Part 1

# Introduction to Manufacturing

This book is about getting a job in a machine shop. But, it's also about keeping that job advancing career responsibility and pay. For career success, you need to know what is expected of you from the very first day. Like any workplace, there are tasks, procedures, and rules to be followed. Some are formal skills or rules, while some are informal and generally accepted by your fellow workers.

*Part 1 is designed to impart basic manufacturing knowledge and skills and to clarify trade expectations to help you*

Chapter 1

# Professionalism in Manufacturing

## Learning Outcomes

**1-1** **Dressing for Career Success** (Pages 3–6)
- Select the correct protective equipment for a machine shop
- Select the correct clothing

**1-2** **Handling Materials** (Pages 6–10)
- Safely lift heavy objects correctly and explain why bending your knees is the right thing to do, but the last resort for heavy lifting
- Safely move metals within the shop
- Store metals and machine accessories

**1-3** **Handling Shop Supplies** (Pages 10–14)
- List the six possible dangers of shop chemicals
- Ask for and read MSDS sheets when in doubt about handling new chemicals
- Handle and store lubricants, solvents, and coolants
- Know how to correctly dispose of waste

**1-4** **Maintaining Equipment and the Work Environment** (Pages 15–22)
- Lubricate complex machinery
- Safely remove metal chips
- Understand what a lean green shop means
- Review fire prevention and safety

## INTRODUCTION

This book represents a manufacturing world where computer-aided design/computer-aided manufacturing (CAD/CAM) and computer numerical control (CNC) have changed everything. Planned by a group of industry leaders and instructors, we used today's job market and tomorrow's career needs as our guide. To make room for the new subjects needed for career success, every effort was made to eliminate old technologies and skills no longer relevant to mainstream employment. Our goal was to equip you, the beginning machinist, with the competencies to get and keep that vital first job.

But we also knew that students often breeze past the usual opening chapters to get to the "real training." So why start with a chapter on professionalism and safety?

Because a critical part, perhaps the most critical part, of your training has nothing to do with measuring, reading prints, and running programs on machines, yet getting it right will have everything to do with your success! It might be called work ethic, team spirit, or job readiness. It's often called attitude on an employee evaluation or a grade report. No matter what you call it, it adds up to how you walk the walk of a skilled craftsperson. A large part of the separation between ordinary and skilled workers is a professional attitude.

While a whole lot more could be said on the subject, these units are enough to get you started fitting into a machine shop environment and starting the lifelong process of being a skilled professional. Taken to heart, the message of this chapter will make a real difference in your career.

# Unit 1-1 Dressing for Career Success

**Introduction:** In Fig. 1-1, which person would you want making precision parts for your new car or outboard motor? In truth, they might all be good machinists but—well, you get the picture. The concern here isn't styles of clothing or grooming, it's about being right for a precision shop environment.

## Terms Toolbox

**Chips** Metal particles of waste removed from the workpiece by machining.

**Natural fibers** Cotton or wool cloth, which tends to resist hot chip damage and melting, thus protecting the wearer from burns.

**Synthetic fibers** Plastic cloth such as nylon and polyester, which tends to melt when hot chips touch it.

**Z87 or Z87.1** The mark found on safety glasses approved for shop work, which means they will protect your eyes from the front and side in a dangerous environment.

***Review the key terms in the Terms Toolbox Challenge!** Just scan the code in every Chapter Review, or go to www.mhhe.com/fitzpatrick3e.

## 1.1.1 Getting Ready for the Work Environment—Eye Protection Always

Figure 1-2 shows several types of eye protection. Most shops supply one or more varieties. The best choice is the one you find comfortable and tend to leave on 100 percent of the time! Many prefer full-vision, wraparound lenses because they are all clear material so you don't see a frame.


**Figure 1-1** Which machinist looks right for the job—and more importantly, for a career?

**Figure 1-2** The best choice for eye protection is the one you find most comfortable and tend to leave on.

**KEYPOINT**

Safety glasses will bear the mark **Z87** or **Z87.1** on the ear piece if they have passed strict testing and are acceptable for shop work.

**Xcursion.** How much torture did your safety glasses endure to get that Z87. approval? For more information and video of the ballistic testing of safety glasses, scan here.

### Clear or Yellow

Either lens color is acceptable. Yellow lenses offset the blue of common fluorescent lighting and many feel that the correction boosts their ability to read precision tools. Never select dark glasses unless you must work near electric welding flashes because they dull your ability to see details.

### Prescription Eyewear

Most wraparound safety glasses can be worn over prescription glasses. But the law requires prescription glass lenses to be made from tempered glass or high-impact plastic, so it is acceptable to wear them alone as long as side shields are added. It's a fact that many eye injuries occur from the side rather than straight on, so shatterproof front lenses aren't enough protection by themselves.

### Extreme Danger Areas

When performing tasks such as disk grinding with lots of flying debris, protect your eyes by adding a full-face shield over safety glasses.

### Just Do It!

Be a trendsetter—wear safety glasses even when others don't. Modern CNC equipment usually has containment

shielding so the operator feels safe from flying metal particles, but don't forget you must occasionally walk though the shop past other unprotected machines. Make safety glasses a habit by putting them on when entering the shop. Here's an attitude check: you've got it right when you feel strange without your safety glasses. No kidding, I've gone home still wearing them! If those provided aren't comfortable, then find an industrial safety supplier and buy a pair just right for you—that's the kind of pro we're talking about.

## 1.1.2 Hearing Protection

Machine shops can be noisy places. Some operations are loud enough to cause hearing loss over time. Prevent permanent damage right now while your hearing is good. Get in the habit of wearing ear protection (Fig. 1-3) where noise gets above moderate—see the chart. The two common types of hearing protection are expandable foam inserts that fit every ear shape and the muff type that fit over your ears.

**Figure 1-3** Machinists protect their hearing when shop noise is loud or high pitched.

### TRADE TIP

**Hearing Is Your Primary Control** Protecting your hearing is more than personal. Just as when driving a car, the machinist almost always hears a problem developing before seeing it, especially on fast CNC equipment.

Earplugs remove the loud spikes but allow controlled hearing. For extreme situations, earmuffs are supplied by your employer. Either way, don't give away your most immediate control sense by not protecting it. And by the way, to control your machine it is important to not use personal music earphones—sorry, but they're out when running a machine.

## 1.1.3 Shop Clothing

The main danger of loose clothing is that it can be caught by moving machinery—but you already knew that. While Fig. 1-4 was set up, really being caught in a machine is no fun—think about it! Nothing loose—sleeves, necklaces, untucked shirts—nothing! Well-fit, **natural fibers** such as cotton or wool, without pockets or tie cords hanging out, are essential.

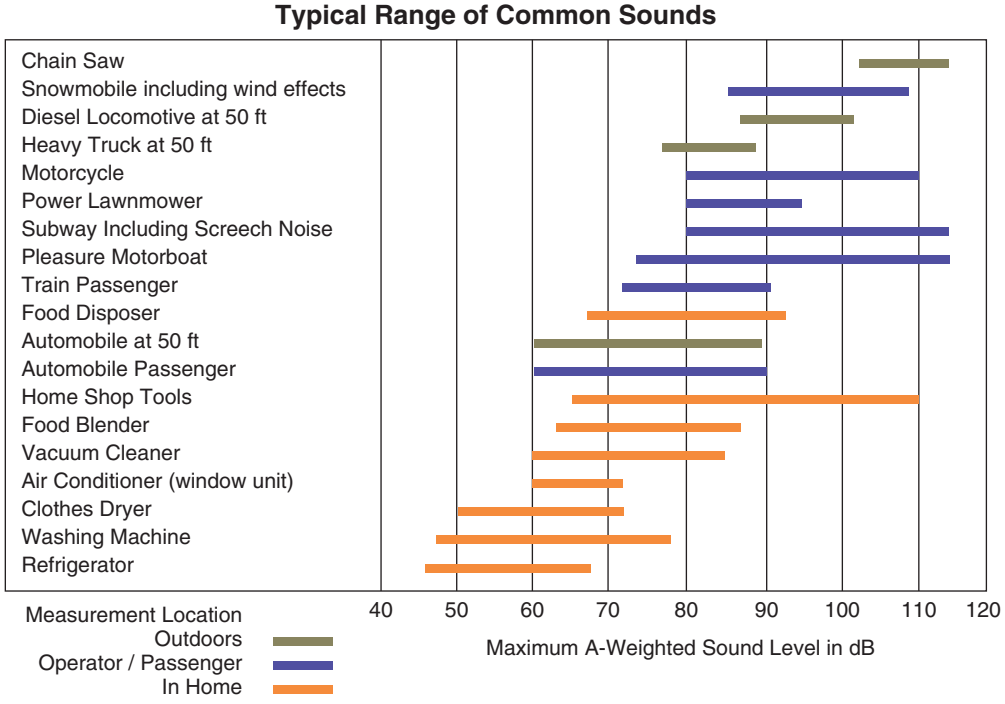


**Figure 1-4** Seriously, loose clothing does get caught in moving machinery!

## Why Natural Fibers?

The shavings made when cutting metal are called **chips.** They're hot, as much as 1,000 degrees. While today's CNC machines won't operate with the safety guard open, many older machines will. Flying hot chips must be dealt with. As we study machine operation we'll see several ways to control them, but one action the pro takes is the kind of fabrics worn on the job.

When hot chips contact **synthetic fibers** such as polyester, rayon, or nylon, they stick, then melt through (Fig. 1-5). So your shirt or pants are ruined and the hot metal is held against your skin. Ouch! Not only that, but that makes it hard to concentrate on the task at hand.

### KEYPOINT

Where hot chips cannot be contained by any other method, *wearing* natural fibers such as cotton denim or wool can work. They will just bounce off your clothing.

**Figure 1-5** Two hot chips melted onto this nylon windbreaker while the center one went completely through to possibly burn the person within!

## Aprons and Shop Coats

An apron or shop coat can be a good choice. But be aware that not all are designed for machining. Some are made for lab work, where machinery won't grab loose ties or pockets. Find one with internal pockets and no loose belts tied in front. Long sleeves are not smart for obvious reasons. A professional approach is to keep a short-sleeved work shirt in your locker.

## How About Shoes?

Your work shoes have three safety aspects. I'll bet the third will surprise you. Work shoes provide

- Protection for your feet from falling objects.
- Nonslip soles designed for a shop where chips, coolants, and oils are often on the floor.
- Protection from fatigue.

Athletic shoes are a poor choice. Even though comfortable, they aren't designed to stand up to a shop environment.

**Steel Toes** Shoes or boots with steel toe caps are better than shoes without and may be required on the job. No matter how careful you are, there's always the inevitable falling heavy object. Don't fall for the old tale that someone knows someone who had their toes severed by the steel insert collapsing when something really heavy fell on it. Think about it: if the thing was that heavy, it would have done the same damage with or without the steel protection!

### SHOPTALK

**Quality Could be Linked to Good Work Shoes or Boots** As a machinist, you're going to be on your feet all day, usually on concrete. Guess when most folks make the most mistakes. That's right, at the end of the day when they're tired. Good-quality work shoes offset some of the problems and help keep your mind sharp.

**Figure 1-6** Jewelry is dangerous. It catches on machines and chips and conducts heat and electricity.

### No Accessories

Jewelry catches on moving machinery (Fig. 1-6). Here's another aspect you may not know: it also conducts electricity and heat. In addition to the safety aspect, jewelry should be left in your locker.

### Hair Up

Think about this: would you reach up and pull a hand full of hair out of your scalp? Painful but that would be just a few hairs! So now, imagine a machine wrapping up most of your hair along with a patch of scalp. No kidding! I've seen it happen twice with my own eyes (Fig. 1-7). It gets caught up by static electricity produced during machining and is blown by the air currents swirling around moving tools. A hair band, a bandanna, or a hat are right when your hair is long enough to be caught.

That's it. With these dress-for-success guidelines, you're ready to step into the shop and, if you see the bigger picture, into a career.

## UNIT 1-1 *Review*

### Replay the Key Points

- Eye protection is best if it's comfortable.
- Well-fitting coats or aprons made of natural fibers are best.
- Ear protection is necessary in many work areas.
- Footwear must be designed for shop use and comfort.
- Any loose item is a danger, including jewelry and hair.
- Safety glasses will bear the mark Z87 or Z87.1 on the earpiece if they have passed strict testing and are acceptable for shop work.

**Figure 1-7** Hair does catch on moving machinery. Keep it out of harm's way.

- Athletic shoes, although comfortable at first, do not stand up to the shop environment.

**Respond** (Answers found at the end of Chapter 1)

1. Are *yellow*-tinted safety glasses acceptable in the shop? Are *brown*- or green-tinted glasses?
2. Describe the two reasons to avoid synthetic fibers and wear natural fiber clothing when running machines.
3. What are three aspects of footwear with regard to safety?
4. Why is hearing such a vital issue for a machinist?
5. For what two reasons does long hair become tangled in moving machines?

## Unit 1-2 Handling Materials

**Introduction:** Working in a machine shop requires the use of many materials. Some are technical chemicals with very specific precautions and earth issues. Some are consumable

supplies meant to be used up but not wasted. Others are heavy and expensive. This unit lays out the ways to handle them all—like a pro. Doing so is an excellent way to demonstrate a well-tuned attitude.

## TERMS TOOLBOX

**Choker strap** A nylon strap that cinches tightly around heavy objects with a strong eye loop on each end to be attached to the crane.

**Heat lot number** The original quality control number for a specific metal bar.

**Intervertebral disk (disk)** The flexible cushion between spinal vertebrae that can be damaged by the wrong lifting techniques.

**Jib crane** A heavy lifting device that may be fastened to a wall or column to swing in an arc, or on portable rollers and often called a cherry picker.

**Traceability** The ability to link a given bar of metal from "birth" all the way to its final shape and individual serial number.

## 1.2.1 Lifting Heavy Materials

### Always Use a Machine If You Can!

After all, we are *machinists*. The very last thing we use to get a job done is muscle power (Fig. 1-8). In most facilities, you will find one or more of these devices:

- Overhead cranes moving on rails
- Rolling lift tables
- Floor jacks for flat pallets of workpieces and boxes
- Forklift trucks
- Portable **jib cranes,** often called "cherry pickers"
- Jib cranes fastened to a column to pivot around a circular area

### 1.2.2 Use Your Legs (and Your Head), Not Your Back

However, there comes a time when lifting by muscle power is the only way to get the job done. At these times, the wise machinist asks for help. Two lifters are better than one. In North America, it's estimated that two out of five adults suffer from back pain that could have been prevented.

Here's the point: It doesn't happen later in life, it starts right now—today! Unlike the common view, common back injuries don't actually happen catastrophically—during one bad lift! They are the product of lifting wrong over a long time. Everyone has heard about the straight back, bent legs method. It's best, but why?

To understand, let's look at your spine as a piece of machinery: a human lifter is a crane of sorts. In Fig. 1-9, the person on the left has turned her back into a long lever with the pivot point right at her lower back. *This wrong action causes pressure in the range of hundreds of pounds per square inch right on the lower back.* In contrast, the person on the right, bent at the knees, is focusing the pressure on his leg muscles, not his back.

### Disks in Your Back

Now focus on that pressure point, the lower back. Your spine is well engineered with cushions between the vertebrae, called **intervertebral disks** (or just **disks**). They provide flexibility and they absorb shock. They also keep the vertebrae apart so nerves are not pinched as you move. Disks are critical and can be damaged (Fig. 1-10). When they are it can really hurt and even immobilize you!

The disks are tough, fluid-filled sacs with several layers containing the fluid center. Lifting wrong overpressurizes them, resulting in a blowout. Here's the part most people do not know: When the disks first stretch and break, it's an inner

a. b. c.

**Figure 1-8** Smart machinists use equipment, not muscle, to lift heavy objects.

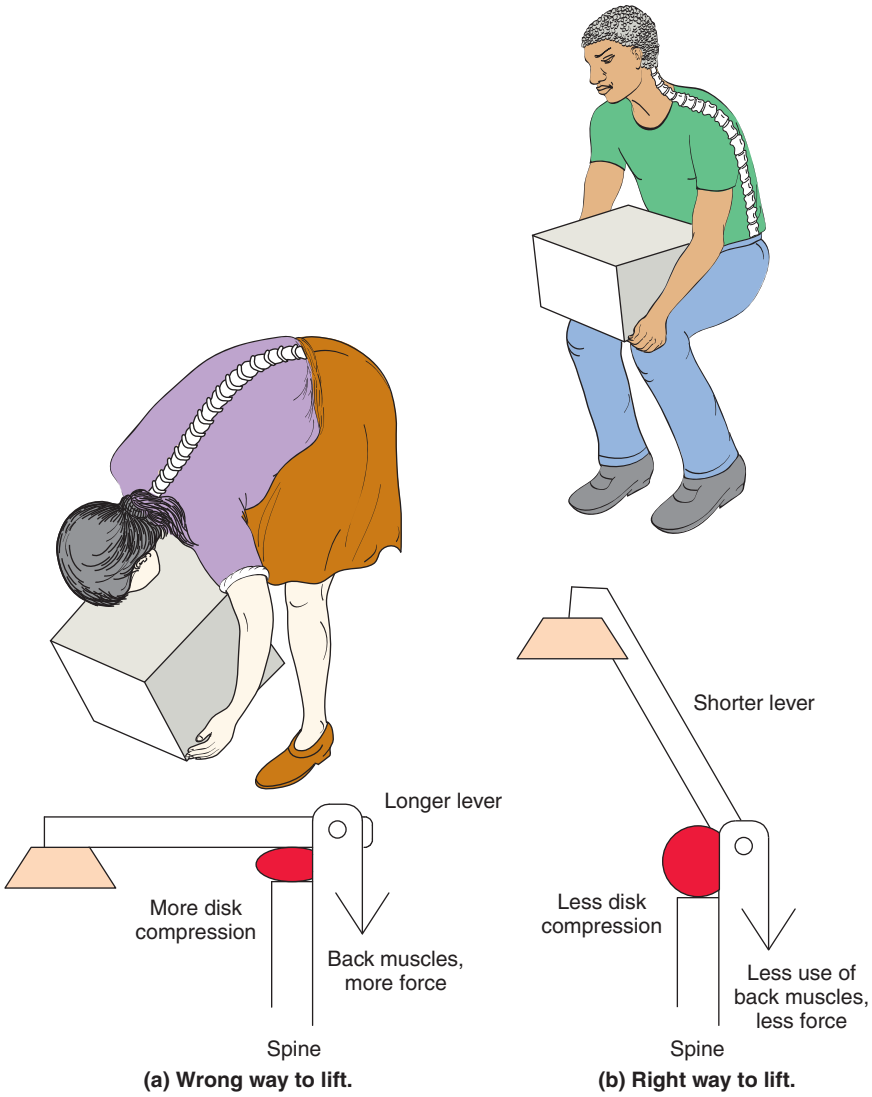



**Figure 1-9** Lifting the wrong way and the right way. The worker on the left is setting up a painful future! Note that the spinal disk is under a lot more pressure because she is bending her back, not her knees.

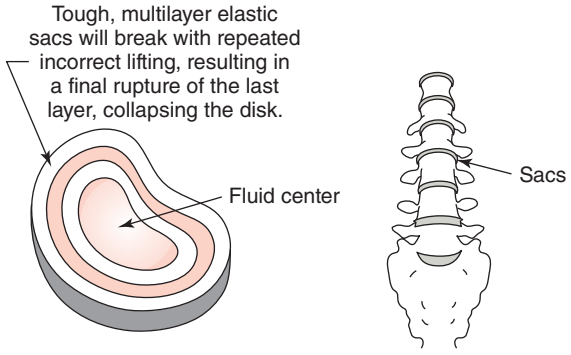



**Figure 1-10** A spinal disk is a tough, multilayered shock absorber. But lifting incorrectly can cause progressive damage, leading to a disaster in the future.

layer or two that goes, and usually the injured person doesn't even know. The layers do not often break all at once! But, with continued bad technique, the last one finally ruptures, resulting in enough pain that the person cannot stand up straight!

**KEYPOINT**

Lifting wrong is not only the start of a painful future, it creates a poor professional image.

## Carrying Materials

Another aspect of handling heavy objects is carrying long bars of metal. Be cautious of the forward end—it's a ram! If the bar is too heavy to safely hand carry (beyond 40 pounds) or if it's over 8 feet long, there are two acceptable methods.

1. **Crane Carry—One Person**
   In the unbalanced carry, hold the bar with a nylon **choker strap** near the leading edge and pull the remaining bar along on the floor using the overhead crane. One person can perform this carry by being at the forward end. A choker strap is a strong nylon flat strap with loop ends that slip closed with pressure. Your instructor or shop lead will demonstrate this aspect of lifting.
2. **Two Person**
   For the balanced carry, choke the bar near the middle and carry it with both ends off the floor. This requires a second person to walk at the leading edge, to prevent hitting people or objects (Fig. 1-11).

### WARNING: Crane Overswing

A suspended heavy bar is a mass in motion that can't "stop on a dime." It will swing forward when you stop pushing or driving the crane forward. Anticipate a short swing forward upon stopping (Fig. 1-12).

Heavy lifting is a skill requiring knowledge of rigging (the lifting devices that contact the work), lift machines, and the physics of lifting. Due to the specialized skills and knowledge required, many shops employ a lifting crew. But this subject is also considered part of the machinist's duty. If you are the slightest bit unsure about how to lift or move an object, get help.

**KEYPOINT**

Never reach under, or worse, walk under a heavy object during a lift.

## 1.2.3 Storing Metals

Our school has received many donations of expensive metal from local shops because careless workers cut the color-coded identification off the bar end or lost the identification tag. Once gone, the bar is useless in most cases, especially when the shop makes people-moving products. In situations where lives could be at stake, once the **heat lot number** (the original manufacturing quality control number) is lost, the metal is not only worthless, it's illegal to use!

When the design specs must be followed exactly, as in making airplane parts, for example, a continuous history must be traceable from the foundry to final part number. This

**Figure 1-11** Use a crane and choker to haul heavy bars, while an assistant helps control the metal bar!

**Figure 1-12** Two people hand carry long bars by preventing the leading edge from harming people and objects.

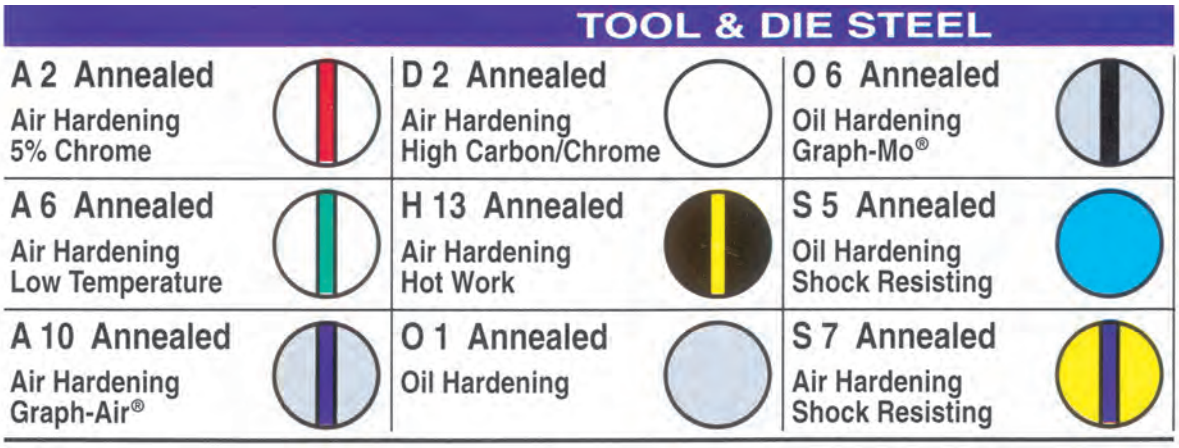



**Figure 1-13** Correctly stored and color-code-identified raw materials.

is known as **traceability.** A specific part will have a specific number assigned to it, called the serial number (S/N). The manufacturer must be able to provide documents tracing the S/N to the heat lot of the metal's original manufacture. Material can be tested in an independent lab and then recertified, but that's more costly than just buying more metal!

One of several good methods of storing metals is a rack. Note that the bars cannot fall out of the safety storage rack and that short bars are not kept here. "Shorts" are kept on smaller shelves where they won't fall through. Note that they are sorted by type and alloy such that the color-coded identification is facing out (Fig. 1-13). Later, we'll take a look at material identifications and alloys.

**KEYPOINT**

These are not small details. You must have exactly the right material for the design and it often must be kept in storage for a specific job.

## UNIT 1-2 *Review*

### Replay the Key Points

- Always use a lifting device for your first choice.
- If physical lifting is absolutely necessary, get help—all should bend their knees.
- Carry long bars safely by protecting the leading edge.
- Get help with any lift.
- Store long bars in a safety rack and short pieces away from the rack on shelves designed for this purpose.
- Mind the color coding and/or stamps—*never cut it off the bar.*

### Respond (Answers found at the end of Chapter 1)

1. Name at least three shop lifting aids other than human muscle?
2. A choker strap can be used to carry long material through the shop as long as the forward end of the bar is high in the air. Is this statement true or false? If it's false, what could make it true?
3. Why is material identification important for many types of work?
4. Describe a disk in your spine?
5. Where must short bars be stored?

## Unit 1-3 Handling Shop Supplies

**Introduction:** Today's professional must know the rules when handling materials. Beyond the cost of waste and a ruined planet, the fines for ignoring the rules can cost dollars and company image. Machinists must use chemicals and consume materials with an awareness of the issues concerning each. That means

- CONSERVE, REUSE, RECYCLE, and DISPOSE RESPONSIBLY.

## TERMS TOOLBOX

**Hydrostatic bearings** Found on modern CNC machines, these require an exact oil viscosity to separate two sliding components apart as they move.

**Material safety data system or sheet (MSDS)** The product of the federal "Right to Know" act that ensures that workers must be provided the information needed to handle materials safely—found on MSDS sheets.

**Spindle oil** Lubricant designed to prevent rolling friction.

**Viscosity** The rated property of lubricants to resist thinning out and flow rate.

**Way oil** A lubricant used to control sliding friction in machines (the part that slides is called the machine's ways).

## 1.3.1 Your Right (and Obligation) to Know About Shop Chemicals

Promanagement begins by finding out what hazards a material might have and taking the right actions. Those issues and the correct use of each chemical are found in documents called **MSDS sheets**—the **material safety data system** (Fig. 1-14). Mandated by federal law, manufacturers of chemicals must supply these sheets and employers must have them on file for all to read.

In general, machine shop chemicals are not overly dangerous. Still, some will ignite, some people's skin can react, and some produce fumes. Nearly every one involves some precaution.

*The six precautions are*

- Fire hazard
- Chemical stripping of skin oils—direct contact
- Fume *toxicity* and oxygen exclusion (displaces breathing oxygen)
- Eye irritation

CRC. **MATERIAL SAFETY DATA SHEET** SILOO

*CRC Industries, Inc. • 885 Louis Drive • Warminster, PA 18974 • (215) 674-4300*

PRODUCT NAME CLEAN-R-CARB (AEROSOL) #- MSDS05079
PRODUCT- 5079, 5079T, 5081, 5081T
(Page 1 of 2)

| 1. INGREDIENTS | CAS # | ACGIH TLV | OSHA PEL | OTHER LIMITS | % |
|---|---|---|---|---|---|
| Acetone | 67–64–1 | 750 ppm | 750 ppm | | 2–5 |
| Xylene | 1330–20–7 | 100 ppm | 100 ppm | | 68–75 |
| 2-Butoxy Ethanol | 111–76–2 | 25 ppm | 25 ppm | (skin) | 3–5 |
| Methanol | 67–56–1 | 200 ppm | 200 ppm | | 3–5 |
| Detergent | – | NA | NA | | 0–1 |
| Propane | 74–98–6 | NA | 1000 ppm | | 10–20 |
| Isobutane | 75–28–5 | NA | NA | 1000 ppm | 10–20 |

2. PHYSICAL DATA : (without propellent)
Specific Gravity : 0.865
Vapor Pressure : ND
% Volatile : > 99
Boiling Point : 176 F initial
Evaporation Rate : Moderately fast
Freezing Point : ND
Vapor Density : ND
Appearance and Odor: pH : NA
A clear colorless liquid, aromatic odor

Solubility : Partially soluble in water.

3. FIRE AND EXPLOSION DATA
Flashpoint : –40 F Method : TCC
Flammable Limits : propellent LEL : 1.8 UEL : 9.5
Extinguishing Media : $CO_2$, dry chemical, foam
Unusual Hazards : Aerosol cans may explode when heated above 120 F.

4. REACTIVITY AND STABILITY
Stability : Stable
Hazardous decomposition products
: $CO_2$, carbon monoxide (thermal)

Materials to avoid : Strong oxidizing agents and sources of ignition.

5. PROTECTION INFORMATION
Ventilation : Use mechanical means to insure vapor conc. is below TLV.

Respiratory : Use self-contained breathing apparatus above TLV.

Gloves : Solvent resistant Eye & Face : Safety glasses
Other Protective Equipment : Not normally required for aerosol product usage.

**Figure 1-14** An MSDS sheet for acetone. When in doubt, read these bulletins. It's your right to know.

- Allergic reactions
- Contamination of other fluids or chemicals, with possible side reactions

For example, we sometimes use acetone to clean and remove dyes from parts. Using the MSDS in Fig. 1-14, we find that

- Acetone must be stored in a fire-resistant container.
- It should not be in contact with skin or eyes.
- You must avoid breathing excessive or concentrated acetone fumes.

So, using acetone requires several actions. Use a steel, fireproof container. Wear chemical-resistant gloves and work in a place where air circulates—never a small room with closed doors and windows.

**KEYPOINT**

Although shop chemicals are generally not extremely dangerous, each has its own set of precautions and procedures found in its own MSDS. Each also has a correct disposal procedure that must be followed.

## The Five Kinds of Shop Chemicals

1. Lubricants
2. Coolants
3. Solvents/coatings
4. Cleaning products
5. Gasses (compressed and liquefied)

You might be called on to use compressed gasses for welding and brazing. We also use liquefied nitrogen for deep chilling when shrinking metal parts for special assemblies. But these tasks are beyond beginners, so we do not study gas safety here. However, be aware there are some highly specialized skills needed to use them. That leaves the other four categories.

## 1.3.2 Using Lubricants the Right Way

Other than fire hazard, today's machine lubricants are safe and *benign* (not toxic).

**TRADE TIP**

**You Should Know!** Fast, modern computer-controlled (CNC) machines are fussy about getting the exact oil for the duty and there are many kinds. An expensive machine can be damaged by adding the wrong lube nearly as fast as by not adding any at all. Of highest priority: oil thickness and resistance to flow, called **viscosity,** is absolutely critical—both from the standpoint of the precision action of the machine and to prevent wear.


**Figure 1-15** Specialized lubricants must be stored in fireproof surroundings and kept free from contamination.

### Special Oils Must be Identified and Kept Clean

Several application-specific lubricants are necessary, especially where there is a variety of CNC machines. Both sliding and rotating equipment must have lubrication, but especially faster machines equipped with high-tech **hydrostatic bearings.** Hydrostatic bearings depend on an exact thickness of oil between moving components. Components actually "float" on a predictable thickness of oil much like an air hockey puck. Introducing the wrong oil causes a double problem: it can create inaccurate machine movements, but even worse, a thinner film than that required can let metal touch and rub with sure damage to follow!

**KEYPOINT**

Keep oilcans labeled and stored in a marked, fire-protected area with their tops closed to avoid contamination (Fig. 1-15).

### Sliding Lubricants and Rolling Action Lubes

Oils are used in two very different ways: to prevent sliding friction or rolling friction. The sliding type oil is called **way oil** because the machine parts it lubricates are also called "ways" (discussed in lathe and mill training coming up). Way oil is thicker than spindle oil. Even thicker yet, grease is occasionally used to prevent sliding friction in some older machines, but it's far less common today. However, if the machine needs grease, then using way oil would be a big mistake!

For bearings that rotate, **spindle oil** is the correct lubricant. There are more kinds of spindle oils than ways due to the wide differences in the kinds of spindle bearings. This is the area where you must be doubly sure to have exactly the right oil. Some bearings are made of ceramic composites, while others are ceramic/steel and still others are steel alone. Some spindles are refrigerated to maintain perfect accuracy, while others aren't. Spindle accuracy and tool life depend on lubrication.

## KEYPOINT

Never leave open oilcans in the work area or even in the storage area. They become contaminated with chips and dirt. They could even catch on fire from heated flying chips.

### How Do You Know Which Lube to Use?

Lubrication instructions are usually found on a metal plate fastened to the machine, right at the input point. If no plate or other tag is visible, look it up in the owner's manual (Fig. 1-16). Or just ask.

## SHOPTALK

**Pros Do It!** It's often the little things that identify the pro. Here are a few examples. When putting oil in a machine, clean the funnel and spout and do not pour oil while chips are flying. When finished with the fill, wipe the oilcan top before storing it so that it won't collect dirt. Last, put the can in the cabinet with the label turned out for the next user.

## Using Cutting Fluids (Coolants)

Later in Chapter 9 you will learn the technology of coolants, also called cutting fluids. Here we'll look at them as shop chemicals. Coolants often make machining safer and faster. Most of today's coolants are water-based fluids that are either flooded or sprayed over the cut area. When they are used correctly, tools often last longer, productivity increases, and horsepower is reduced along with excess heat. Today most shops mix coolants such that one dilution can be used throughout the shop, but others prefer to custom mix for a specific application. For example, a thicker mixture is needed for milling, but a thinner one works best for grinding. The important issues for coolants are

- If a vapor or spray is produced in the machine operation, it must not be inhaled. Containment barriers and a breathing mask are two good solutions.
- The undiluted syrup used to make coolant is ultracostly. A barrel of the unmixed syrup can cost a week's wages for a journeyman!
- Coolants must be maintained by checking density and adding fresh water because the heat from machining evaporates the water and thickens the dilution ratio.
- Coolants become contaminated with lube oils from the equipment and dirt from machining, called "tramp oil." Tramp oil must be skimmed or filtered out.
- Coolants can be revitalized by chemical treatment and filtration, but at some point coolants must be disposed of. When the time comes, disposal must be done in the right, legal way!

*Coolants come in three forms:* synthetic, organic, and special threading compounds. *Synthetic coolant* is the most common, especially for CNC work. Synthetics are nonclinging, meaning that they run off the workpiece easily, thus parts come away clean from the machine, and the shop stays cleaner too. Synthetics last longer in the machine compared to older organic oils. *Organic coolants* can rot due to bacterial action, over time. Finally, even though their main ingredient is water, synthetic coolants prevent rust on machines and on steel or iron parts similar to antifreeze mixed with water in your car's engine block.


**Figure 1-16** Be absolutely certain to add the right oil, especially on CNC equipment!

## TRADE TIP

**Knowing Coolant Ratios** While there is a general shop ratio usually around 40 to 1 for most products, different applications may require an exact dilution ratio. For example, a given coolant might work best at 25/1 for milling but 45/1 for grinding. Too much syrup adds nearly no benefit but adds needless cost. But more importantly, too little degrades the performance of the mix and it even rusts the machines! Cutting different metals on the same machine can even require differing ratios: steel can be successfully cut with thinner coolant mixes than titanium, for example.

Highly engineered synthetics (Fig. 1-17) are designed to be both nonallergenic to people and nonreactive to metals.

*Cutting oils and cutting compounds* (Fig. 1-18) are lubricants that tend to cling to the work, called the wetting property. Different from synthetics, these oils and compounds stay on the tool or work by design. Each has its use. They are either brushed or poured on during the operation. A few of these products are designed for thread machining and are exceptionally effective, but they're also expensive! They pay for themselves in results, but please don't waste them. If not


**Figure 1-17** Synthetic coolants are highly designed shop chemicals that are mixed with water to make machining more efficient and safer.

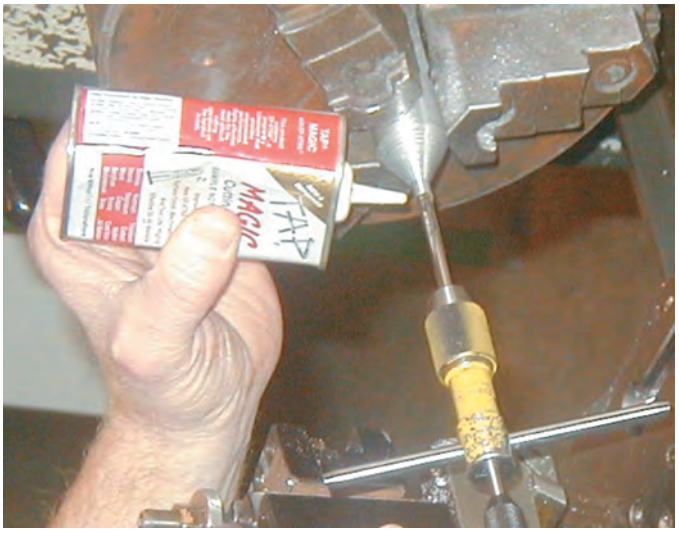



**Figure 1-18** Thread-cutting compound makes a huge difference in thread quality and tool life, but it is expensive.

used sparingly, they can contaminate the water-based coolants in the machine reservoir, which becomes tramp oil.

### 1.3.3 Recycling and Disposing of Waste

All responsible persons working with chemicals today must understand how to sort and dispose of them. That too can be found in the MSDS sheet. Very few chemicals can be released as-is back into the environment.

Most coolants, solvents, and oils must be turned over to a company equipped to either burn or chemically neutralize them based on the type. This is a very specialized operation that is regulated by state and federal agencies. Not surprisingly, it can be more expensive to dispose of chemicals than to buy them. Recycling within the shop whenever possible makes good sense. Your shop will undoubtedly sort the various kinds of scrap and have a well-defined waste program.

**SHOPTALK**

**Try This Online Research** Have your instructor suggest one solvent, cleaner, or other shop chemical. Now search out how it must be handled. Words that might work are *Environmental Protection Agency* and *chemical disposal procedures*. You might also seek a home page from a local agency that accepts chemicals for disposal.

## UNIT 1-3 *Review*

### Replay the Key Points

- Know the correct use and potential hazards of all shop chemicals.
- Store all chemicals and oils in designated containers and areas.
- Be absolutely certain that you're using the right lube for the application.
- Two kinds of coolants are used in the shop: synthetic coolants are syrups mixed with water and cutting oils and compounds are wetting lubricants for cutting metal.
- Always ask for supervision or read the MSDS sheet if in doubt about how to handle a chemical.

### Respond (Answers found at the end of Chapter 1)

1. We find information about shop chemicals on MSDS sheets. Is this statement true or false? If false, what will make it true?
2. Synthetic coolants are mixed at dilution ratios of water to syrup, of from
   A. 20 to 1 up to 50 to 1
   B. 10 to 1 up to 20 to 1
   C. 1 to 20 up to 1 to 50
   D. 1 to 10 up to 1 to 20
3. Machine lubrication falls into two general types (other than grease used on old machines). Name them.
4. Without looking back, name as many precautions as you can recall with regard to shop chemicals (there are six).
5. The sliding parts of machines that must have a specific kind of lubrication are called_____.

## Unit 1-4 Maintaining Equipment and the Work Environment

**Introduction:** Our next professionalism subject is not unlike taking care of your car. We all want to believe a clean car gets better mileage but more to the pro point, a messy car says a lot about the driver! Organization equals efficiency. Need proof? When working on your car, how much time do you spend looking for that wrench you just used a few minutes ago?

While the mileage issue might be false, long life and precision results on machine tools is true if they are maintained with care. Operating a new CNC machine means management has trusted you with the value of a dozen or more high-dollar automobiles and more, with the profit that can be made with it if it keeps running.

## TERMS TOOLBOX

**Axis lock (override)** One of the options a machinist might have to prevent any possibility of a machine moving while cleaning chips from the bin.

**Chip breaking** The action of breaking chips into easier to handle, short segments.

**Flow glass** A glass window in an older machine that indicates the pump is working as oil flows over the window.

**Lean manufacturing** The study of organizing and managing an efficient work environment.

**One-shot lubricator** A manual lubrication pump found on smaller machine tools such as school machines.

**Sight glass** Functions like a dipstick by allowing the fluid level to be seen and compared to a line.

### 1.4.1 Maintaining Machinery and Work Area

The following duties fall on the machinist. Done well they keep your machine and shop humming. We'll look at three categories:

1. Keeping chips under control
2. Doing under-the-hood checks: lubrication, coolants, and air pressure
3. Maintaining your work area

### Removing and Handling Chips

Chips are the ever-present challenge for machinists. They come off the work in two varieties: short and long. Short broken pieces are the ones we try to produce because they're less dangerous and easier to clean up. The long ones can be nasty since they can snag and cut hands. But whatever the chip shape, here is a list of possible hazards to control (Fig. 1-19):

**Figure 1-19** Long, stringy chips are strong *razor wires* that catch clothing and cut skin. All chips, even the safer "C" shapes on the right, can be dangerously hot.

- Chips are *hot* right after they are made—they may be up to 1,000 degrees Fahrenheit in standard machining and even higher when special ceramic cutters are used.
- Chips are *sharp*—as sharp as a razor at times—sharper actually since the edge may be only a few microns wide due to the way they are sheared off the workpiece!
- Chips *fly like bullets*—as much as 150 miles per hour on manually operated machines but up to 250 or more for CNC high-speed machining!
- Chips are *strong*. The long, string type can catch and drag the unwary machinist into machines—this is the greatest danger. They can also cut deeply if drawn across your skin.
- Chips are *slippery* on bare concrete floors.

Thinking of resigning? Hold on, with some preparation and prevention, these nasty critters can be tamed and controlled. There are lots of ways that we'll learn as we study drilling, milling, and turning.

#### Two Different Ways to Clean Up Chips

For now, lets talk about getting them out of the area. There are two ways we remove chips from machinery, depending on what the machine is doing.

- When the machine is operating and making chips.
- When it's stopped; for example, when the chip bin is full at shift change or at the end of the job.

For safety, each requires a very different action on your part.

**Machine Not Running** Chips pile up fast (Fig. 1-20). Many CNC machines feature some form of automatic removal system, while others require the machinist or helper to intervene by blowing, raking, or brushing them away. We dispose of chips as we go but sometimes they get ahead of us and even the automatic chip conveyors get backed up. Whatever the reason, it's time to stop machining and get them out of the way.

**Figure 1-20** Chips can pile up quickly and must be removed from the machine.

**Figure 1-21** Lock it out or lock it up—never perform maintenance on a machine that can be started accidentally.

That means cleaning the chip bin, which almost always puts some part of your body at risk if the machine were to start.

### Lock It Up or Lock It Out

Before reaching in to clear chips out be absolutely sure the machine is locked or blocked from accidental start-up, if you bump it on, or if someone else might start it by accident (Fig. 1-21). Many CNC machines feature an **axis lock** function. Other machines such as manual lathes require throwing the main power switch. But that might be a disaster on an older computer-driven machine because of the loss of data and/or setup positions.

**KEYPOINT**

Never reach into a machine to remove chips unless it is locked up or out. If you must go to the back of the machine, tell someone you are there so it can't be accidentally started.

If neither locking out nor turning off is possible, then

A. Turn CNC axis overrides to zero whereby no movement will occur.
B. Place a sign over the panel "*Operator Cleaning Chip Bin*."
C. Tell fellow machinists you are cleaning in the back or out of sight.

**TRADE TIP**

**Chip Breaking** There are two ways of breaking stringy chips into safe little packets. In the first, using heavier machining action forms thicker, stiffer chips that cannot take the bending action of being removed from the parent metal. They then break into small "C" shapes. The other answer is using a cutting tool with a chip breaking dam (Fig. 1-22). The obstruction redirects the flowing chip such that it snaps off. We'll see more on both techniques in tool geometry later.

Now with the machine safely locked up or locked out, no possible machine movement, put on gloves and rake the chips out safely. If you are assisting other machinists (you aren't the machine operator), be absolutely sure that the person who is the operator knows you are working in the machine chip bin.

### Clearing Chips from Operating Machines

This is a very different procedure from the standpoint of safety. It's often necessary to clear away chips from machines while they're being made. This is a machinist's prime duty. Here are the details:

- If your machine is moving *do not wear gloves*. Lacking sensitivity, gloves put your hands at increased risk of being caught in the machine.

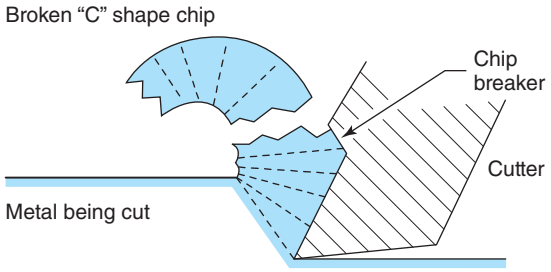



**Figure 1-22** A chip breaker bends the flowing chip so quickly that it snaps off into small "C" shapes rather than a long string.

- Never reach in the machine with your hand or a gripping tool such as a pliers or vise grip. Can you guess why? Because you can't let go fast enough if the chips or machine catch the gripping tool.

Here are four safe ways to remove chips from moving machines:

- A sturdy brush
- Coolant stream
- Compressed air
- A chip rake or chip hook

The brush is a safe, self-explanatory tool used on drills and mills but not lathes and CNC operations since your hand is too close to the action. Although they sometimes get "eaten" by the machine, you can't hold on tightly enough to a brush to get hurt. A brush is the first choice of beginning machinists in training where chip volume is low.

## SHOPTALK

**Recycling Metal Chips Is Good to Mother Earth** Most modern shops recycle as part of an environmental effort and because of cost savings too. Larger chunks of metal are kept separated from the chips since each is handled differently at the recycling center and has different values. Correct sorting ensures value. The wing spar in Fig. 1-23 started out weighing over 500 pounds but when finished weighed only 8 pounds—96 percent of the weight became chips. Recycled aluminum chips require *80 percent less energy* to remelt and pour back into useful aluminum again compared to refining raw material from the earth.

### Using a Chip Hook or Chip Rake

The longer chip hook pulls long, stringy chips out of the machine, while a rake removes broken chips. Both tools are made with handles that can't grab your hand should the business end accidentally get caught in the machine. The handle should not turn back into a closed loop. Figure 1-24 shows the right shape. Notice too that the hook end is not a full 90 degrees either. The open hook tends not to catch on the machine and also to release the chips easily.

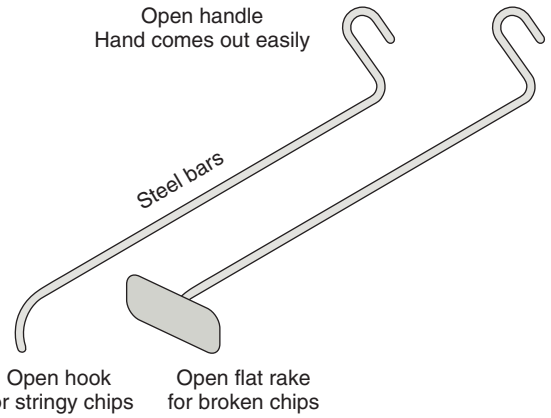



**Figure 1-24** Chip hooks and chip rakes feature open handles designed to not get caught in moving machinery.

### Compressed Air

Nearly every shop uses compressed air to power hand tools, to actuate machine actions such as pneumatic clamps, and also for cleanup work. Air is a safe and efficient tool used for chip removal in modern machining. But it can be misused against both people and machines. Use these two pro guidelines to stay out of trouble (Fig. 1-25).

**Guide 1. Personal Danger—Never blow off chips from your skin or clothing or point the air at fellow workers!** You can embed chips in skin or even inject air under the skin. It is possible to introduce air into veins and arteries,

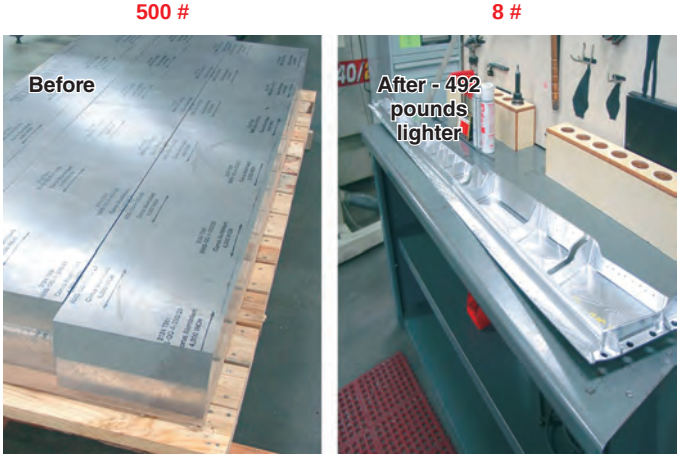



**Figure 1-23** Sorting chips from scrap metal, then recycling each improves profitability plus it saves 80 percent of the energy required to mine and then refine raw metal.

**Figure 1-25** Compressed air is a good chip removal and cleanup tool when correctly used.

where serious consequences can occur. It should be obvious: never point the airstream, with or without ejected chips, at someone or at other machines. At the *very least*, damage to computers, delicate measuring tools, and your reputation can occur. When using air on a manually operated machine it's best to place a guard wall behind or beside it to protect others. CNC machines often feature full containment shields that do the job nicely.

**Guide 2. Machine Safety—Never point compressed air at seals on the machine.** All machine tools are equipped with seals designed to keep dirt and metal chips away from bearings and precision flat sliding surfaces. However, these tough seals are not able to stop pressurized air. Air can force chips under the seals, defeating their ability to stop further invasion.

**KEYPOINT**

A carelessly air-injected chip in a machine seal lifts the seal, thus defeating its usefulness. The embedded chips can also scratch precision surfaces.

Used correctly, compressed air works well to keep chips out of the immediate machining area, especially when the machine is moving. An airstream enables chip ejection without holding any solid object between you and the machine. It can't get caught and pull you into the machine. However, air cleaning and chip ejection is controversial. Many supervisors, instructors, and textbooks rule that it can't be used. But in the real world it's used pretty much every day.

**KEYPOINT**

**Ask First**
Be aware that due to the potential for machine damage some shops have a strict rule against using air as a chip cleanup tool.

**TRADE TIP**

**Coolant as an Air Substitute** Where air is banned for chip control, try a directed coolant stream with less velocity but more mass. It can do the job every bit as well with no danger to seals. Plus the hand-aimed stream can improve tool life since the operator can concentrate coolant right when and where it's needed during heavy machine cuts. This tip works especially well on CNC machines with strong coolant systems and full containment guards to catch the splashing. A tee-fitting put in the coolant delivery hose is connected to any flexible hose and garden nozzle. This little accessory works wonders—try it!

## Maintaining the Work Area

As boring as a list might be, it can't be avoided here if you are to know what the other machinists will expect of you when you enter the craft. Here are a few unwritten rules on how to keep your shop lean and mean:

- As much as possible, keep measuring tools away from the machine and in their case.
- When laying measuring tools or wrenches down, never lay them on sliding machine parts such as lathe ways. Do put a shop towel under them on your workbench.
- Keep clutter such as rags, metal scraps, and especially old paperwork picked up. Keep personal items to a minimum too.
- Keep chips swept and picked up.
- If you see something that needs maintaining, fix it or report it, but don't ignore it.

### Checking Machine Fluid Levels

Oils are consumed and coolant levels fall due to splashing, evaporation, and small amounts leaving on the work itself, called *clinging*. Nearly all newer CNC machines feature sensors and low-fluid alarms, but not all are so equipped and no manually operated machines have this protection. To determine fluid levels in these machines, there might be a dipstick or a **sight glass,** such as the one in the drawing. This is simply a little glass window into the side of the reservoir. Add the lubricant or coolant to the indicated full line (Fig. 1-26).

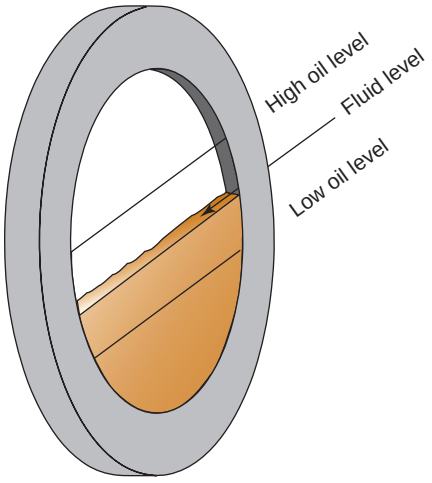



**Figure 1-26** Sight glasses are small windows in the machine's oil sump that show the fluid level.

## TRADE TIP

After wiping the oil and dirt from exposed, precision sliding surfaces, remember to replace with a wipe or spray of clean oil of the correct type. While these surfaces will be automatically lubricated by the next motion of the machine, however, the oil is absent unless you put it there for the first movement.

### Lubrication Flow Glasses

When maintaining older machine tools, you must know the difference between a sight glass for checking fluid levels and a **flow glass** for coolants and lubrication. A *sight glass* has a line on the clear window; its purpose is to see critical fluid levels. It's like a dipstick, telling you how much oil or coolant to add.

No line on the glass or around the window's outside rim means it is a *flow glass*. It's a foolproof way of seeing that the fluid pump is working. A flow glass shows when oil is moving. When the pump is working, the oil flows down over this glass.

## KEYPOINT

Caution, machines may have more than one sump with different oils in each.

On many smaller machines like those used in a typical machining course, there is probably a central, manual lubricating oil pump for sliding surfaces. Its handle must be lifted or pumped each time you step up to the machine and once each hour of operation. This is sometimes referred to as a **one-shot lubricator** (Fig. 1-27).


**Figure 1-27** A one-shot central lubricator. Use at least once per half day or on the schedule set by your instructor.

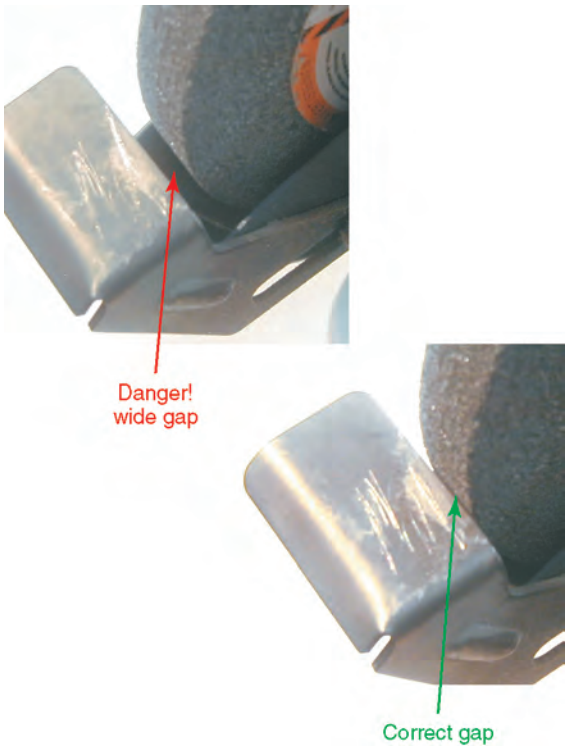



**Figure 1-28** Due to grinding wheel wear, this tool rest gap has become dangerously wide and must be adjusted closer to the wheel to avoid pulling in small parts and fingers!

### Adjustments to Equipment

Naturally, there are many routine adjustments that must be made on machining equipment—to walk the walk, don't walk away from them. Make adjustments when they need to be done and on a schedule too. Safety guards, for example, or eye shields, and doors that close for containment, chuck guards, limit switches and belts—they're everywhere in a machine shop and they are part of your job.

Tool rests on bench grinders (Fig. 1-28) are a perfect example. As the grinding wheel is used, the gap widens. To minimize the pinch point created between the grinding wheel and rest, keep adjusting it to a minimum of 1/16 in. or less. Zero clearance is acceptable because items cannot be pulled into the gap, but it could result in the tool rest being eventually worn away.

## 1.4.2 Managing the Workplace—Lean and Green

Along with the machines and tools of the trade, the work area is also a tool that requires attention and proper care. A recognized trait of professional machinists is the pride they show in the way they organize and maintain their work area. But the subject involves more than pride—if managed right, tasks go faster and have more reliable results.

There are several names for the science of efficient work areas and environments, but the most common is **lean manufacturing.** The heart of lean manufacturing is finding the most efficient, logical way to organize and manage a working space. Using the lean concepts we count the steps and minutes required to complete a task, then do whatever it takes to reduce them. After observing the task, or a process and the people doing it, we ask what tools and supplies are needed and whether they can be placed closer to the task. Once they are provided, far more importantly, a system is created to keep them there consistently.

So you can see that lean focuses on common sense applied to shop procedures. Another aspect of lean lies in reducing unused inventory and clutter—old tools, leftover materials, that item "you might need sometime"—called the 5S process. While there's a lot more to the science, it starts with people having exactly what they need to do a job right where they need it and eliminating clutter. It also means returning tools to their place throughout the shift—not just at quitting time. Lean people constantly control the space in which they work. It's a habit.

A picture says it all, see Fig. 1-29. Your company may sponsor workshops where teams work together to get their area up to this level of efficiency. But there's nothing wrong with you becoming a committee of one! Start with your toolbox and the immediate area in which you work. Here are a few more ways to keep the workspace humming.

## Safely Storing Machine Accessories

Machine accessories are precise, heavy, and expensive. Use lifting equipment to move them to avoid back injury and to minimize the chance of dropping them. Store them on shelves made for the load they represent and set them back from the edge (Fig. 1-30). If the stored item is a machine accessory or finished metal part prone to rusting and if it will not be used for some time, a light coat of protective oil is in order before storage.


**Figure 1-29** A lean shadow board and machine.

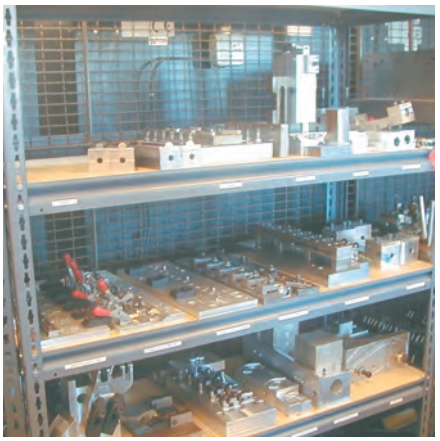


**Figure 1-30** Machine accessories must be stored and transported correctly. Make sure they are on shelves made for heavy storage.

## 1.4.3 The 5S Process to Become Lean

The obvious goal of becoming a lean machine shop (or company) is to be more efficient, thus profitable, by identifying and eliminating several categories of waste:

- People time
- Unused inventory
- Process time
- Inefficient processes
- Overproduction

But in a much greater sense, it's a way to change the essential culture of how you go about manufacturing. Shops wishing to become lean follow a set of steps called the *5S Process:*

**Sort (Inventory everything)**

To be certain of upcoming decisions to surplus or not, a team surveys tools, parts, inventory, and fixtures, then determines which are useful and which must be eliminated. They then surplus the unneeded, unused, and clutter! This is not an easy step, but it is necessary!

**Straighten (Organize)**

Everything—tools, supplies, and instruction—gets a specific location such as a shadow board or labeled shelf. Figure 1-29 is as close to the point of use as possible. This phase is also about creating a culture of putting it back continuously—not just at the end of the day or week.

**Sweep (Make it look lean) (See Fig. 1-30)**

This is as much a visual kick-off to the newly improved shop as it is a lean-making tool in itself. Clean, paint,

label where things go—make the shop shine! Completing the sweep, add to the lean culture that everyone keeps it that way! Taken as a whole, the sweep phase is a celebration of the new you.

**Standardize (Make it permanent and ingrained)**

This is where you solidify all the changes—create third-order change, not just paint and labels. Lean becomes the shop norm—planning and scheduling upkeep and preventive maintenance, for example, assigning responsibility, anything that makes your decision to be lean a permanent change with 100 percent buy-in from all workers.

**Sustain (Set up schedules and audits—reevaluate)**

Now lean is a way of doing your job. Schedule and post audits about how it's going. The objective is to be on and stay on track, and to get even leaner as you learn. This is the long-term investment: investigate and improve systems and culture—encourage each other, and celebrate success by recognizing improvements in quality, costs, and customer satisfaction!

## 1.4.4 ISO 14001 to Become Environmentally Responsible—Green

Reacting to several earth-related issues facing us all, the International Standards Organization has developed standards that help organizations take a proactive approach to managing environmental issues. 14000 sets the standard and 14001 guides implementation.

The ISO 14000 family of environmental management standards can be implemented in any type of organization in either public or private sectors—from companies to administrations to public utilities. ISO is helping to meet the challenge of climate change with standards for

- Greenhouse gas accounting
- Verification and emissions trading
- Carbon footprint measurement of products

ISO develops informative documents to facilitate the fusion of business and environmental goals by encouraging the inclusion of environmental aspects in product design. ISO offers a wide-ranging portfolio of standards for sampling and testing methods to deal with specific environmental challenges. It has developed some 570 International Standards for monitoring

- Quality of air, water
- Soil, as well as noise, radiation
- Control of the transport of dangerous goods
- The technical basis for environmental regulations

(Credits: *Material reproduced from ISO with kind permission from the ISO Central Secretariat.*)

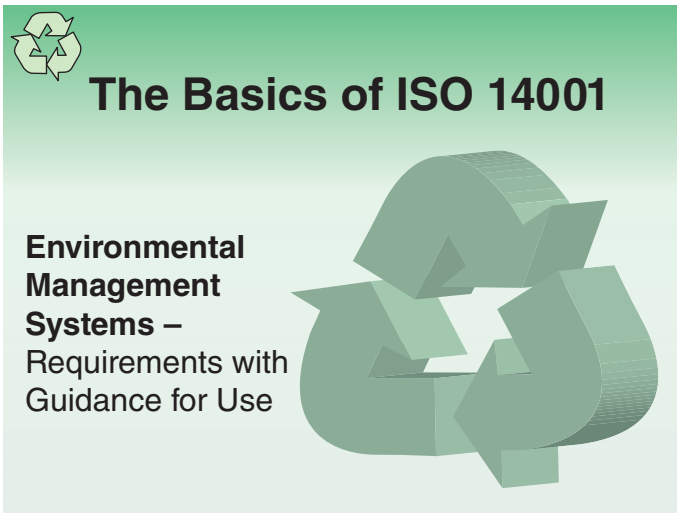
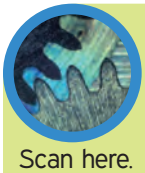



**Figure 1-31** The basics of ISO.



Scan here.

**Xcursion.** Become an informed machinist, and sign up for the ISP newsletter and view their informative presentations.

**ISO Environmental Standards 1400 and 14001** for business, government, and society as a whole make a positive contribution to the world we live in—and are accepted in 160 countries. They ensure vital features such as quality, ecology, safety, economy, reliability, compatibility, interoperability, conformity, efficiency, and effectiveness. They facilitate trade, spread knowledge, and share technological advances and good management practice.

ISO develops only those standards that are required by the market. This work is carried out by experts on loan from the industrial, technical, and business sectors who have asked for the standards and have subsequently put them to use. These experts may be joined by others with relevant knowledge, such as representatives of government agencies, testing laboratories, consumer associations, and academia, and by nongovernmental or other stakeholder organizations that have a specific interest in the issues addressed in the standards.

## 1.4.5 Fire Prevention and Safety

You will be given specific training in your school lab and on the job about fire prevention. Here are a few rules for safely controlling a shop fire:

1. Know where the exits are located in your shop.
2. Never attempt to fight a fire without knowing how you can escape. Fight a fire with your exit clear.

| | | | |
|---|---|---|---|
| A |  | Common Combustibles | Wood, paper, cloth, etc. |
| B |  | Flammable liquids and gasses | Gasoline, propane, and solvents |
| C |  | Live electrical equipment | Computers, fax machines (see note!) |
| D |  | Combustible metals | Magnesium, lithium, titanium |
| K |  | Cooking media | Cooking oils and fats |

**Figure 1-32** Notice the flammable metals category—titanium and especially magnesium and the new symbols.

3. Know which kind of extinguisher fights which kind of fire:
   a. **A** = Common burning objects—wood, paper—anything that leaves an **A**sh.
   b. **B** = Volatile liquids—lubricants, gasoline—anything that goes **B**ooom!
   c. **C** = Electrical fires—anything with an energized **C**ircuit.

   Remember: never attempt to fight an electrical fire with an extinguisher not designed for the purpose. Turn the power off before attempting to fight an electrical fire.

   Most shops employ A-B-C extinguishers, but read the label to be certain (Fig. 1-32)—you can get it wrong with unwanted results!
4. Be certain you CAN extinguish the fire—schools may have specific rules on this.
5. Above all else—be certain that all persons have been informed and evacuated—your first concern before extinguishing the fire!
6. Be certain that someone calls the EMS fire department immediately—don't wait until you KNOW you can't control the fire. This is a critical step—do it simultaneously with the effort to control the fire. (Author: "I speak from experience; the fire department doesn't mind being told that the emergency is under control—while racing to the fire, they like to hear a radio call to 'lower your code to an inspection.' But they do mind finding they could have controlled the fire if called in time!")
7. Review the PASS process for fighting a fire:
   **P**ull the pin
   **A**im at the base source of the flame
   **S**queeze the trigger
   **S**weep over the whole source to exclude oxygen from reaching any area

## UNIT 1-4 *Review*

### Replay the Key Points

- Depending on whether the machine is working or stopped, safe chip removal actions are very different. Identify or describe them.
- Air is a safe chip removal and cleanup tool, but some shops ban its use in this capacity.
- Lubrication is technical and often the machine operator's responsibility. Using the wrong oil can damage technical equipment almost as soon as using none at all!
- Savvy machinists keep their eyes open for conditions that need attention and they fix problems themselves.

### Respond (Answers found at the end of Chapter 1)

1. Why is air not always permitted as a cleanup tool?
2. Gloves are acceptable when removing long, stringy chips. Is this statement true or false? If false, what makes it true?
3. Why are flow glasses not found on modern CNC machines?
4. Name the four safe methods of removing chips from moving machinery.
5. Complete this sentence: Shop-made chip hooks and rakes are made such that _____.
6. List and describe the 5S Process.
7. What is the ISO Standard that aids shops in becoming environmentally responsible?

# CHAPTER 1 *Review*

**Terms Toolbox!** Scan this code to review the key terms, or, if you do not have a smart phone, please go to **www.mhhe.com/fitzpatrick3e**.

**Unit 1-1**

No part of Chapter 1 has been filler material. Demonstrating a professional attitude in the way you dress for the shop environment is one of the best tools you can develop to show your instructor and employer early on that you are on your way to becoming a top gun.

**Unit 1-2**

**Unit 1-3**

**Unit 1-4**

I once took my CNC class on a tour of a local shop. As we walked in I saw an apprentice I had previously trained, putting away a five-gallon oilcan. Not realizing we were watching her, she carefully wiped the top, then rotated it so the label could be read. Only then did she close the door to the fireproof cabinet. I was truly proud but also noticed her supervisor nod toward me with approval!

It's details like that, taking care of shop supplies, knowing their value, and using them responsibly along with having a good respect for machine accessories and tools that give the beginner the walk of a journeyman. They will be noticed, or more importantly, when they are ignored, they get noticed even faster.

## QUESTIONS AND PROBLEMS

1. Describe a well-dressed machinist. Use at least five dos and two don'ts. (LO 1-1)
2. True or false? It's OK to listen to music with a personal player as long as you leave one earphone out to be able to hear your machine. If it is false, why? (LO 1-1)
3. List the best to worst ways to lift heavy objects. (LO 1-2)
4. Name two professional precautions (of three) for storing metal bars. (LO 1-2)
5. Explain why we use the bent knees lifting technique in 10 words or less. (LO 1-2)
6. What would you expect to find on an MSDS sheet? (LO 1-3)
7. Lubricants fall into two general groups to prevent _____ and _____ friction. (LO 1-3)
8. True or false? It's OK to substitute lubricants as long as the new one has a higher viscosity than the required oil so it prevents friction better than the original. (LO 1-3)
9. Why do we not wear gloves around moving machinery? (LO 1-4)
10. True or false? Pressurized air is permitted as a cleanup and chip removal tool in all modern shops. If it is false, why? (LO 1-4)

## CRITICAL THINKING

11. A bar of spring steel has been misplaced, but you have found another that you are sure is the same material. Can it be substituted for the job? Is there a way to maintain the traceability? (LO 1-2)
12. True or false? Dark glasses impair vision and they are never worn in the machine shop. If it's false, why? (LO 1-1)

## CNC QUESTIONS

13. Your CNC mill has stopped after completing a part cycle and a red light flashes while your operator's panel tells you that the way lubricant is low. Name three or more professional steps needed to get the machine up and running again. (LO 1-2)
14. Why do you suppose the machine completed the cycle in Question 13 before it shut down due to low supply of a vital fluid? (LO 1-2)
15. Why must a specific lubricant be used in most modern CNC bearings? (LO 1-3)

# CHAPTER 1 *Answers*

### ANSWERS 1-1

1. Yes for yellow lenses, no for dark unless working near incidental welding light. Note: Dark lenses will not protect your eyes from looking directly at a welding flash, they only protect from incidental light reflected off walls and ceiling.
2. Natural fibers stand up to hot chips so they don't melt or burn the wearers—breaking their concentration.
3. Traction, foot protection, and fatigue
4. Besides the joy of hearing, it's your prime control of the process.
5. Air currents and static electricity

### ANSWERS 1-2

1. Three or more: overhead cranes moving on rails, rolling lift tables, floor jacks for pallets and tub skids, forklift trucks, portable jib cranes often called "cherry pickers," jib cranes fastened to a column to pivot around a circular area
2. False. The forward end high makes it out of your reach and out of your control.
3. For two reasons: Once the ID is lost the metal cannot be proven without a lab test as to what alloy it is. Traceability demands that there be a trail from original manufacture all the way to a specific part. Losing the ID means that it is gone.
4. A fluid center surrounded by several layers of tough skin
5. On a shelf where they cannot fall through

### ANSWERS 1-3

1. True
2. A
3. Sliding (way oil) or rolling (spindle oil)
4. The precautions are fire hazard, chemical stripping of skin oils—direct contact, fume toxicity and oxygen exclusion (displacing oxygen), eye irritation, allergic reactions, contamination of other fluids or chemicals with possible side reactions.
5. Ways

### ANSWERS 1-4

1. It may be banned due to potential damage to machine seals.
2. False. Use gloves only when the machine is not moving.
3. They are equipped with oil level sensors and alarms.
4. Chip hooks/rakes, airstream, coolant stream, brushes
5. Neither end can catch on machines or hands.
6. Sort (Inventory everything)
   Straighten (Organize)
   Sweep (Make it look lean)
   Standardize (Make it permanent and ingrained)
   Sustain (Set up schedules and audits—reevaluate)
7. ISO 14000 sets standards; 14001 guides for implementing.

### Answers to Chapter Review Questions

1. Do wear: eye protection, shoes designed for the shop, hearing protection, tight-fitting clothing of natural fibers, a shop apron or coat. Don't wear jewelry or gloves or leave long hair uncontrolled. Any shop coat or apron should not have loose ties or pockets.
2. False. Any disturbance to hearing impairs machine control.
3. Mechanical devices (crane, shop lift, forklift, etc.); two or more people working together, all using correct technique; one person using the bent knee method

4. Never store short bars in the long bar rack where they could fall through. Store them with their ID visible and never cut the color code or stamp from the bar.
5. To prevent excessive pressurization and damage to disks in the spine.
6. Instructions for the safe use and disposal of specific chemicals plus storage and special precautions
7. Sliding and rolling friction
8. False
9. Gloves desensitize your hands, which tends to help get fingers caught in machinery.
10. While air is used by many as a cleanup tool, it can also cause damage to machine seals and other items in the area. It may be banned for this purpose in many shops.
11. The short answer is *no*, at least not by you. However, if the heat lot for the new bar is on record and its specification matches the lost bar, then the paperwork can be cut to make the substitution—the traceability thread is not lost this way.
12. It's mostly true. But we sometimes must work around electric welding. Then they are OK to prevent incidental light damage to eyes.
13. A. Determine the specific way lube that's right for that machine.
    B. After getting the right oil, make sure the funnel and can are clean before opening the oil port on the machine (to avoid contamination of the reservoir).
    C. Fill until the sight glass line shows the reservoir is full.
    D. Close the can and return it to the storage area (to prevent fire hazard and to keep the can from being contaminated).
14. Modern CNC machines tell the operator when necessary fluids are low long before they reach the critical point. Therefore, the control allows finishing a cycle before stopping.
15. They depend on an exact viscosity for accuracy as well as long life.