CRITERIA FOR A RECOMMENDED STANDARD

Occupational Exposure to Hand-Arm Vibration

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FOREWORD

The purpose of the Occupational Safety and Health Act of 1970 (Public Law 91-596) is to assure safe and healthful working conditions for every working person and to preserve our human resources by providing medical and other criteria that will assure, insofar as practicable, that no worker will suffer diminished health, functional capacity, or life expectancy as a result of his or her work experience. The Act authorizes the National Institute for Occupational Safety and Health (NIOSH) to develop and recommend occupational safety and health standards and to develop criteria for improving them. By this means, NIOSH communicates these criteria to regulatory agencies (including the Occupational Safety and Health Administration and the Mine Safety and Health Administration) and others in the community of occupational safety and health.

Criteria documents provide the basis for the occupational safety and health standards sought by Congress. These documents generally contain a critical review of the scientific and technical information available on the prevalence of hazards, the existence of safety and health risks, and the adequacy of control methods. NIOSH distributes these documents to health professionals in academic institutions, industry, organized labor, public interest groups, and other government agencies.

This criteria document examines the occupational health problems associated with the use of vibrating tools and provides criteria for reducing the risk of developing vibration-induced health problems. In this document, the term "vibrating tools" includes both hand-held vibrating tools and stationary tools that transmit vibration through a workpiece. The major health problems associated with the use of vibrating tools are signs and symptoms of peripheral vascular and peripheral neural disorders of the fingers and hands. These signs and symptoms include numbness, pain, and blanching of the fingers, and loss of finger dexterity. This composite of vibration-induced signs and symptoms is referred to as hand-arm vibration syndrome (HAVS).

On the basis of the 1983 National Occupational Exposure Survey, an estimated 1.45 million U.S. workers use vibrating tools. The prevalence of HAVS in workers who use such tools is reported to range from 6% to 100%, with an average of approximately 50%. Primary Raynaud's disease, whose signs and symptoms resemble those of HAVS, has been reported to occur in an estimated 5% of the general population. This percentage is consistent with the number of unexposed comparison workers who report such symptoms in studies of HAVS.

HAVS is a chronic progressive disorder with a latency period that may vary from a few months to several years. The development of HAVS in a population of workers and the length of the latency period depend on many interacting factors, including vibration level produced by the tool, hours of tool use per day, environmental conditions, type and design

of the tool, manner in which the tool is held, vibration spectrum produced by the tool, vibration tolerance of the worker, and tobacco and drug use by the worker.

Because of the complex interactions among these and other factors, the general lack of epidemiologic and clinical data, and the uncertainty associated with some vibration measurements, it is not currently possible to establish meaningful dose-response relationships. Thus it is not possible to establish a specific recommended exposure limit (REL) that will protect workers against the development of HAVS in all occupational situations. However, the problem of HAVS is too serious and pervasive to delay measures for correcting it.

NIOSH has therefore recommended a standard for exposure to hand-arm vibration that includes no specific exposure limit but does include engineering controls, good work practices, use of protective clothing and equipment, worker training programs, administrative controls such as limited daily use time, and medical monitoring and surveillance. Frequency-unweighted measurements of acceleration are also recommended since they provide simpler, more appropriate means for assessing the health risk of using vibrating tools at all frequencies. A cornerstone of this standard is the requirement for medical monitoring of all vibration-exposed workers to identify the first signs and symptoms of HAVS and to remove such workers from the job until they are free of all vibration-related symptoms.

Implementation of this standard will protect users of vibrating tools from the debilitating effects of HAVS. NIOSH also anticipates that this criteria document will stimulate research and development in all areas relating to hand-arm vibration. Future research may provide new and more effective methods for reducing occupational exposure to vibration.

When appropriate data become available to develop a specific REL for vibration exposures, NIOSH will revise its recommended standard. Until then, adherence to the standard described in this criteria document should prevent or greatly reduce the potential for vibration-exposed workers to develop the painful and disabling HAVS.

NIOSH takes sole responsibility for the conclusions and recommendations presented in this document. All reviewers' comments are being sent with this document to the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) for consideration in standard setting.

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ABSTRACT

This document examines the occupational health problems associated with the use of vibrating tools (including both hand-held vibrating tools and stationary tools that transmit vibration through a workpiece), and it provides criteria for reducing the risk of developing vibration-induced health problems. The major health problems associated with the use of vibrating tools are signs and symptoms of peripheral vascular and peripheral neural disorders of the fingers and hands. These signs and symptoms include numbness, pain, and blanching of the fingers. This composite of vibration-induced signs and symptoms is referred to as hand-arm vibration syndrome (HAVS), sometimes called Raynaud's phenomenon of occupational origin, or vibration white finger disease.

In the United States, an estimated 1.45 million workers use vibrating tools. The prevalence of HAVS in a worker population that has used vibrating tools ranges from 6% to 100%, with an average of about 50%. The development of HAVS depends on many factors, including the level of acceleration (vibration energy) produced by the tool, the length of time the tool is used each day, the cumulative number of months or years the worker has used the tool, and the ergonomics of tool use. The tools most commonly associated with HAVS are powered hammers, chisels, chain saws, sanders, grinders, riveters, breakers, drills, compactors, sharpeners, and shapers.

The prevalence and severity of HAVS usually increase as the acceleration level and duration of use increase. HAVS is a chronic, progressive disorder with a latency period that may vary from a few months to several years. The early stages of HAVS are usually reversible if further exposure to vibration is reduced or eliminated; but treatment is usually ineffective for the advanced stages of HAVS, and the disorder may progress to loss of effective hand function and necrosis of the fingers. Prevention is therefore critical. Adherence to the exposure controls recommended in this document should prevent or greatly reduce the potential for vibration-exposed workers to develop HAVS.

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GLOSSARY

Acceleration: The time rate of change in velocity (ft/sec^2 or m/sec^2 or gravity). The second derivative of displacement with respect to time.

Acceleration exposure dose: The level of acceleration and years of exposure.

Acceleration, Gravity: The acceleration produced by the force of gravity (1 g = 9.81 m/sec^2 or 32.19 ft/sec^2).

Accelerometer: Transducer used to measure acceleration or time rate of change in velocity.

Amplitude: The maximum displacement in an oscillatory motion from a reference position.

Compliance, mechanical: Displacement of a structure per unit of load; the ease with which a system may be displaced.

Coupling: The linkage between the hand and a vibrating source. The integrity of the contact between the hand and the handle surface of a vibrating tool.

Damping: The process by which the amplitude of the crest of a vibration is decreased.

Displacement: A vector quantity specifying the change in the position of a body from its reference position.

Dyne: A force that gives a free mass of 1 gram an acceleration of 1 cm/sec^2.

Elasticity: The property that enables a body to resist and recover from deformation produced by a force.

ERG: A unit of work produced by a force of 1 dyne acting through a distance of 1 cm.

Force: A vector quantity that accelerates a body in the direction in which it is applied. Units of force are expressed as newtons (N).

Frequency: Rate of oscillation; number of oscillations per unit of time; the number of complete cycles per unit of time. One hertz (Hz) is one cycle per second.

Gravity (g): Acceleration resulting from gravitational force (32 ft/sec2 or 9.81 m/sec2).

Harmonic: A frequency that is an integral multiple of some fundamental or base frequency.

Hertz: A unit of frequency (cycles per second).

Impedance: The ratio of a harmonic excitation of a system to its response; ratio of applied force to resulting velocity.

Impedance, mechanical: Ratio of applied vibratory force to the resulting velocity.

Incidence: Number of new cases of a disease or condition reported in a population over a given period.

Jerk: Time rate of acceleration change.

Joule: A unit of energy equal to the amount of work done when a point is displaced 1 m by the application of a force of 1 N. A unit of energy equal to 107 ergs, or about 0.738 foot pounds.

Latency: The time interval between the application of force or stimulus and the appearance of a response.

Mass: Quantity of matter; the inertial resistance of a body to acceleration.

Mass, dynamic: Ratio of applied force to resulting acceleration.

Modulus, dynamic: Ratio of stress to strain; stress required to produce a unit of strain.

Newton: Force required to accelerate a 1-kg mass 1 m/sec2 (100,000 dynes).

Oscillation: The variation in the position of an object over time in reference to its starting point.

Oscillation, period of: Time required for an oscillation to be completed.

Power, spectral density: The mean square value of energy per unit of time passed through a given frequency range.

Prevalence: Number of current cases (old and new) of a disease or condition in a population at a given point in time (point prevalence) or during a given period (period prevalence).

Radians: The angle subtended at the center of a circle by an arc equal in length to a radius of the circle.

Resonance: The tendency of a body to act in concert with an externally generated vibration to amplify the impinging vibration; the amplification of an oscillation of a system by a force wave or oscillation of exactly equal period or frequency.

Root mean square: The square root of the arithmetic mean of the squares of a series of numbers.

Stiffness: The ratio of force or torque to the resulting change in displacement of an elastic body.

Spectrum, vibration: The distribution of frequencies that describes the frequencies that are present in a vibrating system.

Transfer function: The mathematical relation between the input into a system and the response.

Transmissibility: The ratio of vibration output divided by the input as a function of frequency.

Velocity: The first derivative of displacement with respect to time (m/sec).

Vibration: The oscillation or periodic motion of a rigid or elastic body from a position of equilibrium.

Vibration, random: An oscillatory motion in which the acceleration varies over time in a nonperiodic manner; a vibration whose magnitude is not precisely predictable for any point in time.

ABBREVIATIONS

a	acceleration
ACGIH	American Conference of Governmental Industrial Hygienists
ACTU	Australian Council of Trade Unions
ANSI	American National Standards Institute
A/V	antivibration
BSI	British Standards Institute
$^{\circ}C$	degree Celsius
CFR	Code of Federal Regulations
clo	unit of insulation value of clothing
CPT	cold provocation test
CTS	carpal tunnel syndrome
cm	centimeter
D.A.	double amplitude displacement
dB	decibel
DL	distal latency
f	frequency
F	force
$^{\circ}F$	degree Fahrenheit
FSBP	finger systolic blood pressure
ft	foot
g	gravity

H-A	hand-arm
HAVS	hand-arm vibration syndrome
hr	hour
Hz	hertz
ISO	International Standards Organization
J	joule
JAIH	Japanese Association of Industrial Health
kcal	kilocalorie
kg	kilogram
km	kilometer
M	mega
m	meter
MCV	motor nerve conduction velocity
min	minute
ml	milliliter
mm	millimeter
m/sec	meter per second
m/sec^2	meter per second squared
MSHA	Mine Safety and Health Administration
N	newton
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
REL	recommended exposure limit
rms	root mean square
SCV	sensory nerve conduction velocity

sec	second
SHE	sentinel health event
TLV®	threshold limit value
TWA	time-weighted average
USSR	Union of Soviet Socialist Republic
VTHC	Victorian Trades Hall Council
VWF	vibration white finger
v	velocity

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