PALO VERDE
NUCLEAR GENERATING STATION

Mechanical Maintenance Training
Common Milling Machine Operations
Classroom Lesson

Mechanical Maintenance Training	**Date: 12/3/2010 5:16:58 PM**
LP Number: NMS61C000204	**Rev Author: MARK TAGUE**
Title: Common Milling Machine Operations	**Technical Review:** Fredrickson, Rodney J(Z36022) Digitally signed by Fredrickson, Rodney J(Z36022) DN: cn=Fredrickson, Rodney J(Z36022) Date: 2011.08.02 10:42:17 -07'00'
Duration : 11 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 12:09:29 -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

Machine Tool Metalworking, John L. Feirer, 2nd Edition

PVNGS OSHP Manual

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

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 Common Milling Machine Operations :

Task or Topic Number*	**Task Statement**
Lesson:	Common Milling Machine Operations
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 that requires the performance of milling machine operations, the Maintenance Mechanic will , describe the proper set-up and performance of the various milling machine operations. Mastery will be demonstrated by successfully passing a written examination with a minimum score of 80% correct.

1.1 Describe the proper set-up of a milling machine for various milling machine operations.

1.2 Describe the more common milling operations performed on a vertical milling machine.

	CONTENT	METHODS & ACTIVITIES
I.	Motivation	Focus student attention on "What's In It For Me".
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 (Terminal Objectives) Given a job assignment that requires the performance of milling machine operations, the Maintenance Mechanic will, describe the proper set-up and performance of the various milling machine operations. Mastery will be demonstrated by the completion of a comprehensive written examination with a minimum score of 80% correct.	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)	Look at Error Precursors in S&E book
a.	Discuss at least one specific error likely situation	
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.	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.
6.	Break policy	
a.	Two Minute Drill – After lunch at a minimum	At Instructor's discretion, not to interrupt class flow

CONTENT	METHODS & ACTIVITIES
III. Lesson Enabling Objectives	Read and/or discuss the lesson objectives
EO01 Describe the proper set-up of a milling machine for various milling machine operations.	
EO02 Describe the more common milling operations performed on a vertical milling machine.	

TO: 1 Given a job assignment that requires the performance of milling machine operations, the Maintenance Mechanic will , describe the proper set-up and performance of the various milling machine operations. Mastery will be demonstrated by successfully passing a written examination with a minimum score of 80% correct.

EO: 1.1 Describe the proper set-up of a milling machine for various milling machine operations.

CONTENT	METHODS & ACTIVITIES
I. Operating Experience #22171	Slide 102 - 103
A. In February of 2006 three contract employees were coordinating the drilling of 7/8” diameter holes in ¼” thick aluminum diamond plate to facilitate installation of hoist rings so the decking could be hoisted into position. While operating the drill press, one of the workers was brushing away metal filings with his gloved left hand. The worker's left sleeve became entangled in the operating drill bit, which pulled his hand into the bit resulting in portions of two fingers on his left hand being severed. A co-worker observed the worker's situation and pushed the "off" button to secure the drill press. The other co-worker called the site emergency number and reported the accident to the control room supervisor (CRS). The first aid team responded and provided treatment for the hand injury until the ambulance arrived. The worker was transported by ambulance to the airport where a helicopter was waiting to take him to the hospital. CAUSES Contrary to the drill press operator's manual instructions, the employee was wearing loose clothing, did not keep hands and clothing away from moving parts, and tried to remove metal filings while the bit was rotating. As a result, the employee placed his hand in the "Line-Of-Fire," the drill bit caught the clothing on his arm, and his hand was pulled into the moving parts.	

CONTENT	METHODS & ACTIVITIES

Use of Human performance tools like a good two minute drill should have been able to identify the hazards associated with operating rotating machinery, including the mention of loose fitting sleeves and not wearing gloves when operating rotating machinery.

PVNGS safety manual Section 7, article 8, paragraph B states that gloves should not be worn when working around rotating equipment because just like loose fitting clothing, badge lanyards etc., the gloves can be sucked into the rotating equipment causing injuries.

NOTE: Hand drills, grinders, impact guns etc. are NOT considered rotating machinery and gloves will be required to operate those tools.

Because a milling machine rotates the same as a drill press, this event demonstrates that the same hazards exist when operating the mill and prevent event tools must be used to mitigate hazards.

II. ALIGNMENT TECHNIQUES

A. Generally, the stationary jaw of the vise must be either at right angles to the face of the machine column, or it must be parallel with the face of the column

B. Methods:

Prevent Event Tool: Questioning attitude. Realize that if the vise or fixture holding the work is not in proper alignment with the spindle; the cuts being made to the part will not be square, level or straight. This can have significant impact on whether the finished product is acceptable or not.

CONTENT	METHODS & ACTIVITIES
1. Right angle squareness of the vise with the column can be checked by placing the blade of a precision steel square against the stationary jaw of the vise while placing the beam of the square against the machined surface of the column.	Slide #104
2. Place parallel bars between the machine column and the angle plate.	Slide #105
a. No light should show between the parallel and the table or between the parallel and the column	
3. Parallelism of the stationary jaw can be checked with a dial indicator. (.001" TIR)	Slide #106
a. Clamp the indicator to the arbor with the plunger touching the stationary vise jaw.	
b. Correct any misalignment.	
C. Setting the Cutter to the Work Surface	
1. Raise the work to within 1/8 in. of the cutter and directly under it.	
2. Hold a long piece of paper on the surface of the work.	
a. Before laying the paper on the work measure the thickness of the paper with a dial caliper so you know how thick it is.	
b. Have the paper long enough to prevent the fingers from contacting the revolving cutter.	

CONTENT	METHODS & ACTIVITIES

3. Shift the Hi-Lo range gearbox lever to neutral (in between Hi and Lo).

    a. This will allow you to manually rock the spindle back and forth with your hand.

    Prevent Event Tool: Two Minute Drill and maintaining Situational Awareness. There is always the possibility of being cut by sharp tooling when setting up mill operations. Ensure this is understood before rocking the spindle and checking for clearance. Be sure to keep hands and fingers a safe distance away from the cutter while rocking and adjusting table height.

4. Start rocking the spindle/cutter back and forth with your hand.

5. With the left hand on the knee elevating handle, raise the work up ***slowly*** until the cutter just touches the paper.

    a. At this point you know the cutter is approximately; the thickness of the paper you measured in step 2 above, away from the work.

CONTENT	METHODS & ACTIVITIES
6. Move the machine table so that the cutter just clears the end of the work piece. 7. Raise the knee the same amount as the thickness of the paper. 8. Set the graduated collar on the elevating screw handle to zero. Do not move the elevating screw handle. 9. Move the work clear of the cutter and raise the table to the desired depth of cut. **NOTE:** This method can also be used when setting the edge of a cutter to the side of a piece of work. In this case, the paper will be placed between the side of the cutter and the side of the work piece.	

EO: 1.2 Describe the more common milling operations performed on a vertical milling machine.

CONTENT	METHODS & ACTIVITIES
I. COMMON MILLING OPERATIONS - VERTICAL MILL	Slide 107
Prevent Event Tool: Two minute drill & self checking. Ensuring that the vise or fixture holding the work is square/parallel to the column of the mill and runs exactly parallel to the spindle is very important. If these set up steps aren't verified, the mill can cut the work on an angle so slight that it won't be detected visually, however will be noticed when measured with a micrometer or caliper. The taper could be so bad that the part or work piece is ruined and a new part will need to be fabricated.	
A. Aligning the Vertical Head	Slide 108
1. Mount a dial indicator on the spindle at 90^{O}, on a suitable rod.	
2. Position the indicator over the top of the table	
3. Carefully lower the spindle until the indicator button touches the table and the dial indicator registers about a half of a revolution.	
a. Set the indicator to zero and lock the spindle in place.	
4. Carefully rotate the vertical mill spindle 180^{O} by hand until the button bears on the opposite side of the table.	Slide #109
a. Compare the two readings.	

CONTENT	METHODS & ACTIVITIES

5. If there is any discrepancy in the readings, loosen the locking nuts on the swivel mounting and adjust the head until the indicator registers one-half the difference between the two readings.

    a. Tighten the locking nuts.

6. Recheck the accuracy of the head and adjust if necessary.

7. Rotate the vertical mill spindle 90^{O}, and set the dial indicator again.

8. Rotate the spindle 180^{O} and compare the two readings. Adjust as necessary

9. Tighten the locking nuts on the swivel head.

10. Recheck the readings and adjust as necessary.

    a. Prevent Event Tool: Self Checking. When readings are taken, it is important that the indicator button does not catch in the T-slot on the table and break the indicator. To prevent this, it is advised to work from the high reading first and then rotate to the low reading ensuring the button is lifted by hand or with shim material past the slots in the table.

    b. The longer the rod used on the dial indicator, the more accurate the setting will be.

CONTENT **METHODS & ACTIVITIES**

B. Machining a Flat Surface

1. Clean the vise and mount the work securely in the vise, on parallels if necessary.

PREVENT EVENT TOOL: Self Checking. Any time a work piece is installed in the vise or fixture the worker must insure that the work piece is free of debris, metal chips or burrs. This same inspection for debris on the mill table, vise, or fixtures must be performed. Any debris, metal chips, or burrs not removed, can have a dramatic effect on the accuracy of the cuts made.

2. Check that the vertical head is square with the table.

3. If possible, select a cutter that will just overlap the edges of the work. It will then require only one cut to machine the surface.

    a. If the surface to be machined is narrow; an end mill slightly larger in diameter than the width of the work should be used.

    b. If the surface is large and requires several passes, a shell end mill or suitable fly cutter should be used.

4. Set the proper spindle speed for the size and type of cutter and material being machined.

5. Tighten the quill clamps.

CONTENT	METHODS & ACTIVITIES
Prevent Event Tool: Questioning Attitude/ Two minute drill. Before the mill is started a two minute drill needs to be performed. Have a questioning attitude as the drill is performed and ask questions like the following. "Is the part tight in the vise? Are the hold down bolts for the fixture tight? When the cutter starts spinning will it run into any part of the vise, fixture or obstruction not intended to be cut? Is the speed set properly for the material and diameter of cutter being used?	
6. Start the machine, and adjust the table until the end of the work is under the edge of the cutter.	
7. Raise the table until the work surface just touches the cutter.	
a. Move the work clear of the cutter.	
8. Raise the table about 1/32 inch and take a trial cut for approximately 1/4 inch.	
9. Move the work clear of the cutter, stop the cutter, and measure the work.	
10. Raise the table the desired amount, and lock the knee clamp.	
11. Mill the surface to size using the automatic feed (or hand feed if desired).	
C. Squaring Work	Slide #110
1. Machining Side 1	
a. Clean the vise thoroughly and remove all burrs from the work piece.	
b. Set the work in the vise with the first surface (Side 1) facing up.	

CONTENT	METHODS & ACTIVITIES
c. Insert a soft metal rod between the work and the movable jaw if that portion of the work is rough or not square.	
d. Tighten the vise securely.	
e. With a soft-faced hammer, tap the work piece down in the vise until it sits securely.	
f. Mount a suitable cutter in the milling machine spindle.	
g. Set the machine for the proper speed for the size of cutter and the material to be machined.	
h. Start the machine and raise the table until the cutter just touches the right-hand end of side 1.	Two Minute Drill Questioning Attitude & Self Checking.
i. Move the work clear of the cutter.	
j. Raise the table about .030 in. and machine side 1 using a steady feed rate.	
k. Take the work out of the vise and remove all burrs from the edges with a file.	
2. Machining Side 2	
a. Clean the vise, work, and parallels thoroughly	
b. Place the work on parallels, if necessary, with side 1 against the solid jaw of the vise and side 2 up.	
c. Place a round bar between side 4 and the moveable jaw, if necessary.	
d. Secure the work piece in the vise by tapping with a soft-faced hammer.	

CONTENT	METHODS & ACTIVITIES
3. Machining Side 3	
a. Clean the vise, work, and parallels.	
b. Place side 2 against the solid vise jaw with side 1 resting on parallels.	
c. Place the round bar between side 4 and the moveable jaw.	
d. Tighten the vise securely and tap the work piece down until the parallels don't move.	Method of self-check
e. Start the machine and raise the table until the cutter just touches the right-hand end of side 3.	
f. Move the work clear of the cutter and raise the table about 0.010 in.	
g. Take a trial cut, stop the machine, and measure the width of the work.	
h. Raise the table the required amount and machine side 3 to the correct width.	
i. Remove the work and file off all burrs.	
4. Machining Side 4	
a. Clean the vise, work, and parallels.	
b. Place side 2 down on the parallels (or bottom of the vise) with side 4 up.	
c. Tighten the vise.	
d. Machine side 4 to the correct size.	

CONTENT	METHODS & ACTIVITIES
D. Machining the Ends Square	Slide 111
1. Two common methods	
a. Short pieces are generally held vertically in the vise and are machined with an end mill or flycutter.	
b. Long pieces are generally held flat in the vise with one end extending past the end of the vise.	
1) The end surface is then cut square with and end mill.	
2. Short Work Squaring	
a. Set the work in the center of the vise with one of the end up and tighten the vise.	
b. Hold a square down firmly on the top and bring the blade into contact with the side of the work.	
c. Tap the work until its edge is aligned with the blade of the square.	
d. Tighten the vise securely and recheck the squareness.	
e. Take about 0.030 in. cut, and machine the end square.	
f. Remove the burrs from the end of the machined surface.	
g. Clean the vise and set the machined end on paper feelers in the bottom of the vise.	
h. Tighten the vise securely and tap the work down until the paper feelers are tight.	
i. Take a trial cut from the end to clean up the surface.	

CONTENT	METHODS & ACTIVITIES
j. Measure the length of the work piece with a depth micrometer.	
k. Raise the table the required amount and machine the work to length.	
E. Machining an Angular Surface	Note: The instructor should demonstrate this setup and layout if possible.
1. Layout and mark the angular surface.	
2. Clean the vise.	
Prevent Event Tool: *Self-Check-Use a brush to clean chips from the vise, not your hands.*	
3. Align the vise with the direction of feed.	
4. Mount the work on parallels in the vise.	
5. Part can be set up in a vise that can be set to the required angle or the head can be tilted to the proper angle depending on what kind of cut is being made.	
6. Tighten the quill clamp.	
7. Start the machine and raise the table until the cutter touches the work.	Two Minute Drill – Self Check
a. Carefully raise the table to set the desired depth of cut.	
8. Take a trial cut for about 1/2 inch.	
9. Check the angle with a protractor	
10. If the angle is correct, continue the cut.	
11. Machine to the required depth, taking several cuts if necessary	

CONTENT	METHODS & ACTIVITIES
12. Alternate Method	
a. Angles may sometimes be cut by leaving the head in a vertical position and setting the work on an angle in the vise. This will depend on the shape and size of the work piece. Sometimes, a universal vise can be set to the required angle.	
F. Cutting Slots and Keyways	Slide #112
1. If the key seat has two blind ends, a two or three-lip end mill must be used since they will act as a drill to start the slot.	
a. If the slot is at an end of the shaft (one blind end), a four-fluted end mill may be used, but a two- or three-lip end mill would give better chip clearance.	
2. Lay out the position of the key seat on the shaft and scribe reference lines on the end of the shaft.	Slide 113
3. Secure the work piece in a vise on a parallel.	
a. If the shaft is long, it may be clamped directly to the table by placing it in one of the table slots, or on V-blocks.	
4. Using the layout lines on the end of the shaft, set the shaft so that the key seat layout is in the proper position on the top of the shaft.	
5. Mount a two- or three-fluted end mill of a diameter equal to the width of the keyway, in the milling machine spindle.	

CONTENT	METHODS & ACTIVITIES
6. Center the work piece by carefully touching the cutter to one side of the shaft. a. A thin piece of paper can be used to protect the finish of the shaft. b. Zero the adjustment collar for the cross feed screw handle.	
7. Lower the table until the cutter clears the work piece.	
8. Move the table over an amount equal to half the diameter of the shaft plus half the diameter of the cutter (plus the thickness of paper if used). NOTE: Alternate methods include the use of an edge finder or a dial test (Trammel) indicator.	
9. If the key seat being cut has two blind ends, adjust the work until the end of the key seat is aligned with the edge of the cutter.	Slide 114 -115
10. Feed the cutter down (or raise the table up) until the cutter just cuts to its full diameter. a. If the key seat has only one blind end, the work is adjusted so that this cut is taken at the end of the work. b. The work is then moved clear of the cutter.	
11. Set the depth of cut to one-half the thickness of the key and machine the key seat to the proper length.	

CONTENT	METHODS & ACTIVITIES
G. Woodruff Keyways	Slide 116 Note: It would be a good training aid to pass around a Woodruff key and key cutter. Also, a previously cut keyway in a shaft could show the difference between the straight key and the Woodruff.
1. Used when keying shafts and mating parts.	
a. More quickly cut than square key seats are, and the key should not require any fitting after the key seat has been cut.	
b. Semicircular in shape and can be purchased in standard sizes (designated by E numbers).	
c. Also can be made from round bar stock of the required diameter.	
H. Cutting a Woodruff Key seat.	
1. Align the spindle of the vertical milling machine to 90^{O}.	
2. Lay out the position of the key seat.	
3. Set the shaft in the vise of the milling machine or on V-blocks.	
a. Be sure that the shaft is level and parallel to the table.	
4. Mount a cutter of the proper size in the spindle.	Slide 117
5. Start the cutter and touch the bottom of the cutter to the top of the work piece.	Slide 118
a. Set the vertical graduated feed collar to zero.	

CONTENT	METHODS & ACTIVITIES
6. Move the work clear of the cutter and raise the table half of the diameter of the work plus half the thickness of the cutter. a. Lock the knee at this position. 7. Position the center of the slot with the center of the cutter. a. Lock the table in this position. 8. Touch the revolving cutter to the work. a. Set the cross feed collar to zero. 9. Cut the key seat to the proper depth.	

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.