PALO VERDE
NUCLEAR GENERATING STATION

Mechanical Maintenance Training
Milling Machine Components
Classroom Lesson

Mechanical Maintenance Training	**Date: 12/3/2010 5:08:31 PM**
LP Number: NMS61C000104	**Rev Author: MARK TAGUE**
Title: Milling Machine Components	**Technical Review:** Fredrickson, Rodney J(Z36022) Digitally signed by Fredrickson, Rodney J(Z36022) DN: cn=Fredrickson, Rodney J(Z36022) Date: 2011.08.02 11:42:10 -07'00'
Duration : 9 HOURS	**Teaching Approval:** Baker Sr, Lee E(Z07641) Digitally signed by Baker Sr, Lee E(Z07641) DN: cn=Baker Sr, Lee E(Z07641) Date: 2011.08.02 12:09:57 -07'00'

INITIATING DOCUMENTS

Task Analysis of Tasks

REQUIRED TOPICS

None

CONTENT REFERENCES

Machine Tool Practices, Fifth Edition

Machinery's Handbook

Technology of Machine Tools, Fifth Edition, KRAR-CHECK

PVNGS OSHP Manual

TCS# 03-0417 Revise NMS61 to reference new task numbers

Bridgeport Milling Machine Operation Manual

LESSON PLAN REVISION DATA

Dec 03, 2010	Mark Tague	12/02/2010: Incorporate Human Performance and Prevent Events strategies. Added operating experience and reworded Course and Lesson Terminal objectives to better reflect what the course covers. [TCSAI 3478466]

Tasks and Topics Covered

The following tasks are covered in Milling Machine Components :

Task or Topic Number*	Task Statement
Lesson:	Milling Machine Components
MILL002	Perform precision milling machine operations
MILL001	Perform basic milling machine operations and maintenance

Total task or topics: 2

TERMINAL OBJECTIVE:

1 Given a job assignment requiring the use of a milling machine the Maintenance Mechanic will, identify the component parts, tooling and accessories and explain the basic safety rules for operation of the mill. Mastery will be demonstrated by completion of a written exam with a minimum score of 80% correct.

1.1 Describe the components of a vertical milling machine.

1.2 Identify and state the purpose of the common milling machine accessories.

1.3 Identify and state the purpose of the common milling cutters.

1.4 State the methods for determining the proper cutting speeds, feeds, and depth of cut for various materials and cutters.

1.5 State the safety precautions when working on a milling machine.

CONTENT	METHODS & ACTIVITIES
I. Motivation	Focus student attention on "What's In It For Me".
A. The class will not grant the student any qualification but it will meet the prerequisite for performing the qualification card.	
II. Pre-Job Brief	
A. Pre-job briefing on the day's activities modeling the use of the ***Palo Verde Standards & Expectations, Preventing Events***	
B. Focus On Five (Task Preview) Familiarize worker with the scope of work, task sequence, and critical steps.	
1. Critical Steps (**COURSE** Terminal Objective) Given various machine operations on the Mill, the Maintenance Mechanic will describe how to safely and properly operate the mill applying Palo Verde standards and expectations. Mastery will be demonstrated by successfully completing a written examination with a score of 80% or better.	PVNGS Standards & Expectation book (Focus on five) Highlight the critical steps (Terminal Objectives) on the power point presentation.
2. Identify error likely situations (error traps) a. Discuss at least one specific error likely situation b. Most will be covered during the course	Look at Error Precursors in S&E book
3. Identify the Worst thing that can happen.	Apply to the setting you're in. (Lab versus Classroom)
4. Identify specific error prevention defenses to be used. Will be covered during the course – this is the purpose of this course	What defenses can we employ to prevent the "Worst thing that could happen"
5. Identify actions to assure proper configuration control.	This may not be applicable in every training setting.

CONTENT	METHODS & ACTIVITIES
C. Schedule	Lay out the schedule and expectations for schedule adherence
1. Length of class	
2. Break policy	
a. Two Minute Drill – After lunch at a minimum	At Instructor's discretion, not to interrupt class flow
3. Evaluation	
4. Post training critique	Feedback (i.e. Class Climate)
D. Qualification No qualifications until completed with the JQC, independent of this course	Identify what they will be qualified to do upon completion of the course
III. Lesson Introduction	
A. **LESSON** Terminal Objective Given a job assignment requiring the use of a milling machine the Maintenance Mechanic will identify the component parts, tooling, and accessories and explain the basic safety rules for operation of the mill. Mastery will be demonstrated by completion of a written exam with a minimum score of 80% correct.	Read and/or discuss the lesson objectives
B. Lesson Enabling Objectives	
EO01 Describe the components of a vertical milling machine.	
EO02 Identify and state the purpose of the common milling machine accessories.	
EO03 Identify and state the purpose of the common milling cutters.	
EO04 State the methods for determining the proper cutting speeds, feeds, and depth of cut for various materials and cutters.	
EO05 State the safety precautions when working on a milling machine.	

Title:	**Milling Machine Components**	**Lesson Plan #:**	**NMS61C000104**

TO: 1	**Given a job assignment requiring the use of a milling machine the Maintenance Mechanic will, identify the component parts, tooling and accessories and explain the basic safety rules for operation of the mill. Mastery will be demonstrated by completion of a written exam with a minimum score of 80% correct.**

EO: 1.1 Describe the components of a vertical milling machine.

CONTENT	METHODS & ACTIVITIES
I. Operating Experience & Human Performance Tools	Slide#15
A. Operating any type of rotating machinery can pose numerous hazards that can cause serious injury or even death. Here at Palo Verde we employ the use of Human Performance Tools to provide us with an extra margin of safety BEFORE we begin any task.	
1. Tools like Pre-Job brief prepare the worker by helping them understand what the task is and the scope of the work.	
2. Two minute drills allow the worker to identify hazards in the area that weren't anticipated during the Pre-Job brief. They also allow the worker to reset after they have been focused on another task.	
a. For example in a milling operation a great deal of time goes into dialing in the vise and the head. Then the work needs to be set up in a vise or with clamps. The proper cutter needs to be selected and installed.	
b. BEFORE the milling machine gets turned on though, a two minute drill needs to be done to insure that the cutter isn't going to run into an obstruction and that the cutter speed is set right for the cutter and material being used.	
3. Other HU tools like Self-checking, Questioning Attitude and Stopping when unsure are often used during a machining operation. Be sure to employ the use of these tools. They are here to keep us, our co-workers and the plant safe.	

CONTENT	METHODS & ACTIVITIES
B. Operating Experience	Slide#16
1. On August 19, 2006, at approximately 11:45 a.m., a 52-year-old machine operator died when he was struck in the abdomen by a piece of acrylic that was being milled on a vertical milling machine.	
2. An OSHA investigator traveled to the company site where the incident occurred and interviewed the company's owner and other employees of the company.	
3. The victim had worked for the company for 5 years and had been trained on-the-job. The owner stated that the victim had operated the machine many times in the past without incident. There was no documentation available to verify the victim's training or testing of his competency level.	
4. On the day of the incident, the victim was milling a piece of acrylic that was approximately 3/8" thick and 2" in diameter.	
5. The ideal spindle speed for the type and size of acrylic the victim was milling, according to the milling machine's manufacturer's specifications, was about 80 rpm (revolutions per minute), but the spindle had been set to a much higher speed.	
6. As the victim milled the piece of acrylic at the higher speed, it shattered into pieces and one of the pieces struck the victim in the abdomen. The victim fell to the floor holding his abdomen. Other employees heard the victim and went to his assistance.	
7. Paramedics examined and treated the patient and then transported him to a trauma center. On the way to the trauma unit the victim's heart and breathing stopped and CPR was administered. Upon arrival at the trauma center, the victim was taken immediately to an operating room but died during surgery.	
8. Cause of death according to the death certificate was blunt abdominal trauma.	

CONTENT	METHODS & ACTIVITIES
9. As you can see rotating machinery can be very dangerous if not operated properly and at the proper speeds for the material and cutter.	
a. Something as simple as a two minute drill or a self check to STOP and reset before turning on the machine to verify the proper speed setting may have mitigated this tragedy.	
II. MILLING MACHINES (Introduction)	Slide #17
A. It's been said that a milling machine is the only machine that can build itself.	
1. Milling machines are a valuable tool in that an experienced operator can make any part or tool that can be thought of.	
2. This is especially useful in an industrial setting like a power plant because tools can be fabricated and parts from equipment can be repaired on site.	
a. This is also a plus when a piece of equipment is no longer made by a manufacturer, but a simple repair could put the equipment back in service.	
III. Vertical Milling Machines	
A. The standard vertical milling machine has the cutter spindle mounted in a vertical position	
B. The head on most vertical milling machines may be swiveled horizontally and vertically, which readily permits the machining of angular surfaces.	
C. The cutters used are of the end mill or shell end mill types	Have some cutters available to show
D. Parts of a Vertical Milling Machine	Slide #18
1. Base - made of ribbed cast iron. It may contain a coolant reservoir.	

CONTENT	METHODS & ACTIVITIES
2. Column - often cast integrally with the base. The machined face of the column provides the ways for vertical movement of the knee.	
3. The upper part of the column is machined to receive a turret on which the overarm is mounted.	
4. Overarm - round, or of the ram type. It may be adjusted toward or away from the column to increase the capacity of the machine.	
5. Head - attached to the end of the ram. Provision is made to swivel the head in one plane. On universal-type machines, the head may be swiveled in two planes.	
6. Mounted on top of the head is the motor, which provides the drive to the spindle.	
7. The Quill houses the spindle and may be fed by means of a hand lever, a handwheel, or automatic power feed. Most machines are equipped with a micrometer quill stop for precision drilling or boring to depth.	
8. Knee moves up and down on the face of the column and supports the saddle and the table. *Discuss the need to be aware of body position if changing knee height manually, as the potential exists to injure your back while bending over and cranking the handle.*	
9. Most of the cutting on the vertical machine is done by end mill cutters; therefore, it is not necessary to swing the table, however if necessary you can swing the turret. As a result, vertical milling machines are equipped with plain tables only.	
10. The turret pivots the entire upper assembly for special setups or to use the slotting attachment (accessory).	Slide #19

CONTENT	METHODS & ACTIVITIES
11. HI-LOW Switch. This is the motor reversing switch as well as the on/off switch on the Bridgeport mill. a. This switch does not actually change the mill from Hi to Lo range, that is done with the Hi/LO range gear lever. b. When the switch is in the High position the motor and spindle are turning in the clockwise direction as viewed from the top of the machine c. When the switch is in Low position the spindle will turn backwards (counter clockwise) on a Bridgeport machine. d. **Important** Spindle should run in the clockwise position because most cutters are made to cut in that direction. e. An example of needing to run the machine backwards would be during the use of a left-hand drill or something of that nature.	Slide #20 -21
12. The back-gear lever is marked Hi-Lo and is the lever that actually puts the machine in Hi or Lo range. This will indicate the proper on/off switch position. They should be positioned alike or the spindle will run backwards on a Bridgeport machine. a. This lever is used to put the machine into either backgear or direct drive. b. In the High position (direct drive) the spindle is driven by tapered clutch teeth. 1) When shifting to “Hi”, DO NOT FORCE THE LEVER if the clutch teeth do not mesh. It is a simple matter to engage the brake and rotate the spindle nose by hand until the clutch engages.	Slide #22 - 23

CONTENT	METHODS & ACTIVITIES
c. In the “LO” position the backgear is engaged and puts the machine in Lo range. 1) When shifting to “Lo” DO NOT FORCE THE LEVER if the back gears do not mesh. Hold the lever so the gears are clear of one another, rotate the spindle nose by hand until the gears line up, then put the unit in “Lo” position (back gear). d. **Caution** Do not shift Hi-Lo lever while motor is running, it will crash the gears together and could cause severe damage to the machine. e. **Caution** Avoid shifting the HI-LO lever when the feed worm is engaged. This could damage gearing as well.	
13. Variable Speed Dial. Visibly indicates, in windows, the speed range machine is operating in, 60 to 500 low range, or 500 to 4200 high range. a. Do not attempt to change spindle RPM unless the motor is running. b. Dial speeds will only be approximate. Belt wear will cause a slight variation in speeds from what is indicated on the dial. c. Spindle speeds are adjusted by turning the speed change handwheel to the desired speed indicated on the front of the belt housing WHILE the motor is running. d. Low speed is obtained by positioning the backgear lever mentioned earlier to the LO range position. e. 500 to 4200 RPM is obtained through direct drive and is the high range. The same lever and switch as above are used; selecting the “Hi” range.	Slide #24 - 26

CONTENT	METHODS & ACTIVITIES
14. Spindle Brake. Brake lever can be moved in either direction to stop spindle; however, when locking spindle, lever should be moved pulling toward the operator or pushing away from the operator then raised. When brake is worn out it has to be replaced. There are no adjustments to be made. a. **Caution** Be certain that the spindle brake is released before starting the motor. This is important as the motor can be damaged if switch is turned on with brake in the locked position.	Slide #27 - 28
15. Quill Feed Selector. This crank is used for selecting the three feeds; .0015", .003" and .006" travel per revolution. It is shifted by pulling knob out and turning from one position to the other. Feeds are stamped on the cover below indentation hole. Feed is more readily engaged when spindle is running.	Slide #29 - 30
16. Quill Stop Knob. Is used to disengage automatic feed in either direction as well as the stop point setting working depths. a. Micrometer Nut. This nut is used for setting depths. Each graduation on nut indicates .001" of depth, it reads directly to scale mounted along side of it. Depths may be obtained by setting micrometer nut in conjunction with quill stop.	Slide #31 -32
17. Feed Reverse Knob. Position of this knob depends upon the direction of spindle rotation. If boring with right hand cutting tools, pull feed handle towards operator until clutch becomes engaged. Neutral position is between forward and reverse position. It is recommended that the handle be left in neutral position when not in use.	Slide #33 -34

CONTENT	METHODS & ACTIVITIES
18. Manual Feed Handwheel. Feed reversing knob should be in neutral position and feed control lever engaged. Clockwise rotation of the handwheel moves the quill down. The Manual Feed Handwheel and the Quill Feed Handwheel may be disengaged by moving them outward about 1/8”	
19. Feed Control Lever. Engages over-load clutch on pinion shaft when positioned left and will stay engaged until either quill stop comes in contact with micrometer adjusting nut, forcing feed control lever to drop out automatically, or release manually by engaging lever to right.	Slide 35
a. Feed Control Overload Clutch. Overload clutch is set is set at factory to hold up to 200lbs. down pressure on the quill, which will accommodate drills up to 3/8” diameter in mild tool steel.	
b. **Caution** This clutch should not be tampered with in the field as it has been set by the factory for approximately 200 lbs down pressure.	
c. **Note.** The feed control lever must be engaged in order to use manual feed controls. The quill feed handle and manual feed handle may be taken off when not in use.	

CONTENT	METHODS & ACTIVITIES
20. Power Feed Transmission Engagement Crank. Engages power feed worm gear. When lever is in right hand hole, the power feed worm gear is engaged. To disengage worm gear, pull knob out and crank handle in the clockwise or down direction and move to opposite position. a. **Note** Crank should be rotated counter clockwise to engage power quill feed. Crank should be rotated clockwise to disengage. b. **Caution** Power feed worm gear may be engaged when spindle is rotating, however, it should be engaged gently to avoid damage to worm gear. The worm gear may be disengaged at any time. Do not use power feed at speeds above 3000 rpm.	Slide 36
21. Quill. Contains the spindle assembly and can be raised or lowered by means of the Quill Feed Handle. Spindle. Does the actual rotation and also retains the machine tooling. Quill Lock. This is a friction quill lock to be used when quill is in the stationary position such as milling operations. It is recommended that this lock be used whenever quill movement is not desired.	Slide #37
22. Quill Feed Handle. May be removed by simply pulling handle off. It is recommended that handle be disengaged when using power feed. This is the handle used to raise and lower quill manually.	Slide #38
23. Motor. 2 H.P. variable speed (with 2J head). #H.P. 30 minute duty rate.	Slide 39

CONTENT	METHODS & ACTIVITIES
24. Drawbar. When tightening or loosening the drawbar, it is necessary to lock the spindle. To accomplish this, use the spindle brake which is located on the left side of the belt housing, pulling towards the operator or pushing away from the operator until it binds, then raise the quill feed handle.	Slide 39 - 45
25. Some tables have a power feed set up for one or both directions of table travel.	Slide 46
a. They will usually have a lever that engages and disengages the power feed so the option is available to move the table manually or power feed.	
b. Most power feed set ups will have a dial that allows the operator to control the feed speed.	
IV. Review Practical Steps to actually operate the machine	Slide 47
A. Always perform a two minute drill before turning the machine on.	
1. Ensure the cutter is clear of the work piece and won't hit any other obstruction.	
2. Ensure the proper PPE is being worn to guard against metal chips getting in the eyes.	
3. Insure guards are installed and properly adjusted so chips won't be cast out into a walkway or affect bystanders.	
4. If needed turn the handle for the knee height inward so that the knee position doesn't get inadvertently bumped; ruining the cut.	

CONTENT	METHODS & ACTIVITIES
B. Spindle Speed (Change only when spindle is running)	Slide #48
1. Change speed to the proper range.	
a. Start spindle	
b. Turn handwheel “A” to select required speed	
c. Change only when spindle is running	
2. Back Gear (Low Speed)	Slide #49
a. Change Range from direct to back gear drive:	
1) Switch “B” to OFF (stop spindle rotation)	
2) Move lever “C” through neutral to LOW (this reverses the spindle rotation)	
3) Switch “B” to LOW	
3. Direct Drive (Hi Speed)	Slide #50
a. From back gear to direct drive:	
1) Switch “B” to OFF (stop spindle rotation)	
2) Move lever “C” through neutral to HIGH	
3) Rotate spindle by hand until the clutches are felt to engage	
4) Switch “B” to HIGH	
4. Quill Feed	Slide #51
a. Fine Hand Feed	
1) Disengage Auto Quill Feed “A”	
2) Locate “C” in mid (neutral) position.	
3) The quill is now under handwheel control	

CONTENT	METHODS & ACTIVITIES

5. Automatic Feed — Slide #52

Do not engage quill feed "A" over 3000 RPM

a. Maximum loading 3/8" diameter drill steel

b. Ensure lock is off "D"

c. Set micrometer to required depth "E"

d. Engage auto quill feed "A" when motor has stopped.

e. Select feed rate "F"

f. Select feed direction "C"

g. Engage feed trip lever "B"

h. The feed will automatically trip out at a depth within .010"

i. Hand feed to dead stop for repeating accuracy .001"

6. Move Ram Slide — Slide #53

a. Use Bridgeport wrench and loosen bolts 1 and 2

b. Use wrench to move slide to the desired position using bolt 3.

c. Retighten bolts 1 and 2 starting with the rear bolt.

NOTE: It is recommended that on heavy milling work, head should be kept as close to column as possible, where maximum rigidity is obtained.

CONTENT	METHODS & ACTIVITIES
7. Spindle Brake	Slide #54
a. Brake lever has the capability to rotate in either direction to brake and lock, CAM upwards to lock and prevent movement of spindle.	
8. Quill Sensitive Hand Feed	Slide #55
a. Place the handle on the quill feed shaft.	
b. Select the most suitable position.	
c. Push home until the locating pin engages.	
9. Saddle Clamping. When milling with longitudinal table feed only, it is advisable to clamp the knee to the column and the saddle to the knee to add rigidity to these members and provide for heavier cuts with a minimum of vibration. The saddle locking lever is located on the left hand side of the saddle.	Slide #56
a. Excessive pressure can cause slight table bind. Use moderate clamping pressure, as this will hold sufficiently.	
10. Table Clamping. The table clamp levers are located on front of the saddle and should always be clamped when longitudinal movement is not required.	Slide #57
11. Knee Clamping. The knee clamping levers are at the left side of the knee and front of knee. Leave clamped at all times unless using the knee in operation.	Slide #58

EO: 1.2 Identify and state the purpose of the common milling machine accessories.

CONTENT	METHODS & ACTIVITIES
I. MILLING MACHINE ACCESSORIES	
A. Fixtures- work holding devices fastened to table of machine or to machine accessory. *OSHP Manual Article 7 Section VII Paragraph C.3 states in part "the work shall be properly secured"*	PJB & 2-MINUTE DRILL Never attempt to perform machining without the workpiece securely held.
1. Hold workpieces not readily held in vise.	Slide 61
2. Used in production for large quantities of parts to be machined.	
3. Custom designed so identical parts will be positioned exactly	
4. Holds parts securely.	
B. Attachments - three classes	Slide 62
1. Those designed to hold special attachments; these are attached to the quill or spindle and column of the machine	Slide 63 & 64
2. Those designed to hold standard cutters	Slide 65 & 66
a. Arbors	Arbors, Collets, and Adapters
1) Inserted and held in the main spindle by a draw bolt or special quick-change adapter.	This is a good place for the instructor to show arbor and cutter assemblies.
b. Collet adapters are used for mounting drills or other taper-shanked tools in the main spindle of the machine or vertical attachment.	Slide 67 - 69

CONTENT	METHODS & ACTIVITIES
c. Quick-change adapter, mounted in the spindle, permits such operations as drilling, boring, and milling without a change in the setup of the workpiece.	
3. Those designed as work holding devices. - Work holding devices are precision equipment. Don't abuse them. They are not anvils or to be used for bending or forming metal	Slide 70
a. Milling vise - may be bolted to the table so that its jaws are parallel or at right angles to the axis of the spindle.	Slide #71
1) Positioned quickly and accurately by keys on the bottom, which fit into T-slots on the table.	
b. Swivel base vise - is similar to the plain vise, except that it has a swivel base that enables the vise to be swiveled through 360^{O} in a horizontal plane.	Slide #72
c. Universal vise – may be swiveled through 360º in a horizontal plane and may be tilted from 0 to 90º in a vertical plane.	Slide #73

EO: 1.3 Identify and state the purpose of the common milling cutters.

CONTENT	METHODS & ACTIVITIES
I. MILLING CUTTERS	Slide 74
Two Minute Drill All cutters used to perform milling operations are very sharp and have the ability to cut easily. Any time a cutter is being handled, caution must be used and situational awareness maintained to ensure that the operator doesn't place themselves in a position to be cut. This is especially true during installation and removal of the cutter.	
A. Metal-Slitting Saws	Slide 75
1. Basically thin plain milling cutters with sides relieved or "dished" to prevent rubbing or binding.	
2. Slitting saws are made in width from 1/32 - 3/16 in.	
3. Because of their thin cross section, they should be operated at approximately one-quarter to one-eighth of the feed per tooth used for other cutters.	
4. Unless a special driving flange is used, it is <u>not</u> advisable to key the saw to the milling arbor.	
a. The arbor nut should be pulled up as tightly as possible *by hand only*.	
B. End Mills	Slide 76
1. Have cutting teeth on the end as well as on the periphery and are fitted to the spindle by a suitable adapter.	

CONTENT	METHODS & ACTIVITIES
2. Two types	
a. Solid end mill - shank and cutter are one piece	Slide 77 - 81
b. Shell mills - may have either straight or helical flutes and use a separate arbor.	Slide 82
c. Shell Mill Arbors are available with various shanks for adaptability to the machine.	
3. When a slot is cut with a two-flute end mill, the depth of cut should not exceed one-half the diameter of the cutter.	
4. When the four-flute end mill is used for slot cutting, it is started at the edge of the metal.	
C. T-slot Cutter	Slide #83
1. Used to cut the wide horizontal groove at the bottom of a T-slot after the narrow vertical groove has been machined with an end mill.	
2. Consists of a small side-milling cutter with teeth on both sides and a shank for mounting.	
D. Dovetail Cutter	Slide #84
1. Similar to a single-angle milling cutter with an integral shank.	
2. Available with an internal thread to be mounted on a special shank.	
3. Used to form the sides of a dovetail after the tongue or groove has been machined with a side milling cutter	
4. Available with 45, 50, 55, or 60^{O} angles.	

CONTENT	METHODS & ACTIVITIES
E. Woodruff Keyseat Cutter	Slide #85
1. Similar to a plain and side milling cutter.	
2. Smaller sizes are made with a solid shank and straight teeth; larger sizes are mounted on an arbor and have staggered teeth.	
3. Used for milling semi-cylindrical keyseat in shafts.	
F. Flycutter	Slide #86
1. A single-pointed cutting tool with the cutting end ground to the desired shape	
2. Since all the cutting is done with one tool, a fine feed must be used.	
3. Used in limited work where the high cost of a special cutter would not be warranted.	

EO: 1.4 State the methods for determining the proper cutting speeds, feeds, and depth of cut for various materials and cutters.

CONTENT	METHODS & ACTIVITIES
I. CUTTING SPEEDS AND MILLING FEEDS	Slide 87
A. Speeds	
1. The cutting speed of a metal may be defined as the speed, in surface feet per minute (sfm), at which the metal may be machined efficiently.	
2. When work is machined in a milling machine, the cutter must be revolved at a specified rpm, depending on its diameter, to achieve the proper cutting speed	
3. Factors to be considered:	
a. The type of work material	
b. The cutter material	
c. The diameter of the cutter	
d. The surface finish required	
e. The depth of cut being taken	
f. The rigidity of the machine and work setup	
4. Cutting Speed (surface feet) Table	Slide #88
5. Best results are obtained:	
a. For longer cutter life, use the lower CS in the recommended range.	
b. Know the hardness of the material to be machined.	

CONTENT **METHODS & ACTIVITIES**

c. When starting a new job, use the lower range of the CS and gradually increase to the higher range if conditions permit.

d. If a fine finish is required, reduce the feed rather than increase the cutter speed.

e. The use of coolant, properly applied will generally produce a better finish and lengthen the life of the cutter because it absorbs heat, acts as a lubricant, and washes chips away.

B. Feed

1. The distance in inches per minute that the work moves into the cutter

2. Regulated in inches per minute (IPM) and is independent of the spindle speed.

   a. This arrangement permits faster feeds for larger, slowly rotating cutters.

3. The milling feed is determined by multiplying the desired chip size (chip amount per tooth) by, the number of teeth in the cutter and the rpm of the cutter.

   a. Chip per tooth (CPT) is the amount of material, which should be removed by each tooth of the cutter as it revolves and advances into the work piece.

4. Factors:

   a. The depth and width of cut

   b. The design or type of cutter

   c. The sharpness of the cutter

   d. The work piece material

CONTENT	METHODS & ACTIVITIES
e. The strength and uniformity of the work piece	
f. The type of finish and accuracy required	
g. The power and rigidity of the machine	
5. Formula: Feed = number of teeth x feed/tooth x cutter rpm	
6. Feed Table	Slide #89
C. Depth of Cut	
1. Roughing cuts should be deep, with a feed as heavy as the work and the machine will allow	
a. Heavier cuts may be taken with helical cutters having fewer teeth since they are stronger and have a greater chip clearance than cutters with more teeth.	
2. Finishing cuts should be light, with a finer feed than is used for roughing cuts.	
a. The depth of the cut should be at least 1/64 inch.	
b. Lighter cuts and extremely fine feeds are not advisable since the chip taken by each tooth will be thin and the cutter will rub on the surface of the work, rather than bite into it, dulling the cutter.	
c. When a fine finish is required, the feed should be reduced rather than speeding the cutter up. (More cutters are dulled by high speeds than by high feeds.)	

CONTENT	METHODS & ACTIVITIES
3. To prevent damage to the finished surface, never stop the feed when the cutter is revolving over the work. 4. For the same reason, move the cutter before returning the work to the starting position upon completion of the cut.	

EO: 1.5 State the safety precautions when working on a milling machine.

	CONTENT	METHODS & ACTIVITIES
I.	SAFETY PRECAUTIONS	Slide 90
	Pre-Job Brief and 2-Minute Drill talking points	
A.	Be sure that the work and cutter are mounted securely before taking a cut. *OSHP Manual Section VII, Art. 7, Para. C.3 states in part "the work shall be properly secured and the correct tool used."*	Slide #91
B.	Always wear safety glasses.	Slide #92
C.	When mounting or removing milling cutters, always hold them with a cloth to avoid the sharp edges.	Slide #93
D.	When setting up work, move the table as far as possible from the cutter to avoid any injury.	Slide #94
E.	Be sure that the cutter and machine parts will clear the work before making any cut.	Slide #95
F.	Never attempt to mount, measure, or adjust work until the cutter is completely stopped. Do not attempt to stop the cutter with your hand. *OSHP Manual Section VII, Art. 7, Para. C.1 tells us not to stop the machine with our hands.*	Slide #96

G. Keep hands, brushes, and rags away from a revolving milling cutter at all times. Slide #97

H. When using milling cutters, do not use an excessively heavy cut or feed. This can cause the cutter to break and the resulting flying pieces may cause injury. Slide #98

I. Always use a brush, never a rag, to remove the cuttings after the cutter has stopped revolving. Slide #99

J. Never reach over or near a revolving cutter; keep hands at least 12 inches from the revolving cutter. *OSHP Manual Section VII, Art. 7, Para. A.2 tells us that we will not wear loose clothing, jewelry, watches, rings or neckties around operating equipment.* Slide #100

K. Keep the floor around the machine free of chips, oil and cutting fluid. Slide #101

SUMMARY OF MAIN PRINCIPLES

The following items are things to consider in your lesson summary. They are not mandatory. You should develop your own summary.,

Objectives Review

Review the Lesson Objectives

Topic Review

Restate the main principles or ideas covered in the lesson. Relate key points to the objectives. Use a question and answer session with the objectives.

Questions and Answers

Oral questioning

Ask questions that implement the objectives. Discuss students answers as needed to ensure the objectives are being met.

Problem Areas

Review any problem areas discovered during the oral questioning, quiz, or previous tests, if applicable. Use this opportunity to solicit final questions from the students (last chance).

Concluding Statement

If not done in the previous step, review the motivational points that apply this lesson to students needs. If applicable, end with a statement leading to the next lesson.

You may also use this opportunity to address an impending exam or practical exercise.

Should be used as a transitional function to tie the relationship of this lesson to the next lesson. Should provide a note of finality.