



Whole-Body Vibration Analysis of Military Range Operation Maintenance Tasks

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Introduction

Request

An employer from a military base requested a health hazard evaluation regarding range operators' exposure to whole-body vibration during vehicle operation.

Workplace

The military base had varied road conditions, including paved, dirt, and gravel roads. Range operators traveled on roads, routes, and trails. Conditions of routes and trails varied, including dirt, gravel, and grass. One route included firebreak paths that lacked vegetation to prevent the spread of fires into the base. Range operator tasks involved navigating the diverse road conditions to support base operations and monitoring the land for any shrapnel.

To learn more about the workplace, go to [Section A in the Supporting Technical Information](#)

Our Approach

We visited the military base in July 2024 to learn more about the health concerns and to measure whole-body vibration exposure. We completed the following activities during our evaluation:

- Observed work processes, work practices, and workplace conditions.
- Measured range operators' exposure to whole-body vibration during work shifts.

To learn more about our methods, go to [Section B in the Supporting Technical Information](#)

Our Key Findings

Whole-body vibration exposures for job tasks were below American Conference of Governmental Industrial Hygienists (ACGIH®) guidelines

- ACGIH is a scientific organization that publishes guidelines for use by safety and health professionals to make decisions about safe levels of exposure in the workplace.
- The ACGIH threshold limit value (TLV®) is the level above which a worker's vibration exposure is associated with likely health risks. ACGIH also has an action limit (AL) for vibration exposure. Exposure levels above the AL have been associated with the potential for health risks. All job tasks were below both of these levels.
- However, the whole-body vibration crest factor ratios (ratio of peak acceleration to the root-mean square) indicated an underestimate of the vibration exposure and potentially more harm.

To learn more about our results, go to [Section B in the Supporting Technical Information](#)

Our Recommendations

The Occupational Safety and Health Act requires employers to provide a safe workplace.

Potential Benefits of Improving Workplace Health and Safety:

- | | |
|--|--|
| ↑ Improved worker health and well-being | ↑ Enhanced image and reputation |
| ↑ Better workplace morale | ↑ Superior products, processes, and services |
| ↑ Easier employee recruiting and retention | ↑ Increased overall cost savings |

The recommendations below are based on the findings of our evaluation. For each recommendation, we list a series of actions you can take to address the issue at your workplace. The actions at the beginning of each list are preferable to the ones listed later. The list order is based on a well-accepted approach called the “hierarchy of controls.” The hierarchy of controls is a way of determining which actions will best control exposures. In most cases, the preferred approach is to eliminate hazards or to replace the hazard with something less hazardous (i.e., substitution). Installing engineering controls to isolate people from the hazard is the next step in the hierarchy. Until such controls are in place, or if they are not effective or practical, administrative controls and personal protective equipment might be needed. Read more about the hierarchy of controls at <https://www.cdc.gov/niosh/hierarchy-of-controls/about/index.html>.



We encourage the company to use a health and safety committee to discuss our recommendations and develop an action plan. Both employee representatives and management representatives should be included on the committee. Helpful guidance can be found in *Recommended Practices for Safety and Health Programs* at <https://www.osha.gov/safety-management>.

Recommendation: Reduce exposure to whole-body vibration

Why? Whole-body vibration is a physical exposure that occurs when mechanical energy from vibration is transmitted through the body. It is associated with an increased risk of low back disorders, particularly when combined with other work-related factors such as prolonged sitting, lifting, and awkward postures. Strong research evidence shows a positive association between whole-body vibration and low back pain. The preferred approach for minimizing whole-body vibration-related health risks involves modifying job tasks, vehicles, and equipment to reduce vibration exposure and align with employees’ physical comfort.

How? At your workplace, we recommend these specific actions:



Upgrade to vehicles with enhanced vibration dampening.

- Consider new vehicle replacements specifically designed to reduce whole-body vibration exposure.
- Prioritize vehicles equipped with advanced suspension systems, ergonomic or comfortable seating, and vibration-dampening technologies.
- Consider installing vibration dampening seats for vehicles in use.
- Conduct regular maintenance on all vehicles to ensure optimal performance of vibration-reducing components, such as shock absorbers and tires.
- Add additional lumbar support and seat belt strap cushions for vehicles in use.



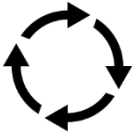
Minimize exposure to rough and uneven terrain.

- Avoid having range operators on sections of the training course known as particularly rough or uneven, when possible.
- Establish clear maps and signage to guide range operators away from these areas.
- Advise range operators to take the shortest and smoothest route to their destination, whenever possible, to reduce prolonged exposure to whole-body vibration.
- Maintain training course surfaces, such as improved road grading, more often to minimize uneven terrain and decrease vibration exposure.
- Note that at current staffing levels more crew and equipment would be required to perform grading duties.



Control driving speeds.

- Implement speed limits tailored to specific road conditions to minimize vibration intensity.
- Provide training for range operators on safe and effective driving practices that reduce vibration exposure, such as maintaining steady speeds and avoiding sudden acceleration or braking.



Continue established job rotation.

- Develop a job rotation schedule that alternates range operators between tasks involving vehicle operation and other less vibration-intensive duties. This reduces the cumulative exposure to whole-body vibration for any single individual.
- Ensure that job rotation schedules provide adequate recovery time and that all range operators receive cross-training for various tasks to support efficient and safe transitions between roles.

Supporting Technical Information

Whole-Body Vibration Analysis of Military Range
Operation Maintenance Tasks

HHE Report No. 2024-0048-3421

September 2025

Section A: Workplace Information

Military Basic Training Course

Size: 339,000 acres of land

Employee Information

Number of range operators at time of evaluation: 4

Length of shift: 8–10 hours per day

Union: American Federation of Government Employees

Process Description

Range operators reviewed, monitored, and inspected access to ranges, impact areas, and facilities (Figure A1). Most of the tasks required range operators to travel between ranges and the training areas on roads, routes, and trails that were paved, dirt, or gravel. In some cases, the range operators provided technical support to unit training staff and monitored the land for any shrapnel. One route included firebreak roads that lacked vegetation to prevent the spread of fires into the base. The trucks involved in the evaluation were a Ford F-350® long wheelbase (long bed), a Ford F-250® short wheelbase (short bed), and two Ford F-350 short bed pickup trucks. All trucks were 4-wheel drive and were received from available options with Fleet Services.



Figure A1. Map of the range, including darker lines designating separate areas and lighter lines designating roads. Figure by facility.

Section B: Methods, Results, and Discussion

Methods: Work Processes, Practices, and Conditions

We discussed the roads, routes, and trails taken by the range operators around the small impact area, airburst zones, and across the large training areas for data collection. We also discussed the process to purchase and maintain vehicles.

Results: Work Processes, Practices, and Conditions

Range operators rotated every 3 months between small impact, large impact, and training areas. We observed heavy to light rain on both afternoons during sample collection. Range operators switched routes due to weather-related safety concerns (e.g., slippery roads). Roads were also treated as needed with magnesium chloride for dust control and soil stabilization. However, when first applied, it made the road slippery, and range operators tried to avoid those areas. We observed grading the small impact roads for maintenance. Range operators told us that roads are usually graded twice a year, and the firebreak was graded once a year. The range operators stated that more frequent grading helped improve road surfaces, remove ruts from rain, and reduced vibration when driving. The facility has a land rehabilitation and maintenance department for employees to report areas with road issues. However, the department had fewer employees than in past years. As a result, surfaces were graded less frequently than in the past and differences were noted when less experienced employees performed grading.

Management selected vehicles from available options from Fleet Services. None of the options were “offroad” vehicles with better suspension for the types of roads traversed. Maintenance switched out tires and regularly maintained vehicles. Due to the rough road conditions, range operators regularly had flat tires. Each vehicle averaged around 4 sets of tires per year. Management replaced vehicles after 2–4 years when the vehicle reached 60,000–75,000 miles.

Methods: Whole-Body Vibration (WBV)

We used two Larson Davis Human Vibration Meters 200 to measure WBV following the guidelines of the International Organization for Standardization (ISO) 2631-1 [ISO 1997]. This standard outlines methods for measuring, analyzing, and reporting WBV in seated operators of vehicle cabs. The sensors were embedded in a rubber seat pad and recorded motion (acceleration) in three axes at a sampling rate of 1,000 Hertz (Hz) (1,000 samples per second). The positive z-axis was oriented vertically upward, perpendicular to the seating surface, while the positive x-axis projected forward from the operator’s position and positive y-axis projected left horizontally from the operator’s position. Section D provides additional description of whole-body vibration measurements.

The data collection system included a data logger that we mounted on the side of the operator’s seat using a padded pouch. We taped the seat pad to the seat and secured the wires and data logger using plastic ties or tape to ensure the setup was non-intrusive during operation (shown in Figure B1). We used a continuous measurement approach in which the data logger was manually started and was uninterrupted throughout the evaluation.



Figure B1. Rubber seat pad with embedded triaxial sensor for measuring WBV on the range operator truck seat. Photo by NIOSH.

We recorded WBV data while range operators performed their routine tasks, including driving, loading, transporting, and idling under normal conditions. WBV exposure for these tasks was assessed across all road types to understand the range of vibration levels under field conditions. Time periods when range operators were not seated, such as during breaks or task adjustments, were excluded from analysis. Range operators were asked to follow their typical work activities to ensure realistic acceleration measurements. Tasks included navigating between locations using the shortest practical routes, per routine procedures.

Root Mean Squared (RMS) Acceleration Data Analysis

We calculated the overall weighted RMS acceleration (A RMS vector sum) for each sample standardized to an 8-hour reference period (A RMS daily (8)). We applied equations from ACGIH [ACGIH 2024]. The first equation calculates the vector sum of the daily acceleration from all three orthogonal axes x, y and z. To compare the measured exposure to an 8-hour exposure we converted both measured time and reference time to seconds. We used 28,800 seconds for the standard reference duration of 8 hours.

$$A \text{ RMS vector sum} = ([A_{\text{daily},x}]^2 + [A_{\text{daily},y}]^2 + [A_{\text{daily},z}]^2)^{1/2}$$

$$A \text{ RMS daily (8)} = A \text{ RMS vector sum} * [T_{\text{meas}} / T_{\text{exp}}]^{1/2}$$

Where:

$A_{\text{daily}, x, y, \text{ or } z}$ = calculated overweighted acceleration RMS exposure for estimated task duration

T_{meas} = duration of measurement (seconds)

T_{exp} = duration of task for estimated vibration exposure (8 hours reference as 28,800 seconds)

In addition, we calculated a time-weighted average for the overall weighted RMS by job task (A_e), in this case vehicle sampled, within that day. We applied the equation from ACGIH [2024].

$$A_e = (\Sigma [A_{wj} * T_j] / \Sigma T_j)^{1/2}$$

Where:

A_e = calculated overall weighted acceleration RMS exposure for job task

A_{wj} = overall weighted acceleration RMS in the orientation x, y, or z for the job task.

T_j = the time for the exposure period for that job task.

Vibration Dose Value (VDV) Data Analysis

We applied equations from the ACGIH VDV [ACGIH 2024]. We calculated each axes (x, y and z) with sample time duration using the following calculation:

$$\text{VDV}_{\text{exp},x} = 1.4 * \text{VDV}_{\text{meas},x} (\text{T}_{\text{exp}} / \text{T}_{\text{meas}})^{1/4}$$

$$\text{VDV}_{\text{exp},y} = 1.4 * \text{VDV}_{\text{meas},y} (\text{T}_{\text{exp}} / \text{T}_{\text{meas}})^{1/4}$$

$$\text{VDV}_{\text{exp},z} = 1.0 * \text{VDV}_{\text{meas},z} (\text{T}_{\text{exp}} / \text{T}_{\text{meas}})^{1/4}$$

Where:

$\text{VDV}_{\text{exp}, x, y, \text{ or } z}$ = calculated VDV exposure for estimated task duration

$\text{VDV}_{\text{meas}, x, y, \text{ or } z}$ = VDV for measurement period

T_{exp} = duration of task for estimated vibration exposure (8 hours reference as 28,800 seconds)

T_{meas} = duration of measurement (seconds)

Then we calculated daily VDV ($\text{VDV}_{\text{ldaily}}$) of the different exposure durations. First, we calculated the partial V DVs for each sample measurement and each axis. Then, a daily VDV was calculated from the partial vibration exposures for each axis, using the following calculation:

$$\text{VDV}_{\text{ldaily}} = ([\text{VDV}_{j1}]^4 + [\text{VDV}_{j2}]^4)^{1/4}$$

Where:

VDV_{j1} = calculated $\text{VDV}_{x, y, \text{ or } z}$ exposure for morning

VDV_{j2} = calculated $\text{VDV}_{x, y, \text{ or } z}$ exposure for afternoon

Results: Whole-Body Vibration

We evaluated WBV exposure for 2 days among military base personnel navigating various road conditions. We collected eight samples, two samples on four different range operators each lasting between 2 and 3.5 hours. This timeframe was the typical time range operators drove during morning and afternoon sessions, with breaks and lunch in between.

RMS Acceleration

The AL for RMS acceleration is set at 0.43 meters per seconds squared (m/s^2), while the ACGIH TLV is 0.87 m/s^2 for an 8-hour exposure period. RMS acceleration that falls between the AL and TLV indicates a potential for experiencing adverse health effects. The measured calculated RMS acceleration values in our evaluation showed all tasks were below the AL and TLV (Table C1). The overall weighted acceleration RMS exposure for vehicle types sampled within that day in all three orthogonal axes x, y, and z were below the AL and TLV (Table C2).

VDV

We calculated crest factors, which measure the impulsiveness of vibrations, by determining the ratio of weighted peak acceleration to weighted RMS acceleration. Vibrations with higher impulsiveness, indicated by elevated crest factor values, are potentially more harmful than less impulsive vibrations [NIOSH 2022]. In our evaluation, crest factors for the measured tasks ranged between 10 and 26, as shown in Table C3. Each individual axis had a crest factor with a wide range between 10 and 40.

ISO 2631-1:2010 standard highlights that when crest factors exceed 9, the basic vibration evaluation method may underestimate the discomfort and potential severity of vibration [ISO 2010]. For WBV with crest factors above 9, ISO Standard 2631-1 recommends using the fourth power VDV method, which is more sensitive to vibrational peaks, to assess potential health risks. ACGIH aligns with this VDV method, providing an AL and TLV for VDV exposures based on ISO 2631-1 standards [ACGIH 2024]. The VDV AL is set at $8.5 \text{ m/s}^{1.75}$, while the TLV is $17.0 \text{ m/s}^{1.75}$ for an 8-hour exposure period. V DVs that fall between the AL and TLV indicate a potential for adverse health effects. The measured VDV values in our evaluation showed all task were below the AL of $8.5 \text{ m/s}^{1.75}$ (Table C4).

The daily VDV is the highest axis of VDV_x , VDV_y , or VDV_z . Table C4 shows the range operator's daily WBV exposure when combining the different durations between morning and afternoon tasks. ISO 2631-1 and ACGIH do not define a vector sum for VDV unlike the vector sum for overall weighted acceleration [ACGIH 2024].

Discussion

In the United States, an estimated 6.8 million employees are exposed to WBV in the workplace [Paschold and Mayton 2011; Wasserman et al. 1974]. Chronic exposure to vibration can result in adverse health effects, particularly in the spine and back [Cohen et al. 1977; Smith and Leggat 2025]. NIOSH has found strong evidence linking WBV to low back disorders in 15 of 19 studies reviewed. Additionally, WBV often interacts with other occupational risk factors, such as prolonged sitting, lifting, and awkward postures, increasing the risk of musculoskeletal disorders [NIOSH 1997].

Our evaluation showed that employees operating specific vehicles were below the recommended AL, but crest factors could suggest exposure measurements are underestimated. Weather conditions resulted in smoother routes being evaluated and could explain why some afternoon vibration exposure levels were lower compared to the morning measurements. These exposures may elevate the risk of discomfort and chronic musculoskeletal health issues. To mitigate these risks, it is critical to implement vibration-dampening interventions, such as modifying vehicle suspension and upgrading or replacing seats with models designed to reduce vibration transmission. Driving behaviors also influence vibration levels; although we did not measure speed, existing research [NIOSH 2013, 2022] suggests that reducing speed can significantly decrease vibration exposure. Additionally, workers should aim to minimize travel over rough surfaces and choose smoother paths whenever feasible to reduce vibration levels further.

Limitations

The WBV measurements we collected represent a snapshot of the conditions during the evaluation period, focusing on specific vehicles and tasks. These results might vary across different days, weather conditions, terrains, or equipment configurations. Not all routes or vehicles used by workers were measured during the evaluation, meaning actual exposures might be higher or lower under different conditions. Additionally, operator-specific factors, such as weight, posture, and driving style, can also influence the vibration levels recorded during the evaluation.

Conclusions

Our evaluation showed that range operators operating specific vehicles were below the recommended AL, but crest factors could suggest exposure measurements may be underestimated due to impact vibration. To address these risks, we recommend interventions aim to minimize exposure and improve the long-term health and comfort of range operators

Section C: Tables

Table C1. Overall weighted RMS acceleration results for different types of vehicles during the site visit based on measured whole-body vibration and standardized to an 8-hour reference period

Day / Vehicle type	Duration (hh:mm:ss)	Total measured duration (seconds)	A RMS vector sum (m/s ²)	A RMS daily (8) (m/s ²)
Day 1				
Morning F-350 long bed	3:49:00	13,740	0.10	0.069
Afternoon F-350 long bed	2:49:20	10,160	0.058	0.035
Morning F-250 short bed	3:33:04	12,784	0.12	0.081
Afternoon F-250 short bed	2:40:50	9,650	0.097	0.056
Day 2				
Morning F-350 short bed	3:01:40	10,900	0.12	0.072
Afternoon F-350 short bed	2:53:13	10,393	0.10	0.060
Morning F-250 short bed	2:54:09	10,449	0.10	0.060
Afternoon F-250 short bed	2:00:22	7,222	0.076	0.038
ACGIH AL acceleration	8:00:00	28,800	—	0.43
ACGIH TLV acceleration	8:00:00	28,800	—	0.87

Table C2. Overall weighted RMS acceleration exposure for different types of vehicles in each orthogonal axis

Day / Vehicle type	A _e overall weighted RMS x-axis (m/s ²)	A _e overall weighted RMS y-axis (m/s ²)	A _e overall weighted RMS z-axis (m/s ²)	Total measured duration (seconds)
Day 1				
F-350 long bed	0.042	0.051	0.054	23,900
F-250 short bed	0.047	0.066	0.076	22,434
Day 2				
F-350 short bed	0.044	0.060	0.080	21,293
F-350 short bed	0.041	0.051	0.063	17,671

Table C3. Whole-body vibration frequency weighted peak acceleration, frequency weighted RMS acceleration, and crest factor values measured for different types of vehicles

Day / vehicle type	Frequency weighted peak acceleration (m/s ²)	Frequency weighted RMS acceleration (m/s ²)	Crest factor (no units)
Day 1			
Morning F-350 long bed	1.3	0.10	13
Afternoon F-350 long bed	1.4	0.058	24
Morning F-250 short bed	1.7	0.12	14
Afternoon F-250 short bed	0.99	0.10	10
Day 2			
Morning F-350 short bed	1.5	0.12	13
Afternoon F-350 short bed	2.6	0.10	26
Morning F-350 short bed	1.9	0.10	19
Afternoon F-350 short bed	1.1	0.076	15

Table C4. VDV results for different types of vehicles during the site visit based on measured whole-body vibration and cumulative task duration

Day / vehicle type	Axis with highest VDV	Total measured duration (seconds)	VDV (8 hours) (m/s ²)
Day 1			
F-350 long bed	y	23,900	2.4
F-250 short bed	y	22,434	2.6
Day 2			
F-350 short bed	y	21,293	2.5
F-350 short bed	y	17,671	2.2
ACGIH AL VDV	—	—	8.5
ACGIH TLV VDV	—	—	17

Section D: Occupational Exposure Limits

NIOSH investigators refer to mandatory (legally enforceable) and recommended occupational exposure limits (OELs) for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects.

However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a preexisting medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a time-weighted average (TWA) exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short-term exposure limits (STEL) or ceiling values. Unless otherwise noted, the STEL is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations.

- OSHA, an agency of the U.S. Department of Labor, publishes permissible exposure limits [29 CFR 1910 for general industry; 29 CFR 1926 for construction industry; and 29 CFR 1917 for maritime industry] called PELs. These legal limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH recommended exposure limits (RELs) are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2007]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, PPE, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Another set of OELs commonly used and cited in the United States includes the threshold limit values or TLVs, which are recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH TLVs are developed by committee members of this professional organization from a review of the published, peer-reviewed literature. TLVs are not consensus standards. They are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline “to assist in the control of health hazards” [ACGIH 2019].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at <https://www.dguv.de/ifa/gestis/gestis-stoffdatenbank/index-2.jsp>, contains international limits for more than 2,000 hazardous substances and is updated periodically.

OSHA (Public Law 91-596) requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions.

Whole-Body Vibration

Neither NIOSH nor OSHA has exposure limits for whole-body vibration. ACGIH has a TLV for whole-body vibration that measures RMS acceleration in m/s^2 for the one-third octave bands from 0.5 Hz to 80 Hz [ACGIH 2024]. The one-third octave bands are weighted the same for the x- and y-axes but differently for the z-axis. The x-axis and y-axis are maximally sensitive at the frequencies of 1 to 2 Hz, while the z-axis is most sensitive between 4 Hz and 8 Hz. These most sensitive bands correspond to the natural resonances of the human body when it is vibrated in these directions. Resonance is the condition where vibration is optimally transmitted from the vibrating source to the person, with the individual actually amplifying the acceleration, possibly exacerbating the effects of the whole-body vibration [Coermann 1962].

Acceleration measurements are simultaneously collected in each of the three orthogonal axes and compared to the TLV's two weighting functions. The criterion has exposure time limits from 1 minute to 24 hours that correspond to the RMS acceleration measured at each one-third octave band. The TLV also presents formulas to calculate the single-vector sum of the weighted accelerations from all three orthogonal axes. According to the ACGIH TLV, this single value of the sum of the weighted accelerations can be compared to the Commission of the European Communities directive [Commission of the European Communities 2002]. Specifically, the directive requires a daily exposure limit value standardized to an 8-hour reference period of $1.15 m/s^2$ and a daily exposure action value of $0.5 m/s^2$ for the same standardized period. Once the exposure action value has been exceeded, the employer should establish a program to reduce exposure to mechanical vibration. The program can include engineering controls, new equipment that produces lower levels of vibration, changes in work practices, and training programs to instruct workers in the use of the equipment to reduce vibration.

The ISO has defined methods for the measurement of periodic, random, and transient whole-body vibration to indicate the degree to which vibration exposure will be acceptable [ISO 1997]. The standard presents different weighting factors of one-third octave bands for the frequency range of 0.5 to 80 Hz in each of the three orthogonal directional axes. The principal weighting curves vary depending on

whether the standard is being applied to health, comfort, or perception guidelines and whether the worker is seated, standing, or recumbent. As is the case with the ACGIH TLV, the weighting curves are maximally sensitive at the natural resonance of the human body, 1 to 2 Hz in the x and y directions, and 4 to 8 Hz in the z direction. The standard contains informative guides to the effects of vibration on health, comfort, and perception in a series of appendices. The guidance on health effects is primarily intended to reduce the risk of injury to the lumbar spine and the nervous system. A health guidance caution zone is presented in the standard to which the RMS acceleration value of the frequency-weighted accelerations can be compared for varying exposure durations from 10 minutes to 24 hours. The lower boundary of the health guidance caution zone runs from approximately 3 m/s² for 10 minutes or less to 0.25 m/s² for 24-hour exposures [ACGIH 2024].

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