1988 Update on Regulating Occupational Exposure to Noise

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SOMMAIRE

L'article est une mise à jour du texte paru antérieurement intitulé "Regulating Occupational Exposure to Noise" (1). Y sont décrits les travaux menés récemment au Canada en matière de règlements et de lignes directrices concernant l'exposition professionnelle au bruit, ainsi que les documents sur lesquelles ils s'appuyent. Un sommaire des règlements en vigueur et proposés, et des lignes directrices est présenté en dégageant les principales limites d'exposition et les mesures de contrôle du bruit. Les procédures d'évaluation de la perte d'audition pour fins d'indemnisation de la surdité professionnelle sont également résumées.

ABSTRACT

An update is provided to the review paper "Regulating Occupational Exposure to Noise" (1). Recent Canadian activities concerning occupational noise standards, guidelines, and background documents are described. A summary of Canadian existing and proposed regulations and voluntary guidelines, are presented, outlining noise limits and other noise control measures. Methods of assessment of compensation for occupational hearing loss are summarized.

1.0 INTRODUCTION

A brief historical background to occupational noise regulations has been given previously by Benwell (1), together with a description of noise "dose-relationships". A more detailed description of exposure to steady and intermittent noise and exposure to impulsive noises is given by Shaw (2,3), who draws on the 2 decades of such research to make general conclusions that help put present occupational noise regulations on a firm scientific base.

The present paper provides an up-to-date (as of July 1988), summary of Canadian occupational noise legislation in the context of other recent activities in the area of occupational noise. Present workers' compensation claims for occupational noise-induced hearing loss in Canada are illustrated. The National Health and Welfare program in occupational noise is outlined. It is recommended that Federal/Provincial Guidelines (4) and the Shaw Report (2) be used in the formulation of new or revised Canadian occupational noise regulations.

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2.0 RECENT ACTIVITIES IN HEARING CONSERVATION

For the last five years effort has been made in Canada to develop uniform national occupational noise standards. This has been aided by an important publication by Shaw clearly delineating the scientific and technical and practical background on the subject (2). ISO DIS 1999.2 (1985), an important international document on occupational noise exposure and noise-induced hearing impairment has also been revised and is in press (5).

2.1 C.S.A. Standards

The Canadian Standards Association (C.S.A.) Committee Z107 on "Acoustics and Noise Control", has been active in the area of hearing conservation standards for a number of years. More recent activities have included the appointment of a Task Force on Occupational Noise. This Task Force conducted a mail survey (1981-82) to some 150 users of standards on occupational noise. Over 60 replies were received, supporting the Task Force recommendation made in 1982 that there was a need for national guidelines on occupational noise and hearing conservation regulations (1).

In recent years, a number of new and revised standards for occupational noise exposure regulations have also been published by C.S.A. The most significant of these is probably the CAN/CSA Z107.56-M86 on occupational noise exposure measurement (6). In addition there are standards on acoustical definitions (7), and on pure tone audiometers for hearing conservation and for screening (8). There is also a draft standard on audiometric testing for hearing conservation purposes (9) and a standard on hearing protectors (10), the latter having been produced by C.S.A. Committee Z94 on Hearing Protectors. In addition international standards for instrumentation (produced by the International Electrotechnical Commission) are used directly (11,12).

2.2 Shaw Report

The Shaw Report (2) was prepared by Edgar Shaw of National Research Council for the Special Advisory Committee on the Ontario Noise Regulation.

The report reviews the scientific evidence, discusses the issues, draws conclusions and presents recommendations within the context of the proposals made by the Ontario Ministry of Labour. The Ontario Ministry of Labour had previously determined that a noise regulation would include: 1) mandatory measurement of noise at and above 80 dBA; 2) the requirement to reduce noise at the workplace to 90 decibels on a time weighted average basis by means of engineering controls, and in case to the lowest practical level; 3) the mandatory use of hearing protection where a worker is exposed to noise that cannot be reduced to 90 decibels on a time weighted average basis or to 85 decibels for 4 hours or more during a work day; 4) the requirement of a hearing conservation program where a worker is exposed to $L_{Aeq4} > 85$ dBA (10).

The Shaw report (2) enables Canadian occupational noise regulations to be put on a firm scientific foundation by drawing on two decades of research and by carefully analyzing and summarizing the results in the context of present day occupational noise problems. The report summary is reproduced below: -

> "In 1983, a Special Advisory Committee was appointed to study and report to the Minister of Labour on several major issues affecting the formulation of a Noise Regulation in the Province of Ontario under the Occupational Health and Safety Act of 1980. This report, prepared for the Committee, reviews the scientific evidence, discusses the issues, draws conclusions and presents recommendations. Exposure to steady and intermittent noise is considered in relation to the total energy theory, the principle of equinocivity, the CHABA damage risk contours based on studies of temporary threshold shift, the "5 dB rule", Ward's laboratory experiments with animals, and industrial epidemiology with particular reference to Passchier-Vermeer's work. Impulsive noise is considered in relation to the CHABA criterion of 1968, the concept of critical level, the energy principle, industrial epidemiology, interaction with steady noise and instrumentation. It is concluded that there is adequate scientific support for the acceptance of equivalent continuous A-weighted sound pressure level (the "3 dB rule"), as defined in ISO/R1999-1984, as the best available measure of sound exposure, that this measure is approximate and cannot at present be refined, that there is at present no scientifically acceptable alternative measure and that no distinction should be made between impulsive and other types of noise. Various hypothetical patterns of sound exposure other than the standard work week are considered in relation to industrial epidemiology, the formulation of permanent threshold shift given in ISO/R1999-1984 and studies of recovery from temporary threshold shift following prolonged exposure to steady noise. It is concluded that the 40 hour work week is acceptable as the integration period provided that an upper limit is placed on the daily duration of exposure and a lower limit on the duration of effective quiet between exposures. Specific recommendations pertaining to mandatory hearing protection, engineering controls, hearing conservation, hearing protector performance and ceiling level are presented within the context of decisions already made by the Ontario Ministry of Labour."

The Shaw report was incorporated in the final report of the Special Advisory Committee on the Ontario Noise Regulation which was published in December 1985 (3). The report of the Special Advisory Committee contains three conclusions and five recommendations.

The conclusions state the following: (i) the 3dB exchange rate be accepted for the measurement of noise; (ii) all noise should be included in one comprehensive measurement; and (iii) the 40 hour work week is an acceptable integration time. All of these conclusions contain certain provisions. Measurements are referenced to a revised international standards document, ISO/DIS 1999-1984. This document, (see Section 2.0) was subsequently reissued for voting as ISO/DIS 1999.2 (1985) and is presently in press to be issued as a full standard ISO 1999 (198x) (5).

The recommendations of the Special Advisory Committee, in response to the specific terms of reference received from the Ontario Ministry of Labour, are that the use of hearing protectors should be mandatory where the noise level $L_{Aeq8} \geq$ 85 dBA and that a programme of education and instruction be provided; engineering controls be required when L_{Aeq40} > 90 dBA; a hearing conservation programme with periodic audiometry be required when $L_{Aeq40} \geq$ 85 dBA; CSA Standard Z94.2-M1984 be recognized for the assessment of hearing protector performance; and that the use of hearing protectors be mandatory where there is exposure to occupational noise with instantaneous peak sound pressures exceeding 200 Pa (140 dB relative to 20 μPa). It should be noted that the 40 hour work week is accepted as the integration period for the development of engineering control and for hearing conservation with periodic audiometry subject to special provision being made for the unconditional distribution of hours within the work week. For details regarding the provisos accompanying these conclusions and recommendations the Special Advisory Committee Report should be consulted (3).

2.3 Federal/Provincial Guidelines

In 1982 the Federal/Provincial Advisory Committee on Environmental and Occupational Health established a Working Group on Occupational Noise Exposure and Hearing Conservation. The terms of reference of this group were to prepare guidelines on occupational noise exposure and hearing conservation regulations. This was done at the direction of the Committee, which was, in part, in response to the results of the Questionnaire circulated by the CSA Task Force described in 2.1. Part 1 of the document is now published (4). It was written to assist provincial and other agencies for provision of an effective level of protection against excessive noise in the workplace; the primary goal being the conservation of workers' hearing. The model regulation in the document may be adopted in its entirety or may be modified to satisfy the specific requirements of the regulatory agency. The use of the document by provincial and other agencies should promote greater uniformity in workplace noise control regulations.

The document provides the framework for an occupational noise exposure and hearing conservation regulation (model regulation), together with Codes of Practice for audiometry, hearing protectors and noise measurements. The rationale for the framework with explanatory notes, indicating alternatives and discussing the various factors under consideration, is given in an Appendix to the document.

A summary of limits and required actions is given in Table 2.1. The model regulation defines noise as sound levels greater than 80 dBA and uses the equivalent sound exposure level (L_{EX}) as the measure of sound (This is similar to L_{Aeq8h}). The Codes reference the appropriate CSA standards where available. L_{EX} is defined as the steady sound level in dBA which, if present in a workplace for 8 hours in one day, would contain the same total acoustic energy as that generated by the actual and varying sound levels including impulse noise to which a worker is taken to be exposed in one day.

TABLE 2.1

FEDERAL/PROVINCIAL GUIDELINES

SUMMARY OF LIMITS AND REQUIRED ACTIONS (4)

LIMITS	REQUIRED ACTION
. Sound level is greater than 80 dBA for a significant period of time.	Screening assessment*
. Exposure level, Lex, greater than 85 dBA (for 8 hours per work day)	Noise measurement Hearing conservation program Voluntary hearing protection Warning signs Audiometric tests Records Worker education
. Exposure level, Lex, greater than 90 dBA (for 8 hours per work day) and/or . Impulse noise, peak sound pressure level greater than 140 dB	Mandatory exposure control - engineering controls - work practices - hearing protection

3.0 SUMMARY OF CANADIAN LEGISLATION

Occupational noise legislation in Canada is for the most part covered by legislation having general health application and promulgated by the individual provinces and the Federal Government. Table 3.1 lists current and proposed occupational noise regulations of wide application in Canada. In some provinces there is specific legislation for industries such as lumbering, mining, construction and forestry. These are listed in Benwell 1983 (1) and in a Labour Canada publication on the subject (13) together with its later updated inserts.

The primary legislation on occupational noise applicable to Federal employees is the Canada Labour Act (1976, Revised in 1984). The Noise Control Regulations contained in the Canada Labour Code under this Act were proclaimed in 1971 and modified in 1973 (14). At present these

* defined as a methodical examination of the workplace with respect to noise exposure and may or may not include preliminary sound level measurements(4).

TABLE 3.1

CURRENT AND PROPOSED OCCUPATIONAL NOISE REGULATIONS OF WIDE APPLICATION IN CANADA

JURISDICTION (Agency)	REGULATION (Proposed/Guidelines)		YEAR	REFERENCE
Federal				
Labour Canada	Canada Noise Control Regulations	SOR/71-584 Amended by SOR/73-66 and SOR/76-436	1976	14
Federal				
Health & Welfare	Treasury Board Guidelines	Noise Control and Hearing Conservation Standard. TB STD 3-12	1978	15
Provincial				
Alberta	Occupational Health & Safety Act (S.A. August 27) Noise Regulations	Regulation 314/81	1981	17
British Columbia	Workers Compensation Act (SBC1968c59 as amended)			
	Industrial Health & Safety Regulations	BC Reg 585/77	Oct.1 1979	20
Manitoba	Workplace Safety & Health Act (S.M.1976c63)	116/85	Nov. 1985	21
	Hearing Conservation and Noise Control Regulation			
New Brunswick	Occupational Health & Safety Act (SNB1976c0-0-1 as amended)	NB Reg 77-1 amended by NB Reg 77-19 and NB Reg 77-92	1977	24
	Occupational Safety Code			
Newfoundland	Workers' Occupational Health & Safety Act (RSN1979c104)		1979	26
	Occupational Health & Safety Regulations	O.C. 799/77 Section 31(5)		

TABLE 3.1 (continued)

CURRENT AND PROPOSED OCCUPATIONAL NOISE REGULATIONS OF WIDE APPLICATION IN CANADA

JURISDICTION (Agency)	REGULATION (Proposed/Guidelines)		YEAR	REFERENCE
North West Territories	Industrial Safety Regulations Safety Ordinance	RONWT271-77 Sections 32,33	June 1977	28
Nova Scotia	Industrial Safety Act - Industrial Safety Regulations	R.S.N.S. C141 as amended	1967	29
Ontario (existing)	Occupational Health & Safety Act (R.S.O.c321, 1980) Regulations for Industrial Establishments	Ont. Reg. 692/80	1980	33
Ontario (Proposed)	Proposed Regulation under the Occupational Health & Safety Act. Designated Substance - Noise		July 1986	34
Quebec	Environmental Quality Act (SQ1972c49 as amended). Regulation concerning industrial & commercial establishment. Reglement relatifà la qualité du milleu de travail.	O.C.3787-72 as amended by O.C.1576-74, O.C.1958-76 and O.C.3326-76 O.C.3169-79	Jan. 1981	36
Saskatchewan	Occupational Health & Safety Act Section 13 (1981c567/81). The Occupational Health & General Regulations Part IX Noise.	c567/81	Apr.15 1981	40
P.E.I.	Industrial Safety Regs.	Royal Gazette, p.253 as amended.	1975	35
Yukon	Occupational Health & Safety Act. Occupational Noise Regs.	Ch.46	1984	43

Noise Control Regulations are commencing revision and a consensus process is being used whereby labour and management and selected technical experts jointly formulate the regulation, using resource documents of their choice. These noise regulations apply to Federal Works, undertakings, and businesses. Public service departments and agencies are also covered by the Canada Labour Code, but in this case the Treasury Board also administers its own standards. Treasury Board Standards on occupational noise exposure were issued in 1972 and modified in 1978 (15). A draft Treasury Board Standard was written in 1982 (16), but this was not implemented since it was decided to wait until the Labour Canada Noise Regulations were rewritten for consistency within Federal jurisdictions. Approximately 750,000 people are covered by these Federal regulations.

Other occupational noise legislation in Canada (17-43) falls within provincial jurisdiction, and thus applies to the majority of working Canadians.

3.1 Noise Exposure Limits

Limits of noise exposure prescribed in Canadian occupational noise legislation are shown in Table 3.2. It is implicit in these regulations that noise levels are measured in a diffuse sound field with an omnidirectional microphone. It can be seen that there are some differences between the various regulations. The three main differences are: 1) the 85 or 90 dBA for an 8 hour per day exposure, 2) the variation between a 5 dB increase for a halving of exposure time prescribed in most provinces and a 3 dB increase for a halving of exposure time prescribed in some provinces, and 3) combined or separate assessment of impulse noise. A recent trend toward a 3 dB trading relationship is reflected in Manitoba (1985), Yukon (1984), and draft Ontario (1986) legislation. This enables a combined assessment of impulse and steady-state noise. Seven provinces specify a separate assessment for impulse/impact noises that varies with the number of impulses, as shown in Table 3.3. The Canada Labour Code presently prohibits exposure to impact/impulse sound "the peak sound pressure level of which, measured by a method acceptable to the regional safety officer, exceeds 140 dB unless that employee is wearing (prescribed) hearing protectors" (14). Impulse noise limits are not specified by 4 provinces. Impulse noise exposure level measurements are now incorporated with steady-state noise measurement in two regulations, two proposed regulations and the Federal/Provincial Guidelines (1987) (4), considerably simplifying exposure calculations. Maximum impulse noise limits are also set for these four regulations. At present Saskatchewan legislation (1981) specifies that noise levels in excess of 85 dBA be monitored and controlled, and aural protection of workers be required. Details of compliance, including an 85 dBA maximum daily 8 hour exposure level with a 3 dB increase for a halving of exposure time are given in a guide to compliance published by Saskatchewan Labour (41).

3.2 Alternative Noise Protection Measures

A summary of noise protection measures, other than noise exposure limits prescribed in Canadian Occupational Noise Regulations, is provided in Table 3.4.

TABLE 3.2 CURRENT AND PROPOSED OCCUPATIONAL NOISE REGULATIONS OF WIDE APPLICATION IN CANADIAN PROVINCES

(JANUARY 1988)

JURISDICTION / AGENCY	REGULATION OR GUIDELINES OR PROPOSAL	STEADY-STATE NOISE				IMPULSE NOISE		
		40 HOUR WEEK LIMIT (dBA)	8 HOUR/DAY LIMIT[1] (dBA)	EXCHANGE RATE[2] (dB)	MAXIMUM (dBA)[3]	SEPARATE (S) OR COMBINED (C)	MAXIMUM (PEAK)[4] (dB)	DAILY LIMIT ON NUMBER OF IMPULSES
Federal Labour Canada	Regulation		92	5	115	S	140	No
Federal Health & Welfare	Guideline		92	5	115	S	140	No
Alberta	Regulation		85	5	115	S	140	Yes
British Columbia	Regulation		90	3	105	S	140	Yes
Manitoba	Regulation		90	3	115	C	140	No
New Brunswick	Regulation		90	5	115	S	140	Yes
Newfoundland	Regulation		85	5	115	S	140	Yes
North West Territories	Regulation		90	5	—	—	140	No
Nova Scotia	Regulation		85	5	115	S	140	Yes
Ontario (Existing)	Regulation		90	5	115	S	140	Yes
Ontario (Proposed)	Proposal	90	—	3	115	C	140	No
Prince Edward Island	Regulation		Note 6			—	—	
Quebec	Regulation		90	5	115	S	140	Yes

TABLE 3.2 CURRENT AND PROPOSED OCCUPATIONAL NOISE REGULATIONS OF WIDE APPLICATION IN CANADIAN PROVINCES

(JANUARY 1988) (continued)

JURISDICTION / AGENCY	REGULATION OR GUIDELINES OR PROPOSAL	STEADY-STATE NOISE				IMPULSE NOISE		
		40 HOUR WEEK LIMIT (dBA)	8 HOUR/DAY LIMIT[1] (dBA)	EXCHANGE RATE[2] (dB)	MAXIMUM (dBA)[3]	SEPARATE (S) OR COMBINED (S)	MAXIMUM (PEAK)[4] (dB)	DAILY LIMIT ON NUMBER OF IMPULSES
Saskatchewan	Regulation[5]		85	3	—	C	—	No
Yukon	Regulation		85	3	103	S	140	Yes
Federal/Provincial Guidelines	Guidelines		90	3	—	C	140	No

Notes

1. Maximum permissible daily 8 hour time weighted average exposure level Leq (dBA).

2. Time/intensity doubling rate.

3. Maximum permissible hearing level without hearing protection (dBA).

4. Maximum permissible level (dB peak SPL).

5. Details taken from "Noise Regulations - A guide to compliance for occupational health committees, employers and workers", 6M/09/81, Saskatchewan Labour.

6. In Prince Edward Island levels are not specified in the legislation. Federal Labour Canada regulations are followed.

TABLE 3.3 IMPULSE NOISE EXPOSURE LIMIT

Peak Sound Pressure Level (dB)	Maximum Number of Impulses Per Day
120	10,000
130	1,000
140	100
Greater than 140	0

Hearing Protectors

All provinces with occupational noise regulations prescribe hearing protectors under certain conditions. The majority (British Columbia, Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island and Quebec), state in general terms, that hearing protectors must be worn when employers are unable to reduce the noise below harmful levels (or the noise limit table indicated in the regulation).

The Federal Government requires the use of hearing protection at noise levels over 90 dBA, as do Manitoba regulations, who also ask for voluntary use at 85 dBA. Saskatchewan regulations, Alberta, and Ontario draft regulations, require hearing protection at noise levels over 85 dBA, as do Nova Scotia draft regulation guidelines (30). Proposed new Federal Treasury Board Standards require hearing protection at noise levels over 84 dBA.

Certain legislation (Federal Government and Quebec) specify that hearing protectors must comply with Canadian Standards Association (C.S.A.), Standard Z.94.2.1965, although only the Federal Government specifies "as amended". New Brunswick legislation specifies that hearing protectors must comply with C.S.A. Standard Z.94.2-1974, as does British Columbia. However, legislation in British Columbia also has a table giving the C.S.A. Standard Class of hearing protector that may be worn in prescribed sound levels as in Table 3.5. Alberta legislation contains a similar table to that in Table 3.5 as does Ontario draft legislation.

The Federal/Provincial Guidelines (4) require that hearing protectors be provided upon request by workers' at noise exposure levels (L_{EX}) greater than 85 dBA for an 8 hour work day, and that they must be worn where noise exposure levels (L_{EX}) $\geq$ 90 dBA for an 8 hour work day. The Code of Practice for Hearing Protectors in these guidelines provides procedures for the selection, fitting, use and maintenance of hearing

TABLE 3.4 NOISE PROTECTION IN PRESENT AND PROPOSED OCCUPATIONAL NOISE REGULATIONS

(JANUARY 1988)

JURISDICTION / AGENCY	NOISE PROTECTION MEASURES							
	HEARING PROTECTORS			AUDIOMETRIC TESTING REQUIRED	WARNING SIGNS REQUIRED	NOISE SURVEY REQUIRED	NOISE & VIBRATION CONTROL REQUIRED	HEARING CONSERVATION PROGRAM
	REQUIRED WHEN OCCUPATIONAL EXPOSURE LIMITS ARE EXCEEDED	MEET CSA STD.[1]	MEET ANSI[2]					
Federal Labour Canada	≥ 90 dBA or ≥ 140 dB peak SPL	✓	—	✓ Conditional	✓	✓	—	—
Federal Health & Welfare (Existing)	≥ 90 dBA or ≥ 140 dB peak SPL	✓	—	✓ Conditional	✓	✓	—	—
Alberta	✓	✓	—	✓	—	—	—	✓
British Columbia	Detailed level requirements	✓	—	✓	✓	—	Yes	✓
Manitoba	≥ 85 dBA	—	—	✓	✓	✓	Yes	✓
New Brunswick	✓	✓		No	✓	—	—	—
Newfoundland	✓	—	—	No	—	—	—	—
North West Territories	✓	—	—	No	—	—	—	—
Nova Scotia	✓ At discretion of Inspector	—	—	Specifications (included in guidelines)	—	—	—	—

NOTE: 1. CSA Z94.2-M1984 "Hearing Protectors" (10).
2. ANSI S3.19-1984 "Method for the Measurement of Real-Ear Protection of Hearing Protectors and Physical Attenuation of Earmuffs" (44).

TABLE 3.4 NOISE PROTECTION IN PRESENT AND PROPOSED OCCUPATIONAL NOISE REGULATIONS

(JANUARY 1988) (continued)

JURISDICTION / AGENCY	NOISE PROTECTION MEASURES							
	HEARING PROTECTORS			AUDIOMETRIC TESTING REQUIRED	WARNING SIGNS REQUIRED	NOISE SURVEY REQUIRED	NOISE & VIBRATION CONTROL REQUIRED	HEARING CONSERVATION PROGRAM
	REQUIRED WHEN OCCUPATIONAL EXPOSURE LIMITS ARE EXCEEDED	MEET CSA STD.[1]	MEET ANSI[2]					
Ontario (Existing)	✓	—	—	No	✓	—	—	—
Ontario (Proposed)	85 dBA	✓	✓	✓ 85 dBA	—	✓	Yes	✓
Prince Edward Island	✓	—	—	No	—	—	—	—
Quebec	✓	✓		No	—	—	Yes	—
Saskatchewan	≥ 85 dBA	—	—	✓ Recommended	✓	✓	Yes	—
Yukon	✓ 85 dBA	—	—	✓	✓	—	—	✓
Federal/Provincial Guidelines	✓ 85 dBA voluntary ✓ 90 dBA mandatory	✓	✓ modified	✓	✓	✓	—	✓

NOTE: 1. CSA Z94.2-M1984 "Hearing Protectors" (10).

2. ANSI S3.19-1984 "Method for the Measurement of Real-Ear Protection of Hearing Protectors and Physical Attenuation of Earmuffs" (44).

✓ = yes

TABLE 3.5 HEARING PROTECTOR REQUIREMENTS IN B.C. LEGISLATION (20)

C.S.A. STANDARD Z94.2.-M1984 CLASS	SOUND LEVEL dBA (Note 1)
C	85-93
B	94-99
A	Over 100
A	Impulse (Note 2)

Note 1: This is understood to mean steady level (45).
Note 2: This is understood to mean where Impulse Noise exceeds the B.C. Schedule for impact noise where the maximum number of impacts per 24 hour period are given for specified peak sound pressure levels (20, 45).

protectors, education of workers' and posting of warning signs. The Code allows for either CSA Z94.2-M1984 (10) Section A2 and Table A1 of Appendix A or for ANSI methods with a 10 dB correction factor to be used in hearing protector selection (44).

Audiometric Testing

Four provinces, Alberta, British Columbia, Manitoba and Saskatchewan, Yukon specify requirements for audiometric testing (Saskatchewan in their compliance code), as do draft Ontario regulations and Nova Scotia and Federal/Provincial guidelines. In Quebec, medical examinations may be required periodically, while the Federal Government specifies that audiometric tests may be required in certain situations (>84 dBA in Treasury Board Proposed Standard). New Brunswick, Newfoundland, North West Territories, Ontario, Quebec, Prince Edward Island, and the Yukon do not presently require audiometric tests.

Alberta legislation requires establishments with high noise levels to set up a hearing conservation programme which must include audiometric testing. When audiometric testing is required, it may only be conducted by qualified people. In this case the audiograms shall be made available to the Department of Health. Permissible background noise conditions for audiometric testing are specified in the regulations.

British Columbia legislation states that in any area where levels exceed the criteria, the employer is responsible for the establishment and maintenance of a hearing test program. The criteria are: 1) 85 dBA steady noise or 2) an impact noise table as shown in Table 3.6 and at least one worker with an $L_{EX} \geq 90$. Details of when hearing testing should be conducted, by whom, and recording and keeping of the test results are also required.

TABLE 3.6 BRITISH COLUMBIA SCHEDULE FOR IMPACT NOISE LEVELS ABOVE WHICH AUDIOMETRIC TESTING ROUTINELY REQUIRED (20)

PEAK SOUND PRESSURE LEVEL (dB)	MAXIMUM NUMBER OF IMPACTS PER 24 HOUR PERIOD
Over 135	0
134	112
131	225
128	450
125	900
122	1800
119	3600
116	7200
113	14400

Federal/Provincial Guidelines (4) require an audiometric testing programme where noise exposure levels (L_{EX}) are greater than 85 dBA for an eight hour day. The Code of Practice for Audiometry in these guidelines gives procedures to be followed. The Guidelines reference CSA Standards Z107.4 (8) and Z107.6 (draft) (9).

Warning Signs

Although warning signs are described in six of the present occupational noise laws in Canada, the requirements vary, particularly in the wording of the sign. The Federal Government, New Brunswick, Manitoba, Ontario and Quebec, require warning signs where the level is greater than 90 dBA, Saskatchewan, Nova Scotia and Alberta where the level is greater than 85 dBA. The Federal Government also requires signs where the impact noise is greater than 140 dB peak sound pressure level. British Columbia, requires signs where levels exceed the specified limits. Newfoundland, Prince Edward Island, and Yukon do not require warning signs.

The Canada Labour Code and British Columbia require signs warning persons that a noise hazard exists and the type of hearing protection

required. Canada Labour Code also requires the permissible exposure time to be stated. Saskatchewan requires the range of noise levels measured to be stated. New Brunswick requires signs which 1) warn individuals that hearing protectors are required, 2) are in contrasting letters at least 4" (102 mm) high and 3) are at least 18" x 24" (457 mm x 609 mm) in size.

Manitoba legislation requires warning signs that not only clearly identify that a potential sound exposure hazard exists but also that hearing protection is required to be worn and used in that area. The Federal/Provincial Guidelines (4) require that, where hearing protectors must be worn, warning signs be posted at the work place to specify this.

Noise Surveys

Surveys of noisy places are specifically required to be conducted by the employer by the Federal Government, Manitoba, Saskatchewan, and Quebec. Ontario's proposed legislation contains a similar requirement. The Federal Government states that noise surveys may be required where the safety officer believes levels are sufficient to impair employees hearing. Saskatchewan legislation states that all occupational establishments with noise levels $\geq$ 85 dBA must be surveyed and documented within 3 months of the promulgation of the regulation and thereafter when there is reason to believe that substantial changes in noise levels have occurred. Quebec Legislation (36a) states that any employer hiring more than 50 workers should make yearly noise surveys in areas where the noise levels may be above the allowable limit and also within 30 days of a new installation being installed. Ontario proposed regulations contain a detailed code for noise measurement as do the Federal/Provincial Guidelines (4). In most provinces, a noise survey comes under the powers of an inspector.

Noise and Vibration Control

A number of regulations specify the need for "engineering controls" (see Table 3.4). Quebec specifically mentions noise and vibration control. In their workplace regulations under the Quebec Environmental Quality Act (36), it is stated that noise and vibration capable of producing harmful effects on workers shall be reduced by one or all of the following means:

(a) isolation of noise sources;
(b) limitation of the intensity and duration of these noises; and
(c) installation of a soundproof device to isolate working areas from sources of noises or vibrations.

4.0 HEARING CONSERVATION PROGRAMMES AND EDUCATION

Whenever noise exposures are such that an unavoidable risk of permanent hearing loss exists, according to WHO, a hearing conservation programme should be provided (46,4). In the author's opinion, such programmes should contain 3 elements: education

concerning the hazards of noise; education in the proper use and supervision of the wearing of hearing protection; and monitoring audiometry, including periodical medical examination, performed when necessary. Monitoring audiometry, if properly planned and executed, identifies workers at risk from incipient hearing impairment, so that they can be removed from the noisy workplace before excessive irreversible damage is caused. (Monitoring audiometry has recently become a controversial issue and is not supported by the Canadian Centre for Occupational Safety and Health). Since occupational noise regulations allow a certain risk of permanent hearing loss, a hearing conservation programme is highly desirable in addition to the specification of maximum exposure levels. Hearing conservation programmes are considered desirable when 8 hour daily exposures exceed 75 dBA (46). Present concepts of acceptable risk and economic constraints limit the practical application of these programmes in most countries including Canada to levels around 85 dBA.

There is good evidence that well managed hearing conservation programs do protect the hearing of workmen (47a, 47b, 47c). Some aggressive hearing conservation programmes have been introduced into Canadian industry over the last 10 years and these should soon begin to bear fruit. More and more industries are becoming conscious of sound levels. Specifications for noise levels are being included when new machinery is ordered, and industries are becoming aware that very often the cost of engineering controls for minimizing noise is less than the cost of compensation paid for hearing loss. Awareness of the harmful effect of noise, both by labour and by management is probably the largest single factor that provides the incentive required to reduce occupational hearing loss.

Occupational noise regulations are beginning to recognize the importance of hearing conservation programs. Alberta regulations detail regular audiometric testing for noise exposed workers and a reporting system for those showing signs of hearing loss. British Columbia requires annual hearing tests for noise-exposed workers and records to be kept for the period of employment (48).

The Ontario proposed regulation contains a "Code for Medical Surveillance of Noise Exposed Workers". The objective of the Ontario Medical Surveillance programme is to protect the health of workers by: 1) evaluating the effect of noise on workers, 2) enabling remedial action to be taken when necessary; and 3) providing health education. To achieve this the programme must consist of the following: 1) pre-placement and periodic audiometric tests, 2) medical examinations as necessary, 3) health education, and 4) record keeping. The Manitoba regulation is discussed here as an example of a basic element of a hearing conservation programme. Other elements of the Manitoba programme include development of educational materials for employers and workers, and a Code of Practice, which contains detailed information to provide practical guidance with respect to provisions of the regulation. Exposure monitoring data, audiometric test results, health histories and associated reports must be maintained for the duration of a worker's exposure plus 10 years. The employer and workplace safety and health committee or worker representative are advised regarding the

effectiveness of existing practices to control worker exposure to noise and the need for additional control measures.

The Federal/Provincial Guidelines (4) require a hearing conservation programme to be administered by the employer, where equivalent sound exposure levels (L_{EX}) are 85 dBA or greater in one work day. The hearing conservation programme is defined as a work place programme including provisions for: 1) noise measurement and assessment of workers' noise exposure, 2) engineering controls, work practices, hearing protectors, and warning signs, 3) maintenance of noise measurement and exposure records, 4) audiometric tests, 5) maintenance of workers confidential audiometric records, and 6) educational programs. All these provisions are required where exposure levels are $L_{EX} \geq 85$ dBA over a work day but 2) is only mandatory at $L_{EX} \geq 90$ dBA.

5.0 LIMITATIONS OF PRESENT REGULATIONS

Until recently, there has been a lack of uniformity of occupational noise regulations in Canada, and a lack of a firm scientific basis underlying the regulations. The publication of the Shaw report (2) draws on the 2 decades of such research to make general conclusions that help put present occupational noise regulations on a firm scientific base, and the Federal/Provincial Guidelines (4) provide the framework for more uniform occupational noise regulations in Canada.

The purpose of controlling occupational noise exposure is primarily to conserve hearing. One problem with this is that there are limits to the protection that can be afforded, and current regulations do allow some workers to lose some hearing. Another problem in the area of compensable hearing loss is the lack of agreement on the appropriate methods of assessing both hearing loss and hearing disability and their relationship with each other. The question of what constitutes a hearing handicap and how it should be measured has not been resolved. A successful method of assessing hearing handicap should take into account the economic and social handicap of the hard-of-hearing person and yet should be relatively quickly measured in a reproducible manner. At the present time evaluations of social and economic handicap are very time-consuming to undertake and are still in the experimental state (49,50). Current methods rely on the indirect relationship between hearing threshold as measured by pure tone threshold acuity and subjective complaints.

A limitation of any regulation is that its effectiveness relies heavily on its enforcement, voluntary or otherwise. Since most Canadian occupational noise regulations allow hearing protection to be used where the noise cannot be reduced to acceptable levels, the employer must not only provide hearing protection, but also ensure that it is worn properly to give adequate protection against hearing loss.

6.0 WORKER'S COMPENSATION FOR OCCUPATIONAL NOISE IN CANADA

In general industrial noise-induced hearing loss claims are accepted by the Workers' Compensation Boards if:

(a) there is an adequate history of exposure to hazardous noise in the workplace, and
(b) an otologist finds that the worker has a hearing loss that could have been caused by noise exposure.

It then has to be determined if the hearing loss is of sufficient magnitude to be considered pensionable.

Compensation for hearing loss due to occupational noise is dealt with very similarly in all provinces except British Columbia and Quebec, as shown in Table 6.1. This figure shows that most provinces use a 35 dB low fence (the smallest amount of hearing loss that is compensated) and an 80 dB high fence (total deafness in one ear). The hearing loss is calculated from an average of the hearing loss of 500, 1000, 2000 and 3000 Hz frequencies for each ear. In Quebec the 4000 Hz frequency is used in place of 3000 Hz. In British Columbia the better ear is weighted by 5/1 which means that the disability rating for the better ear is five times as great as the rating for the poorer ear. The disability rating schedule used by British Columbia is shown in Table 6.2, Table A. Total deafness in one ear is rated at the equivalent of 5% total body impairment. Total deafness in both ears is rated at 30% total body impairment.

Slight differences in the way some of the provinces compensate hearing loss include: 1) applying a presbycusis correction factor of .5 dB for each year over 60 (Newfoundland, Ontario and Alberta), 2) giving an additional 2% compensation for tinnitus (Ontario and Alberta), and 3) giving 60% disability for sudden complete bilateral deafness (New Brunswick and Alberta), who also have a schedule for unilateral deafness (see Table 6.2, Table B).

Hearing loss compensation in the British Columbia regulation presently varies significantly from the above. It is not subject to WCB Industrial Health and Safety Regulations, but follows an Act of the B.C. Legislature. However, they apparently have proposed legislation to change the audiometric frequencies averaged to include 3000 Hz. Since this recommendation has been under consideration for several years now and immediate action is not anticipated (45), the low fence would also increase from 28 dB to 35 dB (45). Their present disability rating schedule is shown in Table 6.2, Table C. British Columbia awards a lower percentage compensation for total deafness, 3% for one ear and 15% for both ears, however their definition of total deafness in one ear is 68 dB rather than 80 dB, and thus the actual monetary compensation is claimed to be comparable with other provinces (48).

Only the province of Ontario includes guidelines to be taken for rehabilitation in its draft. These include authorization for hearing aids, lip-reading classes and vocational rehabilitation (the latter when employees are recommended for non-hazardous noise exposure employment).

TABLE 6.1

WORKERS COMPENSATION FOR OCCUPATIONAL HEARING LOSS IN CANADA

PROVINCES	AUDIOMETRIC FREQUENCIES USED (Hz)	METHOD OF CALCULATION	LOW FENCE (ANSI/ ISO)	HIGH FENCE (ANSI/ ISO)	BETTER EAR CORRECTION	PRESBYCUSIS CORRECTION	% PER DECIBEL LOSS		MAXIMUM % FOR TOTAL DEAFNESS			% FOR TINNITUS
							Partial (Both Ears)	Unilateral or Acute Traumatic Hearing Loss	One Ear	Both Ears	Sudden Complete Bilateral Deafness	
Alberta	500, 1000, 2000, 3000	average	35 dB	80 dB	5/1	.5 dB each year over 60	A*	B*	5	30	60	2
British Columbia	500, 1000, 2000	average	28 dB	68 dB	4/1	-	C*	-	3	15	30	-
Manitoba Ontario Prince Edward Island	500, 1000, 2000, 3000	average	35 dB	80 dB	5/1	.5 dB each year over 60	A*	-	5	30	-	2
New Brunswick	500, 1000, 2000, 3000	average (rounded up to next 5 dB increment)	35 dB	80 dB	5/1	-	A*	B*	5	30	60	-
Newfoundland	500, 1000, 2000, 3000	average	35 dB	80 dB	5/1	.5 dB each year over 60	A*	-	5	30	-	-
North West Territories	500, 1000, 2000, 3000	average	30 dB	80 dB	5/1	.5 dB each year over 60	A* extended down to .1% at 30 dB	-	5	30	60	-

TABLE 6.1

WORKERS COMPENSATION FOR OCCUPATIONAL HEARING LOSS IN CANADA (continued)

PROVINCES	AUDIOMETRIC FREQUENCIES USED (Hz)	METHOD OF CALCULATION	LOW FENCE[1] (ANSI/ ISO)	HIGH FENCE[1] (ANSI/ ISO)	BETTER EAR CORRECTION	PRESBYCUSIS CORRECTION	% PER DECIBEL LOSS		MAXIMUM % FOR TOTAL DEAFNESS			% FOR TINNITUS
							Partial (Both Ears)	Unilateral or Acute Traumatic Hearing Loss	One Ear	Both Ears	Sudden Complete Bilateral Deafness	
Nova Scotia	500, 1000, 2000, 3000	average	35 dB	80 dB	5/1	.5 dB each year over 60	A*	-	5	30	60	Up to 5
Quebec	500, 1000, 2000, 4000	average	25 dB	65 dB	5/1	.5 dB each year over 60	Not known	-	5	30	30-60	-
Saskatchewan	500, 1000, 2000, 3000	average	35 dB	80 dB	5/1	-	A*	-	5	30	-	-

* A, B, C, see Figure 4.2 Tables A, B, and C.

[1] fence means

TABLE 6.2 PERCENT DISABILITY FOR VARYING DEGREES OF HEARING LOSS

Table A. Partial Hearing Loss Where Both Ears are Affected

dB Hearing Loss	% Disability
35 dB (ANSI/ISO)	.4
40	.7
45	1.0
50	1.4
55	1.8
60	2.3
65	2.8
70	3.4
75	4.0
80	5.0

Table B. Unilateral Deafness (Alberta) or Acute Traumatic Hearing Loss (New Brunswick)

dB Hearing Loss	% Disability
30 dB (ANSI/ISO)	1
40	2
50	3
60	4
70	5

Table C. Non-Traumatic Hearing Loss (British Columbia)

Loss of Hearing in dB	% of Total Disability	
	Ear Most Affected PLUS	Ear Least Affected
0 - 27 (ANSI/ISO)	0	0
28 - 32	0.3	1.2
33 - 37	0.5	2.0
38 - 42	0.7	2.8
43 - 47	1.0	4.0
48 - 52	1.3	5.2
53 - 57	1.7	6.8
58 - 62	2.1	8.4
63 - 67	2.6	10.4
68 or more	3.0	12.0

Discrepancies exist in the relationship between percentage hearing loss and total pensional disability. In Canada total hearing loss is rated at between 15% and 50% of total pensionable disability. Blindness is equated with 100% pensionable disability. However, total hearing is one of the primary senses, and most jobs are impossible for the totally deaf and many are impossible for the hard of hearing (47).

Hearing loss produced by occupational exposure to noise has aroused increasing interest over the last decade (47). One of the main reasons for this is the rise in the number of claims. Table 6.3, shows, as an example, the dramatic increases in Ontario over the last 37 years. Recent figures illustrating the increase in costs is given in Table 6.3b. It is likely, as the cost increases, and engineering technology improves, that high noise levels will be eliminated by engineering controls of the source or by masking. Until such time the cost of compensation is borne directly by industry and thus passed back to the consumer. A similar, but less dramatic example of increases in costs is given for Manitoba in Table 6.4.

TABLE 6.3a PROVINCE OF ONTARIO: WCBO INDUSTRIAL HEARING LOSS CLAIMS (57)

YEAR	RECEIVED	PENSIONED
1950-55	10	2
1956	14	4
1957	17	4
1958	11	20
1959	50	9
1960	28	10
1961	28	10
1962	28	11
1963	36	14
1964	59	15
1965	92	12
1966	97	30
1967	100	46
1968	112	41
1969	177	58
1970	301	63
1971	370	130
1972	382	148
1973	582	208
1974	986	482
1975	1519	639
1976	2463	1066
1977	2405	1364
1978	2091	1338
1979	1992	1045
1980	2414	950
1981	2900	968
1982	3178	1458
1983	3119	1475
1984	3262	1249
1985	3080	1393
1986	3521	1372
1987	3866	1693

Table 6.3b PROVINCE OF ONTARIO: WCBO INDUSTRIAL HEARING LOSS CLAIMS (57)

Year	Number of Hearing Claims Initially Settled As Temporary Permanent Disabilities	Average Cost Per Claim
1983	631	$ 8,011
1984	847	9,321
1985	763	9,246
1986	914	9,814
1987	1,004	11,199

TABLE 6.4

PROVINCE OF MANITOBA : WCBM INDUSTRIAL HEARING LOSS CLAIMS (52)

Year	Total No. Claims Filed	Total Awarded Permanent Disability	Av. Disability Rating %	Approx. Av. Capitalized Award $	Total Approx. Cost to Industry
1974	37	19	6.1	4.7K	92K
1975	61	30	6.7	5.0K	152K
1976	96	57	6.7	6.3K	359K
1977	96	44	6.3	6.9K	306K
1978	86	44	6.3	7.0K	309K
1979	116	52	6.1	7.7K	399K
1980	146	45	7.3	8.2K	368K
1981	231	73	5.8	8.2K	594K
1982	240	80	6.4	9.6K	772K
1983	321	89	5.7	9.1K	806K
1984	317	86	5.8	10.5K	899K
1985	214	58	6.4	12.9K	750K

7.0 NATIONAL HEALTH & WELFARE PROGRAMME IN PROTECTION FROM OCCUPATIONAL HEARING LOSS

National Health and Welfare (NHW) has had a number of activities in the area of occupational hearing loss over the years. The Medical Services Branch has an ongoing responsibility for monitoring the hearing and work environment of public service employees and for enforcing Treasury Board Standards for occupational noise exposure and hearing conservation. The Health Services and Promotion Branch publishes topical documents related to occupational noise from time to time, the most recent document concerns acquired hearing impairment in adults (53).

The Health Protection Branch has a responsibility for protecting the health of Canadians from the adverse effects of noise. This has been carried out by the Non-Ionizing Radiation Section (NIRS) of the Radiation and Medical Devices Bureau, Health Protection Branch. The noise program began with a background document entitled "Noise Hazard and Control", published in 1979 (54). This document summarized known health effects of noise (both auditory and non-auditory) indicated the major sources of noise, and described Canadian noise legislation. It also indicated areas of incomplete knowledge, mainly related to noise-induced hearing loss, which were:

(a) the effects of impulse noise and continuous noise in the 4 - 6 kHz frequency range
(b) the accuracy and effectiveness of screening audiometric testing and screening audiometers
(c) the assessment of the total noise exposure of Canadians and its relation to hearing loss, and
(d) the investigation of the amount of hearing loss incurred from various noise exposure limits.

Since then, noise levels and the progression of noise-induced hearing loss in specific industries in Canada have been evaluated (55). The method of testing hearing (audiometric testing), and the acoustic accuracy of audiometers have also been investigated (56).

The most recent Canadian activity has been the preparation of the "Guidelines for Regulatory Control of Occupational Noise Exposure and Hearing Conservation. Part I. Model Regulation" (4), described in Section 2.3.

There is an ongoing active interest in Canadian and International Noise standards work to support activities in protection from the hazards of noise exposure.

8.0 CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the Federal/Provincial Guidelines (4) be used as a basis for future occupational noise regulations in Canada in conjunction with the scientific basis provided by the Shaw Report (2). In summary, therefore, occupational noise exposure and hearing loss regulations are particularly encouraged to include the following:-

(1) Provision for education of employers and employees.
(2) All possible aspects of hearing conservation programmes.
(3) Equivalent continuous noise levels (or noise exposure levels) be used to measure sound exposure (L_{Aeq} or L_{Aex}).
(4) 3 dB dose trading relationship.
(5) 90 dBA sound exposure limit for an 8 hour working day.
(6) No distinction be made between impulsive or other type of noise.

It is also recommended that new installations be required before construction to obtain approval so that occupational noise criteria will be met.

Finally, the increasing number of claims for occupational hearing loss and the cost of its compensation should provide a strong incentive for effective hearing conservation programmes.

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