AMERICAN SOCIETY OF SAFETY PROFESSIONALS

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Controlling Health and Safety Hazards from Powered Hand Tools in the Construction Industries

Mark Geiger, MS, MSE, CIH, CSP
Volunteer Chair, SAE International EG1B1 Committee
Power Tool Productivity, Ergonomics and Safety

Disclaimers

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Objectives

- Describe approaches to evaluate and improve safety of power tools with focus upon
  - Improving vibration, noise and ergonomics characteristics
  - Improving tool/process productivity and quality
  - Improving the quality of tools available to Federal workers and the construction industry in general
- Describe a process management approach applicable to other occupational health and safety areas
- Provide background of a project addressing hand-arm vibration through supply management and education.
- Describe EG-1B1 Committee of SAE International to development standard approaches for power tool evaluation and procurement
- Enhancing the influence of safety and health professionals in leading process improvement efforts that enhance safety and productivity

Outline

- History and background of hand-held power tool use
  - How new technologies created new hazards or increased the risk of old hazards
  - Current trends
- Hand arm vibration disease – an ignored disease
- How a project to address hand-arm vibration led to an approach to control multiple hazards and improve productivity from power tools
  - A balanced scorecard to estimate risk and benefits
  - Process management approach to hazard control
  - Resources
- Process management and outreach approaches to improving project safety
- Additional Resources – provided following presentation slides

Why Focus on Power Tools?
100s Power tools are essential to modern industry
$34.3 Billion Global Market in 2021
Essential to Modern Industry-Lower cost and shorter life than larger equipment

Type I Pneumatic and Type II Electric Tools, Corded and Battery Powered From AS 6228A

- **Class 1: Grinders/polishers**
- **Class 2: Drills**
- **Class 3: Percussive tools (chipping and riveting hammers and needle scalers, etc.)**
- **Class 4: Nailers/staplers**
- **Class 5: Impact wrenches (impulse tools)**
- **Class 6: Nut runners/screwdrivers**
- **Class 7: Saws**

Hand tools courtesy Atlas Copco

Pneumatic Tools in History

- Samuel Ingersoll invented the pneumatic drill in 1871.
- Charles Brady King of Detroit invented the pneumatic hammer (a hammer which is driven by compressed air) in 1890 and patented on January 28, 1894.
- Charles King exhibited two of his inventions at the 1893 Worlds Columbia Exposition; a pneumatic hammer for riveting and caulking and a steel brake beam for railroad road cars.
- A safety breakthrough for pneumatic power-
- Westinghouse invented the pneumatic break for trains in 1872
- The technology prevented many train crashes and fatalities for brakemen.
- https://en.wikipedia.org/wiki/Westinghouse_Air_Brake_Company

Pneumatic Hammer

Beam, George L. 1868-1935. (George Lytle)

Men use pneumatic hammers to tamp Denver and Rio Grande Western Railroad track base, in Garfield County, Colorado.

http://inventors.about.com/od/weirdmuseums/ig/The-Films-of-Thomas-Edison/Pneumatic-Hammer-.htm

More History – New Technology- New Hazards

- Most power tools operate at noise levels> 85dBA, some are above 100 dBA
- Hand-arm vibration syndrome- first reported in the US in the early 1900s
- Prior to the 1930s, power tools were often housed in cast metal housings.
- Heavy cast metal housings heavy, contributing to repetitive use injuries, as well as conductive - often shocking the user.
- WWI - Henry Ford requested that A. H. Peterson develop a lighter product- resulted in “the shooter” a 5-pound drill
- In the early 30's, companies started to experiment with housings of thermoset polymer plastics.
- In 1956, under the influence of Dr. Hans Erich Slany, Robert Bosch GmbH was one of the first companies to introduce a power tool housing made of glass filled nylon.

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New Technology
New levels of productivity

Dust
Noise
Vibration
Mechanical hazards

Photo courtesy of Earl Dotter, Photo Journalist
www.Earldotter.com

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Powered Hand Tools
Process management and equipment selection factors

Factor or Risk	Health 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-containing (silicosis) Heavy metals	Visibility of work	Alternative process, wet work, local exhaust

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Powered Hand Tools
Process management and equipment selection factors

Factor or Risk	Health Impacts	Productivity Impacts	Potential controls
Ergonomic design of workplace and tools	Long-term disease potential	Direct link between comfort and productivity	Equipment selection and process design
Physical safety hazards/ controls	Potential injuries	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 are expensive)	Note that labor and consumables are highest costs (up to 80% for grinding)

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Noise Levels of Common Construction Tools

Tool	Noise Level will probably exceed (dBA scale)	Reference
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 Shown from a longer list)

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Noise Levels of Common Construction Tools

Update with information from 2020 standard- Not available at The Library of Congress

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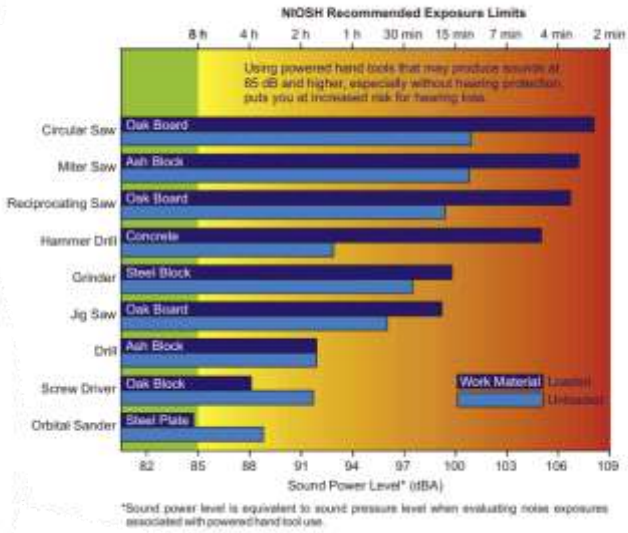
Fig. 1—Tools and tasks vs. Noise level demonstrate carpenters' noise exposure[8]. Sound pressure level in A-weighted dB measured at typical operator's ear distance.



Relevant test methods for establishing sound power levels of powered hand tools
Charles S. Hayden and Edward L. Zechmann Noise Control Eng. J. 57 (3), May-June 2009

Hand Vibration Injuries

Hands of vibrating pneumatic hand-tool operator in later stages of irreversible Hand Arm Vibration Syndrome1

Common "White Finger" effect termed Reynaud's Disease

Copyright 1990, D.E. Wasserman, Inc.
Image of hands (not US Navy worker).
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Hand Arm Vibration Syndrome (HAVS) is an illness caused by vibration when working with tools or holding a vibrating work piece.

Hand-arm Vibration -An Ignored Disease?

- **In 1918, Alice Hamilton, MD, identified and documented HAVS in Indiana limestone quarry workers. (She was actually looking for silicosis).**
- **Sixty years later in 1978, the National Institute for Occupational Safety and Health, NIOSH (Don Wasserman) studied the same quarry**
  - **Incidence of disease was the same, about 80% of the exposed workers had symptoms of HAVS.**
  - **Up to 1978, there were no changes in pneumatic rock-breaking tools**
  - **The "attack rate " was about 50% for "at risk" exposed workers**
- **2005 European Union regulations help make better tools available**
- **2024 No immediate prospect of US regulations**

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Hand-arm Vibration from Hand-arm vibration syndrome- What family physicians should know Shixin (Cindy) Shen, MD MPH Ronald A. House, MD MSc FRCPC

Canadian Family Physician • Le Médecin de famille canadien | Vol 63: March • mars 2017

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5349719/

- Stockholm Workshop Scale; each hand should be graded separately: A) Classification of cold-induced Raynaud phenomenon in HAVS;

STAGE	GRADE	DESCRIPTION
0	None	No attacks
1	Mild	Occasional attacks affecting the tips of ≥ 1 fingers
2	Moderate	Occasional attacks affecting distal and middle (rarely also proximal) phalanges of ≥ 1 fingers
3	Severe	Frequent attacks affecting all phalanges of most fingers
4	Very severe	As in stage 3, with trophic changes in the fingertips

- Ref 19: Gemne G, Pyykkö I, Taylor W, Pelmear PL. The Stockholm Workshop scale for the classification of cold-induced Raynaud's phenomenon in the hand-arm vibration syndrome (revision of the Taylor-Pelmear scale) Scand J Work Environ Health. 1987;13(4):275–8. [PubMed] [Google Scholar]

- Stockholm Workshop Scale; each hand should be graded separately:
- B) Sensorineural stages of HAVS

STAGE	DESCRIPTION
0SN	Exposed to vibration but no symptoms
1SN	Intermittent numbness with or without tingling
2SN	Intermittent or persistent numbness, reduced sensory perception
3SN	Intermittent or persistent numbness, reduced tactile discrimination or manipulative dexterity

- Ref.28 Brammer AJ, Taylor W, Lundborg G. Sensorineural stages of the hand-arm vibration syndrome. Scand J Work Environ Health. 1987;13(4):279–83. [PubMed] [Google Scholar]

Occupational exposure limits for hand-arm vibration

Exposure Standard

5 m/s^2 8-hour TWA European Union and ISO Std

Action Level

2.5 m/s^2 8-hour TWA European Union and ISO Std

Good correlation between exposures to vibration (measured as acceleration) and the incidence or prevention of disease.

An example from the forestry industry in Finland (Koskimies et. al. 1992):

Equipment Type (Chain Saw)	Vibration	Prevalence of HAV
Existing equipment (unimproved)	14 m/s2	40% (1972)
Anti-vibration design	2 m/s2	5% (1990)

Kosimies K, Pyykko I, Starck J, Inaba R [1992] Vibration Syndrome Among Finish Forestry Workers between 1972 and 1990. Int . Archives of Occupational Environmental Health 64:251-256

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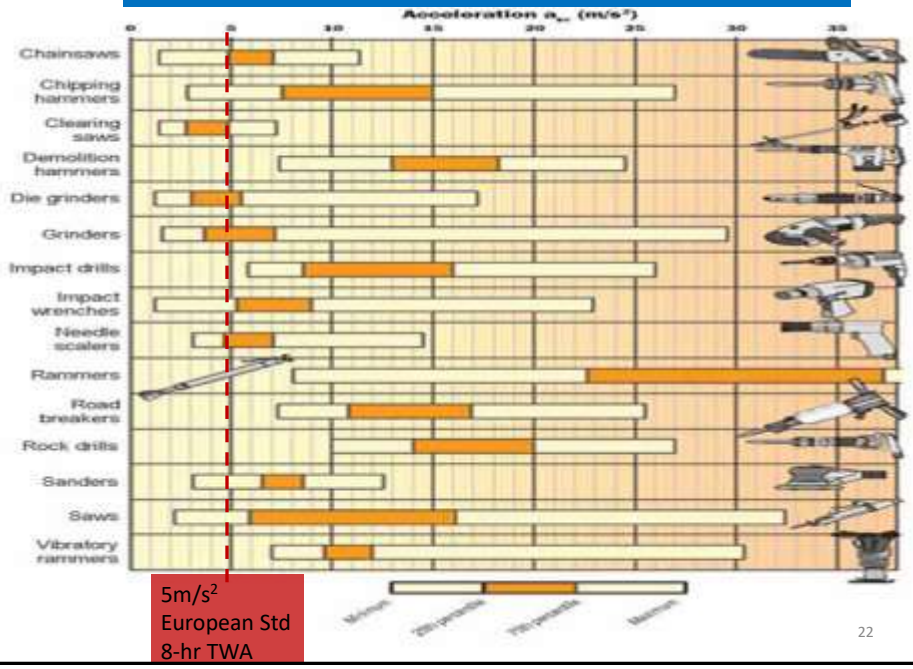
Product Selection is Vital for Vibration (and Noise) Control



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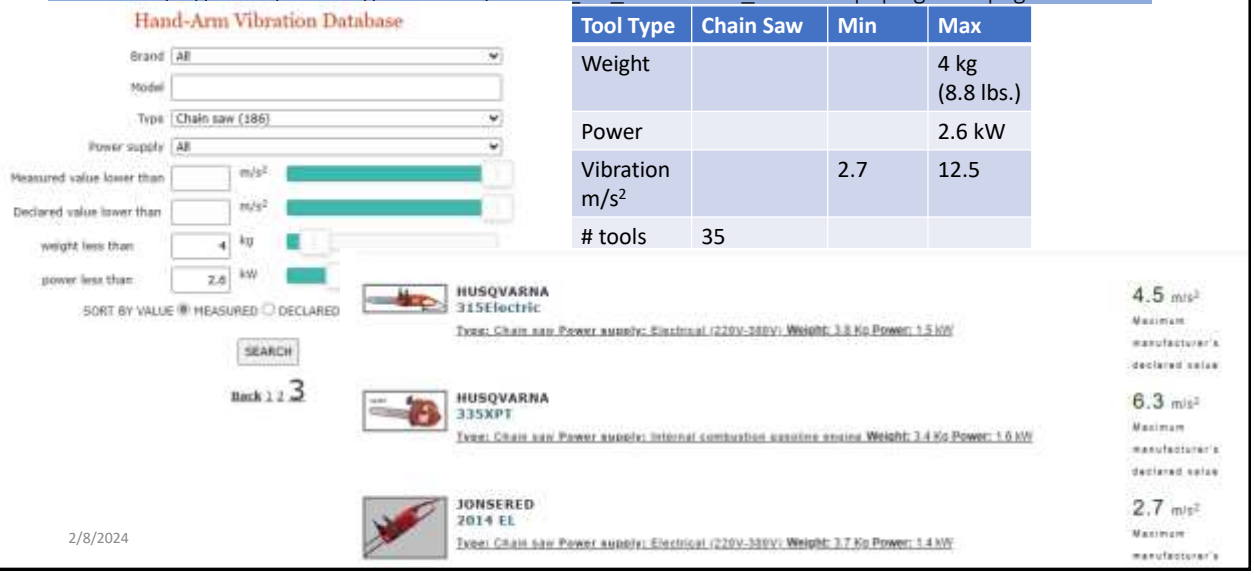
Product Vibration Evaluation Using the Italian Hand-arm vibration Database

https://www.portaleagentifisici.it/fo_hav_list_macchinari_avanzata.php?lg=EN&page=0



Tool Type	Chain Saw	Min	Max
Weight			4 kg (8.8 lbs.)
Power			2.6 kW
Vibration m/s²		2.7	12.5
# tools	35		

Some Simple Fixes

- Buy better, lower vibration tools!
  - See European Union and NIOSH databases for screening
  - Use GSA websites for vibration-controlled power tools
- Maintain tools!
  - Literally, sharpen the saw!

Before and After Pavement Breaker Substitution
Work done by Naval Medical Center, San Diego

Work method	Initial Pavement breaker (jack hammer)	Alternative Bobcat equipped with pavement breaker	Notes
Tool type/brand	Hand-arm Vibration exposure (re 5 m/s^2 criteria)	Hand-arm Vibration exposure (re 5 m/s^2 criteria)	5 m/s^2 criteria applied
Chicago (standard)	382 (m/s^2) Initial product	--	Initial efforts to select better tools
Chicago (anti-vibration)	277 (m/s^2) 1st Alternative product	--	Slightly better
Atlas Copco (anti-vibration)	18.9 (m/s^2) Product substitution	--	Much better but >> 5 m/s^2
Bobcat – with pavement breaker		--Nil-	Final control by process change
Man-hours	80	8	
Labor cost	$2000	$200	Lower cost/risk

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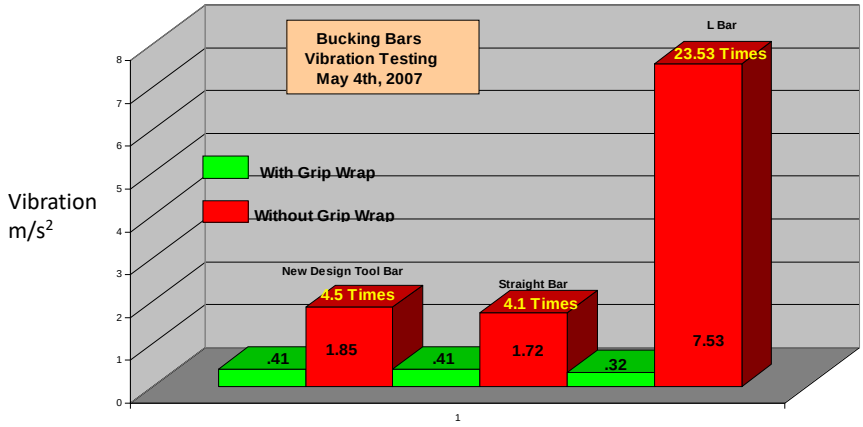
Comparison of Bucking Bars

Richard Borcicky, Ergonomist
Fleet Readiness Center, East, Cherry Point, NC
February 2008



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Ergonomic Hazards - Controls through process design

- Tool weight
- Balance
- Bending
- Static postures

- Factors to consider
  - Counter balancing
  - Suspended tools
  - Lighter weight
  - Workplace design for accessibility

Photo Courtesy of Earl Dotter

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Common hazards versus process management gaps

Dusts produced.

- Materials worked on: silica, wood, metals..
- Respiratory syndrome and illnesses: e.g., silicosis, other carcinogens such as chromates (zinc and lead chromates especially in primers)
- Safety issues: combustible dusts
  - Potential fire/explosion risk (depending on materials)
- Non-respiratory illness

  (Example; lung as entry point for lead containing dusts).
- Visibility of work

Noise - Hearing protection (NRR limited by fit)

- Commonly less than ½ ideal NRR

Vibration – Hand arm exposure – can also affect work quality

Unused Alternatives for safety and productivity

- Ventilation (LEV) and/or wet methods…
- Suspension of the tool
- Improved access to and rotation of work piece

Photo Courtesy of Earl Dotter

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Process Improvement Opportunities?

Earl Dotter, Photojournalist
Documenting the lives of working people
http://www.earldotter.com

Defense Safety Oversight Council Projects

Project outcomes include

- Influenced General Services Administration (GSA) procurement criteria for power hand tools
- Provided certified (third-party) anti-vibration gloves in the Federal supply system via Defense Logistics Agency (DLA).
  - Berry Amendment compliant (US Mfr) made in the U.S.
- Increased awareness throughout DOD and industry partners of hand-arm vibration issues
- Supported several NIOSH research projects
- Guidelines on how to justify and purchase AV tools and gloves
- **But- still limited/unfocused influence on everyday-purchase decisions for powered hand tools**
- **Guidelines have not been accepted as policy requirements**
- **Lack of OSHA regulatory requirements for vibration evaluation and control**

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Challenges

- Integrating information for change as opposed to traditional surveys and reports
- Linking productivity, safety and efficiency
  - Includes education to overcome common misunderstandings
- Justifying proactive investments in competitive industries with a rotating workforce (example construction)
  - Difficult justify investments to protect “short” term workers – especially construction
  - Challenges in establishing accountability for long-term occupational diseases sustained by “short-term” workforce

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U.S. Regulatory Challenges
Great old music - Not such great old standards

- OSHA Permissible Exposure Limits (PELs) stuck in the 1970s
- Proposed Ergonomics Standard derailed in 1999
- Budget, signed into law Dec. 23, 2011 prohibits OSHA from developing a rule that would add a musculoskeletal disorder column to the OSHA 300 form.
- **Contrast with European Union regulation of vibration since 2005**

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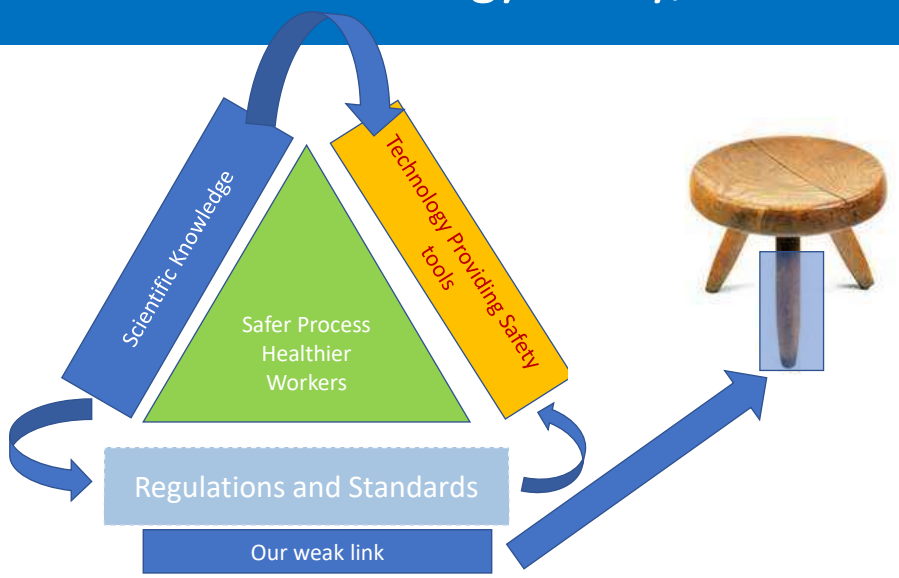
Triad- Science-Technology-Policy/Standards



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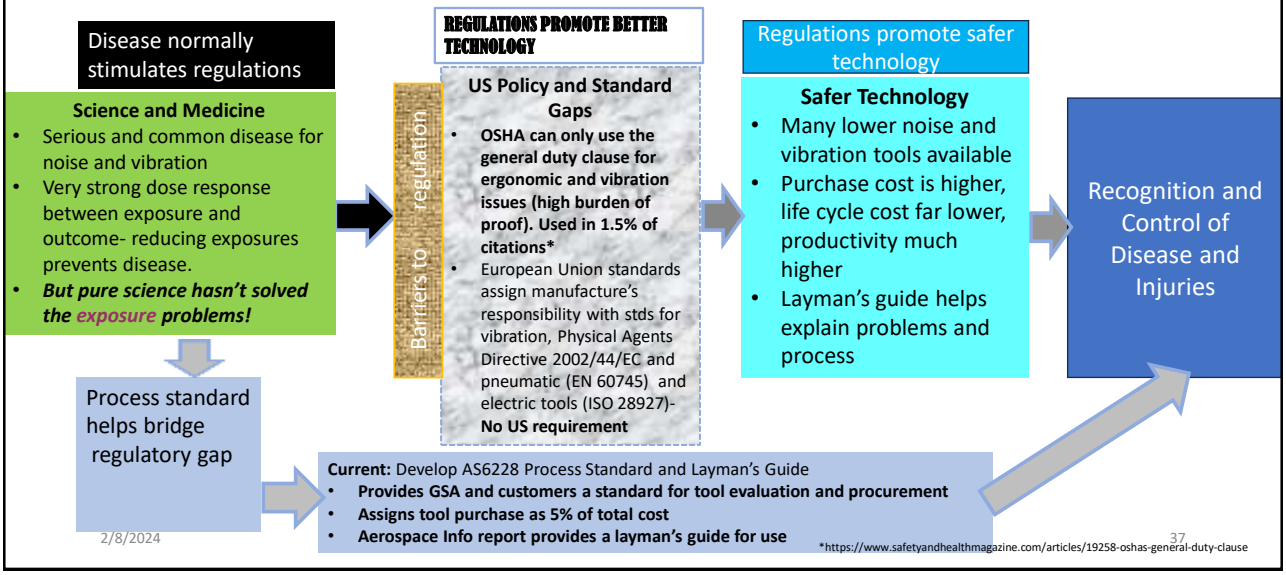
Normal Triad – Science-> Regulations –> Safer Technology

The Current U.S. Triad has weak regulations

Process standard is a partial substitute



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*https://www.safetyandhealthmagazine.com/articles/19258-oshas-general-duty-clause

Need for "Balanced Scorecard"

SAE International E1B Committee Meeting in Kansas City, Mo Jan 18-19, 2012

- GSA* Power tool leads, tool manufactures, DOD safety and Health and NIOSH represented
- Mutual interest in obtaining and selling better tools
  - Better products can (and will) be undercut if initial cost is the only purchase criteria
  - Safety/ Ergonomics/Productivity and Quality coincide
- Developing rating criteria to consider all aspects of life-cycle
  - Productivity
  - Safety and health – Noise -Vibration - Ergonomics
  - Life-cycle costs
    - Maintenance/parts * Energy-Utilities (especially air) * Injuries/Illness
  - GSA - US Government General Services Administration, main buyer for the Federal Government

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Need New Approach- Systems Engineering!

- Tried the moral approach – failed due to perceived budgetary constraints
- Only looked at initial tool cost and ignored Total Cost of Ownership (TCO)
  - DOD term is TOC (total ownership cost)
- Need to make a "business case" to show total cost to shop

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SAE Aerospace Standard AS6228A "Balanced Score Card" Rating Factors (possible total 100 points)

Factors	Weighting	Notes
Productivity	20%	Cycle time; amount of material removed; time to accomplish work. Task/job specific.
Ergonomic	20%	Stresses experienced representative of the category of work accomplished. (Often influences productivity)
Noise	10%	Octave band data preferred. Noise exposure evaluation linked to the noise dose during performance of a given amount of work.
Hand-arm vibration	20%	Vendor's declared values as initial estimate. Subject to verification.
Physical safety	10%	Many factors are also basic purchase criteria
Purchase cost	5%	Shocking to purchase agents, but consistent with real life. Purchase cost alone is overrated as a selection factor.
Life cycle costs	15%	Consumables, maintenance, down-time, defects, labor, energy costs. Hard to estimate initially.

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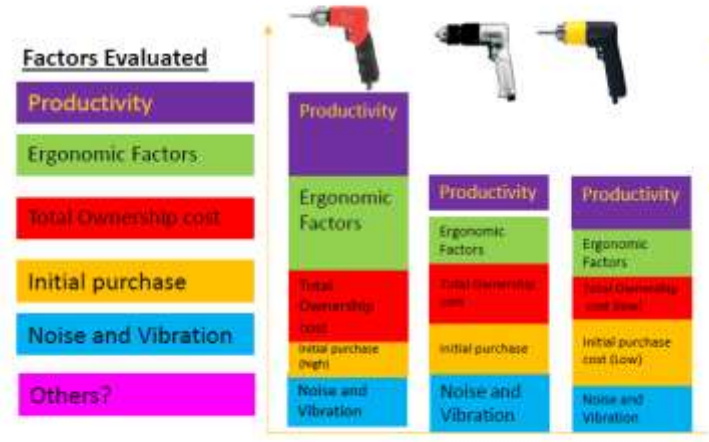
Balanced Scorecard



- An "ideal" tool could have a maximum score of 100 points
- The higher score in each category indicates the more favorable performance, such as higher productivity or lower noise levels.

- Balanced scorecard acts as a screening tool for comparative evaluation of multiple tools
- Final selection is typically made by trial use of alternative tools.
- The standard and the layman guide contain a worker evaluation form

Ergonomic Factor Example

Tool weight identified as the key risk factor for job (overhead grinding)

Tool weight (lbs.)	15	14	13	12.0	11.5	11.0	10.0
Evaluation	Too heavy!	Marginally Acceptable		Fair	Preferred		Desired
Score assigned	N/A	3	4	6	7	8	10
Multiplier (2 x score - (20% of total)	N/A	6	8	12	14	16	20
Weight of tools (lbs.)	Tool 4 15.3	Tool 2 14.1			Tool 3 11.4	Tool 1 11.2	
Assigned score (20 points possible best rating)	Too heavy! Not considered	6 points			14 points	15	

- Other factors; noise, vibration and life cycle cost are evaluated by similar semi-quantitative methods
- Tools should be tested by workers after preliminary screening using the "balanced scorecard" approach
- An example of the user evaluation form in AIR 6916 and AS 6228 is available for review

Possible alternative to hand-held grinder support

Stabilized arm supporting workers using grinding tools

Significant productivity improvements.

NOTIONAL EVALUATION OF ALTERNATIVE NOISE LEVELS IN PORTABLE TOOL OPERATION*

Sound level (dBA)*	**≥115**	**114**	**112**	**108**	**105**	**102**	**99**	**96**	**93**	**90**	**87**
Score (highest possible rating of 10)	≥ 115 dBA Unacceptable	1	2	3	4	5	6	7	8	9	10
Multiplier 1 (10% of total score)		1	2	3	4	5	6	7	8	9	10
Products evaluated and sound level						Tool 3 **101 dBA**		Tool 2 **97 dBA**			Tool 3 88 dBA
Noise "score"		Acceptable, but not optimal				5		7			10

Tool 4- 115 dBA Unacceptable For purchase ← Threshold = Acceptable minimum performance level

Objective-Preferred (desired) sound level

*From Table A1-4C in AS 6228A Safety Requirements for Procurement, Maintenance and Use of Hand-held Powered Tools (2024)

Preliminary noise (and vibration) estimates may be from European Union and/or NIOSH databases

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Vibration Weighting for Tool Evaluation

Aerospace Information Report AIR 6916

Table C2 - Comparison of alternative grinders for welding bead removal

Grinder	B	D	A	C	E
Vibration level	15.4	7.5	6.1	5.1	4.2
Allowable use period/day (hours)(1)	1	4	7	8	8+
Score assigned (20 possible points)	N/A	4	8	12	18
Evaluation	Do not buy	Acceptable, but not preferred		Preferred products	

(1) Based on 5.0 m/s^2 exposure for an 8-hour day.

Preliminary evaluation: Grinder B should not be considered for purchase. It could only be safely used for an hour a day, at best. Grinders D and A are acceptable; they could probably be used for most of a workday. Grinders C and E are preferred from a standpoint of anticipated hand-arm vibration exposures.

It's also likely that the grinders with lower vibration levels will be quieter, easier to control, less fatiguing for the user, and produce a better-quality result.

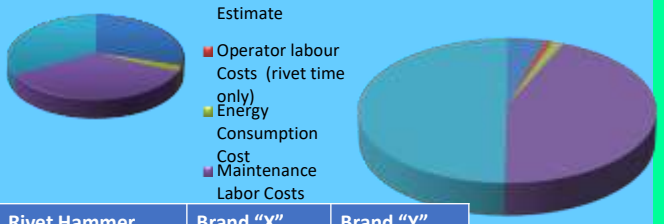
Why Purchase Cost is Weighed as 5% of Tool Evaluation

Comparison of Two Rivet Gun

Boeing Atlas Copco Study*

Brand "X" Rivet Hammer

Brand "Y" Rivet Hammer



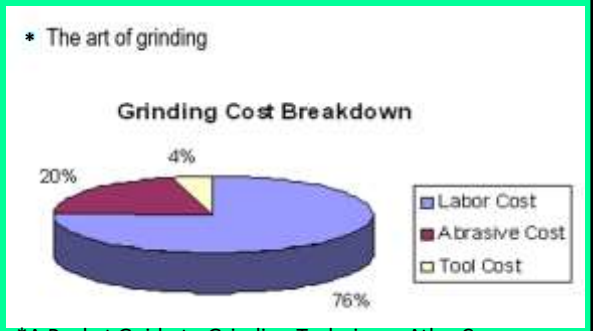
Rivet Hammer	Brand "X"	Brand "Y"
Initial tool cost	$1200	$312
5-year cost	$15,750	$32,312

* Reported in Hand Arm Vibration Syndrome- Protecting Powered Hand Tool Operators; Geiger et al, Professional Safety, November 2014

The Grinding Process

As an example of cost breakdown

Most production costs are labor and consumables

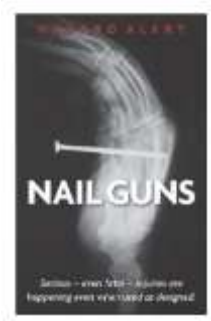


*A Pocket Guide to Grinding Technique, Atlas Copco
https://www.atlascopco.com/content/dam/atlas-copco/industrial-technique/general/documents/pocketguides/9833864101_L.pdf

Physical Safety Hazards

Roof nailers as a case study

- 37,000 ER visits annually
- Basic safety criteria-
- Sequential versus contact trigger
- Type of power mechanisms



- https://www.osha.gov/nail-gun-safety
- A Roofer's Guide To Nail Gun Safety
- https://www.iko.com/blog/roofers-guide-nail-gun-safety/
- Nail Gun Safety: A Guide for Construction Contractors (EPUB | MOBI). OSHA Publication 3459, (2011). https://www.cdc.gov/niosh/docs/2011-202/default.html
- Center for Construction Research and Training
- https://www.cpwr.com/publications/nail-guns/

General Safety Considerations

- Trigger mechanisms
- Ease of handling
- Compliance with electrical safety codes
- Battery Safety – include approval of battery and charger as a unit
- Compliance will typically be a basic (threshold) criteria for purchase rather than a numerical rating

Using the Balanced Scorecard Approach to Compare Two Drills

Factor	Relative Weight	Range for available products	Tool A Score	Tool B Score
Productivity	20%	60-98 holes drilled/ hour	98 holes (20 Points)	75 holes (10 Points)
Ergonomic factors	20%	Tool weight 3-6 pounds	3.5 pounds (17 points)	5 pounds (10 points)
Noise	10%	88 to 96 dBA	90 dBA (8 points)	96 dBA (0 points)
Hand arm vibration	20%	3 to 5.8 m/s^2	3.0 m/s^2 (15 points)	4 m/s^2 (10 points)
Initial procurement cost	5%	$275 to $550	$525 (2 points)	$350 (4 points)
Five-year operation cost	10%	$350 to $700 based on 300 hours use/ year and parts	$500 (6 Points)	$630 (4 points)
Cost to produce given amount	5%	$100 to $175 for time cost to drill 100 holes	98 holes/hour ($100) 5 points	75 holes/hour ($133) 2 points
Physical safety	10%		Best electrical safety (10 points)	Fair grip, marginal electrical safety 3 pts.
Total	100%		83 points	49 points

Dust Control Annex to AS 6228A and AIR 6916

Step1 Determine if dust may be an issue

- Describe the process
- Determine the composition of the dust being generated
  - May need to take bulk samples
- Estimate levels of exposure
  - Visual observations
  - Past measurements
  - Literature (studies of similar operations)

Step 2 Add weighting to tool selection

Relative Weighting –Additional to balanced scorecard where hazardous dust may be created

0% to 40% depend on concentration and level of hazard

Implement evaluation and control

- Process substitution
- Wet methods
- Local Exhaust
- Regulated areas
- Housekeeping
- Measurement of exposures
- Evaluation of controls

User Evaluation of Tools
Trials after initial selection using the balanced scorecard

Collect preliminary process information

- Describe tool(s)
- Evaluate process
- Obtain preliminary inputs from users
- Identify possible issues and benefits of tools
- Vendors will often provide tools for trial use if they contemplate sales.

Obtain user feedback during operation

- Yes, we have a form!
- Ensure trial period is long enough to replicate normal working conditions
- Compare information on alternative tools
- Use information to improve the balance scorecard assessment

Comparions of the Standard and Layman's Guide

Aerospace Standard AS6228A™ (2023 Update) **Safety Requirements for Procurement, Maintenance, and Use of Held-Held Power Tools**	Aerospace Information Report (AIR) 6196™ (2023) **Guide for Safety, Efficiency, and Productivity in Buying Power Hand Tools** **Layman's Guide**
• Provides scoring system for tool evaluation and selection • Revision with Annex added to include dust control • Better address physical safety hazards and raise possible score from 90 to 100 points. • Updated references and source information • Includes worksheet for user evaluation of tools	• Explains scoring system for tool evaluation and selection • Provides health hazard, physical safety guidance • Stand-alone enclosures on productivity, noise, vibration, ergonomics and dust control and quality control • Limited technical references, mostly associated with enclosures. • Non-technical language used • Includes worksheet for user evaluation of tools

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Comparison of the standard and layman's guide

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Role of Technology and Process Management Example from the Automotive Industry

Are you still driving a 1960s Vintage Car?

- Gas mileage 15 mpg
- Planned obsolescence
- Weight 4000 + pounds
- Tune up every 6000 miles
- Drum brakes
- Seat belts optional
- Unpadded dash in some models
- **Ralph Nader Declares "Unsafe at Any Speed"**
- **50,000 people die in the US annually in car crashes**

Technology advances 1960s to present include

- Gas mileage 35 mpg
- Longer lifespan
- Weight ~2500 pounds
- Tune up every 30000 miles, often 100,000 miles
- Disk brakes and anti-lock features
- Seat belts
- Air bags and padded dash
- Crashworthy construction
- **Improved focus on quality**
- **30,000 US fatalities/year despite increased population and miles driven**

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Role of Technology and Process Management in Powered Tools

Are you still using 1960s Design Power Tools?

- Underpowered
- Noisy
- Heavy case
- Case and handle are <u>not</u> vibration isolated
- High vibration levels
- Poor ergonomics- hard to hold
- Hard to maintain quality
- Limited guarding of moving parts
- Low power to weight ratio

Technology advances 1960 to present include

- Quieter
- Lighter
- Case and handle vibration-isolated
- Auto-balancing of grinding wheel
- Lower vibration
- Better ergonomics
- Easter to maintain quality
- Reduced use/wastage of consumables
- Better machine guarding- less likely to injure user
- Improved productivity and quality
- Better power to weight ratio
- **Labor and consumables are 80% of cost for grinding- Un-economical <u>not</u> to spend a little more for a better tool!**

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Current Trends –Some Safety-related

- Atlas Copco- sustainable productivity
  - Tool design and process focus on ergonomics
  - Atlas Copco. (2015). The art of ergonomics.

European Union regulation of vibration exposures 2003- Stimulated production of low-vibration tools •

- Increased use of electric tools
  - Portable belt mounted battery packs
  - Lithium-ion battery technology
- Assistive Technology –stabilized arm
  - ZeroG for Sanding Aircraft: 53% Reduction in Labor Hours
- Increased concerns for silica and other dusts
  - Unfortunately, not universally
  - High-velocity-low volume local exhaust and other controls
  - See slide notes for website links

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Newer technology- some hazards remain

Image courtesy of
EARL DOTTER PHOTOJOURNALIST

- www.earldotter.com

Notes

- Fall protection- anchor point TBD
- Probably lithium-ion battery

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New Technology
Doesn't Always Use Good Ergonomics

Images courtesy of
EARL DOTTER PHOTOJOURNALIST
www.earldotter.com

Alternatives: NIOSH Publication No. 2007-122: Simple Solutions: Ergonomics for Construction Workers

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Local Exhaust?

Image courtesy of
EARL DOTTER PHOTOJOURNALIST
www.earldotter.com

Could reduce clean-up, avoid fire hazards and reduce dust exposure

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- 1938 US Department of Labor identified silicosis as a severe industrial disease which could be controlled by engineering and work practices

  2017 OSHA Silica Standard released Enforceable in Sept 2018 in General industry and 2019 in Construction

  Suggest visiting some construction sites to see the current status

  Appendix to AS6228A and AIR 6916 provides practical guidance for power tool evaluation and selection

  Image courtesy of
  EARL DOTTER PHOTOJOURNALIST
  www.earldotter.com

Summary and Suggested Way Ahead

- Power hand tools are a potential source of significant safety and health exposures, especially in the construction industries
- Knowledgeable product selection can increase productivity while reducing risks to power tool users.
- Evaluating and selecting better products must be a team effort involving management, engineering, project managers, logistics, workers and safety professionals
- Education must begin with management
  - May need to overcome some myths and misunderstandings
  - Initial purchase costs commonly accountst for only about 5% of life-cycle costs
  - Better products usually pay for themselves in risk reduction and improved productivity

DISCLAIMER: Conclusions are not final statements of U.S. government policy or those of author's employers. Mention of any company or product pictures do not constitute endorsement by NIOSH or other U.S. government bodies.

Summary and Suggested Way Ahead

- SAE Aerospace Standard AS6228A™ uses a cost and life cycle approach for power hand tool selection. A semi-quantitative scale is used to compare factors such as noise, vibration, ergonomic risks, procurement cost and life-cycle costs.
- AS6228A™ helps safety professionals and engineers understand and implement tool selection with risk factors for ergonomic, noise and vibration injury reduction.
- Aerospace Information Report AIR 6916[iv] -Layman's guide -explains hazards and makes the AS 6228A standard understandable in basic terms for a wider audience.
- Further outreach is needed to help implement this process management approach for hand-held power tools and apply to other areas of risk management.
- Your engagement is needed to use the standards approach and select equipment based on safety, health and productivity criteria. SAE contacts for EG1B1 Committee

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Additional Resources

Resources for Noise and Vibration

- Industrial Noise and Vibration Centre. (n.d.). Hand-arm vibration - HAV - assessment. Available at
- https://invc.com/vibration/hand-arm-vibration-hav-assessment/.
- Italian Physical Agents Portal (PAF). (n.d.). Hand-arm vibration database. Available at
- https://www.portaleagentifisici.it/fo_hav_list_macchinari_avanzata.php?lg=EN&page=0.
- National Institute for Occupational Safety and Health (NIOSH). (n.d.). Database for power hand tool noise and vibration.
- Available at https://www.cdc.gov/niosh/topics/noise/solutions/downloads/ALL_TOOLS_SWLA.pdf.
- National Institute for Working Life. (n.d.). Centralized European hand-arm database on the internet. Available at
- http://resource.isvr.soton.ac.uk/HRV/VINET/pdf_files/Appendix_H4B.pdf.
- NOTE: The database cited in this guide has been relocated to another site. The hand-arm vibration database is available
- at https://www.vibration.db.umu.se/app/.

EU Resources for Vibration

- EU. (2006). Guide to good practice on hand-arm vibration. European Union. Available at
- http://www.fosterohs.com/EU%20Good%20Practice%20Guide%20on%20Hand-Arm%20Vibration%20V7.7%20-%20HSE%202006.pdf.
- Health and Safety Executive (HSE). (n.d.). Guide to using HSE hand-arm vibration exposure calculator. Available at
- https://www.hse.gov.uk/vibration/HAV/calcinst.htm.
- Health and Safety Executive (HSE). (n.d.). Hand-arm vibration at work. Available at
- https://www.hse.gov.uk/vibration/hav/index.htm.
- Health and Safety Executive (HSE). (n.d.). HAV good practice controls. Available at
- https://www.hse.gov.uk/vibration/hav/campaign/index.htm.
- Health and Safety Executive (HSE). (n.d.). Monitoring exposure to hand-arm vibration: An innovative method for use with grinding machines. Available at https://www.hse.gov.uk/vibration/hav/casestudies/mhav-carlwest.htm.

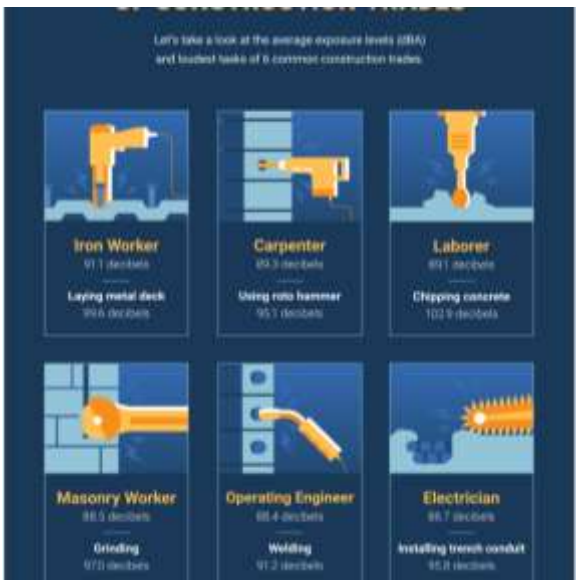
Noise Exposure Levels for Construction Workers

- How Loud Is Construction Site Noise? ANSI Blog October 26, 2018 How Loud Is Construction Site Noise? https://blog.ansi.org/2018/10/how-loud-is-construction-site-noise/
- 10 million construction workers have significant noise exposure
- CDC indicates that 14% have considerable hearing difficulty because of job-related noise
- https://www.cdc.gov/mmwr/volumes/65/wr/mm6515a2.htm
- But, construction workers report wearing hearing protection devices less than 20% of the time.
- Read more at the ANSI Blog: How Loud Is Construction Site Noise? https://blog.ansi.org/?p=158966

- ANSI/ASSP A10.46-2020: Construction Hearing Loss Prevention ansi.org/2020/03/ansi-assp-a10-46-hearing-loss-construction/ https://blog.ansi.org/2020/03/ansi-assp-a10-46-hearing-loss-construction/
- HEAVY CONSTRUCTION EQUIPMENT NOISE STUDY USING DOSIMETRY AND TIME-MOTION STUDIES https://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/hcensu.pdf
- Seixas, N. (2004) University of Washington Final Report: Noise and Hearing Damage in Construction Apprentices.

Construction Site Noise: How Loud is Too Loud? By: BigRentz on August 23, 2018

- https://www.bigrentz.com/blog/construction-noise
- Also see How to prevent noise exposures in construction
- https://www.bigrentz.com/blog/how-to-prevent-noise-pollution



Ergonomic Resources

- Albers, J.T. and Estill, C.F. (2007). Ergonomics for construction workers. National Institute for Occupational Safety and
- Health. Available at https://blogs.cdc.gov/niosh-science-blog/2007/12/17/erg/.
- Atlas Copco. (2015). The art of ergonomics. Available at https://www.atlascopco.com/content/dam/atlas-copco/industrialtechnique/ergonomics/documents/Pocket%20Guide%20Ergonomics%209833858701_L.pdf.
- Defense Centers for Public Health - Aberdeen. (2022). Ergonomics. Available at
- https://phc.amedd.army.mil/topics/workplacehealth/ergo/Pages/default.aspx
- Lindqvist, B., Skogsberg, L., Graf, F., Haettel, R., and Mazaheri, A. (2022). Power tool ergonomics: Evaluation of power
- tools. Atlas Copco, ISBN 978-91-527-0284-0. Available at https://www.atlascopco.com/content/dam/atlas-copco/industrialtechnique/ergonomics/documents/PowerToolErgonomics.pdf.
- National Institute for Occupational Safety and Health (NIOSH). (2006). Simple solutions ergonomics for construction
- workers. Available at https://www.cdc.gov/niosh/docs/2007-122/.
- National Safety Council. (1993). Ergonomics: A practical guide. Second edition. Available at https://www.nsc.org/shop/workplace-safety/ergonomics/ergonomics-practical-guide-2ed-cd-kit.
- Washington State Department of Labor and Industries. (n.d.). Caution zone checklist. Available at https://lni.wa.gov/safetyhealth/_docs/CautionZoneJobsChecklist.pdf.

New Technology- New hazards Powered Hand Tools Process management and equipment selection factors

Factor or Risk	Health & 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-containing (silicosis) Heavy metals	Visibility of work	Alternative process, wet work, local exhaust
Ergonomic design of workplace and tools	Long-term disease potential	Direct link between comfort and productivity	Equipment selection and process design
Physical safety hazards/ controls	Potential injuries	Productivity impacts of work-arounds	Equipment selection and maintenance Note that labor and consumables are highest costs (up to 80% for grinding)
Life-cycle costs (replacement/ repair)	Low-cost tools are likely to be noisier, and less “ergonomic”	Decreased productivity and quality (cheap tools are expensive)	
New Hazard- Lithium- ion batteries	Fire safety and explosive risks	Improves portability and life cycle of tools	Selection of charger and batteries as single system Proper treatment, charging of batteries

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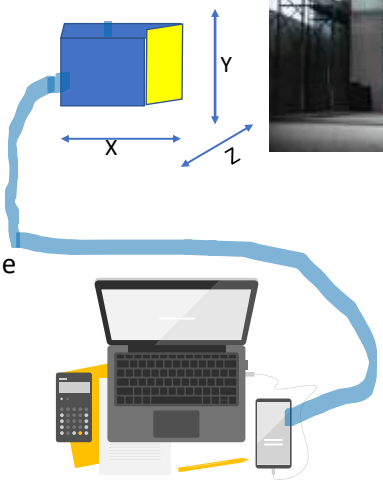
Dusts – Common Construction Risk – Often related to power hand tools

Material being 'worked"	Common Processes	Potential hazards	Notes
Painted surfaces	Grinding for paint removal; Spray painting	Metals, especially from pigments and lead driers Lead, chromium, sometimes silica	Standards for chrome VI are lower than chrome III. Include lead and zinc chromates
Stainless steel	Grinding surfaces, often post-welding, drilling and polishing	Nickel Chrome (depends on form)	
Masonry or stone; concrete, sand, mortar, fiber cement board, engineered stone countertops, granite countertops	Grinding, tuck pointing, drilling	Respirable crystalline silica	Crystalline silica is associate with an irrevsiible lung disease, silicosis. (Governed by OSHA Silica Standard)
Wood	Sanding, grinding, cutting	Some hardwoods cause sensitization	Oak and beach are confirmed human carcinogens

Hand Arm Vibration Measurement

- Sensor (accelerometer) measures in 3 axis – x, y, z
  - X -sideways
  - Y- up-down
  - Z –back and forth
- Attached to tool to pick up vibration
- Meter picks up vibration signal
  - Acceleration =rate of change in motion/time
  - Because motion is back and forth
  - Ax= $(a_x^2)^{1/2}$
  - A total = $\sqrt{(a_x)^2 + (a_y)^2 + (a_z)^2}$



Sources for Instruments – with gentle technical guidance

- The Modal Shop
- www.modalshop.com
- 513 351-9919

- Larson Davis www.larsondavis.com
- Bruel & Kjaer (B&K) https://www.bksv.com/en
- Svantek https://vantek.com
- Reactec www.reactec.com watch-like dosimeter

- U.S. Army Public Health Command
- TG 356 November 2014Vibration Pocket Guide https://ph.health.mil/PHC%20Resource%20Library/TG356_VibrationPocketGuide.pdf

Selected References on Hand Arm Vibration

- United Kingdom Health and Safety Executive (HSE) Resources on hand-arm vibration
  https://www.hse.gov.uk/vibration/hav/publications.htm

- Vibration Syndrome NIOSH Current Intelligence Bulletin (NIOSH Pub 83-110)
- https://www.cdc.gov/niosh/docs/83-110/default.html

- TG 356 November 2014Vibration Pocket Guide U.S. Army Public Health Command
  https://ph.health.mil/PHC%20Resource%20Library/TG356_VibrationPocketGuide.pdf

- Hand-Arm Vibration (HAV) – A Step by Step Guide to Evaluate & Control Risk Ergo Plus MARK MIDDLESWORTH | JANUARY 15, 2024 https://ergo-plus.com/hand-arm-vibration-hav/

- How to Buy Safer, Quieter Tools A Process Management Approach to Reducing Noise and Hand-arm Vibration while Improving Productivity and Quality, AIHA Synergist February 2018
- BY EDWARD ZECHMANN, MARK GEIGER, AND BRYAN BEAMER
- https://synergist.aiha.org/201801-how-to-buy-safer-quieter-tools

Measurement Location(s)

Evaluate trigger time –some instruments will integrate

Sometimes it takes two

Images courtesy of
EARL DOTTER PHOTOJOURNALIST
www.earldotter.com

Safety and Health Education must start with Management

Staff Category	Key Education Components	Possible Approaches
Senior management	▪ Fiscal and sustainability factors supporting productivity and safety. ▪ Safety and health risks associated with operations, including risk acceptance at the appropriate management level. Associated accountability and potential liability for occupational illness and injuries. ▪ Results of periodic program evaluations.	▪ Senior level policy documents. ▪ Periodic program reviews. ▪ Production and quality reports. ▪ Safety summary and mishap reports.
Engineering and production management	▪ Safety and health risk factors inherent in processes. ▪ Basic ergonomic risk factors. ▪ Cos/benefit considerations associated with ergonomic programs. ▪ Lean six-sigma and other process/productivity evaluation approaches.	▪ Management policy and related training. ▪ Ergonomic working group involving engineering, production, and support personnel.
Procurement/ logistics department	▪ Risk factors inherent in processes and role of purchasing in modulating risks of productivity impairment and injury risk. ▪ Life-cycle cost/benefit accounting considerations supporting best value procurement.	▪ Management policy and related training. ▪ User feedback related to product procurement. ▪ Rating systems based on customer/user feedback, including satisfaction with procurement support.

Safety and Health Education for Management
Some common myths to address

Common myth or misconception	Alternative Information	Additional Factors
Hearing protection is sufficient for noise control	Effective noise reduction from PPE is typically about ½ of the ideal NRR	Both protective equipment and equipment selection are needed.
Protective equipment use is obvious	Education and motivation is necessary. Worker buy-in is essential.	OSHA requirements for a written PPE program.
Engineers can design the project without considering safety. Workers can adapt as needed	Higher costs and less effective "controls" if not considered as part of the project. Example, fall protection costs increase by 10x for each stage of design implementation.	Organizational and personal professional liability considerations. Insurance costs. Delays and higher costs if safety delays the project. Army Corps of Engineers and related Federal contracting requirements
Over-emphasis on initial cost of power tools.	Purchase cost accounts for about 5% of life-cycle cost. Productivity and safety improve with better equipment. Cheap equipment is uneconomical!	Higher rates of equipment replacement. Lower quality and productivity. Rapid evolution of power tools

Guidance for user and safety-associated training

Staff Category	Key Education Components	Possible Approaches
Maintenance and tool room	▪ Productivity evaluation. ▪ Purchasing process and approaches to justify procurement. ▪ Safety and health considerations associated with work and maintenance operations.	▪ Collaboration and routine meetings between procurement and production.
Production and maintenance staff using power hand tools	▪ Safety and health requirements and rationale for their adaption including risks relevant to their work and appropriate control measures. ▪ Link between safety and productivity. ▪ Protective equipment requirements, limitations, and evaluation of effectiveness. ▪ Overview of the organizations safety and health program including feedback/risk reporting.	▪ Safety and health training required/recommended by organizational policy and by regulations such as the European Union and related national regulations or U.S. OSHA regulations. ▪ New employee orientation.(2) ▪ Routine training and training related to updated processes.(2)
Safety and health personnel	▪ Productivity evaluation. ▪ Purchasing process and approaches to justify procurement. ▪ Lean six-sigma and other process/productivity evaluation approaches.	▪ Collaboration and routine meetings between procurement and production.

Safety and Health Education must start with management

Powered hand tool procurement, maintenance, and use (Summary)

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Guidance for Federal Employees and Contractors

Wider Applications

- Many Federal contractors can order via GSA under certain conditions
- GSA has done the hard part- providing expert review, identifying alternative products, developing specifications
  - You can use this information to review alternative products and specifications –even if you can't buy directly from GSA
- Federal construction contracts invoke Army Corps of Engineers EM-385-10-1 Safety Manual
  - Federal Acquisition Regulations FAR Clause 52.236-13
  - Currently addresses cumulative trauma and tool safety
  - New edition will require control of whole body and segmental vibration and an organizational safety policy
- EM 385-1-1 Safety and Occupational Health Requirements This major revision, dated 15 March 2024 —
- https://www.publications.usace.army.mil/Portals/76/EM%20385-1-1%20_EFFECTIVE%2015March2024.pdf

GSA

U.S. General Services Administration

Federal Acquisition Service

The Department of Defense/ Industry Working Group and the General Services Administration Heartland Acquisition Center (HAC) have been working together to ensure a wide variety of ergonomic, low-vibration tools are offered to the DoD community. We have chosen to focus on lower vibration because of the risks of hand-arm vibration, producing Hand-Arm Vibration Syndrome (HAVS), a potentially irreversible disease associated with prolonged and intense exposure to this vibration. Tools developed to reduce vibration often also have other desirable performance properties such as longer life-spans, improved ergonomics and lower noise levels. This brochure outlines program details.

General Ergonomic Program Details can be found at the following sites, or at your unit safety officer office. https://www.gsaglobalsupply.gsa.gov/

and See slide notes for details on vibration-controlled tools

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Approach- Power Tools and Other products

- Evaluate power hand tools (or other products) where vibration, noise or other safety concerns are a hazard
- Identify and communicate with GSA/DLA product manager regarding procurement criteria **(See SD-1 Standardization Directory)**
  - **https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=113341**
  - Identify the same need at local and process management level
- Establish procedures for the Qualified Products List (QPL)
  - Evaluate possible approaches to facilitate and document labs which can provide testing and evaluation
- Make improved products available via GSA schedule both to Federal and Federal contractor buyers
  - Contractors can buy through GSA for certain government projects
  - Product marketed by GSA have open description of specifications (Usable to any prospective purchaser-even if they don't buy from GSA)

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Approaches to Tool and Process Management

- Getting the best (versus best marketing) vendors
- What aspects of European and other approaches might be considered?
- It's not just the tools –it's the process management!
- Cultural issues and organizational impediments to progress
- How integrate safety and health as an indicator of process quality and effectiveness

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