Process Management Approaches to Power Hand Tool Selection and Use

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Disclaimer

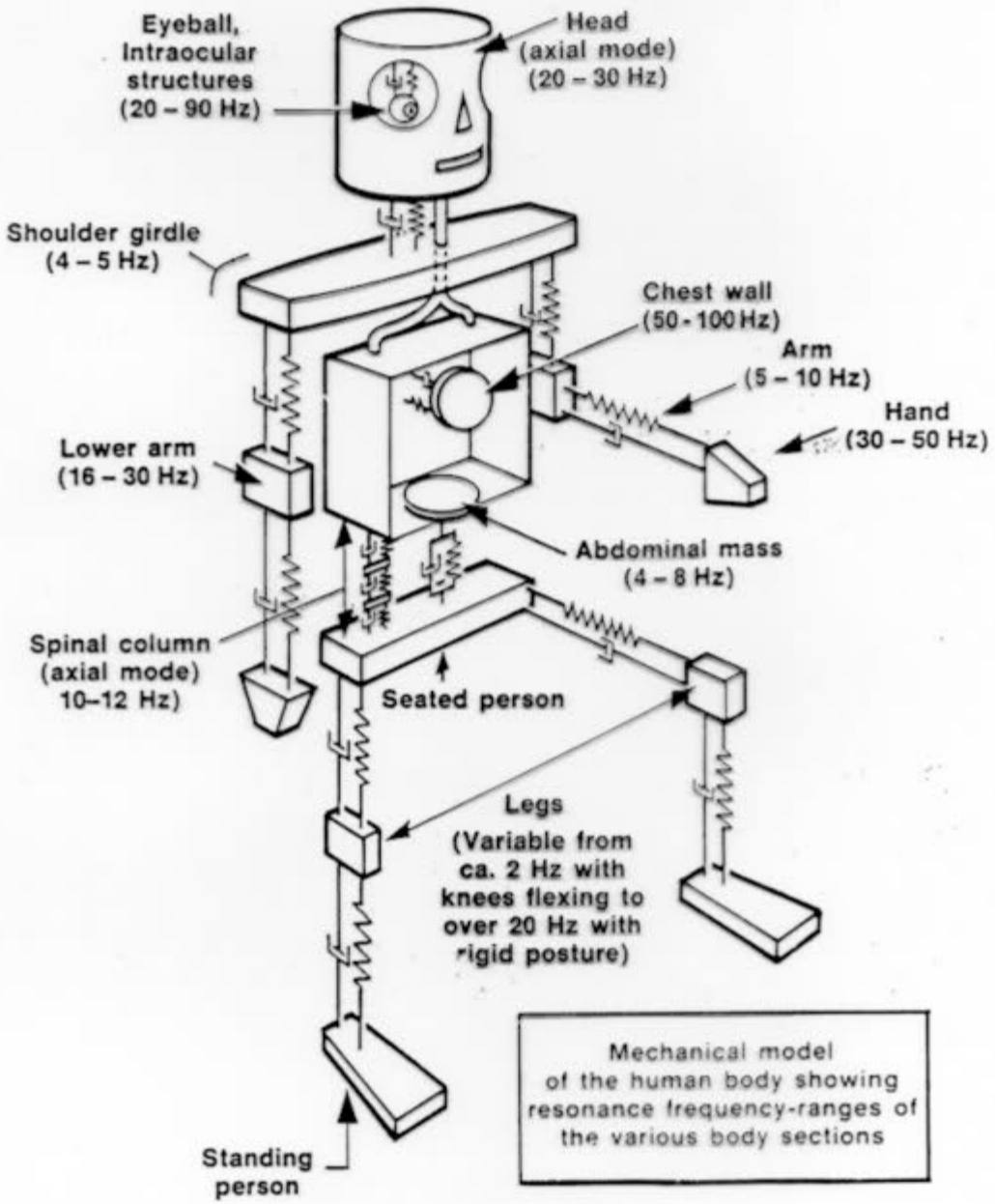
Material and views presented are the responsibility of the authors and do not necessarily represent official Navy/DOD policy

Members of Society of Automotive Engineers standards activities participate on their own behalf as technical experts and do not necessarily represent the views of their employing organizations.

Objectives

- Describe safety and influence of power tools with particular reference to vibration, noise and ergonomics improving quality of tools available to Federal workers and the construction industry in general
- Provide background of Defense Safety Oversight Council Project addressing hand-arm vibration, minimize direct cost associated with personnel downtime and medical.
- Describe EG-1B1 Committee of the Society of Automotive development standard approaches for power tool evaluation and procurement

Human body resonance frequencies



Mechanical model of the human body showing resonance frequency-ranges of the various body sections

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

Hand Arm Vibration Syndrome (HAVS) is an illness caused by vibration when working with tools or holding a vibrating work piece.

An Ignored Disease?

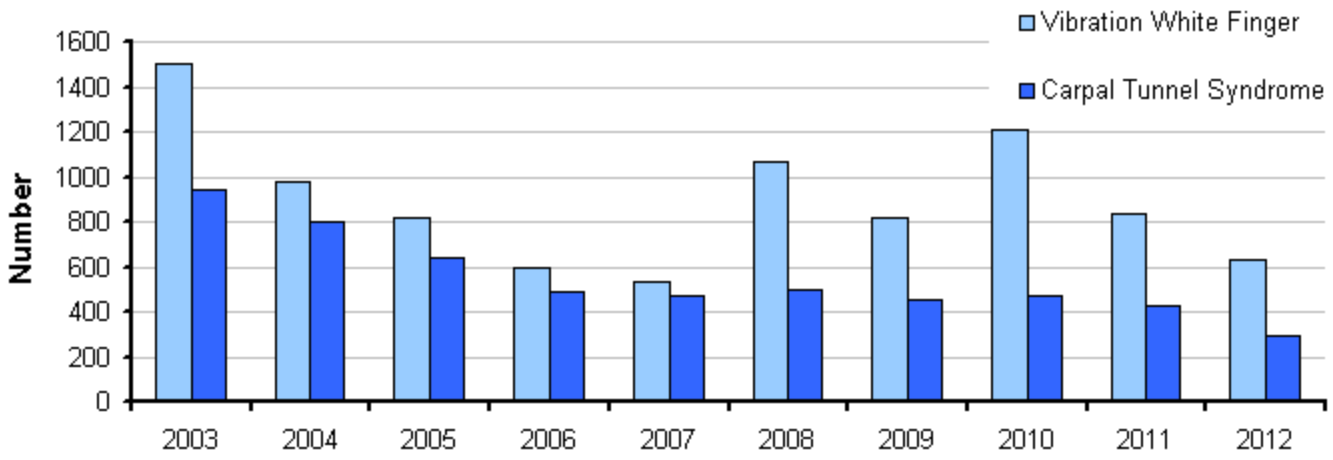
- **In 1918, Alice Hamilton, MD, identified and documented HAVS in Indiana limestone quarry workers**
- **Sixty years later in 1978, the National Institute for Occupational Safety and Health, NIOSH (Don Wasserman) completed a study at the same quarry and the incidence of disease was the same, about 80% of the exposed workers had symptoms of HAVS.**
  - **Up to 1978, there were no changes in pneumatic rock-breaking tools**
  - **“attack rate “ was about 50% for “at risk” exposed workers**

Hand-Arm-Vibration (HAV)

- Long Term vibration causes resonance in the affected body part, i.e., the hands
  - Causes damage to neurovascular structures in fingers
  - Carpal Tunnel, Vibration White Finger (VWF)
  - Incidence rate in the US is under-reported due to limitations on recognition as a compensable disease and lack of specific exposure regulation.
  - See UK Statistics http://www.hse.gov.uk/VIBRATION/hav/statistics.htm
  - Dr. Ron House, Canadian Physician- A problem common undiagnosed
  - About 198/claims year in Canada) Should be 75,000 –144,000 based on UK and US data

    https://www.ohao.org/PDF/Hand%20Arm%20Vibration%20Syndrome%20March%2020.pdf

New cases of Prescribed Vibration White Finger (VWF) and Carpal Tunnel Syndrome (CTS) in Great Britain 1995-2007



http://www.hse.gov.uk/VIBRATION/hav/statistics.htm

Population of Britain = 62 million
Population of the USA = 307 million
Population of Canada = 31 million
/

Occupational exposure limits for hand-arm vibration demonstrate a good correlation between exposures to vibration (measured as acceleration) and the incidence & 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) (1972)	14 m/s2	40%
Anti-vibration design (1990)	2 m/s2	5%

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

Project outcomes include

Defense Safety Oversight Council Projects

- Influenced GSA procurement criteria for power hand tools
- Provided certified (third-party) anti-vibration gloves in the Federal supply system via 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**

Meeting at National Institute for Occupational Safety and Health, Morgantown, West VA February 2008

Population at risk

- **Health and Safety Executive (HSE) in Britain estimates 2 million persons are at risk in the U.K.**
- **NIOSH estimated 1.5 million at risk in the U.S.**
  - **Seems to underestimate the affected population based on the number of working persons in Britain compared to the number of worker persons in the U.S.**
- **Using HSE estimates, more than 3 million U.S. workers are at risk.**
- **The European Agency for Safety and Health at Work data shows between 5 and 10% of workers in the EU are exposed to a potential HAVS risk from the use of powered hand tools.**
- **No one knows for sure the number of U.S. workers at risk because of disease under-reporting**

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.

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

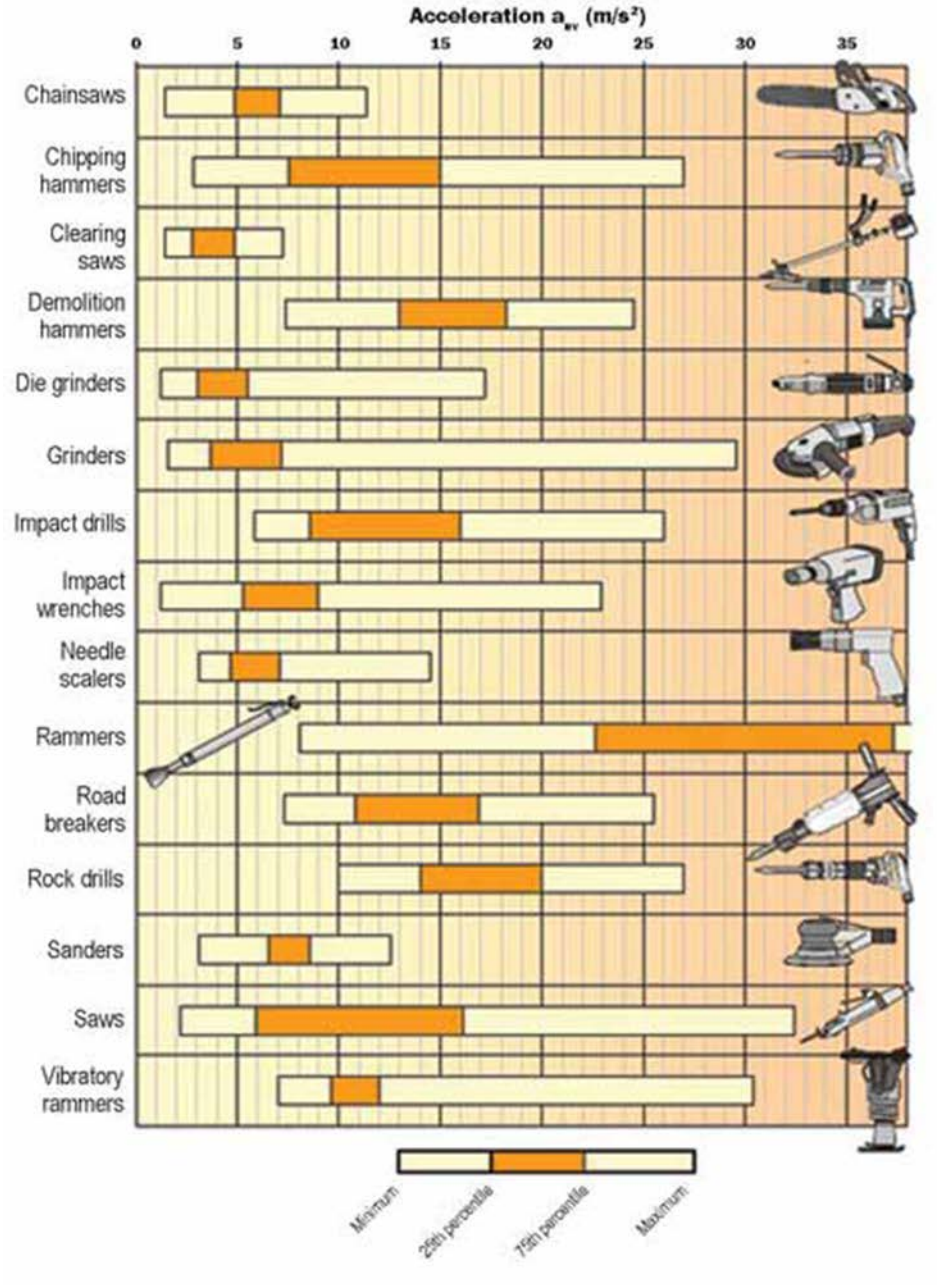
Powered Hand Tools $10.9 Billion Annual US Market

Power & Hand Tools - Industry Market Research, Market Share, Market Size, Sales, Demand Forecast, Market Leaders, Company Profiles, Industry Trends
http://www.freedoniagroup.com/Power-And-Hand-Tools.html

Hand Power Tool Use in the Department of Defense

Tool Type	Industry Area			
	Maritime /Shipyard	Aircraft and Vehicles	Ground/Road and Facility Maintenance	Construction
Grinders	X	X	X	X
Polishers	X	X	X	
Welding/pre-post grinding	XX	X	X	X
Metal cutting	Submarine recycling	X	X	X
Woodwork	Support structures		X	X
Concrete work			X	XX
Impact wrenches	X	X	X	X
Demolition	X		XX	X pavement breakers
Foundry (finishing cast work)	X			
Drilling	X	XX	X	X

Product Selection is Vital for Vibration (and Noise) Control



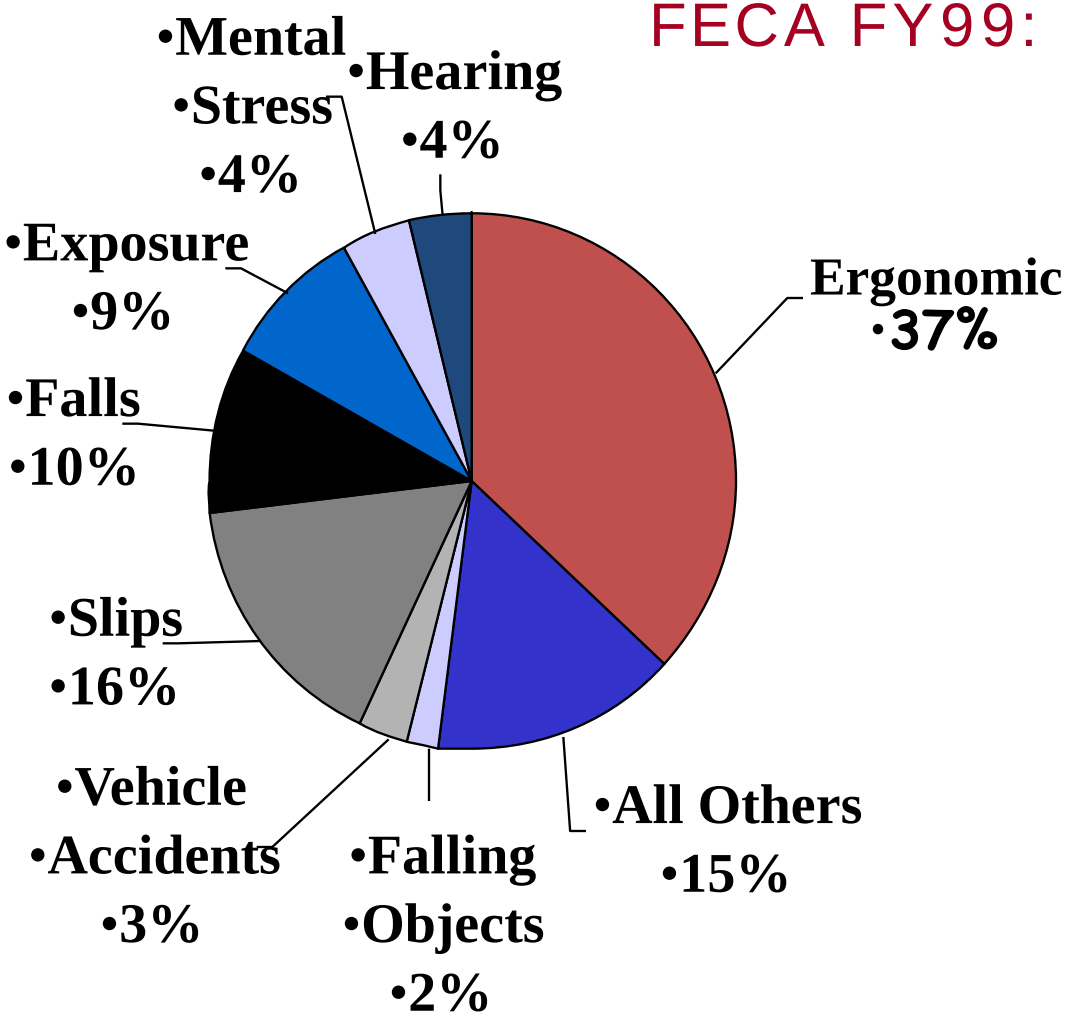
Effect of Tools

Resource: NIOSH Buy- Quiet Programs
http://www.cdc.gov/niosh/topics/buyquiet/component.html

ERGONOMICS AFFECTS THE NAVY
Other Services Likely to be Similarly Impacted

- Ergonomic injuries and illnesses*
  - **Represent the single largest source of claims and costs to the Navy**
  - **Roughly $90 million annually or one-third of all recent claims**
- If left unchecked, the Navy's annual cost is
  - **Projected to increase to $111 million by FY 2009.**
- * Analyzing the Navy's Safety Data by CNA, December 2001

FECA FY99:

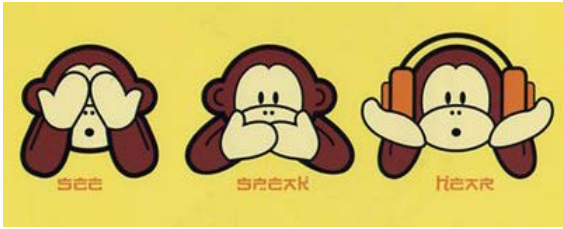


Powered Hand Tools

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		
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)	

Regulatory Challenges



- OSHA Permissible Exposure Limits (PELs) stuck in the 1970s
- Proposed Ergonomics Standard derailed in 1999
- Recent 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.

Overcoming Tunnel Vision?

- Perspective on all aspects of usability (not just vibration)
- Focused application of relevant standards
- Application of “safety for use” approach
- Reviewer with diverse backgrounds and perspectives
- Improved user feedback

Challenges

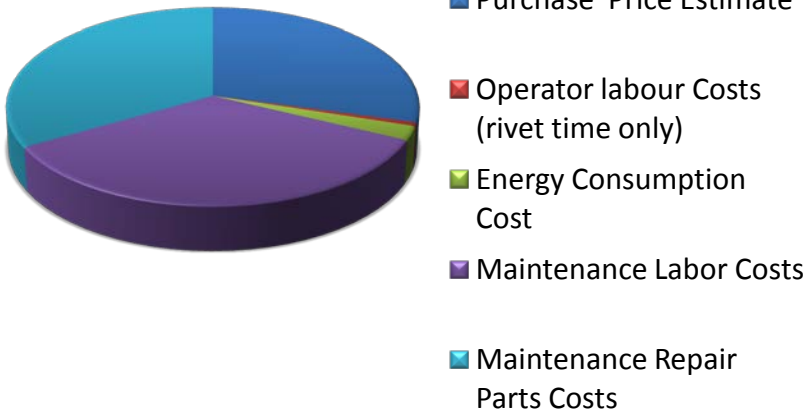
- Educating industrial hygienists and safety professionals to understand and engage in existing processes for feedback
- Integrating information for change as opposed to traditional surveys and reports
- Streamlining and clarifying current processes and policies
- Establishing new policies and procedures, if needed

Need New Approach
Systems Engineering!

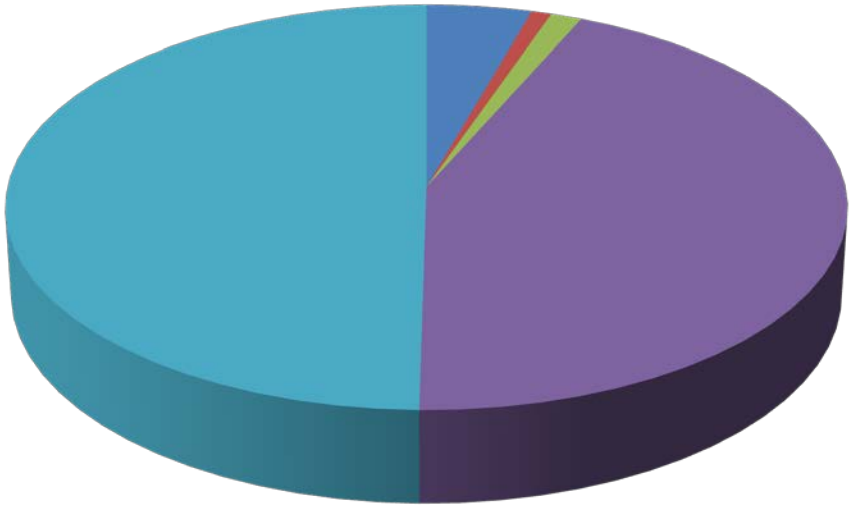
- Tried the moral approach – failed due to perceived budgetary constraints
- Only looked at initial tool cost and ignored Total Cost of Ownership (TCO)
  - DOD term is TOC (total ownership cost)
- Need to make a "business case" to show total cost to shop

4. TCO (Total Cost of Ownership)

Brand "X" Rivet Hammer



Brand "Y" Rivet Hammer



Initial tool cost $1,200 ⟺ **Initial tool cost $312**

5 year cost $15,750 ⟺ **5 year cost $32,312**

Low price ≠ Low TCO

SAE TECHNICAL COMMITTEE EG-1B1, POWERED HAND TOOLS - PRODUCTIVITY, ERGONOMICS AND SAFETY
Fact Sheet

- Addresses evaluation, procurement, use and support of powered hand tools
  - Integrating safety, health and productivity into procurement and process management.
- Complements the SAE EG-1B Aerospace Hand Tool Committee which addresses all facets of aerospace hand tools and tool kits.
- Focus on development of aerospace standard AS6228,which provides programmatic guidance for sustainable tool evaluation and procurement
  - Will educate tool users and program managers
  - Promote economic effectiveness and efficiency.
- Members include government, original equipment manufacturers, and users

Need for "Balanced Scorecard"

Society of Automotive Engineers (SAE)
E1B Committee Project
Meeting in Kansas City, Mo Jan 18-19, 2012

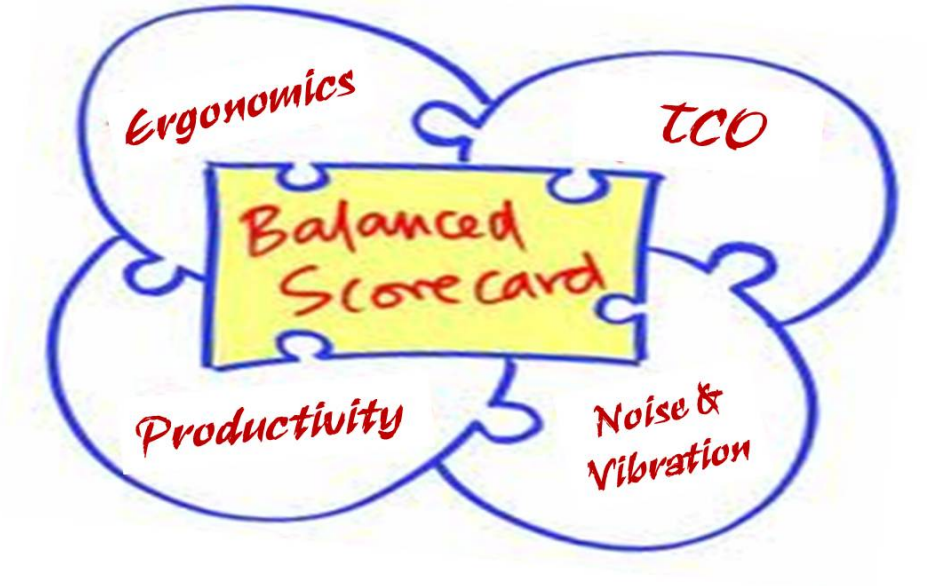
- GSA Power tool leads, Tool manufactures, DOD Safety and Health and NIOSH represented

- Mutual interest in obtaining and selling better tools
  - Better products can (and will) be undercut if initial cost is the only 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

“Balanced Scorecard”

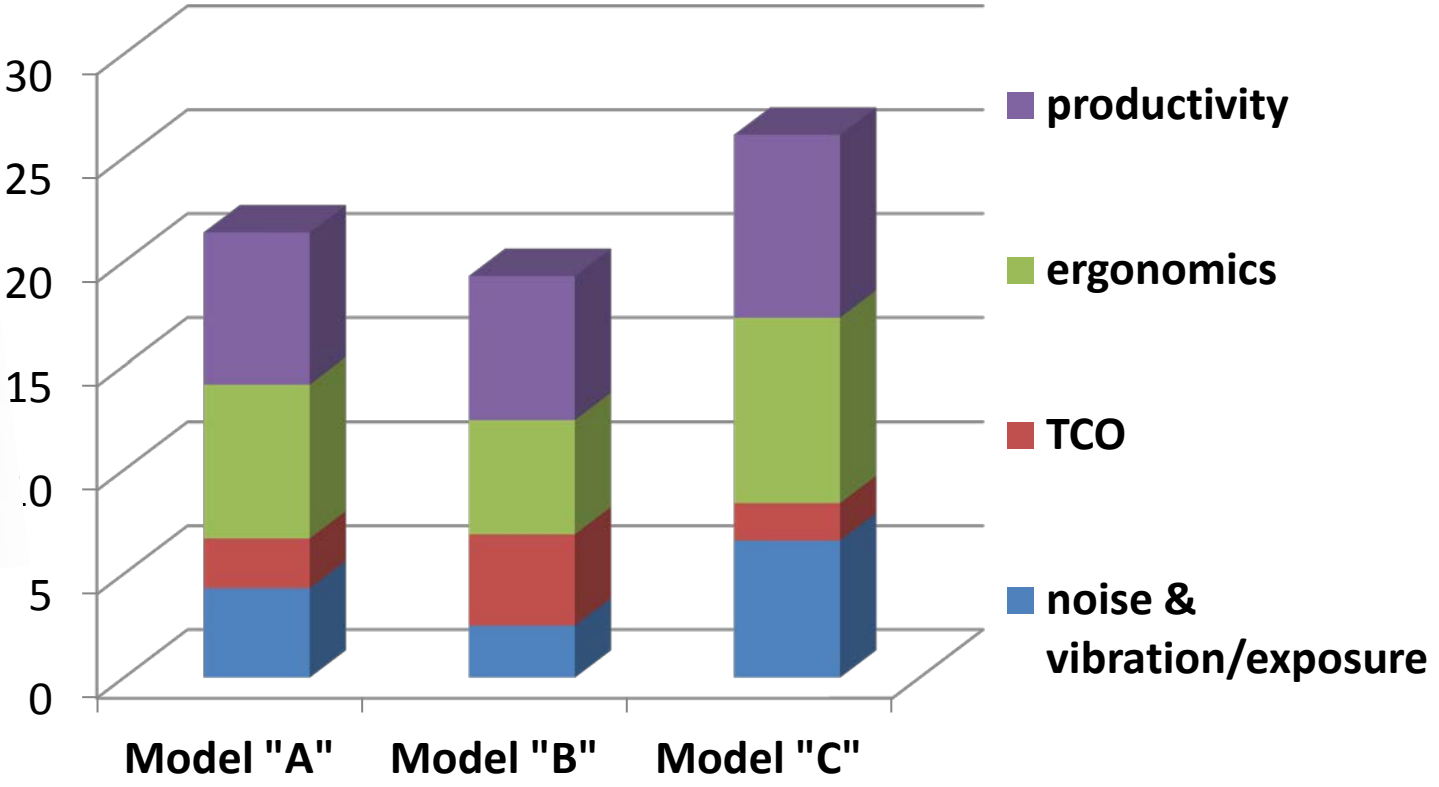
- **Develop a COMPLETE evaluation and procurement process for portable power tools**
- **Use a WEIGHTED approach to key parameters**
- **Produce input for ISO/SAE/ASME standards**



AS 6228 Safety Requirements for Procurement, Maintenance and Use of Hand-held Powered Tools

Factor	Relative Weighting	Notes
Productivity	20%	May include cycle time; amount of material removed, time to accomplish a particular amount of work.
Noise	10%	Depend on relative contribution as a risk factor. For example:
Hand-arm vibration	20%	Depend on relative contribution as a risk factor. For example: 5% of the evaluation based on vibration levels if < 2.5%. 10% if tools operate in the range of > 5.0 m/s^2 15% if tools > 10 m/s^2 and used >2 hours/day
Ergonomic factors other than shock and vibration	20%	Guidance from Atlas Copco Guide to Power Hand tool Ergonomics and associated references.
Initial procurement cost	5%	May depend on anticipated life-span of tool and intensity of use (for example, occasional; periodic; daily).
Life cycle cost	15%	Includes maintenance - parts and labor

Scorecard Presentation



Can a Department of Defense (DOD) effort provide leadership and suitable equipment that will influence others within this organization and the larger marketplace?

- Role of DOD occupational health establishment
  - Role of DOD in many health and safety areas including noise, heat/cold stress, ergonomics
  - Recent initiatives to reduce mishaps
- Market influence
  - DOD and allied defense industry size
  - International role (Europe, Asia)
  - Corps of Engineers safety and health guidance for Federal contracts

Alternative Views of Federal Procurement
The 800 pound Gorilla and/or hopeless maze

Amazing complexity

- Each organization has their own maze
- Progress is slow and inconsistent- even if the process can be understood

The 800 pound gorilla with widespread market influence

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

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/

Power Tools: The Approach

- Evaluate power hand tools where vibration, noise or other safety concerns are a hazard
- Identify and communicate with GSA product manager regarding procurement criteria
  - 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
- Crosslink GSA, DLA and NIOSH websites
- 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)

Naval Safety Center Outreach Efforts

NAVAL SAFETY CENTER
Work, Play, Live...Safely!

Naval Safety Center COMNAVSAFECEN

Advanced Search
Naval Safety CenterAcquisitionAfloat Ashore Aviation
Media PAOORMOSH Training SitemapStatisticsWESS

Acquisition Safety - Vibration

Introduction | Background | Relevance of Vibration Control to Acquisition | Discussion | Recommendations | Resources

Introduction

- The Navy cares deeply about protecting the safety and health of its greatest resource - its people. In today's workplaces, there exist many potentially serious occupational hazards. Some hazards, like noise-induced hearing loss and heat stress, are well known, heavily reported, and well documented. Much less is known about other workplace perils, which can produce serious, irreversible, and unsuspected diseases. *Occupational Vibration*, affecting eight to ten million people in the U.S. alone, is one of these less obvious workplace hazards. Because Navy Leadership is concerned about the safety and health of its military and civilian workers, they are working hard to address this under-recognized occupational health problem through acquisition of safe, cost-effective, and performance-improving designs and equipment. This section of the Acquisition Safety website addresses the vibration issue uniquely and in depth. Included are the potential health effects of uncontrolled vibration and ongoing efforts to control this risk to Navy personnel. Also provided are best business practices and technical assistance for acquisition (research, development, design and procurement) of designs and equipment that will maximize productivity and operational effectiveness while protecting operators and maintainers of this

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

* Copyright 1990, D.E. Wasserman, Inc.; Image of hands (not U.S. Navy worker) used with permission.

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http://www.public.navy.mil/navsafecen/PublishingImages/home/acquisition.png

Wrap-up – Systems Engineering Approach is Needed!

- HAVS and other safety/health risk factors will be addressed through a tool evaluation process employing a Balanced Scorecard approach.
- Society of Automotive Engineers EG1-B1 Committee Subcommittee developing evaluation guidance
  - Members include DOD Health and Safety, General Services Administration and industry representatives
  - Standard would allow common approach to procurement without needing to justify each purchase individually
- DOD and allied defense industry size = market influence
  - International role (Europe, Asia)
  - Corps of Engineers safety and health guidance for Federal contracts a possible consideration
- Regulatory challenges will need to be addressed.
- Link with NIOSH is vital to this effort
  - Health Effects Research Laboratory (Vibration evaluation)
  - Construction Safety and Health
  - Prevention through Design
- Support for outreach to industry and Federal agencies

Thank you

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703 695-4703

SAE EG-1B1 Committee Powered Hand Tools – Productivity, ergonomics and safety (www.sae.org)

Back-up Materials

Publications

- Society of Automotive Engineers Standard AS 6228 Safety Requirements for Procurement, Maintenance and Use of Hand-held Powered Tools September 2014 (available www.sae.org)

- Development of a Balanced Scorecard for Evaluation and Procurement of Powered Hand Tools, paper and presentation in Proceedings of the 3rd American Conference for Human Vibration, Hartford, CT, US, June 14, 2012

- Minimizing Hand-arm Vibration Syndrome among Powered Hand Tool Operators (2014) Mark B. Geiger, Donald Wasserman, Steven G. Chervak, Craig M. Henderson, Elizabeth Rodriquez-Johnson, Aimee Ritchey, Professional Safety (In Press, to be published November 2014)

DEVELOPMENT OF A BALANCED SCORECARD FOR EVALUATION AND PROCUREMENT OF POWERED HAND TOOLS

Richard Borcicky, NAVAIR Fleet Readiness Center, East, Cherry Point, NC
Steve Chervak, Army Public Health Command, Aberdeen Proving Ground, MD
Ren Dong, National Institute for Occupational Safety and Health, Morgantown, WV
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Craig Kuznia, General Services Administration, Kansas City, MO
Mark Lehnert, Stanley Black and Decker, New Britain, CT
Thomas McDowell, National Institute for Occupational Safety and Health, Morgantown, WV
Magnus Persson, Atlas Copco, Stockholm, Sweden
John Ster, JMS Aerospace Engineering and Consulting (previously Engineering Director GSA Kansas City)
Don Wasserman, Consultant, Frederick, MD
Andrew Wells, USAF Health Risk Assessment Division, Wright Pat AFB, Dayton, OH

NIOSH Data Base for Powered Hand Tools
Includes noise and vibration

NIOSH provides a power-tool data base on their website with information on belt sanders, circular saws, drills, grinders, hammer drills, impact wrenches, jigsaw, miter saw, orbital saw, reciprocating saw and powered screw drivers

Web site: http://wwwn.cdc.gov/niosh-sound-vibration/Default.aspx

European Union Database

Provides for search of tools and manufactures products for sound and vibration levels

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http://www.vibration.db.umu.se/HavSok.aspx?lang=en

Hand-Arm Vibration as a Risk Factor in Systems Design, Development, and Support

Paper/Presentation at International System Safety Conference
San Diego August 2005

Carol Lavery, MPH, CIH *
Alec Wong, MS*
LT Kristen Harrer, MS*
Nancy Estrada, MPH*
Jane Nowell, MS, CIH*
Mark Geiger, MS, CIH, CSP**

* Naval Medical Center, San Diego

**OPNAV Safety Liaison Office

Evaluation of Three Pavement Breakers

- Construction Battalion 405 (CBU) cement pad removal (40X80 ft)
- Comparison
  - standard pavement breaker
  - 2 anti-vibration pavement breakers

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 efforts to select better tools
Chicago (anti-vibration)	277 (m/s^2)	--	Slightly better
Atlas Copco (anti-vibration)	18.9 (m/s^2)	--	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	

Sanding Aircraft

- Paint Shop prepares surfaces for painting
- All aircraft require some sanding prior to painting
- Thickness of previous layers of paint dictates how much sanding

Effects of Process Substitution

Sanding versus Blasting Parts

F/A-18 Wing Corrosion Shop

Small parts have paint removed to look for corrosion

- Dirty, corroded small parts
- Hand sanding with power tools
- Because the parts are small and have corners and tight areas to get into it took 3-4 hours to remove paint and corrosion from the parts.
- High hand-arm vibration exposures

- Clean, un-corroded parts
- Whereas, in the blasting cabinet (glove box) it takes about 20 minutes.
- Other advantages include: Less stress to hands and arms due to vibration and repetitive motion, dust control (chromates), less damage to part.

Frequency-weighted rms Acceleration of a Random Orbital Sanders for the Dominant Axis (Z-Axis)

Sander	Average Acceleration Dominant Handle Axis (m/s^2)	Allowable Vibration Exposure Duration
National Detroit	14.4	<1 hour
George Renault	6.0	<4 hours
Dynabrade	7.0	2 hours
Clayton	6.3*	Less than 1 hour

*The HVM 100 registered an overload while taking measurements generated by the Clayton sander. Therefore, this value is not accurate and the actual value could not be determined.

This study used the ACGIH TLVs (dominant axis) to evaluate exposures

Mishap Risk Assessment Matrix Before and After Process Change

Using Military Standard 882 System Safety per DOD Acquisition Regulations

Probability (Frequency)	Severity			
	I Catastrophic	II Critical	III Marginal	IV Negligible
A Frequent	IA - 1	IIA – 3	IIIA – 7	IVA – 13
B Probable	IB – 2	IIB – 5	IIIB – 9	IVB – 16
C Occasional	IC – 4	IIC – 6	IIIC – 11	IVC – 18
D Remote	ID – 8	IID – 10	IIID – 14	IVD – 19
E Improbable	IE - 12	IIE - 15	IIIE - 17	IVE - 20

Modified risk level IIID or IVC, Medium to Low (somewhat dependent on length of exposure)
PM or local risk acceptance.

Initial Exposures – SERIOUS- PEO Initial risk level IIIB to IIC, depending upon length of exposure

Comparison of Bucking Bars

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