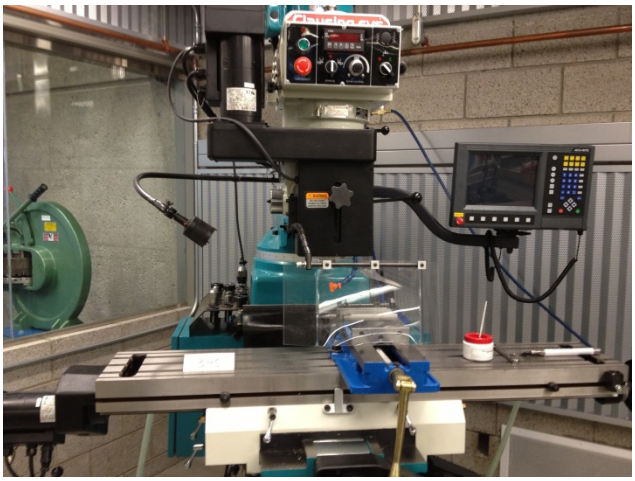
Yale *Environmental Health & Safety*

Shop Safety Procedure



Equipment/Task Name:	VERTICAL MILLING MACHINE
Equipment/Task Hazard Class:	4 & 5 http://ehs.yale.edu/forms-tools/tool-classification-matrix
Shop Name:	
Shop Hazard Class:	

Purpose

The vertical milling machine is a precision tool used for shaping and fabrication by the removal of stock typically from metallic work pieces. Plastics and other materials can also be machined on the mill depending upon tooling and material. Mill controls may be manually operated, computer numerical controlled (CNC), or a combination of both. Mill machining and material removal is typically made by a rotary cutter held in a spindle. Cutting options are more sophisticated and variable than a drill press by virtue of a moveable table and/or vise (x and y-axes) and vertical spindle movement (z-axis). Many vertical mills also have a rotatable turret for the upper cutting head which provides even greater machining options (b-axis). A diagram is included in this procedure to help illustrate the varying axes.

Some of the common operations that can be performed on the mill include:

- Milling– These operations provide a flat surface or spot on a work piece, typically with a specific orientation to other work piece features, surfaces, or another piece. Facing is sometimes used on an irregular shaped work piece to "true" one surface at a time to ensure that all surfaces have appropriate specific geometric relationships with each other.
- Slotting or keyways – Slots, flats, or keyways can be cut with proper fixturing.
- Drilling or boring – Where specific orientations are required between work piece features, the vertical mill provides the means to accurately index and machine holes.

Hazards

As with all shop tools, there are many potential hazards associated with the use of a milling machine. Full sized milling machines are Class 5 tools while small/bench top versions are Class 4 tools (http://ehs.yale.edu/forms-tools/tool-classification-matrix). Particular hazards associated with vertical milling machine are listed below. Note that the list is not exhaustive as unusual or specialized uses may generate additional unique hazards. A diagram is included in this procedure as a reference for the machine component names.

Rotating Cutters and Spindle

- Large amounts of energy are embodied in rotating parts.
- Do not set spindle speed at excessive RPM's. . In emergencies and when the emergency stop is activated, the machine will take much longer to stop. Limit spindle rotation to 1000 RPM or slower whenever possible
- Potential for loose clothing, jewelry, hair, or other items can become entangled in rotating parts, potentially drawing the operator close to or into the cutter or spindle.

Hazards (cont'd)

Sharp Tooling and Edges on Work Piece

- Potential for cuts, lacerations, and puncture wounds.
- Fresh cuts on work piece may produce burrs and other sharp edges.

Flying or Rotating Objects

- Cutting and boring activities can generate sharp flying chips posing skin, facial, and eye injury hazards.
- Work pieces, cutters and other tooling, or clamps can become disengaged and rotate or be flung across the room. Insufficiently secured work pieces can be rotated at high speed, potentially striking or crushing fingers, hands, or other close body parts.

Hot Objects and Components

- The friction associated with cutting generates significant amounts of heat that can cause skin burns, flying sparks, and fire hazards.

Power Feed and Computer Controls

- These components introduce additional rotating and moving objects that can create pinch points and blunt object injury.

Crush & Drop Hazards

- During machine operation the operator usually concentrates their attention towards the cutting action. Usually the machine is in motion and unexpected crush hazards can develop.

Pinch points / in-running nip points:

- Pinchpoints and in-running nip points can be found between the:
  - Cutting tool and work piece
  - Cutting tool and work holding devices
- Pinchpoints and in-running nip points can cause bruising, crushing, and even amputation hazards, and can also offer additional entanglement hazards to clothing and other loose hanging materials.

Limitations

- Check with the shop instructor or supervisor before machining unusual or unique materials such as composites, plastics, titanium, magnesium, or beryllium copper. These materials may create secondary hazards including fire and toxic fumes.
- One of the most significant limitations to mill use is the ability to properly and securely clamp or fixture the work-piece to the machine table. This must be done in such a way that it is secure and the physical shape/size allows for full travel and clearance with all machine components.
- The weight of the work piece can be a limitation. This can be more problematic on smaller, bench top style mills. Verify manufacture specifications in advance.
- At times, a work piece may extend off of the machine table. In this situation provide safety awareness barriers for other employees working in the shop. Also, beware of pinch point between the overhanging component and other shop equipment.

Required Personal Protective Equipment

- Refer to the Shop Safety Postings and instructions provided by the Shop Supervisor.

Shop specific required PPE:

Required Training

- Applicable Shop Rules
  - **Student Shop Rules** (http://ehs.yale.edu/forms-tools/shop-rules-student-accessible-shops)
  - **Professional Shop Rules** (http://ehs.yale.edu/forms-tools/guidelines-professional-shops)

Required Training (cont'd)

- For Class 2 through 5 Student Shops, review and signing of the **Yale University Shop/Tool Use Safety Agreement** (http://ehs.yale.edu/forms-tools/shoptool-use-safety-agreement).
- Shop Supervisors or Instructors must evaluate the tool user based on successful demonstration of the Training Competencies and Practical Exercises listed below as applicable.

Training Competencies:

- □ Identify the uses, limitation, and hazards of the machine.
- □ Demonstrate use of appropriate clothing, work boots and correct personal protective equipment.
- □ Demonstrate how to inspect the mill and adjust all components for selected operation.
- □ Properly demonstrate the equipment start-up process.
- □ Demonstrate how to secure or fixture various work pieces.
- □ Demonstrate safe milling operation, including using adequate lubrication and appropriate spindle speed and feed for work piece material, cutting bit selected and secure work holding methods
- □ Demonstrate how to properly set spindle speeds

Shop specific training requirements:

Authorized Tool Users

Shop Supervisor, Shop Monitors and those authorized by shop supervision to operate the tool.

Tool Safety Rules

- Observe and follow all Yale Professional or Student Shop Rules as posted.
- Report any safety concerns to the shop supervisor immediately.
- Understand and follow manufacturer operating procedures.
- Inspect the cutting tool for damage prior to use.
- Verify all guards are in place and adjusted properly.
- Do not bypass any safety devices.
- Always stay at the machine while it is running.
- Clean the machine completely after use.
- Report any malfunction or damage to the Shop Supervisor after tagging the machine tool "Out of Service, do not use".
- Maintain exclusive control of the machine. Don't allow anyone else to touch the machine while in operation.
- Do not make measurements of the stock while the machine is rotating.
- Do not allow large quantities of chips to accumulate around the work piece or machine table. After stopping the machine, use a chip brush plyers to remove all excess chips from the mill table and stock. Never use your hands
- Work pieces, stock, cutting tools and accessories must be secure before operation.
- Use appropriate speeds and feeds for the type and size of cutter being used and the material being machined.
- Make sure the cutting tool is clear of the work piece before starting the machine.
- Obtain help or use lifting aids when placing or removing awkward or heavy work pieces.

Shop specific rules:

Proper Setup and Use

Prior to Use

- Verify that the work piece is safe and appropriate for use on the particular mill.
- Identify the edge or cutting location on the work piece. Set the machine hand dials or digital readout to zero.
- Identify the appropriate speed setting for the material and intended tooling.
- Determine any need for cooling or lubrication during cutting, and prepare it.
- Prepare for milling by verifying that any loose clothing or jewelry has been removed or secured, and hair (including beards) is tied back.
- Don personal protective equipment.

At the Mill

- Inspect the mill and ensure all fixed guards are in place. Ensure the area around the mill and the mill table is free of obstructions.
- Identify the locations for all controls and the emergency stop.
- Ensure power is off and cutter is removed prior to clamping the work piece.
- Securely clamp the work piece and support the work piece so that it cannot shift while being machined.
- Ensure that the clamp and fixtures will not interfere with the cutting tool motion.
- Ensure the spindle is off and install the cutting tool. Undergraduate students are required to have all fixtures inspected by a monitor or supervisor.
- Install, adjust, and secure adjustable point of operation guards when appropriate.
- Ensure the spindle wrench/key is removed.
- Disengage any automatic machine feeding devices.
- Select the proper speed range and motor rotation for the required material & operation.
- Only turn the spindle on after the fixtures have been thoroughly inspected.
- When first energized, ensure the cutting tool is rotating in the proper direction. Usually clockwise.
- Immediately shut down the mill if the cutting tool or work piece vibrates or makes unusual noise.
- Shut down the mill prior to taking any measurements.
- Move the work piece away from the cutting tool prior to measuring or inspecting.

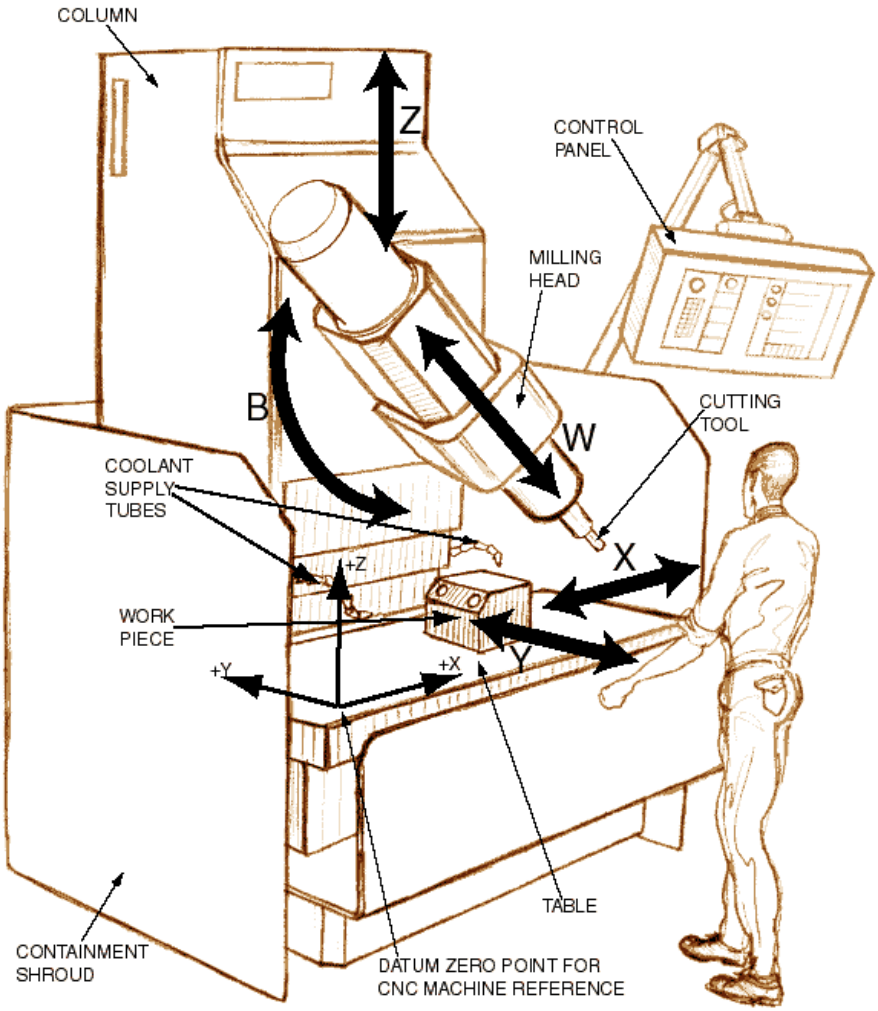
Completion

- Shut down the mill and ensure that the spindle has fully stopped rotation.
- Remove clamps from the work piece – beware of hot, sharp chips, tooling, and any work piece burrs.
- Remove cutting tool, clean as needed, and return to proper storage location.
- Clean chips and any lubricating fluids from the machine.
- Clean and sweep the floor surrounding the machine of any chips, tools or materials

Shop specific procedures:

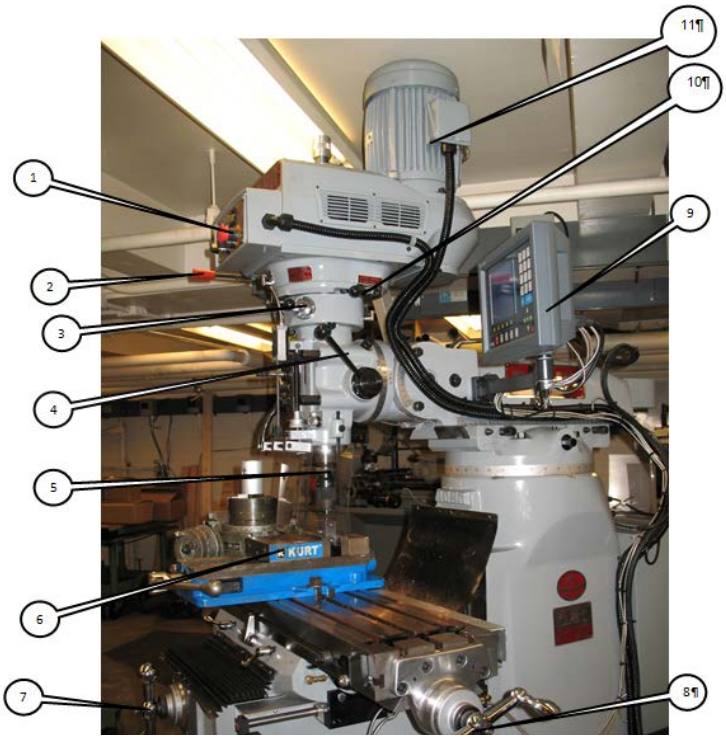
Diagrams/Illustrations

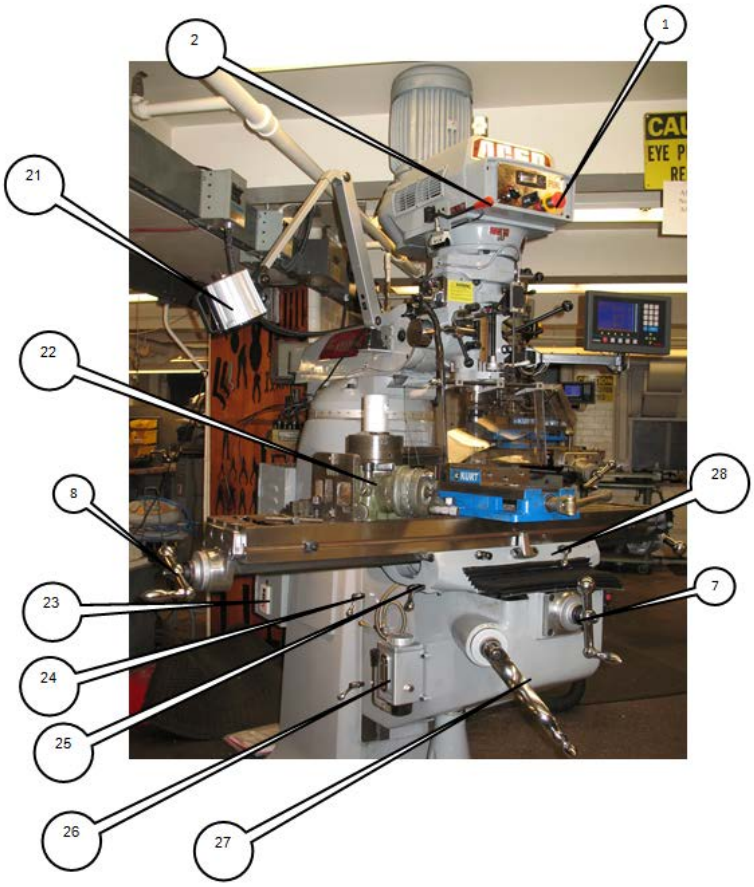
Five Axis Milling Machine



Vertical Milling Machine Components

Item #	Name
1	Emergency Stop
2	Spindle Brake
3	Quill Feed Drive Engagement
4	Quill Feed Handle
5	Spindle
6	Work Piece Vice
7	Cross Feed Crank Handle
8	Longitudinal Feed Crank handle
9	Table Position Digital Readout
10	Spindle Speed Range Control
11	Spindle Motor
12	Spindle Forward/ Reverse
13	Spindle Speed Indicator
14	Spindle Speed Control
15	Power Feed Speed range
16	Power Feed Engagement
17	Spindle Guard
18	Spindle Chuck
19	Spindle Depth Lock
20	Unassigned
21	Work Light
22	Rotary Work Piece Vice
23	Main Power Shutoff
24	Table Elevation Locks
25	Table Cross Feed Locks
26	Machine Oiler
27	Table Elevation Crank
28	Table Longitudinal travel locks





Creation/Revision Dates:	

Suggestions, questions, or comments? Please contact your shop supervisor or EHS.