Safety lecture

Working safely in the shop can be divided into two main topics of concern; Protection against personal injury and prevention of damage to tools, equipment and machines. This is about personal safety. When working in the shop, you must use great care to avoid personal injury. Solid metals and other materials common in the shop are hard and often have sharp edges. Hot, sharp metal chips, produced in cutting operations, can burn and cut. Grinding wheels can throw abrasive particles into unprotected eyes. Rotating tools and work pieces can catch loose clothing and hair. Harmful rays from electric welding arcs can burn unprotected skin and eyes. Liquid metals can spatter and cause painful burns. These are just a few of the possible hazards in the fabrication shop. Remember that machines have no conscience, no mercy, no regrets....they just cut.

A careless worker can be painfully injured or cause others to be injured. Workers who work safely can avoid being injured. They must dress properly, follow correct work procedures and work well as a team with fellow workers.

Safety is a fact of modern life and safe working practices can make you an asset to those who may hire you. Failure to follow safe working practices will cause you to be dismissed from the services of an employer and result in large fines. Of course you may be injured, disabled or even killed if you fail to follow safe working practices. Your unsafe practices may also result in injury, disability or even death to others and the liability there involved. Take the time to work safely. If you are working for an employer, you have to remember he is not just paying you to work, he is paying you to work safely. Here at CSUS, you must work safely to participate in this program.

Wear safety glasses at all times in the shop. This is maximum eye protection which means wearing clean, properly fitted safety glasses with side shields, goggles or a face shield. Eye protection is required at all times, not just when operating machinery.

Wear close fitting clothing made of hard smooth-finished fabrics that will not easily catch on the sharp edges or rotating tools. Long sleeves should be close fitting or rolled up above the elbow. Machines are often oily and chips are dirty, so you should wear clothing that will stand up to the shop environment. A shop coat or apron will help protect school clothing.

Feet should be protected from hot, sharp chips, heavy falling objects and hot liquid metals. Safety shoes are best, but ordinary leather shoes offer considerable protection. Canvas shoes and open-toed sandals offer no protection and are not allowed in the shop.

Remove all jewelry before working with machines. Watches, rings, necklaces and bracelets can get caught on equipment and cause serious injury.

If you choose to have long hair, you must keep it tied back or under a cap to keep it from becoming engaged in machines.

Never wear gloves while operating machinery. They are easily caught in moving parts and may cause serious injury. Gloves must be used when handling chips, hot metals or welding.

Do not use any machine that you are not checked out on. You must know all the safety aspects of every machine you operate and you must be familiar with all aspects of its operation. If you are not checked out or if you are not sure of your status with a particular machine, consult the shop supervisor.

Make it a habit to stop, look and think in unfamiliar situations. Make a plan for all machine activities, before taking action. Give serious and undivided attention to all activities in the shop.

Do not walk or stand in areas of the shop that are hazardous or where you are exposed to the hazards created by others. Minimizing your exposure to danger is a legitimate approach to safety.

Inspect any machine that you use, to see that all safety devices are in place and working correctly.

See that the work pieces and cutting tools are securely tightened in the machine so that cutting pressures or machine revolutions cannot loosen them.

Always keep your hands away from moving machinery or any part that may move unexpectedly. Never use hands to stop moving machines or parts such as a lathe or drill press chuck.

Never leave a running machine. Someone not expecting the machine to be running may be injured. Always supervise a machine in use.

Always stop a machine before making measurements. Tools you are using may get caught in the turning components. It is impossible to accurately measure a moving part.

Stop machines to adjust, clean, oil or repair them. When making hazardous repairs, disconnect the machine from its power source using lock out tag out procedures.

Disconnect out-of order equipment and identify with lock out tag out procedures. Notify the shop supervisor of out-of-order machines so that lock out tag out procedures can be administered by trained personnel.

When changing speeds on belt driven systems, see that the machine is completely stopped before handling the belt.

Handle materials carefully to avoid being cut. Test materials that may be hot before touching them. Get help in lifting or moving heavy metal or machine parts. Also get help when handling long pieces to avoid injury or damaging equipment.

Use a brush, a piece of cardboard or a stick to sweep away chips created in machining. Never use your hands. Chips are hot and sharp and sometimes still attached to the rotating parts of the work.

Never use compressed air to blow chips from a machine or work station unless you can do so safely.

Keep the area around your machine clear of chips and other waste and tools that may cause hazardous travel. Keep floors clear of oil, grease and other liquids that may cause someone to slip and fall.

Do not disturb someone who is actively involved in operating a machine or other potentially hazardous equipment. You may cause them to make a mistake which may cause an accident. A strict one person at a machine will be enforced at all times.

The improper use of hand tools frequently results in personal injury. Simplicity of the tool does not reduce it's possible hazard.

Use the right tool for the job to be performed. This is an issue for machine longevity as well as safety.   See that the tools and your hands are clean and free of grease or oil before use so that the tools can be held firmly.

Cutting tools should be sharp when using them. Dull tools cause accidents because they require greater force to use them. Dull tools require greater time and may never accomplish the work.

Edge tools should be carried with their points and cutting edges pointing downward. Heads of cold chisels and punches must not be allowed to mushroom or crack. They must be properly dressed or repaired.

The laws of safety which we must all follow require that persons operating machinery must be trained on that machinery and there by qualified to operate it. You must be trained on each type of machinery. In other words, if you are trained to operate horizontal lathes, you are presumed to be trained on all horizontal lathes regardless of manufacturer and minor variations between machines and machine models. The same will apply to milling machines, drills and grinders, etc.

Shop hygiene is very important not only to keep our work areas functional but also for the safety of everyone that works in the shop. There are no food or drinks allowed in the lab at any time. After brushing off your machine and sweeping the surrounding area, the machine and floor must be vacuumed with a HEPA Shop vacuum before leaving the lab. Students, staff, and faculty must wash their hands before leaving the shop.

Working with Drawings

Technical drawings are the media we use to convey ideas and concepts to those who help us create a product. In the planning stages we may make drawings that are more like art. They will be pictorial, to convey ideas but will lack specifics such as dimensions and details. But as we get closer to actual production it is necessary to make drawings which are detailed in every way that is necessary to make the part.

Of course when we are talking about technical drawings we are usually thinking in terms of very formal, very exact drawings which we encounter in the production manufacturing world or the scientific world. Many times we must work from much less formal drawings. Sometimes, just a sketch. Whatever the form of the technical drawing, it must have all the necessary information to make the part. If we are making the part ourselves, we quite often have many of the details such as finish and tolerance in our minds. In this case we can work from a very informal drawing, virtually devoid of detail. On the other hand, if we are working with a machinist or fabricator or a partner, the drawing must be very complete or the part made may be wrong for your needs. At the least, the fabricator will have to contact you time and again to get the details needed.

In the prototype shop we tend to be rather casual with drawings since they take a lot of time to make and we are usually only making one part. The reality is that drawings are still an important part of the work as they provide the records needed to make more parts, if they are needed, long after the details have slipped from memory. So, we will look at the technical drawing and some terminology which we may use or encounter in our work.

To show an object completely, two or more views are usually needed. A few objects, such as a ball, can be shown on one view. A cylinder or a tube can usually be shown in two views. In some cases it is necessary to show every side of an object. Realistically you should show only the minimum number of views to show all the necessary detail.

Our provided text is good on drawings however we offer the following comments and additions.

Tolerances are an important part of any drawing. You must remember that accuracy in a part is time consuming and therefore, expensive. Of course, accuracy may be the feature which makes a part usable. Specify the amount of accuracy needed to make the part usable, but where close tolerances are not needed, specify a looser tolerance.

The same is true of the finish. A fine finish is attractive and may be required for other things such as sealing or smooth motion. But fine finishes take time and sometimes require more expensive tooling or more elaborate set-ups. Time and expense. (display surface finish comparator)

The term "stock" when applied to a dimension, means that the designer is willing to accept the size of the stock from the rack. In the case of a piece of 3/4 inch aluminum which you might order. The actual piece of aluminum which you receive may be as much as .015 inch smaller than .750 (3/4 inch) and in some cases it may be as much as .030 oversize. This is within the industry standard for manufacture of aluminum stock. As we will see in the case of the handle for the hammer, since it only has to fit into the hand of the operator, a wide tolerance is allowed and the "stock" size will be adequate. This means that no machining operations must be performed on the outside of the handle to bring it to size.

The origin of dimensioning. The origin is the point from which dimensions are indicated. It is best, where possible to originate all dimensions from a common point. The center of the part or a corner. We will find in future machine work that in the case of parts which can be held in a vice of some sort, the best origin is at the top left or right corner. This is because the back jaw of a vice, at the top of the part, is fixed in location, so that tolerances can be maintained more easily. Of course many objects which we may machine are complex shapes and the problem of holding them is as troublesome as the origin. In any case the designer must pay attention to this problem.

View sample drawing. The sample drawing is an example of a problem part. It has a very difficult shape to make but even harder to measure. Here are some of the problems.

- The only line which lays along either the X or the Y axis is the line between the .266 and the.328 thru holes. The long side is not truly parallel to an axis as the radii around these thru holes is different. Perhaps it would have been better to make the long side parallel to an axis so that the perpendicular axis would run through the large hole (as it does).
- Note how the two small holes are located. They are an angle and distance off the larger hole. Machines do X and Y and Z moves which are straight lines. They don't do angles very well. An X and Y dimension would have been easier to make and to check.
- The designer did not take advantage of the tolerance schedule (bottom right corner) to save time where the tolerances could be looser.
- The large hole is for a press fit bearing. The tolerance for all dimensions listed on this drawing is +-.01. A press fit bearing in most cases must be +-.0003.

We could go on with problems. Still this part is so difficult that it's drawing may always look complex and be hard to understand. The drawing is best when made with the mechanics of manufacturing in mind.

Finishing with the comment that drawings need not be impressive, but they must be complete and accurate. Just because you can draw a picture of it...doesn't mean you can actually make it. Familiarity with machining techniques will help designers create products which will perform as required and still be reproducible with available facilities.

Cutting Fluids (often referred to as coolants)

Cutting fluids function in the following ways to improve the cutting or machining of metals.

- Cool the cutting tool and the work piece.
- Lubricate the face of the cutting tool and the chip.
- Prevent the adhesion, or pressure welding of a built up edge on the cutting tool. A built up edge is caused by a small metal chip sticking to the cutting edge of a cutting tool.
- Flush away chips.
- Improve the quality of the machined surface.
- Increase tool life by reducing tool wear.
- Permit higher cutting speeds and feeds than those used in dry machining.

Realistically we must consider cutting fluids in the context of the type of machine that we are using and the type of shop we have available. There is no question that machining in flood coolants is best for high production machining. Flood coolant is a coolant which is pumped at a relatively low pressure through nozzles, directly onto the cutting tool and the work from several directions. It is very efficient at all aspects of cutting fluid performance....but......it's very messy especially in older machines not specifically designed for flood coolant.

Most of the work performed in our prototype shop is done at machining rates which are below the maximums. Therefore the best use of cutting fluids, as we use them, is to improve surface finish and improve tool performance. For these purposes we provide two cutting fluids in small containers. The first cutting fluid is a general purpose cutting fluid which can be used on most any metal part with most any tooling. The second cutting fluid is for use on aluminum. The aluminum cutting fluid is for use on aluminum only and must not be used with other metals. When it is used with other metals the result may be rapid oxidation of the part you are working on and the tool and the machine, along with some nasty smelling smoke. The cans of cutting fluid look similar but the cans which are for aluminum are clearly marked with a large "**ALUMINUM**", so there is little excuse for using the wrong fluid. Pay attention to this detail. It may save a part.

When using cutting fluid from a can you should apply a drop or two to the tip of the tool and a small amount to the surface of the material to be cut. Applying too much cutting fluid is not effective and some may be thrown off on you or others. When making cuts it is common to have a light white smoke rise from the cutter or the chips. This is normal and not a problem. The operator can often make two, or sometimes many more, cutting passes with a single application of cutting fluid. Cutting fluid should be reapplied when the surface finish degrades. Cutting fluid is lost in the process.

Now we expand to conversation to include flood coolants. Recent years have brought many changes to the cutting fluids we see in the shop. Most texts are obsolete due to changes in available cutting fluids and EPA and OSHA regulation. News flash....cutting fluids are no longer made from whale oil, lard, pig fat, mineral oils or kerosene. Although all of these materials make fine cutting fluids, they do have their problems from species sensitivity, to flammability, to problems with rancidity.

Flood coolants used in circulating machines are now much more environmentally friendly and they are also biodegradable. They are mostly made of water soluble synthetic oils. Still the used coolant is carefully controlled and should be disposed of by professionals in accordance with procedures on the MSDS. We use cutting fluids which are general purpose so that they can be used with many types of materials. Cutting fluids which are material specific are available and should be used when the same material is machined, all the time. These fluids are optimized for the material for which they are designed and are therefore more efficient. Of course they are not versatile enough for the prototype shop where we may machine any material on any day.

Safety Note: Water based cutting fluids must never be used on magnesium. When water reacts with hot magnesium, hydrogen gas is released which may catch fire, burn vigorously and explode.

Another method of cutting fluid or coolant application is through mist-spray systems. A water based coolant is siphoned into a stream of compressed air. The coolant is atomized and then blown directly on the cutting tool. The evaporation of the coolant in the stream of air provides considerable cooling effect and minimal lubrication. Some chip removal is obtained. The coolant is lost in the process.

Many materials such as brass, bronze, cast iron, malleable iron, plastics and rubber can be machined without cutting fluids or optionally with cutting fluid.