



# How to Buy Safer, Quieter Tools

**P**owered hand tools have become essential to a range of industrial operations since Samuel Ingersoll invented the pneumatic drill in 1871. However, progress often comes with risk. Potential hazards associated with hand-held powered tool use include noise, hand-arm vibration, and a range of ergonomic stresses and physical safety hazards. Acute physical injuries from failure or misuse of the control or trigger mechanism are a particular concern, especially for products such as nail guns.

At the same time, many companies using power tools fail to employ a process management approach to selection, procurement, and maintenance, or to educate users

of these tools. This often results in unnecessary exposures to noise, vibration, and other physical hazards, as well as impaired productivity and quality. (Table 1 summarizes the health and safety risks of using powered hand tools.)

Because few purchasing groups are trained in safety, they are unlikely to consider the hazards and lifecycle costs associated with operating power tools. Efforts to promote purchasing of tools with lower lifecycle costs have failed due to a lack of regulatory criteria, misguided pressure to purchase the tools with the lowest initial costs, and poor understanding of hazardous exposures. Concurrently, safety and health professionals have often failed to influence the purchasing process. A purchasing



# A Process Management Approach to Reducing Noise and Hand-arm Vibration while Improving Productivity and Quality

BY EDWARD ZECHMANN, MARK GEIGER, AND BRYAN BEAMER

and process management standard was needed to correct these failings and to stimulate the market conditions for manufacturing and purchasing of power tools that optimize productivity and minimize lifecycle costs. This article outlines a process management approach to the purchase of powered hand-held tools promoted in SAE International Standard AS6228, “Safety Requirements for Procurement, Maintenance and Use of Hand-held Powered Tools.”

## **NOISE AND HAND-ARM VIBRATION SYNDROME**

Occupational hearing loss is among the most prevalent occupational illnesses. NIOSH estimates that 22 million

workers in the United States are exposed to hazardous levels of noise ( $\geq 85$  dBA) each year. Hazardous noise is the primary risk factor for hearing loss. A similar, or even greater, fraction of workers in the developing world is likely exposed to hazardous industrial noise, often without the level of attention to noise controls more common in developed nations. Powered hand tools have been identified as such a major contributor to worker risk of hearing loss that ANSI has published a standard (ANSI/ASSE A10.46-2013, “Hearing Loss Prevention for Construction and Demolition Workers”) addressing noise of powered equipment in the construction industry, including powered hand tools.



In addition to noise, tool operators are subjected to potentially hazardous hand-arm vibrations. The operator must maintain sufficient grip to make sure the tool is cutting properly and that it won't break away from the operator's hands. Maintaining a tight grip provides the tool's vibrations a path from source to receiver. The source may be the motor, turbine, or cutter-workpiece interaction. The vibrations proceed through the structure of the tool to its handles and to the hands, arms, shoulders, and skeleton of the operator.

Use of power tools that produce hazardous levels of vibrations can result in serious damage to the tool operator. A 2015 study published in *Industrial Health* shows that prolonged exposure to hazardous vibrations from hand-held power tools causes damage to vascular, skeletal, and sensory tissues such as blood vessels, bones, and nerves. Hand-Arm Vibration Syndrome (HAVS) is an occupational illness caused by vibrations of the hands and arms when working with tools or holding a vibrating work piece. HAVS symptoms vary from annoying to crippling. Many HAVS victims suffer from acute pain and decreased hand and arm function.

The European Union has regulated both whole-body and segmental vibration since 2005, but in the U.S., OSHA has yet to address this issue. The primary U.S. exposure standard, ANSI/ASA S2.70, "Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand," addresses the relationship between exposure, risk of developing symptoms, and allowable duration and intensity of exposures, and recommends a daily exposure limit of 5 m/s<sup>2</sup> (8-hour time weighted average) with an action level of 2.5 m/s<sup>2</sup> (8-hour TWA).

#### A STRATEGY TO IMPROVE TOOL PROCUREMENT

A comparison of alternative riveting hammers published in 2007 demonstrated that the higher quality tool had a life-cycle cost less than 50 percent of the lower-cost product. Further, it was shown that initial purchase costs—often the critical factor in purchasing decisions—amounted to less than 1 percent of these long-term life-cycle costs. According to Atlas Copco, a manufacturer of industrial tools, 85 percent of costs for common operations such as grinding are associated with labor and disposables. The cost of better tools is generally offset by higher productivity, better quality of workmanship, and reduced safety and health risks.

But logistics supply groups may not be educated on quality, productivity, or occupational safety and health considerations. Without such training, they won't accept a justification for purchasing a tool with a higher initial but a lower long-term cost. The need became apparent for a standard that addresses occupational disease, productivity, and total life-cycle cost in the selection of powered hand tools.

The SAE AS6228 standard grew out of a collaboration between the SAE International EG1-B Hand Tools

**Table 1.** Powered Hand Tool Health and Safety Risk Factors and Productivity Effects

Factor or Risk	Health Impacts	Productivity Impacts	Potential controls
Vibration	Hand-arm vibration disease	Impaired product quality Long-term impact on skilled work force	Equipment selection and maintenance, process selection
Noise	Hearing loss	Communication issues	Equipment selection and maintenance, process selection
Dust (varied respiratory hazards)	Silicosis from silica-containing heavy metals	Visibility of work	Alternative process, wet work, local exhaust
Ergonomic design of workplace and tools	Repetitive strain injury and other long-term disease	Direct link between comfort and productivity	Equipment selection and process design
Physical safety hazards	Physical injuries and trauma	Productivity impacts of work-arounds	Equipment selection and maintenance
Life-cycle costs (replacement/repair)	Low-cost tools are likely to be noisier and less "ergonomic"	Decreased productivity and quality (cheap tools have high long-term costs)	Equipment selection and maintenance  Labor and consumables are highest costs (up to 80% for grinding)

**Table 2:** Notional Guidance on Weighting Factors for Tool Evaluation

Factor	Relative Weighting	Notes
Productivity	20%	Sub-factors may include cycle time; amount of material removed; and time to accomplish a particular amount of work.
Physical safety factors*	10%	Physical safety factors are risks that may cause immediate injury or acute trauma. Examples might include catastrophic failure of a moving part, which creates a projectile injury; improper machine guarding; or ineffective isolation of electrical power sources, which could produce shock.
Ergonomic factors (other than shock and vibration)	20%	May include deviation of wrist from neutral position; balance of tool; area of trigger (and force necessary to activate tool); and weight. Table A1-2 in SAE AS6228 provides specific factors.
Noise	10%	Report sound levels obtained in a representative setting in decibels un-weighted (dB) and weighted (dBA). Octave band data are preferred. Noise exposure evaluation may also be linked to the noise dose experienced during performance of a given amount of work.
Hand-arm vibration	20%	Weighting depends on relative contribution as a risk factor. For example, tools typically operating below 2.5 m/s <sup>2</sup> might have 5 percent of the evaluation based on vibration levels. Tools operating in the range of >5.0 m/s <sup>2</sup> would have 10 percent of the evaluation based on vibration levels. Information from EU and NIOSH databases may be used.
Initial procurement cost	5%	May depend on anticipated lifespan of tool and intensity of use (occasional, periodic, or daily).
Five-year operational cost	10%	
Cost to produce given quantity of work, including utility costs	5%	
<b>Possible Supplemental Factors</b> (User's hands-on evaluation isn't always available for small-quantity purchase or for preliminary screening of alternative products.)		
User acceptance	15% (above baseline score)	NIOSH evaluation provides a good prototype for worker review of the product, including comfort and perceived productivity considerations. User acceptance may also be a requirement for procurement of numbers of products above a key threshold of cost/quantity.
Reliability and down-time issues	15% (above baseline or determined by users)	Reliability and tool failure may be highly dependent on the industrial setting and the specific tool being considered. This might also be a component of five-year operational costs.

Adapted from Table A1-1 of SAE AS6228.

\* Physical safety criteria are not part of the scoring system for the current standard. However, meeting relevant criteria is a basis for qualification (or rejection) for potential purchase.

Committee, affiliated industry participants and producers, and personnel from the U.S. Department of Defense, the General Services Administration, and NIOSH. GSA was strongly supportive of procuring improved tools for Federal customers, but indicated the need for a standard for product evaluation and purchase. Manufacturers of better quality tools were interested in an approach that customers could employ to rank-order products based on safety and cost effectiveness.

Published in September 2014, SAE AS6228 not only considers productivity, hand-arm vibration, noise, and other safety and health factors but also life-cycle costs in the procurement of powered hand tools. 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, while identifying new products based on customers' requests. Table 2 provides

a simplified version of the updated draft of the current criteria for powered hand tool evaluation as described in SAE AS6228.

The standard provides for a two-phase evaluation. For the first phase, the table of weighting factors provides a preliminary comparison of alternative products, ideally compiled from on-site data. However, a preliminary assessment is likely to compare information obtained from sources such as the European or NIOSH databases for noise and vibration and vendors' reported data. The intent is to select among better products for a hands-on user comparison. In cases where a limited number of products are purchased, the first phase alone may be used for selection purposes. The second phase provides two formats for user evaluation of powered tools considering such factors as comfort and productivity. The intent is for educated users to make a final determination among alternative products pre-screened for acceptability.

### CASE STUDY: APPLYING SAE AS6228

During a visit to an Ohio manufacturing facility, a NIOSH team observed that two different tools were being used for the same stainless-steel polishing and grinding task. Field measurements indicated a sound pressure level over 90 dBA for one tool and under 90 dBA for the other. A conversation with the plant engineer made it clear that there was a significant difference in initial purchase cost between the two tools.

NIOSH researchers initiated a comparative evaluation of three pneumatic grinding tools (the two products used at the Ohio facility and one additional tool). The researchers used the SAE AS6228 criteria at the University of Cincinnati Mechanical Engineering sound power laboratory over several days of testing in the autumn of 2016. The study was conducted according to ISO 15744, “Hand-held Non-electric Power Tools—Noise Measurement Code—Engineering Method,” which specifies test methods for noise emissions from hand-held power tools. The following are some of the findings from the study:

- The ISO standard contains testing procedures for both unloaded and loaded conditions. The loaded conditions most accurately reflect typical usage and provide the best data for evaluating and comparing tools.
- The manufacturer-supplied information about mechanical power output is easily confused with the actual power consumption. Manufacturer-supplied power rating information was not indicative of the power consumption documented in the lab.
- The manufacturers’ estimates of sound power noise

were greater than or practically equal to the measured values. Manufacturer-supplied sound power information was useful for these tools and tasks.

- The manufacturers’ data for hand-arm vibrations were generally less than the measured values and were not as accurate as desired to apply SAE AS6228.
- The tool most cost-effective in the long term had the highest initial cost. The tool most effective at removing paint had the highest hand-arm vibrations, and the operator felt tingling in the hands after usage.

### UPDATING SAE AS6228

The NIOSH team’s recommendations and the inputs of other committee members have been incorporated into a draft update of SAE AS6228 submitted in October 2017. In response to feedback about the length of the standard, a shorter technical report has been developed to accompany the standard as a guide. Since different users might assign different weights to the factors outlined in SAE AS6228, the committee is working to host representative weighting factors on a publicly available website. Where feasible, supplemental material has been condensed and moved to appendices.

Choosing ISO standards for evaluation requires their purchase, so the technical report provides simplified screening guidance. Tool manufacturers and research organizations will still need to obtain ISO standards or similar references.

Using ISO standards to evaluate noise and vibration may be impractical for small- and medium-sized organizations, and most purchasing managers lack the skills and equipment needed to apply these standards. The SAE AS6228 committee is outlining more basic field evaluation methods to increase the practicality of SAE AS6228. Data from NIOSH and EU noise and vibration databases can be used for initial comparative review. Publication of the updated standard is anticipated in the coming months. Readers are urged to use the approach described in the standard to support improved safety in their workplaces and encourage the availability of safer, more productive equipment. 📞

---

**EDWARD ZECHMANN, MS, PE, INCE bd. cert.**, is a U.S. Public Health Service Officer currently working for NIOSH in the Hearing Loss Prevention Team.

**MARK GEIGER, MS, MSE, CIH, CSP**, is a retired employee of the U.S. Navy, now employed by DynCorp International at Joint Base Andrews, outside of Washington, DC. He is currently working on the revision of SAE AS6228 as chair of the standards committee.

**BRYAN BEAMER, PHD, PE, CSP**, is a U.S. Public Health Service Officer currently working for NIOSH in the Hearing Loss Prevention Team.

Send feedback to [synergist@aiha.org](mailto:synergist@aiha.org).

## RESOURCES

*American Journal of Industrial Medicine*: “Exposure to Hazardous Workplace Noise and Use of Hearing Protection Devices among U.S. Workers—NHANES, 1999–2004” (May 2009).

ANSI/ASA S2.70-2006 (R 2016), “Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand” (2016).

Atlas Copco: “Power Tool Ergonomics: Evaluation of Power Tools,” <http://bit.ly/atlascopepowertools> (PDF, 2007).

Ergonomics Plus: “Hand-Arm Vibration (HAV)—A Step by Step Guide to Evaluate & Control Risk,” <http://bit.ly/ergoplushav>.

European Union: EU Vibration Directive 2002/44/EC, <http://euvibrationdirective.com> (2002).

Health and Safety Executive: “Vibration Risk Assessment,” <http://bit.ly/hsevibrationra>.

*Industrial Health*: “Effect of Higher Frequency Components and Duration of Vibration on Bone Tissue Alterations in the Rat-tail Model” (May 2015).

NIOSH: “Noise and Hearing Loss Prevention,” <http://bit.ly/noisehearingloss>.

NIOSH: “Power Tools Database,” <http://bit.ly/nioshpowertoolsdbase>.

Off-highway Plant and Equipment Research Centre: “Hand-Arm Vibration Test Centre,” <http://bit.ly/operchavtec>.

OSHA: “Protecting Yourself from Noise in Construction,” <http://bit.ly/oshanoiseconstruction> (PDF, 2011).

*Professional Safety*: “Minimizing Hand-arm Vibration Syndrome among Powered Hand Tool Operators” (November 2014).

SAE International: Aerospace Standard AS 6228, “Safety Requirements for Procurement, Maintenance and Use of Hand-held Powered Tools” (2014).

U.S. General Services Administration: “Vibration-Controlled Tools,” <http://bit.ly/gsavibration>.