

Aerospace Standard 6228 Developed to Support Improved Productivity and Reduce Occupational Disease Among Powered Hand Tool Operators

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ABSTRACT

A joint US Department of Defense (DOD), General Services Administration (GSA) and National Institute for Occupational Safety and Health (NIOSH) project initially addressing procurement criteria for powered hand tools stimulated involvement of the SAE EG1-B Hand Tools committee and affiliated industry participants, producers of powered hand tools. It became apparent of the need to develop a standard that addresses occupational disease, productivity, life-cycle cost in the selection of Hand Power Tools. Committee efforts focused upon development of an SAE International Standard that considers productivity hand-arm vibration, noise, other safety and health factors and life-cycle costs in procurement criteria for powered hand tools. Aerospace Standard, AS 6228 *Safety Requirements for Procurement, Maintenance and Use of Hand-held Powered Tools*, was published in September 2014. Concurrently, a new committee, EG1-B1, Powered hand tools, productivity, Ergonomics and Safety, evolved from the EG1-B subcommittee initially formed to address this topic. The standard provides a process for semi-quantitative assessment and comparative weighting of factors including life-cycle cost, vibration, ergonomics and noise into the evaluation and procurement decision. GSA has adapted the standard in evaluation of powered hand tools and is currently making approximately 140 lower vibration/ergonomic tools available to Federal users and Aerospace Original Equipment Manufacturers (OEM's), while identifying new products based on customers supply support requests. Current efforts are focused on outreach to industry and DOD; development of a technical report describing application of the AS 6228 standard and extending the processes described here to other commodities and industrial processes.

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INTRODUCTION

Powered hand tools have become essential to a range of industrial operations since their first introduction when Samuel Ingersoll invented the pneumatic drill in 1871. The current U.S. powered hand tools market is in the range of \$11 billion annually. However, progress often comes with risk. A range of potential hazards associated with hand-held powered tool use include noise, a range of ergonomic stresses and physical safety hazards. Most books on industrial safety include a chapter or section on hand tools and powered hand-held tools. [1] Acute physical injuries from failure or misuse of control/trigger mechanism are a particular concern, especially for products such as nail guns. At the same time, many users of power tools fail to employ a process management approach to process selection, procurement of the best available tools, maintenance of the equipment and education of users.

Table 1 summarizes the range of common health and safety hazards and their association with quality and productivity factors. Some of the health related impacts summarized in Table 1 will be discussed in more depth in the body of the article and cited references. Ergonomic Issues Associated with Powered Hand Tool Use The selection of

tools, light weight, excellent power to weight ratio and user trigger time are factors within the AS 6228; taking into consideration the work settings/ fixtures which are unsuitable or inefficient for the work task being conducted. These factors compromise the productivity of workers and may create risk of long term disease and even disability. Common potential risk factors and related productivity impacts are summarized in Table 2 below.

ERGONOMIC ISSUES ASSOCIATED WITH POWERED HAND TOOL USE

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NOISE AS A PREVALENT INDUSTRIAL HAZARD

Occupational noise exposure and related hearing loss is considered the most prevalent occupational disease. (See the NIOSH webpage addressing noise associated hearing loss <http://www.cdc.gov/niosh/topics/noise/stats.html>). SAE Standard AS 6228 has established benchmarks for noise with a goal of less than 85 dBA. The exact number of workers exposed to excessive levels of noise, which create risk of hearing loss, is not certain. NIOSH estimates this population to be in the range of four million within the United States. [2] A similar, or even greater fraction, of workers in the developing world

Table 1. Powered Hand Tools- Safety, Process Management and Equipment Selection Factors

Factor or Risk	Health and Safety Impacts	Productivity Impacts	Potential Controls
Vibration	Hand-arm vibration disease risk	Long-term impact on skilled workforce	Equipment selection and maintenance, Process selection
Noise	Hearing loss	Communication issues	
Dust-varied respiratory hazards- Silica, asbestos and many metals are potentially associated with long-term disabling occupational disease	Silica-containing (silicosis); heavy metal exposures and related disease (lead, chromium, cadmium are the most prevalent). Silica and some heavy metals are known or suspect carcinogens.	Poor visibility at point of operation, expense and time loss for poor control measures	Process selection, use of wet techniques, high-velocity-low volume local exhaust*
Ergonomic stressors related to design of workplace and tools	Discomfort; Long-term repetitive motion disease potential	Direct link between comfort and productivity	Equipment selection and process design
Physical safety hazards/ controls	Potential injuries, especially acute trauma	Productivity impacts of work-around	Equipment selection and maintenance
Electrical safety hazards	Shock and acute injury/burn	Disruption of process, potentially fire and physical damage	Use of UL or other third-party tested tools; use of double insulation or ground fault interrupters
Life-cycle costs (replacement/ repair)	Low-cost tools are likely to be noisier, and less "ergonomic"	Decreased productivity and quality (Cheap tools are expensive)	Process and equipment selection to optimize products purchased. Equipment maintenance

are likely to be exposed to industrial noise, often without the level of attention to controls and/or protective equipment common in settings with a higher level of awareness, or enforcement, of industrial safety precautions.

Table 2. Physical Risk Factors Ergonomics Checklist*

Risk Factor	Risks/Remarks (Many risks are increased by task duration)**
Working with or raising hand(s) above head or elbows above shoulders	May impair blood flow arms due to elevated position
Working with neck bent (without support and without the ability to vary posture)	Stress on soft tissues, decreased productivity due to increased discomfort and greater rest cycle
Working with the back bent forward (without support and without the ability to vary posture)	Stress on soft tissues, decreased productivity due to increased discomfort and greater rest cycle
Squatting	Stress on knees and ultimately soft tissue damage (chronic knee problems)
Kneeling	Stress on knees and ultimately soft tissue damage (chronic knee problems)
Pinching an unsupported object(s)	Carpal tunnel syndrome and other overuse syndromes
Gripping an unsupported object(s) weighing 10 or more pounds per hand	Overuse syndromes, fatigue, reduced productivity due to increase rest cycle
Repeating the same motion with the neck, shoulders, elbows, wrists, or hands (excluding keying activities)	Overuse syndromes, fatigue, reduced productivity. Wrist and joint issues may include tendonitis and/or carpal tunnel syndrome**
Using the hand (heel/base of palm) or knee as a hammer	Soft tissue injuries
Heavy, frequent or awkward lifting	Back injuries both acute and chronic damage to soft tissues. Criteria depends on weight and frequency refer to ACGIH guidelines, ref 5, or Mil Std 1472

*Developed by the Army Public Health Command, extracted from the Navy Shore Safety Manual OPNAVINST 5100.23 Chapter 23 Navy Ergonomics Program and available at https://navalforms.documentservices.dla.mil/formsDir/_OPNAV_5100_20_3279.pdf

** A "caution level" of two hours/day is shown for most tasks. Risk is increased by non-neutral postures such as wrist deviation. In the case of back and neck deviation the risk factor includes deviation > 30 degrees.

The relationship between uncontrolled noise exposure and occupational hearing loss is so well established that there is an ANSI standard which correlates these factors mathematically. (**ANSI S3.44-1996 1996**) The relative contribution of powered hand tools hasn't been established, but even the casual visitor to many factories, maintenance facilities and construction sites is likely to notice the presence of power tools by the noise associated with their operation. **Table 3** shows representative noise levels for common powered hand tools from the standard for hearing loss prevention for construction and demolition workers

Noise is measured on a logarithmic scale because of the wide range of sound level pressures created by natural and man-made sources and the non-linear response of the human ear to sound exposure. These noise levels shown above be compared to the recommended occupational exposure limit of 85 dBA for an 8-hour time weighted average exposure, with a 3 dB doubling of intensity which has been recommended by most standards organizations [2] [5] and adapted by the US Department of Defense [6], as well as applied to contractors performing work for DOD [7] in accordance with Federal Acquisition Regulations (Federal Acquisition Regulation (FAR) Clause 52.236-13). This standard is much more stringent than the OSHA Permissible Exposure Limit (PEL) of 90 dBA for an 8-hour time weighted average. [8] The OSHA standard is known to be incompletely protective- up to 17% of unprotected workers would experience significant hearing loss if exposed to this level of noise for a working life-time. [5] (Also see DHHS (NIOSH) Publication Number 2010-136 <http://www.cdc.gov/niosh/docs/2010-136/>).

Table 3. Probable Noise Levels of Common Construction Tools*

Tool	Noise Level will probably exceed (dBA scale)	Reference cited in ANSI/ASSE A10.46-2007
Air Gun	108	CDC 2005
Air Hammer	110	Bragdon (1971)
Asphalt Grinder	111	Greenspan et al (1995)
Brick saw	94	Burgess and Lai (1999)
Chipper, pneumatic	100	Hassel (1979), Olishifski (1975)
Concrete saw	98	CDC (2005)
Electric grinder	98	NZ DOSH (2002)
Jackhammer	102	CDC (2005)
Nail gun	97	NZ DOSH (2002)
Reciprocating saw	86	NIOSH (2005)

* ANSI/ASSE A10.46-2007 Hearing Loss Prevention for Construction and Demolition Workers, Appendix 2 (Representative tools are selected from a longer list)

The effectiveness of personal protective equipment is widely overestimated and as a “rule of thumb” the effective level of noise attenuation provided by hearing protective equipment is approximately half the “ideal” Noise Reductive Rating (NRR) achieved in a laboratory setting. The OSHA hearing conservation standard includes an annex for calculation of effective NRR. [8] Thus, the selection and management of processes and equipment to minimize noise exposure are the paramount and most effective control measure.

HAND ARM-VIBRATION AS AN UNDER-RECOGNIZED RISK FACTOR

One of the less publicized risks is hand-arm vibration, previously called Raynaud's Syndrome of occupational origin, a neurovascular disease associated with intense and prolonged exposures to vibration - most commonly from powered hand tools. (Pelmear 1998) Despite initial US reports in the early 1900s, the disease has remained under-recognized in the US. (Taylor, et al. 1984) (Wasserman, et al. 1982) (Pelmear 1998).

European Union regulations have created an increased awareness of hand-arm vibration disease and demand for low-vibration powered hand tools, while the US has lagged in this regard. (European Parliament and the Council of the European Union 2002) (European Agency for Safety and Health at Work 2008) (American National Standards Institute/ASA 2006 R-2011) (Also see additional resources). The criteria adapted as the basis of the Europe Union Standard and generally recommended criteria within the US, includes a dose response relation between exposure and risk of disease, which is a normative part of the standard. (American National Standards Institute/ASA 2006 R-2011) AS 6228 has established a working vibration of level of 2.5 m/s². (SAE International EG1-B1 Committee 2014) Early recognition, control and exposure of this debilitating condition are critical because HAVS has been shown to be virtually irreversible after symptoms progress past initial stages. (Pelmear 1998). Muscular Skeletal Disorders such as HAVS, also known as “White Finger Disease” and carpal tunnel syndrome are typically developed over prolonged, daily regular exposure. (Bernard 1997)

Figure 1 illustrates the dose response curve associated with 10% incidence of HAV symptoms. The wide range of vibration (and noise) created by alternative products performing the same function makes initial product selection critical. **Figure 2** illustrates the range of vibration exposures in a number of common powered hand tools and the presence of vibration levels exceeding the recommended standard of 5 m/s² for an eight hour time weighted average. *Selecting the correct Power tool can minimize the risk of Hand Arm-Vibration Syndrome (HAVS).*

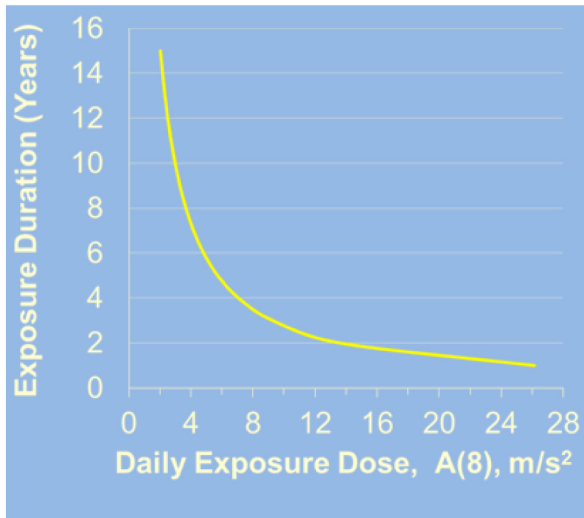


Figure 1. Dose-Response to Hand-arm vibration Associated with 10% Prevalence of VWF^{*}

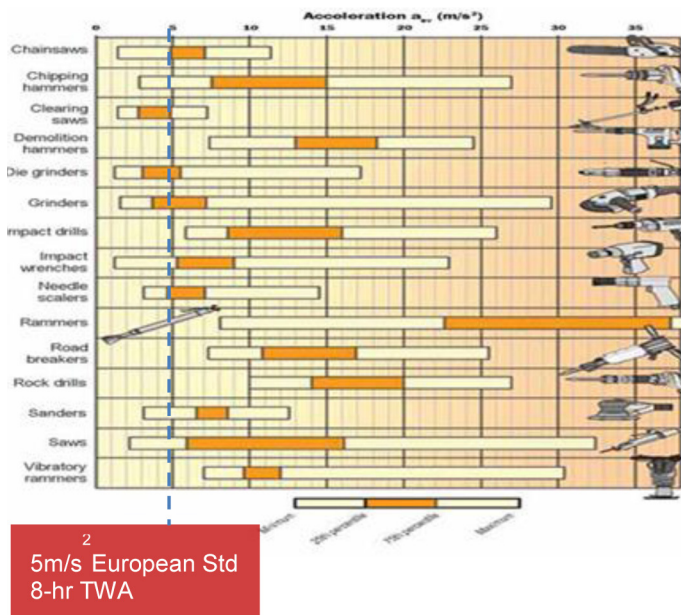


Figure 2. Examples of vibration magnitudes for common tools¹

INITIAL PROJECT TO REDUCE HAND-ARM VIBRATION THROUGH PROCUREMENT GUIDELINES AND THE DEVELOPMENT OF AS 6228

A DOD-funded project to address hand arm vibration was stimulated by outreach at the Puget Sound Naval Shipyard and Intermediate Maintenance Facility (IMF). Craig Henderson, the ergonomics program manager in the Safety and Health Department at Puget Sound Naval Shipyard and IMF, approached the General Services

Administration (GSA) for assistance in obtaining low-vibration power hand tools. A representative of the tools section of GSA communicated this issue to the DOD Ergonomics Working Group (Moran February 2006).² This presentation provided the basis for a project sponsored by the Defense Safety Oversight Council (DSOC) and its Acquisition and Technology Task Force (working group) to improve education and awareness of HAVs and affect procurement specifications for power hand tools and certified anti-vibration (A/V) gloves. (M. Geiger 2006) DOD also requested GSA FAS collaboration in procurement of low-vibration power hand tools. (Readiness October 31, 2007)³ Prior to this project, low-vibration characteristics had not been routinely applied to selection criteria for Power Tool procurement or selection. Also, there were no suitable (certified) A/V gloves in the Federal supply system meeting relevant ISO/ANSI standards.

This project began in 2008 and was a part of a larger DOD/Naval effort to better integrate safety and health requirements and technology into management of defense acquisition, sustainment, and procurement processes. Technical outreach included education of safety and health professionals in operation of the Defense acquisition and logistics system; application of the system safety process to management of HAV and influencing process requirements for maintenance and support operations. Initial efforts included publication of a website describing common safety and health hazards associated with operation and maintenance of Navy ships, which included a section on whole body and segmental vibration (HAV).⁴

(See <http://www.public.navy.mil/navsafecen/Pages/acquisition/acquisition.aspx> or www.safetycenter.navy.mil - select the section on acquisition).

The issue of HAVS as a process issue requiring attention in design and support was communicated as a “system safety risk” necessitating the recognition and management involvement at an organizational level to ensure minimized risk/exposure. (Estrada 2005 August)

This project focused on minimizing HAVS risks through application and improvement of existing management processes, and the related education of both safety and health professionals and managers of maintenance and logistics processes; including maintenance training centers. Concurrently, it provided selective update of available power hand-tools and provision of certified anti-vibration A/V gloves, to minimize the risk of HAV injury. (M. (. Geiger October 26-29, 2009) The approach is also consistent with the National Occupational Research Agenda (NORA) of the National Institute for Occupational Safety and Health (NIOSH) to provide guidance to the entire

2. Geiger, M.B. (2006) Hand-Arm Vibration- Criteria for Tools and Glove Selection Project Proposal submitted to the Defense Safety Oversight Council December 2006

3. Chaney, J Branch Chief and Division Director Ster, JM Heartland Supply Operations Center, GSA FAS, Kansas City, MO

4. Bucher, R and Geiger, M.B., (2003) Acquisition Safety Awareness and Education: Acquisition System and Safety and Health Issues with a Focus on Ship Systems) <http://www.public.navy.mil/comnavsafecen/Pages/acquisition/index.aspx>

* Basic Control Targets (ANSI S2.70, 2006; European Union Directive, 2002)

1. Taken from EU Guide to Good Practice on Hand-Arm Vibration, <http://www.humanvibration.com/EU/VIBGUIDE/HAV%20Good%20practice%20Guide%20V7.7%20English%20260506.pdf>