1)	33 (10.2)	Yes	17	___

I.D. No.	Manufacturer or Supplier	Model	Type	125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
				Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB)											
109	Mine Safety Appliances (cont'd)	Comfo 500 Over the Head	Earmuff	13 (2.4)	13 (1.8)	18 (3.0)	27 (3.4)	30 (3.0)	40 (4.7)	43 (4.3)	42 (7.3)	35 (7.3)	Yes	13	___
110		Behind the Head	Earmuff	12 (3.3)	13 (3.6)	15 (3.5)	29 (4.5)	30 (3.5)	38 (4.9)	45 (4.0)	42 (4.8)	38 (5.9)	Yes	13	___
111		Under the Chin	Earmuff	13 (3.1)	14 (3.8)	18 (3.9)	29 (4.4)	30 (3.6)	40 (4.2)	45 (3.8)	40 (5.5)	36 (6.5)	Yes	13	___
112		Circumaural Mark IV on MSA V-Gard Cap	Earmuff	9 (4.1)	13 (4.3)	26 (6.0)	35 (6.9)	37 (7.1)	41 (5.3)	41 (7.9)	36 (7.6)	24 (4.5)	Yes[6]	11	___
113		Circumaural MK-IV on MSA Comfo Cap	Earmuff	9 (4.1)	16 (5.0)	25 (4.4)	34 (5.7)	36 (6.1)	38 (5.2)	43 (3.8)	37 (7.6)	29 (9.1)	Yes[6]	11	___
114		Comfo 600 on MSA V-Gard Cap	Earmuff	10 (2.7)	15 (2.6)	25 (2.4)	36 (2.7)	33 (3.6)	43 (3.9)	43 (4.9)	32 (4.5)	27 (5.4)	Yes	13	___
115		Comfo 610, 620	Earmuff	10 (2.7)	15 (2.6)	25 (2.4)	36 (2.7)	33 (3.6)	43 (3.9)	43 (4.9)	32 (4.5)	27 (5.4)	Yes[5]	11	___
116	Morse Safety Products Company, 18103 Roseland Avenue, Cleveland, Ohio 44112	Morsafe 1305 Over the Head	Earmuff	13 (1.9)	19 (3.2)	29 (4.3)	39 (7.0)	36 (4.3)	42 (4.4)	36 (3.7)	33 (4.3)	31 (4.8)	Yes	18	___
117		Behind the Head	Earmuff	10 (1.9)	17 (3.0)	24 (3.5)	34 (4.7)	37 (4.5)	41 (4.5)	35 (4.1)	32 (3.5)	30 (4.7)	Yes	18	___
118		Under the Chin	Earmuff	11 (2.1)	17 (3.8)	27 (5.3)	37 (4.4)	32 (3.0)	38 (3.4)	32 (3.4)	31 (4.1)	31 (3.6)	Yes	18	___
119		Morsafe 1310 Over the Head	Earmuff	13 (2.2)	19 (3.3)	27 (3.8)	38 (4.6)	36 (3.9)	39 (4.7)	41 (5.5)	36 (5.2)	33 (4.3)	Yes	18	___
120		Behind the Head	Earmuff	12 (2.6)	19 (3.8)	26 (3.7)	35 (4.8)	35 (4.3)	38 (4.5)	42 (5.1)	36 (5.1)	33 (3.6)	Yes	18	___
121		Under the Chin	Earmuff	13 (2.2)	19 (2.9)	28 (4.0)	36 (4.3)	34 (3.4)	39 (3.3)	39 (4.4)	35 (4.4)	33 (4.1)	Yes	18	___
122		Morsafe 1705	Earmuff	12 (2.5)	17 (3.0)	30 (4.6)	35 (5.6)	35 (4.5)	36 (4.3)	37 (4.2)	32 (4.1)	30 (2.9)	Yes	18	___

I.D. No.	Manufacturer or Supplier	Model	Type	125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
				Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB)											
123	Pulmosan Safety Equipment Corp. 30-48 Linden Place Flushing, New York	PEP E (80333) Over the Head	Earmuff	13 (1.9)	19 (3.2)	29 (4.3)	39 (7.0)	36 (4.3)	42 (4.4)	36 (3.7)	33 (4.3)	31 (4.8)	Yes	18	
124		Behind the Head	Earmuff	10 (1.9)	17 (3.0)	24 (3.5)	34 (4.7)	37 (4.5)	41 (4.5)	35 (4.1)	32 (3.5)	30 (4.7)	Yes	18	
125		Under the Chin	Earmuff	11 (2.1)	17 (3.8)	27 (5.3)	37 (4.4)	32 (3.0)	38 (3.4)	32 (3.4)	31 (4.1)	31 (3.6)	Yes	18	
126		PEP 50 (80336)	Earmuff	15 (1.9)	22 (1.9)	33 (3.1)	44 (4.3)	43 (3.7)	48 (6.8)	48 (5.4)	39 (4.0)	32 (6.1)	Yes	18	
127		PEP 60 (80339)	Earmuff	12 (2.5)	17 (3.0)	30 (4.6)	35 (5.6)	35 (4.5)	36 (4.3)	37 (4.2)	32 (4.1)	30 (2.9)	Yes	18	
128		PEP 70 (80342)	Earmuff	10 (2.0)	17 (2.6)	28 (4.3)	37 (5.4)	36 (4.5)	44 (5.6)	39 (3.8)	32 (5.4)	30 (4.9)	Yes	18	
129		Comfit (80318)	Earplug	27 (6.9)	26 (5.9)	27 (6.4)	28 (4.5)	36 (6.6)	39 (7.4)	41 (8.7)	43 (9.6)	41 (5.6)	Yes	8	
130		# 80720	Disposable Earplugs	17 (3.8)	18 (3.5)	21 (4.2)	27 (5.5)	34 (3.4)	42 (3.1)	43 (3.6)	36 (2.7)	35 (3.9)	Yes	12	
131	Safety Direct P.O. Box 8907 Reno, Nevada 89507	Silencio Model # RBW-71	Earmuff	14 (2)	20 (2)	31 (2)	45 (2)	42 (2)	44 (3)	39 (3)	31 (3)	30 (3)	Yes	1	
132	Safety Ear Protector Co. 5356 West Pico Boulevard Los Angeles, California 90019	Sepco Model 100 PE	Pressure Equalized Earplug	18 (2.7)	17 (3.1)	18 (2.1)	24 (6.1)	30 (4.9)	36 (4.8)	39 (3.9)	43 (6.2)	46 (7.5)	Yes	4	
133		Sepco Model 200 PE	Pressure Equalized Earplug	18 (3.6)	17 (3.8)	19 (4.1)	28 (7.1)	30 (6.4)	35 (3.4)	38 (7.8)	41 (6.2)	43 (6.0)	Yes	4	
134	Scintrex Audio Division Scintrex Inc. 400 Creekside Drive Amherst Industrial Park Tonawanda, New York 14150	ED-50 Protectear	Earmuff	22	22	27	40 (Not Applicable)	40	46	43	38	48	No[7]	16	

I.D. No.	Manufacturer or Supplier	Model	Type	Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB) 125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
135	Sellstrom Manufacturing Co. Palatine, Illinois 60067	No. 400 Tonedown	Earmuff	9 (3)	18 (3)	28 (3)	42 (5)	38 (5)	40 (7)	45 (5)	37 (5)	34 (8)	Yes	10	—
136	Sigma Engineering Norton Safety Products Div. 11320 Burbank Blvd.	Com-Fit	Earplug	27 (6.9)	26 (5.9)	27 (6.4)	28 (4.5)	36 (6.6)	39 (7.4)	41 (8.7)	43 (9.6)	41 (5.6)	Yes	8	—
137	North Hollywood, Calif. 91601	Auri-Seal	Earplug	25 (6.8)	33 (6.2)	32 (6.9)	33 (6.6)	39 (5.9)	43 (8.8)	44 (9.4)	39 (8.4)	40 (7.8)	Yes	3	—
138		Sonic Ear-Valve Model 1-D	Ear Valve	Non-Linear; also for Impulsive Noises									No[8]		
139		Model 4-D	Ear Valve	Non-Linear; also for Impulsive Noises									No[8]		
140	Sound Master Corporation 1530 Broadway Oakland, California 94612	Sound Master Noise Attenuator	Custom formed Earplug (Silicone)	19	20	23	24	34	42	44	39	42	Yes	15	—
141	Southern First Aid Supply Co. 1120 Piedmont Drive Lexington, North Carolina 27292	Sound Checks	Earplug												
142	Surgical Mechanical Research, Inc. 900 W. 16th Street P.O. Box 1185 Newport Beach, California 92663	SMR Model #506	Earplug	30 (6.6)	31 (8.0)	34 (10.0)	32 (8.8)	34 (4.9)	39 (6.4)	43 (7.3)	43 (8.7)	43 (7.9)	Yes	19	—
143	United States Safety Service Co. 1535 Walnut Street Kansas City, Missouri 64108	SAF-EAR SHIELD Model 840	Earmuff	15 (1.9)	22 (1.9)	33 (3.1)	44 (4.3)	43 (3.7)	48 (6.8)	48 (5.4)	39 (4.0)	32 (6.1)	Yes	18	—
144		Model 842 Tri-Fit Over the Head	Earmuff	13 (1.9)	19 (3.2)	29 (4.3)	39 (7.0)	36 (4.3)	42 (4.4)	36 (3.7)	33 (4.3)	31 (4.8)	Yes	18	—
145		Behind the Head	Earmuff	10 (1.9)	17 (3.0)	24 (3.5)	34 (4.7)	37 (4.5)	41 (4.5)	35 (4.1)	32 (3.5)	30 (4.7)	Yes	18	—
146		Under the Chin	Earmuff	11 (2.1)	17 (3.8)	27 (5.3)	37 (4.4)	32 (3.0)	38 (3.4)	32 (3.4)	31 (4.1)	31 (3.6)	Yes	18	—

I.D. No.	Manufacturer or Supplier	Model	Type	125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
				Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB)											
147	U.S. Safety Service Co. (cont'd)	Model 845	Earmuff	15 (1.9)	22 (1.9)	33 (3.1)	44 (4.3)	43 (3.7)	48 (6.8)	48 (5.4)	39 (4.0)	32 (6.1)	Yes	18	___
148		Model 846	Earmuff	8 (3.5)	7 (3.3)	12 (3.6)	24 (4.1)	28 (5.4)	38 (4.8)	39 (5.6)	33 (6.1)	29 (5.9)	Yes	18	___
		Model 848													
149		Over the Head	Earmuff	13 (2.2)	19 (3.3)	27 (3.8)	38 (4.6)	36 (3.9)	39 (4.7)	41 (5.5)	36 (5.2)	33 (4.3)	Yes	18	___
150		Behind the Head	Earmuff	12 (2.6)	19 (3.8)	26 (3.7)	35 (4.8)	35 (4.3)	38 (4.5)	42 (5.1)	36 (5.1)	33 (3.6)	Yes	18	___
151		Under the Chin	Earmuff	13 (2.2)	19 (2.9)	28 (4.0)	36 (4.3)	34 (3.4)	39 (3.3)	39 (4.4)	35 (4.4)	33 (4.1)	Yes	18	___
		SAF-EAR INSERT													
152		Model 850	Earplug	22 (6.1)	23 (6.1)	25 (6.5)	30 (4.5)	33 (5.8)	41 (4.5)	39 (5.7)	36 (6.5)	36 (6.0)	Yes	18	___
	Welsh, A Textron Co. 2000 Plainfield Pike Cranston, R. I. 02920	SOUND-OFF													
		Model 4520													
153		Over the Head	Earmuff	16 (3.5)	21 (2.6)	31 (4.0)	42 (6.1)	43 (5.6)	44 (4.9)	46 (4.9)	38 (3.6)	34 (6.0)	Yes	13	___
154		Behind the Head	Earmuff	14 (3.4)	20 (3.7)	31 (3.5)	40 (5.1)	40 (5.4)	42 (4.5)	42 (5.0)	36 (5.4)	30 (5.2)	Yes	13	___
155		Under the Chin	Earmuff	13 (3.2)	19 (5.7)	31 (4.0)	40 (4.0)	41 (5.0)	42 (5.9)	42 (6.5)	36 (4.1)	30 (6.2)	Yes	13	___
		Model 4530													
156		Over the Head	Earmuff	17 (3.2)	21 (3.1)	32 (3.0)	42 (5.0)	44 (5.9)	45 (4.1)	50 (4.1)	40 (4.6)	37 (7.4)	Yes	13	___
157		Behind the Head	Earmuff	14 (3.3)	20 (4.6)	30 (5.1)	39 (4.7)	43 (5.5)	41 (6.3)	47 (6.9)	40 (4.8)	34 (6.0)	Yes	13	___
158		Under the Chin	Earmuff	15 (3.0)	21 (3.0)	32 (3.6)	40 (4.1)	43 (4.8)	43 (6.2)	48 (5.0)	39 (5.4)	32 (7.9)	Yes	13	___
		SOUND-OFF EAR INSERT													
159		Models 4551-4555 (sized)	Earplug	24 (7.7)	25 (6.8)	26 (7.3)	30 (4.4)	36 (5.9)	40 (6.8)	36 (6.1)	37 (8.7)	38 (8.3)	Yes	13	___

I.D. No.	Manufacturer or Supplier	Model	Type	125	250	500	1000	2000	3000	4000	6000	8000	Tested by ANSI Z24.22-1957	Test Lab.	R
				Average Attenuation in dB vs. Frequency in Hz (Standard Deviation in dB)											
160	Willson Products Div. ESB Incorporated 2nd & Washington Sts. P.O. Box 622 Reading, Pennsylvania 19603	Sound Ban #10 Under the Chin	Headband Earplug	23 (3.3)	19 (3.1)	18 (2.8)	21 (4.1)	34 (5.3)	42 (5.9)	44 (9.2)	43 (6.3)	46 (4.6)	Yes	4	
161		Behind the Head	Headband Earplug	22 (4.0)	18 (3.1)	19 (1.6)	24 (6.4)	34 (4.6)	48 (5.4)	44 (4.8)	40 (3.4)	36 (9.6)	Yes	4	
162		Over the Head	Headband Earplug	21 (4.2)	20 (3.0)	20 (4.8)	22 (3.4)	35 (3.5)	43 (4.7)	42 (5.0)	42 (12.7)	42 (4.1)	Yes	4	
163		Sound Ban #20 Behind the Head	Headband Earplug	22 (6.1)	18 (2.7)	19 (5.4)	24 (6.4)	33 (3.8)	47 (5.0)	44 (4.9)	42 (5.4)	45 (3.7)	Yes	4	
164		Under the Chin	Headband Earplug	18 (3.9)	18 (5.2)	19 (5.8)	25 (5.8)	35 (7.9)	45 (8.0)	46 (7.8)	46 (8.0)	43 (8.0)	Yes	4	
165		Sound Barrier Model 155	Earmuff	10 (6.0)	12 (6.1)	22 (5.9)	31 (7.8)	37 (7.1)	42 (7.7)	35 (6.2)	27 (9.0)	21 (8.0)	Yes	13	
166		Model 155A	Earmuff	15 (4.3)	18 (4.4)	25 (6.3)	35 (7.4)	40 (6.8)	44 (8.0)	36 (7.8)	26 (8.7)	23 (8.2)	Yes	13	
167		Model 250	Earmuff	9 (4.9)	16 (3.9)	26 (5.1)	34 (7.1)	35 (6.6)	39 (6.4)	39 (5.4)	30 (8.2)	25 (10.1)	Yes	5	
168		Model 258	Earmuff	15 (3.0)	20 (2.8)	35 (3.5)	41 (6.5)	44 (4.4)	45 (6.7)	47 (4.9)	40 (8.0)	34 (7.9)	Yes	5	
169		Model 360 Over the Head	Earmuff	19 (4.5)	27 (2.9)	37 (4.6)	44 (5.1)	41 (7.6)	46 (4.9)	46 (6.8)	39 (5.1)	42 (5.9)	Yes	5	
170		Behind the Head	Earmuff	15 (5.2)	17 (3.9)	26 (8.8)	42 (3.6)	36 (4.9)	38 (6.6)	38 (6.8)	33 (1.3)	34 (5.3)	Yes	4	
171		Under the Chin	Earmuff	14 (3.7)	16 (2.5)	24 (3.8)	39 (4.9)	33 (4.2)	39 (5.4)	39 (7.2)	34 (4.1)	40 (2.5)	Yes	4	
172		Model 360A Over the Head	Earmuff	21 (5.1)	24 (2.4)	35 (4.3)	46 (4.8)	42 (8.0)	47 (8.6)	45 (5.8)	37 (6.0)	41 (6.4)	Yes	5	
173		Behind the Head	Earmuff	17 (3.0)	16 (3.4)	25 (4.0)	36 (5.7)	34 (6.1)	39 (5.4)	36 (3.0)	35 (3.1)	41 (1.6)	Yes	4	
174		Under the Chin	Earmuff	17 (2.9)	17 (6.7)	26 (3.3)	40 (5.9)	35 (4.0)	38 (7.7)	34 (5.1)	34 (8.7)	41 (3.2)	Yes	4	
175		Sound Silencer EP100, EP100S, EP101, EP101S	Earplug	21 (7.1)	25 (8.0)	25 (7.6)	27 (7.5)	32 (6.8)	41 (6.3)	44 (7.5)	40 (8.5)	37 (11.2)	Yes	5	

FOOTNOTES REFERENCED IN THE LIST

1. ANSI A24.22-1957 was followed, except 15 subjects were tested once instead of 10 subjects three times.

2. ANSI Z24.22-1957 was followed, except 1/5 octave bands of white noise were used instead of pure tones.

3. Impulses were used to measure attenuation which increases from 5 dB for 140 dB-impulses to 27 dB for 190 dB-impulses. The hearing protector was designed to protect against impulsive sounds of gunfire or explosives without unwanted attenuation of speech.

4. Measured using an artificial external auditory meatus (canal) and broad band noise.

Sound	Attenuation in dB by Octave Bands							
Level	63	125	250	500	1000	2000	4000	8000
100 dBA	52	44	44	52	61	66	65	65
110 dBA	55	45	44	53	64	66	74	75
120 dBA	58	50	46	55	56	70	76	84

5. MSA tested these hearing protectors and reported that the attenuation values for the Noisefoe Mark IV (behind the head) and the Comfo 600 models could also be used for the Noisefoe Mark IV (under the chin) and the Comfo 610 and 620 models, respectively.

6. According to the specification sheets from MSA, a modification was made in the ANSI Z24.22-1957 test method to test this hearing protector, however, no explanation was given.

7. The hearing protector was tested mounted on a flat plate coupler attached to a microphone. The differences between the sound levels of tones reaching the microphone with and without the hearing protector in place are the attenuation values reported here.

8. No test procedure was indicated. It was stated that the hearing protectors are "for the attenuation of high level, impulsive, and repetitive impulse noises."

TEST LABORATORIES

1. Arcon Audiology Research Consultants, Inc.
   Palo Alto, California

2. Biological Acoustics Branch
   Biodynamics and Bionics Division
   Wright Patterson Air Force Base, Ohio

3. Bolt Beranek, Newman, Inc.
   235 Wyman Street
   Waltham, Mass. 02154

4. Century Speech and Hearing Center
   2080 Century Park East
   Los Angeles, California 99067

5. Dayton T. Brown Inc.
   Church Street
   Bohemia, LI, New York 11716

6. Department of Hearing and Speech Sciences
   University of Maryland
   College Park, Maryland 20742
   Mark E. Doudna, Ph.D.

7. Electrical Testing Laboratory
   2 East End Avenue
   New York, New York

8. Environmental Acoustics
   11322 Idaho Avenue
   Los Angeles, California 90025

9. Environmental Systems Corporation
   Suite 101 Parkway Bldg.
   11212 Pierce Parkway
   Knoxville, Tennessee 37921
   David M. Lipscomb
   Director, Noise and Acoustics Division

10. IIT Research Institute
    Engineering Mechanics Divisions
    10 West 35th Street
    Chicago, Illinois 60616

11. Mine Safety Appliances
    400 Penn Center Blvd.
    Pittsburgh, Pennsylvania 15235

12. Noise Pollution Consultants, Inc.
    705 Flatbush Avenue
    Brooklyn, New York 11225

13. Paul Michael and Associates
    667 Franklin Street
    State College, Pennsylvania 16801

14. Racal-Amplivox
    Beresford Avenue
    Wembly, Middlesex, England

15. San Diego State University
    Biomedical Section
    San Diego, California
    Maurice Schiff and Richard Riedman

16. Scintrex, Inc.
    400 Creekside Drive
    Amherst Industrial Park
    Tonawanda, New York 14150
    H. L. Schmidt, Director of Engineering

17. University of Pittsburgh
    Pittsburgh, Pennsylvania
    Kenneth C. Steward
    Associated Professor of Industrial Hygiene

18. Worcester Polytechnic Institute
    Institute Road
    Worcester, Massachusetts 01609

19. Subcommittee on Noise Research
    6041-1/2 Alston Street
    Los Angeles, California 90057

APPENDIX

DETERMINATION OF NOISE REDUCTION FOR HEARING PROTECTORS

by

Barry Lempert and Roy Fleming

The attenuation data listed in this report show how the effectiveness of each hearing protector depends upon the pitch or "frequency" (Hz) of the incoming sound. In industrial situations one usually needs to determine the amount by which the total workplace noise level (dBA) is effectively reduced by the hearing protector. Since industrial noise is usually made up of a mixture or "spectrum" of individual noises of various frequencies, it is necessary to employ some sort of formula in computing the noise reduction to take account of this spectrum. If information regarding the workplace noise spectrum (e.g. octave band levels) is not available, then safety factors must be included to adjust for this uncertainty. Furthermore, the performance of a hearing protector cannot be predicted exactly because of statistical variations, and it is therefore appropriate to adjust for these as well.

The "adjusted dBA-reduction factor" is denoted by "R" in the discussion that follows. After R has been calculated, it can be subtracted from the measured workplace noise level (dBA) to obtain the effective noise exposure level for the worker. For example, if the measured workplace noise level is 112 dBA and the R factor has been calculated as 27 decibels, then the worker's effective noise level is 85 dBA.

Three methods for calculating reduction factors are presented below with examples to illustrate how they are used. For all three methods the calculations are similar, using logarithms and antilogarithms. (Many electronic calculators can compute logarithms with the "log x" button and antilogarithms with the "10^x" or "y^x" button.) The general distinction among the three methods is the accuracy in determining the true reduction factor. Accuracy is affected by the type of noise data (e.g. octave band levels, dBC levels, dBA levels) which are available for use in calculations. The three computational methods may yield different R factors for a given hearing protector/noise combination because the less precise methods include adjustments to guard against overestimating the R factor, based on assumptions concerning possible noise spectra encountered in industry. As a general rule: the greater the accuracy of a method, the greater the computed value of R. Another consideration which affects the value of R in all methods is the adjustment factor to account for statistical variations from person to person. One such adjustment procedure which has been proposed is to reduce the listed attenuation values by subtracting twice the standard-deviation values obtained in the laboratory measurements. This procedure should rarely overestimate the degree of protection. If the standard deviations are not listed for a particular hearing protector, then it may be suitable to use the worst-case data listed for other protectors of similar design.

The attenuation data presented in this list of hearing protectors are used to calculate the "Q" values defined below, which are needed to calculate the dBA reduction factor. For convenience, Q values are given in Table 1 for the hearing protectors in this list.

Q_1 = attenuation at 125 Hz, plus 16.2 dB, minus 2 x (standard deviation)*

Q_2 = attenuation at 250 Hz, plus 8.7 dB, minus 2 x (standard deviation)

Q_3 = attenuation at 500 Hz, plus 3.3 dB, minus 2 x (standard deviation)

Q_4 = attenuation at 1000 Hz, minus 2 x (standard deviation)

Q_5 = attenuation at 2000 Hz, minus 1.2 dB, minus 2 x (standard deviation)

Q_6 = average of attenuations at 3000 and 4000 Hz, minus 1.0 dB, minus standard deviation at 3000 Hz, minus standard deviation at 4000 Hz

Q_7 = average of attenuations at 6000 and 8000 Hz, plus 1.1 dB, minus standard deviation at 6000 Hz, minus standard deviation at 8000 Hz

The numbers +16.2, +8.7, +3.3, 0, -1.2, -1.0, and +1.1 represent the A weighting relative response at the indicated octave band center frequencies.

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* The reader may choose to use some adjustment other than twice the listed standard deviations in order to account for statistical variations. If so, he should make appropriate modifications in the Q values.

Guide to choosing a method -

Method 1

Data required: Octave band noise levels at 125, 250, 500, 1000, 2000, 4000 and 8000 Hz, denoted by L_1, L_2, L_3, L_4, L_5, L_6, and L_7, respectively.
The dBA noise level.
Q values.

Comments: Most precise of the three methods.
Does not require an adjustment for spectrum uncertainty.
Computed R factor is appropriate only for a given noise spectrum, but the same R can be used for different dBA levels if only the intensity of the given noise changes.
R factor is subtracted from the workplace dBA level to give the effective dBA level.

Method 2

Data required: Q values
The difference (δ) between the dBC and dBA levels is needed to compute R, but not for the modified R described below.
δ (delta) = $L_C - L_A$

Comments: Second-most precise of the three methods.
Incorporates an adjustment of minus 3 dB to account for spectrum uncertainty.
The effective dBA level can be computed by using R or a modified R factor called "R_c." R_c is subtracted from the workplace dBC level, whereas R is subtracted from the dBA level.
R_c is a constant and can be written into the list by the user for permanent reference. R, however, will change for each situation in which the δ is not the same.

Method 3 (SIMPLEST METHOD)

Data required: Q values

Comments: Least precise of the three methods.
Incorporates an adjustment of minus 8.5 dB to account for spectrum uncertainty. (A less constraining procedure may be used if a certain assumption can be made - see "Discussion" for method 3.)
R factor can be computed without noise level data, and can be written into the list by the user for permanent reference.
R factor is subtracted from workplace dBA level to give the effective dBA level.

METHOD 1

Formula

$R = L_A - 10 \log S$

where R = dBA-reduction factor

L_A = workplace dBA noise level

$$S = \text{antilog}\,[0.1 \times (L_1-Q_1)] + \text{antilog}\,[0.1 \times (L_2-Q_2)] + \text{antilog}\,[0.1 \times (L_3-Q_3)] + \text{antilog}\,(0.1 \times (L_4-Q_4)] + \text{antilog}\,[0.1 \times (L_5-Q_5)] + \text{antilog}\,[0.1 \times (L_6-Q_6)] + \text{antilog}\,[0.1 \times (L_7-Q_7)]$$

L_1, L_2, L_3, L_4, L_5, L_6, and L_7 denote octave band sound levels at 125, 250, 500, 1000, 2000, 4000, and 8000 Hz, respectively

Q_1, Q_2, Q_3, Q_4, Q_5, Q_6, and Q_7 account for the attenuation of a given hearing protector (method of computation shown on page 22)

Notes: 1. Q VALUES FOR HEARING PROTECTORS IN THE LIST ARE IN TABLE 1.

2. antilog $[x] = 10^x$.

Example

Suppose a hearing protector is needed in an area with a noise level of 95 dBA and octave band noise levels of

125	250	500	1000	2000	5000	8000 Hz
88	89	85	89	89	89	80 dB

and a fictitious hearing protector with the following attenuation characteristics is used:

	125	250	500	1000	2000	3000	4000	6000	8000 Hz
Mean Attenuation	21	22	23	29	41	47	43	40	37 dB
Standard Deviation	3.7	3.3	3.8	4.7	3.3	4.0	2.7	6.0	6.6

The "Q" (see page 22 and Table 1) and "L-Q" values in S are:

$Q_1 = 21 + 16.2 - (2 \times 3.7) = 29.8$ $\quad (L_1-Q_1) = 88 - 29.8 = 58.2$
$Q_2 = 22 + 8.7 - (2 \times 3.3) = 24.1$ $\quad (L_2-Q_2) = 89 - 24.1 = 64.9$
$Q_3 = 23 + 3.3 - (2 \times 3.8) = 18.7$ $\quad (L_3-Q_3) = 85 - 18.7 = 66.3$
$Q_4 = 29 - (2 \times 4.7) = 19.6$ $\quad (L_4-Q_4) = 89 - 19.6 = 69.4$
$Q_5 = 41 - 1.2 - (2 \times 3.3) = 33.2$ $\quad (L_5-Q_5) = 89 - 33.2 = 55.8$
$Q_6 = (47 + 43)/2 - 1.0 - 4.0 - 2.7 = 37.3$ $\quad (L_6-Q_6) = 89 - 37.3 = 51.7$
$Q_7 = (40 + 37)/2 + 1.1 - 6.0 - 6.6 = 27.0$ $\quad (L_7-Q_7) = 80 - 27.0 = 53.0$

Applying the formula for the dBA reduction factor,

$$R = L_A - 10 \log S$$

where $L_A = 95$

$$\begin{aligned} \text{and } S &= \text{antilog } (0.1 \times 58.2) + \text{antilog } (0.1 \times 64.9) \\ &+ \text{antilog } (0.1 \times 66.3) + \text{antilog } (0.1 \times 69.4) \\ &+ \text{antilog } (0.1 \times 55.8) + \text{antilog } (0.1 \times 51.7) \\ &+ \text{antilog } (0.1 \times 53.0) \\ &= 660{,}693 + 3{,}090{,}295 + 4{,}265{,}795 + 8{,}709{,}636 \\ &+ 380{,}189 + 147{,}911 + 199{,}526 \\ &= 17{,}454{,}045. \end{aligned}$$

$$R = 95 - 10 \log (17{,}454{,}045) = 95 - 72.4 = \underline{22.6 \text{ dB}}$$

The effective dBA level is

$$L_A - R = 95 - 22.6 = 72.4 \text{ dBA},$$

which, incidently, is equal to the value of the term "10 log S."

Discussion

The R factor calculated by this method only has an adjustment to account for statistical variations which is accomplished by subtracting twice the standard deviation values from the corresponding attenuation values. No adjustment for spectrum uncertainty is needed because the attenuation data are subtracted directly from the octave band levels of the noise. This method has the drawback that a different R has to be calculated for each noise spectrum; however, it is the most precise method and may be used as an ideal against which other methods can be compared.

METHOD 2

Formula

$R = R_c - \delta$

$= 5.5 - 10 \log T - \delta$

where R = dBA-reduction factor

R_c = 5.5 - 10 log T (see discussion of R_c, p. 28)

$\delta = L_C - L_A$

L_C = workplace dBC noise level

L_A = workplace dBA noise level

10 log T values* are given in Table 1 for hearing protectors in this list

Example

Suppose a fictitious hearing protector with the following attenuation characteristics is used:

	125	250	500	1000	2000	3000	4000	6000	8000 Hz
Mean Attenuation	21	22	23	29	41	47	43	40	37 dB
Standard Deviation	3.7	3.3	3.8	4.7	3.3	4.0	2.7	6.0	6.6

If this hearing protector were actually in the list, "10 log T" could be found by using the protector's I.D. No. to locate the value in Table 1. In this case, however, the "10 log T" value must be computed as shown on page 27, and is equal to -14.9.

Workplace noise levels are: $L_C = 96$, $L_A = 95$

---

* If "10 log T" is not listed, T can be calculated by the formula:

$$T = \text{antilog}(-0.1 \times Q_1) + \text{antilog}(-0.1 \times Q_2) + \text{antilog}(-0.1 \times Q_3) + \text{antilog}(-0.1 \times Q_4) + \text{antilog}(-0.1 \times Q_5) + \text{antilog}(-0.1 \times Q_6) + \text{antilog}(-0.1 \times Q_7)$$

where Q_1, Q_2, Q_3, Q_4, Q_5, Q_6, and Q_7 account for attenuation of the hearing protector (method of computation shown on page 22).

Note that antilog $(x) = 10^x$.

Applying the formula,

$$R = R_c - \delta$$

$$\begin{aligned} \text{where } R_c &= 5.5 - 10 \log T \\ &= 5.5 - (-14.9) \\ &= 20.4 \text{ dB} \end{aligned}$$

and $\delta = 96 - 95 = 1$

$$R = 20.4 - 1$$

$$= 19.4 \text{ dB}$$

The effective dBA level is

$$L_A - R = 95 - 19.4 = 75.6 \text{ dBA}$$

or, using R_c and the dBC noise level, the effective dBA level is

$$L_C - R_C = 96 - 20.4 = 75.6 \text{ dBA}$$

Computation of "10 log T"

The "Q" values are:

$$\begin{aligned}
Q_1 &= 21 + 16.2 - (2 \times 3.7) = 29.8 \\
Q_2 &= 22 + 8.7 - (2 \times 3.3) = 24.1 \\
Q_3 &= 23 + 3.3 - (2 \times 3.8) = 18.7 \\
Q_4 &= 29 - (2 \times 4.7) = 19.6 \\
Q_5 &= 41 - 1.2 - (2 \times 3.3) = 33.2 \\
Q_6 &= (47 + 43)/2 - 1.0 - 4.0 - 2.7 = 37.3 \\
Q_7 &= (40 + 37)/2 - 1.1 - 6.0 - 6.6 = 27.0
\end{aligned}$$

$$\begin{aligned}
\text{and } T &= \text{antilog}(-0.1 \times 29.8) + \text{antilog}(-0.1 \times 24.1) \\
&+ \text{antilog}(-0.1 \times 18.7) + \text{antilog}(-0.1 \times 19.6) \\
&+ \text{antilog}(-0.1 \times 33.2) + \text{antilog}(-0.1 \times 37.3) \\
&+ \text{antilog}(-0.1 \times 27.0) \\
&= 0.00105 + 0.00389 + 0.01349 + 0.01906 \\
&+ 0.00048 + 0.00019 + 0.00200 \\
&= 0.03205
\end{aligned}$$

$$\begin{aligned}
10 \log T &= 10 \log (0.03205) \\
&= 10 \times (-1.49) \\
&= -14.9
\end{aligned}$$

Discussion

This method is based upon a simplifying assumption which is applied to a procedure developed by J. Botsford (Sound and Vibration, Nov. 1973). A "sound level conversion" value, or a modified R factor (denoted herein as R_c), is computed by using the attenuation data of a hearing protector and a single noise spectrum which is composed of equal sound pressure levels for all octave bands ("pink" noise). (This noise spectrum represents the median "shape," with δ equal to approximately 1.5, of the sample of 100 noise spectra shown in Figure 1, which were chosen to correspond to the distribution of noise exposures found in major industries in the U.S.) The computation of R_c involves subtracting the effective dBA level from the dBC level of the assumed pink noise. The result of this subtraction can be shown to equal "8.5 - 10 log T," where T is derived from the hearing protector attenuation data including adjustments for statistical variations. However, an additional adjustment* of 3 dB is then required to protect against overestimation because of the possible variations in the spectra of actual workplace noises. The dBA-reduction factor, R, is then just R_c minus δ. Thus, the expression for R is:

$$\begin{aligned} R &= 8.5 - 10 \log T - \delta - 3 \\ &= 5.5 - 10 \log T - \delta \\ &= R_c - \delta \end{aligned}$$

As shown in the example for this method, the effective dBA level can be computed using R_c as well as R. The only difference is that R_c is subtracted from the dBC level whereas R is subtracted from the dBA level. Being a constant for a given hearing protector, R_c is convenient to use if the workplace dBC noise level is known; furthermore, it makes determination of δ unnecessary. R, however, is dependent on the value of δ (i.e. $L_C - L_A$) for the workplace noise and is not necessarily constant for a given hearing protector.

Since a variable R factor could cause some difficulty in its use, a conservative procedure can be used to calculate a constant value of R if one has sufficient knowledge of the δ values of noise in his workplace. The procedure is to determine the highest value of δ at the workers' positions of concern and use that value in the equation for R. The resulting R factor can be subtacted from dBA levels throughout the workplace to determine the effective dBA noise levels. As an example, if one were sure that the value of δ were no greater than 5.0 at all locations in his factory, then a single R factor of 15.4 dB could be used for the hearing protector of the above example ($R = R_c - \delta = 20.4 - 5.0$).

---

*This adjustment factor is the 98th percentile point in the error distribution of values of R computed using δ as an index of the noise spectrum versus values of R computed using octave band sound pressure levels.

METHOD 3

Formula

$R = -1.5 - 10 \log T$

where R = dBA-reduction factor

10 log T values* are given in Table 1 for hearing protectors in this list

Example

Suppose a hearing protector is selected from the list. The "10 log T" value can be found by using the I.D. No. corresponding to the selected protector to locate the value in Table 1.

As an example, a fictitious hearing protector with a "10 log T" value of -14.9 is used below.

Applying the formula,

$$\begin{aligned} R &= -1.5 - 10 \log T \\ &= -1.5 - (-14.9) \\ &= \underline{13.4 \text{ dB}} \end{aligned}$$

For a workplace dBA level of 95, the effective dBA level is

$L_A - R = 95 - 13.4 = 81.6$ dBA

If a hearing protector is used which is not in this list, "10 log T" must be computed. For the fictitious protector used in the example of method 2, the computations are shown on page 27.

* If "10 log T" is not listed, T can be calculated by the formula:

$$\begin{aligned} T &= \text{antilog } (-0.1 \times Q_1) + \text{antilog } (-0.1 \times Q_2) \\ &+ \text{antilog } (-0.1 \times Q_3) + \text{antilog } (-0.1 \times Q_4) \\ &+ \text{antilog } (-0.1 \times Q_5) + \text{antilog } (-0.1 \times Q_6) \\ &+ \text{antilog } (-0.1 \times Q_7) \end{aligned}$$

where Q_1, Q_2, Q_3, Q_4, Q_5, Q_6, and Q_7 account for attenuation of the hearing protector (method of computation shown on page 22).

Note that antilog $(x) = 10^x$.

Discussion

This method requires no noise measurements to compute R. The formula has been derived by assuming a noise spectrum which is composed of equal sound pressure levels for all octave bands ("pink" noise). (This noise spectrum represents the median "shape" of the sample of 100 noise spectra shown in Figure 1, which were chosen to correspond to the distribution of noise exposures found in major industries in the U.S.). The computation of R involves subtracting the effective dBA level from the dBA level of the assumed pink noise. The result of this subtraction can be shown to equal "7.0 - 10 log T," where T is derived from the hearing protector attenuation data including adjustments for statistical variations. However, an additional adjustment* of 8.5 dB is then required to protect against overestimation of R because of variation in the noise spectra of actual industrial noises. The resulting expression for R is:

$$R = 7.0 - 10 \log T - 8.5$$
$$= -1.5 - 10 \log T$$

Once the value of "10 log T" is determined, either by calculations or by finding it in Table 1, R is computed by a single subtraction. A possible disadvantage with this method is that too low of a value of R might result because of the necessity for having a large adjustment factor (8.5 dB). To demonstrate differences that can occur between the methods, the R factors in the examples for methods 1, 2, and 3 were computed using the same hearing protector. The results are: method 1 (22.6 dB), method 2 (19.4 dB), and method 3 (13.4 dB). If an unsatisfactory R is computed using method 3, several alternatives are available to the user. Possibly a different hearing protector with a larger R factor could be selected, or additional noise data (octave band sound levels or dBC levels) can be obtained in order to use method 1 or method 2, which will usually yield greater values of R.

Even if the noise data needed to compute R by method 2 is not directly available, the method may still be used if a certain assumption can be made about the term δ (delta), which is the difference between the dBC (L_C) and dBA (L_A) levels of the workplace noise ($\delta = L_C - L_A$). The procedure is to assume the highest value of δ expected for actual noises within a given workplace and use that value in the formula for R presented in method 2 (i.e. $R = 5.5 - 10 \log T - \delta$). The assumed value of δ should be based on actual noise measurements, noise data from a similar operation, or some other well-founded reason.

---

* This adjustment factor is the 98th percentile point in the error distribution of values of R computed by the method 3 procedure versus values of R computed using octave band sound pressure levels of the 100 noises shown in Figure 1.

The formula for R in method 3 can be rearranged to illustrate how it is similar to the method 2 formula:

$$
\begin{aligned}
R &= -1.4 - 10 \log T \\
  &= 5.5 - 10 \log T - 7.0
\end{aligned}
$$

In this form, the method 3 formula is shown to be equal to the method 2 formula for a δ value of 7.0. This point is important because a certain amount of caution should be exercised in using method 3 in workplaces where δ might be greater than 7.0. This situation is relatively easy to recognize because it implies dominant low frequency noise, with a heavy rumble or deep roar. This slight restriction in the application of the formula emerged out of the development of the method. Method 3 was designed to meet the requirements of (1) having a simple, short procedure for calculating R without knowing any noise levels; (2) obtaining a constant R factor (for a given hearing protector) which can be subtracted from measured dBA levels to give the effective dBA level; and (3) having a value of R which is not unreasonably small for most protectors. Without the indicated restriction, an adjustment factor larger than 8.5 dB would be needed which could result in values of R being almost too low to be useful. Therefore, use caution in applying a method 3 R factor if low frequency noises are present, and when in doubt, use method 1 or 2, if possible.

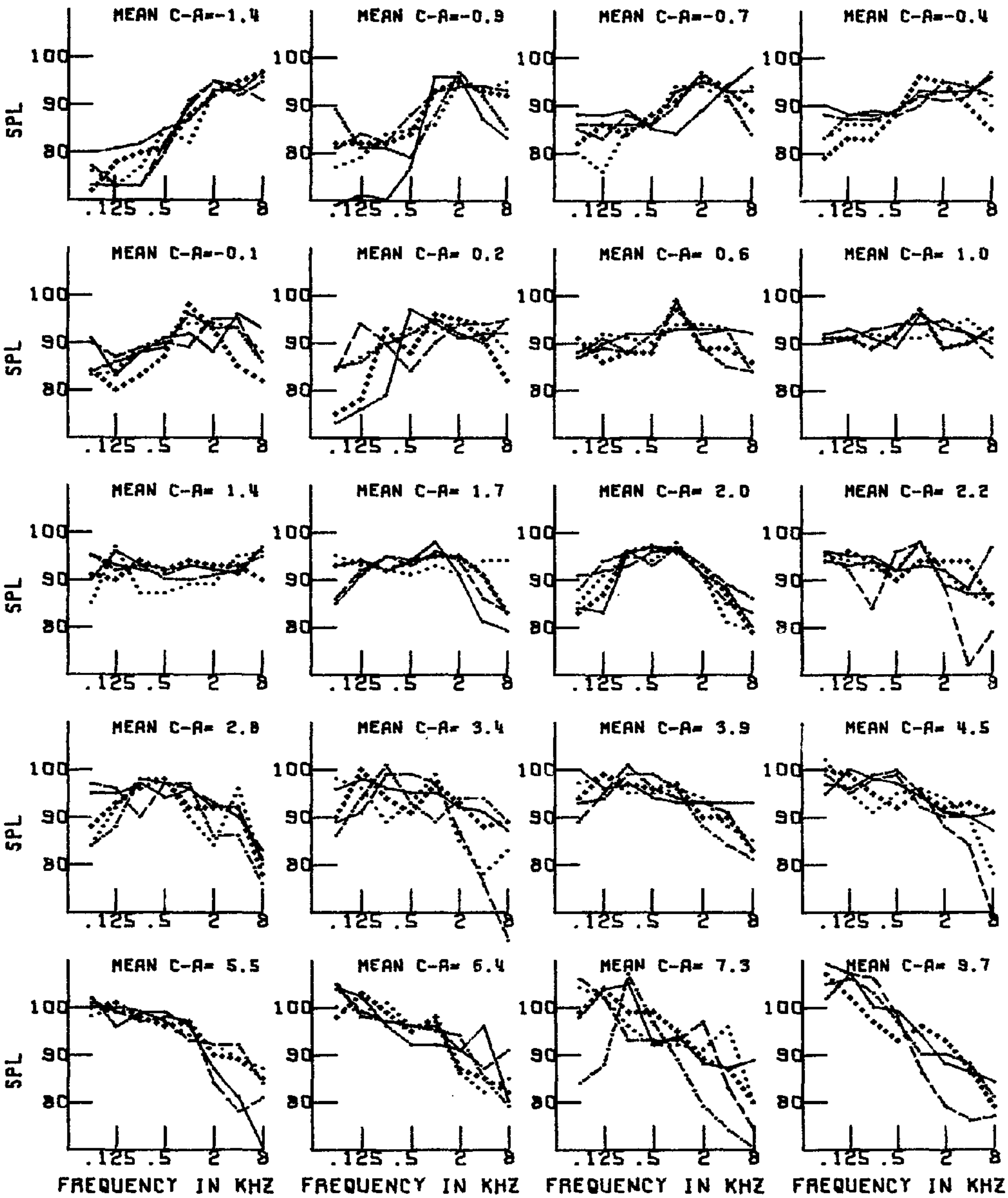

Figure 1. TYPICAL INDUSTRIAL NOISE SPECTRA, 20 groups of 5 spectra ordered on the basis of their δ values ($L_C - L_A$ or C-A). The 100 spectra have been "normalized" to 100 dBA to facilitate comparisons. (This sample of 100 noise spectra was selected from 579 spectra presented by Karplug and Bonvallet in "A Noise Survey of Manufacturing Industries," <u>AIHA Quarterly</u>, Dec. 1953.)

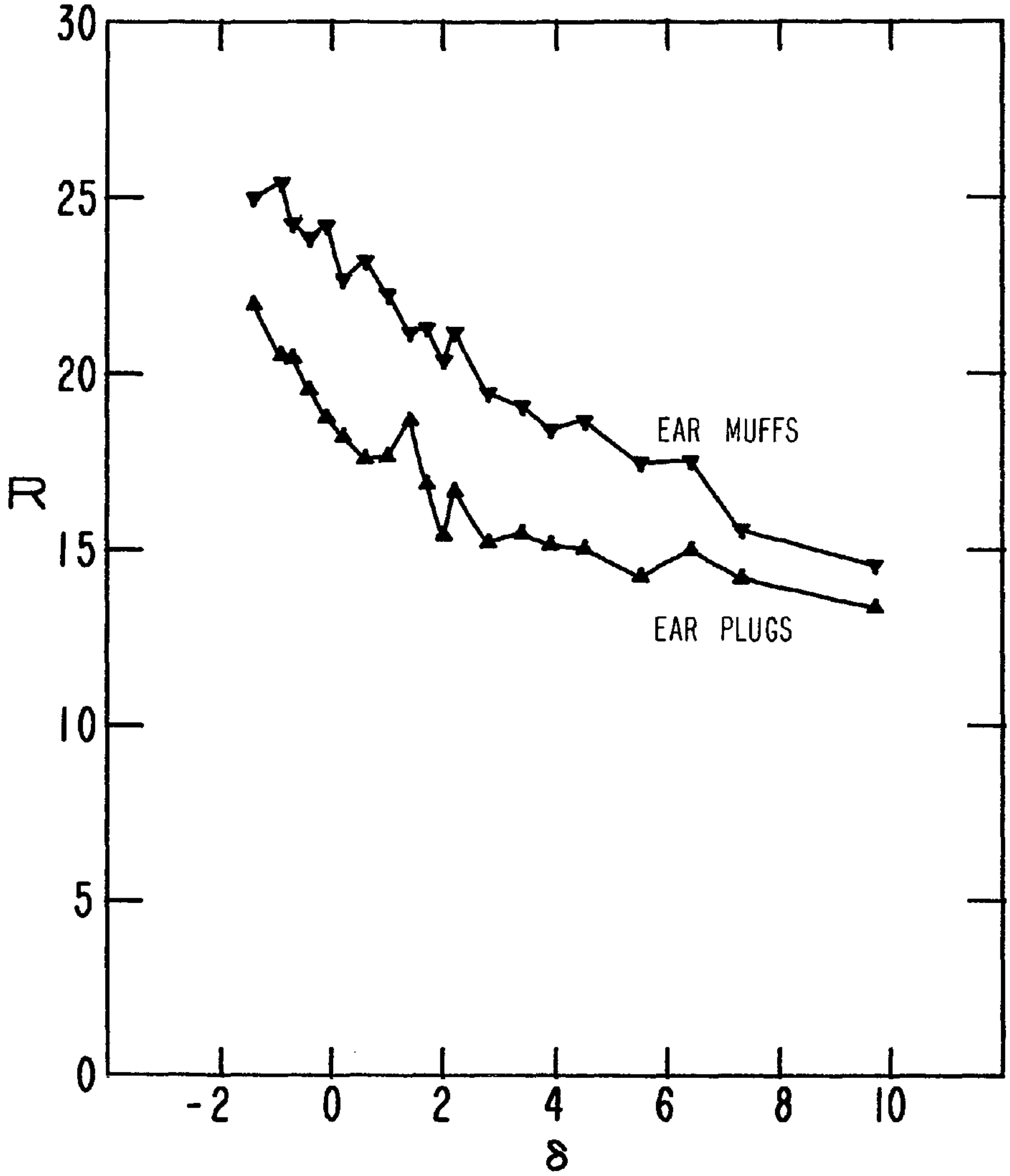

Figure 2. MEAN ADJUSTED dBA-REDUCTION FACTOR (R) FOR 48 EARPLUGS AND 102 EARMUFFS AS A FUNCTION OF δ(i.e. $L_C - L_A$)

Table 1. VALUES OF "Q" AND "10 LOG T" FOR HEARING PROTECTORS IN THIS LIST (Values were not calculated for hearing protectors not tested by ANSI Z24.22-1957 and/or not having standard deviation data.)

I.D. NO.	TYPE	Q1	Q2	Q3	Q4	Q5	Q6	Q7	10 LOG T
1	PLUG	25.2	23.7	18.3	18.0	24.8	34.5	32.1	-13.7
2	PLUG	29.6	22.9	20.7	19.8	22.8	31.8	29.4	-14.9
3	PLUG	20.4	15.9	15.5	18.2	16.4	23.8	22.8	-9.6
4	PLUG	30.8	21.1	18.7	19.8	22.6	25.8	26.8	-13.7
5	PLUG	22.2	14.7	6.3	7.0	15.8	13.5	24.6	-2.6
6	PLUG								
7	MUFF	25.2	24.7	30.3	41.0	37.8	34.5	25.6	-19.7
8	PLUG	25.8	20.5	17.7	20.6	28.8	31.0	30.8	-14.0
9	MUFF	20.8	20.3	22.7	30.2	34.8	30.3	21.6	-14.9
10	MUFF	27.2	23.3	27.1	34.0	30.0	30.6	25.6	-18.7
11	MUFF	25.2	23.1	29.9	37.2	32.0	28.9	23.1	-18.0
12	MUFF	24.2	25.1	29.7	33.8	34.2	32.0	25.3	-19.1
13	MUFF	18.0	16.5	17.5	26.2	32.2	29.9	18.2	-11.2
14	MUFF	20.0	18.3	22.7	30.4	26.2	28.9	29.6	-14.5
15	MUFF	19.2	16.1	19.5	25.0	27.4	30.6	28.0	-12.6
16	MUFF	18.4	17.3	22.1	24.2	27.2	31.1	27.5	-13.2
17	MUFF	19.8	19.7	22.7	23.8	27.0	26.2	21.6	-13.8
18	MUFF	24.6	20.5	27.9	33.2	39.4	31.1	27.3	-17.6
19	MUFF	26.0	20.1	18.9	28.0	16.6	25.5	17.7	-11.6
20	MUFF	25.2	18.1	22.9	27.2	18.4	24.4	22.7	-13.1
21*	PLUG	21.0	16.9	14.7	17.6	23.0	30.5	28.3	-10.6
22*	PLUG	21.0	16.5	17.1	15.2	22.6	29.7	29.0	-10.6
23*	MUFF	25.6	19.7	25.1	31.8	31.4	36.2	34.7	-17.3
24*	MUFF	24.4	24.1	27.1	31.6	36.4	36.3	24.6	-18.5
25*	MUFF	23.6	18.7	24.9	26.8	29.0	34.1	31.4	-15.9
26	PLUG	26.0	19.5	15.3	21.0	20.2	28.8	24.6	-11.8
27	PLUG	26.0	19.5	15.3	21.0	20.2	28.8	24.6	-11.8
28	MUFF	27.4	26.9	30.1	35.4	34.4	34.8	26.5	-20.9
29	MUFF	28.4	26.7	30.3	32.0	31.0	27.9	18.8	-16.8
30	MUFF	33.2	28.3	28.7	32.0	26.0	28.1	27.0	-20.0
31	MUFF	23.2	19.7	24.1	23.8	24.8	27.0	25.1	-15.0
32	MUFF	22.2	20.5	22.7	26.2	25.8	31.1	21.8	-14.9
33	MUFF	25.4	21.3	23.7	25.0	26.2	29.9	24.0	-16.0
34	MUFF	22.4	19.7	20.3	24.6	26.8	28.4	23.9	-14.3
35	MUFF	23.0	18.1	19.7	28.2	24.8	27.2	24.4	-13.8
36	MUFF	24.8	21.1	22.7	28.8	27.0	28.8	26.1	-16.3
37	MUFF	23.0	20.1	21.9	25.4	25.2	29.4	26.9	-15.2
38	MUFF	24.8	21.9	23.3	27.4	26.0	30.3	26.6	-16.6
39	MUFF	23.8	22.1	23.5	26.0	28.2	28.5	27.7	-16.6
40	MUFF	23.0	23.3	22.3	26.2	27.0	30.0	28.7	-16.5
41	MUFF	21.6	20.5	20.7	22.2	23.6	27.9	23.8	-13.9
42	MUFF	17.6	8.7	6.7	13.4	16.8	24.1	22.3	-3.5
43	MUFF	17.2	9.1	8.1	15.8	16.0	27.1	20.1	-4.4
44	MUFF	13.4	6.9	16.5	14.6	2.4	15.2	4.2	1.1
45	MUFF	35.6	33.1	30.7	31.0	31.8	32.7	24.7	-21.6

* The ANSI 1957 test standard was not followed explicitly; see footnote 1 on page 17.

Table 1. Continued

I.D. NO.	TYPE	Q1	Q2	Q3	Q4	Q5	Q6	Q7	10 LOG T
46	MUFF	28.2	26.7	30.5	22.2	25.2	29.4	23.4	-17.1
47	MUFF	21.4	20.3	24.5	29.6	18.2	26.8	20.3	-13.2
48	MUFF	20.6	18.5	21.3	26.8	20.8	30.4	17.1	-12.1
49	MUFF	24.0	23.5	24.3	27.6	23.0	30.5	19.3	-15.0
50	MUFF	19.6	9.5	11.9	11.2	12.2	23.6	19.6	-4.7
51	MUFF	13.2	8.9	8.7	10.6	15.0	28.2	28.8	-3.6
52	MUFF	22.4	20.3	19.3	18.0	24.2	25.2	22.7	-12.6
53	PLUG	24.4	18.5	12.5	14.6	23.4	24.6	19.4	-8.9
54	PLUG	22.0	16.1	11.1	8.8	18.8	21.7	18.9	-5.6
55	PLUG	29.8	24.1	18.7	19.6	33.2	37.3	27.0	-14.9
56	PLUG	39.8	34.7	29.5	32.2	33.2	37.3	39.2	-25.3
57	MUFF	25.4	21.3	23.7	25.0	26.2	29.9	24.0	-16.0
58	MUFF	23.2	19.7	24.1	23.8	24.8	27.0	25.1	-15.0
59	PLUG								
60	PLUG	28.4	26.9	22.1	22.0	28.2	31.0	29.6	-17.1
61	PLUG	30.8	21.1	18.7	19.8	22.6	25.8	26.8	-13.7
62	MUFF								
63	MUFF	15.8	6.7	-2.7	-0.4	12.2	24.3	21.7	5.1
64	MUFF	21.6	16.5	16.9	21.8	29.0	28.1	19.3	-11.5
65	MUFF								
66	PLUG	20.4	15.9	15.5	18.2	16.4	23.8	22.8	-9.6
67	PLUG	22.4	20.5	18.3	17.6	22.6	33.8	28.6	-12.7
68	PLUG	25.6	19.7	15.9	16.0	26.0	34.8	30.0	-11.7
69	PLUG	21.8	19.1	14.3	15.0	12.4	24.9	26.5	-8.2
70	PLUG	25.4	18.7	27.7	22.4	21.8	24.6	30.3	-14.6
71	PLUG	26.0	18.9	15.3	21.0	20.2	28.8	24.6	-11.7
72	MUFF	20.4	16.3	23.3	31.2	29.8	32.3	30.7	-13.9
73	MUFF	19.0	14.3	21.7	33.0	26.6	30.1	27.4	-12.1
74	MUFF	19.8	11.9	14.5	17.8	23.8	31.3	24.4	-8.7
75	PLUG	26.0	19.5	15.3	21.0	20.2	28.8	24.6	-11.8
76	MUFF	17.2	9.1	8.1	15.8	16.0	27.1	20.1	-4.4
77	PLUG	19.2	13.7	11.3	13.0	21.8	25.5	20.6	-7.1
78	PLUG	18.2	12.7	11.3	10.0	13.8	22.0	20.6	-5.2
79	MUFF	25.0	23.5	28.9	31.2	32.6	34.5	31.8	-19.5
80	MUFF	25.0	23.5	28.9	31.2	32.6	34.5	31.8	-19.5
81	MUFF	21.0	15.9	23.5	27.2	31.0	33.6	32.2	-13.8
82	MUFF	23.0	15.9	16.5	19.0	21.4	29.2	27.7	-11.2
83	PLUG	28.2	15.7	14.3	19.0	20.8	23.0	20.1	-9.9
84*	MUFF	24.6	21.3	17.3	26.2	25.8	28.7	26.5	-14.2
85*	MUFF	19.6	11.1	15.7	20.2	25.2	30.2	21.9	-8.7
86*	MUFF	26.2	22.7	25.3	33.0	29.8	32.5	29.1	-18.5
87	PLUG								
88	PLUG								
89	PLUG								
90	PLUG	19.2	9.7	8.3	11.0	11.8	17.0	30.6	-3.6

* The ANSI 1957 test standard was not followed explicitly; see footnote 2 on page 17.

Table 1. Continued

I.D. NO.	TYPE	Q1	Q2	Q3	Q4	Q5	Q6	Q7	10 LOG T
91	PLUG	13.2	5.7	2.3	5.0	7.8	11.5	21.6	1.7
92	PLUG	22.2	14.7	6.3	7.0	15.8	13.5	24.6	-2.6
93	PLUG								
94	PLUG	21.2	14.5	11.1	16.6	16.6	20.3	24.4	-7.5
95	PLUG	23.6	16.9	8.5	10.4	23.4	30.6	20.6	-5.7
96	PLUG	30.2	22.5	21.7	24.6	30.2	32.6	34.3	-17.3
97	PLUG	39.8	34.7	29.5	32.2	33.2	37.3	39.2	-25.3
98	MUFF	26.2	24.7	30.3	41.0	36.8	34.5	25.6	-19.9
99	MUFF	24.8	21.1	22.7	28.8	27.0	28.8	26.1	-16.3
100	PLUG	26.0	19.5	15.3	21.0	20.2	28.8	24.6	-11.8
101	PLUG	26.6	16.9	14.3	15.2	17.6	20.2	13.9	-8.0
102	PLUG	30.4	20.7	12.5	18.8	23.0	21.1	13.8	-8.8
103	MUFF	27.6	26.3	29.1	30.6	28.4	23.4	26.7	-18.4
104	MUFF	23.4	20.9	21.9	31.0	28.4	33.2	31.9	-16.5
105	MUFF	28.0	21.5	26.1	29.6	28.6	31.2	33.7	-18.3
106	MUFF	28.0	21.5	26.1	29.6	28.6	31.2	33.7	-18.3
107	MUFF	27.0	24.5	27.3	35.4	28.0	32.0	22.4	-18.1
108	MUFF	23.6	20.3	25.9	27.8	27.6	29.6	18.3	-14.5
109	MUFF	24.4	18.1	15.3	20.2	22.8	31.5	25.0	-11.7
110	MUFF	21.6	14.5	11.3	20.0	21.8	31.6	30.4	-8.7
111	MUFF	23.0	15.1	13.5	20.2	21.6	33.5	27.1	-10.0
112*	MUFF	17.0	13.1	17.3	21.2	21.6	26.8	19.0	-9.3
113*	MUFF	17.0	14.7	19.5	22.6	22.6	30.5	17.4	-10.2
114	MUFF	20.8	18.5	23.5	30.6	24.6	33.2	20.7	-14.0
115	MUFF	20.8	18.5	23.5	30.6	24.6	33.2	20.7	-14.0
116	MUFF	25.4	21.3	23.7	25.0	26.2	29.9	24.0	-16.0
117	MUFF	22.4	19.7	20.3	24.6	26.8	28.4	23.9	-14.3
118	MUFF	23.0	18.1	19.7	28.2	24.8	27.2	24.4	-13.8
119	MUFF	24.8	21.1	22.7	28.8	27.0	28.8	26.1	-16.3
120	MUFF	23.0	20.1	21.9	25.4	25.2	29.4	26.9	-15.2
121	MUFF	24.8	21.9	23.3	27.4	26.0	30.3	26.6	-16.6
122	MUFF	23.2	19.7	24.1	23.8	24.8	27.0	25.1	-15.0
123	MUFF	25.4	21.3	23.7	25.0	26.2	29.9	24.0	-16.0
124	MUFF	22.4	19.7	20.3	24.6	26.8	28.4	23.9	-14.3
125	MUFF	23.0	18.1	19.7	28.2	24.8	27.2	24.4	-13.8
126	MUFF	27.4	26.9	30.1	35.4	34.4	34.8	26.5	-20.9
127	MUFF	23.2	19.7	24.1	23.8	24.8	27.0	25.1	-15.0
128	MUFF	22.2	20.5	22.7	26.2	25.8	31.1	21.8	-14.9
129	MUFF	29.4	22.9	17.5	19.0	21.6	22.9	27.9	-13.0
130	PLUG	25.6	19.7	15.9	16.0	26.0	34.8	30.0	-11.7
131	MUFF	26.2	24.7	30.3	41.0	36.8	34.5	25.6	-19.9
132	PLUG	28.8	19.5	17.1	11.8	19.0	27.8	31.9	-9.5
133	PLUG	27.0	18.1	14.1	13.8	16.0	24.3	30.9	-8.9
134	MUFF								
135	MUFF	19.2	20.7	25.3	32.0	26.8	29.5	23.6	-15.0

* The ANSI 1957 test standard was not followed explicitly; see footnote 6 on page 17.

Table 1. Continued

I.D. NO.	TYPE	Q1	Q2	Q3	Q4	Q5	Q6	Q7	10 LOG T
136	PLUG	29.4	22.9	17.5	19.0	21.6	22.9	27.9	-13.0
137	PLUG	27.6	29.3	21.5	19.8	26.0	24.3	24.4	-15.2
138	PLUG								
139	PLUG								
140	PLUG								
141	PLUG								
142	PLUG	33.0	23.7	17.3	14.4	23.0	26.3	27.5	-11.6
143	MUFF	27.4	26.9	30.1	35.4	34.4	34.8	26.5	-20.9
144	MUFF	25.4	21.3	23.7	25.0	26.2	29.9	24.0	-16.0
145	MUFF	22.4	19.7	20.3	24.6	26.8	28.4	23.9	-14.3
146	MUFF	23.0	18.1	19.7	28.2	24.8	27.2	24.4	-13.8
147	MUFF	27.4	26.9	30.1	35.4	34.4	34.8	26.5	-20.9
148	MUFF	17.2	9.1	8.1	15.8	16.0	27.1	20.1	-4.4
149	MUFF	24.8	21.1	22.7	28.8	27.0	28.8	26.1	-16.3
150	MUFF	23.0	20.1	21.9	25.4	25.2	29.4	26.9	-15.2
151	MUFF	24.8	21.9	23.3	27.4	26.0	30.3	26.6	-16.6
152	PLUG	26.0	19.5	15.3	21.0	20.2	28.8	24.6	-11.8
153	MUFF	25.2	24.5	26.3	29.8	30.6	34.2	27.5	-18.9
154	MUFF	23.4	21.3	27.3	29.8	28.0	31.5	23.5	-16.6
155	MUFF	22.8	16.3	26.3	32.0	29.8	26.6	23.8	-14.2
156	MUFF	26.8	23.5	29.3	32.0	31.0	38.3	27.6	-19.6
157	MUFF	23.6	19.5	23.1	29.6	30.8	29.8	27.3	-16.0
158	MUFF	25.2	23.7	28.1	31.8	32.2	33.3	23.3	-18.2
159	PLUG	24.8	20.1	14.7	21.2	23.0	24.1	21.6	-11.5
160	PLUG	32.6	21.5	15.7	12.8	22.2	26.9	34.7	-10.2
161	PLUG	30.2	20.5	19.1	11.2	23.6	34.8	26.1	-9.8
162	PLUG	28.8	22.7	13.7	15.2	26.8	31.8	26.3	-10.7
163	PLUG	26.0	21.3	11.5	11.2	24.2	34.6	35.5	-7.9
164	PLUG	26.4	16.3	10.7	13.4	18.0	28.7	29.6	-7.6
165	MUFF	14.2	8.5	13.5	15.4	21.6	23.6	8.1	-3.8
166	MUFF	22.6	17.9	15.7	20.2	25.2	23.2	8.7	-7.0
167	MUFF	15.4	16.9	19.1	19.8	20.6	26.2	10.3	-7.5
168	MUFF	25.2	23.1	31.3	28.0	34.0	33.4	22.2	-17.7
169	MUFF	26.2	29.9	31.1	33.8	24.6	33.3	30.6	-20.3
170	MUFF	20.8	17.9	11.7	34.8	25.0	23.6	28.0	-9.9
171	MUFF	22.8	19.7	19.7	29.2	23.4	25.4	31.5	-14.4
172	MUFF	27.0	27.9	29.7	36.4	24.8	30.6	27.7	-19.7
173	MUFF	27.2	17.9	20.3	24.6	20.6	28.1	34.4	-13.8
174	MUFF	27.4	12.3	22.7	28.2	25.8	22.2	26.7	-11.1
175	PLUG	23.0	17.7	13.1	12.0	17.2	27.7	19.9	-7.8

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