Repetitive use of manual or powered hand tools is often a factor in carpal tunnel syndrome and other hand and wrist disorders. While most tools are satisfactory for general purpose use, they may be entirely inappropriate for continual or repetitive use in a production situation. For instance, a 15-pound hand tool may be perfectly acceptable for occasional use, but tools that are used frequently or repetitively should weigh no more than 4 pounds (1.75 kg). In addition, the working environment as a whole may also have to be evaluated and corrected. A properly designed hand tool used in an awkward posture will not solve the problem.

Hand tools vary considerably in shape, size, and weight. The way a tool is designed influences the hand positions and motions that are required to use it. Fortunately, there are typically several designs to choose from in each tool category. Ask workers for their opinion about the tools you provide. Ease of maintenance and repair should also be a consideration in tool selection. Proper maintenance, such as keeping bits sharp, will help minimize forces.

This reference note gives some of the ergonomic principles that can help guide you in selecting the proper manual or powered hand tools for repetitive tasks.

**General Principles**

Before selecting any tool, you should first ensure that the work area is ergonomically sound in terms of work surface height, adjustable seating, acceptable manual handling requirements, etc. (See LP 185, “Ergonomic Recommendations for Workplace Design.”) Tilting the work surface or using fixtures to hold, tilt, or rotate the work can help minimize awkward wrist motions and simplify tool selection.

Powered hand tools, rather than manual, should be used whenever possible, because repeated manual exertion is more likely to cause discomfort and injury.

Look for tool designs that allow the user to keep the elbows in close to the body. While using a hand tool, the worker should not have to reach more than 15 inches (38 cm). The tool design should also allow users to keep their forearms at right angles to the upper arms, and the wrists straight or in a natural position. It is much better to bend the tool than to bend the wrist.
Power tool models may have pistol-grip, right-angle grip, or in-line handles. Pistol-grip tool handles should be at an angle of approximately 80° from the long axis of the tool. In-line tool handles may have straight, offset, or right-angled heads. Hand tools such as pliers can be obtained with bent handles (so-called ergonomic pliers) or in curved-nose models.

Caution is advised when using bent-handled tools in the workplace. The optimum angle with respect to wrist deviation depends on the height of work. Research has shown bent-handled tools are best used when work heights are located at elbow height. Workspaces at elbow height optimize straight wrist operations and performance. However, workspaces with work heights above or below elbow height increase wrist deviation and decrease performance.10

The appropriate diameter of the handle (or the part of the tool that the user holds) depends on the way it is gripped and the size of the worker’s hand. As Figure 1 shows, the recommended diameter for tools that require a power grip is in the range of 1 to 1.6 inches (2.5 to 4 cm); for a hook grip 0.80 inches (2 cm); and for a precision or pinch grip at least 0.25 inches (0.6 cm).

Manual Hand Tools

When selecting manual hand tools, look for tool designs that have the following features:

- Handles that use a power grip and that are longer than hand breadth – that is, at least 4 inches (10.2 cm), but preferably more than 5 inches (13 cm) long.3
- Different sizes for workers with different sized hands. The handle diameter should be 0.4 inches (1 cm) smaller than the user’s grip diameter measured with the thumb meeting the middle finger.
- A handle which, when gripped, distributes forces over all fingers and the entire surface of the palm.

The following guidelines apply to pliers-type manual hand tools, including wire cutters, scissors, and pop riveters:
When the pliers are fully closed, the space between the pliers handles should be at least 1 inch (2.5 cm). For tools that are squeezed with two hands, the space should be at least 2 inches (5.1 cm).

If the pliers-type handles must be opened and closed during tool operation, they should be no more than 4.5 inches apart (11.5 cm) when fully opened (this is the open grip span).

If high squeeze forces are required, the grip span should be in the range of 2 to 2.4 inches (5 to 6 cm). The smaller size is better for users with small hands.

For tasks requiring sustained effort (≤1 min.), grip forces should not exceed 25 pounds (11.3 kg) for ungloved hands, and 22 pounds (10.2 kg) for gloved hands.

Spring action should return the handles to the open position.

If the handle has an opening for fingers (e.g., conventional snips or scissors), the handle should allow at least 5 inches (12 cm) spread for the fingers and an additional 1 inch (2.5 cm) if gloves are worn.

**Powered Hand Tools**

When selecting power tools, keep these considerations in mind:

- For power tool use on a horizontal surface, adjust the surface height so that the work is kept at or below elbow height. If the work cannot be kept at this level, use tools with in-line handles.
- If the tool is operated by means of a trigger, consider tools with an extended trigger that can be operated by two or more fingers together, or tools with a thumb trigger (the thumb is much stronger than the other fingers). Avoid designs where the index finger will be overused for triggering.
- The tool’s center of gravity should align with the center of the grasping hand, so that the hand will not have to compensate for rotational moments or torque of the tools.
- Power tools should be designed to minimize vibration, rotational torque, or impact forces on the hand and wrist.

**Force Guidelines**

Much of the research data on hand tools comes from studies of grip strength at a variety of postures and psychophysical methodology. Psychophysical methodology is what people feel to be the “right” weight, maximum force, or size in some cases.

The data in Table 1 (next page) come primarily from psychophysics and can be used to identify what a large percentage of the population can do without overexertion. In general, the maximum acceptable force for repetitive exertion is 30% of a maximum voluntary contraction (MVC).

For example, a worker who can grip a tool with 15 pounds of force at his or her MVC should only use a 4.5-pound grip (30% of 15 pounds) to avoid overexertion during repetitive tasks.

Some of the force and torque requirements of a task are difficult to measure. Consult your Loss Prevention consultant for assistance.
Table 1. Force Guidelines For Tool Selection

<table>
<thead>
<tr>
<th>Grip Type</th>
<th>Power Grip</th>
<th>Pinch Grip</th>
<th>Wrench (8-inch)</th>
<th>Socket Wrench (10-inch)</th>
<th>Screwdriver (10-inch)</th>
<th>Rotating Tools</th>
<th>Trigger Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Occasional..................25 pounds for 2.5- to 3.5-inch grip; 10 pounds for &lt;2-inch grip</td>
<td>Frequent ............................................4.8 pounds for &lt;2-inch grip</td>
<td>User Standing............44 inch-pounds</td>
<td>User Standing............53 inch-pounds</td>
<td>User Standing............4 inch-pounds</td>
<td>In-Line Handles ............12 inch-pounds</td>
<td>Single-Finger Trigger ..........2.2 pounds</td>
</tr>
<tr>
<td></td>
<td>Frequent ............................................2.2 pounds</td>
<td>Frequent ............................................29 inch-pounds</td>
<td>User Sitting.............29 inch-pounds</td>
<td>User Sitting.............37 inch-pounds</td>
<td>User Sitting.............5 inch-pounds</td>
<td></td>
<td>Note: These grip forces should be reduced by at least 25% if the tool user wears gloves.</td>
</tr>
</tbody>
</table>

References