

I. RECOMMENDATIONS FOR A STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to vibration from the use of vibrating tools be controlled by compliance with all recommendations given in Chapter I of this document. Adherence to these recommendations should prevent or greatly reduce the risk of incurring hand-arm vibration syndrome (HAVS) in workers who use vibrating tools. In this document, the term "vibrating tools" includes both hand-held vibrating tools and stationary tools that transmit vibration through a workpiece. An estimated 5% of the general population may develop primary Raynaud's disease (whose signs and symptoms resemble those of HAVS) without exposure to vibration. The recommendations are designed to prevent workers who use vibrating tools from developing the signs and symptoms of Stage 1* HAVS during a working lifetime.

SECTION 1. VIBRATION EXPOSURE

HAVS has been observed in workers who have used vibrating tools that transmit vibration energy to the hands and arms over a wide range of acceleration levels. The level of acceleration produced by a tool is influenced by many factors, including tool type and weight, operating speed, ergonomics of tool use, environmental conditions, antivibration materials used, etc. (see Chapter III, D and Chapter VII). Thus NIOSH cannot currently establish a specific quantitative exposure limit that will eliminate the risk of developing HAVS in all workers exposed to hand-transmitted vibration from all types of vibrating tools. NIOSH therefore recommends that exposure to hand-arm vibration be reduced to the lowest feasible acceleration levels and exposure times by adhering to the requirements presented in Section 4, Control of Vibration.

SECTION 2. EXPOSURE MONITORING

The epidemiologic and clinical evidence reviewed in Chapter IV supports the conclusion that a linear relationship exists between the acceleration exposure dose (level of acceleration and years of exposure) and the time of onset and severity of HAVS. Data on the vibration acceleration level produced by the vibrating tools are needed for the design of tools and work strategies that will help prevent and control HAVS at the earliest possible stage.

The components of the hand-transmitted vibration that shall be measured are (a) acceleration (m/sec^2 or g), (b) frequency (Hz), and (c) duration of exposure (min/day or hr/day).

*Stockholm Workshop classification. See Tables IV-4 and IV-5.

(a) Vibration acceleration shall be measured in the three orthogonal basicentric axes (Figure III-2) at the point on the tool where the vibration enters the hand or as close as possible to that point. The basicentric axis of greatest acceleration may be used to calculate acceleration levels. The magnitude of acceleration shall be measured using an accelerometer with sufficient dynamic range to cover the acceleration band of 1 to 1,000 m/sec^2 . The mass of the accelerometer shall be small enough that it does not affect the vibration amplitude being measured (<5 grams if possible). The vibration measuring system shall be calibrated in accordance with appropriate standards based on National Bureau of Standards procedures. The accelerometer(s) shall be attached to the vibrating source as described in Chapter III, B, Methods of Measuring Hand-Transmitted Vibration.

(b) The frequency-unweighted acceleration shall be expressed in m/sec^2 (rms) of the 1/3-octave-band center frequencies from 6.3 to 5,000 Hz.

(c) The vibration measurement system shall have a uniform response integrated over 1/3-octave-band center frequencies of 6.3 to 5,000 Hz. All measurements and analyses of the vibration acceleration and frequency shall be performed by trained technical personnel.

(d) The vibration characteristics (acceleration and frequency spectrum) for each tool shall be measured at the time the tool is first put into use and at annual intervals thereafter. The vibration shall be measured when the tool is operating under full power and actual or simulated conditions of use.

(e) The time the tool is in use shall be determined by measuring actual operating time over a workday; these measurements can then be used to calculate average daily vibration acceleration exposures. The total daily vibration acceleration exposure shall be converted to a normalized 4-hr acceleration amplitude in m/sec^2 (frequency unweighted) (see Chapter III, Equation 13).

(f) A hand-held vibration meter may be used for screening or monitoring purposes to determine the approximate acceleration levels being produced by the vibrating system. However, proper mounting of such an acceleration measuring device onto the vibrating tool is critical (see Chapter III, B).

SECTION 3. MEDICAL MONITORING

(a) General

(1) The employer shall provide a health monitoring program for all workers occupationally exposed to hand-arm vibration from the use of vibrating tools.

(2) The employer shall ensure that all medical examinations and procedures are per-

formed by or under the direction of a licensed physician with special training and experience in occupational health problems. Board certification in occupational medicine is one way to demonstrate such training and experience.

(3) The employer or physician shall (a) counsel all workers who use tobacco about its possible role in augmenting the harmful effects of vibrating tools, and (b) encourage these workers to stop using tobacco.

(b) Preplacement Medical Examinations

At a minimum, a preplacement medical examination shall be conducted for each worker who will use vibrating tools on the job. The baseline data obtained from these examinations are for comparison with the data derived from the periodic medical examinations. The examination shall include the following:

- (1) A comprehensive work history with special emphasis on present or past use of vibrating tools during work or hobby activities
- (2) A medical history, including relevant information on any peripheral vascular, peripheral neural, or musculoskeletal complaints
- (3) A comprehensive physical examination with special attention to peripheral vascular and peripheral neural integrity, grip strength, muscle force, and signs and symptoms of the disorders listed in Table IV-1
- (4) An assessment of the use of substances that influence normal vascular and neural function, which include certain prescription drugs, alcohol, tobacco, and illicit substances.

(c) Periodic Medical Examinations

(1) Periodic medical examinations shall be made available at least annually to all workers who use vibrating tools on the job. The periodic medical examination shall include all those items specified in Chapter 1, Section 3b, and any other items considered relevant by the examining physician. If circumstances warrant (e.g., an increase in job-related vibration exposure, or a change in health status), the medical examination shall be offered at shorter intervals at the discretion of the attending physician.

(2) The peripheral neural and peripheral vascular signs and symptoms noted during the examination shall be reported in conformance with the classification presented in Tables IV-4 and IV-5.

(d) Medical Removal

Any worker occupationally exposed to hand-transmitted vibration who develops peripheral

neural or peripheral vascular signs and symptoms of Stage 2 HAVS or above on the Stockholm Workshop classification described in Tables IV-4 and IV-5 shall not be exposed to further hand-arm vibration until his or her signs and symptoms have improved sufficiently that they no longer meet the criteria for Stage 1 HAVS.

If the attending physician recommends that a worker be removed from a job requiring the use of vibrating tools, the employer shall ensure that the worker retains all earnings, seniority, and other employment rights and benefits.

(e) Information for Health Care Professionals

The employer shall furnish the following information to the health care professional responsible for the medical monitoring program:

- A copy of this criteria document
- A description of the worker's duties and activities as they relate to vibration exposure
- An estimate of the worker's daily exposure to vibration and years of exposure
- A list of basic types of vibrating tools used
- A list of the acceleration levels produced by the tools
- A description of antivibration protective clothing and antivibration tool designs in use
- A list of all tasks that involve vibrating tools and workpieces and that require strong hand grip force
- Relevant information from previous work and medical histories and medical examinations
- A description of the special features of the task and the way in which this task is performed
- A description of the environmental conditions at the work site (ambient temperature, humidity, wind velocity, rain, snow, etc.)

(f) Written Report and Opinion

The employer shall receive the following information from the attending health care professional:

- An opinion as to the worker's ability to use vibrating tools
- Any recommended limitations to on-the-job exposure
- Any limitation to the worker's ability to use any required protective equipment or clothing
- With the worker's written consent, information about any condition requiring treatment or special consideration

SECTION 4. CONTROL OF VIBRATION

(a) General

Engineering and work practice controls shall be used to reduce hand-transmitted vibration exposure to the lowest feasible level. These controls shall also be supplemented by other control strategies such as the use of antivibration clothing, mittens, gloves, and equipment, and by worker training programs in the proper handling of the vibrating tools.

(b) Engineering Controls

- (1) The vibration acceleration level shall be controlled by reducing the vibration energy produced by the vibrating tool to the lowest level consistent with optimal operations and/or by changing the process to reduce the requirement for using the tool.
- (2) The power and weight of the tool shall be optimized to levels that minimize vibration but still permit the work to be efficiently performed.
- (3) The tool manufacturers shall furnish data on the vibration acceleration and frequency characteristics of their tools as measured by a standard test protocol of simulated operation.

(c) Work Practices

In addition to all possible engineering controls, work shall be modified to minimize vibration exposure. Work modification approaches include but are not limited to the following procedures:

Hand-Arm Vibration

- Reducing the number of hours a worker uses a vibrating tool during the workday
- Reducing the number of days per week the vibrating tool is used
- Arranging work tasks so that vibrating and nonvibrating tools can be used alternately, and assuring that the nonvibrating tools do not introduce other musculoskeletal stress factors
- Scheduling maintenance breaks as necessary to ensure that tools are sharp, lubricated, and tuned
- Selecting tools that produce the least amount of vibration consistent with satisfactory performance of the task
- Designing the work task and workplace to incorporate ergonomic principles to minimize vibration stress
- Reducing the grip force on the tool handle and the force applied at the tool/workpiece interface in a manner consistent with safety and performance
- Restricting the use of piecework and incentive pay

(d) Protective Clothing and Equipment

Protective clothing and equipment shall be used where feasible to reduce the level of the vibration energy transmitted to the hand and arm. Some approaches to protecting the worker with clothing and equipment are

- Incorporating vibration-damping materials into the palms and fingers of gloves and mittens
- Incorporating vibration-damping material into or on the tool handle or areas where worker-tool coupling occurs. Damping materials can be especially effective for high-frequency vibration
- Using antivibration isolators or damping techniques on tools such as the isolator used on antivibration chain saws

- Wearing adequate cold weather clothing to maintain body core temperature and prevent cold-induced peripheral vasoconstriction
- Ensuring that the antivibration equipment, clothing, and hand gear are ergonomically appropriate (e.g., glove fit, freedom of movement, and grip force required to control the tool)

(e) Worker Training

The employer shall establish a continuing training program to ensure that all workers who use vibrating tools have current knowledge of the health and safety effects of hand-transmitted vibration and of the procedures for minimizing or preventing the effects. The training program shall be conducted by persons qualified by training in and direct knowledge of the occupational safety and health implications of hand-arm vibration exposure. The program shall include adequate verbal and written information to ensure that each worker fully understands the health and safety hazards and methods for their assessment and control.

The training program shall include, at a minimum, the following topics:

- Source of vibration exposure
- Factors that adversely affect the magnitude of the vibration
- The means by which vibration is transmitted to hands and arms
- Adverse health and safety effects of vibration exposure
- Early signs and symptoms of HAVS
- Progression and reversibility of HAVS
- Exaggeration of vibration-induced health effects as a result of smoking
- Prevention of HAVS
- Use and availability of vibration protective clothing
- Antivibration devices for reducing vibration at the source

- Ergonomic approaches to reduce the effects of using vibrating tools
- The value of good tool maintenance
- The need to keep hands and body warm and dry
- Work practice procedures to minimize the effect of vibration exposure on health and safety

SECTION 5. LABELING

The following data shall be furnished by the manufacturer of vibrating tools and antivibration equipment:

- (a) All hand-held tools that produce vibration shall carry a label stating the frequency-unweighted acceleration level (m/sec^2) produced by the tool during normal operation.
- (b) The manufacturer of antivibration equipment, clothing, and hand gear shall provide information on the vibration-damping characteristics of each type of antivibration item produced for sale.

SECTION 6. RECORDKEEPING

(a) Maintaining Records

For all workers who are occupationally exposed to vibrating tools, the employer shall establish and maintain a record of the following:

- Type, model, and manufacturer of the vibrating tools used
- Vibration acceleration data furnished by the manufacturers on the labels of all vibrating tools used
- Daily use time of each type of vibrating tool
- Number of hours, months, and years each type of vibrating tool or workpiece was used
- Antivibration controls used and date they were first introduced

- Personnel training, including dates and content of any training courses
- Work histories and physicians' written medical reports and opinions
- Records from preplacement and periodic medical examinations
- Signs and symptoms of HAVS (if present) for each worker and date they first appeared

(b) Record Retention

In accordance with the requirements of 29 CFR* 1910.20(d), Preservation of Records, the employer shall retain the records described in Chapter I of this document for at least the following periods:

- (1) Thirty years for exposure monitoring records
- (2) The duration of employment plus 30 years for medical monitoring and surveillance records and other records described in Chapter I of this document

(c) Availability of Records

- (1) In accordance with 29 CFR 1910.20, Access to Employee Exposure and Medical Records, the employer shall, upon request, allow examination and copying of exposure monitoring records by a worker, a former worker, or anyone having the specific written consent of the worker or former worker.
- (2) Any medical records that are required by this recommended standard shall be provided, upon request, for examination and copying to the worker, the former worker, or anyone having the specific written consent of the worker or former worker.

(d) Transfer of Records

The employer shall comply with the requirements for the transfer of records as specified in 29 CFR 1910.20(h), Transfer of Records.

*Code of Federal Regulations. See CFR in references.

II. INTRODUCTION

For more than three-quarters of a century, workers who operated vibrating tools* on the job have reported complaints resembling the signs and symptoms of primary Raynaud's disease. The major complaints were episodic numbness and tingling of the fingers, episodic blanching of the fingers, with pain occurring mainly in response to cold exposure and on return of circulation, and reduction in grip strength and finger dexterity. These signs and symptoms increased in number and severity as the exposure to vibration (acceleration intensity and duration of exposure) increased.

This composite of vibration-induced signs and symptoms is referred to as hand-arm vibration syndrome (HAVS). The syndrome has been known by a number of different names: Raynaud's phenomenon of occupational origin, secondary Raynaud's phenomenon, vibration white finger (VWF), dead finger, traumatic vasospastic disease, and vibration syndrome. The tools most commonly associated with HAVS are powered hammers, chisels, chain saws, sanders, grinders, riveters, breakers, drills, compactors, sharpeners, and shapers. Many publications on the clinical, epidemiologic, and engineering aspects of HAVS have appeared during the past 35 years.

An estimated 1.45 million workers use vibrating tools in the United States [NIOSH 1983b]. In a worker population that has used vibrating tools, the prevalence of HAVS ranges from 6% to 100%, with an average of about 50%. The development of HAVS depends on many factors such as the level of acceleration (vibration energy) produced by the tool, the length of time the tool is used each day, the cumulative number of hours, months, and years the worker has used the tool, and the ergonomics of tool use. Minimum daily exposures for several hours each day for months or years are usually required before the first signs and symptoms appear.

HAVS is a chronic disorder with a latency period of a few months to several years. The early stages of HAVS are usually reversible if further exposure to vibration is reduced or eliminated, but advanced stages are progressive. However, treatment is usually ineffective for the advanced stages of HAVS, and the disorder can progress to loss of effective hand function and necrosis of the fingers.

*In this document, the term "vibrating tools" includes both hand-held vibrating tools and stationary tools that transmit vibration through a workpiece.

In recognition of the health and safety hazards of vibration exposure, NIOSH published *Current Intelligence Bulletin 38, Vibration Syndrome* [NIOSH 1983a]. This Current Intelligence Bulletin emphasized the magnitude of the problem and the seriousness of the health and safety aspects of vibration exposure. The publication was designed to alert management, labor organizations, workers, health specialists, and engineers to the need for recognition, assessment, and control of the problem in industries where vibrating tools are used.

This criteria document presents criteria, techniques, and procedures for the assessment, evaluation, and control of HAVS. Engineering controls, work practices, administrative procedures, medical supervision, worker training, ergonomic design of the tools and the task, and other procedures can be implemented to effectively reduce the risk of developing HAVS.