MAC – 141, Machining Applications I

Orientation and Introduction

Introduction

Concept Content:

In this section you will give an introduction of yourself to your class. This is an opportunity to state your relevant experiences and credentials to teach this subject along with your personal background. This can help connecting with students. You can make a video introduction and upload it to this page as well.

Also, this is where you will give a brief overview of the course and what it's contents will be. There is a section later on in this module where you will give more detail about the course.

Course Syllabus

Concept Goals:

Insert the student learning outcomes for the course here.

Concept Content:

This is where you will upload the syllabus. You can do this either by uploading the syllabus text here or you can upload a copy of the syllabus under the resources tab for this section. If you do upload it to the resources, please be sure to give instructions to your students to look for the syllabus there.

Course Resources

Concept Goals:

You can leave this section blank provided you uploaded the student learning outcomes to the

previous section.

Concept Content:

This is where you would outline student support resources such as tutoring services, listing your office ours, contact info for support for your college's learning management system, etc. If there are documents you wish to upload, be sure to upload them to the resources tab and give instructions for the students to find the documents there.

Course Overview

Concept Goals:

After completion of this course, students will be able to:

1. Safe and competent performance of precision measurement, filing, drilling, sawing, turning and milling
2. Ability to anticipate, choose and troubleshoot the proper tooling based on manufacturing requirements
3. Ability to manufacture piece parts and assemblies to specification

Concept Content:

This course provides an introduction to a variety of material-working processes that are common to the machining industry. Topics include safety, process-specific machining equipment, measurement devices, set-up and layout instruments, and common shop practices. Upon completion, students should be able to safely demonstrate basic machining operations, accurately measure components, and effectively use layout instruments.

Instructor Note: Modular vs Unit Set Up

This course was intially set up with 15 moudles on a with each week having a specific project in mind. However, after speaking with other instructors, a set week by week sechedule might not be the best option for a project heavy course such as this one. Students move through projects at their own pace, etc. Thus, it was rearraged into a unit by unit course thus allowing students more freedom to progress at their own pace. However, the original structure of this course has been left in this Odigia shell (it has just been turn to not live so students will not see it). Decide for yourself which layout is best for your student's needs.

Layout of Unit Schedule: **(Instructor note: delete if this is not the layout you will be using)**

Unit	Unit Learning Objectives

Unit 1 Week 1: Machine Shop Safety	• Recognize what bodily hazards are in the work place (SLO 1) • Know the differences between different eye protection devices (SLO 1) • Know how to properly safeguard machines (SLO 1) • Understand how lockout/tagout procedures work (SLO 1)
Unit 1 Week 2: Measurement and Measuring Tools Week 1	• Recognize and use a micrometer (SLO 1) • Recognize and use a dial caliper (SLO 1) • Recognize other common precision measuring instruments (SLO 1) • Have a good grasp on shop math (SLO 1)
Unit 1 Week 3: Measurement and Measuring Tools Week 2	• Recognize various measuring instruments (SLO 1) • Understand tolerance (SLO 1) • Know how to use the Starrett tap drill chart (SLO 1)
Unit 1 Week 4: Intro to Milling	• Have familiarity of cartesian coordinates (SLO 3) • Know how to use an edge finder (SLO 1) • Know basics of machine maintenance (SLO 2) • Know basics of quality assurance (SLO 2) • Know basics of machine operation (SLO 1)
Unit 1 Week 5: Intro to Lathes	• Know basic lathe operations (SLO 1) • Know how to set tool height (SLO 1, SLO 2) • Know the basic lathe tools (SLO 2)
Unit 2 Projects	• Know how to square a vise (SLO 1) • Know how to mill a part to length (SLO 1) • Know how to drill a hole into a piece of work per specifications of a blueprint (SLO 3) • Do the trigonometry needed to successfully plot out the design on a blueprint (SLO 1, SLO 3) • Have knowledge of how to turn a part (SLO 1) • How to turn a part at an angle (SLO 1, SLO 3) • Have some knowledge of using a die on the lathe (SLO 1) • Have some knowledge of parting on a lathe (SLO 1) • Make use of milling and lathe skills as learned in this course (SLO 1, SLO 3)
Unit 3: Final Exam	• Demonstrate understanding of course material

Layout of Modular Schedule **(Instructor note: delete if this is not the layout you will be using)**

Module	Module Learning Objectives
Module 1: Machine Shop Safety	• Recognize what bodily hazards are in the work place (SLO 1) • Know the differences between different eye protection devices (SLO 1) • Know how to properly safeguard machines (SLO 1) • Understand how lockout/tagout procedures work (SLO 1)
Module 2: Measurement and Measuring Tools Week 1	• Recognize and use a micrometer (SLO 1) • Recognize and use a dial caliper (SLO 1) • Recognize other common precision measuring instruments (SLO 1) • Have a good grasp on shop math (SLO 1)

Module 3: Measurement and Measuring Tools Week 2	• Recognize various measuring instruments (SLO 1) • Understand tolerance (SLO 1) • Know how to use the Starrett tap drill chart (SLO 1)
Module 4: Intro to Milling	• Have familiarity of cartesian coordinates (SLO 3) • Know how to use an edge finder (SLO 1) • Know basics of machine maintenance (SLO 2) • Know basics of quality assurance (SLO 2) • Know basics of machine operation (SLO 1)
Module 5: Milling Project 1	• Know how to square a vise (SLO 1) • Know how to mill a part to length (SLO 1) • Know how to drill a hole into a piece of work per specifications of a blueprint (SLO 3)
Module 6: Milling Project 2	• Know how to drill holes into a piece of work per specifications of a blueprint (SLO 3) • Do the trigonometry needed to successfully plot out the design on a blueprint (SLO 1, SLO 3)
Module 7: Mid Term	• Demonstrate understanding of content from the first half of the semester
Module 8: Intro to Lathe	• Know basic lathe operations (SLO 1) • Know how to set tool height (SLO 1, SLO 2) • Know the basic lathe tools (SLO 2)
Module 9: Lathe Project 1	• Have knowledge of how to turn a part (SLO 1)
Module 10: Lathe Project 2	• How to turn a part at an angle (SLO 1, SLO 3)
Module 11: Lathe Project 3	• Have some knowledge of using a die on the lathe (SLO 1) • Have some knowledge of parting on a lathe (SLO 1)
Module 12: Cannon Project Week 1	• Make use of milling and lathe skills as learned in this course (SLO 1, SLO 3)
Module 13: Cannon Project Week 2	• Make use of milling and lathe skills as learned in this course (SLO 1, SLO 3)
Module 14: Cannon Project Week 3	• Make use of milling and lathe skills as learned in this course (SLO 1, SLO 3)
Module 15: Final Exam	• Demonstrate understanding of course material • Complete Cannon Project if not finished

Notes/Helpful Tips

Next Steps…

Your Census assignments are REQUIRED in order to remain in the class and they MUST be completed prior to the Census Date **[insert census date here]**. **If you do not have a census date requirement, you can delete this section.**

Effective note taking is also important for not only this course, but for your career as well. Note taking is a great way to retain information. The process of taking notes can keep you alert and focused on the information being presented. It also keeps your mind engaged with what you are hearing, increasing the likelihood you will retain that information. Note taking can also allow you to better organize your thoughts on the information being discussed.

Here is a video that provides some tips for effective note taking.

Also, here is a list of what tools you will need for the class.

Unit 1 - Introduction to Machining Applications (Weeks 1-5)

Week 1: Machine Shop Safety

Concept Goals:

By the end of this module, you should:

- Recognize what bodily hazards are in the work place (SLO 1)
- Know the differences between different eye protection devices (SLO 1)
- Know how to properly safeguard machines (SLO 1)
- Understand how lockout/tagout procedures work (SLO 1)

Concept Content:

Welcome to the start of the semester! To start off this course, we will go into machine shop safety.

This week's content:

Reading: Embedded below

This week's assignment:

Module 1 Quiz - 10 Questions - located under the assignments tab.

This week we will go over shop safety. Since you will be working with dangerous machines that, if one is not careful, can cause injury or death, it is important for us to go over safety once again. We will cover topics such as eye protection, lock-out-tag-out procedures, and machine safeguarding among others. Next week we will go over mathematics and proper measuring tools.

Wearing the right protective clothing can keep your body safe from many workplace hazards.

Protective clothing can help keep you safe from workplace hazards that can cause bodily injury while performing your Job.

Body Hazards

In an ideal world, employers could eliminate any risk of bodily injury. In situations where risk elimination isn't possible, appropriate body protection helps keep you safe whenever you face the possibility of bodily injury.

Several workplace hazards can cause bodily injury:

- Cuts
- Radiation
- Temperature extremes
- Scalding liquids
- Potential impacts from tools, machinery, and materials
- Hazardous chemicals
- Contact with potentially infectious materials

Protective Clothing

Many types of protective clothing can protect your body from specific hazards:

- Laboratory coats
- Coveralls
- Vests
- Jackets
- Aprons
- Surgical gowns
- Full body suits

OSHA requires that you wear personal protective equipment only for the parts of your body exposed to possible injury.

Full Body Protection

If the hazard assessment indicates a need for full body protection against toxic substances or harmful physical agents, you should keep the following in mind:

- You should inspect protective clothing carefully before each use.
- Protective clothing must fit properly.
- Protective clothing must function properly.
- Protective clothing must function for its intended purpose.

Protective Clothing Materials Protective clothing, just like the everyday clothes you wear, comes in a

variety of materials:

- Paperlike fiber
- Treated wool and cotton
- Cotton duck
- Leather
- Other synthetic materials Each material works to protect you from a specific hazard.

Paperlike Fiber

Paperlike fiber is used for disposable suits and protects you from airborne dust and splashes.

This material is used in a variety of work environments, including food processing and pharmaceutical manufacturing.

Treated Wool and Cotton

Treated wool and cotton adapts well to changing temperatures. It's also comfortable and fire-resistant and protects against airborne dust, abrasions, and rough and irritating surfaces.

Cotton Duck

Cotton duck is a closely woven cotton fabric that protects against cuts and bruises when handling heavy, sharp, or rough materials.

Jackets and vests made of cotton duck are thermally insulated so that they can be used in low temperature environments.

This material is so durable that military tents are sometimes made from it.

Leather

Leather protects against dry heat and flames.

Other Synthetic Materials

Other synthetic materials include rubber, rubberized fabrics, neoprene, and plastics.

These materials provide excellent protection from a variety of hazards, including certain chemicals, acids, and physical hazards. They also protect against cuts, slashes, and abrasions.

Synthetic materials are typically used in firefighters' suits, chemical gloves, and sanitation aprons.

Training Employees to Use and Care for Body Protection

Employers are required to train employees on the use and care of body protection, as well as the following topics:

- Why protective clothing is necessary
- How protective clothing protects employees
- Limitations of body protection

- Why employees must wear protective clothing
- How to properly put on PPE
- How to adjust parts for a comfortable and effective fit
- How to identify signs of wear
- How to clean and disinfect PPE
    - Signs of wear include rips, tears, scuffs, and loss of elasticity in tight-fitting parts.

1910.133

Employers must provide eye protection for employees whenever they are exposed to potential eye injuries during their work if engineering or work practice controls do not eliminate the risk of injury.

Eye and face PPE purchased after July 5, 1994 must comply with ANSI Z87.1-1989, American National Standard Practice for Occupational and Educational Eye and Face Protection, and must be distinctly marked to facilitate identification of the manufacturer.

Things to remember

- Workplace hazards that can cause bodily injury include temperature extremes, hot metals, scalding liquids, body fluids, hazardous materials or waste, radiation, cuts from sharp objects, and potential impacts from tools, machinery, and materials.
- Protective body clothing includes laboratory coats, coveralls, vests, jackets, aprons, surgical gowns, and full body suits.
- OSHA requires that you wear personal protective equipment only for the parts of your body exposed to possible injury.
- Employers are required to train employees on the use and care of body protection.
- Body Protection

What are some of the causes of eye injuries?

- Dust and other flying particles, such as metal shavings or sawdust
- Molten metal that might splash
- Acids and other caustic liquid chemicals that might splash
- Blood and other potentially infectious body fluids that might splash, spray, or splatter
- Intense light such as that created by welding and lasers

Safety Spectacles

- Made with metal/plastic safety frames
- Most operations require side shields
- Used for moderate impact from particles produced by such jobs as carpentry, woodworking, grinding, and scaling

figure: Safety Spectacles

Goggles

- Protect eyes, eye sockets, and the facial area immediately surrounding the eyes from impact, dust, and splashes
- Some goggles fit over corrective lenses

figure: Goggles

Corrective lenses include contacts and glasses.

Welding Shields

Protect eyes from burns caused by infrared or intense radiant light, and protect face and eyes from flying sparks, metal spatter, and slag chips produced during welding, brazing, soldering, and cutting

figure: Welding Shields

1910.133(a)(5)

Also see 1910 Subpart Q, Welding, Cutting & Brazing.

Laser Safety Goggles

Protect eyes from intense concentrations of light produced by lasers.

figure: Laser Safety Goggles

Face Shields

- Protect the face from nuisance dusts and potential splashes or sprays of hazardous liquids
- Do not protect employees from impact hazards

figure: Face Shield

Whenever you use machines, you risk machinery-related injuries, such as crushed hands, severed limbs, and blindness.

However, you can follow safety guidelines and use machine guards to help protect yourself from dangerous machine motions and action.

Whenever you use machines, you risk machinery-related injuries, such as crushed hands, severed limbs, and blindness. However, you can follow safety guidelines and use machine guards to help protect yourself from dangerous machine motions and action.

Basics of Machine Safeguarding

Machines and their moving parts can cause many workplace injuries, such as crushed hands, severed limbs, and blindness. Safety systems are essential because they protect workers from needless and preventable injuries.

A good rule is to safeguard any machine parts, function, or process that may cause injury. When machine operation or accidental contact can potentially harm you, you must control or eliminate the hazard.

First Things First: Training

Even the most elaborate safeguarding system can't protect you unless you know how to use it and why to use it. Specific and detailed training is a crucial part of safeguarding against machine-related

hazards. Before you use a machine, you must attend safety or OSHA training.

Training should occur when

- New operators or maintenance or setup personnel are hired.
- Any new or altered safeguards are put into service.
- Workers are assigned to a new machine or operation.

Training

Training should be both instructional and hands-on. It should cover the following topics:

- Description and identification of the hazards associated with particular machines
- How and why to use safety systems
- Where safety systems are located, how they provide protection, and what hazards they protect against
- How, when, and who can remove guards
- Procedures to follow if you see damaged, missing, or inadequate guards

Clothing Safety Guidelines

The clothing and accessories you wear to operate a machine can impact your safety. Even if your workplace has no clothing restrictions, you need to follow these guidelines for safety reasons:

- Remove ties, rings, watches, and other jewelry.
- Wear close-fitting clothing.
- Tie back long hair.
- Wear proper shoes to protect your feet.
- Wear approved eye protection with side shields.
- Wear other personal protective equipment (PPE) when appropriate.

Mechanical Hazards

Dangerous moving parts that require safeguarding fall into three basic areas:

- Point of operation
- Power transmission apparatus
- Other moving parts

Point of Operation

The point of operation is the place where the actual work on materials, such as cutting, shaping, boring, or forming of stock, is performed.

Power Transmission Apparatus

Power transmission apparatus consists of all components of the mechanical system that transport energy to the part of the machine performing the work. These components include

- Flywheels
- Pulleys
- Belts
- Connecting rods

- Couplings
- Cams
- Spindles
- Chains a Cranks
- Gears

Other Moving Parts

All parts of a machine that are moving while the machine is working are dangerous. The following components should be safeguarded:

- Reciprocating parts
- Rotating parts
- Transverse moving parts
- Feed mechanisms
- Auxiliary parts of machine

Hazardous Mechanical Motions and Actions

Mechanical motions and actions present a wide variety of hazards. Recognizing hazardous mechanical motions and actions is an important first step toward protecting yourself from their dangers.

These hazardous mechanical motions and actions appear in varying combinations on nearly all machines:

- Movement of rotating members
- Reciprocating arms
- Moving belts
- Meshing gears
- Cutting teeth
- Any parts that impact or shear

Motions

Dangerous types of motions include

- Rotating (including in-running nip points)
- Reciprocating
- Transverse

Rotating Motions

Rotating motions, where a part moves in a circle around an axis or center, can be dangerous. Even smooth, slowly rotating shafts can grab clothing.

It doesn't take much to cause an accident. Mere skin contact can force an arm or hand into a dangerous position, causing severe injuries.

Examples of common rotating mechanisms include

- Collars

- Couplings a Cams
- Clutches
- Flywheels
- Shaft ends
- Spindles
- Meshing gears
- Horizontal or vertical shafting
    - The danger increases when projections, such as set screws and bolts, are exposed.

In-Running Nip Points

In-running nip points are also called pinch points. They occur when two parts of a machine move together and at least one of the parts moves in a rotary or circular motion.

Nip points come in three main types.

One type of nip point occurs when parts rotate in opposite directions while the axes are parallel. A nip point is produced when they make contact or when the stock fed between the rolls produces the nip points.

This type of nip point is common on machines with intermeshing gears, rolling mills, and calendars.

Rotating and tangentially moving parts also create nip points. Examples of this type of nip point include

- The point of contact between a power transmission belt and its pulley
- A chain and a sprocket
- A rack and pinion

Another type of nip point occurs between rotating and fixed parts, creating a shearing, crushing, or abrading action. Examples include

- Spoked hand heels or flywheels
- Screw conveyors
- Periphery of abrasive wheel
- Incorrectly adjusted work rest

Reciprocating Motions

In a reciprocating motion, a part moves back and forth or up and down. As a result, you risk being struck or caught between a moving and stationary part.

Transverse Motions

A transverse motion is a movement in a straight, continuous line. A transverse motion creates a hazard because the moving part may strike or catch you in a pinch or shear point.

Actions

Several types of actions pose hazards:

- Cutting

- Punching
- Shearing
- Bending

Cutting

A cutting action cuts material and may involve a rotating, reciprocating, or transverse motion. The danger is at the point of operation where finger, arm, and body injuries can occur and where flying chips or scrap material can strike your head, particularly in the area of your eyes or face.

Cutting wood, metal, or other material exposes you to this type of action.

Examples of mechanisms involving cutting hazards include

- Bandsaws
- Circular saws
- Boring or drilling machines
- Turning machines (lathes)
- Milling machines

Punching

A punching action occurs when power is applied to a slide (ram) with the goal of blanking, drawing, or stamping metal or other materials.

The danger occurs at the point of operation where stock is inserted, held, or withdrawn by hand.

Power presses and iron workers are examples of machines that use punching operations.

Shearing

In a shearing action, power is applied to a slide or knife to trim or shear metal or other materials.

The hazard occurs at the point of operation where stock is inserted, held, or withdrawn.

An example of a machine used for shearing is mechanically, hydraulically, or pneumatically powered shears.

Bending Action

In a bending action, power is applied to a slide to draw or stamp metal or other materials.

The hazard occurs at the point of operation where stock is inserted, held, or withdrawn.

Machines that use a bending action include power presses, press brakes, and tubing benders.

Requirements for Safeguards

Guards work in different ways, but they must all meet these minimum general requirements:

- Prevent contact
- Be secure
- Protect from falling objects

- Create no new hazards
- Create no interference
- Allow safe lubrication

Prevent Contact

A safeguard must prevent your hands, arms, and other parts of your body from making contact with dangerous moving parts.

A good safeguarding system eliminates the possibility of you placing parts of your body near hazardous moving parts.

Be Secure

A good safeguard should be secure enough that it's not easily removed or tampered with. A safeguard that can easily be made ineffective is no safeguard at all.

Guards should be made of durable material so that they can withstand normal use. They also must be firmly secured to the machine.

Protect from Falling Objects

Safeguards should ensure that no objects fall into moving parts. Even a small tool dropped into a cycling machine can become a projectile and strike and injure someone.

Create No New Hazards

A safeguard should create no new hazards, such as a shear point, a jagged edge, or an unfinished surface that can cause a cut. For example, the edges of guards should be rolled or bolted to eliminate sharp edges.

Create No Interference

If a safeguard prevents you and other workers from performing your job quickly and comfortably, it may be ignored. Proper safeguarding actually enhances efficiency because it relieves anxiety about injury.

- A dirty guard may block your view of your work.

Allow Safe Lubrication

Whenever possible, a safeguard should allow you to lubricate a machine without removing it. For example, oil reservoirs located outside the guard reduce the need for the operator or maintenance worker to enter the hazardous area.

Methods of Machine Safeguarding

A machine can be safeguarded in many ways. The following factors help determine the appropriate method:

- Type of operation
- Size or shape of stock
- Method of handling

- Physical layout of work area
- Type of material
- Production requirements or limitations

As a general rule, fixed guards that enclose the danger areas best protect the power transmission apparatus.

Because hazards at point of operation have several safeguarding options, choose the most effective and practical means available.

General Classifications of Safeguards

OSHA groups safeguards under five general classifications:

- Guards
- Devices
- Location/distance
- Potential feeding and ejection methods
- Miscellaneous aids

This chapter focuses on guards.

Machine Guards

A machine guard is a physical barrier designed to keep you away from a dangerous part of a machine while it's operating.

OSHA groups machine guards into four general types:

- Fixed
- Adjustable
- Self-adjusting
- Interlocked

Fixed Guard

A fixed guard is a permanent part of the machine. It has no moving parts and forms a barrier that prevents contact between the machinery and your body. It allows for stock feeding, but it doesn't let you reach the danger area.

Not only is in-plant construction possible, but a fixed guard can be constructed to suit many specific applications.

Fixed guards may be made of sheet metal, screen, wire cloth, plastic, or any other material substantial enough to withstand impact and prolonged use.

A cover over moving gears is one example of a fixed guard.

Adjustable Guard

An adjustable guard is a barrier that you can customize, or adjust, for a variety of production operations. This type of guard gives you the flexibility to adjust the barrier to accept different sizes of stock.

Advantages of an adjustable guard include the following:

- It can be constructed to suit many specific applications.
- It can be adjusted to fit varying sizes of stock.

Adjustable Guard

Like a fixed guard, an adjustable guard also has limitations:

- It can be limited to specific operations.
- Because hands may enter the danger area, protection isn't complete at all times.
- It may require frequent maintenance or adjustment.
- The operator can make the guard ineffective.
- It may interfere with visibility.

Self-Adjusting Guard

A self-adjusting guard places a barrier between the danger area and the operator and is in place all the time.

This type of guard automatically adjusts to the stock size. When the stock enters the point of operation, the guard moves to provide an opening just big enough to admit the stock. After you remove the stock, the guard returns to its rest position.

Self-adjusting guards are made of plastic, metal, or other substantial material.

While self-adjusting guards are often commercially available, they don't always provide maximum protection against hazards. They may also require frequent maintenance and adjustment.

Interlocked Guard

An interlocked guard prevents a machine from operating automatically. Whenever an interlocked guard is opened or removed, the machine's power shuts off or disengages. The machine can't cycle or restart until the guard is back in place.

An interlocked guard may use electrical, mechanical, hydraulic, or pneumatic power or any combination.

An interlocked guard offers several advantages:

- It can provide maximum protection against hazards.
- It allows access to the machine for removing jams without the time-consuming removal of fixed guards.

An interlocked guard has several limitations:

- It may require careful adjustment and periodic maintenance.
- It can't use movable sections for manual feeding.
- Some designs are easy to defeat.
- Interlock control circuitry may not be used for all maintenance and servicing work.
- It may be easy to disengage jams.

Things to remember

- Machines and their moving parts can cause many workplace injuries.
- A good rule is to safeguard any machine parts, function, or process that may cause injury.
- Training is an essential part of safeguarding because even the most elaborate safeguarding system can't protect you unless you know how to use it and why to use it.
- Before you operate a machine, you should receive the proper training on its setup and operation.
- The clothing and accessories you wear to operate a machine can impact your safety.
- Always remove ties, rings, watches, and other jewelry when operating a machine.
- The point of operation is the place where the actual work on materials is performed.
- Recognizing hazardous mechanical motions and actions is an important first step toward protecting yourself from their dangers.
- Rotating, reciprocating, and transverse motions are all dangerous.
- In-running nip points, which are also called pinch points, occur when two parts of a machine move together and at least one of the parts moves in a rotary or circular motion.
- A safeguard that can easily be made ineffective is no safeguard at all.
- Proper safeguarding actually enhances efficiency because it relieves anxiety about injury.
- A machine guard is a physical barrier designed to keep you away from a dangerous part of a machine while it's operating.
- Machine guards come in four major types: fixed, adjustable, self-adjusting, and interlocked.
- An interlocked guard prevents the machine from operating automatically if the guard is opened or removed. It shuts off or disengages the machine's power.

Machine Safety

In this chapter, you discovered the type of clothing to wear when operating a machine, as well as the safety guidelines to follow. You also learned about the types of machine guards.

Introduction

Crushed hands and arms, severed fingers, blindness - the list of possible machinery-related injuries is as long as it is horrifying. Safeguards are essential for protecting workers from needless and preventable injuries.

A good rule to remember is: Any machine part, function, or process which may cause injury must be safeguarded.

Where the operation of a machine can injure the operator or other workers, the hazard must be controlled or eliminated.

Causes of Machine Accidents

Reaching in to “clear” equipment

Not using Lockout/Tagout

Unauthorized persons doing maintenance or using the machines

Missing or loose machine guards

Where Mechanical Hazards Occur

Point of operation

All parts of the machine which move, such as:

- flywheels, pulleys, belts, couplings, chains, cranks, gears, etc.
- feed mechanisms and auxiliary parts of the machine

In-running nip points

Point of Operation

That point where work is performed on the material, such as cutting, shaping, boring, or forming of stock must be guarded.

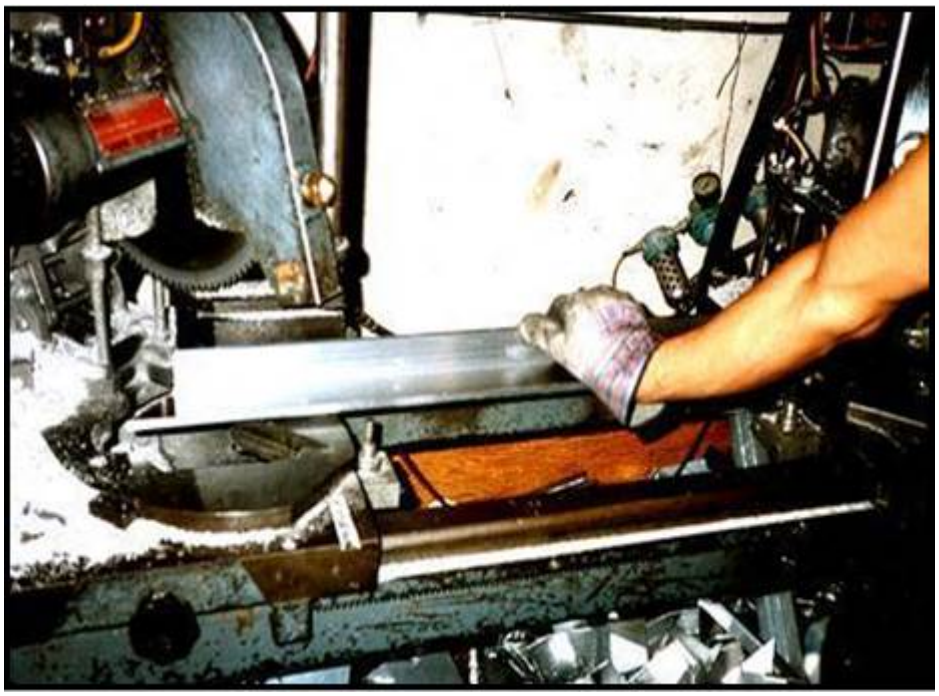


figure: Point of Operation

1910.212(a)(3)(i) & (ii)

Rotating Parts

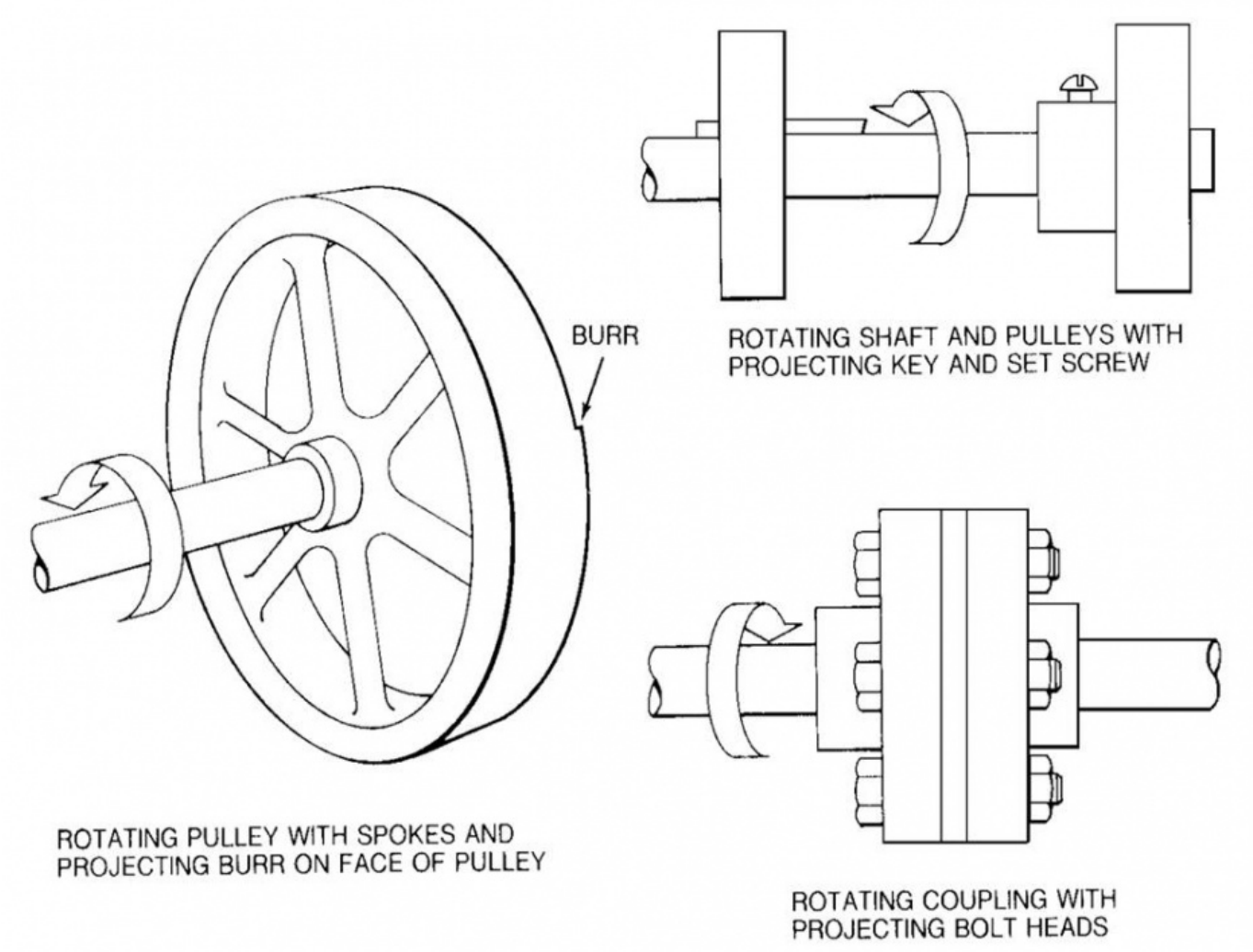


figure: Rotating Parts

In-Running Nip Points

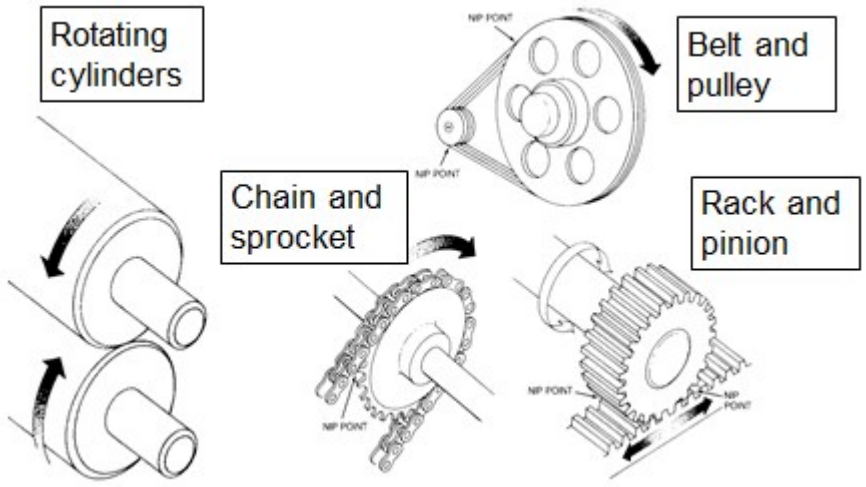


figure: In-Running Nip Points

In-running nip point hazards are caused by the rotating parts on machinery. There are three main types of in-running nips.

Parts can rotate in opposite directions while their axes are parallel to each other. These parts may be in contact (producing a nip point) or in close proximity to each other (where the stock fed between the rolls produces the nip points). This danger is common on machinery with intermeshing gears and rotating cylinders.

Another type of nip point is created between rotating and tangentially moving parts; for example, a chain and a sprocket, a rack and pinion, or the point of contact between a power transmission belt and its pulley.

Nip points can also occur between rotating and fixed parts which create a shearing, crushing, or abrading action; for example, spoked handwheels or flywheels, screw conveyors, or the periphery of an abrasive wheel and an incorrectly adjusted work rest.

Requirements for Safeguards

Prevent contact - prevent worker's body or clothing from contacting hazardous moving parts

Secure - firmly secured to machine and not easily removed

Protect from falling objects - ensure that no objects can fall into moving parts

Create no new hazards - must not have shear points, jagged edges or unfinished surfaces

Create no interference - must not prevent worker from performing the job quickly and comfortably

Allow safe lubrication - if possible, be able to lubricate the machine without removing the safeguards

Prevent Contact - A good safeguarding system eliminates the possibility of the operator or other workers placing parts of their bodies near hazardous moving parts.

Secure - A safeguard that can easily be made ineffective is no safeguard at all. Guards and safety devices should be made of durable material that will withstand the conditions of normal use and be firmly secured to the machine.

Protect from falling objects - A small tool which is dropped into a cycling machine could easily become a projectile that could strike and injure someone.

Create no new hazards - A safeguard defeats its own purpose if it creates a hazard of its own such as a shear point, a jagged edge, or an unfinished surface which can cause a laceration. The edges of guards, for instance, should be rolled or bolted in such a way that they eliminate sharp edges.

Create no interference - Any safeguard which impedes a worker from performing a job quickly and comfortably might soon be overridden or disregarded. Proper safeguarding can actually enhance efficiency since it can relieve the worker's apprehensions about injury.

Allow safe lubrication - Locating oil reservoirs outside the guard, with a line leading to the lubrication point, will reduce the need for the worker to enter the hazardous area.

Methods of Machine Safeguarding

Guards

- fixed
- interlocked
- adjustable
- self-adjusting

Devices

- presence sensing
- pullback
- restraint
- safety controls (tripwire cable, two-hand contol, etc.)
- gates

Location/distance

Feeding and ejection methods

- automatic and/or semi-automatic feed and ejection
- robots

Miscellaneous aids

- awareness barriers
- protective shields
- hand-feeding tools

Fixed Guard

Provides a barrier - a permanent part of the machine, preferable to all other types of guards.

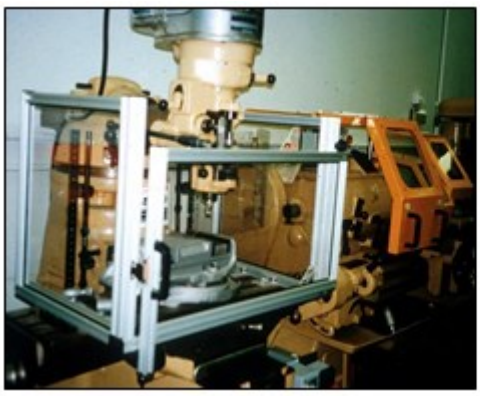


figure: Fixed Guard

1910.212(a)(2)

As a general rule, power-transmission apparatus is best protected by fixed guards that enclose the danger area. For hazards at the point of operation, where moving parts actually perform work on stock, several kinds of safeguarding are possible.

Interlocked Guard

When this type of guard is opened or removed, the tripping mechanism and/or power automatically shuts off or disengages, and the machine cannot cycle or be started until the guard is back in place.

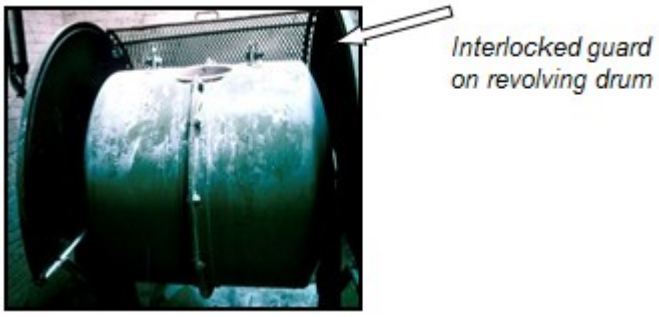


figure: Interlocked guard on revolving drum

An interlocked guard may use electrical, mechanical, hydraulic, or pneumatic power or any combination of these. Interlocks should not prevent “inching” by remote control, if required. Replacing the guard should not automatically restart the machine.

Adjustable Guard

Provides a barrier which may be adjusted to facilitate a variety of production operations.

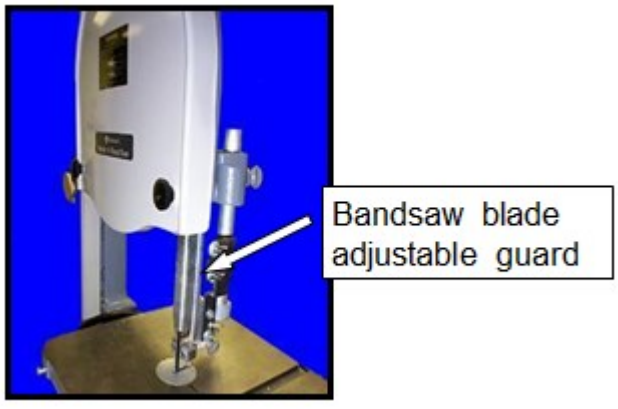


figure: Bandsaw blade adjustable guard

Adjustable guards are useful because they allow flexibility in accommodating various sizes of stock, but, because they require adjusting, they are subject to human error.

Self-Adjusting Guard

Provides a barrier which moves according to the size of the stock entering the danger area.

figure: Circular table saw self-adjusting guard

Self-adjusting guards avoid the potential for human error associated with adjustable guards.

Control of Hazardous Energy

- Know when the control of hazardous energy is required.
- Describe the role of an authorized employee in a LOTO program.
- Explain the difference between Lock out and Tag out
- Describe the various sources of energy that may be found in machinery
- List the procedures for LOTO
- List the procedures for release from LOTO
- Describe how to verify that a machine is at a zero energy state.
- List the procedural steps to follow for testing and positioning machines.
- Explain the difference between group and individual lockout.

When is the control of Hazardous energy required?

- When an employee is required to remove or bypass a guard or other safety device
- When an employee is required to place any part of their body into an area in a machine or piece of equipment at the point of operation.
- When an associated danger zone exists during a machine operating cycle.

Who is an “authorized employee”?

- An authorized employee is a person who locks or implements a tagout system procedure on machines or equipment to perform the servicing or maintenance on that machine or equipment.

What are their responsibilities?

- Notify Affected employees before LOTO is applied
- Follow the established LOTO procedures

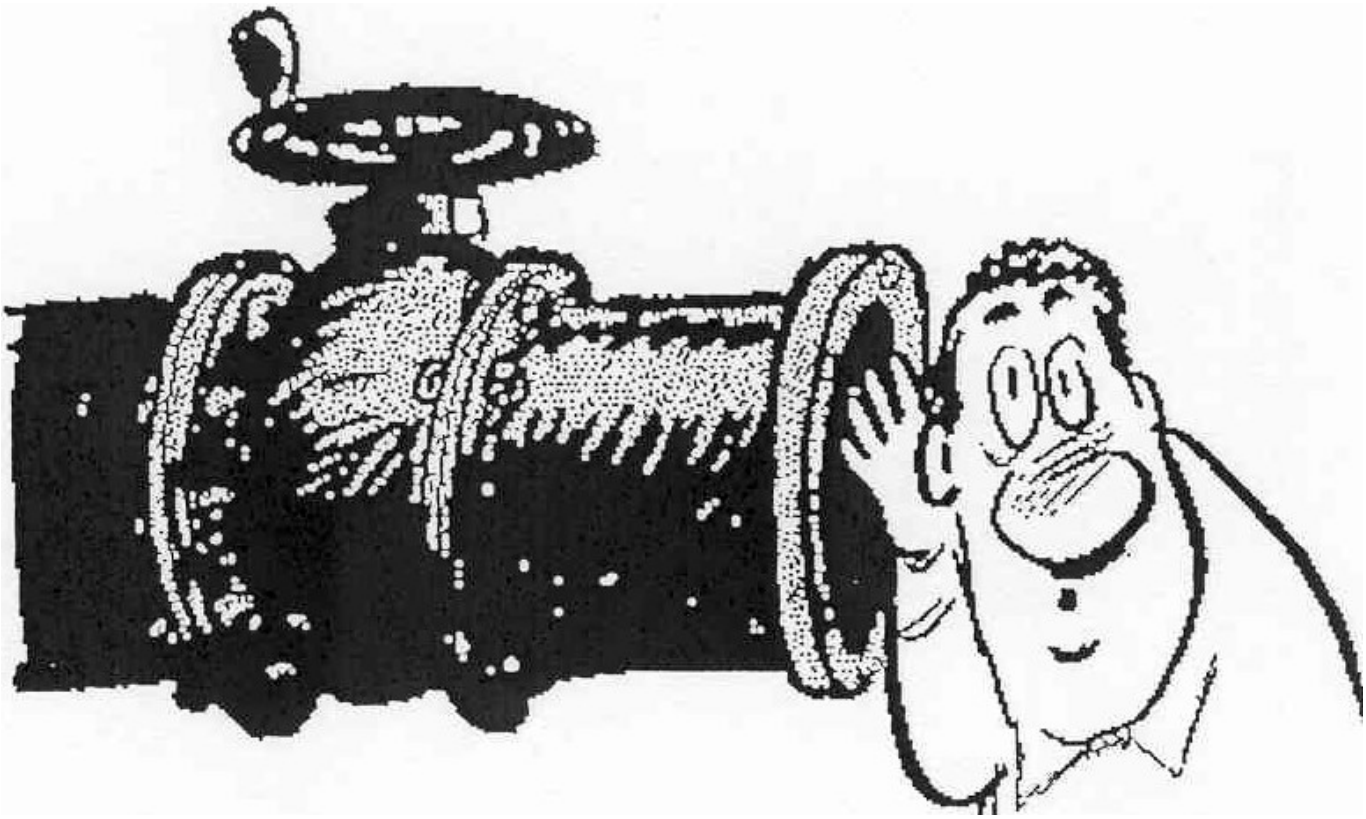
- Notify the employer of machinery or equipment not capable of being locked out
- Remove only the LOTO devices which you apply
- Never remove a lock with bolt cutters.

What's the difference between Lockout and Tagout? Which is better?

- Lockout – The placement of a device that utilizes a positive means such as a lock, on an energy-isolating device ensuring that the device and the equipment being controlled cannot be operated until the device is removed.
- Tagout – The placement of a prominent warning device, such as a tag and means of attachment, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.
- Which is better?

Safety Training

Types of Hazardous Energy



Lock and Tag ALL sources of energy

- Electrical
- Thermal

- Gravitational
- Chemical
- Stored
- Motion
- Hydraulic
- Pneumatic

What kinds of energy might be found in manufacturing equipment?

- Electrical Hydraulic
- Pneumatic Pressure Other forms of pressure
- Potential Energy
- Thermal Energy Kinetic Energy
- Chemical Energy

How Many Locks & **Tags?**

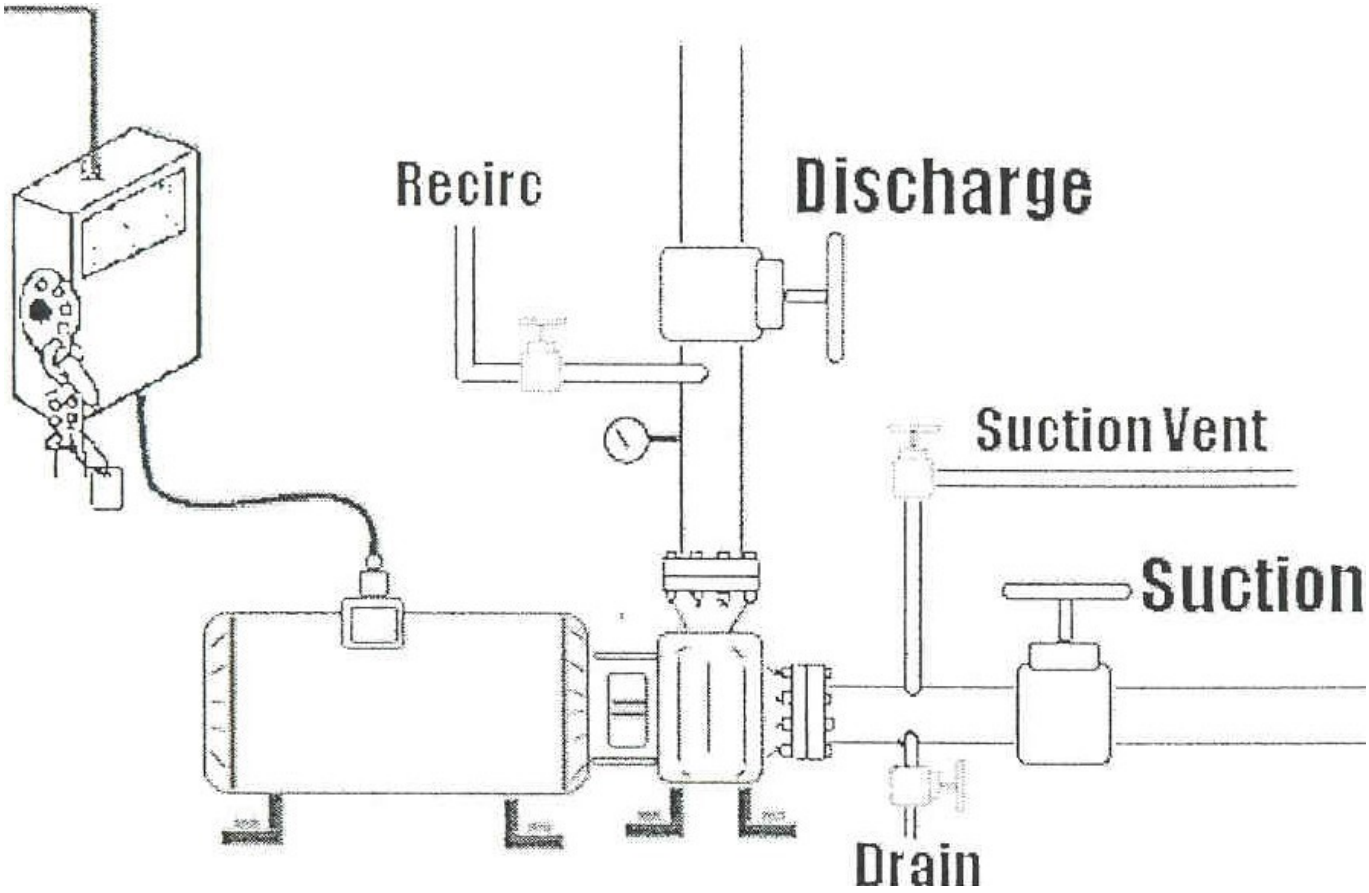


figure: How Many Locks & Tags?

What possible hazards exist?

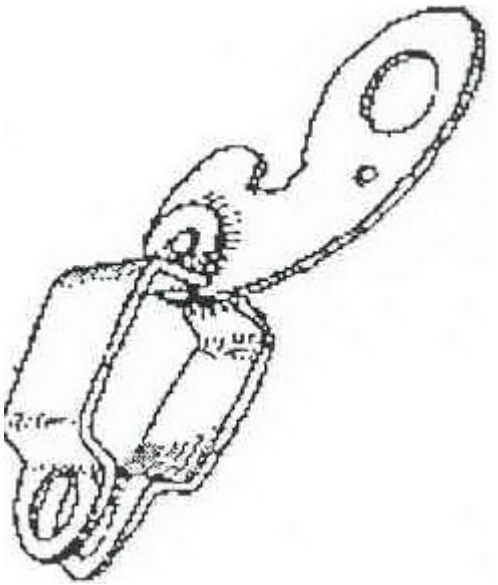
Safety Training

6 Steps for Lockout Tagout

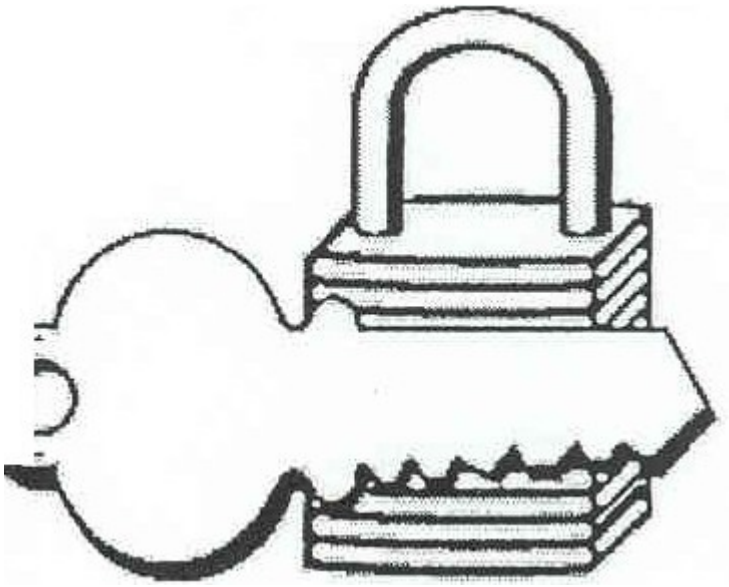
Rule # 1: Know the Equipment

Rule #2: Know the Energy Sources

1. Notify all affected Employees
2. Conduct a Normal Shutdown



1. Place all controls in off & shut all control valves
2. lnstall Lockout - Tagout Devices & Tags



1. Release Stored Energy
2. Verify lsolation

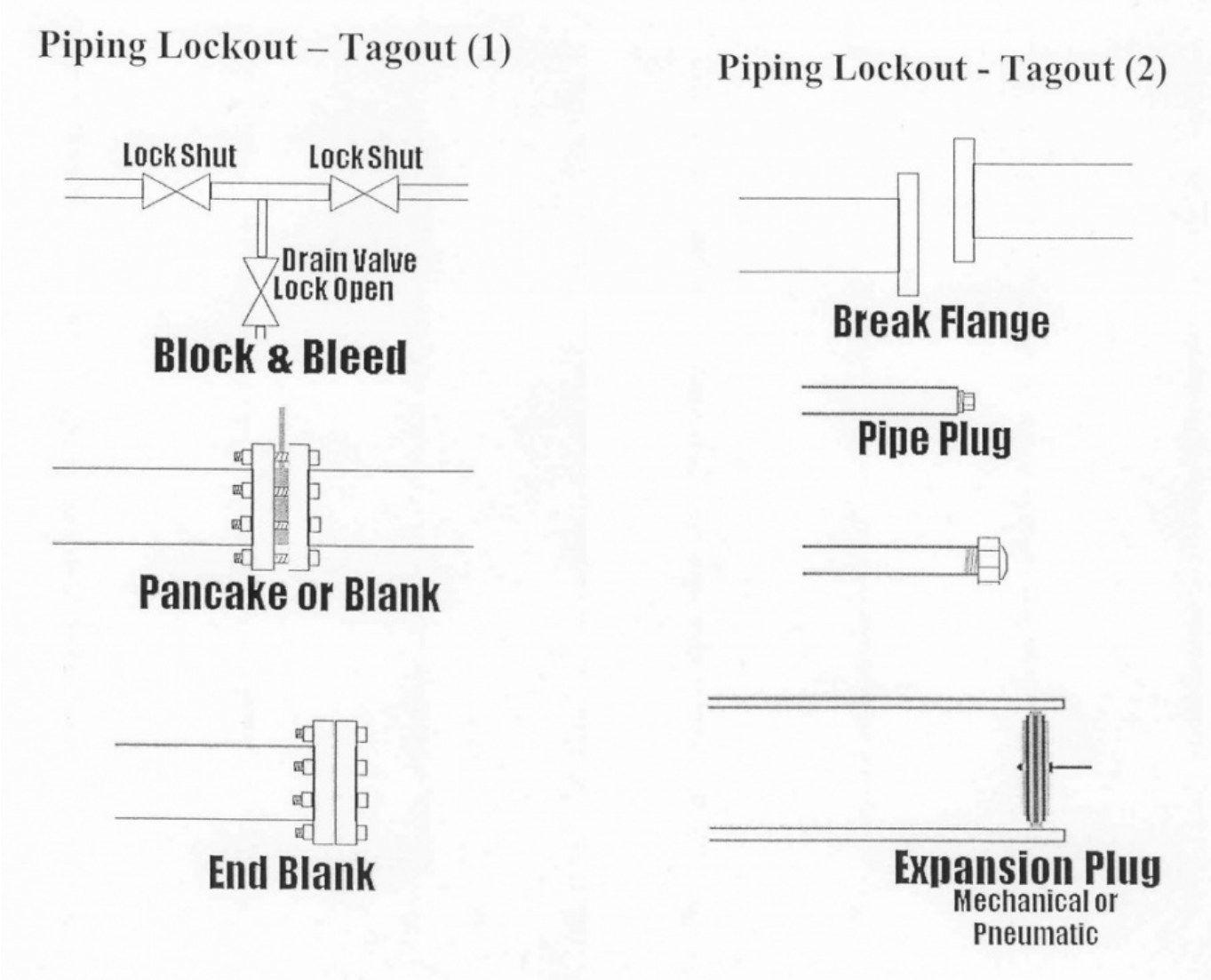


figure: Piping Lockout

Release for Lockout Tagout

- Inspect the work area
- Initial Employee notification
- Removal of Lockout Tagout devices
- Final Employee notification
- Follow machine specific startup procedures

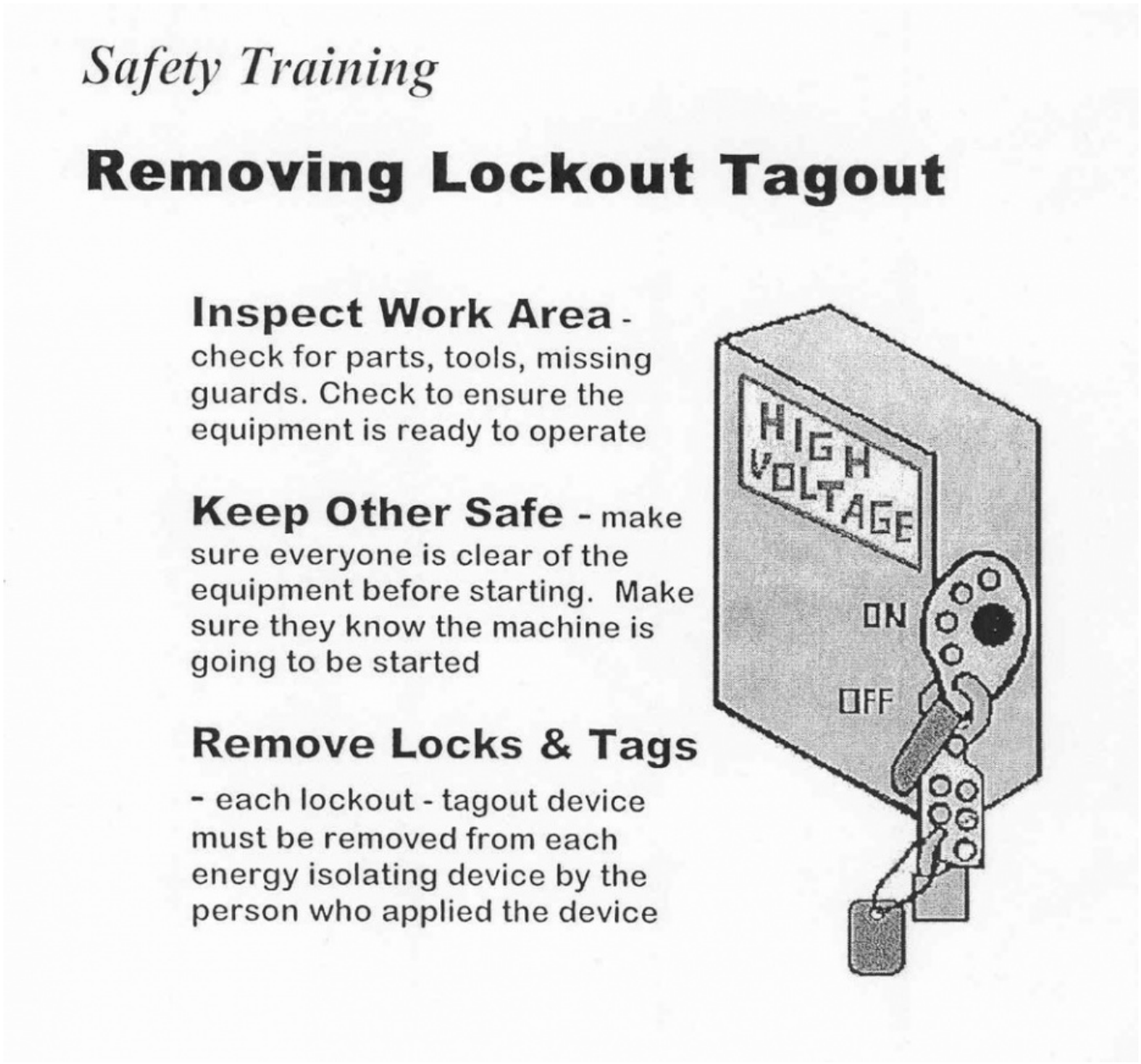


figure: Remove Lockout Tagout

Testing or positioning machines or equipment

- Inspect the work area
- Initial Employee notification
- Removal of Lockout Tagout
- Final Employee notification
- Energize and proceed with test
- De-energize all systems and proceed with energy control procedures for application of lockout tagout

Group Lockout or Tagout

This is what you do if several people are going to be working on Or around a piece of equipment.

1. One person is designated to take primary responsibility to coordinate the affected work

and ensure continuity of protection for all

2. The designated employee is responsible to coordinate activities for the entire group to ensure that the application of lockout or tagout

procedures are followed

3. The designated employee has primary responsibility for Providing the group lockout and/or tagout device and all employee

notification

4. When several shifts are involved it is the responsibility of the designated employee to communicate with the upcoming shift personnel to ensure that the continuity of protection is maintained during service or maintenance.

What to do if you have a machine with multiple energy sources?

• Identify the ZESP(Zero Energy State Procedure) before lockout tagout procedures begin. Departments possessing machinery or equipment that utilizes two or more energy sources shall develop a ZESP.
• Use the ZESP to apply energy controls
• Verify that no other energy sources exist
• Perform service
• Release the energy controls following the procedure for Release from lockout or tagout.

Outside Contractors

• Outside contractors are to be informed of the companies hazardous energy control requirements and are expected to follow the same basic program.

Week 2: Measurement and Measuring Tools Week 1

Concept Goals:

By the end of this module, you should:

- Recognize and use a micrometer (SLO 1)
- Recognize and use a dial caliper (SLO 1)
- Recognize other common precision measuring instruments (SLO 1)
- Have a good grasp on shop math (SLO 1)

Concept Content:

This week, we will discuss measurement and measuring tools.

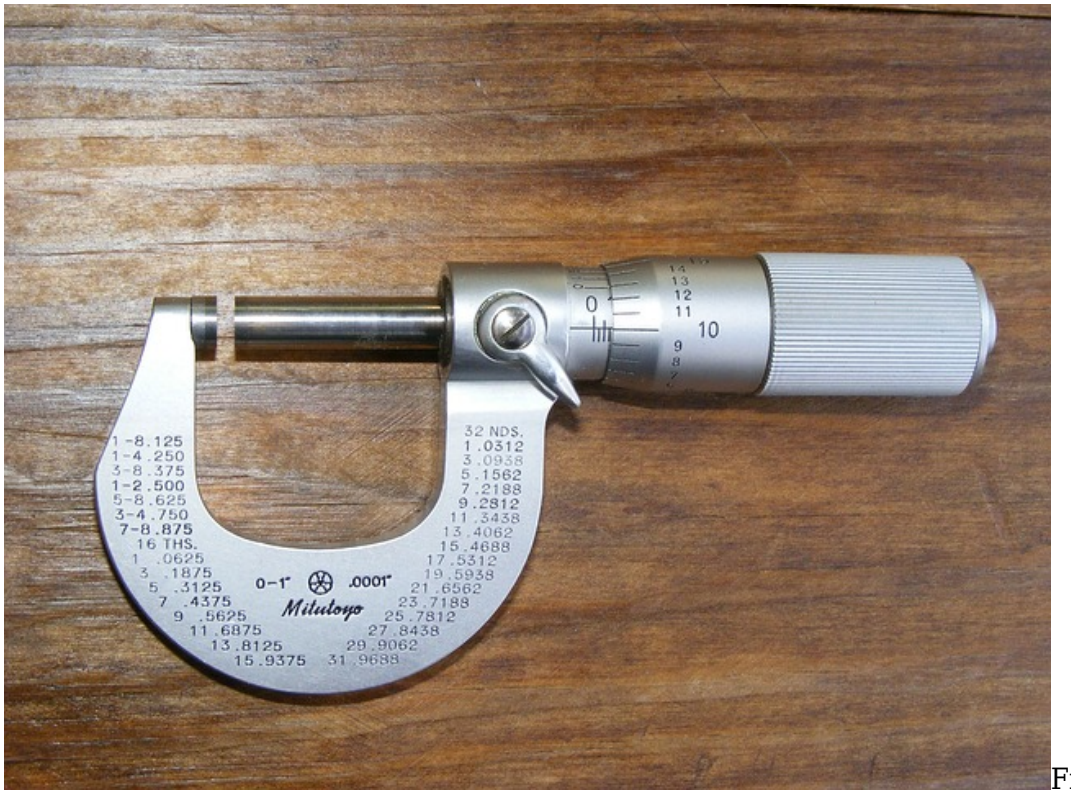


Figure 1: Via Image by Charles Risen from Pixabay

Welcome to week two everyone! As a warmup, let us look at the image above. Have you ever seen this tool before? If so, can you name it? And if you have not, can you guess what it is? Make your guess and keep this image in mind as we go talk about measuring tools.

This week we will cover measurement and measuring tools. In order to operate machines properly, one must be able to do math, measure accurately, and know how to use various measuring tools. These tools include micrometers and dial calipers. Both of these tools, along with others, are foundational to machining shop operations. The content for this week will go over the type of math you will need in the shop and an introduction to the various tools you will be using.

This week's content:

Lectures:

Introduction to Measurement - 14 Slides

Measuring Tools - 9 Slides

Measuring Tools and Measurement - 98 Slides

Videos:

How to Read a Micrometer - 5 Minutes

Calibrating a Depth Micrometer - 2 Minutes

Activities:

How to Read a Dial Caliper - Interactive Activity

Assignments:

Module 2 Quiz - 10 Questions

Week 3 Measurement and Measuring Tools Week 2

Concept Goals:

By the end of this module, you should:

- Recognize various measuring instruments (SLO 1)
- Understand tolerance (SLO 1)
- Know how to use the Starrett tap drill chart (SLO 1)

Concept Content:

This week we will conclude our two-part unit on measurement and measuring instruments. We will discuss concepts such as size determination and tolerance, and going over measuring tools beyond micrometers and dial calipers. Due to the amount of content related to measurement and measuring instruments, this section was stretched to over two weeks.

This week's content:

Lectures:

Size Determination and Tolerance - 10 Slides

Scale Instruments - 10 Slides

Gauge Blocks - 15 Slides

Videos:

Reading the Starrett Tap Drill Chart - 3 Minutes

Machinist Measuring Tools - 45 Minutes

Reading: Embedded below.

Assignments:

Micrometer Worksheet - Download from resource tab

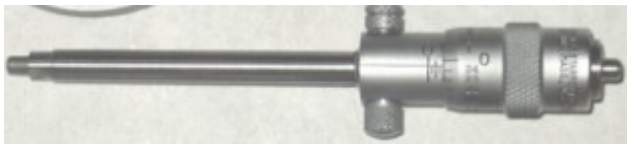
Caliper Worksheet - Download from resource tab

Once you have completed both worksheets, upload a completed copy of them to the assignments tab.

Reading:

A tubular-style inside micrometer.

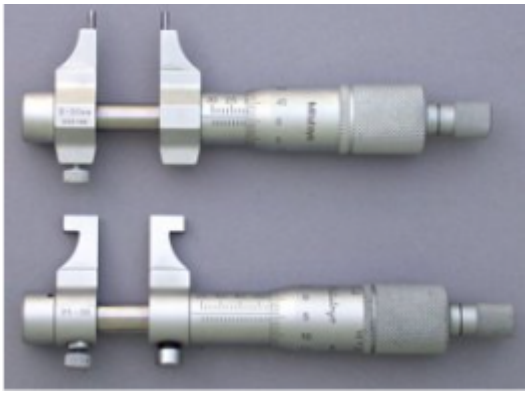
A rod-style inside micrometer.



Inside Micrometer

Taking a measurement using an inside micrometer.

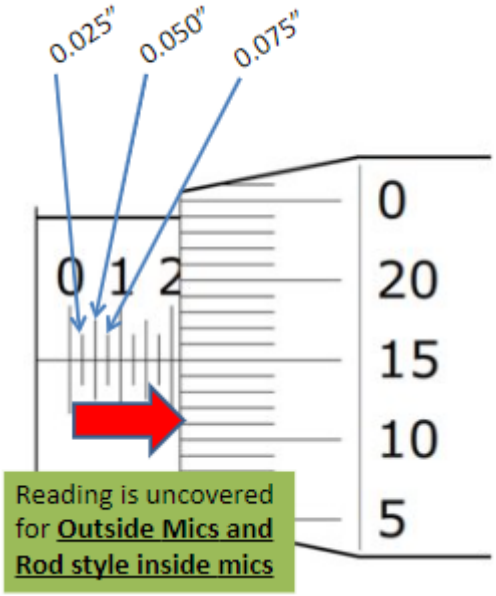
A depth micrometer with rods for different size ranges.



Internal Micrometer Calipers

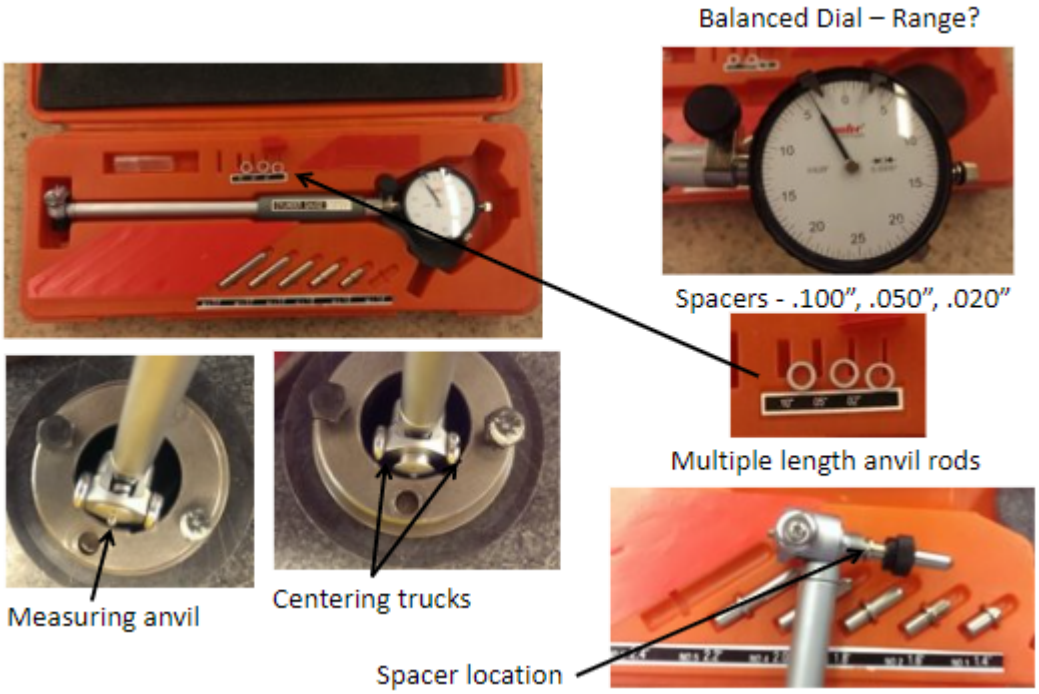
Review of Outside Micrometer Reading

Caliper style inside micrometers and depth micrometers have the same scale divisions, but read in the reverse direction.



Spindle moves 0.025" per thimble revolution

(Cylinder) Bore Gage - (aka Dial indicator bore gage)



Dial Bore Gage

High accuracy dial bore gages

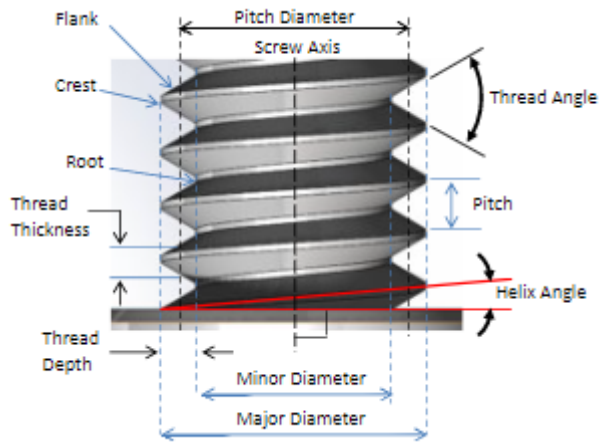
Thread Measuring Tool Review

Determines Threads Per Inch – **TPI**. From which you can determine the **Pitch** – the distance between threads

Also Thread Snap Gages for production measuring

Determines conformance to a thread form and class of fit

Screw Thread Geometry



The major parts of a 60-degree V thread. The flanks are the surfaces where the two mating threads make actual contact.

Screw Thread Terminology

A double lead thread has a much steeper helix angle than that of a single lead thread.

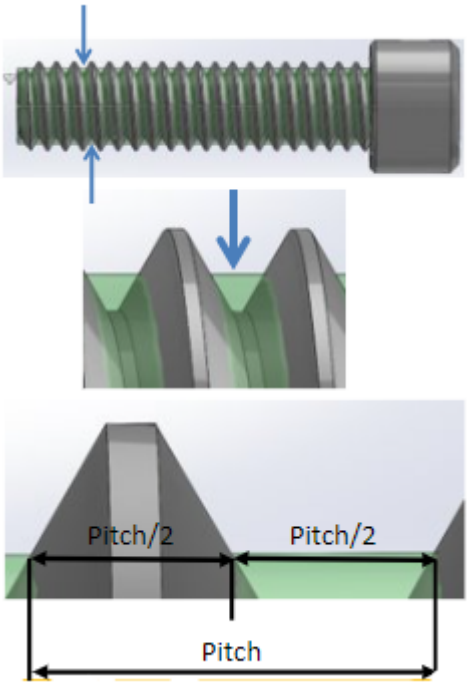
The length of engagement determines how many threads will be engaged with the mating part.

Screw Thread Helix Direction

A right-hand and left-hand thread have an opposite thread helix direction.

Pitch Diameter

- The diameter of an imaginary cylinder where the thread groove width and thread ridge width are equal
- Also Pitch/2
- For symmetric thread forms, it is midway between the minor and major diameters



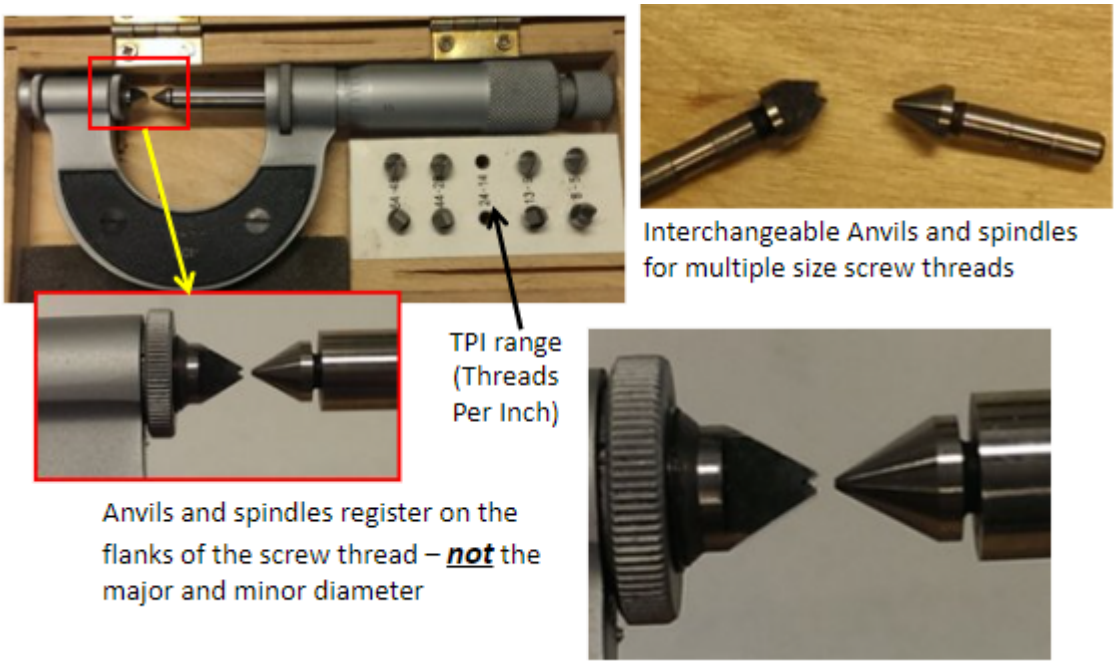
Measuring Threads

Features of interest for measuring

- **Pitch** (inches per thread) and 1/Pitch = Threads per inch
    - Pitch is a distance; TPI is a number (of threads)
    - Example: ¼-20 screw has 20 threads per inch; pitch = 1/20 inch = .050”
- **Major Diameter**
    - Micrometer or optical comparator for external threads (bolt)
- **Minor Diameter**
    - Optical comparator for external threads
    - Inside micrometer caliper for internal threads (nut)
    - Other ways to check minor diameter on internal threads?

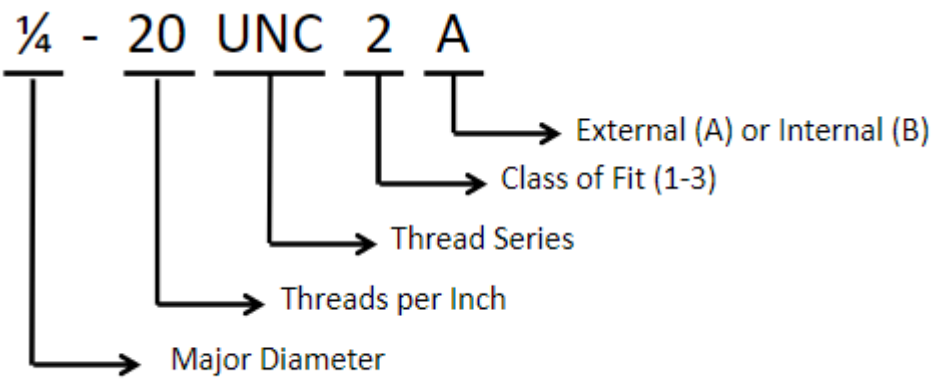
- **Thread Form** (ball screw flanks)
    - Optical comparator
    - Other ways to check thread form and class?
- **Pitch Diameter**
    - Thread micrometer
    - Three wire method with a outside caliper micrometer

Screw Thread Micrometer



Screw Thread Micrometer Measures Pitch Diameter

Thread Designations



Three Wire Method

- Used to measure **Pitch Diameter**
    - While making a thread
    - Inspecting a thread that is already made
- Uses a set of 3 wires of the same diameter
- The correct wire size must be selected based on the screw pitch
- Two calculations for Unified Threads depending on what you are most interested in
- Acquired skill requires practice in holding the screw, micrometer, and wires while measuring

Three Wire Setup

- Two wires on one side
- One wire on the other
- Wires must be sized correctly
- Measure over wires with plain outside micrometer caliper
- Use formula for determining pitch diameter OR
- Use formula for determining range of acceptable measurements

Steps for Inspecting an Existing Thread

- Measure O.D. – Major Diameter
- Match Major Diameter with acceptable range in Table 7 in shop reference to determine Nominal diameter of screw
- Use rule and counting threads or screw thread pitch gage to determine threads per inch (TPI)
- Look up wire size range on best size for TPI in Table 8 – page 310 in shop reference.
- Select standard wire size from measuring wire set that is closest to the best size (Pitch line contact).
- Make measurement over wires
- Use formula for E from Table 9 to calculate pitch diameter
    - $E = M + 0.86603P – 3W$

Determining Acceptable Range of Measurement (while cutting threads)

- Determine complete thread designation for thread to be cut
- Find acceptable pitch diameter range from Table 7 in shop reference

- Calculate measurement M for both the max and min pitch diameter (2 calculations)
    - M = E - 0.86603P + 3W
- As you cut the thread, measure thread before your final pass.
- When measurement falls between min and max measurement, you're done.

Week 4: Intro to Milling

Concept Goals:

By the end of this module, you should:

- Have familiarity of cartesian coordinates (SLO 3)
- Know how to use an edge finder (SLO 1)
- Know basics of machine maintenance (SLO 2)
- Know basics of quality assurance (SLO 2)
- Know basics of machine operation (SLO 1)

Concept Content:

This week we will discuss the milling machine and some basics you will need to know in order to properly operate it. It is important that you know the basics before operating the machines. This is because that milling machines are dangerous when proper caution and care is not taken. It is also easy to mess up a project if you operate a machine with no foreknowledge. The videos below are there to provide visual guidance with these basics.

This week's content:

Videos:

Manual Mill Tutorial - 50 Minutes - The video upload quality is not the best, but the material covered is detailed.

How to use Edge-Finders - 11 Minutes

Climb vs Conventional Milling - 9.5 Minutes

Reading:

Shanghai Sealion Machine Tool Co., Ltd. (2021, April 8). *Basic maintenance methods of milling*

machine. https://www.sealionmachine.com/basic-maintenance-methods-of-milling-machine.html

Ajansı, N. D. R. (n.d.). *Mill Maintenance Methods*. Miller Magazine. https://millermagazine.com/blog/mill-maintenance-methods-2764

https://en.wikipedia.org/wiki/Cutting_fluid

Assignment:

Module 4 Quiz - 9 Questions - Located in the assignments tab.

Unit 2 - Projects (Weeks 6-14)

Unit 2 Learning Materials

Concept Goals:

By the end of Unit 2, you should:

- Know how to square a vise (SLO 1)
- Know how to mill a part to length (SLO 1)
- Know how to drill a hole into a piece of work per specifications of a blueprint (SLO 3)
- Do the trigonometry needed to successfully plot out the design on a blueprint (SLO 1, SLO 3)
- Have knowledge of how to turn a part (SLO 1)
- How to turn a part at an angle (SLO 1, SLO 3)
- Have some knowledge of using a die on the lathe (SLO 1)
- Have some knowledge of parting on a lathe (SLO 1)
- Make use of milling and lathe skills as learned in this course (SLO 1, SLO 3)

Concept Content:

Instructor Note: For this unit you can assign the projects as needed among the students. The next module over will have a bank of projects for you to pick and choose from. Given how students will move at their own pace, there are some more advanced projects in there for those who have the time. You will be responsible for selecting which projects to work on for each student in the order that makes the most sense for them.

This section will have learning materials related to the various projects and what students will be learning from them. There are here in a bank for you to go through with the students as they make sense.

Welcome students to the second part of this class. With the first few weeks of orientation and orientation with math and milling complete, it is time to work on projects. From here to the end of the semester, we will be tackling various projects in class. They are projects for both the mill and the lathe machines. As there are not enough of either machine for all students to work on a singular project, you will each be assigned projects to work on individually. Some may start with a lathe project, some may start on the mill. This will be at my discretion.

Below are materials related to the projects we will be doing in class. This is meant to supplement and expand upon what you are doing by hand in the classroom. These will be assigned as you are working on the relevant projects.

Reading:

Metalworking and Milling Machines - 6 Pages

Custompart.Net. (n.d.). *Overviews*. Machining Hole-making Process, Opertaions, Tools, Machines. https://www.custompartnet.com/wu/hole-making

Harvey Performance Company (2023, November 7). *Speeds and feeds 101 - in the Loupe*. Harvey Performance Company. https://www.harveyperformance.com/in-the-loupe/speeds-and-feeds-101/

Videos:

How to Square a Vise - 8 Minutes

How to Tram a Milling Machine - 7 Minutes

Crash Course in Milling: Drilling, Tapping and Boring - 4 Minutes

Making Accurate Angle Cuts on the Mill - 13 Minutes

The Art of Deburring Video - 7 Minutes

Setting the Lathe to Cut Precision Angles - 12 Minutes

Parting Tutorial - 31 Minutes

A few notes, you will run no higher than 300 RPM, use WD-40 for alum (cutting oil for steel). I will check your tool and set up before you run!
Do NOT use the autofeed….she gives very good advice about using the micrometer handle to understand feel and sound.

Tapping on a Manual Lathe - 6.5 Minutes

How to use a Sine Bar - 7 Minutes

Assignments: **(Instructor note: there is a bank of assignments you can use throughout the semester for this unit)**

RPM Calculation Assignment - Download the worksheet and upload the completed copy to the assignments tab under quiz.

Decimal Review Worksheet - Download the decimal worksheet and upload a completed copy to the assignments tab under quizzes.

Lathe Machine Part Identification Assignment - Located under quiz tab

Unit 2 Projects

Concept Content:

Here are the blueprints for machining projects for this course. **(Instructor note: this is a bank of potential projects, you can pick and choose which ones you like. There are more projects there than most students would be able to do in one semester).**

Your instructor will assign the projects from this bank of projects.

Blueprints:

Drill Block

Bolt Circle

Turning Project (Lathe Project 1)

Lathe Project 2

Lathe Project 3 Blueprint

Hammer

Indicator Holder

Jack Screw

3 Quater Turn Nut

Mil Stop

Tap Gage

Cannon Project Blueprint

Unit 3 - Final Exam (Week 15 & Week 16 if needed)

15.1 Final Exam

Concept Goals:

By the end of this module you should:

Demonstrate understanding of course material

Concept Content:

This week is our final exam. Go to the assignments tab and look under test.

Final Exam - **34 Questions* (This number can change depending on the instructor and how many of the 34 they want to use).**

15.2 Course Wrap-Up

Concept Content:

Thank you all for your hard work over this course. I know that not everything has been easy but I am glad that you were able to stay through the course. The application of the machining concepts we have learned thus far will be of great help to you in the field.