

TABLE I

CHANGES IN MEDIAN HEARING LEVELS OF MALES FROM AGE 20:
 NIOSH,* NATIONAL HEALTH SURVEY, ISO DRAFT PROPOSAL,
 EASTMAN KODAK COMPANY

<u>STUDY</u>	<u>AGE</u>	<u>Audiometric Test Frequencies (Hz)</u>					
		<u>500</u>	<u>1000</u>	<u>2000</u>	<u>3000</u>	<u>4000</u>	<u>6000</u>
NIOSH	30	1	1	1	2	4	4
NHS	25-34	0	0	1	3	6	5
ISO	30	0	0	1	2	3	4
E.K.Co	25-34	0	1	2	-	7	-
NIOSH	40	3	2	3	6	9	11
NHS	35-44	3	2	4	9	14	12
ISO	40	2	2	4	7	10	12
E.K.Co.	35-44	0	2	6	-	18	-
NIOSH	50	5	4	6	12	17	19
NHS	45-54	5	4	8	16	24	20
ISO	50	4	6	8	13	18	22
E.K.Co.	45-54	2	6	9	-	26	-
NIOSH	60	7	6	10	19	28	30
NHS	55-64	6	6	14	26	37	36
ISO	60	8	8	15	22	29	34
E.K.Co.	55-64	5	8	16	-	40	-

*See Table B-1. Appendix B

TABLE II

CHANGES IN MEDIAN HEARING LEVELS OF FEMALES FROM AGE 20:
 NIOSH,* NATIONAL HEALTH SURVEY,
 ISO DRAFT PROPOSAL, AND EASTMAN KODAK COMPANY

<u>STUDY</u>	<u>AGE</u>	<u>Audiometric Test Frequencies (Hz)</u>					<u>6000</u>
		<u>500</u>	<u>1000</u>	<u>2000</u>	<u>3000</u>	<u>4000</u>	
NIOSH	30	2	1	2	2	2	3
NHS	25-34	1	0	2	2	2	4
ISO	30	1	2	1	1	2	2
E.K.Co.	25-34	1	1	1	-	5	-
NIOSH	40	4	3	3	5	5	7
NHS	35-44	2	2	4	4	4	7
ISO	40	2	2	4	5	6	8
E.K.Co.	35-44	2	3	4	-	11	-
NIOSH	50	6	5	6	8	9	11
NHS	45-54	6	5	7	8	9	12
ISO	50	5	5	7	9	11	16
E.K.Co.	45-54	3	5	6	-	14	-
NIOSH	60	5	7	8	13	14	16
NHS	55-64	10	9	12	15	18	22
ISO	60	8	9	12	16	19	25
E.K.Co.	55-64	9	8	12	-	22	-

*See Table B-2. Appendix B

TABLE III

A-WEIGHTING CORRECTIONS FOR OCTAVE BAND LEVELS

<u>Octave Band Frequency (Hz)</u>	<u>Correction</u>
31.5	Subtract 39.5 dB
63.0	Subtract 26.2 dB
125.0	Subtract 16.2 dB
250.0	Subtract 8.7 dB
500.0	Subtract 3.3 dB
1000.0	No Correction
2000.0	Add 1.2 dB
4000.0	Add 1.0 dB
8000.0	Subtract 1.1 dB
16000.0	Subtract 6.7 dB

TABLE IV

AUDIOMETRIC SURVEYS CARRIED OUT IN THE YEARS 1960 to 1970
IN THE UNITED STATES AND OTHER COUNTRIES

Reference and country	Nature of work investigated	Findings
Bonati (1960) <u>Rass. Med. Indust.</u> 29: 127. Italy	103 shipyard workers (riveters, caulkers, and fitters and testers of diesel engines and turbines)	Every riveter and caulker affected.
Coles & Knight (1960) <u>Ann. Occup. Hyg.</u> 2, 267. United Kingdom	Workers in diesel-engine test-house	Maximum noise level 116 dB. Of six men who worked continuously in the intense noise of the two-stroke test-House (average period 3-1/2 years) all had losses of 45-60 dB in one or both ears at 3.4 and 6 kHz and none could be accounted for by an aging factor.
Yaffe and Jones (1961) <u>Public Health</u> Publication No. 850, Wash. D.C. U.S.A.	1952 Federal penitentiary workers (textile mills; wood products and sheet metal products manufacturing; brush, shoe, and clothing factories; and printing) were tested periodically from 1953-59. Octave band noise levels ranged from 75-110 dB.	Those levels which exceeded octave band criteria produced significant hearing threshold shifts at 3,4, and 6 kHz after 24 month exposures. The locations producing the largest shifts were cotton mill twist and weaving departments, woolen mill weaving departments, and furniture mills.

TABLE IV Continued (p.2)

Reference and country	Nature of work investigated	Findings
<p>Schneider, Peterson, Hoyle, Ode, and Holder (1961) <u>Amer. Ind. Hyg. Assoc. J.</u> 22:245. U.S.A.</p>	<p>294 jobs in thirty chemical company departments and 691 screened individuals</p>	<p>Data divided into 4 noise exposure groups based on octave band criteria indicated that the group exceeding criteria more than 10% of the time experienced a permanent threshold shift of 1dB per year at 2, 3, and 4 KHz. For the group near criteria exposure most of the hearing loss occurred within the first 5 or so years.</p>
<p>Waal (1961) <u>Ann. Otol.</u> 70:208 Netherlands</p>	<p>Engine-room personnel</p>	<p>"...out of 234 threshold curves of 117 persons from engine room, 197 curves of 107 persons revealed a threshold shift of 15 dB or more in the frequency range of 1000-8000 Hz...in 69% the center of the threshold shift lies between 3600 Hz and 5600 Hz."</p>
<p>Brohm & Zlamal (1962) <u>Cas. Lek ces.</u> 101:300 Czechoslovakia</p>	<p>Noise in cabins of heavy trucks 90-110 dB</p>	<p>Examinations made on 51 truck drivers and in each case a loss of hearing was determined.</p>

TABLE IV Continued (p.3)

Reference and country	Nature of work investigated	Findings
<p>Mancini & Stancari (1962) <u>Rass. Med. Indust.</u> 31:239. Italy</p>	<p>50 fettlers</p>	<p>Men worked in 9 foundries with noise levels of 92-110 dB. In men who had been working for more than 5-6 years in noisy conditions almost all frequencies were involved; those who had worked less than 2-3 months in noisy conditions showed a loss varying from 30 to 50 dB at 4000 Hz.</p>
<p>Piesse, Rose & Murray (1962) <u>Rept. No. 19, Commonwealth Acoustics Laboratory, Dept. of Health.</u> Australia</p>	<p>5127 skilled and unskilled workers of all ages</p>	<p>Results of initial hearing tests on 5127 skilled and unskilled workers of all ages, performed during reference audiometry, showed 33% of the total number of ears had hearing losses in excess of 45 dB. The hearing losses of 786 tradesmen were as follows (approximate percentage of ears with losses of 45 dB or more at 4000 Hz): boiler-makers 65%, drop forge operators 62%, plumbers 42%, sheet-metal workers 38%, joiners 25%, fitters 22%, electrical mechanics 19% and painters 18%.</p>

TABLE IV Continued (p.4)

Reference and country	Nature of work investigated	Findings
<p>Amelotti & Bandini (1963) <u>Artis Medicae Studia</u> No. 18, 17. Italy</p>	<p>Shipyards workers</p>	<p>6930 audiometric examinations in 38 different occupations. Hyperacusia is characterized by swifter development, and by definite after-effects, even after a few years' exposure to harmful sound levels.</p>
<p>Chadwick (1963) <u>Jour. Laryngol.</u> 77: 467 United Kingdom</p>	<p>12 men exposed to noise from industrial gas-turbine (jet) engine noise</p>	<p>Noise levels reached as high as 113 dB flat. "...the low-tone loss in just over two years was in the region of 10 dB and from 2000 Hz to 4000 Hz was in the order of 20 dB... the average loss for the speech frequencies was...eight times more than that to be expected in a more conventional industry with a known noise hazard."</p>
<p>Filin (1963) <u>Gig. Tr. prof. Zabol</u> 7:3. U.S.S.R.</p>	<p>Drivers of self-propelled jumbos in underground ore mining</p>	<p>Noise levels of 127 dB at frequencies between 1000 Hz and 8000 Hz. Hearing loss in 91 of 135 miners examined; after 10 years' work loss at 4000 Hz was 53 dB; after only 1-2 years' work, 28 dB loss at 4000 Hz.</p>

TABLE IV Continued (p.5)

Reference and country	Nature of work investigated	Findings
Weston (1963) <u>J. Aust. Inst. Agric. Sci. 29:15.</u> Australia	Agricultural tractor drivers	53 drivers of tractors of different horse-power; audiograms showed greater impairment in inland drivers where the tractors are of higher power and exposure is for longer periods than on coastal-plain farms. Noise levels ranged from 92 dB to 106 dB, occasionally as high as 114 dB.
Taylor, Pearson, Mair, and Burns (1964) <u>J. Acoust. Soc. Amer. 38:113</u> United Kingdom	251 working and retired jute weavers subjected to wide band continuous noise of 99-102 SPL (overall) with "transients of peak amplitude 15-18 dB above the mean noise level".	"The most conspicuous feature is an initial deterioration (in hearing) in the first 10-15 years of exposure, followed by a period of about 10 years where deterioration attributable to noise is small. Thereafter, after 20-25 years of exposure, further deterioration occurs, especially marked at 2000 CPS".

TABLE IV Continued (p.6)

Reference and country	Nature of work investigated	Findings
<p>Burns, Hinchcliffe, and Littler (1964) <u>Ann. Occup. Hyg.</u> 7: 323 United Kingdom</p>	<p>174 textile workers (spinners and weavers), 53 of whom were retested after 3 years overall SPL for weaving was 100 dB and for spinning was 101 dB.</p>	<p>Occupational hearing loss occurs in textile workers, "to a greater extent in weavers than in spinners." Over 3 years, "significant threshold shifts occurred in weavers at 2000 c/s and 8000 c/s." At 4000 c/s the deterioration was inversely related to the hearing level."</p>
<p>Harris (1965) <u>Jour. Acoust. Soc. Amer.</u> 37: 444 U.S.A.</p>	<p>Several hundred diesel-engine-room personnel.</p>	<p>About 15% of ears had permanent threshold shifts of more than 20 dB at any frequency.</p>
<p>Antherly, Noble, and Sugden (1967) <u>Ann. Occup. Hyg.</u> 10: 255 United Kingdom</p>	<p>Iron foundry and manganese bronze foundry workers. Octave band noise levels at 0.5, 1, 2, 3 and 4 KHz ranged from 100-115 dB in the dressing and trimming shops.</p>	<p>The hearing levels of the trimmers at 1, 2, 3, and 6 KHz were from 15 to 35 dB higher than other comparable (age, sex, etc.) occupational groups exposed to less intense noise such as bus drivers, printers, boiler makers, and iron molders.</p>

TABLE IV Continued (p.7)

Reference and country	Nature of work investigated	Findings
<p>Cohen, Anticaglia, and Jones (1970) Arch. Environ. Health 20:614. U.S.A.</p>	<p>Hearing levels for heavy earth-moving equipment operators, paper-bag workers, and airport ramp workers were compared with those of non-noise exposed groups. Noise encountered ranged from 80-120 dB (A weighted sound level).</p>	<p>The hearing levels of the heavy earth equipment operators were found to be significantly higher than the non-noise exposed groups. The paper bag workers had higher hearing levels but not as high as the earth equipment operators. The airport ramp personnel, however, had the lowest hearing levels, probably due to the intermittency of their exposures.</p>
<p>Burns and Robinson (1970) <u>Hearing and Noise in Industry</u>, Her Majesty's Stationery Office, London United Kingdom</p>	<p>759 employees in 32 various industrial factories. Noise levels ranged from 78 to 109 dBA.</p>	<p>A relationship between noise, level, exposure duration, and hearing level was defined with two parameters: audiometric frequency and percentage of persons expected to exceed a specified hearing level. A weighted sound level was found to be adequate for estimating hearing level for the industrial noises measured.</p>

TABLE IV Continued (p.8)

Reference and country	Nature of work investigated	Findings
<p>Stone, Freman, and Craig (1971) <u>Amer. Indus. Hyg. Assoc. J. 32:123</u> U.S.A.</p>	<p>3,116 employees of 9 steam electric generating plants and 2 hydroelectric plants were tested. Noise levels from assorted equipment ranged from 91 to 127 dBA, the more intense values associated with coal hoppers, turbine generators and pumps, and forced draft fans.</p>	<p>Prevalence of hearing impairment (defined by hearing levels averaging more than 15 dB (re ASA 1951) at test frequencies of 0.5, 1, and 2 KHz) varied from 4.7 percent for the younger workers having less than two years of service to 31.9 percent for the oldest workers with 26 years or more experience. Boilermakers, heavy equipment operators, and conveyor car operators as classes had high incidences of hearing impairment.</p>

TABLE V
 NATURE OF SPEECH RECEPTION POSSIBLE UNDER NOISE CONDITIONS
 RATED IN dBA*

<u>Noise Level in dBA</u>	<u>Voice Level and Distance</u>	<u>Nature of Communication</u>	<u>Telephone Use</u>
55	Normal Voice at 10 ft.	Relaxed communication	Satisfactory
65	Normal Voice at 3 ft. Raised Voice at 6 ft. Very Loud Voice at 12 ft.	Continuous communication	Satisfactory
75	Raised Voice at 2 ft. Very Loud Voice at 12 ft. Shouting at 8 ft.	Intermittent communication	Marginal
85	Very Loud Voice at 1 ft. Shouting at 2-3 ft.	Minimal communication (restricted, prearranged vocabulary desirable)	Impossible

* Table adopted in part from Bioacoustics Data Book, NASA Report SP-3006
 National Aeronautics and Space Administration, Washington, D.C., Page 301, 1964.

TABLE VI

NOISE EXPOSURES ABOVE 90 dBA IN MANUFACTURING

<u>CODE</u>	<u>NUMBER OF PLANTS IN SAMPLE</u>	<u>TOTAL NUMBER OF EMPL. IN SAMPLE</u>	<u>NUMBER LOCATED IN AREAS 90 dBA AND ABOVE</u>	<u>PERCENT OF WORK FORCE EXPOSED</u>	<u>TOTAL WORK FORCE</u>	<u>NUMBER PROJECTED TO BE LOCATED IN AREAS 90 dBA AND OVER</u>
Textile Mill Products	23	12,764	5,634	44.1	963,300	424,815
Petroleum and Coal Products	16	20,493	5,875	28.6	192,800	55,140
Lumber and Wood Products	14	5,654	1,460	25.8	601,000	155,058
Food and Kindred Products	17	23,690	5,959	25.1	1,898,600	476,549
Furniture and Fixtures	11	10,374	1,849	17.8	465,400	82,841
Fabricated Metal Products	56	41,371	7,079	17.1	1,335,000	228,285
Stone, Clay and Glass Products	5	2,502	416	16.6	643,800	106,870
Primary Metal Industries	51	71,208	11,001	15.4	1,190,000	183,260
Rubber and Plastic Products	4	7,671	1,105	14.4	589,500	84,888
Transportation Equipment	46	199,212	23,445	11.7	1,705,500	199,543
Electrical Equipment and Supplies	7	8,790	973	11.0	1,778,100	195,591
Chemicals and Allied Products	8	3,081	324	10.5	1,014,400	106,512
Apparel and Other Textile Products	1	50	5	10.0	1,353,100	*
Paper and Allied Products	21	14,997	1,385	9.2	687,400	63,240
Ordnance and Accessories	12	39,403	3,480	8.8	193,900	17,063
Instruments and Related Products	6	3,254	193	5.9	433,800	25,594
Machinery Except Electrical	38	25,016	1,144	4.5	1,768,000	79,560
Printing and Publishing	5	5,597	237	4.2	1,085,900	45,607
Total	341**	504,427	71,564	14.1	16,999,500	2,533,416

* Insufficient data for projection

**2709 questionnaires were sent to the manufacturing industries listed, of which 1559 were returned.

341 of these respondents answered this question.

TABLE VII

MEASURED NOISE LEVELS FOR SELECTED INDUSTRIAL OPERATIONS*

Textile Mill

1. loom - 106 dBA
2. cotton spinning - 83 dBA

Lumber and Wood Products

1. planer - 106 dBA
2. molder - 100 dBA
3. router - 93 dBA
4. shaper - 104 dBA
5. boring machine - 94 dBA

Furniture Products

1. cut-off saw - 112 dBA
2. sander - 97 dBA
3. radial arm saw - 98 dBA

Paper Products

1. paper cutter - 96 dBA
2. bag and handle former - 89 dBA

Printing and Publishing

1. newspaper press - 97 dBA
2. mona-casting - 91 dBA
3. postcard press - 91 dBA
4. keyboard mono-type - 84 dBA
5. offset press - 88 dBA
6. small offset press - 82 dBA
7. folding machines - 85 dBA
8. binder - 86 dBA

Petroleum Refining

1. can seaming - 96 dBA
2. furnace heating distilling columns - 100 dBA
3. steam let down - 130 dBA
4. furnace high speed rotating equipment - 100 dBA
5. furnace pumps - 103 dBA

Transportation

1. 1-ton truck - 70 dBA
2. 5-ton truck - 73 dBA
3. 20-ton truck - 92 dBA

*Noise measurements for the specified operations were taken from assorted Public Health Service surveys and references in acoustical and Industrial Hygienists literature. See References 62-65.

TABLE VII Continued

Glass Products

1. inflation of containers - 106 dBA
2. corrugated band saw - 99 dBA

Steel products

1. coke oven - 83 dBA
2. blast furnance - 100 dBA
3. basic oxygen furnace - 91 dBA
4. electric furnance (150 tons) 112 dBA
5. 160" mill - 98 dBA

Various Metal Products

1. milling machine - 90 dBA
2. turret lathe - 90 dBA
3. 4" hand grinder - 85 dBA
4. riveting machine - 110 dBA
5. forge drop hammer - 105 dBA
6. automatic punch press - 95 dBA
7. pneumatic chisel - 101 dBA

Canning Food Products

1. canning punch press - 97 dBA
2. can making body operation - 95 dBA
3. can filling machine - 100 dBA

Mining, Underground

1. axial vane fan - 107 dBA
2. stoper drill - 115 dBA
3. Jackhammer drill - 113 dBA
4. roof bolter - 103 dBA
5. loader (gathering arm) - 96 dBA
6. conveyer belt - 93 dBA
7. continuous miner - 99 dBA

Mining, Open Pit

1. jumbo drill - 107 dBA
2. rotary drill - 93 dBA
3. crusher - 96 dBA
4. locomotive - 85 dBA
5. oxygen torches - 120 dBA

Heavy Equipment (earth moving)

1. double scraper - 92 dBA
2. scraper - 117 dBA
3. bull dozer - 110 dBA
4. road grader - 95 dBA

TABLE VII Continued

Farm Equipment

1. tractor - 98 dBA
2. grain roller mill - 85 dBA
3. pneumatic conveyor - 100 dBA
4. one-row beet puller - 94 dBA
5. two-row corn picker - 106 dBA

TABLE VIII

DAMAGE RISK CRITERIA PRIOR TO 1950

<u>Author</u>	<u>Overall Sound Pressure Level</u>		
	<u>Safe</u>	<u>Borderline</u>	<u>Harmful</u>
McKenzie (1934)			90
Rosenblith (1942)	75-80		
Bunch (1942)		80-90	
McCoy (1944)	80-85	90-100	110-130
Davis (1945)		100	115-120
Goldner (1945)			80
Schweishmer (1945)		80-90	
MacLaren (1947)		100	
Fowler (1947)		100	
Canfield (1949)	80		100-110
Grave (1949)	90		
Guild (1950)	<90 dB above hearing threshold		

Adapted from Jones (Reference 130)

TABLE IX

DAMAGE RISK CRITERIA FOR 5 - 8 HOUR EXPOSURES
AS PROPOSED FROM 1950 - 1971

Author & Year	Ref. No.	Basis of Criteria	Protection Goal	Actual or Computed* Octave Band SPL							Actual or Computed** dB(A)	
				20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800		4800-9600
Kryter (1950)	73	No "critical band" ¹ >85 dB SPL (re: 0.0002 MB)	No PTS or TTS	81	85	90	93	96	97	96	95 ²	88**
		No "critical band" >85 dB SPL (re: MAF)	No PTS or TTS	125	115	108	101	100	92	87	102 ²	94**
Hardy (1952)	131	100 Sones ³ per octave	Upper limit, above which definite hazard to hearing exists	115	112	108	106	104	95	91	102	98**
		50 Sones per octave	Lower limit below which no hazard to hearing exists	104	100	97	95	92	87	85	95	92**
Rosenblith & Stevens (1953)	74	Octave Band SPL with respect to the sensitivity of the ear-Wide Band Noise	Prevention of permanent damage due to noise	110	102	97	95	95	95	95	95	102**

CONTINUATION (2) OF TABLE IX

Author & Year	Ref. No.	Basis of Criteria	Protection Goal	Actual or Computed* Octave Band SPL							Actual or Computed** dB(A)	
				20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800		4800-9600
Rosenblith & Stevens (1953)	74	Same as above except for pure tones and critical bands of noise	Prevention of permanent damage due to noise	100	92	87	85	85	85	85	85	Not Applicable
Lindman (1955)	132	Interpolation between sound pressure of sorting octaves ⁴ & allowance for less sensitivity in lower frequencies	Protects most, but not all persons with unprotected ears	110	105	100	90	90	85	85	85	92**
CFR 160-3 (1956)	100	Octave Band Levels at or above which ear protection must be used	Preservation of hearing of 15 dB or better at the frequencies 500, 1000, 2000 cps.	---	---	---	95	95	95	95	---	102**
		Octave Band Levels at or above which the use of ear protection is recommended	Same as above	---	---	---	85	85	85	85	---	92**

CONTINUATION (3) OF TABLE IX

Author & Year	Ref. No.	Basis of Criteria	Protection Goal	Actual or Computed* Octave Band SPL								Actual or Computed** dB(A)
				20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	4800-9600	
AAOO (1957)	133	Octave Band SPL at these bands most likely to have an effect on the frequency listed in a protection goal	Protect man's hearing for speech (i.e. losses at 500, 1000, 2000 Hz)	---	---	---	---	-85	85	---	---	92**
Jones & Church (1960)	134	Octave Band SPL	Allowable weekly exposure dose, determining when hearing conservation is mandatory	100	91	87	86	85	85	85	92	92**
ISO (1961)	80	Octave Band Levels; Primary Emphasis on those with center Frequency 500, 1000, 2000, NR Curve 85	Protect against TTS ₅ or PTS ₅ greater than 12dB at 500, 1000, 2000 for 50% of the persons exposed	102	95	91	87	85	82	80	79	86**
Kryter (1963 & 1965)	135 136	Octave Band Levels; Broad Band Noise	Protect against normal ears producing TTS ₂ of 10 dB at 1000 Hz, 15 dB at 2000 Hz, & 20 dB at 3000 Hz.	---	98	92	89	86	85	85	86	92**

CONTINUATION (4) OF TABLE IX

Author & Year	Ref. No.	Basis of Criteria	Protection Goal	Actual or Computed* Octave Band SPL								Actual or Computed** dB(A)
				20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	4800-9600	
Kryter (1963 & 1965)	135 136	Narrow Band Levels	Protect against normal ears producing TTS ₂ of 10 dB at 1000 Hz, 15 dB at 2000 Hz, & 20 dB at 3000 Hz	---	93	87	84	81	80	80	81	Not applicable
AAOO (1964)	137	Octave Band Levels encompassing "Speech Frequencies"	Prevention of hearing loss in those people who are "normally" susceptible at the frequencies 500, 1000, 2000 Hz	---	---	---	85	85	85	---	---	92**
CHABA (1966)	107	Octave Band Levels Narrow Band Levels Pure Tones	No permanent or temporary loss greater than 10 dB at 1000 Hz, 15 dB at 2000 Hz, and 20 dB at 3000 Hz in 50% of the people exposed	---	98 92 92	92 88 88	89 84 84	86 81 81	85 80 80	85 80 80	86 81 81	98** Not applicable Not applicable

CONTINUATION (5) OF TABLE IX

Author & Year	Ref. No.	Basis of Criteria	Protection Goal	Actual or Computed* Octave Band SPL							Actual or Computed** dB(A)	
				20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800		4800-9600
Intersociety (1970)	27	dB(A)	An increase of 10 percentage points (10 more people per 100) in the number of people who develop hearing impairment ⁵ by retirement age due to exposure									90
British Occupational Hygiene Society (1971)	87	Noise immission based on dB(A) and total duration of exposure	Protect 99% of the exposed population from developing an average NIPTS of 40 dB or average hearing level of 48 dB for the frequencies .5, 1, 2, 3, 4, & 6 KHz									90
Kryter (1970)	88	Octave Band Level	Maximum allowable TTS or PTS for 75% of those exposed limited to 0 dB below 2 KHz and 10 dB above 2 KHz	91	83	78	73	68	61	52	53	65

* Damage risk criteria not given in octave band levels, but computed by author referenced by number following OBL 4800-9600 Hz.

CONTINUATION (6) OF TABLE IX

** Computed, assuming a "pink" noise spectrum (equal energy in each octave band).

1. Critical band -- ". . . is that frequency band of sound, being a portion of a continuous-spectrum noise covering a wide band that contains sound power equal to that of a simple (pure) tone centered in the critical band and just audible in the presence of the wide-band noise." (Reference 4)
2. From Eldredge, D. H. (Reference 91)
3. Sone -- ". . . a unit of loudness. By definition, a simple tone of frequency 1000 cycles per second, 40 decibels above a listener's threshold, produces a loudness of 1 sone. The loudness of any sound that is judged by the listener to be n times that of the 1-sone tone is n sones." (Reference 4)
4. Levels selected by Z24-X-2 sorting octaves (Reference 138)
5. Average hearing level at 500, 1000, and 2000 Hz of 15 dB re ASA (1951) or 25 dB re ANSI (1969). (References 15 and 95)

TABLE X

Acceptable exposures to noise in dBA as a function of the number of occurrences per day. (From Guidelines for Noise Exposure Control, 1970)

Daily Duration		Number of times the noise occurs per day						
Hours	Min	<u>1</u>	<u>3</u>	<u>7</u>	<u>15</u>	<u>35</u>	<u>75</u>	<u>160 up</u>
8		90	90	90	90	90	90	90
6		91	93	96	98	97	95	94
4		92	95	99	102	104	102	100
2		95	99	102	106	109	114	
1		98	103	107	110	115		
	30	101	106	110	115			
	15	105	110	115				
	8	109	115					
	4	113						

To use the table, select the column headed by the number of times the noise occurs per day, read down to the average sound level of the noise and locate directly to the left in the first column the total duration of noise permitted for any 24 hour period. It is permissible to interpolate if necessary. Noise levels are in dBA.

TABLE XI

Distribution of NIOSH Data Over
Noise Exposure Level, Age, and Experience

<u>Age Groups (in yrs.)</u>	<u>17-27</u>	<u>28-35</u>	<u>36-45</u>	<u>46-54</u>	<u>55-70</u>
Number of Workers	228	292	287	215	150
<u>Experience Groups (in yrs.)</u>	<u>0-1</u>	<u>2-4</u>	<u>5-10</u>	<u>11-20</u>	<u>21-41</u>
Number of Workers	133	154	308	314	263
<u>Exposure Groups* (in dBA-Slow)</u>	<u><80</u>	<u>80-84</u>	<u>85-89</u>	<u>90-94</u>	<u>95-102</u>
Number of Workers	380	51	387	314	40

*In the data analysis, noise exposure levels were not grouped.

TABLE XII

DEPENDENCE OF HEARING IMPAIRMENT ON AGE,
EXPERIENCE, AND NOISE EXPOSURE -- HLI (0.5, 1, 2)

	Noise Exposure in dBA-Slow					
	<u>80*</u>	<u>80</u>	<u>85</u>	<u>90</u>	<u>95</u>	<u>100</u>
<u>Experience: 2 - 4 years</u>						
Age (in years)						
17-27	1.3	1.5	2.4	3.9	6.0	9.0
28-35	3.2	3.5	5.5	8.2	11.9	16.6
36-45	4.9	5.3	8.0	11.6	16.2	--
46-54	9.1	9.8	14.0	19.2	25.4	32.6
<u>Experience: 5-10 years</u>						
Age (in years)						
17-27	1.3	1.5	2.8	4.9	--	--
28-35	3.3	3.7	6.2	10.0	15.2	22.0
36-45	5.0	5.5	9.0	13.8	20.2	28.2
46-54	9.3	10.2	15.4	22.3	30.6	--
<u>Experience: 11-20 years</u>						
Age (in years)						
28-35	3.3	3.8	6.8	11.5	--	--
36-45	5.0	5.7	9.7	15.7	23.6	33.3
46-54	9.4	10.4	16.6	24.7	34.6	45.7
55-70	20.0	21.7	31.0	41.8	--	--
<u>Experienced: 21-41 years</u>						
Age (in years)						
36-45	5.2	6.0	11.7	20.4	32.2	--
46-54	9.6	10.9	19.3	30.8	44.6	59.0
55-70	20.4	22.6	34.9	49.0	63.3	75.9

*Non-Noise Exposed

TABLE XIII

DEPENDENCE OF HEARING IMPAIRMENT ON AGE,
EXPERIENCE, AND NOISE EXPOSURE -- HLI (1, 2, 3)

	Noise Exposure in dBA-Slow					
	<u>80*</u>	<u>80</u>	<u>85</u>	<u>90</u>	<u>95</u>	<u>100</u>
<u>Experience: 2-4 years</u>						
Age (in years)						
17-27	1.4	1.6	2.7	4.4	6.8	10.2
28-35	7.4	8.0	11.8	16.7	22.8	29.9
36-45	8.3	9.0	13.1	18.3	24.7	—
46-54	16.9	18.0	24.4	31.7	39.9	48.5
<u>Experience: 5-10 years</u>						
Age (in years)						
17-27	1.5	1.8	4.0	8.0	—	—
28-35	7.7	8.8	15.7	25.5	37.7	51.3
36-45	8.7	9.8	17.2	27.5	40.1	53.8
46-54	17.5	19.4	30.3	43.3	57.0	—
<u>Experience: 11-20 years</u>						
Age (in years)						
28-35	7.9	9.1	17.6	29.7	—	—
36-45	8.8	10.2	19.2	31.9	47.2	62.9
46-54	17.8	20.0	32.9	48.3	64.0	77.6
55-70	27.6	30.4	45.7	61.6	—	—
<u>Experience: 21-41 years</u>						
Age (in years)						
36-45	8.7	9.8	17.2	40.0	—	—
46-54	17.5	19.4	30.2	43.2	56.9	69.9
55-70	27.3	29.6	42.7	56.5	69.7	80.6

*Non-Noise Exposed

TABLE XIV

COMPARISON OF RISK* FOR RETIREMENT AGE POPULATIONS
AS DETERMINED BY INTERSOCIETY COMMITTEE AND NIOSH

	<u>dB</u> A	<u>80</u>	<u>85</u>	<u>90</u>	<u>95</u>	<u>100</u>
	Total Percent Impaired	23	26	33	43	56
Intersociety**	Normal Percent Impaired	22	22	22	22	22
	Risk	1	4	11	21	34
- - - - -						
	Total Percent Impaired	11	19	31	45	59
NIOSH*** (Age 46-54)	Normal Percent Impaired	10	10	10	10	10
	Risk	1	9	21	35	49
- - - - -						
	Total Percent Impaired	23	35	49	63	76
NIOSH*** (Age 55-70)	Normal Percent Impaired	20	20	20	20	20
	Risk	3	15	29	43	56

*Where impairment is defined as average threshold level in excess of 15 dB re ASA 1951 (25 dB re ANSI (1969)) at 500, 1000, 2000 Hz.

**Age group 50-59, assumes monotonic growth of exposure with age.

***Age groups 46-54 and 55-70, respectively, experience 21-41 years.
(See Table VII-2a)

TABLE XV

COMPARISON OF RISK* FOR RETIREMENT AGE POPULATIONS
AS DETERMINED BY INTERNATIONAL ORGANIZATION
FOR STANDARDIZATION AND NIOSH

		<u>Age 50 Years</u>				
dBA		80	85	90	95	100
ISO**	Total Percent Impaired	14	22	32	45	50
	Normal Percent Impaired	14	14	14	14	14
	Risk	0	8	18	31	44
- - - - -						
NIOSH*** (Age 46-54)	Total Percent Impaired	11	19	31	45	59
	Normal Percent Impaired	10	10	10	10	10
	Risk	1	9	21	35	49

		<u>Age 60 Years</u>				
dBA		80	85	90	95	100
ISO**	Total Percent Impaired	33	43	54	62	74
	Normal Percent Impaired	33	33	33	33	33
	Risk	0	10	21	29	41
- - - - -						
NIOSH*** (Age 55-70)	Total Percent Impaired	23	35	49	63	76
	Normal Percent Impaired	20	20	20	20	20
	Risk	3	15	29	43	56

*Where impairment is defined as average threshold level in excess of 15 dB re ASA 1951 (25 dB re ANSI(1969)) at 500, 1000, 2000 Hz.

**Ages 48 and 58 years, respectively, experience is equal to Age - 18 years.

***Age groups 46-54 and 55-70, respectively, experience is 21-41 years.

TABLE XVI

COMPARISON OF RISK* FOR RETIREMENT AGE POPULATION
AS DETERMINED BY ROBINSON AND NIOSH

		<u>Age 50 Years</u>			
dBA		87	92	97	102
Total Percent Impaired					
	a) thresholds re:97 British controls	3	8	17	33
	b) thresholds re:+10 dB correction	16	26	40	59
Robinson**	Normal Percent Impaired				
	a) thresholds re:97 British controls	1	1	1	1
	b) thresholds re:+10 dB correction	3	3	3	3
Risk					
	a) thresholds re:97 British controls	3	8	17	33
	b) thresholds re:+10 dB correction	13	23	37	56
- - - - -					
	Total Percent Impaired	24	36	50	65
NIOSH***	Normal Percent Impaired	10	10	10	10
	Risk	14	26	40	55

*Where impairment is defined as average threshold level in excess of 15 dB re ASA 1951 (25 dB re ANSI(1969)) at 500, 1000, 2000 Hz.

**Based on 30 years exposure. Risk computed by Robinson⁸⁷ using a fence of 25 dB re ANSI (1969).

***Age group 46-54, experience is 21-41 years.

TABLE XVII

COMPARISON OF NIOSH RISK VALUES FOR TWO
DEFINITIONS OF HEARING IMPAIRMENT

		<u>Age 46-54 Experience 21-41</u>				
		<u>80</u>	<u>85</u>	<u>90</u>	<u>95</u>	<u>100</u>
	dBA					
	Total Percent Impaired	11	19	31	45	59
HLI (0.5,1,2)	Normal Percent Impaired	10	10	10	10	10
	Risk	1	9	21	35	49

	Total Percent Impaired	19	30	43	57	70
HLI (1,2,3)	Normal Percent Impaired	18	18	18	18	18
	Risk	1	12	25	39	52
		<u>Age 55-70 Experience 21-41</u>				
		<u>dBA</u>				
	Total Percent Impaired	23	35	49	63	76
HLI (0.5,1,2)	Normal Percent Impaired	20	20	20	20	20
	Risk	3	15	29	43	56

	Total Percent Impaired	30	43	56	70	81
HLI (1,2,3)	Normal Percent Impaired	27	27	27	27	27
	Risk	3	16	29	43	54