WORK INSTRUCTIONS ON HAND TOOLS

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HAND TOOLS

Introduction

Are hand tools ergonomically designed?

The history of hand tools is as old as the history of mankind. In fact, the invention of hand tools by our ancestors marked the beginning of the development of human civilization. Once invented, hand tools grew and evolved along with us as an extension of our own hand.

Basic hand tool design has not changed appreciably over the last several centuries. Thanks to an "adaptive" process, hand tools have evolved to the ergonomically satisfactory forms that we know today. Such a satisfactory design of hand tools resulted from the fact that the users were also the producers who designed the tools for their specific needs.

The mass production of hand tools brought about by the industrial revolution has also changed our approach to the use of hand tools. The use of tools on an industrial scale made it apparent that using tool which does not fit the person or task can seriously affect a user's health (see Hand Tool Ergonomics - Health Hazards below). Selecting the proper tool for the job and fitting it to the individual has become very important for productivity and worker health. The ergonomic evaluation of work where hand tools are used has helped people to understand that the layout of the workstation (see Hand Tool Ergonomics - Workspace Design afterwards), the variety and scheduling of tasks, (see Hand Tool Ergonomics - Job Design afterwards) and the way tools are used, are all factors as important as tool design itself (see Hand Tool Ergonomics - Tool Design afterwards).

Health Hazards

What are the main health concerns in working with hand tools?

Along with common injuries such as cuts, lacerations, and bruises, the frequent and prolonged use of hand tools can cause soreness, aches, pains, and fatigue, which, when ignored, can lead to chronic musculoskeletal injuries (MSIs) of various kinds. The most common examples of these work-related musculoskeletal disorders (WMSDs) are tendonitis, tenosynovitis, bursitis, epicondylitis (tennis elbow), carpal tunnel syndrome and de Quervain's syndrome.

What factors of working with hand tools cause discomfort, fatigue and, eventually, work-related musculoskeletal disorders (WMSDs)?

Several work factors can affect the health and performance of hand tool users. Major ones include:

- static load on arms and upper body muscles,
- awkward working positions and body postures,
- tissue compression, and
- vibration.

Static load

Static load or *effort* occurs when muscles are kept tense and motionless. Examples of static effort include holding the arms elevated (Figure 1a), or extended forwards or sideways (Figure 1b). (Try holding your arm straight out in front of you for a few minutes and you will see what we mean. Put any object in your outstretched hand and its weight will add to the static effort exponentially.) Bending and twisting the neck or the whole torso can also increase static load considerably. Add the exertion of force required by hand tools, and static load can increase still further (Figure 1c).

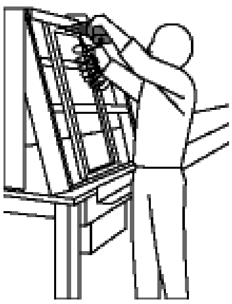


Figure 1a

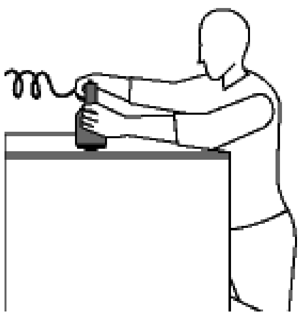


Figure 1b

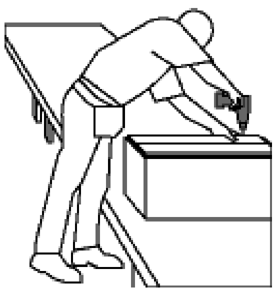


Figure 1c

Static effort, that is holding any strained position for a period of time, is a particularly undesirable component in any work situation. Statically loaded muscles are much more vulnerable to fatigue and subsequent injury than muscles which are performing dynamic work involving movement. Furthermore, muscles which are tired by static work take more than 10 times longer to recover from fatigue.

Awkward working positions and body postures

Hand tools are often (actually, more than often) used where the space is limited and access is difficult; see Figures 2a, 2b, 2c.

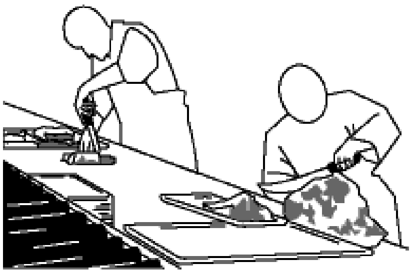
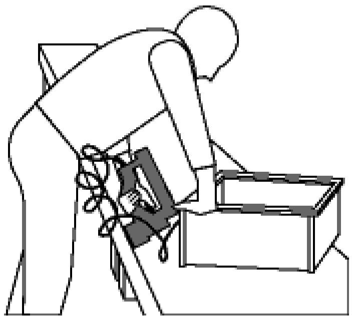


Figure 2a



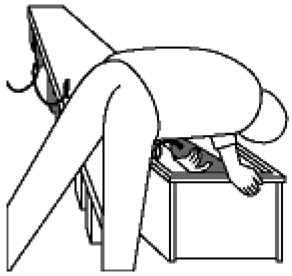


Figure 2c

When the hand holds and uses a tool in an awkward position it has less strength and is consequently more susceptible to soreness and eventual injury. If the arm is uncomfortable, the rest of the body is likely to be so as well, because it is natural to compensate for discomfort by trying to re-align the body by bending the back, rounding the shoulders, tilting the neck, and so on.

Awkward positions of the upper body considerably increase the effort needed to complete the task. The resulting fatigue, discomfort, and pain add further to the risk for developing injury.

Tissue compression

As a rule, using a hand tool requires a firm grip. The resulting compression of soft tissue in the palm and fingers may obstruct blood circulation, resulting in numbness and tingling. Blisters are also common due to friction between the palm of the hand and the handle of the tool.

Vibration

Certain heavy tools such as a chipping hammer can produce significant vibration which is responsible for hand-arm vibration syndrome (HAVS), more commonly known as white finger or Raynaud's syndrome.

Workspace Design

How can work space design help prevent work-related musculoskeletal disorders (WMSDs) resulting from the improper use of hand tools?

Tool selection is of critical importance for user safety, comfort and health. However even the best tool on the market will not transform a poorly designed workstation into a safe and comfortable one for the operator.

Many work space components such as work surfaces, seats, flooring, tools, equipment, environmental conditions, etc., determine whether or not the job is safe and healthy. If the workplace design does not meet your physical needs, it can create risk factors for discomfort, aches and pains, fatigue, and eventually, WMSDs. On the other hand, in a well-designed workplace, where you have the opportunity to choose from a variety of well-balanced working positions and to change between them frequently, work can be carried out safely and injury-free.

How can you control a working body posture?

Avoid bending over your work; instead keep your back straight and, if possible, elevate the work area or task to a comfortable level. Keep your elbows close to the body, and reduce the need to stretch your arms overhead or out in front of you. Tool extensions can help where it is difficult to reach the object of work. Using a stepladder or step-stool can improve the working body position where the task requires elevating your arms above the shoulder. At the same time, frequent stretching breaks will relieve any built-up muscle tension. If standing, distribute your weight evenly between the feet. Even better, use a foot stool or rail to rest your legs, and shift from one to the other periodically.

Proper chairs and sit/stand stools offer support during many hand tool tasks -- read more about these in our WI-OHS-05 documents on Working in a Sitting Position, and Working in a Standing Position. Consider the use of anti-fatigue mats.

How should one design the workstation for precision work?

- Provide the worker with a height-adjustable workstation (Figure 4a
- For a fixed-height workbench:
- provide work platforms to accommodate shorter workers.
- raise the work surface for taller workers.

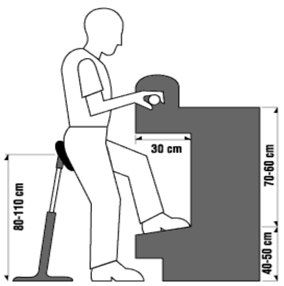


Figure 4a

- Provide sufficient leg clearance to allow the worker to get close to the work object, thereby reducing the need to bend the torso.
- Provide a footrest as foot support that will improve body balance and minimize the static load on the workers back.
- Anti-fatigue matting reduces lower back and leg discomfort and minimizes fatigue.

Figure 4b

- Consider using chairs or stools to allow work in a sitting or standing position.
- Consider using arm slings. This reduces tension in the shoulder-neck area (Figure 4b).
- Where feasible provide the worker with a tilted workstation. This reduces static load on the back and upper body (Figure 4c).

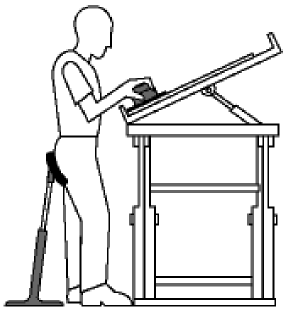


Figure 4c

- Use jigs or vices to hold the work object steady and secure at the proper height and position for optimum comfort (Figure 4d).

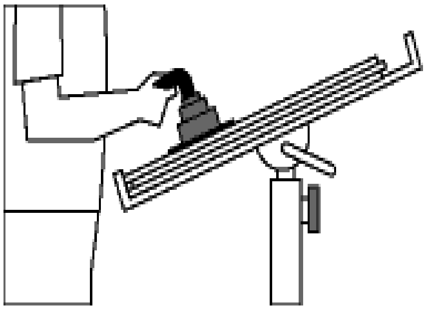


Figure 4d

- Use vices to minimize pinching and gripping forces.

How should one design the workstation for assembly work?

In assembly work, static load, awkward postures and forceful movements are major risk factors for WMSDs. Prolonged standing and the fatigue resulting from it additionally contribute to WMSDs.

- Use jigs and vices to hold the work object steady at the right height and position for optimum comfort (Figure 5a).

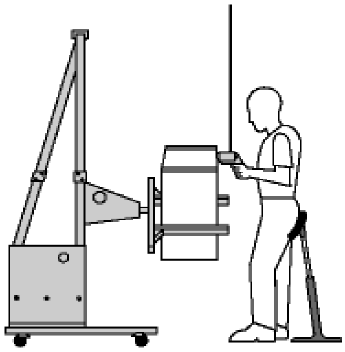


Figure 5a

- Use tool balancers to reduce the effort of holding and operating the tool (Figure 5b).

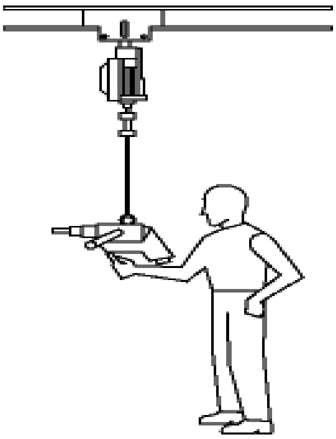


Figure 5b

- If possible use the lightest tool that can get the job done properly, preferably one weighing less than 1 kg (2 lbs).
- Anti-fatigue matting reduces lower back and leg discomfort and minimizes fatigue.

Job Design

How can work organization help prevent work-related musculoskeletal disorders (WMSDs) that can result from using hand tools?

People working at a correctly designed workstation and using the best available tools can still get injured. It happens where their *work* is poorly designed. Work organization involves:

- job content -- task variety
- work pace
- work breaks
- rest breaks
- adjustment or acclimatization time
- training

Task variety

Where a job involves using only one kind of tool for one or a few tasks that vary insignificantly, the same small group of muscles is used over and over again. The resulting overload on the same part of the body can cause pain and injury. A greater variety of tasks allow for changing body position to distribute the workload over different parts of the body, and to give overtaxed muscles some relief and recovery time.

- Rotate tasks among workers; have workers move from one task to another according to a schedule.
- Add more tasks to the job.
- Assign a larger part of work to a team: workers form a team and each member of the team shares several different tasks.

Work pace

A fast pace of work is a strong risk factor for WMSDs. If the pace is too fast, the muscles involved do not have enough time to recover from the effort and to restore sufficient energy to continue the work.

- If the pace of work is imposed externally -- assembly line speed, for example -- adjusts it to the speed that is acceptable for the slowest worker.
- Incentive systems that reward for the *quality* of work naturally determine the "right" pace of work.

- Incentive systems that reward for the *amount or quantity* of work increase the risk for WMSDs and, in the long run, will compromise quality as well.

Work breaks

The work break is a time period between tasks. Even short periods of time, literally seconds, that allow one to relax muscles involved in operating tools are important in preventing injuries.

Rest breaks

The rest break is the period after work stops. Besides allowing for refreshment, rest breaks can be used to stretch and relax.

Adjustment period

An adjustment or acclimatization period is the time needed to get "in shape" when returning to work after a long absence, or when starting a new job. It should allow one to refresh old work habits or get used to a new routine. An adjustment period is a very important element of injury prevention. Inexperienced and "new" workers, as well as "old timers" returning to work after a period of recovery and rehabilitation, are more prone than most workers to both injury and re-injury, so adjustment periods are a vitally important way to reintegrate them into the workflow.

Training

Training workers on the safe use of tools, and on the hazards involved in working with them, has always been extremely important. Today, more than ever, when new materials, new technologies and new equipment are replacing older ones faster then ever before, the importance of such training is magnified. The introduction of a new tool or equipment, as well as any change in way the job has been done previously should be preceded by refresher training that includes new information relevant to the changes being introduced. Even the best-designed tool, or the most ergonomically correct workstation, or the most up-to-date work organization will fail to prevent injuries if the worker is not properly trained.

Tool Design

How can one reduce the risk for work-related musculoskeletal disorders (WMSDs) resulting from the use of hand tools?

Tool design (weight, shape, fit to the user and the task), workstation design (size, shape and layout), and the way tasks are scheduled are all key factors in making hand tool use safe and risk-free. Since, none of those three areas is more important then the other, an effective prevention strategy must address all of them simultaneously.

Major ergonomic concerns of a hand tool design

Weight of the tool

Ideally, a worker should be able to operate a tool with one hand. Therefore the weight of the tool, especially for repetitive use, should not exceed 1 kg (2.2 lb.). It is also important that the centre of gravity be aligned with the centre of the gripping hand.

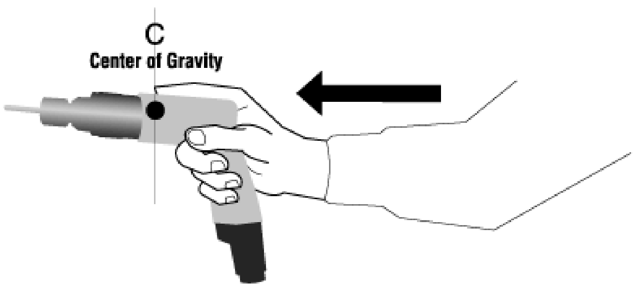


Figure 1

In other words, tools should feel "easy" to hold either in an upright position or in the position it will be used (ie. pointing down). For example, drills that are "front-heavy" will require effort (especially in the wrist and forearm) to hold in a usable position and should be avoided. The exception to this principle is a power hand tool, such as a grinder, that has to be heavy in order to reduce the force that the worker has to exert while using it. Tools heavier than 1 kg or poorly balanced tools should be supported by counter-balancers.

Power

Where possible, power tools should replace hand tools which normally require the exertion of frequent and repetitive force to do the job, because the greater the force exerted with a hand tool, and the more the hand has to twist to use it, then the greater the risk for WMSDs.

Handles

With the exception of tools for precision work (e.g., watchmaking, microsurgery, carving), the handles and grips of hand tools should be designed for a power grip. The belief that smaller tools should have smaller handles while larger tools have larger ones is debatable.

Handle shape

Tools with "bent" or angled handles or tools with pistol-grips are beneficial where the force is exerted in a straight line in the same direction as the straightened forearm and wrist, especially when the force must be applied horizontally (see Figures 2, 3, 4).

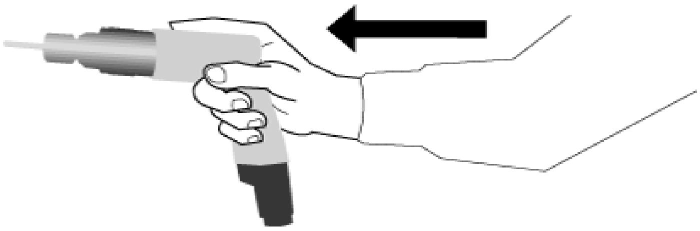


Figure 2

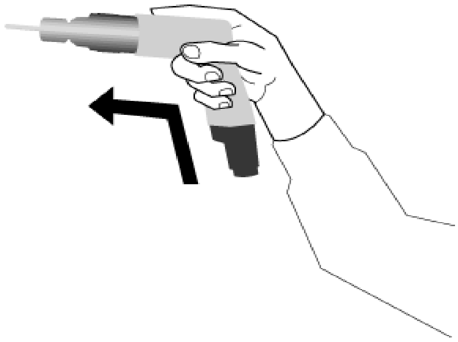


Figure 3

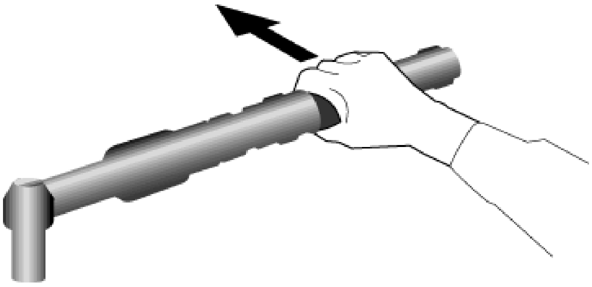


Figure 4

Tools with straight handles are for tasks where the force is exerted perpendicular to the straightened forearm and wrist, for instance, when the force must be applied vertically.

Shaped tools such as bent-handle tools are effective where most of the tasks are done in the same plane and height as the arm and hand, and when only one or two other tools are used (see Figure 5).

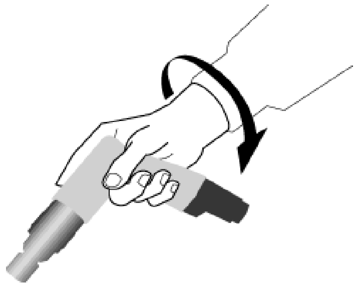


Figure 5

Knowing the tasks and the layout of the workplace where they will be used is vital for selecting the right tools for any given job. Select tools that do NOT require wrist flexion, extension or deviation. In other words, select tools that allow you to keep the wrist straight or in a neutral position.

The crucial ergonomic principle in tool use and design -- **bend the tool, not the wrists** -- however correct and valuable does not always prevent discomfort and injuries when bent-handle tools are used indiscriminately, regardless of the layout of the work situation.

Diameter

Handles should be cylindrical or oval in cross section, with a diameter of between 30 mm and 45 mm. For precision work the recommended diameter for handles is between 5 mm and 12 mm. For a greater torque large screwdrivers should have a handle diameter up to 50-60 mm.

Length

A handle that is too short can cause unnecessary compression in the middle of the palm. It should extend across the entire breadth of the palm. Tool handles longer than 100 mm (preferably 115-120 mm) will reduce the negative effects of any compression exerted. Rounded handles will minimize palm compression on the palm still further. Keep in mind that the use of gloves requires longer tool handles.

Separation between handles

Crushing, gripping or cutting tools such as pliers or tongs are equipped with two handles. The recommended distance separating handle is between 50 mm and 65 mm. Such a range will fit both male and female users. Tools with larger or smaller spans will reduce one's maximum grip strength and may contribute to the onset of carpal tunnel syndrome.

Power tool triggers

Frequent movements of the index finger while operating the trigger of power tools (such as a power drill) poses a considerable risk for both "trigger finger" and "trigger thumb" (tendonitis in the index finger and/or thumb). A longer trigger which allows the use of two or three fingers to activate them reduces discomfort and minimizes the risk for injury. The recommended minimum length of the trigger is 50 mm.

Materials and texture of handles

To ensure a good grip on a handle, sufficient friction must exist between the hand and the handle. This is particularly important where a considerable force must be applied with a sweaty hand. Hand tools should be made of non-slip, non-conductive and compressible materials. For example, textured rubber handles provide a good grip, reduce the effort needed to use the tool effectively, and prevent the tool from slipping out of the hand. Glossy coatings and highly polished handles should be avoided. The electrical and heat insulation properties of the handles are important for power hand tools. Handles made of plastics or compound rubbers are recommended. Sharp edges and contours can be covered with cushioned tape to minimize lacerations.

Vibration

The only effective way to reduce vibration in power tools is at the design stage. This fact makes tool selection most critical. The common practices of covering handles of vibrating tools with a layer of viscoelastic material or of using anti-vibration gloves made of similar material are of dubious value. These "anti-vibration" materials will dampen vibration above certain frequencies that are characteristic for the kind of material, but most of the vibration energy in a handle of a power tool is below those frequencies.

Selecting and using hand tools

When selecting and using a hand tool it is important:

- to "bend" the tool, not the wrist; use tools with angled or "bent" handles, when appropriate)
- to avoid high contact forces and static loading (see Hand Tool Ergonomics - Health Hazards in page 3)
- to reduce excessive gripping force or pressure
- to avoid extreme and awkward joint positions

- to avoid twisting hand and wrist motion by using power tools rather than hand tools.
- to avoid repetitive finger movements, or at least reduce their number
- to avoid or limit vibration
- to minimize the amount of force needed to activate trigger devices on power tools.

How does hand tool maintenance reduce the risk for injuries?

The condition of tools is an important factor. Blunt or dull tools such as scissors, cutters, saws, screwdriver tips, in fact any tools in a poor state of repair, not only compromise safety but also increase (sometimes by a factor of ten) the effort needed to use them. Tools in poor condition should be discarded (with the exception of those few that can be restored to optimum condition, for example, a wood chisel or wood saw) and replaced with new ones.