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ABSTRACT

This guide is intended for use in a course in programming and operating a computerized numerical control system. Addressed in the course are various aspects of programming and planning, setting up, and operating machines with computerized numerical control, including selecting manual or computer-assigned programs and matching them with program/language definitions, determining speeds and operating modes, computing tool coordinates and workpiece geometries, verifying cutter paths, plotting programs, programming tool change procedures, matching codes with responses, calculating running times, preparing tapes, writing manual programs, programming with purchased software, designing special features for custom jobs, repairing broken tapes, updating programs for engineering changes, determining job priorities, scheduling programs, checking tooling sheets, installing and loading tools, making dry runs of programs, adding and altering commands, editing programs, running segments of programs, performing sequence searching, and resetting equipment. Each unit contains some or all of the following: a guide sheet consisting of a duty statement, performance and enabling objectives, a list of resources, teaching activities, criterion-referenced measures, and performance guides; visual aids; student worksheets and answers; and checklists. Appendixes include a cross-referenced list of tasks and job titles, definitions, a list of necessary tools and equipment, and a 38-item bibliography. (MN)

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Computerized Numerical Control

Curriculum Guide

CE 045 123

V-TECS

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VOCATIONAL—TECHNICAL EDUCATION CONSORTIUM OF STATES

V-TECS GUIDE

FOR

COMPUTERIZED NUMERICAL CONTROL

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1986

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INTRODUCTION

Simply, V-TECS guides are extensions of the V-TECS catalog. While the V-TECS catalogs compile duties, task performance objectives, and performance guides, the catalogs emphasize the psychomotor aspect of an occupation. In addition, V-TECS catalogs establish blueprints of the occupations, while V-TECS guides consider background information surrounding the tasks as well as the process of making inferences, generalizations, and decisions. V-TECS guides take these aspects of the learning process in consideration, and go a step further by including job seeking skills, work attitudes, energy conservation practices, and safety.

Experience has shown that the art of learning can also be taught while teaching subject matter. Studies indicated that people need to learn how to learn. V-TECS guides are written to deal with this learning process as an efficient means of assisting instructors in the task of teaching.

V-TECS guides are centered around all three domains of learning: psychomotor, cognitive, and affective. The following is a brief explanation of each of these learning domains.

PSYCHOMOTOR

V-TECS guides are developed around the psychomotor tasks that are considered worker oriented. Psychomotor or manipulative skills such as tightening a nut, replacing a hubcap, or machining a key slot in a steel shaft, are identified in the V-TECS catalog, but the suggestions on how to learn to do these tasks are addressed in the V-TECS guides.

COGNITIVE

To perform psychomotor tasks, students must think. To tighten a nut they must know which way to turn it and when to stop turning it so that they won't strip the threads. If replacing a hubcap, there is a certain technique that may vary from one car to another. For example, start the hubcap by placing the cap in a tilted position and tapping it all the way around until it is seated. On a different model, it may be necessary to position the hubcap and snap t all at once. At any rate, students must think about what is being done. This is cognition or a mental activity. cognition is what goes on in the mind about any job being done. V-TECS guide provide both the collateral knowledge and the impetus to apply cognition to psychomotor tasks.

Students gain cognition through both real and vicarious experiences. They may read, view tapes, memorize or practice a process or procedure until they are certain of it. To test their knowledge, students may be required to decide the procedure, method, or sequence for performance. This is decision making or cognitive activity in its highest form.

Cognition is that process by which information is stored and used. The voice that warns one of potential dangers, is cognition. It is cognition that tells one to lock and tag out the power supply to an electrical apparatus before starting to repair it. However, cognition does not apply only to safety. Good cognition, or thinking, can help employees do a job better and quicker. V-TECS guides provide for the cognitive aspects of learning.

AFFECTIVE

Curriculum writers, supervisors, and instructors often fail to assist students in acquiring a positive attitude toward themselves, their job, school or fellow students. V-TECS guides seek to provide assistance to the instructor in achieving positive attitudes. It is difficult for the instructor to identify little bits and pieces of desirable behavior for every unit and often harder yet to teach them. In this area, students might be judged on how well they clean up their work area, whether they showed up to do the job in time, or whether they must be told several times to do something. Potential employers are interested in student attitudes because attitudes directly reflect upon work habits.

A student's ability to succeed on the job depends largely on attitude. If, for example, students have the attitude: "Let someone else do it," they could be in trouble. Realizing this, V-TECS guides include activities designed to help the student get along with others.

USE OF V-TECS GUIDE

The guides are designed to provide job-relevant tasks, performance objectives, performance guides, resources, learning activities, evaluation standards and achievement testing in selected occupations.

A V-TECS guide is designed to be used with any teaching methods. If a lecture/demonstration method is best for you, you will find sufficient help to meet your needs. If, however, you prefer to use discussions or other methods that require student participation, the V-TECS guides can save preparation time and offer innovative methods and procedures. Further, this work takes into consideration students' attitudes, thinking skills, and mathematical reading skills.

The use of small groups in teaching can be helpful in a number of ways: (1) many students may feel inadequate due to their lack of background information in mechanical areas; (2) some may feel that they are physically incompetent or lack the necessary background experiences. A successful program can provide students with a sense of security by reinforcing positive attitudes while improving their skills and knowledge. The task/learner-centered approach can be achieved by allowing students to interact on a personal level. Confidence increases when students discover that they are an essential part of a team engaged in the learning-teaching process. Students learning to work without direct supervision, permits the instructor to vary instructional routines away from the lecture or other full-class methods.

The V-TECS guides provide suggestions for specific classroom activities. These activities are not meant to be restrictive but a suggested variety of learning activities for each task statement. Students may complete any or all parts of the activities.

CURRICULUM GUIDES

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #1

TASK: Develop programmed instructions from blueprint.

STANDARD OF PERFORMANCE OF TASK:

Programmed instructions must meet blueprint dimensions and range of plus or minus tolerance standards as set by employer.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook.

CONDITIONS FOR PERFORMANCE OF TASK:

Computer
Software
Calculator
Trigonometry
Blueprint
3-D perspective
Basic Machining skills

ENABLING OBJECTIVE:

1. Plan, visualize, and predict machining operations and sequences.
2. Determine feeds and speeds of cutting tool.
3. Specify part position on machine.
4. Prepare operator instructions and programmed instructions from workpiece blueprint.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. Krar, Oswald, and Amand. Technology of Machine Tools, Second Edition. McGraw Hill Book Company, Chicago, IL.
4. Milling Handbook of High Efficiency Metal Cutting. Carboloy Systems Department, Detroit, MI.
5. French and Swensen. Mechanical Drawing. McGraw Hill Book Company, New York, NY. 1966.

RESOURCES: (cont.)

6. W. C. Brown. Blueprint Reading For Industry. Goodheart-Wilcox, South Holland, IL. 1983.
7. E. G. Hoffman. Jig and Fixture Design. Delmar Publishers, Chicago, IL. 1985.
8. Manufacturer's programming manual.
9. Checklist - Develop programmed instructions from a blueprint.
10. Sample workpiece blueprint.

TEACHING ACTIVITIES:

1. Present lecture on blueprint reading. (*6)
2. Demonstrate blueprint reading techniques.
3. Instruct student to locate indicated specifications on the assigned workpiece blueprint. (*9 & 10)
4. Present lecture on manual drawing of tool path. (*5 & 7)
5. Demonstrate procedure for tool path manual drawing.
6. Instruct student to complete a manual drawing of tool path for assigned workpiece blueprint. (*9 & 10)
7. Present lecture on determining feeds, speeds and cutting tool specifications. (3,4 & 8)
8. Demonstrate techniques for determining feeds, speeds and cutting tool specifications.
9. Instruct student to determine feeds, speeds, and cutting tool specifications using assigned workpiece blueprint. (*9 & 10)
10. Present lecture on writing programmed instructions and operator instructions. (*1,2 & 8)
11. Demonstrate how to write programmed instructions and operator instructions.
12. Instruct student to write programmed instructions and operator instruction for assigned blueprint.

CRITERION-REFERENCED MEASURE:

Given a workpiece blueprint, the student will prepare a computer part program, process the program and prepare related documentation for the operator.

PERFORMANCE GUIDE:

1. Visualize machining sequences.
2. Establish reference point to align workpiece and machine tool.
3. Specify cutting tool.
4. Specify feeds and speeds of cutting tool.
5. Specify location of holding devices in reference to machine table and workpiece.
6. Specify spindle rotation, coolant flow, and table indexing (depending on type of machine tool used).
7. Prepare list of each machining instruction in format that can be utilized by particular control unit/ machine tool combination to be used.

PERFORMANCE GUIDE: (cont.)

8. Examine list to determine:
   a. First machining operation.
   b. Sequence of remaining machining operations.
9. Develop manuscript to document sequence of operations.
10. Prepare explicit operator instructions.

CHECKLIST

DUTY Programming and planning.

TASK Develop programmed instructions from blueprint.

ENABLER Prepare operator instructions and programmed instructions from workpiece blueprint.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate developing programmed instruct ons from a blueprint.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Determined machine sequences.	____	____
- Established reference point to align workpiece and machine tool.	____	____
- Specified cutting tool.	____	____
- Specified cutting tool feeds and speeds.	____	____
- Specified location of holding device.	____	____
- Specified spindle rotation, coolant flow and table indexing.	____	____
- Prepared a list of machining instructions.	____	____
- Checked the machining instruction list for first machining operation and sequence of remaining operations.	____	____
- Developed a manuscript documenting sequence of operations.	____	____
- Developed explicit operator instructions.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #2

TASK: Develop programmed instructions from piece part.

STANDARD OF PERFORMANCE OF TASK:

Programmed piece part must meet blueprint dimensions and range of plus or minus tolerance standards as set by employer.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Geometry
Caliper
Trigonometry
Piece part
Micrometer
Calculator
Measuring instrument
Computer and software
3-D perspective
Basic programming skills
Basic machining skills
Coordinate measuring machine

ENABLING OBJECTIVE:

1. Determine dimensions of piece part.
2. Determine machining operations/sequence.
3. Determine cutting tool feeds and speeds.
4. Specify tooling and machine codes.
5. Prepare operator instructions and programmed instructions from piece part.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
3. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY. 1982.
4. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.

RESOURCES: (cont.)

5. Milling Handbook of High Efficiency Metal Cutting. Carboloy Systems Department, Detroit, MI.
6. Turning Handbook of High Efficiency Metal Cutting. Carboloy Systems Department, Detroit, MI.
7. Krar, Oswald and Amand. Technology of Machine Tools. Second Edition. McGraw Hill Book Company, Chicago, IL.
8. French and Swensen. Mechanical Drawing. McGraw Hill Book Company, New York, NY. 1966.
9. A. Washington. Basic Technical Mathematics. The Benjamin/Cummings Publishing Company, Reading, PA. 1985.
10. E. G. Huffman. Jig and Fixture Design. Delmar Publishers, Chicago, IL. 1985.
11. Manufacturer's programming manual.
12. Practice piece part.
13. Checklist - Develop programmed instructions from a piece part.

TEACHING ACTIVITIES:

1. Present lecture types of measuring tools and measuring procedures. (*1,7 & 9)
2. Demonstrate measuring procedures for different types of measuring tools.
3. Instruct student to measure example piece part.
4. Present lecture on drawing and dimensioning a piece part. (*8,9 & 10)
5. Demonstrate drawing and dimensioning procedure.
6. Instruct student to draw and dimension tool path. (*12 & 13)
7. Present lecture on selecting cutting tool, tool alignment reference point, tool feeds and speeds, and part holding device. (*1,2,3,4,5,6 & 7)
8. Demonstrate cutting tool, reference point, feeds and speeds and holding device selection. (*12 & 13)
9. Present lecture on writing programmed instructions and operator instructions.
10. Demonstrate how to write programmed instructions and operator instructions.
11. Instruct student to write programmed instructions and operator instructions based on example piece part. (*12 & 13)

CRITERION-REFERENCED MEASURE:

Given a machined piece part, the student will write a complete computer part program, process the program and prepare related documentation for the operator.

PERFORMANCE GUIDE:

1. Measure machined surface.
2. Make a print or sketch.
3. Dimension the sketch.

PERFORMANCE GUIDE: (cont.)

4. Visualize machining sequences.
5. Establish reference point to permit alignment of workpiece and machine tool.
6. Specify cutting tools.
7. Specify setting of feeds and speeds.
8. Specify location of holding devices.
9. Specify spindle rotation, coolant flow, and table indexing (depending on type of machine tool used).
10. Prepare list of each machining instruction in format that can be utilized by particular control unit/ machine tool combination to be used.
11. Develop manuscript to document sequence of operations.
12. Prepare explicit operator instructions.

CHECKLIST

DUTY Programming and planning.

TASK Develop programmed instructions from piece part.

ENABLER Prepare operator instructions and programmed instructions from piece part.

STUDENT'S NAME ______________ DATE ______

EVALUATOR'S NAME ______________ COURSE ______

TIME : STARTED ______ COMPLETED ______________

TOTAL ______

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate developing programmed instructions from piece part.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Measured the piece part machined surface.	____	____
- Made a sketch or drawing of the piece part.	____	____
- Dimensioned the sketch or drawing.	____	____
- Identified machining sequences.	____	____
- Established workpiece and machine tool alignment reference point.	____	____
- Identified cutting tools.	____	____
- Determined feed and speed settings.	____	____
- Identified holding device locations.	____	____
- Determined spindle rotation, coolant flow and table indexing.	____	____
- Prepared a machining instruction list.	____	____
- Developed a sequence of operations manuscript.	____	____
- Developed explicit operator instructions.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #3

TASK: Draw sketch of desired workpiece.

STANDARD OF PERFORMANCE OF TASK:

Sketch must provide programmer with dimensioning information for developing programmed instructions for the production of piece part.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Numerical Control Machining series.

CONDITIONS FOR PERFORMANCE OF TASK:

Sketch pad
Measuring instruments
Pencils
Spacial perception
Erasers
Workpiece scales

ENABLING OBJECTIVE:

1. Use precision measuring instruments.
2. Sketch orthographic views and a pictorial view of workpiece.
3. Locate rectangular coordinates relative to workpiece.
4. Design fixture applicable to locate and hold the part when machining.

*RESOURCES:

1. Washington,A.J., Basic Technical Mathematics. The Benjamin Cummings Publishing Co.,Reading, 1985.
2. French and Swensen. Mechanical Drawing. McGraw Hill Book Company, New York, NY. 1966.
3. W. C. Brown. Blueprint Reading For Industry. Goodheart-Wilcox, South Holland, IL. 1983.
4. E. G. Hoffman. Jig and Fixture Design. Delmar Publishers, Chicago, IL. 1985.
5. Checklist - Sketching desired workpiece.
6. Visual aid - Workpiece.

TEACHING ACTIVITIES:

1. Present lecture on use of measuring tools. (*2)
2. Demonstrate use of measuring tools.
3. Instruct student to measure a part.
4. Present lecture on sketching a workpiece. (*1,3 & 4)
5. Discuss the rectangular coordinate system, its relation to the machine tool, and application to the workpiece design/function.
6. Discuss orthographic vs. pictorial of the workpiece.
7. Demonstrate principles of fixture design.
8. Discuss, illustrate special notes to the operator.
9. Instruct student to draw a sketch of a workpiece. (*5)

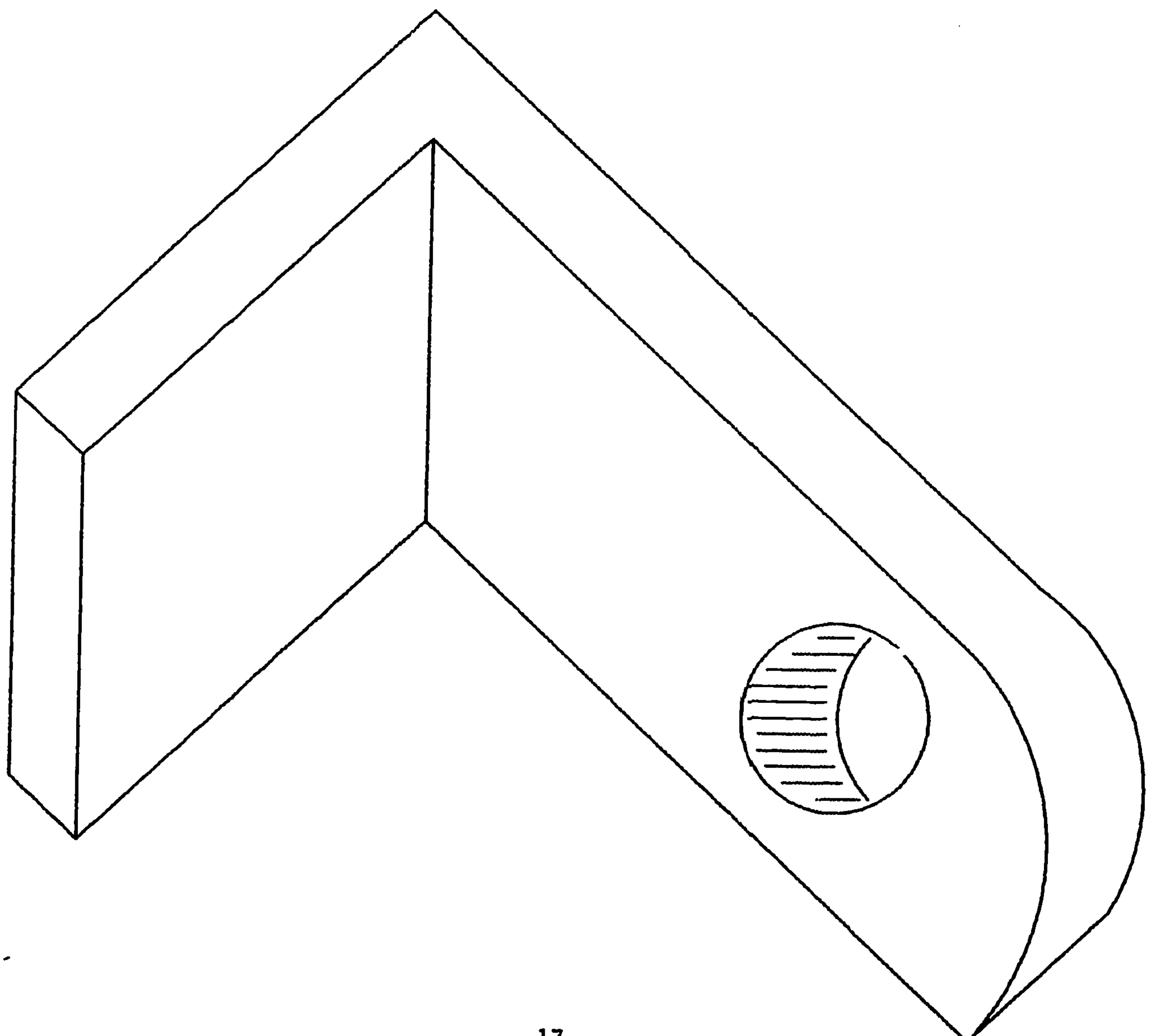
CRITERION-REFERENCED MEASURE:

Given a workpiece, the student will measure the part, determine a coordinate system, design a position/holding fixture, specify operation notes, and sketch the workpiece.

PERFORMANCE GUIDE:

1. Develop front elevation view of workpiece.
2. Develop top and side view of workpiece.
3. Locate all dimensions from one common datum:
   a. Locate zero point.
   b. Locate fixturing.
   c. Locate setup point.
   d. Locate reference datums.
   e. Locate coordinates.
4. Place reference notes and safety notes at lower right hand corner of sketch.

ORTHOGRAPHIC VIEW



CHECKLIST

DUTY Programming and planning.

TASK Draw sketch of desired workpiece.

ENABLER Sketch orthographic views and a pictorial view of workpiece.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED __________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate sketching orthographic views and a pictorial view of workpiece.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Measured workpiece using percision tools.	____	____
- Developed a front elevation view of the workpiece.	____	____
- Developed a top and side view of the workpiece.	____	____
- Located all dimensions from one datum.	____	____
- Placed reference notes at the lower right hand corner of the sketch.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #4

TASK: Select manual or computer-assisted program.

STANDARD OF PERFORMANCE OF TASK:

Completion of acceptable workpiece by selected program and economic utilization of machines and manpower.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook

CONDITIONS FOR PERFORMANCE OF TASK:

Computer software
Tape punch
Program part
Tape reader
Workpiece Print
Manual Programming Manuals
Tool part specifications

ENABLING OBJECTIVE:

1. Estimate time/cost needed to manually program part.
2. Estimate time/cost needed to program part with computer assist.
3. Determine whether manual part programming or computer assisted part programming would require less time/cost.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers Inc., Albany, NY. 1984.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY. 1982.
5. Compact II Programming Manual. Manufacturing Data System Inc, Ann Arbor, MI. 1983.

RESOURCES: (cont.)

6. Bridgeport Series I CNC Programming Manual, Boss 6 Software. Bridgeport Machine Tools, Bridgeport, CT.

TEACHING ACTIVITIES:

1. Present lecture on types of programming. (1,2,3,4, 5 & 6)
2. Discuss the time/cost considerations for different types of programming
3. Discuss Manual Programming: each tool position per block.
4. Discuss Manual Programming: canned cycles.
5. Discuss computer assisted programming.
6. Conduct question and answer session on workpiece features vs. programming considerations.
7. Instruct student to select the most efficient method of programming given a list of part features to be programmed.

CRITERION-REFERENCED MEASURE:

Given a variety of workpiece features to program the student will determine/elect the most efficient method of programming.

PERFORMANCE GUIDE:

1. Check source for family of parts:
    a. Edit for adaptation.
    b. Make changes on standards with program (if necessary).
2. Determine degree of complexity of shapes for program:
    a. Simple shapes - use manual program.
    b. Complex shapes - use computer.
3. Determine availability of computer access.
4. Make program selection.

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #5

TASK: Choose machine tools for part.

STANDARD OF PERFORMANCE OF TASK:

Based on availability, machine tool must yield the most economical output with highest productivity.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 CNC/CAM Guidebook
Machinery Data Handbook, 3rd Edition.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tools
Cutting tool list
Blueprint for piece part
Machinery data handbook
Knowledge of shop facilities

ENABLING OBJECTIVE:

1. Identify tool materials used on specific part materials.
2. Identify geometry used for specific part materials.
3. Determine machine tools to be used.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. Milling Handbook of High Efficiency Metal Cutting. Carboloy Systems Department, Detroit, MI.
4. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
5. Bridgeport Series I CNC Programming Manual. Boss 6 Software. Bridgeport Machine Tools, Bridgeport, CT.
6. Turning Handbook of High Efficiency Metal Cutting. Carboloy Systems Dept, Detroit, MI.
7. Visual aid - Machining tools.
8. Checklist - Selecting machine tools.

TEACHING ACTIVITIES:

1. Present lecture on types of CNC machine tools. (*1,2 & 3)
2. Discuss tool/material machining reference charts.
3. Demonstrate how to use tool machining reference charts to determine optimum tooling.
4. Present lecture on tooling considerations. (*1,2,3,4, 5 & 6)
5. Discuss types of materials vs. tool choice.
6. Discuss tool choice vs. cost.
7. Discuss tool choice vs. operation to be performed.
8. Discuss speed, feed, depth of cut as factors of tool cost.
9. Demonstrate how to match tooling operation, material type and machine tool to obtain the optimum quality and cost efficiency.
10. Instruct student to select the machine tools to be used to machine a workpiece out of a specified material.

CRITERION-REFERENCED MEASURE:

Given a variety of machining operations and part materials the student will select tool materials and tool geometry.

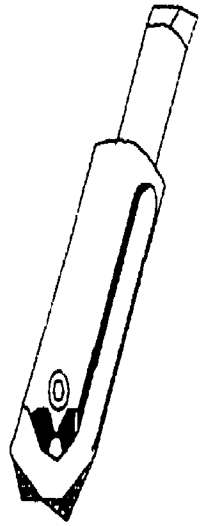
PERFORMANCE GUIDE:

1. Determine type of materials to be machined.
2. Identify machining processes.
3. Adapt machining process to combine operations where possible.
4. Select automatic tool changers for multiple cutting tool operations.
5. Establish machine tool loading and unloading requirements for workpiece.
6. Match machining requirements to minimize labor costs, minimize machine tool operating cost.
7. Maximize piece part production to machine tool on which operation can be most efficiently performed.

MACHINING TOOLS

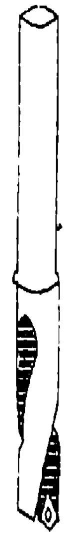
DRILLING

Twist Shank Drill



DRILLING

Space Drill

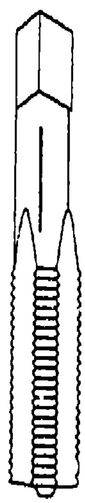


DRILLING

Carbide Insert Drill

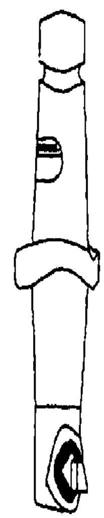
REAMING

Spiral Flute Reamer



TAPPING

Fluted Tap

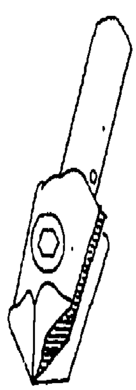


BORING

Boring Bar with Carbide Insert

MILLING

Double-end Endmill



COUNTERSINKING

Single-fluted Countersink

COUNTERBORING

Piloted Counterbore

CHECKLIST

DUTY Programming and planning.

TASK Choose machine tools for part.

ENABLER Determine machine tools to be used.

STUDENT'S NAME ______________ DATE ______

EVALUATOR'S NAME ______________ COURSE ______

TIME : STARTED ______ COMPLETED ______

TOTAL ______

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate choosing machine tools to be used.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Identified the materials to be machined.	____	____
- Identified the machining processes /operations to be performed.	____	____
- Identified machine tools needed to perform the process.	____	____
- Consulted tool machining reference charts for optimum combinations.	____	____
- Adapted machining process to combine operations where possible.	____	____
- Identified machine tool loading and unloading requirements.	____	____
- Matched machining requirements to minimize labor and operating costs and maximize production efficiency.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #6

TASK: Select tools and holders.

STANDARD OF PERFORMANCE OF TASK:

Cutting tool selected must create piece part as specified on print. Tool holder must fit cutting tool.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook
Machining Centers Operator's Training Guide.

CONDITIONS FOR PERFORMANCE OF TASK:

Cutting tools
Tool holders
Cutting tool numbers
Cutter diameters
Tool length compensation values
Piece part specifications
Tooling policies and standards
Manufacturer's operator's/programming manual
Knowledge of machine tool parameters and capabilities

ENABLING OBJECTIVE:

1. Specifically machining procedures.
2. Select carbide grade tools and insert holders.
3. Read manufacturers catalogs and reference materials.
4. Complete tool data sheet for machine.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. Milling Handbook of High Efficiency Metal Cutting. Carboloy Systems Department, Detroit, MI.
4. Turning Handbook of High Efficiency Metal Cutting Carboloy Systems Dept, Detroit, MI.
5. Bridgeport Series I CNC Programming Manual. Boss 6 Software. Bridgeport Machine Tools, Bridgeport, CT.

RESOURCES: (cont.)

6. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
7. Checklist - Selecting tools and holders.

TEACHING ACTIVITIES:

1. Present lecture on types of machining tools and holders. (*1,2,3,4,5 & 6)
2. Discuss types of machine tools and their applications.
3. Discuss carbide grades and their applications.
4. Discuss tool geometry relative to material to be cut.
5. Discuss tool holders needed to hold carbide inserts.
6. Discuss speed, feed, depth of cut factors effect tool life/cost.
7. Demonstrate different types of machining tools and their corresponding holders.
8. Discuss completing a tool data sheet.
9. Demonstrate completing a tool data sheet.
10. Instruct student to select the machining tools and holders needed to machine a given workpiece. (*7)

CRITERION-REFERENCED MEASURE:

For a variety of machining operations the student will select the machine tools and tool holders that optimize machining. Student will complete a tool data sheet.

PERFORMANCE GUIDE:

1. Outline machining procedures.
2. Check cutting tool dimensional standards for precision tolerance.
3. Select shortest and most rigid cutting tool that can be applied to job.
4. Utilize graded carbide and carbide indexable-insert type tools wherever possible in preference to high speed steel.
5. Utilize commercial, pre-set, or qualified types of tools on lathe orerations--but do not mix types on any particular machine.
6. Identify tools and holders for piece part on basis of type, specific cutting edge materials, diameter, and maximum tool length.
7. Check for tool holders and cutting tool number on operation or procedure sheet.
8. Enter cutting tool number or program sequence number in computer program. (Refer to specific machine tool manufacturer's programming manual.)
9. Identify tools for set-up of machine operator.

CHECKLIST

DUTY Programming and planning.

TASK Select tools and holders.

ENABLER Select carbide grade tools, and insert holders.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED ______________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate selecting carbide grade tools, and inserting holders.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Outlined machining procedures.	____	____
- Checked cutting to dimensional standards for precision tolerances.	____	____
- Selected appropriate machining tools and holders.	____	____
- Used carbide tools whenever possible.	____	____
- Identified tools and holders for piece part based on type, cutting edge materials, diameter and maximum tool length.	____	____
- Entered cutting tool number or program number in computer program.	____	____
- Made up a tool list for set-up.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #7

TASK: Select spindle speed.

STANDARD OF PERFORMANCE OF TASK:

Spindle speed must be set to the revolutions per minute or for material as specified in machinery handbook.

SOURCE OF STANDARD:

Numerical Control Machining Series.
Writing team of incumbent workers.
Machinery Data Handbook

CONDITIONS FOR PERFORMANCE OF TASK:

Computer
Machinery handbook
Identification of material type and hardness to be machined

ENABLING OBJECTIVE:

1. Determine machining operation.
2. Determine tool material.
3. Determine workpiece material, hardness.
4. Calculate spindle speed. (RPM)

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. Milling Handbook of High Efficiency Metal Cutting. Carboloy Systems Department, Detroit, MI.
4. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
5. James Childs. Principles of Numerical Control, Third Edition. Industrial Press Inc., New York, NY. 1982.
6. Turning Handbook of High Efficiency Metal Cutting. Carboloy System Dept, Detroit, MI.
7. Krar S.F., Oswald J.W., and Amand J.E., Technology of Machine Tools, Second Edition McGraw Hill Book Co, Chicago, IL.

RESOURCES: (cont.)

8. Checklist - Calculating spindle speed.
9. Machining Data Handbook, Machinability Data Center, Metcut Research Associates, Inc., Cincinnati, OH.
10. American Machinist. Numerical Control Machine Series.
    Beckworth and Associates, Cleveland, OH, 1978.

TEACHING ACTIVITIES:

1. Present lecture on selecting spindle applications, tool materials, and recommended cutting speeds.
2. Discuss speed/material reference charts.
3. Discuss tool materials and applications.
4. Discuss workpiece materials vs. cutting rates.
5. Discuss conversion of cutting rate to spindle speed. (revolution per minute)
6. Demonstrate use of speed/material reference charts.
7. Demonstrate converting cutting rate to spindle speed (revolution per minute)
8. Instruct student to select spindle speed based on tool material, tool application and workpiece material.

CRITERION-REFERENCED MEASURE:

The student will determine an acceptable recommended spindle speed by calculation and table reference for various machining applications and materials.

PERFORMANCE GUIDE:

1. Determine type of machining process to be used (i.e. drilling reaming, turning).
2. Identify work material to be used.
3. Obtain cutter diameter.
4. Identify from the machinery handbook for standard value cutting rate. (NOTE: Utilize constant surface feed per minute when available on machine.)
5. Convert cutting rate to revolutions per minute [formula: rpm (revolutions per minute) = sfm (surface feet per minute) x constant (3.1416) divided by D (diameter of cutter)].
   NOTE: Cutting rate is measured in inches per minute (ipm) or meters per minute (mpm).

CHECKLIST

DUTY Programming and planning.

TASK Select spindle speed.

ENABLER Calculate spindle speed (RPM).

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate calculating spindle speed.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Determined the type of machining process/application to be used.	____	____
- Obtained appropriate machining tools.	____	____
- Obtained speed/materials reference charts.	____	____
- Found the spindle speed setting on the reference charts.	____	____
- Calculated the spindle speed setting by hand to verify chart setting.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #8

TASK: Select feedrate for axis travel.

STANDARD OF PERFORMANCE OF TASK:

Feedrate must be in compliance to the design of the cutter and type of material being machined. Feedrate must provide for smooth and continuous operation of cutting tool through the workpiece for completion of piece part.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Computer
Machinery handbook
Identification of material type and hardness to be machined

ENABLING OBJECTIVE:

1. Determine spindle speed.
2. Determine feed per revolution or feed per tooth.
3. Calculate feed value using a formula.
4. Determine feedrate for axis travel.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. Krar, Oswald, and Amand. Technology of Machine Tools, Second Edition. McGraw Hill Book Company, Chicago, IL.
4. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984
5. James Childs. Principles of Numerical Control, Third Edition. Industrial Press Inc., New York, NY. 1982
6. Checklist - Determining feedrate.
7. Visual aid - Axis travel.

TEACHING ACTIVITIES:

1. Present lecture on determining feed rate. (*1,2,3, 4 & 5)
2. Discuss factors affecting feed rate including cutter diameter, cutter material & spindle speed.
3. Discuss feed rate reference charts.
4. Discuss feed per revolution and feed per tooth.
5. Demonstrate how to use feed rate reference charts.
6. Demonstrate how to convert feed per revolution and feed per tooth feed per minute and feed per millimeter.
7. Instruct student to determine feed rate for axis travel in millimeters and inches per minute. (*6)

CRITERION-REFERENCED MEASURE:

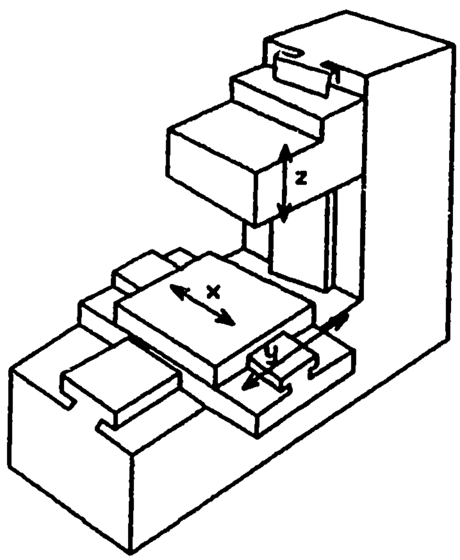
The student will calculate the axis travel feed rate in inches per minute or millimeter for "spindle plunge" and contour milling operations.

PERFORMANCE GUIDE:

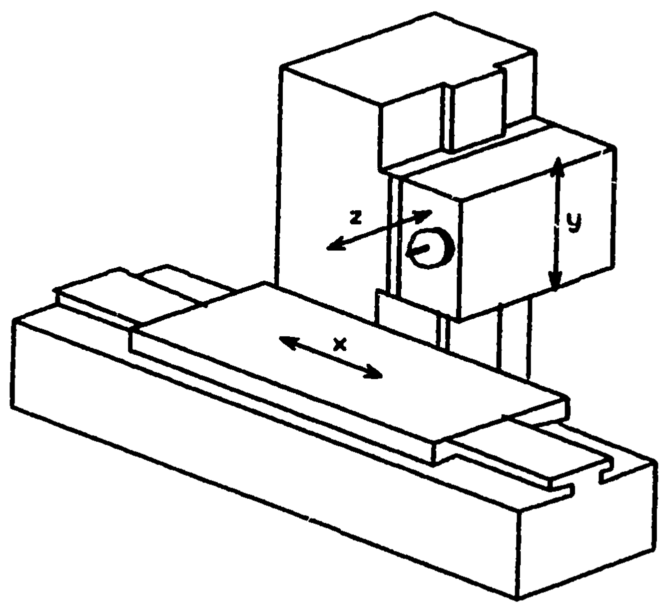
1. Identify feeds table chart in machinery handbook.
2. Determine cutter dimension.
3. Identify cutter material.
4. Obtain feed in inches per minute or millimeters per minute.
5. Convert feed to feedrate using the following formula:
   Drilling process:
   Feedrate=Feed x Spindle speed
   Inches or millimeters per minute = inches or millimeters per revolutions x revolutions per minute (ipm = ipr x rpm).

   Milling process:
   Feed in inches per minute is equal to feed per tooth in inches times number of teeth per cutter times revolutions per minute
   (F= f x T x rpm).

AXIS TRAVEL FOR HORIZONTAL
AND VERTICAL N/C MACHINES



A vertical N/C machine



A horizontal N/C machine

CHECKLIST

DUTY Programming and planning.

TASK Select feedrate for axis travel.

ENABLER Determine feedrate for axis travel.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate determining feedrate for axis travel.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Determined machining processes or operations to be performed.	____	____
- Identified workpiece material.	____	____
- Identified the cutter material and cutter dimension.	____	____
- Determined spindle speed (revolutions per minute).	____	____
- Determined the feedrate in inches or milli-meter per minute.	____	____
- Readied the feedrate to provide a smooth and continuous operation through the completion of piece part.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #9

TASK: Position workpiece in relation to machine axis.

STANDARD OF PERFORMANCE OF TASK:

Positioning of piece part in work holdi-g device or on table must allow complete machining of part without the occurrence of axis overtravel or creating clearance problems.

SOURCE OF STANDARD:

Numerical Control Machining Series.
Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Computer
CNC machine tool
Print specification
Workpiece
Computer software

ENABLING OBJECTIVE:

1. Position the workpiece on the CNC machine worktable so that the programmed tool travel is within machine travel limits.
2. Determine machine axis motions.

*RESOURCES:

1. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
2. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
3. Bridgeport Series I CNC Programming Manual, Boss 6 Software. Bridgeport Machine Tools, Bridgeport, CT.
4. Manufacturer's operator manual.
5. Checklist - Positioning workpiece.
6. Visual aids - a. Workpiece relating travel axis.
   b. Axis motions and right hand rule.

TEACHING ACTIVITIES:

1. Present lecture on positioning workpiece on worktable or in holding device. (*1,2,3 & 4)
2. Discuss the axis motion of travel for the CNC machine.

TEACHING ACTIVITIES: (cont.)

3. Discuss the right hand rule for establishing axis motion.
4. Demonstrate the right hand rule for axis motion.
5. Discuss worktable and tool travel limitations.
6. Demonstrate how to determine programmed tool and worktable travel limits.
7. Demonstrate good and bad workpiece positions.
8. Conduct a question and answer session on workpiece positioning and axis motion determination.
9. Instruct student to position workpiece on worktable in relation to machine axis motions. (*5)

CRITERION-REFERENCED MEASURE:

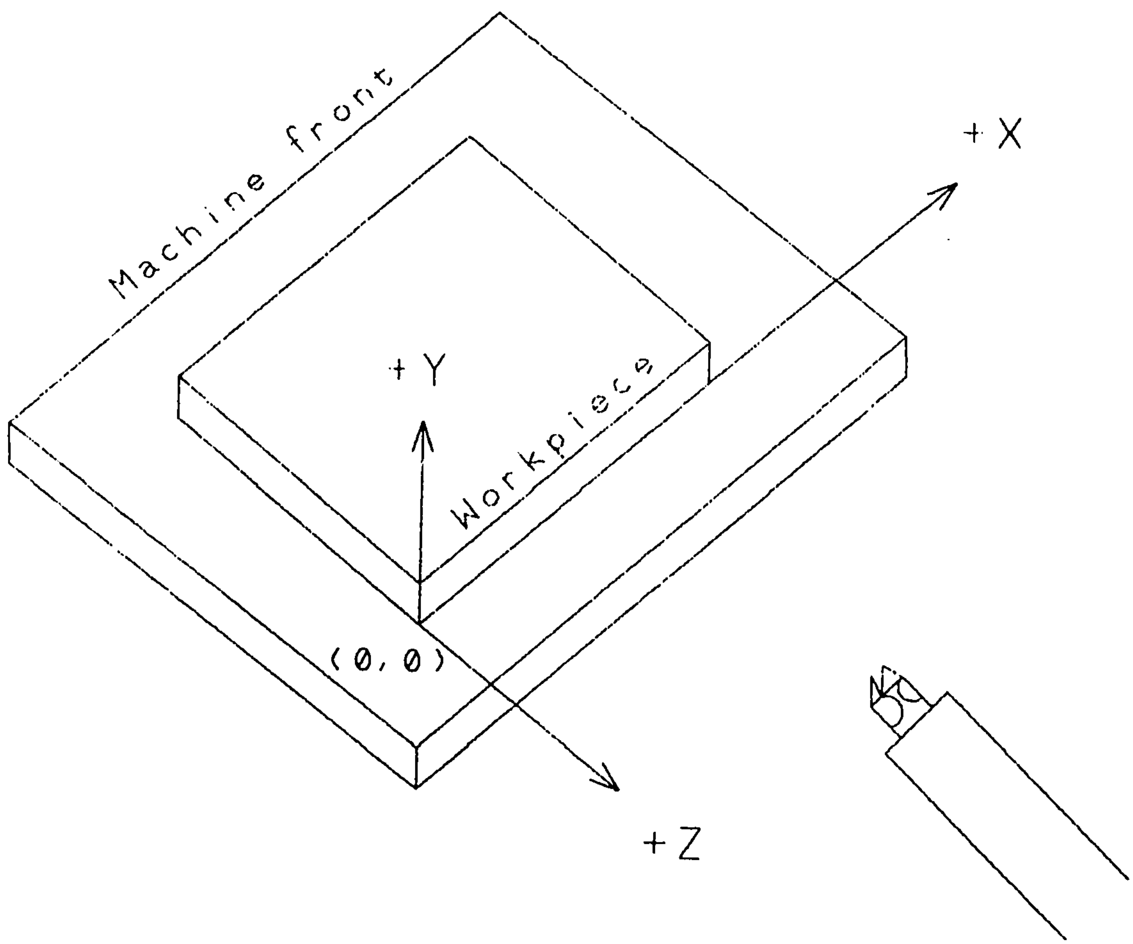
The student will position the workpiece in relation to the machine axis motions so that the programmed tool travel limits and enhance operator function.

PERFORMANCE GUIDE:

1. Determine size of piece part and/or workholding device.
2. Check manual for axis travel range of specific machine tool.
3. Establish datum plane or set point in relation to machine axis:
   a. Long side of the part surface corresponds to the X axis.
   b. Short side of the part surface corresponds to the Y axis.
   c. Depth of the part corresponds to the X axis.
4. Compare datums and ordinate dimensioning to establish machining guidelines.

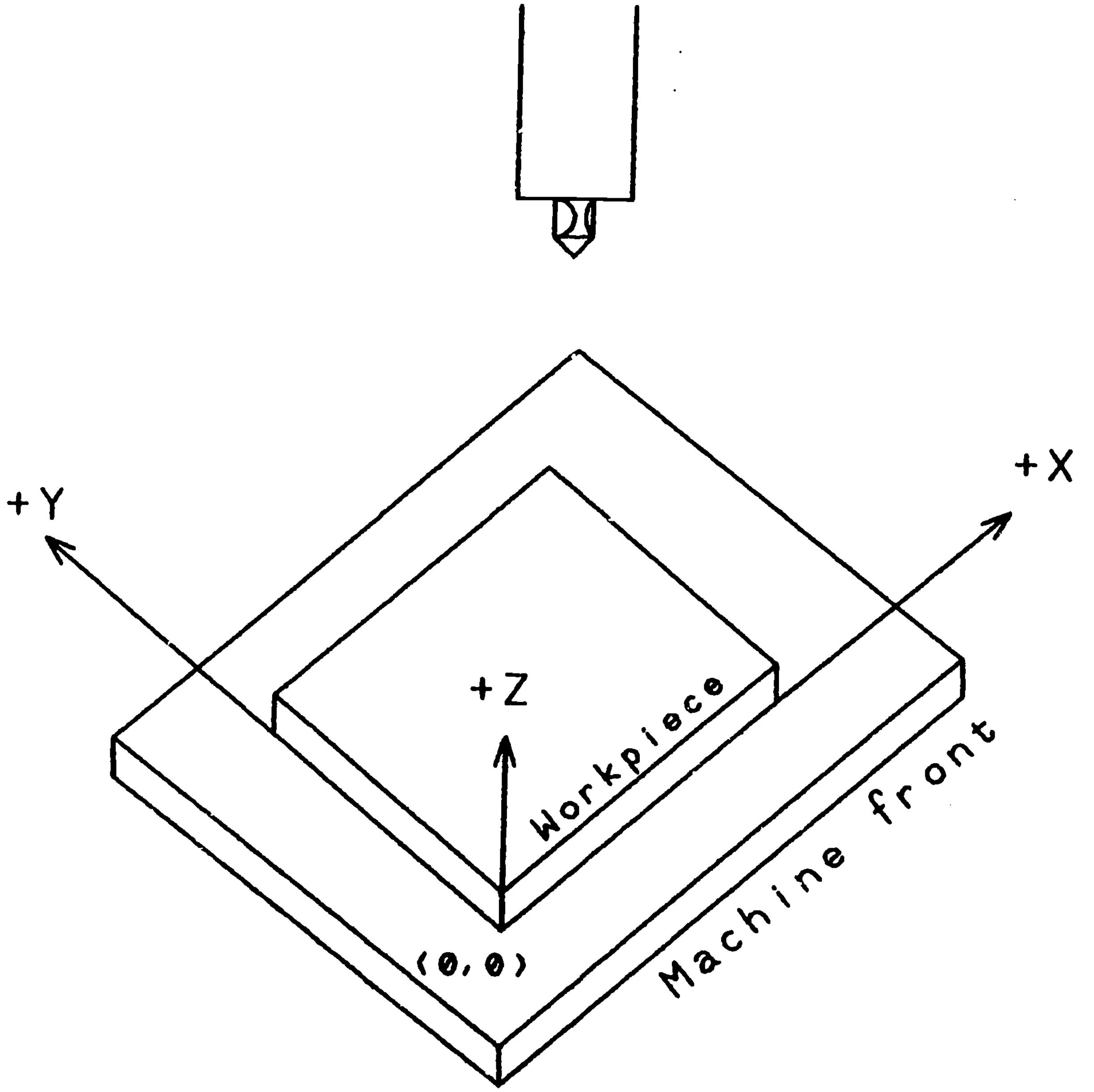
NOTE: Guidelines a, b, and c are the more common methods, however, when exceptions occur, the datum plane is determined by the method of clamping, the geometry of the part, or the area to be cut.

RELATION OF WORKPIECE TO AXES



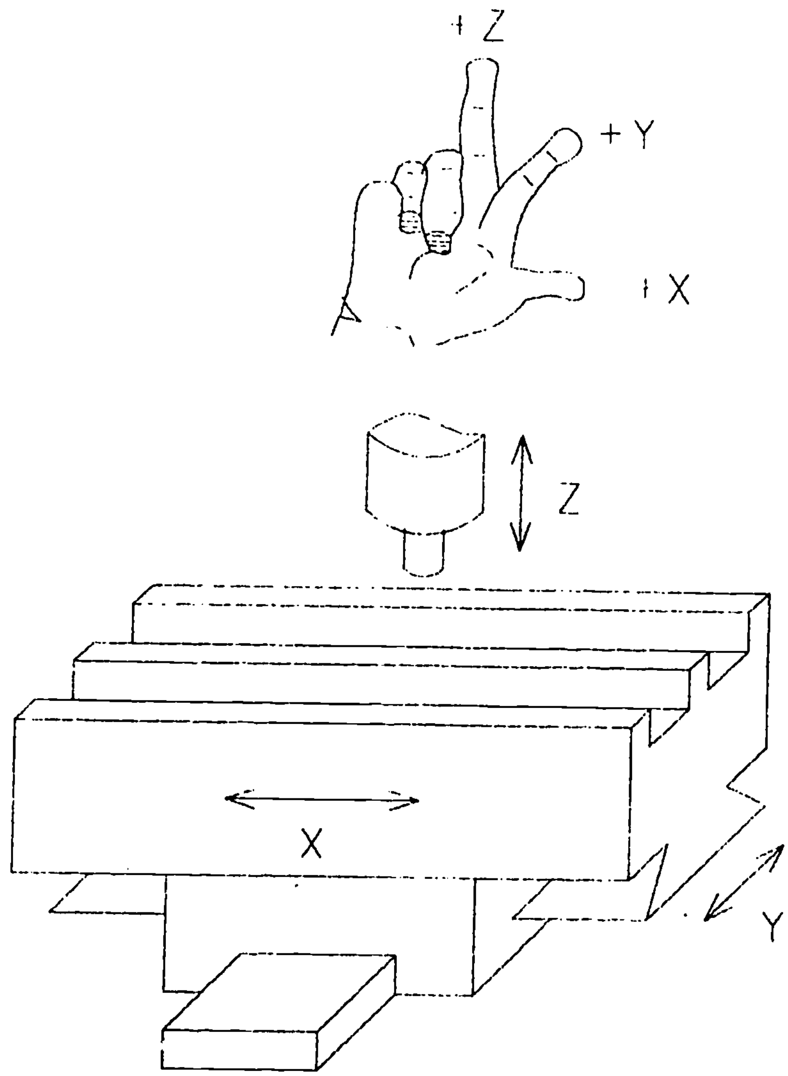
Horizontal Z axis is drawn in relation to the X and Y axes, workpiece, and machine table.

RELATIONSHIP OF WORKPIECE TO AXES



Vertical Z axis is drawn in relation to the X and Y axes, workpiece, and machine table.

RIGHT HAND RULE FOR THREE AXIS MACHINE



The right hand rule shown above establishes the plus (+) X, Y, and Z directions. The minus (-) directions would be opposite to those shown above.

CHECKLIST

DUTY Programming and planning.

TASK Position workpiece in relation to machine axis.

ENABLER Position the workpiece on the CNC machine worktable so that the programmed tool travel is within machine travel limits.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate positioning the workpiece on the CNC machine worktable so that the programmed tool travel is within machine travel limits.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Identified the type of CNC machine (horizontal or vertical).	____	____
- Determined workpiece and holding device size.	____	____
- Determined worktable or holding device axis motions and travel range.	____	____
- Determined machine tool axis motions and travel.	____	____
- Determined the position of the workpiece in relation to machine axis motions.	____	____
- Positioned the workpiece on the worktable or in holding device allowing complete machining without axis overtravel or clearance problems.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #10

TASK: Determine absolute or incremental mode.

STANDARD OF PERFORMANCE OF TASK:

Absolute or incremental mode as specified by machine code must appear on machine program and/or control panel of machine tool.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Computer
Piece part
CNC machine tool
Print specification

ENABLING OBJECTIVE:

1. Program machine G word/code to specify type of mode.
2. Define absolute tool dimension and incremental tool dimension.
3. From a workpiece print:
   A. Identify incremental dimension and absolute dimension.
   B. Convert incremental dimensions to absolute dimensions and vice versa.
4. State advantages, disadvantages and applications of incremental dimension and absolute dimensions.
5. Select absolute or incremental mode.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. James Childs. Principles of Numerical Control. Industrial Press Inc., New York, NY. 1982.
4. William Luggen. Fundamentals of Numerical Control. Delmar Publishers Inc., Albany, NY. 1984.
5. Manufacturer's programming manual.
6. Selected workpiece prints.

RESOURCES: (cont.)

7. Checklist - Selecting absolute or incremental mode.
8. Visual aid - Absolute/Incremental system chart.

TEACHING ACTIVITIES:

1. Present lecture on absolute vs.incremental programming modes and their functions. (*1,2,3,4 & 5)
2. Discuss G word codes used to specify incremental tool dimensions and absolute tool dimensions.
3. Definition of absolute dimensions and incremental dimensions.
4. Discuss advantages, disadvantages and applications of absolute dimension and incremental dimensions.
5. Identify absolute dimensions and incremental dimensions from a workpiece print. (*6)
6. Demonstrate how to convert absolute dimension to incremental dimensions and visa versa.
7. Instruct student to identify absolute and incremental dimensions and select proper program mode. (*6)

CRITERION-REFERENCED MEASURE:

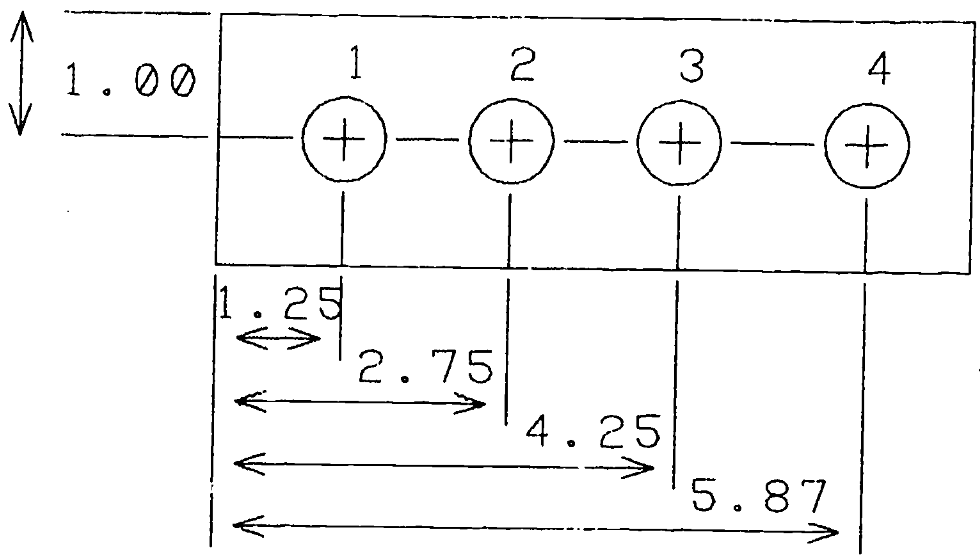
The student will specify a G word/code which the machine operation will use. Identify absolute dimensions and incremental dimensions for each machine operation/process determine if the absolute or incremental mode should be programmed

PERFORMANCE GUIDE:

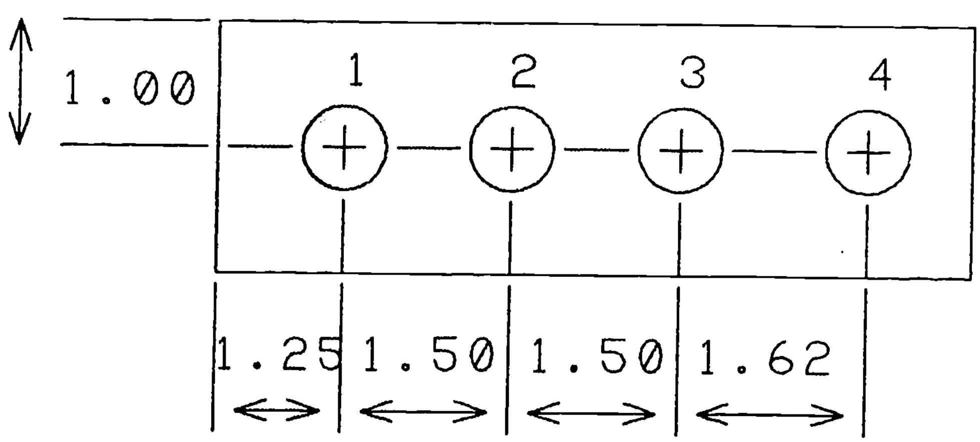
1. Examine piece part detail for:
   a. Number of locations that require accurate drilling, boring, reaming, tapping, or turning.
   b. Number of locations that require straight or contour milling.
   c. Tolerance and accuracy required.
   d. Complexity of contour shapes in piece part.
2. Select incremental mode if:
   a. Accuracy and tolerance do not present any problems.
   b. Little or no contour milling is required.
3. Select absolute mode if:
   a. Close tolerances and high accuracy are required.
   b. Complex contour milling is required.
   c. Determine cutting tool location in relation to specific datum point.

NOTE: Absolute mode is the most widely used and accepted of the two modes. Use of both modes can be used to complete a machining operation using sub-routines.

ABSOLUTE vs. INCREMENTAL DIMENSIONING



ABSOLUTE DIMENSIONING



INCREMENTAL DIMENSIONING

CHECKLIST

DUTY Programming and planning.

TASK Determine absolute or incremental mode.

ENABLER Select absolute or incremental mode.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate selecting absolute or incremental mode.

PERFORMANCE DETERMINANTS	YES	NO
- Identified workpiece locations requiring drilling, boring, reaming, taping or turning.	____	____
- Identified workpiece locations requiring straight or contour milling.	____	____
- Determined the tolerance and accuracy required for the workpiece.	____	____
- Identified the complexity of the contour shapes in the workpiece.	____	____
- Identified the operations which could be performed in absolute mode.	____	____
- Identified the operations which could be performed in incremental mode.	____	____
- Programmed the proper G words/ codes at the beginning of each operation.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #11

TASK: Compute polar/rectangular coordinates.

STANDARD OF PERFORMANCE OF TASK:

Computation of coordinates must result in completion of workpiece in accordance to blueprint specifications with optimum results form CNC equipment.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook.

CONDITIONS FOR PERFORMANCE OF TASK:

Computer
Part print specifications
Manufacturer's programming manual

ENABLING OBJECTIVE:

1. Identify rectangular and polar coordinates.
2. Convert rectangular coordinates to polar coordinates and vice versa.
3. Program rectangular and polar coordinates.
4. Establish rectangular coordinate system to the part used for programming.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. William Luggen. Fundamental Of Numerical Control, Delmar Publisher Inc., Albany New York 1984.
3. A.J. Washington. Basic Technical Mathematics, The Benjamin/Cummings Publishing Company, Reading, 1985.
4. Manufacturer's programming manual.
5. Visual aid - Cartesian and Polar coordinate systems.
6. Checklist - Establish ploar/rectangular coordinates.

TEACHING ACTIVITIES:

1. Present lecture on polar verses cartesian coordinate system. (*1,2 & 3)

TEACHING ACTIVITIES: (cont.)

2. Discuss definitions of polar coordinates (cylindrical) and cartesian coordinates (rectangular). (*5)
3. Discuss and illustrate the tanget trigonometric function to determine the angle of a polar coordinate.
4. Discuss and illustrate the Pythagorean theorem to calculate the radius of the polar coordinate.
5. Discuss and illustrate how to convert polar coordinates to rectangular coordinates and vice versa.
6. Discuss and illustrate how to program polar and rectangular coordinates.
7. Discuss factors used to determine the position of rectangular coordinates to parts.
8. Instruct student to compute polar and rectangular coordinates.

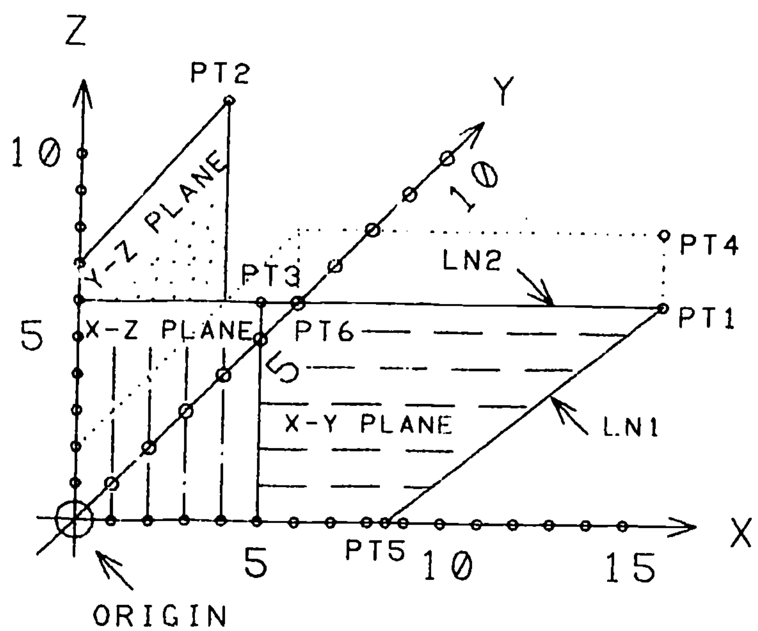
CRITERION-REFERENCED MEASURE:

The student will mathematically convert polar coordinates to rectangular coordinates, determine the orientation and position of a rectangular coordinate system to various workpieces and program rectangular coordinates and polar coordinates.

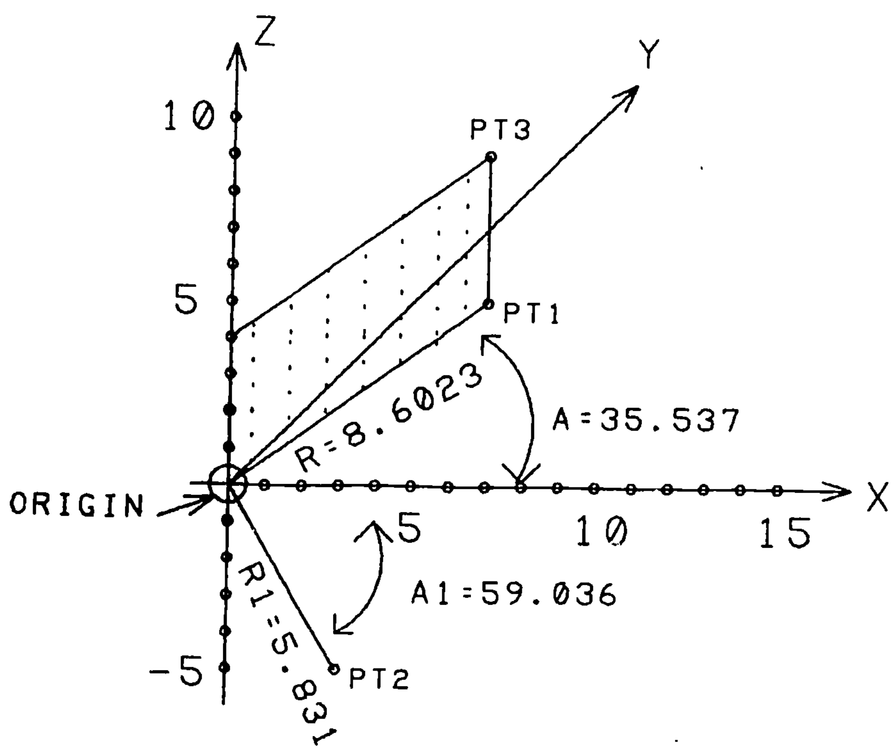
PERFORMANCE GUIDE:

1. Read blueprint.
2. Define part surfaces from three mutually perpendicular reference planes.
3. Establish reference planes along part surfaces which parallel the machine axes.
4. Dimension from a physical point on the surface.
5. Determine allowable tolerance for the part.
6. Analyze surface irregularities on sculptured surfaces of piece part.
7. Dimension the part to determine physical shape without downstream calculations and assumptions.
8. Describe or define part to permit cutter path to be readily computed.
9. Enter information in program. (See manufacturer's programming manual.)

CARTESIAN vs. POLAR COORDINATE SYSTEM



Cartesian or Rectangular Coordinate System



Polar and/or Cylindrical Coordinate System

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #12

TASK: Compute workpiece geometry.

STANDARD OF PERFORMANCE OF TASK:

When converted into machine language, the workpiece geometry must provide data for completed workpiece which meets blueprint specifications.

SOURCE OF STANDARD:

Writing team of incumbent workers.
NC Programming Premier.

CONDITIONS FOR PERFORMANCE OF TASK:

Sketch
Computer
Blueprint
Coordinate value
Determine metric or inch
Appropriate direction sign
Decimal or no decimal point
Fixed block programming
Leading or trailing zero suppression

ENABLING OBJECTIVE:

1. Read blueprint and computer statements necessary to define coordinate systems, geometry, and computation expressions.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. William Luggen. Fundamental of Numerical Control. Delmar Publisher Inc., Albany New York 1984.
3. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY, 1973.
4. James Childs. Principles Of Numerical Control, Third Edition. Industrial Press Inc., New York, NY 1982.
5. W.C. Brown. Blueprint Reading F Industry. Goodhart-Willcox, South Holland, 1983.

RESOURCES: (cont.)

6. A.J. Washington. Basic Technical Mathematics, The Benjamin/Cummings Publishing Company, Reading, 1985.
7. Manufacturer's programming manual.
8. Visual aid - Workpiece blueprint.

TEACHING ACTIVITIES:

1. Present lecture on computing workpiece geometry. (*1,2,3,4,6)
2. Discuss reading a workpiece blueprint. (*5)
3. Define: the points, lines and circles on a workpiece print.
4. Discuss definition and motion statements.
5. Discuss and demonstrate reading and interpreting a list file of the geometry statements.
6. Illustrate computational expressions to determine geometry data.
7. Demonstrate how to compute workpiece geometry.
8. Instruct student to compute workpiece geometry using a workpiece blueprint.

CRITERION-REFERENCED MEASURE:

With the use of a computer system and a workpiece print the student will define workpiece geometry necessary to produce a part program.

PERFORMANCE GUIDE:

1. Load computer system software.
2. Utilize zero suppression and decimal points to eliminate extra characters in the program.
3. Enter geometric dimensions as needed for machining process (as per instructions in specific computer systems software/hardware guide):
   a. Axis coordinates.
   b. Tool positioning coordinates.
   c. Z and R depth.
   d. Speeds and feeds.
   e. Zero reference plane.
   f. Overtravel.

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #13

TASK: Verify cutter path.

STANDARD OF PERFORMANCE OF TASK:

Verified cutter path must provide documentation of piece part outline and cutter clearances and maintain blueprint specifications and standards.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook.

CONDITIONS FOR PERFORMANCE OF TASK:

Template
Computer
Pencil
Computer graphics software
Part one of part program
Print specifications
Pen-type plotting unit

ENABLING OBJECTIVE:

1. Write a program defining workpiece geometry, fixture geometry and tool path.
2. Computer process program and verify via plot.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany New York, NY, 1973.
3. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY, 1973.
4. James Childs. Principles of Numerical Control, Third Edition. Industrial Press Inc., New York, NY, 1982.
5. Compact II Programming Manual. Manufacturing Data Inc., Ann Arbor, MI, 1983.
6. Manufacturer's programming manual.
7. Visual aid - Plotted cutter path.

TEACHING ACTIVITIES:

1. Present lecture on plotting, verifying and documenting cutter path. (*1,2,3,4,5 & 6)

TEACHING ACTIVITIES: (cont.)

2. Discuss developing initial program.
3. Demonstrate how to define workpiece geometry.
4. Discuss and demonstrate activate tools.
5. Discuss how to run the program.
6. Discuss and demonstrate how to plot geometry and verify cutter tool path.
7. Instruct student to plot and verify cutter tool path.

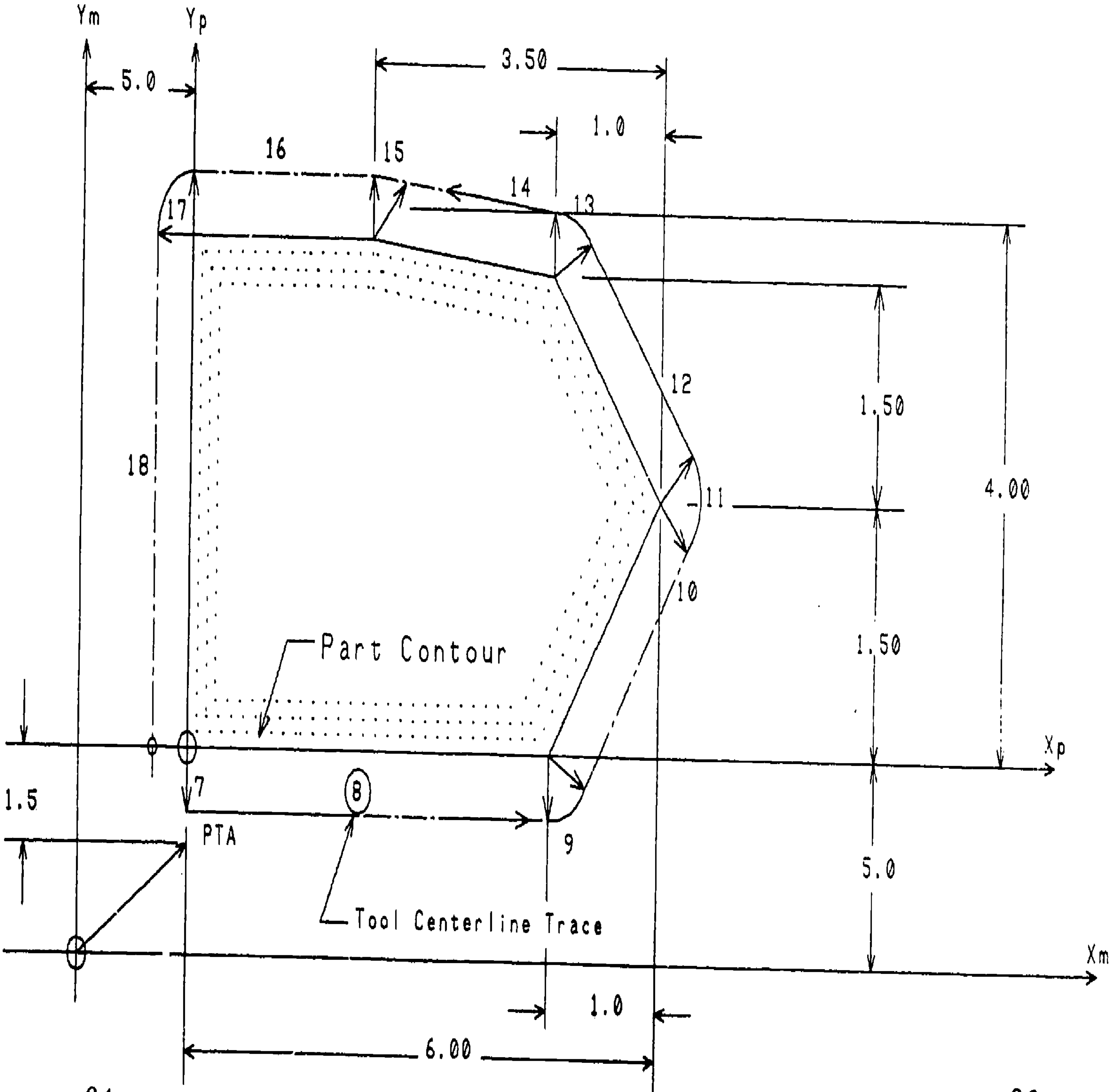
CRITERION-REFERENCED MEASURE:

The student will demonstrate how to produce, run, and plot a program illustrating the relationship between workpiece geometry, fixture geometry, and tool path.

PERFORMANCE GUIDE:

1. Complete procedures necessary to define cutter path.
2. Develop documentation.
   a. Plot cutter path using pen plotter and computer print-out.
   b. Manually:
      1. Construct circles along plotted cutter path (using plastic templates) to represent a cutter.
      2. Develop drawing to show cutter path outline in relation to fixture to determine possible interference.
   c. Computer-generated graphics:
      1. Enter GL geometry.
      2. Generate cutter path on CRT screen and/or plotter.
3. Maintain defined cutter path documentation for use in setting up machine and for CNC machine operator.

CUTTER PATH ROADMAP



GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #14

TASK: Plot program.

STANDARD OF PERFORMANCE OF TASK:

Plotter program must represent part geometry and shape as specified on part print before program is committed to the machine tool loaded with workpiece.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Computer
Part print specifications
Computer software
Plotter

ENABLING OBJECTIVE:

1. Setup hardcopy plotter.
2. Program plotter to setup scale, views and pen.
3. Activate plotter using computer terminal.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA, 1983.
2. Compact II Programming Manual. Manufacturing Data System Inc, Ann Arbor, MI. 1983.
3. Manufacturer's programming manual.
4. Checklist - Plot program.

TEACHING ACTIVITIES:

1. Present lecture on program plotting procedures. (*1, 2 & 3)
2. Demonstrate how to setup hardcopy plotter.
3. Discuss various DRAW commands to designate plot.
4. Demonstrate computer terminal operation to produce plot.
5. Discuss creating a source program.

TEACHING ACTIVITIES: (cont.)

6. Discuss creating a list file.
7. Discuss checking part geometry against tool path.
8. Discuss color coding different tool operations.
9. Demonstrate ploting a program.
10. Instruct student to plot a program.

CRITERION-REFERENCED MEASURE:

The student will produce a hardcopy plot depicting a point to point and contouring tool path scaled to fit the paper size.

PERFORMANCE GUIDE:

1. Enable computer system.
2. Call up tool geometry (if necessary).
3. Enter commands necessary to build tool path display file.
4. Enter start mode.
5. Activate display device.

CHECKLIST

DUTY Programming and planning.

TASK Plot program.

ENABLER Program plotter to setup scale, views and pen.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED __________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate programming plotter to setup scale, views and pen.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Enabled the computer system.	____	____
- Setup the plotter.	____	____
- Identified the tool geometry.	____	____
- Entered the commands necessary to build the tool path display.	____	____
- Activated source program and created list file.	____	____
- Color coded different tool operations.	____	____
- Checked tool geometry against tool path.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #15

TASK: Depict part graphically.

STANDARD OF PERFORMANCE OF TASK:

Computer must make use of visual geometric entities on screen and create either actual machine commands or computer statement necessary for generating machine code.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook

CONDITIONS FOR PERFORMANCE OF TASK:

CAD/CAM system
Part print
Basic programming skills
Basic trigonometry

ENABLING OBJECTIVE:

1. Duplicate the workpiece print on a CAD CAM system.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. Computervision 2D, 3D Graphics. Computervision Corp, Boston.
3. CAD/CAM operator's manual.
4. CAD/CAM programer's manual.
5. Checklist - Depicting part graphically.

TEACHING ACTIVITIES:

1. Present lecture on graphic depiction of a workpiece. (*1,2,3 & 4)
2. Demonstrate log in.
3. Discuss graphic views.
4. Discuss and demonstrate part geometry, line, circle, chamfer, arc,fillet.
5. Demonstrate zoom.

TEACHING ACTIVITIES: (cont.)

6. Demonstrate dynamic view.
7. Demonstrate file/delete.
8. Instruct student to depict part graphically. (*5)

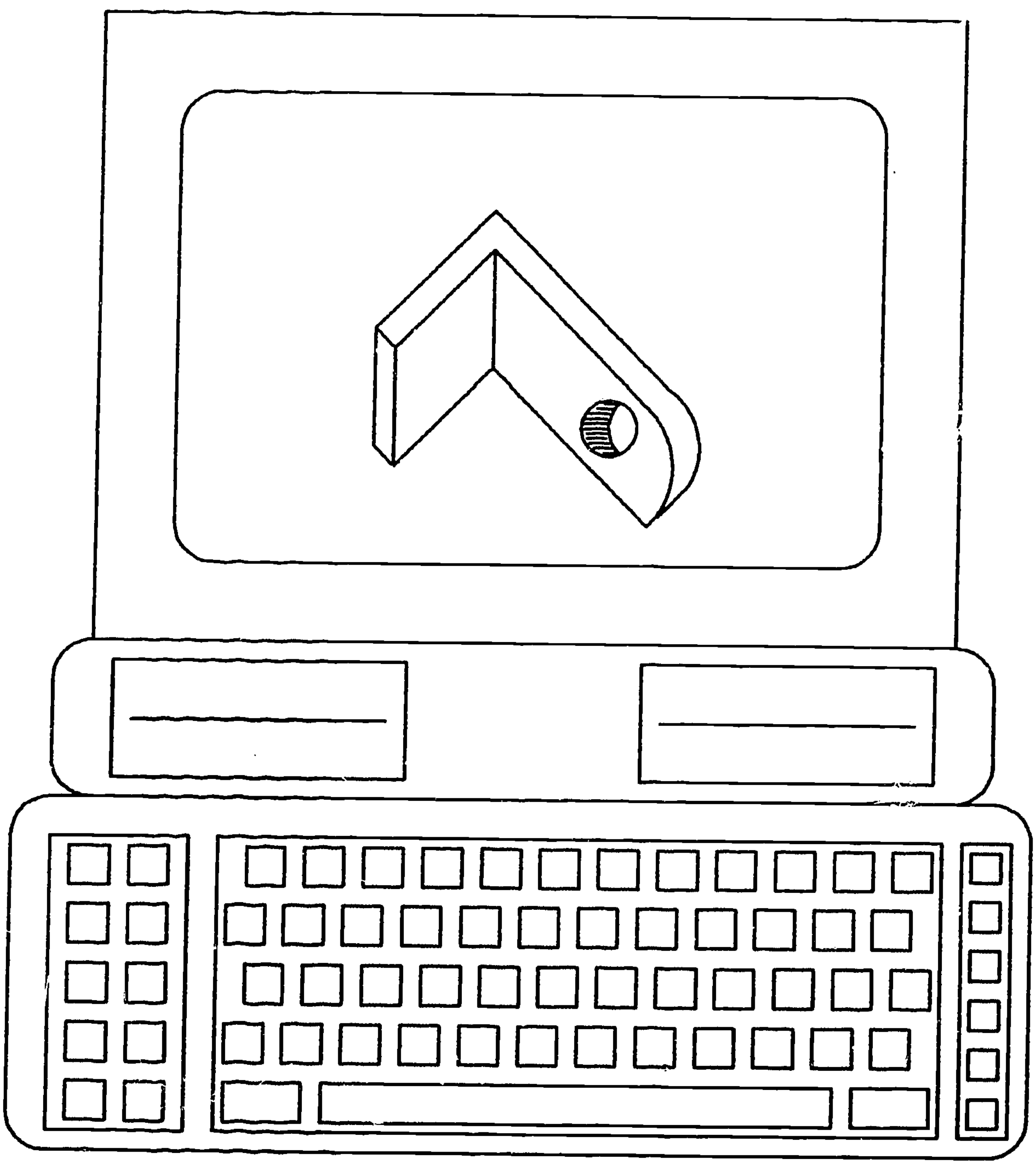
CRITERION-REFERENCED MEASURE:

The student will produce a multi view picture containing part, lines, circles, chamfer, arc and fillet. Must depict sufficient data to later generate tool path.

PERFORMANCE GUIDE:

1. Load system software.
2. Create and design elements to appear on a CRT screen.
3. Rotate, enlarge, and zoom in on specific design features using computer software (if system permits).
4. Call up line and direct cutter move along line.
5. Complete design functions using workpiece data base.

COMPUTER GRAPHIC DEPICTION OF WORKPIECE



CHECKLIST

DUTY Programming and planning.

TASK Depict part graphically.

ENABLER Duplicate the workpiece by printing on a CAD/CAM system.

STUDENT'S NAME ____________ DATE ______

EVALUATOR'S NAME ____________ COURSE ______

TIME : STARTED ______ COMPLETED ____________

TOTAL ______

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate duplicating the workpiece by printing on a CAD/CAM system.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Obtained workpiece print.	____	____
- Loaded the CAD/CAM system software.	____	____
- Created workpiece geometry elements on CRT screen.	____	____
- Rotated, enlarged and zoomed in on specific features.	____	____
- Depicted part graphically.	____	____
- Stored graphic data in a file.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #19

TASK: Define cutter path.

STANDARD OF PERFORMANCE OF TASK:

Program must indicate the necessary tool path coordinates to describe the path of the center of the cutter for machining process as specified on piece part blueprint. Cutter path should provide for standard clearance.

SOURCE OF STANDARD:

Numerical Control Machining Series.
1985 NC/CAM Guidebook.
Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Computer
Software
Basic geometry
Basic trigonometry
Print specifications
Format classification sheet
Tooling and tooling procedure selected

ENABLING OBJECTIVE:

1. Complete a NC computer program to produce necessary machining operations and depict tool positions.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York. 1982.
5. Manufacturer's programming manual.
6. Visual aid - Cutter path roadmap.

TEACHING ACTIVITIES:

1. Present lecture on defining cutter path. (*1,2,3,4 & 5)
2. Discuss and demonstrate program initialize.
3. Discuss and demonstrate part geometry definitions.
4. Discuss and demonstrate tool change.
5. Discuss and demonstrate tool motion.
6. Discuss and demonstrate tool plotting.
7. Discuss and demonstrate tool location file.
8. Instruct student to define cutter path.

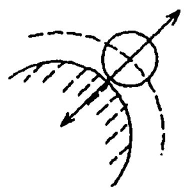
CRITERION-REFERENCED MEASURE:

Given a workpiece print, the student will prepare a program, process,debug and depict the tool path.

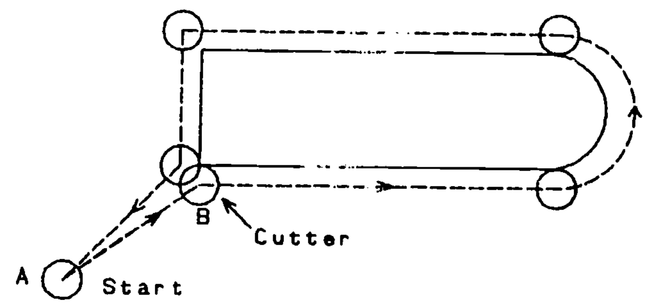
PERFORMANCE GUIDE:

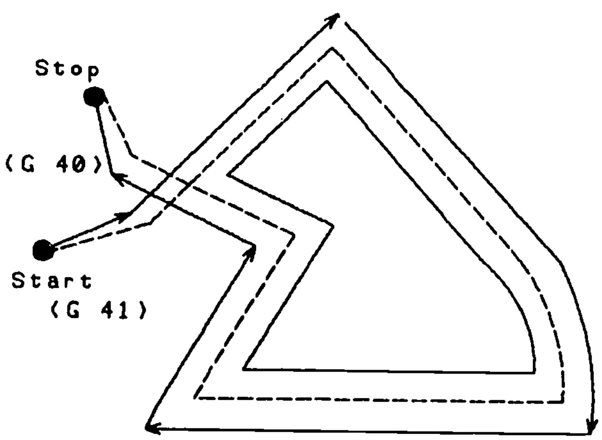
1. Review part print specifications.
2. Determine tool position coordinates for machining process.
3. Compute total tolerance for contour (if contouring operation).
4. Enter geometry from tool position coordinated into computer (refer to format instructions in specific computer programmer's manual).
5. Check for cutter path clearance:
   a. Check location of clamps and holders.
   b. Check for table and other obstructions.
   c. Check for tool interchanges or indexing turret.
6. Document cutter path.

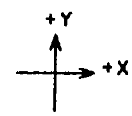
CUTTER PATH



Cutter compensation is particularly helpful for making adjustments for closer accuracy and for compensating for cutter wear.







= Tape Path
= Tool Path
FILL• Fill nerated by N/C.

Example shown uses oversized tool G 41.

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #17

TASK: Operate post processor.

STANDARD OF PERFORMANCE OF TASK:

Computer must convert geometry data to machine language to produce acceptable machine code. Prepared program code format must be acceptable for machine tool used.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Numerical Machining Series.
1985 NC/CAM Guidebook

CONDITIONS FOR PERFORMANCE OF TASK:

Computer
Software system
Part print specifications
Manufacturer's programming manual

ENABLING OBJECTIVE:

1. Activate the post processor.
2. Operate N.C. computer system.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY, 1982.
5. Compact II Series Programming Manual. Manufacturing Data System Inc., Ann Arbor, MI. 1983.
6. Postprocessor documentation.
7. Manufacturer's programming manual.

TEACHING ACTIVITIES:

1. Present lecture on postprocessors purpose and procedures. (*1,2,3,4,5,6 & 7)
2. Discuss post processor functions and purposes.

TEACHING ACTIVITIES: (cont.)

3. Discuss available computer language.
4. Demonstrate how to activate the post processor.
5. Present lecture on primary function of a post processing. (*1,2,3 & 4)
6. Discuss centerline output, physical limits of the machine overshoot, reader limitations, output preparatory and miscellaneous functions, cutter compensation information, circular or parabolic points and error diagnostics.
7. Instruct student to operate postprocessor.

CRITERION-REFERENCED MEASURE:

The student will post process an N.C. post program.

PERFORMANCE GUIDE:

1. Review prepared program format.
2. Select post processor able to convert processor language to machine language.
3. Enter data from processor to post processor (follow format in manufacturer's programming manual).

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #18

TASK: Write post processor.

STANDARD OF PERFORMANCE OF TASK:

The post processor must produce a program which meets program format requirements for CNC machine tool control unit.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Processor language
Program format requirements
Post processor input requirements
Computer or tape preparation system
Computer instruction manual

ENABLING OBJECTIVE:

1. Knowledge of a post processor is.
2. Knowledge of machine code.
3. Determine post (G post) processor preparation.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical control. Delmar Publishers, Inc., Albany, NY. 1984.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY 1982.
5. Industrial N.C. Computer Mechanical Drawing. McGraw Hill Book Company, New York, Systems documentation. Bridgeport, Numeridex, University computing Company.
6. Manufacturer's programming manual.

TEACHING ACTIVITIES:

1. Present lecture on writing postprocessor. (*1,2,3,4,5 & 6)

TEACHING ACTIVITIES: (cont.)

2. Discuss purpose of post processing.
3. Discuss/demonstrate use of a general post (G post) processor preparation.
4. Discuss definition statements.
5. Discuss tool motion statements.
6 Discuss specifications of conditions required at the machine control.
7. Demonstrate how to write a postprocessor program.
8. Instruct student to write postprocessor program.

CRITERION-REFERENCED MEASURE:

The student will prepare a post processor for a specified machine tool.

PERFORMANCE GUIDE:

1. Determine program format requirements for each CNC machine program codes.
2. Utilize processor language requirements for writing post processor commands.
3. Build post processor by setting up formal requirements in system (see computer system manual for individualized post processors instructions NOTE: Most post processors are provided by manufacturer of computer system. In some systems, alterations may be instituted for specific machine tools.

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #19

TASK: Program tool change procedure.

STANDARD OF PERFORMANCE OF TASK:

Program must provide identification number to permit calling up tool from the storage matrix to assigned tool position to provide basis for repetitive tool selection.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Numerical Control Machining Series.
1985 NC/CAM Guidebook.

CONDITIONS FOR PERFORMANCE OF TASK:

Tool holders
Cutting tools
Tool position number
Tool identification number
Manufacturer's programming manual
Storage matrix capacity of machine tool

ENABLING OBJECTIVE:

1. Recommend tools for machining operations.
2. Program tool change.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY 1982.
5. Compact II Programming Manual. Manufacturing Data System Inc., Ann Arbor, MI. 1983.
6. Manufacturing programming manual.
7. Checklist - Programming tool change.

TEACHING ACTIVITIES:

1. Present lecture on programming tool changes. (*1,2,3, 4,5 & 6)
2. Discuss tool/application selection.
3. Demonstrate tool application selection.
4. Discuss type of tool changers.
5. Discuss tool identification and location numbers.
6. Discuss automatic tool changers (ATC) and their programming.
7. Discuss other events effected by a tool change.
8. Demonstrate programming a tool change.
9. Instruct student to program a tool change procedure.

CRITERION-REFERENCED MEASURE:

The student will program a tool change and tool offsets for a given CNC machine and tool operation.

PERFORMANCE GUIDE:

1. Identify tool number.
2. Identify tool position number (when using automatic tool changer).
3. Identify information needed to set tool matrix (if machine tool does not provide automatic tool changer).
4. Determine sequence of operations to allow for minimum tool changes.
5. Enter tooling in program in sequential order (common format is "T" format code for word address plus number value--see specific manufacture's programming manual).
6. Specify feedrate and spindle speed for each new tool.
7. Establish tool offset value if needed.

CHECKLIST

DUTY Programming and planning.

TASK Program tool change procedure.

ENABLER Program tool change.

STUDENT'S NAME ______________ DATE ______

EVALUATOR'S NAME ______________ COURSE ______

TIME : STARTED ______ COMPLETED ______

TOTAL ______

DIRECTIONS TO THE EVALUATOR:

Use the performance determinants checklist to evaluate programming tool change.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Determined tool identification number.	____	____
- Determined tool position/location number.	____	____
- Identified events effected by tool change.	____	____
- Identified tool matrix information.	____	____
- Identified sequence of operations to allow minimum tool change.	____	____
- Programmed tooling in sequential order.	____	____
- Identified feedrate and spindle speed for the new tool.	____	____
- Determined tool offset value.	____	____

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #20

TASK: Prepare operator instructions for piece part.

STANDARD OF PERFORMANCE OF TASK:

Prepared instructions must provide information to implement programmed machine commands to complete all machining processes for piece part.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Computer
Pencil
Tooling sheet
Set-up sheet
Operator instruction sheet

ENABLING OBJECTIVE:

1. Determining needed machine codes (Ex: G01, G90,G03)
2. Calculate speeds, feeds, & RPM formulas.
3. Develop clear & specific instructions to machine operator.
4. Determine what type of tooling is compatible with various machines.
5. Determine machine limitations:
   (a) horsepower
   (b) axis - travel limits
   (c) weight load capacity

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY 1982.
5. Manufacturer's operators manual.
6. Manufacturer's programming manual.

TEACHING ACTIVITIES:

1. Present lecture on preparing operator instructions.
2. Discuss formulas for spindle speed, feedrates and RPM.
3. Require students to know formulas for spindle speed, feedrates and RPM.
4. Demonstrate how to calculate spindle speed, feedrate, and RPM.
5. Instruct student to practice calculating spindle speed, feedrate and RPM.
6. Discuss preparing comment instruction for a particular cycle.
7. Instruct student to prepare comment instruction for a particular cycle to be performed, with other students having to give interpretation.
8. Discuss building a working relationship between programmers and the machine operator.
9. Acquire from manufacturers, information that would be helpful to students.
10. Demonstrate how to prepare operator instructions.
11. conduct a question and answer session on the purpose and importance of operator instructions.
12. Instruct student to prepare operator instructions for a piece part.

CRITERION-REFERENCED MEASURE:

Student will identify programming codes, calculate spindle speed, feedrate and RPM and will provide clear and specific instructions to the machine operator for the development of a piece part.

PERFORMANCE GUIDE:

1. Review machining sequence.
2. Determine procedures which require operator assistance or intervention:
   a. Tool changes.
   b. Unusual positioning of work piece.
3. Enter operator messages in computer:
   a. Enter edit mode.
   b. Make additions in sequential blocks, or:
4. Hand-write operator messages on:
   a. Computer print-out.
   b. Set-up sheet.

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #21

TASK: Calculate run time.

STANDARD OF PERFORMANCE OF TASK:

Time must be in accordance to feedrate of machine and type of material being machined.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine
Workpiece
Fixture
Tool holders
Stop watch
Time standards
Tooling sheet
Print specifications
Programmed piece part

ENABLING OBJECTIVE:

1. Identify and calculate necessary mathematics.
2. Read time meter on machine control.
3. Identify and use speeds & feeds formulas.
4. Look in manufacturer's programming for cycle times.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY. 1982.
5. Manufacturer's programming manual.
6. Manfacturer's operators manual.
7. Machining Data Handbook Machinability Data Center, Metcut Research Associates, Inc., Cincinnati, OH.

TEACHING ACTIVITIES:

1. Present lecture on procedure for calculating run time. (*1,2,3,4,5,6 & 7)
2. Require student to know formulas for spindle speeds, feedrates, and revolution per minute. (*1,2,3 & 4)
3. Discuss the most popular grades of steel & machinability requirements involved when calculating run time.
4. Discuss the location and use of the machine control time meter.
5. Discuss obtaining cycle times from manufacturers programming manual.
6. Demonstrate how to determine and total cycle times.
7. Instruct student to calculate run time.
8. Conduct question and answer session on CNC tape coding and specifications.
9. Instruct student to prepare sample tape, then run it through machine control tape reader for verification.

CRITERION-REFERENCED MEASURE:

Student will calculate run time in accordance with time used for machining a particular type of material.

PERFORMANCE GUIDE:

Manually: machining sequence.

1. Enter program.
2. Enter dry run cycle.
3. Time procedure with timing watch.
4. Stop running time when machine has finished part.
5. Record time for one piece part.

Using the computer:

1. Load software program.
2. Enter search mode for sequence search for final prepared program block.
3. Activate post-processor.
4. Enter time mode.
5. Enter cycle data from tooling sheet.
6. Process data with computer.
7. Write run time notation from computer on print-out.

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #22

TASK: Prepare tape.

STANDARD OF PERFORMANCE OF TASK:

Tape must feed through read head, rollers, or sprocket tooth feeder without tearing, kinking or binding and produce piece part to meet blueprint range of plus or minus tolerances and dimensions.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Handbook of Standards.

CONDITIONS FOR PERFORMANCE OF TASK:

Tape machine
Software
Tape reader
Part program
Computer
Paper mylar tape
Format classification sheet
Basic programming skills

ENABLING OBJECTIVE:

1. Use computers and post-processors.
2. Identify types of CNC tape
3. Use paper tape punch.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY.21984.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY. 1982.
5. Manufacturer's operating manual.
6. Manufacturer's programming manual.

RESOURCES: (cont.)

7. Electronic Industries Association. Handbook of Standards. Washington, D.C. 1985.
8. Worksheet - CNC tape codes and specifications.
9. Visual aid - CNC tape codes and specifications.

TEACHING ACTIVITIES:

1. Present lecture on the procedure for preparing a CNC tape. (*1,2,3,4 & 5)
2. Discuss the difference in types of paper tapes.
3. Demonstrate the difference between mylar and paper tapes.
4. Demonstrate sample tape with code holes punched in it. (*8)
5. Discuss what code holes do and how the machine controller interprets them.
6. Discuss tape leader at the beginning and ending of tape.
7. Discuss and demonstrate CNC tape puncher.
8. Conduct question and answer session on CNC tape ending specifications.
9. Instruct student to prepare sample tape, then run it through machine control tape reader for verification.

CRITERION-REFERENCED MEASURE:

Student will prepare actual program and tape for a particular job to be formed and have a successful completion of running in machine controller.

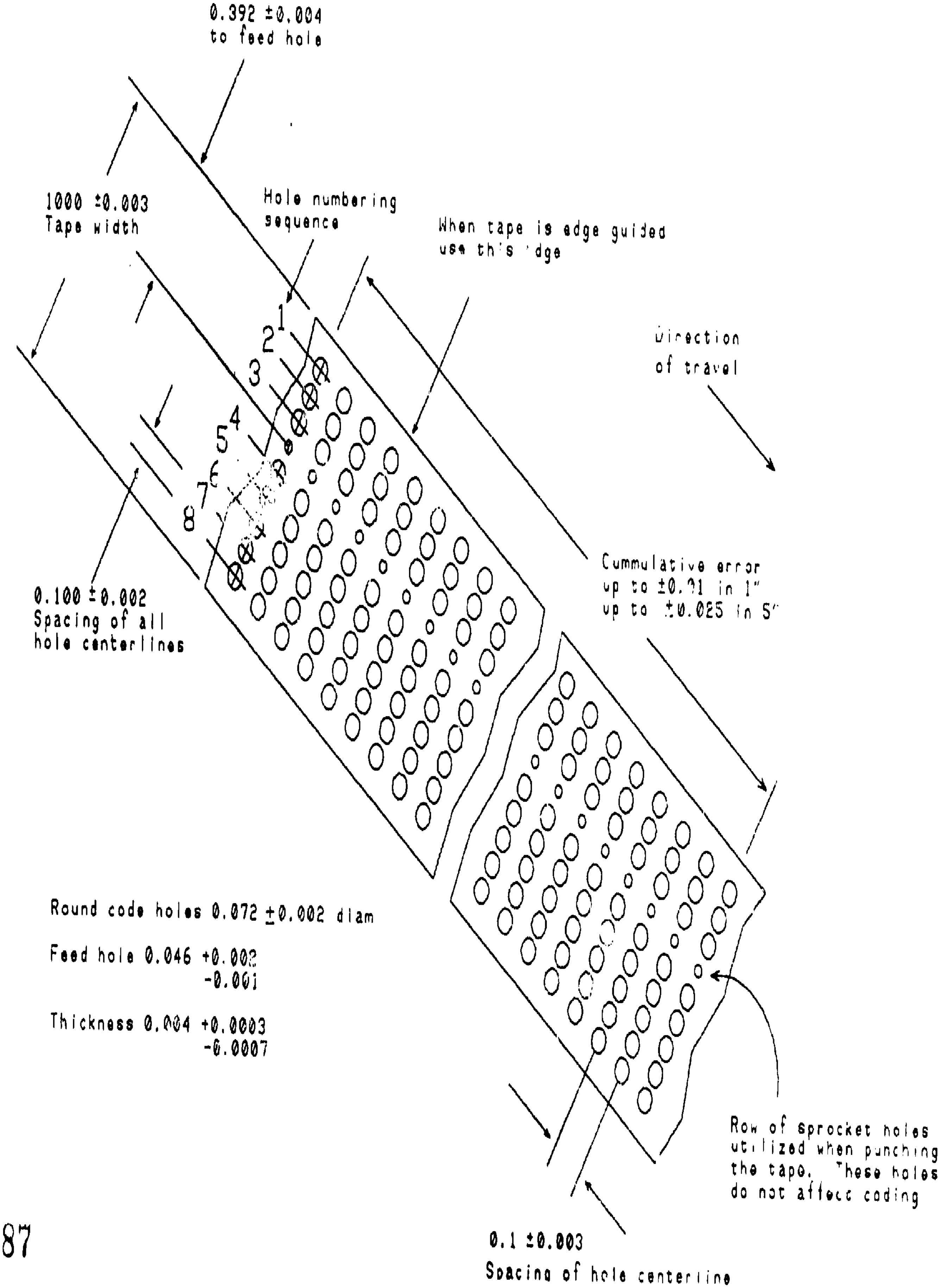
PERFORMANCE GUIDE:

1. Obtain prepared part program manuscript.
2. Provide for adequate leader at beginning and end of punched tape.
3. Punch holes in paper or mylar tape to correspond to codes in prepared part program manuscript:
   a. Utilize binary coded decimal method of individual digit coding.
   b. Designate numerical quantity from 0-9 on one horizontal level of tape using assigned values (0,1,2,4, and 8) to 5 of the 8 channels in a standard eight-channel tape.
   c. Place multi-digit quantities (example, X-axis position) in consecutive horizontal rows induced by the binary code for the symbol X.
   d. Express each numerical digit, letter or symbol code with its own combination of holes in a single row on the tape.
   e. Meet either Electronic Industries Association RS-244 (tab sequential block) or ASC II RS-385 American National Standard Institute standards.

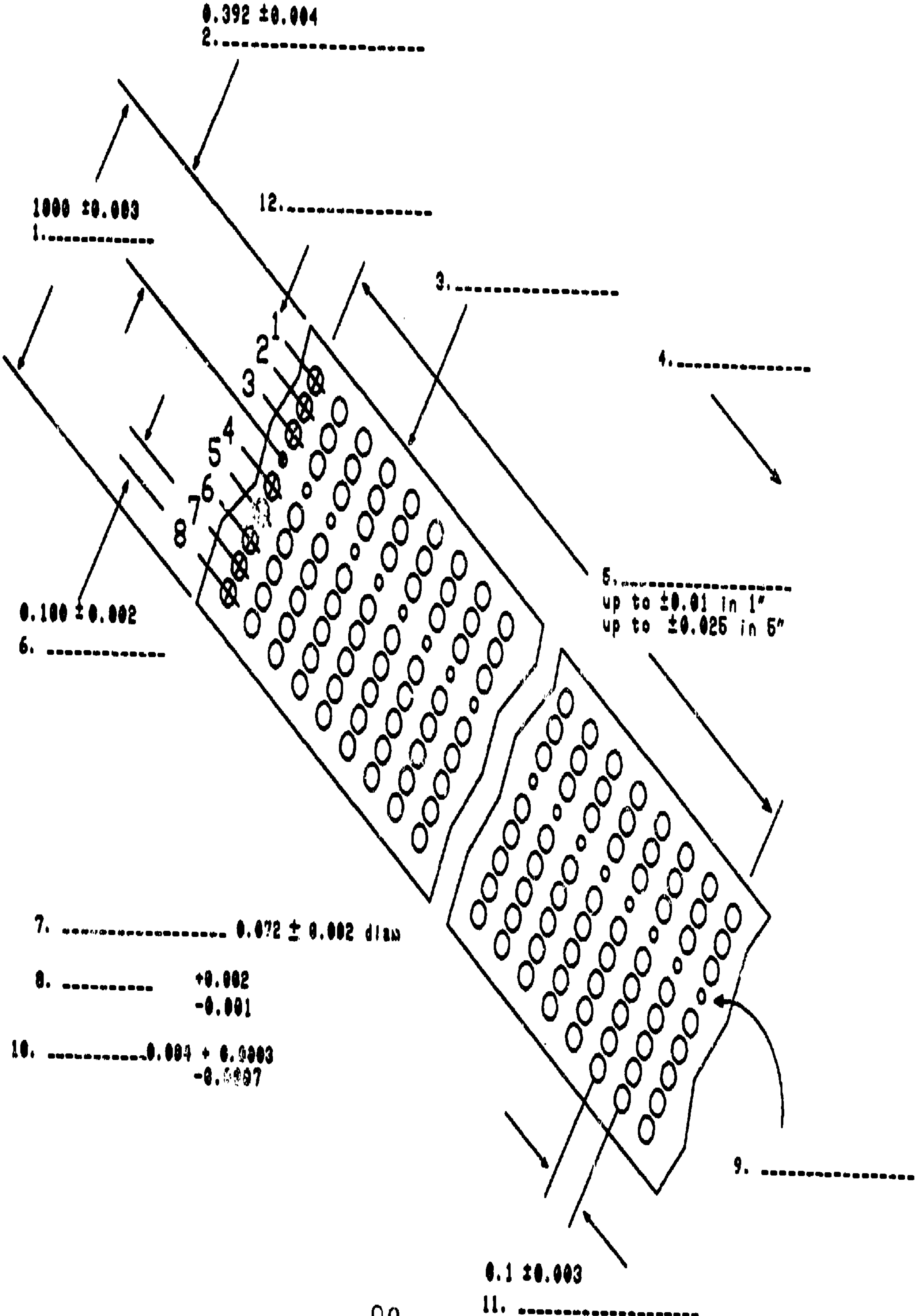
PERFORMANCE GUIDE: (cont.)

4. Proofread or verify tape (for programming and keypunch errors by running program line by line on CRT screen or on printed manuscript).
5. Dry run tape to test actual operation with machine tool.
6. Edit and revise tape as needed.
   NOTE: Place prepared tape in appropriate safe storage system.

CNC TAPE FORMAT



TAPE FORMAT WORKSHEET



WORKSHEET ANSWERS

1. Tape width
2. Distance from guide edge to feed hole
3. Guide edge
4. Direction of travel
5. Cumulative error
6. Spacing of hole centerlines
7. Round code hole diameter
8. Feed hole diameter (sprocket hole)
9. Sprocket holes
10. Thickness
11. Spacing of hole centerlines
12. Hole numbering sequence

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #23

TASK: Select canned cycles.

STANDARD OF PERFORMANCE OF TASK:

Machine tool must perform canned cycle function initiated by the CNC program.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine with canned cycles
Specific machine tool manufacturer's programming manual

ENABLING OBJECTIVE:

1. Understand canned cycle codes & their meanings.
2. Determine what canned cycles are available for that specified machine tool.
3. Identify programming language for various machine [illegible].

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Principles of Numerical Control, third. Edition. Industrial Press Inc., New York, NY. 1982.
3. William Luggen. Fundamentals of Numerical Control. Delmar publishers, Inc., Albany, NY. 1984.
4. Manufacturer's programming Manual.

TEACHING ACTIVITIES:

1. Present lecture on the definition of canned cycle codes. (*1,2, & 3)
2. Discuss the advantages and disadvantages of canned cycles.
3. Present lecture on different types of canned cycle programming. (*1,2,3 & 4)
4. Discuss fixed canned cycle programming.

TEACHING ACTIVITIES: (cont.)

5. Discuss variable canned cycle programming.
6. Present lecture on canned cycle codes and their function.
7. Discuss drilling, tapping, boring, turning, facing and cancellation canned cycle codes.
8. Demonstrate a canned cycle.
9. Instruct student to select needed canned cycles to complete a workpiece.

CRITERION-REFERENCED MEASURE:

The student will select various canned cycles needed to complete a workpiece and explain the function of each canned cycle.

PERFORMANCE GUIDE:

1. Identify canned cycles for specific CNC control.
2. Select canned cycle for combination of machine moves.
3. Choose area of program where canned cycle can be used.
4. Insert code to indicate canned cycle to be executed (see specific manufacturer's programming manual for command codes).

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #34

TASK: Program restart points.

STANDARD OF PERFORMANCE OF TASK:

Program must contain restart points which are used when program is interrupted by tool breakage, machine tool failure, operator error, or emergency conditions.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Computer and software
Piece part specifications
Verified cutter path
Manufacturer's operating/programming manual

ENABLING OBJECTIVE:

1. Identify programming procedures.
2. Calculate mathematics.
3. Determine where restart points need to be placed.

*RESOURCES:

1. Manufacturer's programming manual.
2. Manufacturer's operating manual.

TEACHING ACTIVITIES:

1. Present lecture on procedures for programming restart points. (*1 & 2)
2. Conduct a class discussion on what types of situations would require restart points.
3. Discuss safe restart points.
4. Demonstrate a safe vs. unsafe restart point.
5. Instruct student to identify safe restart point in a CNC program.

CRITERION-REFERENCED MEASURE:

Student will write a program containing safe restart points to be used when program is interupted.

PERFORMANCE GUIDE:

1. Activate automatic restart or safe-start option on machine control.
   NOTE: Machine tool or program may be equipped with automatic restart feature to provide continuous execution of program without operator intervention.
2. Determine possible restart points or safe-start location along cutter path for movement of the cutting tool to desired safe-start point.
3. Enter restart or safe-start points and program information necessary to start machining process safely. (Entry of restart or safe-start command must follow procedures outlined by programmer's manual for type of computer/software system used.)
   NOTE: Programmer may provide block delete commands to allow operator to utilize additional checks for machine operations (if needed).

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #25

TASK: Write manual program.

STANDARD OF PERFORMANCE OF TASK:

Specified workpiece must be completed according to tolerances on blueprint dimensions and range of plus or minus tolerance standards.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Part print
Calculator
Trigonometry
Analytic Geometry
Basic machining practices
Basic NC programming
Manual data input capacity on machine tool

ENABLING OBJECTIVE:

1. How to read blueprint or sketch.
2. How to write manual program.
3. How to use mathematics.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. Brown W.C., Blueprint Reading for Industry. Goodheart-Wilcox, South Holland, IL. 1963.
4. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
5. James Childs. Principles of Numerical Control, third Edition. Industrial press Inc., New York, NY. 1982.
6. Manufacturer's programming manual.
7. Manufacturer's operating manual.
8. Visual aid - Manual programming manuscript.

TEACHING ACTIVITIES:

1. Present lecture on reading and interpreting blueprints. (*5)
2. Instruct student to read and interpret blueprints.
3. Present lecture on the pro's and con's of manual programming vs. computer aided programming. (*1,2,3 & 4)
4. Present lecture on developing a program manuscript. (*1,2,3 & 4)
5. Discuss different machine languages.
6. Discuss absolute and incremental modes.
7. Demonstrate how to write a manual program.
8. Assign home projects that require manual programming using various canned cycles & tool changes.
9. Instruct students to review sample programs manually written in absolute and incremental.
10. Review each of the sample programs in class, step by step, so student can visually see the difference.
11. Instruct student to write a,manual program

CRITERION-REFERENCED MEASURE:

Student will successfully write a manual program usin various canned cycles in the absolute mode, then convert the same program to incremental mode. Both programs must perform the same when run on a CNC machine.

PERFORMANCE GUIDE:

1. Read part print visual machining sequence.
2. Draw sketch of desired workpiece.
3. Dimension sketch.
4. Identify program by means specified by employer (may be by part name, part number, tape number, or operation number).
5. Select machine tool and cutting tool for part.
6. Determine location of clamps and holders.
7. Determine zero location.
8. Determine datum point for starting workpiece.
9. Determine workpiece location in relation to machine axis.
10. Title part of program using blueprint name and detail number.
11. Select for each operation: Preparatory and Miscellaneous codes, offset register codes, axis coordinates, other specific machine codes, and specify sequence for each line number.
12. Write machine operator instructions and tool selection for each machining operation.
13. Continue process for each written line of program.

MANUAL PROGRAMMING MANUSCRIPT

MANUSCRIPT

PTP

XXXX MACHINE

Part No. ______

Part Name: ______

Date: ______

Prepared By: ______

Checked By: ______

Sequence No. (N)	X	Y	Spindle Speed (S)	Aux Code (M)	Comments

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #26

TASK: Program with purchased software.

STANDARD OF PERFORMANCE OF TASK:

Purchased software will create precise, clear part program to produce piece part (which meets blueprint dimensions and range of plus or minus tolerances).

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Compatible computer system
Processor language
Purchased software
Part print
Manufacturer's programming/operating manual

ENABLING OBJECTIVE:

1. Understand how to program.
2. Determine how to operate computers.
3. Determine how to operate post-processor.
4. Identify how to get punched tape & paper printout.
5. Determine software functions.

*RESOURCES:

1. Software documentation.
2. Manufacturer's operating manual.
3. Manufacturer's programming manual.

TEACHING ACTIVITIES:

1. Present lecture on program codes & their meaning.
2. Instruct students time to become familiar with the basic steps used by the purchased software.
3. Instruct student to choose a specific cycle & have them prepare a tape & printout by using the computer & postprocessor.
4. Discuss different software functions.
5. Demonstrate programming with software.

TEACHING ACTIVITIES: (cont.)

6. Assign student a project involving programming with software.
7. Instruct student to program a part program using purchased software.

CRITERION-REFERENCED MEASURE:

Student will produce tape & printout of a part program using software. The program will be error free & meet all requirements necessary to produce a good part.

PERFORMANCE GUIDE:

1. Visualize necessary machining sequences.
2. Determine degree of complexity of shape to be machined.
3. Select software options to allow maximum use of computer functions available.
4. Establish reference point to permit alignment of workpiece and the machine tool.
5. Specify cutting tools and setting of feeds and speeds.
6. Program tool changes and tool offsets (where needed).
7. Specify holding devices and where they are located.
8. Determine starting operation.
9. Document sequence of operations on manuscript.
10. Define cutter path.
11. Verify cutter tool path.
12. Prepare machine operator instructions.
13. Activate post processor.
14. Give part a name or detail number.
15. Prepare machine tape, disc, or download program (DNC).

GUIDE SHEET

DUTY: Programming and Planning

PERFORMANCE OBJECTIVE #27

TASK: Design special fixtures for custom job.

STANDARD OF PERFORMANCE OF TASK:

Fixture must operate under excessive force conditions, hold workpiece securely during machining process, must and range of plus or minus tolerances).

SOURCE OF STANDARD:

Writing team of incumbent workers.
Advanced Machine Technology.

CONDITIONS FOR PERFORMANCE OF TASK:

Blueprint
Erasers
Sketch pad
Scales
Pencils
Basic machining skills

ENABLING OBJECTIVE:

1. Design fundamental.
2. Various types of machines.
3. Mathematics.
4. Various types of machines.
5. Time value.

*RESOURCES:

1. W. C. Brown. Blueprint Reading For Industry. Goodheart-Wilcox, South Holland, IL. 1983.
2. E. G. Hoffman. Jig and Fixture Design. Delmar Publishers, Chicago, IL. 1985.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. Olivo, C. Thomas. Advanced Machine Technology. Belmont, CA: Brenton Publishers. 1982.
5. Manufacturer's operating manual.
8. Manufacturer's programming manual.

TEACHING ACTIVITIES:

1. Present lecture on the importance of proper fixturing. (*1,3 & 4)
2. Discuss the economic values involved in special fixtures.
3. Discuss why special fixtures for custom jobs are needed & where they are used.
4. Present lecture on major considerations for fixture design. (*1,2,3,4,5 & 6)
5. Discuss workpiece size and clamping.
6. Discuss part orientation and machining efficiency.
7. Discuss safety considerations.
8. Stress to students the need to design safety around each fixture.
9. Demonstrate how to design a workpiece fixture.
10. Instruct student to design a special fixture to meet provided specifications.

CRITERION-REFERENCED MEASURE:

Student will design a special fixture that meets all the safety and accuracy requirements for locating and securing a given workpiece.

PERFORMANCE GUIDE:

1. Examine blueprint.
2. Determine needed fixtures by:
   a. Size of workpiece.
   b. Number of parts on fixture.
   c. Accuracy required in production of piece part.
   d. Type of material needed to build.
   e. Location and position of clamps on workpiece.
   f. Position of locating pins in relation to workpiece.
3. Establish fixture number and stamp into fixture.
4. Specify operator instructions for locating and mounting fixture (using set-up sheet or on piece print).
5. Provide sketch of part being held by fixture.

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #28

TASK: Design clamps and holders for custom job.

STANDARD OF PERFORMANCE OF TASK:

Clamps and holders must hold part while machining without allowing any movement of workpiece, provide a quick-acting device for efficient loading and unloading, must not damage nor distort workpiece, and must resist vibrations and chatter.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Advanced Machine technology.

CONDITIONS FOR PERFORMANCE OF TASK:

Piece part
Erasers
Sketch pad
Scales
Pencils
Basic machining skills
Catalog of standard design components.

ENABLING OBJECTIVE:

1. Understand design fundamentals.
2. Identify various types of machines.
3. Calculate mathematics.
4. Determine various types of steel.
5. Understand the value of time.

*RESOURCES:

1. W. C. Brown. Blueprint Reading For Industry. Goodheart-Wilcox, South Holland, IL. 1983.
2. E. G. Hoffman. Jig and Fixture Design. Delmar Publishers, Chicago, IL. 1985.
3. William Luggens. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. Thomas Olivo. Advanced Machine Technology. Brenton Publishers, Belmont, CA ,1982.

*RESOURCES: (cont.)

5. Manufacturer's operating manual.
6. Manufacturer's programming manual.

TEACHING ACTIVITIES:

1. Present lecture on considerations affecting clamp and holder design. (*2,3,4,5 & 6)
2. Discuss the size of workpiece.
3. Discuss types of materials to be held.
4. Discuss machining processes to be done to workpiece.
5. Discuss operator safety.
6. Present lecture on sketching workpiece and fixtures. showing clamps and holders in position. (*1 & 4)
7. Demonstrate to student how to design clamps and holders.
8. Assign project of designing fixture clamps and holders.

CRITERION-REFERENCED MEASURE:

The student will design clamps & holders that meets all the safety requirements while providing quick loading and unloading and inhibiting any movement damage or distortion of the workpiece.

PERFORMANCE GUIDE:

1. Examine blueprint.
2. Determine needed clamps and holders by:
   a. Size of clamps and holders needed.
   b. Clamping surface required for holding part.
   c. Material requirement for clamps and holders.
   d. Number of parts on fixture to determine:
      1. Number of clamps required.
      2. Position of clamps on workpiece.
3. Establish clamp and holder number and stamp into clamp and holder.
4. Specify operator instructions for locating and mounting clamp and holder (using set-up sheet or piece print).
5. Draw sketch of piece part being held by fixture with clamps and holders in place.

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #29

TASK: Write manual complex contouring program.

STANDARD OF PERFORMANCE OF TASK:

The cutting tool must be shifted at all times on a plane of points directly perpendicular or normal to the part outline. The cutting tool must remain in constant contact with the workpiece as coordinate movements take place. Cutter path will not deviate from desired path more than the part tolerance on blueprint.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook.

CONDITIONS FOR PERFORMANCE OF TASK:

Calculator
CNC machines available
Tape preparation function
Interpolator function within MCU

ENABLING OBJECTIVE:

1. Use a calculator.
2. Calculate mathematics.
3. Know how CNC machinery works.
4. Determine interpolation method needed.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY. 1982.
5. Manufacturer's programming manual.
6. Manufacturer's operating manual.

*RESOURCES: (cont.)

7. Modern Machine Shop. 1985 NC/CAM Guidebook. Gardner Publications, Cincinnati, OH ,1985.
8. Visual aid - Point to point vs.contouring.
9. Checklist - Write manual complex contouring program.

TEACHING ACTIVITIES:

1. Present lecture on the purpose of contouring systems. (*1,2,3 & 4)
2. Discuss contour programming vs. point to point programming.
3. Instruct student to learn the preparatory codes for a designed CNC machine.
4. Present lecture on interpolation methods. (*1,2,3,4,5,6&7)
5. Discuss linear, circular, helical, parabolic and cubic interpolation.
6. Discuss and demonstrate programming a square with a radius, circle with a tangent line, a triangle and the letter S with top and bottom tangent lines.
7. Assign student project involving the programming of a square, circle, triangle and letter S with tangent lines.
8. Discuss advantages and disadvantages of constant tool workpiece contact.
9. Instruct student to write a manual contouring program.

CRITERION-REFERENCED MEASURE:

The student will know all the codes associated with a particular CNC machine and will write manual complex contours, such as the letter "s" or the number "8" with a minimum amount of errors.

PERFORMANCE GUIDE:

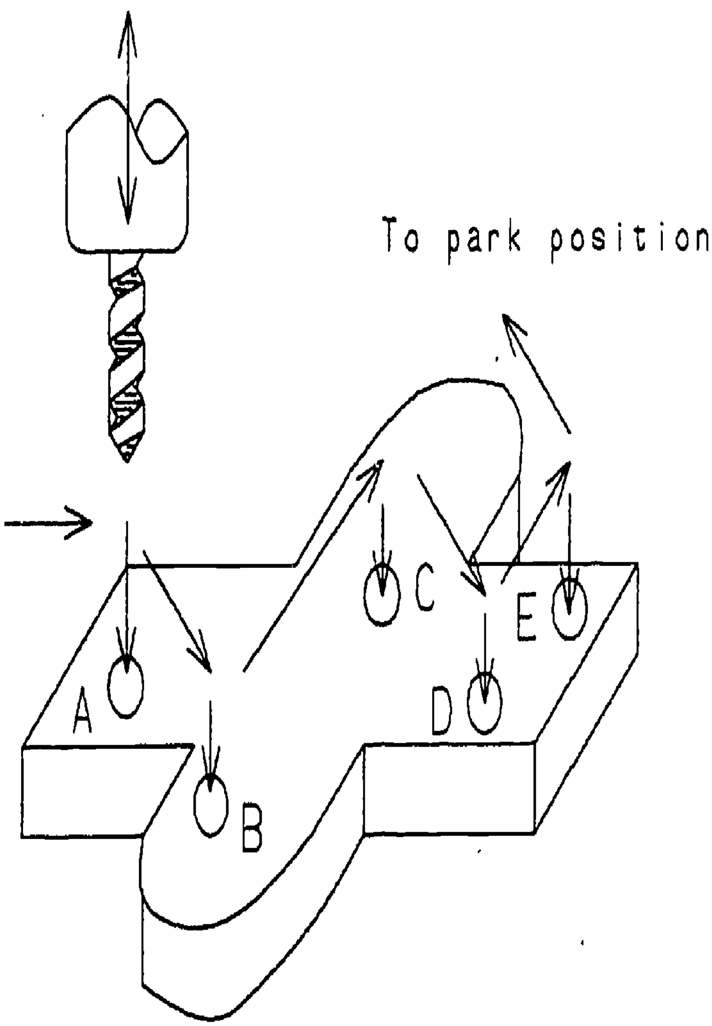
1. Visualize machining sequence.
2. Establish reference point to align workpiece and machine tool.
3. Select cutting tool(s).
4. Calculate cutter centerline path using diameter of cutting tool.
5. Determine tool feedrate at all times by:
   a. Type of tool.
   b. Type and hardness of materials being cut.
   c. Mechanical dynamics of machine tool.
6. Determine distance cutting tool extends beyond reference points for machine tool to be used in orde to program using offset equivalents when:
   a. Using carbide inserts.

PERFORMANCE GUIDE: (cont.)

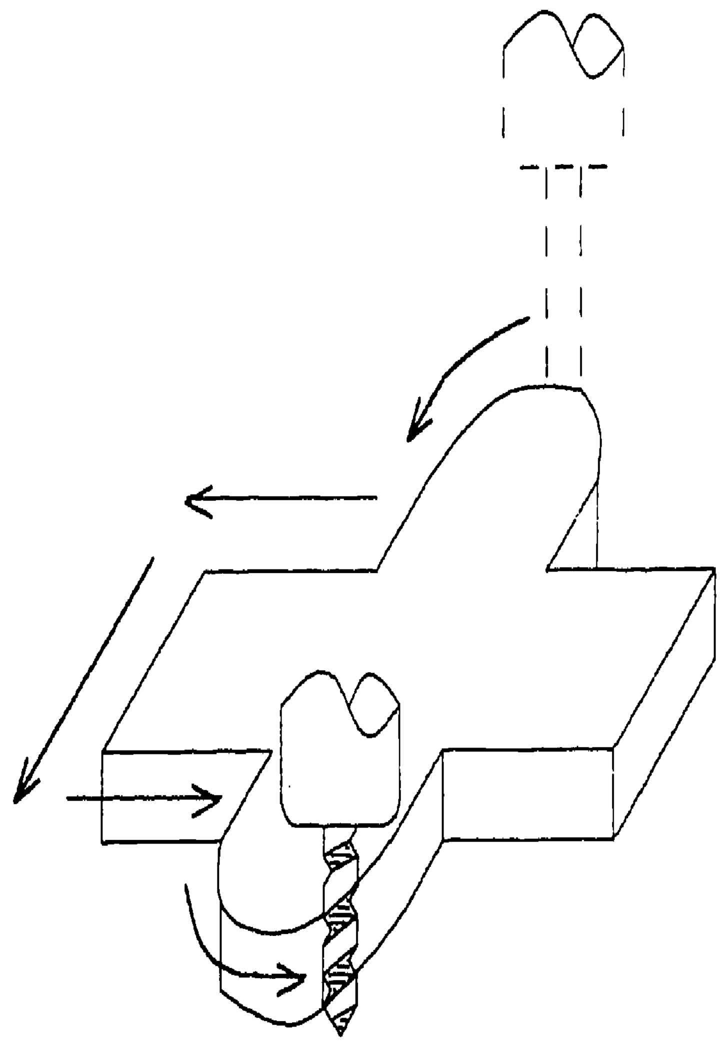
   b. Using milling cutter for sculpturing or contouring.
   c. Using special cutting tools.

7. Ascertain interpolation method to be used for connecting defined coordinate points to generate curved shapes:
   a. Linear - straight lines.
   b. Circular - partial or complete circles.
   c. Helical - helical spiral cutter path.
   d. Parabolic - free form designs.
   e. Cubic - cutter paths to machine sheet metal forming dies.
8. Specify location of holding devices.
9. Prepare list of each machining operation in format to be used by particular control unit/machine tool to be used.
10. Determine starting operation.
11. Determine remaining sequence of machine operations.
12. Develop manuscript to document sequence of operations.
13. Prepare operator instructions u ing one of the following:
    a. Write on set-up sheet.
    b. Insert in program.
    c. Print on print-out.

PART PROGRAMMING - POINT TO POINT VS. CONTOURING



Point to Point



Contouring

CHECKLIST

DUTY Programming and planning.

TASK Write manual complex contouring program.

ENABLER Select absolute or incremental mode.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED ______________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate writing manual complex contouring program.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Established reference point.	____	____
- Selected cutting tool(s).	____	____
- Calculated cutter centerline.	____	____
- Determined tool feedrate.	____	____
- Determined tool overshoot.	____	____
- Identifed interpolation method.	____	____
- Specified location of holding devices.	____	____
- Determined list of machining operations.	____	____
- Determined starting operation.	____	____
- Determined sequence of machining operations.	____	____
- Developed document manuscript.	____	____
- Prepared operator instructions.	____	____

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #30

TASK: Enter tool offset.

STANDARD OF PERFORMANCE OF TASK:

Tool offset value corresponding to tool offset number must be added to the commanded value in the program and the tool must be moved to the offset position.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Basic programming knowledge
Basic machining skills
Format classification sheet
Programming system with cutter compensation system

ENABLING OBJECTIVE:

1. Operate a CNC Controller.
2. Use set-up sheet.
3. Read paper print out.

*RESOURCES:

1. Pusztai and Sava. <u>Computer Numerical Control.</u> Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. <u>Numerical Control Part Programming.</u> Industrial Press Inc., New York, NY. 1973.
3. William Luggen. <u>Fundamentals of Numerical Control.</u> Delmar Publishers, Inc., Albany, NY. 1984.
4. James Childs. <u>Principles of Numerical Control. Third Edition.</u> Industrial Press Inc., New York, NY. 1982.
5. Manufacturer's programming manual.
6. Manufacturer's operating manual.

TEACHING ACTIVITIES:

1. Present lecture on what tool offset means. (*1,2,3 & 4)

TEACHING ACTIVITIES: (cont.)

2. Discuss tool diameter compensation.
3. Discuss tool length compensation.
4. Discuss multiple part machining.
5. Discuss tool offsets for positioning of fixture or part.
6. Present lecture on tool offset codes. (*1,2,3,4,5 & 6)
7. Discuss x,y, & z motions.
8. Demonstrate how to determine and enter tool offset codes.
9. Instruct students to enter tool offset codes.

CRITERION-REFERENCED MEASURE:

The student will run sample programs on CNC machines that require multiple passes with a change in tool offset value for each pass. With each pass around and a different tool offset value,the student will measure a difference in the part equal to the amount part equal to the amount of offset change between passes.

PERFORMANCE GUIDE:

1. Specify tool selection position.
2. Specify tool offset number for offset value.
3. Enter tool position by using command codes specified by software format classification sheet.
4. Enter tool offset value (may also be done at machine with offset input dial and offset load button) using specific command codes specified by software format classification sheet.

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #31

TASK: Enter tool length compensation.

STANDARD OF PERFORMANCE OF TASK:

Operator must set up tooling to specified tooling compensation lengths to enable program to run without further tooling.

SOURCE OF STANDARD:

Machinery Handbook.
1985 NC/CAM Guidebook.
Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Cutting tools available
Piece part specifications
Tooling set-up sheet
Manufacturer's programming/operating manual

ENABLING OBJECTIVE:

1. Operate CNC controller.
2. Use set-up sheet.
3. Read paper printout.

*RESOURCES:

1. Fusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY. 1982.
5. Manufacturer's programming manual.
6. Manufacturer's operating manual.
7. Machinery Handbook. Machinability Data Center. Metcut Research Associates. 1982.
8. Modern Machine Shop. 1985 NC/CAM Guidebook. Cincinnati, OH: Gardner. 1985.

TEACHING ACTIVITIES:

1. Present lecture on the purpose and procedures for tool length compensation.
2. Discuss z-axis motion of a CNC machining center.
3. Present lecture on interpreting the tape block involved with tool length compensation.
4. Discuss sequence number, rapid motion, addition (tool offset), programmed length of tool motion and assigned tool register.
5. Discuss codes used in programming tool length compensation.
6. Demonstrate how to calculate and program tool length compensation.
7. Assign student projects involving the calculation and programming of different tool length compensations.
8. Instruct student to calculate and program tool length compensation.

CRITERION-REFERENCED MEASURE:

The student will run sample programs on CNC machines that require multiple tool changes with different tools that require different settings of tool length compensation. With each change of tool & length compensation value, the student wi l see a difference in distance that each tool will move to reach the workpiece.

PERFORMANCE GUIDE:

1. Provide for operator instructions on tooling set-up sheet.
2. Select tooling form available cutters.
3. Mount tool in spindle or turret station.
4. Align tool to machining position.
5. Jog tool against reference stop (computer records tool position).
6. Observe control display to verify computer computation of tool length compensation.
7. Enter tool identification numbers.
8. Select compensation value for each active tool identification number used.
9. Push enter key to store tool compensation data. (Follow manufacturer's programming manual for specific machine tool.)

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #32

TASK: Repair broken tape.

STANDARD OF PERFORMANCE OF TASK:

Tape must run through reader without loss of program codes due to repair.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Tape splicer
Broken tape
Adhesive tape splicer patches

ENABLING OBJECTIVE:

1. Operate a tape splicer.
2. Determine type of tape.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. William Luggen. Fundamental of Numerical Control. Delmar Publisher Inc., Albany, New York 1984.
3. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY, 1973.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY, 1982.
5. Manufacturer's operating manual.
6. Checklist - Repairing CNC tape.
7. Visual aid - CNC tape format.

TEACHING ACTIVITIES:

1. Present lecture on types of tapes. (*1,2,3,4)
2. Discuss paper, mylar, aluminum and plastic tapes CNC punch tapes.
3. Discuss CNC magnetic tapes.
4. Present lecture on operating tape splicer.

TEACHING ACTIVITIES: (cont.)

5. Discuss acceptable splicing mediums.
6. Discuss splicing procedures.
7. Discuss replacement of damaged tape.
8. Demonstrate how to repair broken CNC tape.
9. Instruct student to repair a broken CNC tape (*6).

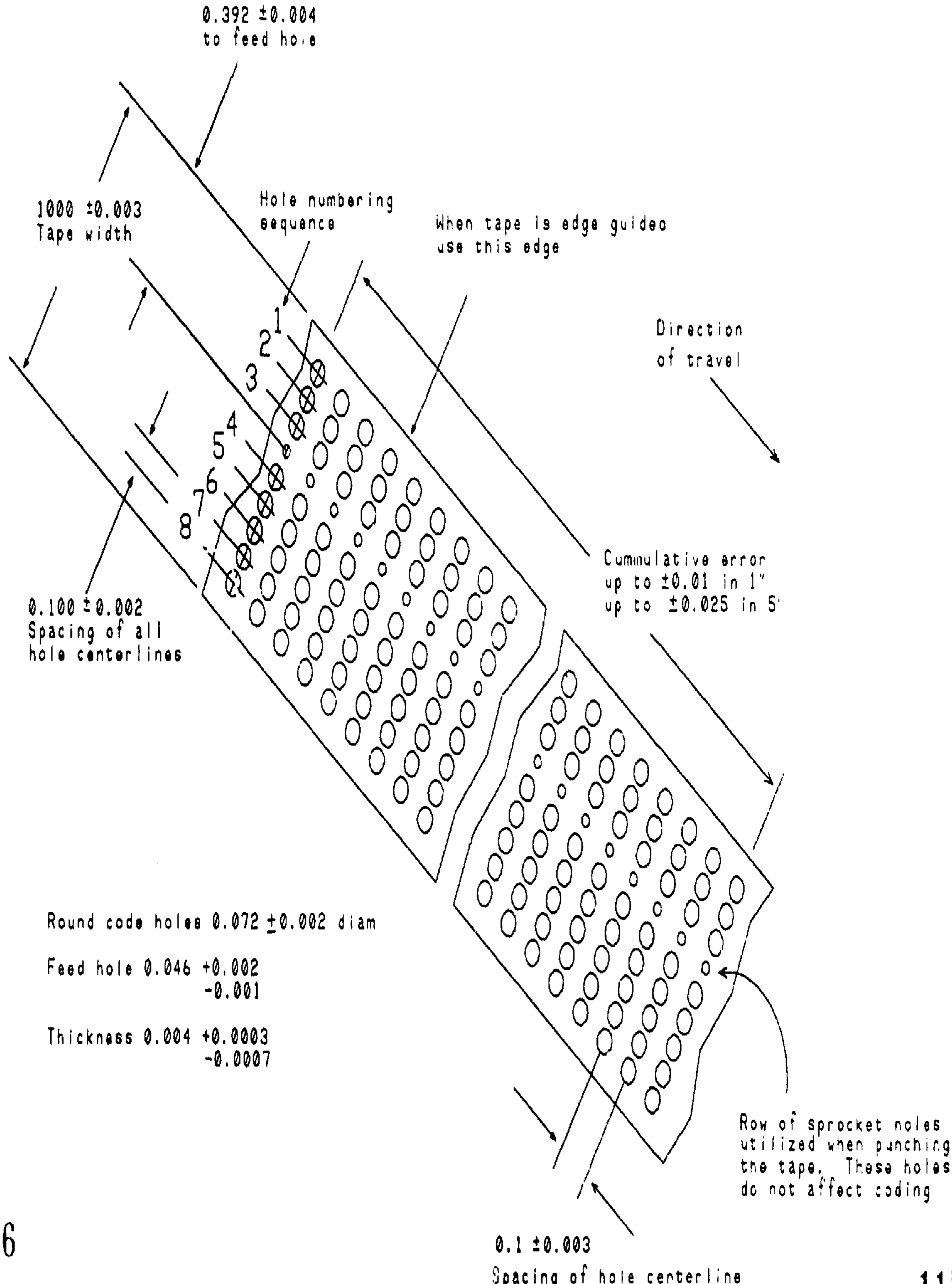
CRITERION-REFERENCED MEASURE:

The student will identify the type of tape to be repaired, the proper type of repair medium, identify and replace any damaged tape and repair (splice) the broken CNC tape. The repaired tape will run through a tape reader without getting a parity error on CNC read out display.

PERFORMANCE GUIDE:

1. Place each end of broken tape over pins of tape splicer so that torn edges of tape meet and punched holes are aligned.
2. Place tape patch over torn edges.
3. Peel off backing from patch, exposing adhesive.
4. Press patch into place.
5. Turn tape over and repeat steps one through four.

CNC TAPE FORMAT



Round code holes 0.072 ±0.002 diam

Feed hole 0.046 +0.002
-0.001

Thickness 0.004 +0.0003
-0.0007

CHECKLIST

DUTY Programming and planning.

TASK Repair broken tape.

ENABLER Repair broken tape on tape splicer.

STUDENT'S NAME ______________ DATE ________

EVALUATOR'S NAME ______________ COURSE ________

TIME : STARTED ________ COMPLETED ______________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate repairing a broken tape using a tape splicer.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Obtained sections of broken tape.	____	____
- Placed broken tape ends over pins of tape splicer.	____	____
- Adjusted tape so that the broken ends meet and punched holes align.	____	____
- Placed tape patch over torn edges.	____	____
- Peeled backing off patch exposing adhesive.	____	____
- Pressed patch into place.	____	____
- Turned tape over and repeated the procedure.	____	____

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #33

TASK: Update programs from engineering changes.

STANDARD OF PERFORMANCE OF TASK:

Original program must contain revision as specified by engineer.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook

CONDITIONS FOR PERFORMANCE OF TASK:

Software
Original program
Computer and/or calculator
Manufacturer's programming manual

ENABLING OBJECTIVE:

1. Read part prints and blueprints.
2. Use computer and software and to incorporate engineering changes.
3. Revise part program.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, New York, NY, 1973.
3. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY, 1982.
5. Modern Machine Shop. 1985 NC/CAM Guidebook. Gardner Publications, Cincinnati, OH , 1985.
6. Manufacturers programming manual.
7. Manufacturers operator manual.

TEACHING ACTIVITIES:

1. Present lecture on part programming. (*1,2,3,4, 5,6,7)

TEACHING ACTIVITIES: (cont.)

2. Discuss reviewing original program and identifying needed revisions.
3. Demonstrate procedure for revising an original program.
4. Assign student an original program and revision documentation and instruct student to revise the program.
5. Demonstrate how to update program file.
6. Instruct student to update program file with revised program.

Note: Emphasize to students that any engineering changes to a part print must be accompanied by a revision number and date, written in the revision area of the part print. Student should compare updated programs from originals to be sure all changes were made.

CRITERION-REFERENCED MEASURE:

The student will review the original program and the revision documentation, revise the program, verify that its runs without error and safe update program.

PERFORMANCE GUIDE:

1. Review documented revision:
   a. Check for authorization.
   b. Maintain paper file copy or save revision in computer memory.
2. Determine program changes necessary to revise original program.
3. Load previous program in computer.
4. Mark tape or program in computer.
5. Revise program as needed (refer to specific computer system programmer's manual for format to edit program).
6. Provide notification of change to all departments or personnel affected by change.

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #34

TASK: Determine job priorities.

STANDARD OF PERFORMANCE OF TASK:

There must be uninterrupted flow of work which results in completion of jobs within specified due dates.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook.

CONDITIONS FOR PERFORMANCE OF TASK:

Tool list
Routing sheet
Job priority list from management
Machine tool selection
Manufacturing work order

ENABLING OBJECTIVE:

1. Determine when the delivery dates occur for each job.
2. Identify which job require special attention, that must be done on the outside.

*RESOURCES:

1. Modern Machine Shop. 1985 NC/CAM Guidebook. Gardner Publications, Cincinnati, OH , 1985
2. Sample priority list.
3. Sample manufacturing list.
4. Sample management priority list.

TEACHING ACTIVITIES:

1. Present lecture on determining job priorities. (*1,2,3,4)
2. Discuss "RUSH" orders.
3. Discuss special treatment orders.
4. Discuss heat treatment; plotting and jig grinding.
5. Discuss management job priorities.
6. Discuss job efficiency versus cost efficiency as affected by priorities.
7. Demonstrate how to rank job priorities.

TEACHING ACTIVITIES: (cont.)

8. Assign student a list of jobs and a management priority list.
9. Instruct student to prioritize the job list.

CRITERION-REFERENCED MEASURE:

All priority job will have been completed on or before due dates that were required by management. Given a list of jobs and a management priority list the student will rank the job list with the highest priority job on top and lowest on the bottom of list.

PERFORMANCE GUIDE:

1. Identify parts or jobs from blueprint or manufacturing work order.
2. Determine materials needed and order in which to use.
3. List machines or processes in order in which to use.
4. Determine number of parts to be made in accordance to manufacturing work order.
5. Analyze system to reduce manufacturing time.
6. Check completion dates indicated on manufacturing work order.
7. Develop coding system for determining production scheduling or routing.

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #35

TASK: Schedule programs.

STANDARD OF PERFORMANCE OF TASK:

Jobs for programmers, machine tools and operators must be scheduled to provide a continuous and efficient work flow process as well as to meet the needs of management.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook.

CONDITIONS FOR PERFORMANCE OF TASK:

Work orders
Routing sheet
Bill of materials
List of job priorities
List of programs available

ENABLING OBJECTIVE:

1. Determine jobs are in progress and what machines are being used, to process those jobs.
2. Determine when the delivery dates occur for each job.
3. Identify when programs will be due.

*RESOURCES:

1. Modern Machine Shop. 1985 NC/CAM Guidebook. Gardner Publications, Cincinnati, OH , 1985
2. Sample priority list.
3. Sample manufacturing work order.
4. Sample management priority list.
5. Worksheet -
6. Information sheet -
7. Visual aid -

TEACHING ACTIVITIES:

1. Present lecture on determining job priorities. (*1,2,3,4)

TEACHING ACTIVITIES: (cont.)

2. Discuss factors affecting job priorities.
3. Discuss program availability.
4. Discuss grouping of programs with similar tool procedures.
5. Demonstrate how to schedule programs according to job priorities.
6. Assign student a list of available programs and a list of job priorities.
7. Instruct student to schedule jobs to provide a continuous and efficient work flow.

CRITERION-REFERENCED MEASURE:

Student will schedule programs to provide a steady and smooth work flow, utilizing all necessary equipment while meeting management requirements and job due dates.

PERFORMANCE GUIDE:

1. Determine priority of programs:
   a. Indicated completion date.
   b. Size and scope of job.
   c. Management commitment.
   d. Type of machining process required.
   e. Available facilities within plant.
2. Determine availability of programs.
3. Determine availability of job details within programs.
4. Categorize programs with similar tools procedures.
5. Complete job order preference based on criteria above.

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #36

TASK: Schedule heat-treated materials.

STANDARD OF PERFORMANCE OF TASK:

Heat-treated process must not interfere with additional or prior machining operations. Completed workpiece must meet range of plus or minus tolerance specifications and finished quality specifications as indicated on blueprint.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Materials list
Blueprint tolerance specifications

ENABLING OBJECTIVE:

1. Determine the type of steel each detail is made up of.
2. Identify heat treat requirements of various types of steel, in order to gather a group of blocks of the same type before going to heat treat.
3. Determine areas to be machined before heat treating.

*RESOURCES:

1. Modern Machine Shop. 1985 NC/CAM Guidebook. Gardner Publications, Cincinnati, OH , 1985.
2. Sample priority list.
3. Sample manufacturing work order.
4. Sample management priority list.

TEACHING ACTIVITIES:

1. Present lecture on factors affecting scheduling of heat-treated materials.
2. Discuss checking material list for any heat-treated materials.
3. Discuss various types and grades of steel, and their heat treat properties.

TEACHING ACTIVITIES: (cont.)

4. Demonstrate various types and grades of steel, and their heat treat properties.
5. Discuss machining processes performed before heat-treating.
6. Discuss machining processes which can be performed after heat-treating.
7. Instruct student to schedule heat-treating processes so that they do not interfere with other machining processes.

CRITERION-REFERENCED MEASURE:

The student will determine and schedule heat-treatment process so that all heat-treated materials shown on material list will have been completed in time, so as to not disrupt the rest of the job.

PERFORMANCE GUIDE:

1. Select materials to be heat-treated from stock list.
2. Establish priority list for materials.
3. Plan for close tolerance areas:
   a. Note on print extra material to be left.
   b. Determine requirements for workpiece squareness and parallelism.
4. Determine areas to be machined before heat-treating.

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #37

TASK: Schedule secondary processes.

STANDARD OF PERFORMANCE OF TASK:

Work flow within machining departments must continue without interruption or unnecessary downtime with production of workpiece.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS OF PERFORMANCE OF TASK:

Part print
Blueing for transfer
Layout blue or layout dye
Means for part identification
Manufacturing finishing equipment

ENABLING OBJECTIVE:

1. Determine type of steel each detail is made up of.
2. Recognize secondary processes from material list or individual detail notes on blueprint.
3. Identify some outside vendors, in case any secondary process cannot be done in house.

*RESOURCES:

1. Modern Machine Shop. 1985 NC/CAM Guidebook. Gardner Publications, Cincinnati, OH , 1985
2. Sample priority list.
3. Sample manufacturing work order.
4. Sample management priority list.

TEACHING ACTIVITIES:

1. Present lecture on types of secondary processes. (*1,2,3,4)
2. Discuss grinding, fitting, deburning, cleaning and blueing.
3. Discuss ranking secondary processes in sequential order.

TEACHING ACTIVITIES: (cont.)

4. Demonstrate how to rank secondary processes.
5. Assign students a list of secondary processes and instruct student to rank them sequentially.
6. Instruct student to schedule secondary processes.

Note: All secondary, such as grinding or fitting still must be tied to scheduling any heat treating.

CRITERION-REFERENCED MEASURE:

The student will identify secondary processes to be completed and schedule them so that the work flow continues without interruption or downtime.

PERFORMANCE GUIDE:

1. Determine detail priority of secondary processing:
   a. List all secondary processes required.
   b. Rank processes in sequential order.
2. Remove all sharp edges and burrs.
3. Perform secondary operations:
   a. Cleaning.
   b. Grinding.
   c. Fitting.
   d. Blueing shut-offs.
4. Identify part with identification code.
5. Inspect detail to verify completion.

GUIDE SHEET

DUTY: Programming and planning

PERFORMANCE OBJECTIVE #38

TASK: Schedule plating.

STANDARD OF PERFORMANCE OF TASK:

Scheduled plating must not interfere with machining process or piece part dimensioning and must not interrupt flow in production.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1985 NC/CAM Guidebook.

CONDITIONS OF PERFORMANCE OF TASK:

Materials list
Scheduling sheet
Routing sheet
Plating facilities in-house
Plating services available

ENABLING OBJECTIVE:

1. Check material list for all details that require planting.
2. Determine detail to be plated requires heat treating before.
3. Identify some outside vendor who do plating, in case it cannot be done in house.

*RESOURCES:

1. Modern Machine Shop. 1985 NC/CAM Guidebook. Gardner Publications, Cincinnati, OH , 1985
2. Sample priority list.
3. Sample manufacturing work order.
4. Sample management priority list.

TEACHING ACTIVITIES:

1. Present lecture on what plating is and how it is done. (*1)

TEACHING ACTIVITIES: (cont.)

2. Discuss plating process.
3. Discuss time and money considerations.
4. Discuss ranking plating process in relation to other machining processes.
6. Instruct student to schedule plating processes.

CRITERION-REFERENCED MEASURE:

The student will schedule plating process so that other machining processes are not interupted or delayed.

PERFORMANCE GUIDE:

1. Select from stock list, all materials for plating.
2. Establish a priority list.
3. Determine if plating is to be done in house or sub-contracted.
4. Establish a time for plating, if done in house:
    a. Make notation on piece print.
    b. Send routing slip to plating department.
5. Check outside source for price and time for plating:
    a. Prepare paperwork.
    b. Schedule materials to be sent.
6. Prepare material by completing machining work prior to plating.

GUIDE SHEET

DUTY: Setting up

PERFORMANCE OBJECTIVE #39

TASK: Check tooling sheet.

STANDARD OF PERFORMANCE OF TASK:

Tools must be listed in order of usage.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS OF PERFORMANCE OF TASK:

Pencil
Tool data
Tool sheet
Tool identification numbers
Tool tag (or system for making tools

ENABLING OBJECTIVE:

1. Select the proper tool from tool information sheet.
2. Position each tool in proper sequence.
3. Select correct place on tool turret.
4. Identify if tool is missing and steps required for reporting.

*RESOURCES:

1. Pusztai J. and Sava M. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggne. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY, 1973.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY, 1982.
5. Manufacturer's operating manual.
6. Manufacturer's programming manual.
7. Visual aid - Tooling sheet.

TEACHING ACTIVITIES:

1. Present lecture on completing tooling sheet.

TEACHING ACTIVITIES: (cont.)

2. Discuss the tool numbering system.
3. Discuss types of tools and the tools purpose.
4. Discuss the tool turret or drum of the machine.
5. Discuss use of tool tagging or marking.
6. Discuss problems associated with broken or missing tools.
7. Demonstrate procedure for reviewing a tooling sheet.
8. Instruct student in reviewing a tooling sheet.

CRITERION-REFERENCED MEASURE:

The student will review the tooling sheet and determine the order of tool usage for the part program.

PERFORMANCE GUIDE:

1. Review tool sheet for order of tool usage for part program.
2. Determine tool positions on turret (or tool drum) as specified on tool sheet.
3. Identify needed tools not currently available:
   a. Recommend vendor name and part number on tool sheet.
   b. Report to specified personnel for missing information.

SAMPLE TOOLING FORM

PART NAME	PART NO.		DRAWING NO.
MACHINE AND CONTROL	REVISION	PROG. BY	DATE
SET UP AND TOOL INFORMATION		CHECK BY	PAGE OF PAGES
TO SET TLC TRAM POSITION			

Operation or Station Number	Tool Description	Assembly No.	Set Dim.	Remarks	Cut Speed	R.P.M.	Feed	CPT or FD/REV

CHECKLIST

DUTY Setting Up.

TASK Check tooling sheet.

ENABLER Select the proper tool from tool information sheet.

STUDENT'S NAME ____________ DATE ____________

EVALUATOR'S NAME ____________ COURSE ____________

TIME : STARTED ____________ COMPLETED ____________

TOTAL ____________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate programming tool change.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Selected the proper tool(s).	____	____
- Matched the tool to identification number.	____	____
- Positioned the tool in sequence.	____	____
- Positioned the turret location.	____	____
- Recognized incorrect tools.	____	____

GUIDE SHEET

DUTY: Setting up

PERFORMANCE OBJECTIVE #40

TASK: Transport tools.

STANDARD OF PERFORMANCE OF TASK:

Cutting tool edges must be protected while in transit. All cutting tools must be available at machine tool during machining process prior to beginning CNC program.

NOTE: Before starting to transport tools, check previously identified tool number and tool location numbers.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS OF PERFORMANCE OF TASK:

Tools
Carrier
Tool holders
Tool list
Tool identification number

ENABLING OBJECTIVE:

1. Identify procedures for grinding(sharpening) tools.
2. Identify procedure for protecting prepared tools.
3. Determine tool identification system, tool lists and associated tools.
4. Identify machine to be used and determine its tool requirement.

*RESOURCES:

1. Manufacturer's operating manual.
2. Manufacturer's programming manual.

TEACHING ACTIVITIES:

1. Present lecture on procedure for transporting tools.

TEACHING ACTIVITIES: (cont.)

2. Discuss and demonstrate preparing tools to require finish for each machine.
3. Discuss the tool list and a description of the machining process it performs.
4. Demonstrate how to handle the tools and remove them from their storage location to and from tool holders and carriers.
5. Discuss tool identification and marking system.
6. Discuss and demonstrate safe tool handling and transporting procedures.
7. Assign student a list of tools to be located, transported to a CNC machine, and loaded into turret/drum.
8. Instruct student to transport tool to and from storage to CNC machine.

CRITERION-REFERENCED MEASURE:

The student will identify tools by number, inspect tools' condition, transport tools from storage to CNC machine and load the tools into the turret/drum.

PERFORMANCE GUIDE:

1. Load tools in carrier.
2. Route tools to specific CNC machine.
3. Protect cutting edge of tools from other surfaces.
4. Unload tools in standby tool carrier.

GUIDE SHEET

DUTY: Setting up

PERFORMANCE OBJECTIVE #41

TASK: Install cutting tools in holders.

STANDARD OF PERFORMANCE OF TASK:

When cutting tools and holders are inserted into machine tool spindle, entire holder and cutting tool setup must be within the programmer's working tolerances and must remain secure during machining process.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS OF PERFORMANCE OF TASK:

Adapters
Cutting tools
Tooling sheet
CNC machine
Tool holders: arbor, fixed lock, and collet

ENABLING OBJECTIVE:

1. Identify tools needed to set up machine.
2. Determine size and shape of tools needed for machining.
3. Set-up tool holder (turret, spindle etc.) to program specifications and tolerances.
4. Check tool for proper cut (sharpness & condition).

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY. 1973.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. James Childs. Principles of Numerical Control, Third Edition. Industrial Press Inc., New York, NY 1982.
5. Manufacturer's operating manual.

*RESOURCES: (cont.)

6. Visual aid - Tool assembly sheet.
7. Checklist - Installing cutting tools in holders.

TEACHING ACTIVITIES:

1. Present lecture on installing cutting tools in holders. (*1,2,3,4,5&6)
2. Discuss selecting process of tool for operations being done.
3. Discuss touch off method of tool for machining.
4. Discuss how to adjust tool or tool holder to program specification and tolerance.
5. Discuss and demonstrate observing tool during operation for error/malfunction.
6. Discuss and demonstrate how to correct malfunction with adjustment tools.
7. Discuss and demonstrate improper tool set-up such as out of machine limits.
8. Discuss and demonstrate safety procedures and considerations for installing cutting tools in holders.
9. Instruct student to install cutting tools in tool holder.

CRITERION-REFERENCED MEASURE:

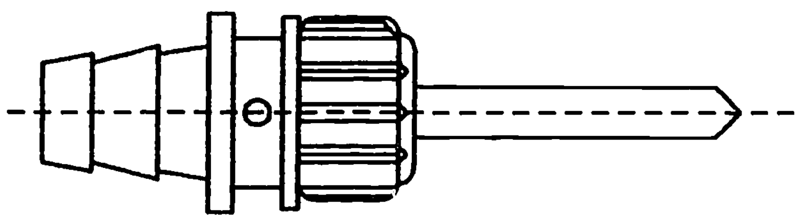
The student will identify tools needed to complete machining process, determine proper holders needed and install tools in their respective holders.

PERFORMANCE GUIDE:

1. Check tooling sheet for cutting tool size to be used.
2. Select holder to fit cutting tool for machining.
3. Check the combined length of tool holder requirements of program printout.
4. Clean turret or pocket of tool drum before loading.
5. Place cutting tool in holder and tighten.
   NOTE: Tools may also be preset into precision made holders.
6. USe one of the following methods (depending upon machine tool) to tighten cutting tool:
   a. Tighten set screw in holder, or
   b. Tighten collet around holder with wrench.
   c. Tighten cutting tool in drill check using chuck key.

TYPICAL TOOL IDENTIFICATION / DATA SHEET

TOOL DATA SHEET TOOL DRAWING	TOOL NAME 5/16" Drill (long)



DURABLE TOOLING	TOOL IDENTIFICATION No.
91501 universal acura-grip collect chuck	01121
901000-5/16 acura-grip collect	DATE SET
901001 acura-grip collect nut	1-1-86
	SET BY
	D.G.H.

PERISHABLE TOOLING	WHERE USED
5/16 extra length drill	327654
at least 7.5" flute lgth.	
9.0" O.A.L.	

TOOL NAME 5/16" Drill (long) TOOL I.D. NUMBER 01121

CHECKLIST

DUTY Setting Up.

TASK Install cutting tool in holders.

ENABLER Set up tool holders to program specifications.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED __________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate programming tool change.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Selected the necessary tools and adapters.	____	____
- Select the correct cutter for the processes.	____	____
- Set the tool holder within the program tolerances and specifications.	____	____
- Checked the tool/cutter for sharpness.	____	____
- Checked the speed/feedrate and made necessary adjustments.	____	____
- Checked the workpiece to make sure it was within the specifications and tolerances.	____	____

GUIDE SHEET

DUTY: Setting up

PERFORMANCE OBJECTIVE #42

TASK: Load tools in tool drum (also called turret or magazine).

STANDARD OF PERFORMANCE OF TASK:

Tools must be inserted securely in tool drum, turret, or tool magazine in the order outlined on tool sheet and production of workpiece must be uninterrupted by machine tool malfunction.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS OF PERFORMANCE OF TASK:

Tools
Tool holders
Tooling set-up sheet
Tool identification numbers
CNC machine with tool drum indexing feature

ENABLING OBJECTIVE:

1. Select individual cutting tools for the machining process as specified by programs.
2. Understand tool set-up for non-destructive malfunction alignment.
3. Identify tool I.D. number and turret location.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY. 1982.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. Manufacturer's operating manual.
5. Manufacturer's programming manual.
6. Visual aid - Rotary tool turret.
7. Checklist - Loading tools.

TEACHING ACTIVITIES:

1. Present lecture on loading tools in tool drum. (*1,2,3,4 & 5)

TEACHING ACTIVITIES: (cont.)

2. Select by I.D. number.
3. Discuss cleaning and preparing tool drum for tool.
4. Demonstrate how to manually operate tool drum through each/all steps of program and set tool for the operation.
5. Demonstrate how to confirm indexing drum to program specifications and tolerance.
6. Discuss and demonstrate monitoring and identifying malfunctions.
7. Discuss and demonstrate positioning tool to malfunction on waste product only.
8. Discuss and demonstrate tool tagging and use of tool sheet.
9. Instruct student to load tools in turret/drum.

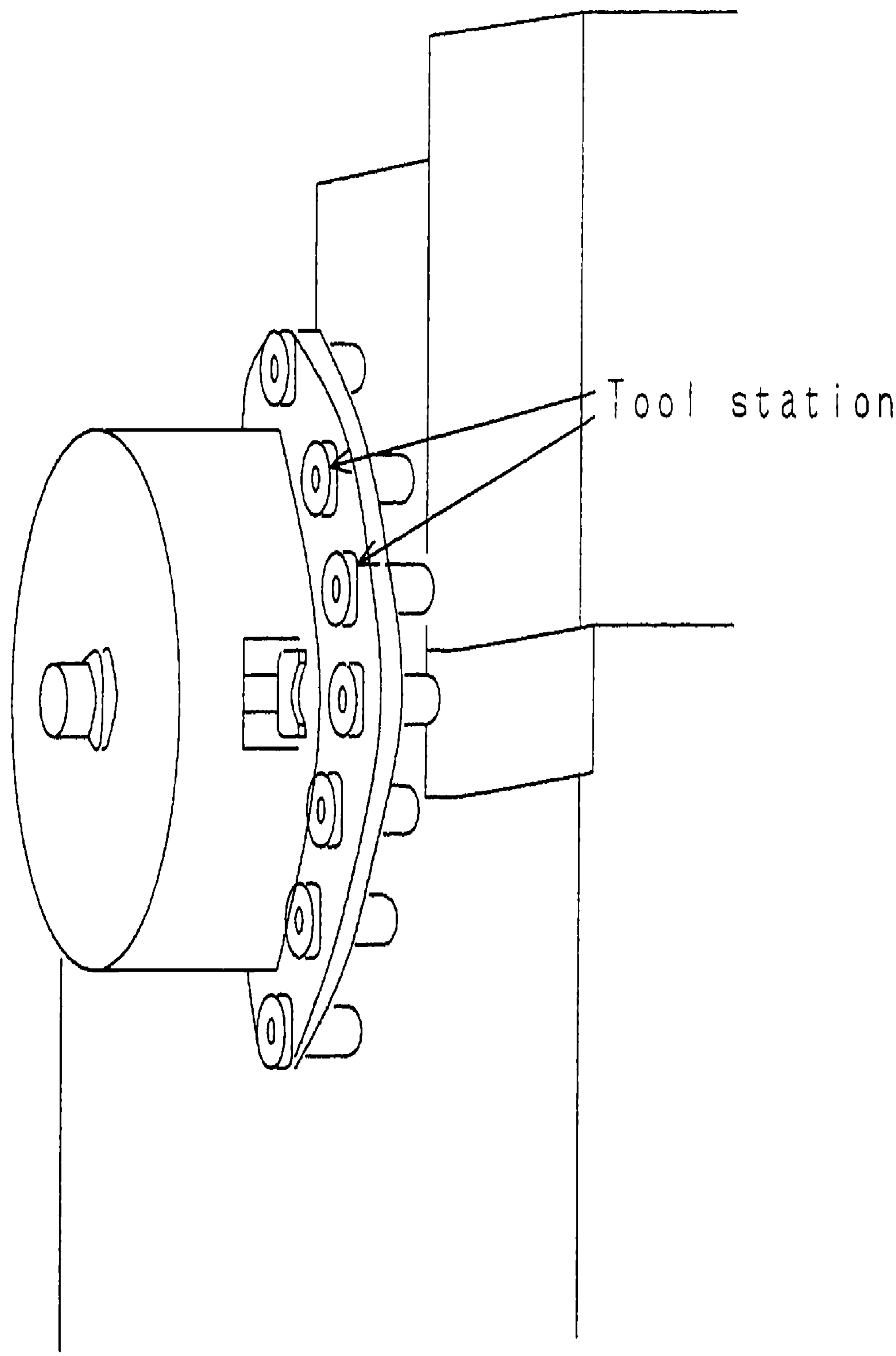
CRITERION-REFERENCED MEASURE:

The student will set-up machine to receive workpiece for operations, clean and adjust tool drum for required operations, check tool drum for limits required by program and position cutting tools in drum for each position of program.

PERFORMANCE GUIDE:

1. Clean holder and pocket prior to installing tool holder in machine.
2. Secure each tool and tool holder as specified by programmer.
3. Depress index tool drum, turret, or tool magazine push button to select desired tool station to be used.
4. Insert tool into the drum, turret, or tool magazine.
   NOTE: In some shops this loading process may also require the setting of tool length compensation lengths.
5. Depress index tool drum, turret, or tool magazine push button to next tool station position.
6. Repeat step 5.

ROTARY TOOL TURRET



CHECKLIST

DUTY Setting Up.

TASK Load tools in tool drum (also called turret or magazine).

ENABLER Select individual cutting tools for the machining process as specified by programs.

STUDENT'S NAME ____________ DATE ________

EVALUATOR'S NAME ____________ COURSE ________

TIME : STARTED ________ COMPLETED ____________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate students performance while loading tools.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Cleaned and prepared the machine for operation.	____	____
- Placed and secured tool(s) and tool holder(s) in the machine as specified by the program.	____	____
- Used the tool control for the drum to correct the position.	____	____
- Inserted the tool into drum and maintained length.	____	____
- Corrected the steps for each tool setting.	____	____

GUIDE SHEET

DUTY: Setting up

PERFORMANCE OBJECTIVE #43

TASK: Mount holder and tool on spindle (manually).

STANDARD OF PERFORMANCE OF TASK:

Tools holder must remain in machine spindle during machining operations.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS OF PERFORMANCE OF TASK:

CNC machine
Tool holder
Cam wrench (in place of automatic draw bar)

ENABLING OBJECTIVE:

1. Demonstrate both manual and automatic operation of machine.
2. Determine set-up of draw bar and spindle for manual tolerance.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
2. James Childs. Principles of Numerical Control, Third Edition. Industrial Press Inc., New York, NY. 1982.
3. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY. 1984.
4. Manufacturer's operating manual.
5. Manufacturer's programming manual.
6. Checklist - Mounting holder and tool on spindle.

TEACHING ACTIVITIES:

1. Present lecture on mounting holder and tool on spindle.
2. Discuss and demonstrate how to clean spindle of foreign matter.
3. Discuss and demonstrate how to clean tool holder of chips and dirt.

TEACHING ACTIVITIES: (cont.)

4. Discuss tool selection and confirm tool I.D. for tool.
5. Discuss and demonstrate placement placement of tool holder in spindle opening.
6. Discuss manual rotation of tool holder in spindle.
7. Discuss and demonstrate use of cam wrench on spindle.
8. Instruct student to manually mount holder and tool on spindle.

CRITERION-REFERENCED MEASURE:

The student will clean spindle and tool holder, select tool and determine tool I.D. number, insert tool into spindle in both automatic and manual, model and mount tool holder using a wrench model or automatic push button.

PERFORMANCE GUIDE:

Without automatic draw bar:
1. Clean spindle.
2. Determine if tool holder is free of chips.
3. Select tool to be used.
4. Place tool holder in spindle.
5. Rotate tool holder in spindle.
6. Place cam wrench on slotted collar of spindle wrench

   counterclockwise until collar tightens down on tool holder.
   NOTE: Some shops will require setting of tool length compensation at this point.

With automatic draw bar:
1. Clean spindle.
2. Determine if tool holder is free of chips.
3. Select tool to be used.
4. Hold tool holder up near spindle and release tool change button.
   NOTE: Some shops will require setting of tool length compensation at this point.

CHECKLIST

DUTY Setting Up.

TASK Mount holder and tool on spindle (manually).

ENABLER Determine set-up of draw bar and spindle for manual tolerance.

STUDENT'S NAME ____________ DATE ________

EVALUATOR'S NAME ____________ COURSE ________

TIME : STARTED ________ COMPLETED ____________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate students performance while manually mounting holder and tool.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Clean and prepare the machine.	____	____
- Cleaned and prepared tool holder.	____	____
- Properly select the tool.	____	____
- Positioned the tool holder in spindle.	____	____
- Manually operated the tool holder.	____	____
- Set the tool length.	____	____
- Aligned the tool holder and operated the control button.	____	____
- Inserted the tool holder in the spindle.	____	____
- Operated the tool change button.	____	____

GUIDE SHEET

DUTY: Setting up

PERFORMANCE OBJECTIVE #44

TASK: Load automatic tool changer.

STANDARD OF PERFORMANCE OF TASK:

When tool number is called up in program, the tool must be loaded into spindle.

NOTE: Loaded tool drum, turret, or magazine should not exceed manufacturer's recommended specifications for total tools, maximum weight, length, and dimension of cutting tools.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Operating Manual for Cincinnati Milacron.

CONDITIONS OF PERFORMANCE OF TASK:

Tools
Tool holders
Tooling set-up sheet
Tool identification numbers
Tool pocket locations
Program with automatic tool changer.
Manufacturer's guidelines for automatic tool changer specifications.

ENABLING OBJECTIVE:

1. Load an automatic tool changer using a tool set up sheet to program specifications and tolerances.
2. Determine if tool conforms to tool I.D. and tool location in automatic changer.
3. Determine if tools utilized in operations will remain within design limitations of automatic tool changer.

*RESOURCES:

1. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.

*RESOURCES (cont.)

2. Manufacturer's operating manual.
3. Manufacturer's programming manual.
4. Checklist - Loading automatic tool changer.

TEACHING ACTIVITIES:

1. Present lecture on procedure for loading automatic tool changers.
2. Discuss and demonstrate checking for cleanliness, burrs, sharpness etc.
3. Discuss tool positioning for special or non standard cutting.
4. Discuss and demonstrate the use of jog or pendant
5. Demonstrate loading tool pocket to program specifications.
6. Discuss and demonstrate loading tools during "off" or "out" cycle. [caution: student must be made aware of the dangers of loading during on or in cycle

CRITERION-REFERENCED MEASURE:

The student will correct tools with burrs or defects, demonstrate loading tool changer while observing safe procedures, select tool with I.D. number and special tools with program specifications while remain within manufacturers design limitations.

PERFORMANCE GUIDE:

1. Check tools to make certain tools are free from chips and burrs.
2. Check orientation of special tools.
3. Use jog tool drum, turret, or magazine push button to select desired tool pocket.
4. Insert tool in pocket:
   a. Secure each tool and tool holder as specified by programmer's set-up sheet.
   b. Install tools only when machine is not in cycle.
      NOTE: Loading or unloading tools while machine is in cycle may result in serious personal injury.
5. Depress jog tool drum push button to next tool pocket.
6. Repeat steps until tool drum, turret, or magazine pockets are loaded or until all tools on set-up sheet are loaded.

CHECKLIST

DUTY Setting Up.

TASK Load automatic tool changer.

ENABLER Load an automatic tool changer using a tool set-up sheet to program specifications and tolerances.

STUDENT'S NAME ____________ DATE ________

EVALUATOR'S NAME ____________ COURSE ________

TIME : STARTED ________ COMPLETED ____________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate students performance while loading an automatic tool changer.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Selected the necessary tools.	____	____
- Checked the condition of the tools or cutters.	____	____
- Checked the tool I.D. number.	____	____
- Used the proper tool sequence.	____	____
- Jogged the drum to the correct position.	____	____
- Loaded the tool specified by the job set-up sheet.	____	____
- Selected correct sequence positions.	____	____
- Safely loaded in "off cycle".	____	____

GUIDE SHEET

DUTY: Setting up

PERFORMANCE OBJECTIVE #45

TASK: Operate drawbar (manually and automatically).

STANDARD OF PERFORMANCE OF TASK:

Cutting tool and holder must remain secure in spindle when machine is in operation.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS OF PERFORMANCE OF TASK:

CNC machine which requires use of drawbar
Drawbar wrench tool
Tool holder

ENABLING OBJECTIVE:

Set up CNC machine drawbar tool in both manual and automatic mode.

*RESOURCES:

1. Manufacturer's operating manual.
2. Manufacturer's programming manual.
3. Checklist - Drawbar operation.

TEACHING ACTIVITIES:

1. Present lecture on manual operation of drawbar. (*1 & 2)
2. Discuss and demonstrate safety considerations when operating drawbar.
3. Discuss and demonstrate procedure for cleaning holde pocket.
4. Demonstrate method for inserting tool holder/ adapter into spindle.
5. Demonstrate how to hold tool holder with one hand and operate draw bar with other hand.
6. Discuss and demonstrate operation of spindle brake and insert wrench to tighten drawbar.
7. Present lecture on automatic operation of drawbar. (*1 & 2)

TEACHING ACTIVITIES: (cont.)

8. Discuss and demonstrate proper cleaning of holder and pocket.
9. Discuss and demonstrate use of operating controls for releasing tool holder.
10. Demonstrate how to manually grasp tool holder, remove tool holder and place in secure area.
11. Demonstrate how to place a new tool holder in spindle and engage draw bar.
12. Discuss and demonstrate aligning keyways and checking keys for burrs, bends and offsets.
13. Instruct student to operate drawbar both manually and automatically.

CRITERION-REFERENCED MEASURE:

The student will inspect keys and keyways, clean holder and pocket, and operate drawbar both manually and automatically while observing all safety conditions at all times.

PERFORMANCE GUIDE:

Manually:
1. Clean holder and pocket prior to installing tool holder in machine.
2. Insert tool holder or adapter into spindle.
3. Hold tool holder or adapter with one hand while operating drawbar with opposite hand.
4. Tighten drawbar to tool holder.
5. Place hand on spindle brake and insert wrench on drawbar head.
6. Tighten until firmly seated.

Automatically:
1. Clean holder and pocket prior to installing tool holder in machine.
2. Turn the switch to out to release the tool holder or adapter in the spindle nose.
3. Grasp tool holder or adapter and turn to remove or engage.
4. Place removed tool holder or adapter assembly on adjoining work area.
5. Place a new tool holder or adapter assembly in spindle nose and turn to engage drawbar.
6. Align keyways in tool holder or adapter with keyways in spindle nose.
7. Release hold on the adapter.
8. Engage selector switch.
NOTE: Care must be taken to protect workpiece and tool holder and cutting tool during engagement or disengagement of drawbar.

CHECKLIST

DUTY Setting Up.

TASK Operate drawbar (manually and automatically).

ENABLER Set-up CNC machine drawbar tool in both manual and automatic mode.

STUDENT'S NAME ______________________ DATE ____________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED ______________________

TOTAL ____________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate students performance while setting-up CNC machine drawbar tool.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Cleaned the machine.	____	____
- Inserted the tool holder.	____	____
- Safely operated the drawbar with the hand.	____	____
- Tighten (within the limits) drawbar to the tools.	____	____
- Automaticly switched out to release the tool in the spindle.	____	____
- Removed the tool from the spindle (while protecting the tool and hands.	____	____
- Exchanged the tool holder.	____	____

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #46

TASK: Dial cutter compensation.

STANDARD OF PERFORMANCE OF TASK:

Programmed center path of cutting tool must be altered to allow for difference between actual and programmed cutter diameter.

SOURCE OF STANDARD:

Writing team of incumbent workers.
1984 NC/CAM Guidebook.
Monarch VMC Three Axis Machining Center Programmers Guide. Producer CNC/NC Operator's Guide for Machining Centers.

CONDITIONS FOR PERFORMANCE OF TASK:

Part program
Control
CNC machine tool
Manufacturer's operators manual

ENABLING OBJECTIVE:

1. Alter machining program to allow for cutter size.
2. Alter machining program on cut line for cutter size compensation.
3. Apply feed rate corrections to program.

*RESOURCES:

1. Modern Machine Shop. 1985 NC/CAM Guidebook. Gardner Publications, Cincinnati, OH , 1985.
2. Manufacturer's operating manual.
3. Manufacturer's programming manual.
4. Checklist - Dial cutter compensation.

TEACHING ACTIVITIES:

1. Present lecture on altering center of cutting tool path.
2. Discuss and demonstrate changes cutter diameter and feed rate.

TEACHING ACTIVITIES: (cont.)

3. Discuss differences between cutter programmed diameter and actual diameter.
4. Explain how to check program for errors.
5. Discuss and demonstrate removing changes and returning program to original specifications or listings.
6. Assign student a programmed center path and instruct the student to alter the program to allow for the actual and programmed cutter diameter.

CRITERION-REFERENCED MEASURE:

The student will compare machine program for cutter changes and will alter program and cancel alterations at conclusion in accordance with machine program guidelines.

PERFORMANCE GUIDE:

1. Define whether cutter path lies to right or left of path.
2. Enter code that describes location of cutter to piece part (inside cut-outside cut). See Manufacturer's operators manual for specific machine tool.
3. Change feedrate for cutter compensation (if necessary).
4. Enter cutter compensation value on machine control.
5. Cancel cutter compensation when program is finished.

CHECKLIST

DUTY Setting Up.

TASK Dial cutter compensation.

ENABLER Alter machining program to allow for cutter size.

STUDENT'S NAME ________________ DATE ________

EVALUATOR'S NAME ________________ COURSE ________

TIME : STARTED ________ COMPLETED ________________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate students performance while adjusting cutter compensation

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Powered up program for checking.	____	____
- Determined the actual cutter path.	____	____
- Entered the code to alter the cutter's path.	____	____
- Enter code for cutter compensation factors.	____	____
- Determine the results.	____	____
- Shut down operation and restored the program.	____	____

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #47

TASK: Mount workpiece.

STANDARD OF PERFORMANCE OF TASK:

Part must be held rigid and secure fixture without piece part movement.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Fixture with clamps
Holding device
CNC machine
Piece part

ENABLING OBJECTIVE:

1. Demonstrate proficiency in working with fixtures.
2. Secure workpiece in fixture.

*RESOURCES:

1. E.G. Hoffman. Jig and Fixture Design. Delmar Publishers Inc., Chicago, 1985.
2. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY, 1984.
3. Manufacturer's operating manual.
4. Manufacturer's programming manual.
5. Checklist - Mount workpiece.

TEACHING ACTIVITIES:

1. Present lecture on the procedure for mounting a workpiece. (*1,2,3,4)
2. Discuss cleaning work area and needed working tools.
3. Demonstrate how to attach a fixture to the work table.
4. Discuss and demonstrate placement of workpiece in fixture.
5. Demonstrate the alignment of positioning blocks, pins, etc.

TEACHING ACTIVITIES: (cont.)

6. Discuss and demonstrate clamping procedures. NOTE: Take caution to prevent damage to finished surfaces.
7. Instruct student to observe worn or damaged fixture parts.
8. Assign student a workpiece and fixture holder and instruct the student to mount the workpiece on the CNC machine work table.

CRITERION-REFERENCED MEASURE:

The student will set up clean work area with needed fixtures, tools and clamps, place the workpiece into fixture protecting finished surfaces, observe fixture for damage or wear, clamp holding device according to specification, remove piece from fixture and protect both fixture and part.

PERFORMANCE GUIDE:

1. Clean table and fixture. (if necessary)
2. Attach fixture to table.
3. Place piece part in fixture.
4. Clamp and hold piece in position by aligning part with location pins or positioning blocks. NOTE: Caution should be used when mounting workpiece to avoid damage to workpiece through mis-handling.

CHECKLIST

DUTY Setting Up.

TASK Mount workpiece.

ENABLER Secure workpiece in fixture.

STUDENT'S NAME ______________ DATE ________

EVALUATOR'S NAME ______________ COURSE ________

TIME : STARTED ________ COMPLETED ______________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate students performance while mounting the workpiece.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Cleaned the machine chip tools.	____	____
- Selected needed tools.	____	____
- Attached the fixture.	____	____
- Attached the workpiece to the fixture with alignment block.	____	____
- Attached the clamps and boots clear of the cutter/tool.	____	____
- Checked the fixture for wear and damage.	____	____

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #48

TASK: Set zero.

STANDARD OF PERFORMANCE OF TASK:

Axis displayed on CRT screen must register as zero coordinate.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine
Blueprint/set-up sheet
Manufacturer's operating manual

If necessary, use one of the following:
Edge finder
Piece part stop
Dial indicator
Automatic pickup probe

ENABLING OBJECTIVE:

1. Set up machine for operation from plan according to machine operation manual.

*RESOURCES:

1. Pusztai J., and Sava M. <u>Computer Numerical Control</u>. Reston Publishing Co., Reston, VA , 1983.
2. William Luggen. <u>Fundamentals of Numerical Control</u>. Delmar Publishers, Inc., Albany, NY , 1984.
3. James Childs. <u>Numerical Control Part Programming</u>. Industrial Press Inc., New York, NY , 1973.
4. James Childs. <u>Principles of Numerical Control, Third Edition</u>. Industrial Press Inc., New York, NY , 1982.
5. Brown, W. C. <u>Blueprint Reading for Industry</u>. Goodheart-Willcox, South Holland, IL , 1983.
6. Manufacturer's operating manual.
7. Manufacturer's programming manual.
8. Checklist - Set zero.

TEACHING ACTIVITIES:

1. Present lecture on the meaning and purpose of zero offset. (*1,2,3, & 4)
2. Present lecture on the procedure determining and setting zero offset. (*1,2,3,4,6 & 7)
3. Instruct student to read blueprint/setup shift to determine starting position.
4. Discuss and demonstrate moving machine to starting point using:
   a. Dial indicator.
   b. Piece part.
   c. Edge finder.
   d. Automatic pickup probe.
5. Discuss setting machine according to manufacturer's operating manual.
6. Discuss and demonstrate checking machine limit switch.
7. Assign a student a CNC machine and workpiece blueprint.
8. Instruct student to identify and set zero offset (starting position) for the machine and workpiece assigned.

CRITERION-REFERENCED ME[illegible]

The student will [illegible] blueprint for starting point and mode, moving m[illegible] to starting point, and set zero offset using a [illegible]ator, piece point, edge finder, automatic pick[illegible] p[illegible]

PERFORMANCE GUIDE:

1. Read blueprint or set-up sheet for specified starting position.
2. Locate and move to starting position on workpiece by using necessary instruments:
   a. Dial indicator.
   b. Piece part stop.
   c. Edge finder.
   d. Automatic pickup probe.
3. Set machine according to special machine requirements as indicated in manufacturer's operating manual.

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #49

TASK: Dry run program.

STANDARD OF PERFORMANCE OF TASK:

Program must run without observed error.
NOTE: Eye protection should be worn during machine dry run.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

* CNC machine tool.
Safety glasses
** CNC vertical mill
Safety shoes
*** CNC wire EDM
Knowledge of safety rules for operating machine in dry run.

ENABLING OBJECTIVE:

1. Activate machine and load program.
2. Prepare machine for dry run.
3. Initiate program run.
4. Conduct dry run of program.

*RESOURCES:

1. Manufacturer's operating manual.
2. Manufacturer's programming manual.
3. Program to be run.
4. Machine for dry run operation.
5. Checklist - Dry run program.

TEACHING ACTIVITIES:

1. Present lecture on the purpose and procedure for performing a dry run. (*1 & 2)
2. Discuss and demonstrate safety considerations when performing a dry run.

TEACHING ACTIVITIES: (cont.)

3. Present lecture on the different types of machines that a dry run might be performed.
4. Discuss and demonstrate a dry run on a CNC machine.
5. Discuss and demonstrate a dry run on a CNC vertical milling machine.
6. Discuss and demonstrate a dry run on a wire EDM.
7. Assign the student a program and a machine to conduct a dry run on.
8. Instruct student to conduct a dry run of a program.

CRITERION-REFERENCED MEASURE:

The student will identify the type of machine needed for a dry run and perform a dry run of the program. The program must run without error.

PERFORMANCE GUIDE:

*CNC machine tool
1. Load program
2. Call up beginning of program.
3. Switch control to dry run.
4. Depress cycle start.

**CNC vertical mill
1. Load program in machine control.
2. Set cutter depths so that cutter will not hit workpiece during dry run.
3. Turn on dry run and start program.
4. Watch cutter travel during dry run to check program. NOTE: Watch cutter during dry run of program and be prepared to stop machine if program malfunctions or if cutter is going to hit workpiece or clamps.

***Wire EDM
1. Load program in machine control.
2. Remove wire from guides.
3. Position guides to clear workpiece, clamps, and machine limit switches.
4. Install drawing pen in holder arm.
5. Place drawing paper in plotting table.
6. Fix paper by rubber magnet and attach to machine.
7. Depress dry run button to start program. (Feedrate in dry run is set by parameters of machine. Caution should be taken to clear nozzles and attachment cables.)

NOTE: Specific machine tools may specify to set machine in block-by-block mode, no motion, or two axis block during the dry-run procedure.

CHECKLIST

DUTY Setting Up.

TASK Dry run program.

ENABLER Activate machine and load program for vertical milling machine.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the student while setting up the vertical milling machine for operation.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Loaded the program.	____	____
- Set the workpiece on the machine.	____	____
- Used the alignment blocks.	____	____
- Set up the clearance from the workpiece.	____	____
- Operated the dry run.	____	____
- Checked the machine for the actual path.	____	____
- Watched for malfunctions.	____	____
- Utilized the safety guards and wore proper clothing.	____	____

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #50

TASK: Add coolant commands.

STANDARD OF PERFORMANCE OF TASK:

As a result of coolant flow on cutting tool, cutting tool must operate with minimum heat and coolant must prevent chip build-up.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Control
CNC machine
Access to edit mode
Manufacturer's operating/programming manual
Carbide insert or metal cutting tool (do not use coolant on ceramic cutting tool)

ENABLING OBJECTIVE:

1. Load program into memory.
2. Select edit mode and insert coolant command.
3. Utilize manual coolant override for adding coolant.
4. Match coolant rate to tool and cutting/feedrate.

*RESOURCES:

1. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY, 1984.
2. Manufacturer's operating manual.
3. Manufacturer's programming manual.
4. Checklist - Add coolant commands.

TEACHING ACTIVITIES:

1. Present lecture on the purpose of coolant.
2. Present lecture on types of coolants and methods of delivery. (*1,2 & 3)
3. Discuss tool coolant requirement depending on tool type, material, size, cutting speed and feedrate.
4. Demonstrate method for recalling program from memory and using edit mode.

TEACHING ACTIVITIES: (cont.)

5. Discuss and demonstrate insertion of coolant command (usually MO 8).
6. Discuss and demonstrate manual operation of coolant override.
7. Assign student a CNC machining process, workpiece, and part program.
8. Instruct student to identify type of coolant needed and insert proper coolant command code.

CRITERION-REFERENCED MEASURE:

The student will determine tool coolant requirements determined by type of cutting, tool cutter speed, feed-rate and cutter tool size. The student must power up machining, enter program, access to memory and coolant commands into program at required position.

PERFORMANCE GUIDE:

1. Load program in memory:
   a. Select edit mode
   b. Insert coolant commands (usually MO8).
2. Utilize manual coolant override for adding coolant (at machine as needed).

CHECKLIST

DUTY Setting Up.

TASK Add coolant commands.

ENABLER Select edit mode and insert coolant command.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE ________

TIME : STARTED __________ COMPLETED ____________________

TOTAL ____________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the student while using the coolant command.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Selected program.	____	____
- Changed to the edit mode.	____	____
- Selected steps compatible to the coolant.	____	____
- Inserted the coolant mode.	____	____
- Matched coolant rates to cutting variables.	____	____
- Checked the program for completeness.	____	____

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #51

TASK: Alter speed/feed commands.

STANDARD OF PERFORMANCE OF TASK:

Feedrate and spindle rpm values must be displayed or otherwise indicated as an increase or decrease on control.

SOURCE OF STANDARD:

Numerical Control Machining Series.
Miyanomatic Model CNC-7BC Instruction Manual.
Operating Manual for Cincinnati Milacron
1985 NC/CAM Guidebook

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tool
Cutting tools
Machine control
Blueprint
Workpiece
Basic machining skills
Manufacturer's operating/programming manual

ENABLING OBJECTIVE:

1. Calculate cutting speeds for material used by machine.
2. Calculate cutting depth and operation limitations of machine.
3. Determine machine speeds/feeds as "off or on speed"
4. Correct program if "off speed" in noted.

*RESOURCES:

1. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY, 1984.
2. Pusztai and Sava. Computer Numerical Control. Reston Publishing Co, Reston, VA, 1983.
3. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY, 1973.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY, 1982.

TEACHING ACTIVITIES: (cont.)

5. American Machinist. Numerical Control Machining Series. Beckworth and Associates, Cleveland, OH ,1978.
6. Modern Machine Shop. 1984 NC/CAM Guidebook. Gardner Publications, Cincinnati, OH , 1984.
7. Manufacturer's operating manual.
8. Manufacturer's programming manual.
9. Checklist - Alter feed/speed commands.

TEACHING ACTIVITIES:

1. Present lecture on procedures for altering speed/ feed commands (#1,2,3,4,5,6,7 & 8)
2. Discuss and demonstrate how to calculate cutting speed for materials being used.
3. Discuss coolant requirements for materials and cutters and how it affects feedrate and spindle speed.
4. Discuss how to identify incorrect cutting speeds.
5. Demonstrate how to change/correct cutting speeds.
6. Assign student a CNC machining and a list of feed/ speed rates.
7. Instruct student to alter the feed/speed commands in order to alter machine feed/speed rate.

CRITERION-REFERENCED MEASURE:

The student will identify current feed/speed rate, the new feed/speed rate and alter the feed/speed command to compensate for the change.

PERFORMANCE GUIDE:

1. Determine amount of feed and spindle rpm increase or decrease.
2. Enter new spindle speed value into machine control (see manufacturer's operating/programming manual for specific machine tool options available.
   a. Adjust spindle speed with variable speed control hand wheel (a specific machine tool option), or
   b. Adjust feedrate with control know on control.
3. Observe machine control for verification of new speeds/feeds.

CHECKLIST

DUTY Setting Up.

TASK Alter speed/feed commands.

ENABLER Calculate cutting speeds for material used by machine.

STUDENT'S NAME ______________ DATE __________

EVALUATOR'S NAME ______________ COURSE __________

TIME : STARTED __________ COMPLETED __________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the student while calculating cutting speeds.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Calculated the cutting speeds.	____	____
- Calculated the cutting depth.	____	____
- Determine that the operations were remaining within the machine limits.	____	____
- Observed that the machine cuts were within the cutting speed/feed limits.	____	____
- Corrected the cutting speed, if necessary.	____	____

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #52

TASK: Update programs stored in bubble memory.

STANDARD OF PERFORMANCE OF TASK:

CRT must register new programs on screen. Machine operating in dry run must run new program after update.

SOURCE OF STANDARD:

Writing Team of Incumbent Workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC with bubble memory
Part program
Manufacturer's operating/programming manual

ENABLING OBJECTIVE:

1. Operate CMC machine with bubble/buffer memory.
2. Edit and alter old program without losing the original program.
3. Extract program and load.
4. Check program by dry run, sceen display, or pen plot.

*RESOURCES:

1. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY, 1984.
2. James Childs. Numerical Control Part Programming. Industrial Press Inc., New York, NY, 1973.
3. James Childs. Principles of Numerical Control, Third Edition. Industrial Press Inc., New York, NY, 1972.
4. Manufacturer's operating manual.
5. Manufacturer's programming manual.
6. Checklist - Update program in memory.

TEACHING ACTIVITIES:

1. Present lecture on the purpose of bubble/buffer memory storage.

TEACHING ACTIVITIES: (cont.)

2. Discuss ways to utilize bubble/buffer memory storage on CNC machines.
3. Discuss and demonstrate how to recall and load a program.
4. Discuss how to edit and load a program without losing the original program.
5. Discuss and demonstrate verifying the program by dry run, screen display, or pen plot.
6. Discuss and demonstrate the removal of change/alteration from the program.
7. Discuss verifying original program for original content and discuss re-saving the program in memory storage.
8. Instruct student to update a program currently stored in a bubble/buffer memory.

CRITERION-REFERENCED MEASURE:

The student will recall a program from the memory storage, update the program with indicated alterations, and resave the program back to memory storage.

PERFORMANCE GUIDE:

1. Load stored program from bubble memory to active or static memory.
2. Edit program as described in the programming and operators manual.
3. Re-save program in bubble memory.
4. Check program changes by:
   a. Using dry run.
   b. Using screen.
   c. Using pen plot.

   NOTE: Machine tool options available will determine the method used by the operator as well as established shop procedure by the employer.

CHECKLIST

DUTY Setting Up.

TASK Update programs stored in bubble memory.

ENABLER Operate CNC machine with bubble/buffer memory.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED __________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the student while using the bubble memory.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Powered up the CNC with the bubble.	____	____
- Gained access to the bubble menu and selected the program.	____	____
- Edited the program.	____	____
- Entered and loaded the program for operation.	____	____
- Checked the program (dry run etc.).	____	____
- Resaved the program into the bubble to maintain the program.	____	____

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #53

TASK: Complete machine tool safety setup.

STANDARD OF PERFORMANCE OF TASK:

Accidents must not occur when machines are in operation from incomplete safety setup. Machining operations must meet OSHA standards for safety.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Operating Manual for Cincinnati Milacron.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine
Safety shoes
Safety glasses
Manufacturer's specific machine tool manual

ENABLING OBJECTIVES:

1. Assemble and use all needed safety equipment.
2. Identify and place all guards, shields, barriers, covers, and safety devices on the machine.
3. Meet and maintain all OHSA standards for machine, work area, and operator.

*RESOURCES:

1. William Luggen. Fundamentals of Numerical Control. Delmar Publishers Inc., Albany, New York, 1984.
2. Operating Manual For Cincinnati Milacron, Heald Machine Division, Cincinnati Milacron-Heald Corporation., Worcester, Massachusetts, 1984.
3. Numerical Control Systems, Bendix Industrial Control Division, DynaPath Systems Inc., Detroit, Michigan, 1983.
4. OSHA Safety Standards, U.S. Department of Labor, Washington, D.C., 1984.
5. Machine operator manual.
6. Checklist - Safety performance.
7. Worksheet - Safety equipment.

TEACHING ACTIVITIES:

1. Read and interpret safety section in operator manual. (*5)
2. Present lecture on safety regulations, equipment/ devices, and procedures.(*1,2,3,4 & 5)
3. Instruct students to complete a Safety Equipment Identification Worksheet.(*8)
4. Assign students to write three questions they wish answered concerning safety regulations, equipment/ devices, and procedures.
5. Conduct class discussion on safety regulations, equipment/devices, and procedures.
6. Instruct students to complete a worksheet identifing safety guards, shields, and other protective devices on the machine. (*5&7)
7. Instruct students to complete a machine tool safety setup, using the Safety Performance Checklist as an evaluation guide. (*5 & 6)

CRITERION-REFERENCED MEASURE:

The student will assemble and use all required safety equipment and check and secure all safety guards, shields, and other protective devices on the machine. The student will also insure that the machine and work area meet OHSA safety standards before machine operation. All items on the Safety Performace Checklist must be approved by the instructor.

PERFORMANCE GUIDE:

1. Place safety guards, shields, barriers, covers, and protective devices on machine.
2. Set up workpiece with clearance standards from cutting tool.
3. Stop spindle and slide when measuring workpiece.
4. Retract workpiece a safe distance from cutting tool when loading and unloading.
5. Remove chips and grit with a chip rake or brush (not your hands).
6. Clear machine tools and table edge out of path of moving units
7. Operate machine control panel without reaching over or though machine.
8. Listen for excessive vibration or unusual sounds from machine.
9. Turn master disconnect to OFF position before cleaning machine.
10. Shut off power whenever leaving machine area(if required).

    NOTE: Wear safety glasses and shoes.

STUDENT WORKSHEET

Student Name ________________ ___________

SAFETY EQUIPMENT WORKSHEET

Complete the worksheet by filling in the safety equipment needed to protect you from each safety hazard listed.

SAFETY HAZARD	SAFETY EQUIPMENT
1. Sharp edges.	____________________
2. Exposed moving parts	____________________
3. Build-up of grit & chips	____________________
4. Flying metal chips	____________________
5. Oil or grease build-up	____________________
6. Objects falling on floor	____________________
7. Excessive noise	____________________
8. Objects falling from above	____________________
9. Horse play	____________________
10. Dangerous areas	____________________

STUDENT WORKSHEET ANSWERS

SAFETY EQUIPMENT

1. Gloves
2. Guards, shields, covers, ect.
3. Chip rake or brush
4. Safety glasses or face shield
5. Degreasing agent
6. Safety shoes
7. Ear plugs
8. Hard hat
9. Common sense
10. Safety zones and signs

CHECKLIST

DUTY Setting Up.

TASK Complete machine tool safety setup.

ENABLER Assemble and use all needed safety equipment.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED __________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the student while completing machine tool safety setup.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Utilized all the safety devices.	____	____
- Noted any missing devices.	____	____
- Set up the workpiece with clearance.	____	____
- Stopped the machine for measurement.	____	____
- Provided clearance when loading/unloading.	____	____
- Used the chip removal tool.	____	____
- Cleared tools away from all moving parts.	____	____
- Operated the control without reaching through.	____	____
- Watched for abnormalities.	____	____
- Disconnected the master before cleaning.	____	____
- Powered down the machine before leaving.	____	____
- Wore safety clothes and glasses.	____	____

TEST ADMINISTRATORS INFORMATION

DUTY SETTING UP

TASK Complete machine tool safety setup

ENABLER Identify and initiate safety conditions and procedures necessary for machine tool safety setup.

Test Environment/Station Set Up:

- Use a work environment with a cnc machine.
- Have a cnc machine with safety hazards available (have the safety hazards identified prior to testing).
- Have all necessary safety tools/equipment available but not assembled.
- Use checklist for evaluation purposes.

Supplies, Equipment and References needed before test:

- Workstation
- CNC Machine
- Safety Equipment
- Safety Tools, Guards, Shields, ect.
- Operator/Reference Manual (Safety Section)
- Performance Evaluation Checklist

Time allowed to perform test:

- 120% of flat time rate.
- Time spent gathering tools and equipment is not part of test time.
- Time spent reading directions is not part of test time.

Special Instructions for Administering the Test:

- Use the checklist to evaluate the student.
- Observe the student procedure thoughout the test.
- Verify the student has read the directions and gathered tools/equipment before starting to time them.
- Record starting time and completion time on checklist.
- Record total time on task, on checklist.
- Make sure all tools and equipment are in working order before administering test.
- Identify safety hazards prior to administering test.

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #54

TASK: Verify workpiece detail identification number.

STANDARD OF PERFORMANCE OF TASK:

Identification number on each detail must agree with identification number on blueprint.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Blueprint
Piece part detail
Revision sheet (if appropriate)

ENABLING OBJECTIVES:

1. Match part detail to blueprint.
2. Match detail identification number to blueprint.
3. Observe for error and if error is observed, be able to eliminate incorrect data.
4. Make correction on revision sheet.

*RESOURCES:

1. W.C. Brown. Blueprint Reading For Industry. Goodheart- Wilcox, South Holland, 1983.
2. Roger Bolz. Production Process: The Productivity Handbook, 5th Edition. Industrial Press Inc., New York, Ny, 1981.
3. Manufacturer's programming manual.
4. Manufacturer's operating manual.
5. Checklist - Identification numbeer.

TEACHING ACTIVITIES:

1. Present a lecture on the purpose of a workpiece identification number. (*1,2,3 & 4)
2. Discuss and demonstrate matching part detail numbers to master blueprint.

TEACHING ACTIVITIES: (cont.)

3. Discuss cross checking identification numbers on part detail with blueprint.
4. Identify all errors or differences and eliminate incorrect identification numbers.
5. Discuss reviewing revision sheet make up and disposition.
6. Demonstrate verifying workpiece identification numbers on all paper work, programs and piece part storage bins.
7. Assign student a workpiece blueprint, documentation, part program and a finished workpiece product.
8. Instruct student to verify the workpiece detail identification number.

CRITERION-REFERENCED MEASURE:

The student will identify the workpiece detail identification number and verify the number on all documentation, computer programs, and piece part storage bin.

PERFORMANCE GUIDE:

1. Match blueprint to job in-process.
2. Compare each piece part detail identification number with blueprint detail identification number and revision number.
3. Place workpiece identification number on all paper work, computer programs, and piece part storage bins.

CHECKLIST

DUTY Setting Up.

TASK Verify workpiece detail identification number.

ENABLER Match detail identification number to blueprint.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED __________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the student while matching identification numbers.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Select piece detail.	____	____
- Displayed confidence in the selection.	____	____
- Extracted the tool data from the piece detail.	____	____
- Made a comparison of the tool to the identification number.	____	____

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #55

TASK: Verify type of material of workpiece.

STANDARD OF PERFORMANCE OF TASK:

Type of material marked on each detail must agree with type of material shown on blueprint.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Blueprint
Piece part detail
Operator's set-up sheet

ENABLING OBJECTIVES:

1. Identify workpiece material composition prior to machine operation.
2. Identify stock material size to over/under size.

*RESOURCES:

1. W.C. Brown. <u>Blueprint Reading For Industry</u>. Goodheart-Wilcox, South Holland, 1983.
2. William Luggen. <u>Fundamentals of Numerical Control</u> Delmar Publishers, Inc., Albany, NY, 1984.
3. <u>Turning Handbook of High Efficiency Metal Cutting.</u> Carboloy System Department, Detroit, MI.
4. <u>Milling Handbook of High Efficiency Metal Cutting.</u> Carboloy system Department, Detroit, MI.
5. Manufacturer's programming manual.
6. Manufacturer's operating manual.
7. Material/tool cutting speed reference charts.

TEACHING ACTIVITIES:

1. Present a lecture on different types of workpiece materials. (*1,2,3,5,6 & 7)
2. Discuss comparing operator set-up sheet to part detail/blueprint for correct workpiece material data.

TEACHING ACTIVITIES: (cont.)

3. Discuss and demonstrate how to identify part row stock material and proper workpiece size (not over or under sized).
4. Demonstrate how to identify part material during wet run and verify with type listed on blueprint.
5. Discuss and demonstrate how to identify type of material notation and use it for a basis for determining cutting and feedrate speeds.
6. Assign student a workpiece blueprint or operators set-up sheet.
7. Instruct student to identify, locate and verify the type of material needed to machine the piece part.

CRITERION-REFERENCED MEASURE:

The student will identify the type and size of the workpiece material to be used and verify it against the workpiece material and size must meet all job specifications.

PERFORMANCE GUIDE:

1. Match blueprint to job in-process.
2. Compare type and size material of each detail with type of material shown on blueprint and/or operator's set-up sheet.
3. Verify type of material notation to be used as basis for determining cutting and feedrate speeds.

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #56

TASK: Establish tolerance requirement.

STANDARD OF PERFORMANCE OF TASK:

Piece part details must conform to tolerance as established on the blueprint.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Advanced Machine Technology.

CONDITIONS FOR PERFORMANCE OF TASK:

Gauge
Blueprint/part print
Set-up sheet/tooling sheet
Profilometer (when necessary)

NG OBJECTIVES:

1. Match blueprint/detail to job in progress.
2. Make adjustments for cutter compensation and tool length/offset.
3. Measure workpiece after machining process to verify tolerance established on the blueprint.
4. Verify maintenance of tolerance standards.

*RESOURCES:

1. William Luggen. Fundamentals of Numerical Control Delmar Publishers, Inc., Albany, NY , 1984.
2. Pusztai and Sava. Computer Numerical Control. Reston Publishing Co., Reston, VA , 1983.
3. James Childs. Numerical Control Part Program. Industrial Press Inc., New York, NY , 1973.
4. James childs. Principles of Numerical Control. Third Edition. Industrial Press Inc., New York, NY, 1982.
5. Thomas Olivio. Advanced Machine Technology. Brenton Publishers, Belmont, CA , 1982.
6. Checklist - Establish tolerance requirements.

TEACHING ACTIVITIES:

1. Present a lecture on procedures for establishing tolerance requirements. (*1,2,3,4,5,6,7 & 8)
2. Discuss matching a blueprint or part detail to job in progress workpiece.
3. Demonstrate how to adjust machining speed, feedrate, cutter compensation and tool length as necessary.
4. Discuss sharpening or changing cutter tool if conditions warrant.
5. Present lecture on stoping machine after each machine process and measure workpiece to insure maintenance of tolerance standards. (*1,2,3,4,5, 6,7 & 8)
6. Discuss and demonstrate taking workpiece measurements using a gauge or profilometer.
7. Assign student a blueprint or partprint and a partially machined workpiece.
8. Instruct student to establish if tolerance requirements are being met.

CRITERION-REFERENCED MEASURE:

The student will identify tolerance requirements listed on blueprint/partprint, and measure the machined workpiece with a gauge or profilometer to establish if tolerance requirements are being met according to job specifications.

PERFORMANCE GUIDE:

1. Match blueprint to job in-process.
2. Adjust on machine tool as needed for:
   a. Cutter compensation.
   b. Tool length compensation or tool offset (depending on machine tool used).
3. Measure workpiece after each machining process to verify maintenance of tolerance standards:
   a. With gauge.
   b. With profilometer (when necessary).
   NOTE: A profilometer is used only on surface characteristics (how smooth a surface can be) and measure in microinches.

CHECKLIST

DUTY Setting Up.

TASK Establish tolerance requirement.

ENABLER Verify maintenance of tolerance standard.

STUDENT'S NAME ____________ DATE ____________

EVALUATOR'S NAME ____________ COURSE ____________

TIME : STARTED ____________ COMPLETED ____________

TOTAL ____________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the student while verifying tolerance standards.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Matched the piece detail with the blueprint.	____	____
- Extracted the measurement data.	____	____
- Adjusted machine for cutter compensation.	____	____
- Measured the workpiece in progress.	____	____
- Maintained safety procedures.	____	____
- Verified the tolerances.	____	____

GUIDE SHEET

DUTY: Setting Up

PERFORMANCE OBJECTIVE #57

TASK: Thread electrical discharge machine (EDM).

STANDARD OF PERFORMANCE OF TASK:

Wire must feed through machine without interference or breakage.
NOTE: Eye protection must be worn when operating machines.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC wire electrical discharge machine (EDM)
Operator's manual for specific machine tool
Safety shoes
Safety glasses
Operator's set up sheet

ENABLING OBJECTIVES:

1. Determine size of wire from operators set up sheet.
2. Verify wire guides are correct size.
3. Feed wire through rollers and guides.
4. Check for malfunctions before use.

*RESOURCES:

1. Manufacturer's programming manual.
2. Manufacturer's operating manual.
3. Checklist - Thread EDM.

TEACHING ACTIVITIES:

1. Present lecture on the purpose of an EDM. (*1,2)
2. Discuss and demonstrate locating required wire size from operators work sheets.
3. Demonstrate how to load the wire through the guides and rollers.
4. Discuss identifing improper feed and how to correct it.

TEACHING ACTIVITIES: (cont.)

5. Discuss returning all changed parts to proper storage areas.
6. Assign the student an EDM and instruct him to change the wire to the size indicated on operator's set-up sheet.

CRITERION-REFERENCED MEASURE:

The student will identify the size wire needed, change the machine guides and rollers as needed and thread the wire through the electrical discharge machine without interference or breakage. The student will wear eye protection at all times when operating the electrical discharge machine.

PERFORMANCE GUIDE:

1. Determine size of wire from operator's set-up sheet.
2. Change wire guides when wire to be used is a different size than the guides on the machine.
3. Feed wire through machine rollers and guides as specified in machine operator's manual.

CHECKLIST

DUTY Setting Up.

TASK Thread electrical discharge machine (EDM).

ENABLER Feed wire through rollers and guide.

STUDENT'S NAME ______________ DATE ______

EVALUATOR'S NAME ______________ COURSE ______

TIME : STARTED ______ COMPLETED ______

TOTAL ______

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the student while threading the EDM.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Selected the wire size and feed through.	____	____
- Changed the guides.	____	____
- Placed the wire through the guides.	____	____
- Set the wire in the feed rollers.	____	____
- Set the wire free of tangles.	____	____
- Followed the operations manual.	____	____
- Followed the safety rules.	____	____
- Wore safety clothes.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #58

TASK: Turn on power.

STANDARD OF PERFORMANCE OF TASK:

Machine control unit lights or indicators must respond when switch is ON.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Numerical Control Machining Series.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tool
Control

ENABLING OBJECTIVE:

1. Locate the main disconnect or power switch on a machine tool, and turn on the power.
2. Inspect table, quill, and tool drum position for possible collision.

*RESOURCES:

1. Machine tool manufacturer operator's manual.
2. Checklist - Power up.

TEACHING ACTIVITIES:

1. Read and discuss operator's manual. (*1)
2. Lecture students about input voltage, current, and phase requirements for machine tools. (*1)
3. Discuss safe power up procedures.
4. Demonstrate power up by locating disconnect, and turning on power. (*2)
5. Instruct students to turn on (power up) a machine tool. (*3)

CRITERION-REFERENCED MEASURE:

The student will demonstrate his ability to locate the power switch on the machine tool. The student will analyze safety implications of the power up procedure, and turn on a machine tool.

PERFORMANCE GUIDE:

1. Locate master control switch on control or machine panel.
2. Position control switch to ON.
3. Jog machine tool in all directions to make sure that all slides move freely.
4. Check the operation of the coolant pump by activating the coolant controls.
5. Observe control panel for start positions shown on display.

CHECKLIST

DUTY Operating Machine.

TASK Turn on power.

ENABLER Locate the main disconnect or power switch on a machine tool and turn on the power.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the "Power up".

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Consulted the operator manual prior to turning on the power.	____	____
- Took all safety precautions prior to turning on the power.	____	____
- Inspected the table, quill and tool drum position for possible collision prior to turning on the power.	____	____
- Located and identified all power switches, and emergency stop switches.	____	____
- Observed control panel for start position.	____	____
- Successfully turned on machine tool.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #59

TASK: Call up program in distributed numerical control.

STANDARD OF PERFORMANCE OF TASK:

When cycle start is activated, program must be available in machine memory to produce workpiece.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Principles of Numerical Control.
1985 NC/CAM Guidebook.

CONDITIONS FOR PERFORMANCE OF TASK:

Software
Data communications system
Format classification sheet
Mainframe computer or access to mainframe
Group of numerically controlled machines

ENABLING OBJECTIVE:

1. Identify the name or code number of the desired program.
2. Configure the machine controller to accept program from host computer.
3. Call up and verify a program from the host computer.

*RESOURCES:

1. Machine tool manufacturer operator's manual.
2. Host computer manufacturer's operating manual.
3. Modern Machine Shop. 1985 NC/CAM Guide Book. Cincinnati, OH. Gardner Publications. 1985.
4. James Childs. Principles of Numerical Control. Third Edition. Industrial Press, Inc., New York, NY. 1982
5. Block diagram of DNC in various configurations (bus, star, ring).
6. Checklist - DNC program call and verify.

TEACHING ACTIVITIES:

1. Read and interpret host computer and machine tool manufacturer's manuals. (*1 & 2)
2. Discuss DNC concept and benefits. (*1,2,3, & 4)
3. Describe industrial LAN's and computer protocol's. (*1,2,3, & 4)
4. Demonstrate configuring machine control to accept host program. (*5)
5. Assign each student a program to be selected form the host directory.
6. Instruct students to download and verify a program. (*6)

CRITERION-REFERENCED MEASURE:

The student will demonstrate his ability to identify, call, load and verify a DNC program. The sutdent will evaluate the DNC process as it is applied to various machining situations.

PERFORMANCE GUIDE:

1. Turn on computer.
2. Enter code name or number for entering software system.
3. Call up directory of programs available.
4. Observe CRT screen for programs available.
5. Check machine tool operator's manual, and computer systems format classification sheet for specialized systems instructions.
6. Enter program (name or number) needed.
7. Check program in computer:
   a. Check for condition of program.
   b. Contact CNC programmer if program not available.
8. Prepare machine tool to receive CNC data. (See manufacturer's operating manual for specific instructions.)
9. Download data from microcomputer to machine control unit.

CHECKLIST

DUTY Operating Machine.

TASK Call up program in distributed numerical control.

ENABLER Call up and verify program from host computer.

STUDENT'S NAME ____________ DATE ________

EVALUATOR'S NAME ____________ COURSE ________

TIME : STARTED ________ COMPLETED ____________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the performance determinants checklist to evaluate the call up, and verification of the program from the host computer.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Consulted host computer and machine tool manufacturers' manuals for proper procedures.	____	____
- Turned on the computer.	____	____
- Identified and called up the assigned DNC program from the directory.	____	____
- Checked the operators' manual and computer systems format classification sheets for specialized system instructions.	____	____
- Loaded the assigned DNC program.	____	____
- Verified loaded DNC program.	____	____
- Prepared machine tool to receive CNC data.	____	____
- Downloaded data from microcomputer to machine control unit.	____	____
- Successfully loaded the DNC program.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #60

TASK: Place tape in reader.

STANDARD OF PERFORMANCE OF TASK:

Tape must feed through read head rollers or sprocket tooth feeder without interruption, tearing, kinking, or binding.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Numerical Control Machining Series.

CONDITIONS FOR PERFORMANCE OF TASK:

Paper tape or Mylar tape
Tape reader
Computer program
Manufacturer's operating manual

ENABLING OBJECTIVE:

1. Understand CNC punched tape format and identify the leading edge of the punched tape.
2. Locate the tape reader head and load CNC punched tape.
3. Operate the load switch.

*RESOURCES:

1. Machine tool manufacturer's operator's manual.
2. William Luggen. <u>Fundamental of Numerical Control.</u> Delmar Publishers, Inc., Albany, NY. 1984.
3. James Childs. <u>Principles of Numerical Control, Third Edition.</u> Industrial Press, Inc., New York, NY. 1982.
4. James Childs. <u>Numerical Control Part Programming.</u> Industrial Press, Inc., New York, NY. 1973.
5. Checklist - Load CNC punched tape.
6. Visual aids - CNC tape format and typical CNC tape reader.

TEACHING ACTIVITIES:

1. Read and interpret the operator's manual. (*1)

TEACHING ACTIVITIES: (cont.)

2. Present lecture on punched tape format and loading procedures. (*2,3,4 & 6)
3. Conduct class discussion on punched tape format, and loading procedures.
4. Demonstrate the tape loading procedure.
5. Assign students dry run opportunities to load tape.
6. Instruct student to complete tape format worksheet. (*7)
7. Instruct the student to clear the machine registers, and select the setup mode. (*5)
8. Instruct student to load a tape in the reader. (*5)

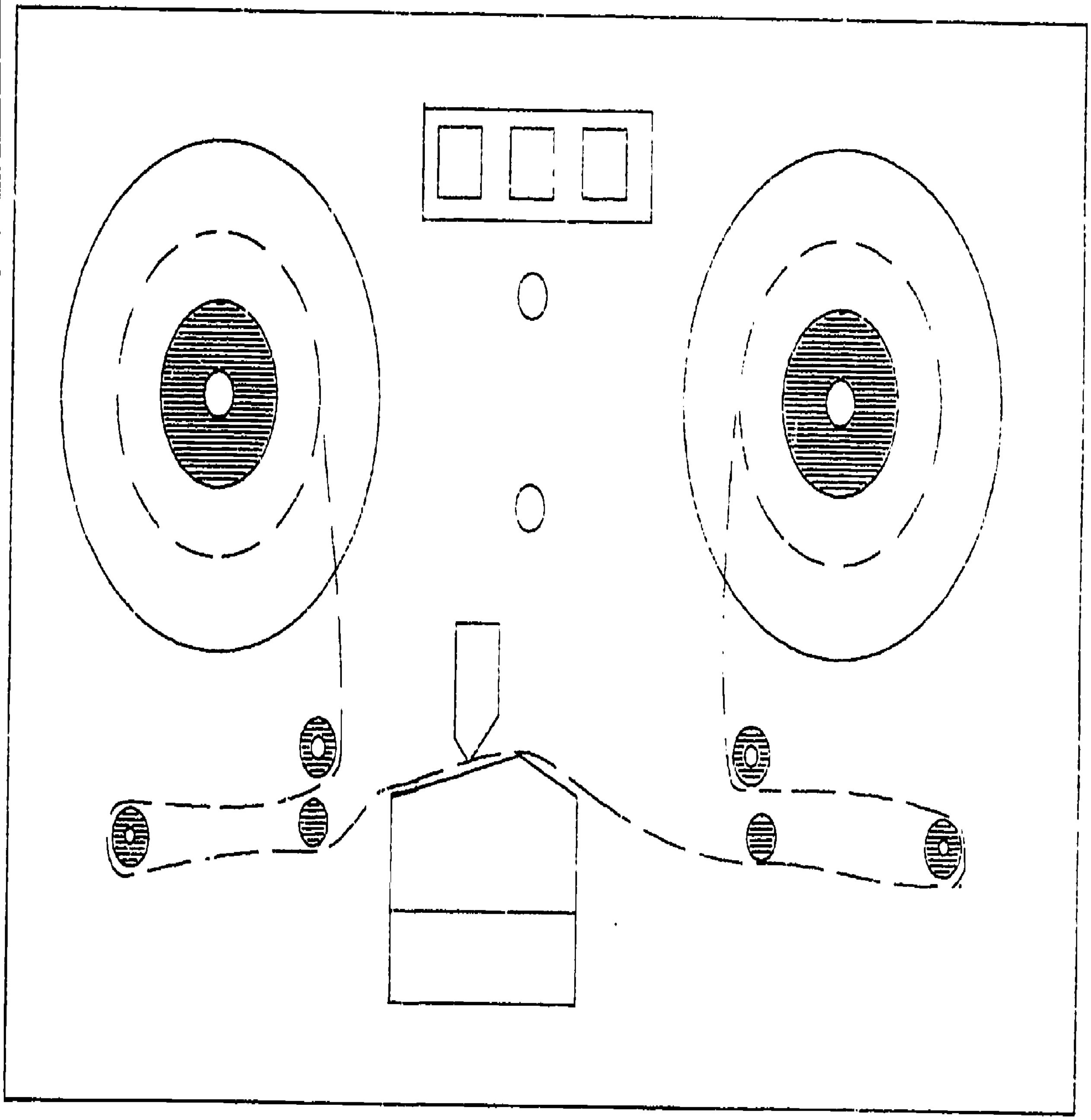
CRITERION-REFERENCED MEASURE:

The student will be able to identify the tape leader, and data portion of the tape. The student will demonstrate understanding of the tape loading procedure by successfully loading a CNC tape into a tape reader.

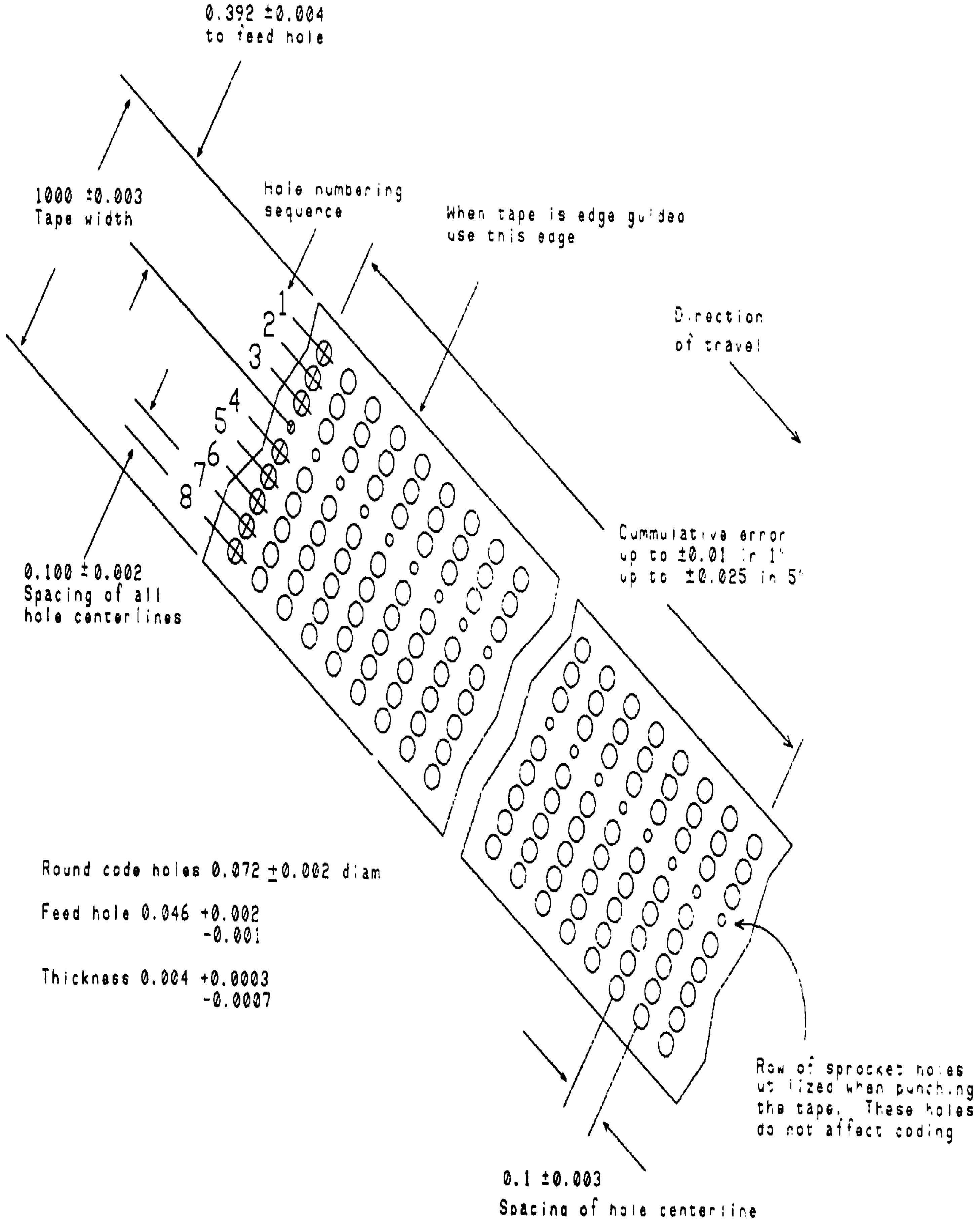
PERFORMANCE GUIDE:

1. Check operating manual before loading tape into system.
2. Set tape load switch to OFF.
3. Place tape on reels (or on spools, or between reading head and cover).
4. Place tape in reader.
5. Check alignment.
6. Align tape in guide rollers.
7. Engage tape with spindle drive pins and clamps.
8. Press tape load switch to take up tape slack.
   NOTE: If paper/tape has been wound too tightly to load correctly, rewind tape before attempting to load into machine.

LOADING TAPE IN READER - SPOOL TYPE



CNC TAPE FORMAT



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CHECKLIST

DUTY Operating Machine.

TASK Place tape in reader.

ENABLER Locate the tape reader head and load the CNC punched tape.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED __________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate loading CNC tape into tape reader.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Consulted the operator's manual for proper loading procedure.	____	____
- Checked the tape load switch to insure that it was in the off position.	____	____
- Identified the tape leader portion of the CNC tape identified.	____	____
- Checked tape for oil or dirt which could cause a read error.	____	____
- Placed the tape supply reel on the supply spindle.	____	____
- Threaded the tape though the read head.	____	____
- Attached tape to the take-up reel.	____	____
- Engaged and clamed the supply and take-up reel to the spindle drive pins.	____	____
- Removed slack in tape	____	____
- Completed loading procedure without damage to tape.	____	____

TEST ADMINISTRATORS' INFORMATION

DUTY Operating machine.

TASK Place tape in reader.

ENABLER Load CNC punched tape.

Test Environment/Station Set Up:

- Workbench with AC power.
- CNC tape reader.
- CNC punched tape.

Supplies, Equipment, and References needed before test:

- Operator's manual.
- Supply spools.
- Take-up spools.
- Punched tape.
- Tape splicer.
- Tool kit.

Time allowed tc perform test:

- Manufacturer's standard rate times 150%.
- Time spent gathering materials is not part of the test.

Special Instructions for Administering the test:

- Have pre-punched CNC tape available.
- Have student gather all necessary materials before starting time.
- Use checklist for student performance evaluation.

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #61

TASK: Key-in program on machine.

STANDARD OF PERFORMANCE OF TASK:

When operator calls up program by program name, CRT screen must indicate verification of program.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tool
Calculator
Control
Part print
Mylar/paper tape
Manufacturer's operating manual

ENABLING OBJECTIVE:

1. Select the proper machine operating mode.
2. Identify key pad and display screen.
3. Determine required codes per part print.
4. Key in (load) a prepared program into machine tool memory.

*RESOURCES:

1. G, M, and S Code Definition Sheet (operator's manual).
2. EIA RS-274D Word Address Standard (operator's manual).
3. Machine tool manufacturer's operators manual.
4. Checklist - Keying-in program

TEACHING ACTIVITIES:

1. Read and interpret operator's manual. (*4)
2. Discuss standard G, M, and S codes. (*1)
3. Demonstrate machine setup for MDI. (*3)
4. Assign part prints to be programmed using the word address format. (*2 & 5)

TEACHING ACTIVITIES: (cont.)

5. Instruct student to key-in (load) a prepared program into the machine tool memory. (*5)

CRITERION-REFERENCED MEASURE:

The student will program, using standard word address format, the tool path from a part print. The student will enter program into the memory of the machine tool via MDI.

PERFORMANCE GUIDE:

To create program at the control:

1. Refer to part print specifications.
2. Assign program number.
3. Write manual program for machining sequence (if desired).
4. Enter all information (See manufacturer's operating manual for specific machine tool.)
5. Edit program for errors.
6. Run program.
7. Download and store data:
   a. Disk.
   b. Tape.
   c. Cassette.

To Key-in (load) prepared program:

1. Identify tape by tape number.
2. Load program into machine.
3. Run program:
   a. Off memory.
   b. Off tape.
4. Remove prepared tape for storage.

CHECKLIST

DUTY Operating Machine.

TASK Key in program on machine.

ENABLER Key-in (load) a prepared program into machine tool memory.

STUDENT'S NAME ______________ DATE ______

EVALUATOR'S NAME ______________ COURSE ______

TIME : STARTED ________ COMPLETED ____________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate keying in program on machine.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Refered to part print specifications.	____	____
- Identified tape and located a tape by tape number.	____	____
- Loaded program into the machine tool memory.	____	____
- Ran program from memory.	____	____
- Removed and stored proper tape from machine.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #62

TASK: Align holding device with machine axis.

STANDARD OF PERFORMANCE OF TASK:

When dial indicator needle exhibits no movement, fixture must be square and parallel to appropriate axes.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Fixture
Tool holder
Dial indicator set
CNC machine tool

ENABLING OBJECTIVE:

1. Zero the dial indicator on the fixture.
2. Move the X, and Y or Z slide of the machine tool.
3. Attach and align work-holding device to machine tool.

*RESOURCES:

1. Machine Tool Manufacturers' Operators' Manual.
2. S. F. Krar. Technology of Machine Tools. Greg Division/McGraw Hill Book Co. New York, NY. 1984.
3. James Childs. Numerical Control Part Programming. Industrial Press, Inc., New York NY. 1973.
4. Checklist - Aligning holding device with machine axis.

TEACHING ACTIVITIES:

1. Present lecture on machine axis alignment.
2. Discuss the proper use of the dial indicator.
3. Describe placing the machine tool in JOG mode.
4. Demonstrate alignment procedures.
5. Assign students to align work-holding devices on traditional machine tools.

CRITERION-REFERENCED MEASURE:

The student will attach and align a work-holding device to the machine tool.

PERFORMANCE GUIDE:

1. Place work-holding device on table.
2. Align edge of work-holding device with machine axis.
3. Snug work-holding device down to table.
4. Place dial indicator in tool holder, collet, or arbor.
5. Place tool holder in spindle. (Does not apply when using magnetic base holder).
6. Place and position dial indicator contact point on edge of work-holding device in appropriate axis.
7. Move table the length of the work-holding device in appropriate axis.
8. Watch indicator dial needle for movement.
9. Adjust work-holding device until dial indicator needle remains constant.
10. Tighten work-holding device to table.
11. Place dial indicator contact point on edge of work-holding device.
12. Move table the length of the work-holding device in appropriate axis.
13. Watch indicator dial needle for movement.
14. Repeat steps 8-13 until dial ndicator exhibits no movement.

    NOTE: Overtightening of work-holding device will cause distortion to workpiece.

CHECKLIST

DUTY Operating Machine.

TASK Align holding device with machine axis.

ENABLER Attach and align a work-holding device to the machine tool.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the follow checklist to evaluate aligning holding device with machine axis.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Placed work-holding device on machine table.	____	____
- Aligned the edge of the work-holding device with the machine axis.	____	____
- Made the work-holding device snug to the table.	____	____
- Placed the dial indicator in the tool holder collet or arbor.	____	____
- Placed the tool holder in spindle.	____	____
- Positioned dial indicator contact point on edge of work-holding device in appropriate axis.	____	____
- Moved the table to the length of the workholding device.	____	____
- Adjusted the work-holding device until dial indicator needle remained constant.	____	____
- Tightened the work-holding device to the table.	____	____

PERFORMANCE DETERMINANTS: (cont.)

	YES	NO
- Followed all steps for each appropriate axis.	____	____
- Checked the work-holding device for overtighting.	____	____
- Made the work-holding device square and parallel to appropriate axis.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #63

TASK: Clamp dial indicator to tool holder.

STANDARD OF PERFORMANCE OF TASK:

Dial indicator must remain attached while in use.

NOTE: Dial indicator is a very precise measuring instrument, and caution should be used in handling.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine
Spindle chucks
Dial indicator set
Tool holder (collet, arbor, magnetic base)

ENABLING OBJECTIVE:

1. Locate dial indicator and magnetic base as needed.
2. Select proper mounting accessory.
3. Position mounting accessory in proper location.
4. Clamp dial indicator to a machine tool.

*RESOURCES:

1. S. Krar & J. Oswald. Technology of Machine Tools. Gregg Division, McGraw Hill Book Co., New York, NY, 1984.
2. Manufacturer's operator manual.
3. Checklist - Clamp dial indicator.

TEACHING ACTIVITIES:

1. Read and discu procedures for cleaning, inserting, and positioning mounting accessories, or tool holders. (*1 & 2)
2. Demonstrate mounting dial indicator on traditional machine tools.

TEACHING ACTIVITIES: (cont.)

3. Demonstrate clamping dial indicator to CNC machine tool.
4. Discuss machine introduced tolerance errors. (*2)
5. Instruct student to clamp a dial indicator device to a CNC machine tool. (*3)

CRITERION-REFERENCED MEASURE:

The student will demonstrate his mastery of mounting indicating devices by clamping a dial indicator to a CNC machine tool.

PERFORMANCE GUIDE:

1. Secure mounting devices (swivels, cam locks, dove tail locks, etc.) for dial indicators.
2. Mount dial indicator into chuck, arbor, collet, or magnetic base holder.
3. Tighten chuck, collet, arbor, or magnetic base holder.

CHECKLIST

DUTY Operating Machine.

TASK Clamp dial indicator to tool holder.

ENABLER Clamp dial indicator to a machine tool.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate clamping dial indicator to tool holder

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Selected a dial indicator and magnetic base.	____	____
- Selected proper mounting accessories.	____	____
- Positioned and secured mounting device to machine tool.	____	____
- Secured dial indicator in mounting base.	____	____
- Tightened down mounting device.	____	____
- Used caution in handling dial indicator.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #64

TASK: Change tool holder.

STANDARD OF PERFORMANCE OF TASK:

Installed tool holder must remain in spindle.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Wrenches
Tool holder
CNC machine
Manufacturer's operating manual

ENABLING OBJECTIVE:

1. Locate required hand tools.
2. Lock all necessary brakes.
3. Remove and remount a tool holder.

*RESOURCES:

1. Manufacturers' operating manual.
2. Checklist - Change tool holder.

TEACHING ACTIVITIES:

1. Read and discuss the tool change procedure described in the operator's manual.
2. Demonstrate tool change procedure.
3. Discuss considerations for proper cleaning of tool holder surfaces. (*1)
4. Instruct student to remove, clean, select, and mount a tool holder. (*2)

CRITERION-REFERENCED MEASURE:

The student will correctly remove, clean, select, and mount a tool holder on a CNC machine tool.

PERFORMANCE GUIDE:

Manually:

1. Engage spindle brake (if necessary).
2. Place wrench on spindle locking collar.
3. Loosen lock collar while holding wrench firmly.
4. Remove tool holder from spindle and place into tray.
5. Place new tool holder in spindle.
6. Tighten lock collar.
7. Release spindle brake (if necessary).

Automatically:

1. Follow manufacturer's operating manual to disengage tool holder automatically.
2. Check new holder and spindle for:
   a. Clearness.
   b. Chips.
3. Load tool holder according to manufacturer's operating manual.

CHECKLIST

DUTY Operating Machine.

TASK Change tool holder.

ENABLER Remove and remount a tool holder.

STUDENT'S NAME ______________ DATE ______

EVALUATOR'S NAME ______________ COURSE ______

TIME : STARTED ______ COMPLETED ______

TOTAL ______

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the changing of a tool holder.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Collected the necessary tools and equipment.	____	____
- Engaged the spindle brake.	____	____
- Used the correct wrench to loosen the spindle locking collar.	____	____
- Removed tool holder from spindle, and placed into tray.	____	____
- Cleaned all dirt, chips, oil and foreign residue from holder and spindle.	____	____
- Placed a new tool holder placed in spindle.	____	____
- Tightened the lock collar.	____	____
- Cleared work area of tools and equipment before releasing spindle brake.	____	____
- Released spindle brake.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #65

TASK: Change cutting tool.

STANDARD OF PERFORMANCE OF TASK:

Cutting tool must be removed and replace with a desired cutting tool. Cutting tool must be securely seated in tool holder.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Wrench
Tool holder
CNC machine
Sharp cutting tools
Manufacturer's tooling manual

ENABLING OBJECTIVE:

1. Visually inspect cutting tool mounted on tool.
2. Select and install desired cutting tool.

*RESOURCES:

1. Manufacturer's operating manual.
2. William Luggen. Fundamentals of Numerical Control. Delmar Publishers, Inc., Albany, NY, 1984.
3. James Childs. Numerical Control Part Programming. Industrial Press, Inc., New York, NY, 1973.
4. Checklist - Change cutting tool.

TEACHING ACTIVITIES:

1. Read and discuss procedures for changing cutting tool. (*1)
2. Discuss tool wear modes.
3. Lecture and discuss tool materials, and tool geometrics. (*2 & 3)
4. Demonstrate tool changing techniques on CNC machine tool.
5. Instruct student to select, and install a new cutting tool. (*4)

CRITERION-REFERENCED MEASURE:

The student will be able to remove, replace, and seat a cutting tools.

PERFORMANCE GUIDE:

When removing holder and cutting tool as one unit:

1. Remove tool holder from machine.
2. Remove cutting tool from tool holder.
3. Clean and insert new cutting tool.
4. Install tool holder with cutting tool in machine. (See manufacturer's tooling manual for specific instructions.)
   NOTE: Preset tools must be set to correct tool height.

When removing cutting tool from holder (using indexable inserts of a qualified tool):

1. Leave holder in machine.
2. Disengage cutting tool from holder. (See manufacturer's tooling manual for specific instructions.)
3. Clean tool holder before inserting.
4. Insert new cutting tool using manufacturer's tooling manual.
   NOTE: Overtightening holder will result in breaking insert or stripping out screw

CHECKLIST

DUTY Operating Machine.

TASK Change cutting tool.

ENABLER Select and install desired cutting tool.

STUDENT'S NAME ____________ DATE ______

EVALUATOR'S NAME ____________ COURSE ______

TIME : STARTED ______ COMPLETED ______

TOTAL ______

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the changing of cutting tool.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Selected desired cutting tool.	____	____
- Engaged spindle brake.	____	____
- Removed cutting tool from tool holder.	____	____
- Cleaned tool holder of all chips, dirt, lubricant, and foreign residue.	____	____
- Cleaned the removed cutting tool of all chips, dirt, lubricant, and foreign residue, before returning to tray.	____	____
- Inserted the desired cutting tool into tool holder.	____	____
- Determined and set cutting tool height.	____	____
- Securely seated cutting tool in tool holder.	____	____
- Removed and replaced cutting tool without damaging tool or equipment.	____	____

GUIDE SHEET

DUTY: Operating Machine.

PERFORMANCE OBJECTIVE #66

TASK: Adjust tool offset manually

STANDARD OF PERFORMANCE OF TASK:

The offset adjustment must move cutting tool amount needed to compensate for tool wear, finish cuts, and tool usage. Measurement of finished piece part must meet standards set by blueprint.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Numerical Control for Two Axis Lathes.

CONDITIONS FOR PERFORMANCE OF TASK:

Fixtures
Safety glasses
CNC machine
Tool holders
Tool offset table
Cutting tools
Measuring instruments
Piece part specifications
Cutting tool sequence numbers

ENABLING OBJECTIVE:

1. Evaluate set-up dimension and finish dimensions.
2. Identify tolerance specification.
3. Call up and enter tool offset information into tool schedules.

*RESOURCES:

1. Manufacturer's operating manual.
2. Joseph Pusztai and Michael Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA, 1983.
3. Dynapath System 10T Computer. Numerical Control for Two Axis Lathes. Dynapath Systems, Detroit, MI, 1984.
4. Checklist - Manual offset.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual. (*1)
2. Fill out tool setting data sheets.
3. Practice calling tool schedules at the operators' terminal, and inserting TLO data.
4. Demonstrate measurement of offset using a mechanical height gauge. (*1 & 2)
5. Instruct student to identify tolerance specifications, and manually adjust a tool offset. (*4)

CRITERION-REFERENCED MEASURE:

The student will fill out a tool length offset data sheet by measuring five tools, and will adjust tool offset within prescribed tolerance values.

PERFORMANCE GUIDE:

1. Measure workpiece.
2. Determine dimensional deviation from blueprint specifications.
3. Determine cutting tool responsible for inaccuracy.
4. Identify tool offset number for cutting tool.
5. Enter amount of tool offset (in either diameter or radius) into tool tables.

CHECKLIST

DUTY Operating Machine.

TASK Adjust tool offset manually.

ENABLER Call-up and enter tool offset information into tool schedules.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED ______________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the manual adjustment of tool offset.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Measured workpiece.	____	____
- Identified tolerance specifications.	____	____
- Determined dimensional deviations from blueprint specifications.	____	____
- Identified cutting tool responsible for inaccuracy.	____	____
- Identified cutting tool offset number.	____	____
- Entered the amount of tool offset into tool tables.	____	____
- Made offset adjustments to adequately compensate for tool wear, finish cuts, and tool usage.	____	____
- Measured the finished work piece.	____	____
- Evaluated the measurement of the finished workpiece as to meet the blueprint standard.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #67

TASK: Interpret operator related messages on screen.

STANDARD OF PERFORMANCE OF TASK:

The execution of operator advisory message on display screen must result in defined procedures for maintaining programmed machining operations, and acceptable quality workpiece as specified on blueprint.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Numerical Control for Two Axis Lathes.
Producer CNC/MC Operator's Guide for Machining Center.
Producer CNC/AF User's Guide for Angle Fabricating Systems.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine
Basic machining skills
Processor language
CRT screen or visual display
Operator's manual for machine tool system
Format of machine computer system commands

ENABLING OBJECTIVE:

1. React to message by performing the desired operator-intervention task as specified by the message code, and program instructions.
2. React to message by immediately modifying the machining conditions using manual data input and/or system override controls.
3. React to message by monitoring machining conditions, and modifying when program allows.

*RESOURCES:

1. Standard G- and M-code definition sheets.
2. Electronics Industry Association Recommended Standards #441 and #447, Operator Interface Functions of Numerical Control (RS-441) Operational Command and Data Format for Numerically Controlled Machines (RS-447), Washington D.C.

3. Machine-Tool manufacturer's operating manuals.
4. Visual aids - Utilizing mock control panels..
5. Checklist - Interpret operator related messages.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual to understand typical message displays. (*3)
2. Present lecture on G- and M-code messages and typical control panel displays. (*1,2,3, & 4)
3. Conduct class discussion on the various types of operating-intervention tasks initiated by programmed operator messages.
4. Conduct class discussion on remedial activities to be performed by maintenance and programming personnel, when messages relate to excessive machine tool operating conditions.
5. Conduct on-machine demonstration of typical operator response to message displays. (*1,2,3, & 4)
6. Instruct students to preview each program; identify programmed and optional stop codes; and identify the tasks associated with codes. (*5)
7. Assign student hands-on operating activities that simulate conditions surrounding message displays.

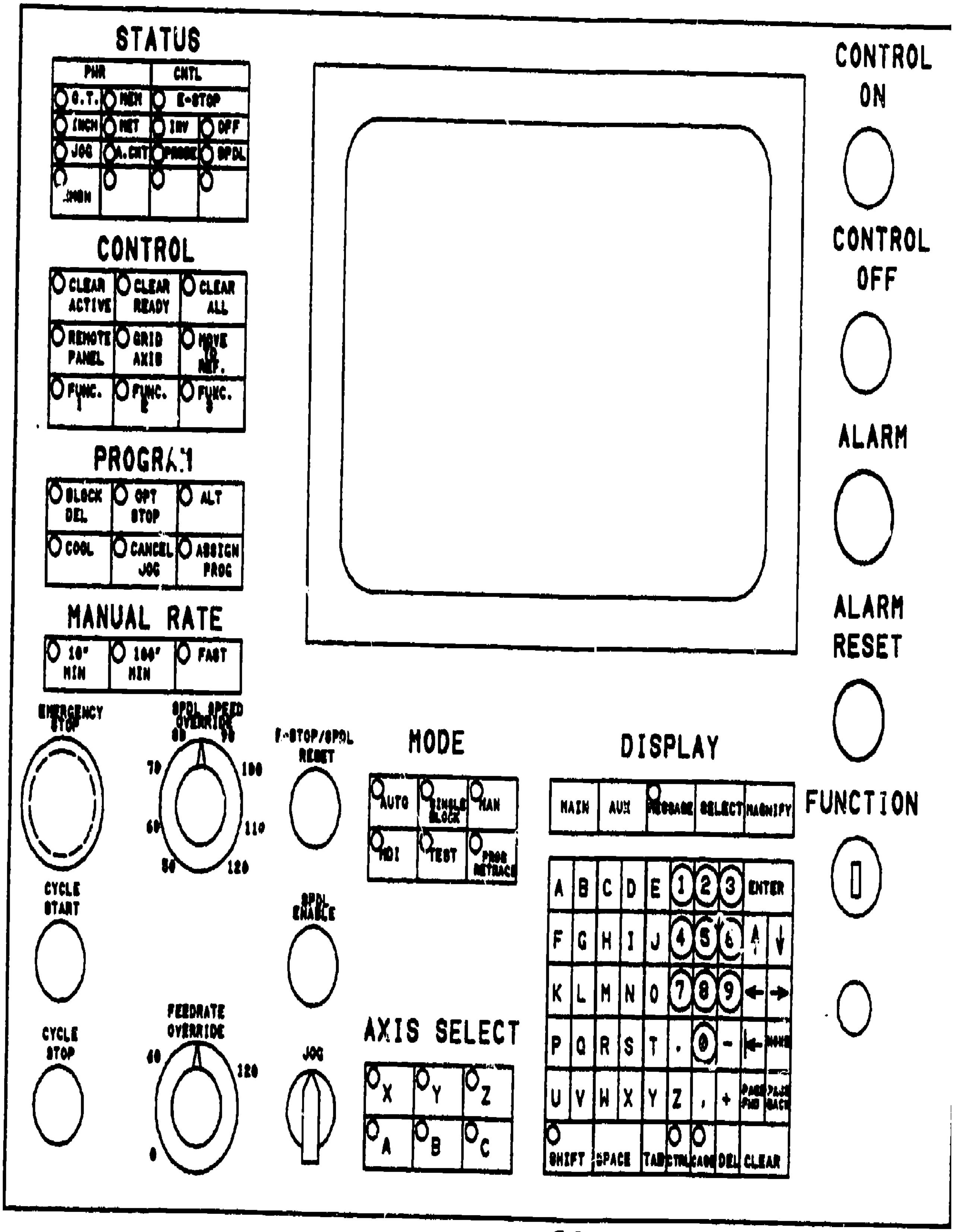
CRITERION-REFERENCED MEASURE:

The student will demonstrate knowledge of message codes and operator intervention tasks, by written and/or verbal examination. The student will demonstrate ability to interpret message displays in actual hands-on operating conditions to the satisfaction of the instructor.

PERFORMANCE GUIDE:

1. View CRT screen during program dry run.
2. Observe operator messages in specific sequence of operations.
3. Follow procedures outlined by machine manual and/or programmer guide for executing commands when message appears during production of piece part.

TYPICAL CONTROL PANEL



CHECKLIST

DUTY Operating Machine.

TASK Interpret operator related messages on screen.

ENABLER Interpret and react to operator related messages on screen.

STUDENT'S NAME ____________ DATE ________

EVALUATOR'S NAME ____________ COURSE ________

TIME : STARTED ________ COMPLETED ____________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the interpretation of operator related messages on screen.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Consulted operator manual for operator messages and procedures for correcting them.	____	____
- Monitored screen during program dry run.	____	____
- Observed operator messages in specific sequence of operation.	____	____
- Interpreted and reacted to operator messages.	____	____
- Followed procedures outlined by machine operators' manual.	____	____
- Correctly interpreted and reacted to all operator messages.	____	____
- Adequately adjusted offset compensation for tool wear, finish cuts, and tool usage.	____	____
- Measured finished work piece.	____	____
- Compared the measurement of the finished workpiece to that of the blue print standard.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #68

TASK: Control spindle speed override.

STANDARD OF PERFORMANCE OF TASK:

Spindle speed must change to desired revolutions per minute.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine
Manufacturer's machine tool operator manual

ENABLING OBJECTIVE:

1. Increase or decrease the programmed speed rate by utilizing the spindle speed override control to maintain optimum safety conditions, and maximize tool life.

*RESOURCES:

1. Machine tool manufacturer's operator manual.
2. Tool and Manufacturing Engineers Handbook. Society of Manufacturing Engineers, Dearborn, MI, 1981.
3. Methods in Metal Cutting. Society of Manufacturing Engineers, Dearborn, MI, 1981.
4. Machining Data Handbook, Third Edition. Machinability Data Center, Metcut Research association, Cincinnati, OH.
5. Visual Aid - Utilizing mock control panel, see performance objective 67.
6. Checklist - Control spindle speed override.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual.

TEACHING ACTIVITIES: (cont.)

2. Conduct class discussions on various machining characteristics of typical materials, explaining the spindle speed calculation equation, and stressing tool life and economics.
3. Demonstrate the use of spindle speed override controls. (*2)
4. Demonstrate to the student where the speed rate command resides in the program text, and how to identify it. (*2)
5. Assign students problems calculating spindle speed for several typical engineering materials, using reference resources.
6. Assign students hands-on operating activities that simulate conditions requiring spindle speed adjustment.
7. Instruct students to machine a typical part manually, while deliberately increasing and decreasing the speed rate for visual and audible reinforcement of non-optimum machining conditions.

CRITERION-REFERENCED MEASURE:

The student will demonstrate his knowledge, and manipulation of the spindle speed equation by written and/or verbal examination. The student will demonstrate his ability to control the speed override in actual hands-on operating conditions to the satisfaction of the instructor.

PERFORMANCE GUIDE:

1. Set spindle revolutions per minute on control to position for decrease or increase.
2. Override program speed until desired speed is obtained. (See manufacturer's machine tool operator manual for specific control board variations.)
3. Observe control to verify spindle speed indicator setting.

CHECKLIST

DUTY Operating Machine.

TASK Control spindle speed override.

ENABLER Increase or decrease the programmed speed rate by utilizing the spindle speed override control to maintain optimum safety conditions and maximize tool life.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED ______________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the control spindle speed override.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Consulted the operator's manual before making the spindle speed change.	____	____
- Set spindle speed on a per tool basis.	____	____
- Entered rpm values via the control panel.	____	____
- Set spindle revolutions per minute on control to position for increase or decrease.	____	____
- Completed override program speed until desired speed was obtained.	____	____
- Observed control to verify spindle speed indicator setting.	____	____
- Obtained and maintained desired spindle speed.	____	____
- Followed all safety precautions.	____	____
- Cancelled spindle speed override after the operation was complete.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #69

TASK: Control feedrate override.

STANDARD OF PERFORMANCE OF TASK:

Control must indicate feedrate override mode.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine
Control

ENABLING OBJECTIVE:

1. Increase or decrease the programmed feedrate by utilizing the feedrate override control.

*RESOURCES:

1. Machine tool manufacturer's operator manual.
2. Tool and Manufacturing Engineers Handbook. Society of Manufacturing Engineers, Dearborn, MI, 1981.
3. Methods in Metal Cutting. Society of Manufacturing Engineers, Dearborn, MI, 1981.
4. Machining Data Handbook, Third Edition. Machinability Data Center, Metcut Research Association, Cincinnati, OH.
5. Visual Aid - Utilizing mock control panel, see performance objective 67.
6. Checklist - Feedrate override.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual. (*1)
2. Conduct class discussions on various machining characteristics of typical materials, explaining the feedrate calculations and stressing surface finish and tool life.
3. Demonstrate the use of feedrate override controls. (*2)

TEACHING ACTIVITIES: (cont.)

4. Demonstrate to the student where the feedrate command resides in the program text, and how to identify it.
5. Assign students problems calculating feedrate for several typical engineering materials using reference resources. (*3,4 & 5)
6. Assign students hands-on operating activities that simulate conditions requiring feedrate adjustments.
7. Instruct students to machine a typical part manually, while deliberately increasing and decreasing the feedrate for visual and audible reinforcement of non-optimum machining conditions. (*6)

CRITERION-REFERENCED MEASURE:

The student will demonstrate ability to control the feedrate override in actual hands-on operating conditions to the satisfaction of the instructor.

PERFORMANCE GUIDE:

1. Position feedrate override for each tooling operation needed.
2. Observe control to verify override feedrate.
3. Cancel feedrate override at completion of override operation (if necessary).

CHECKLIST

DUTY Operating Machine.

TASK Control feedrate override.

ENABLER Increase or decrease the programmed speedrate by utilizing the feedrate override control.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED __________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the control feedrate override.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Consulted the operator's manual for feedrate change.	____	____
- Identified and located the tool to be overridden.	____	____
- Verified tool number/location at the CRT.	____	____
- Positioned feedrate override for each tooling operation needed.	____	____
- Verified override feedrate.	____	____
- Cancelled feedrate override at completion of override operation.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #70

TASK: Activate automatic cycle mode.

STANDARD OF PERFORMANCE OF TASK:

Machine must run entire program or block-by-block execution of program without interruption or operation intervention.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Machining Centers Operator's Training Guide.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine
Control

ENABLING OBJECTIVE:

1. Determine that all set-up conditions are complete, including:
   Fixture attachment, part installed correctly in fixture, program loaded into memory, correct cutting tools preset and installed.

*RESOURCES:

1. Machine tool manufacturer's operator manual.
2. Pusztai and Sava. Complete Numerical Control. Reston Publishing Company, Inc., Reston, VA. 1983.
3. Visual aids - Utilizing mock control panels, see performance objective 67.
4. 2-D computer-driven plotter.
5. Checklist - Set-up model.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual. (*1)
2. Present lecture on all set-up conditions that must be checked before activating automatic mode. (*1 & 2)
3. Instruct students to create a set-up checklist for each machine they are to operate.

TEACHING ACTIVITIES: (cont.)

4. Demonstrate checking set-up of all operator-related equipment.
5. Demonstrate plotter usage to verify tool-path motion. (*3)
6. Instruct students to review a typical coded program and reconcile it with a cutter-path plot that they have made of the program.
7. Instruct students to complete hands-on operating activities leading to, and including activation of automatic mode. (*7)

CRITERION-REFERENCED MEASURE:

The student will create a set-up checklist for each machine to be operated, explain the activities of checking the set-up in written or verbal examination, explain the tool-path motion determined from the coded program and tool-path plot, and will demonstrate actual hands-on activities leading to, and including activation of automatic mode to the satisfaction of the instructor.

PERFORMANCE GUIDE:

1. Power up control.
2. Find zero point for all axes (if necessary).
3. Verify program number.
4. Search for appropriate safe-start up location. (This often relates back to beginning of program.)
5. Set control to automatic cycle mode of single block mode. (See manufacturer's operating guide for specific instructions.)
6. Press "cycle start".
7. Observe control to verify automatic mode.

CHECKLIST

DUTY Operating Machine.

TASK Activate automatic cycle mode.

ENABLER Set machine to automatic cycle mode and activate.

STUDENT'S NAME ______________ DATE ________

EVALUATOR'S NAME ______________ COURSE ________

TIME : STARTED ________ COMPLETED ______________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the setting machine to automatic cycle mode.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Powered up control.	____	____
- Found the zero point for all axes.	____	____
- Verified the program number.	____	____
- Found a safe-start up location.	____	____
- Set control to automatic cycle mode.	____	____
- Activated automatic cycle code control.	____	____
- Verified the automatic cycle mode activation at the control.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #71

TASK: Interrupt automatic cycle mode manually.

STANDARD OF PERFORMANCE OF TASK:

Automatic cycle mode must be interrupted when stop button is activated.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine
Control
Manufacturer's operating manual

ENABLING OBJECTIVES:

1. Identify conditions that will result in interruption of the automatic cycle.
2. Activate the correct control.

*RESOURCES:

1. Pusztai & Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA, 1983.
2. Machine tool manufacturer's operators manual.
3. Visual aids - Utilizing mock control panels. (see objective # 67)
4. Checklist - Interrupting automatic cycle mode.

TEACHING ACTIVITIES:

1. Read and interpret operators manual. (*2)
2. Present lecture on "first-run" or "proofing" conditions that typically would require a block-by-block execution in automatic mode. (*1 & 2)
3. Present lecture on machining or setup conditions that typically require activation of the feed-hold control,
temporarily interrupting the automatic cycle. (*1 & 2)

TEACHING ACTIVITIES: (cont.)

4. Discuss emergency conditions that typically would require activation of the emergency-stop control, stopping all machine feeds and spindle motion. (*3)
5. Demonstrate activation of auto-block, hold, and emergency stop.
6. Assign students hands-on operating activities that require activation of auto-block, hold, and emergency stop.
7. Instruct student to interrupt automatic cycle mode manually. (*4)

CRITERION-REFERENCED MEASURE:

The student will demonstrate knowledge of conditions requiring the interruption of an automatic cycle, and the proper interruption action to be taken, by written and/or verbal examination and will demonstrate the ability to interrupt the automatic cycle correctly in actual hands-on operating conditions to the satisfaction of the instructor.

PERFORMANCE GUIDE:

Note: Operator must consider the machining process to determine which of the following methods will be used to interrupt the automatic cycle mode.

1. Switch from automatic cycle mode to single block mode. (See manufacturer's operators/programmers manual for specific instructions.)
2. Activate feed hold on control.(See manufacturers operators/programmers manual for specific instructions).
3. Execute emergency stop.

CHECKLIST

DUTY Operating Machine.

TASK Interrupt automatic cycle mode manually.

ENABLER Identify conditions that will result in interruption of the automatic cycle and activate the correct control.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate interrupting automatic cycle mode manually.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Reviewed manufacturer's operators manual.	____	____
- Activated automatic cycle mode.	____	____
- Switched automatic cycle mode to single block mode.	____	____
- Activated feed hold.	____	____
- Executed an emergency stop.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #72

TASK: Set manual mode control.

STANDARD OF PERFORMANCE OF TASK:

Control must indicate that manual mode is in operation.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tool
Control
Manufacturer's operating/programming manual

ENABLING OBJECTIVES:

1. Identify conditions that would result in setting the control in manual mode.
2. Activate the manual mode control.

*RESOURCES:

1. Machine tool manufacturer's operators manual.
2. James Childs. Principles of Numerical Control, Third Edition. Industrial Press, Inc., New York, NY. 1982.
3. Visual aids - Manual mode control panel and Mock control panel, see performance objective 67.
4. Checklist - Setting manual mode control.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual. (*1)
2. Present lecture on set-up conditions that typically would require a mode-control change from automatic or block-by-block. (*1 & 2)
3. Demonstrate activation of manual mode setting.
4. Instruct students to complete hands-on operating activities that require activation of manual mode. (*4)

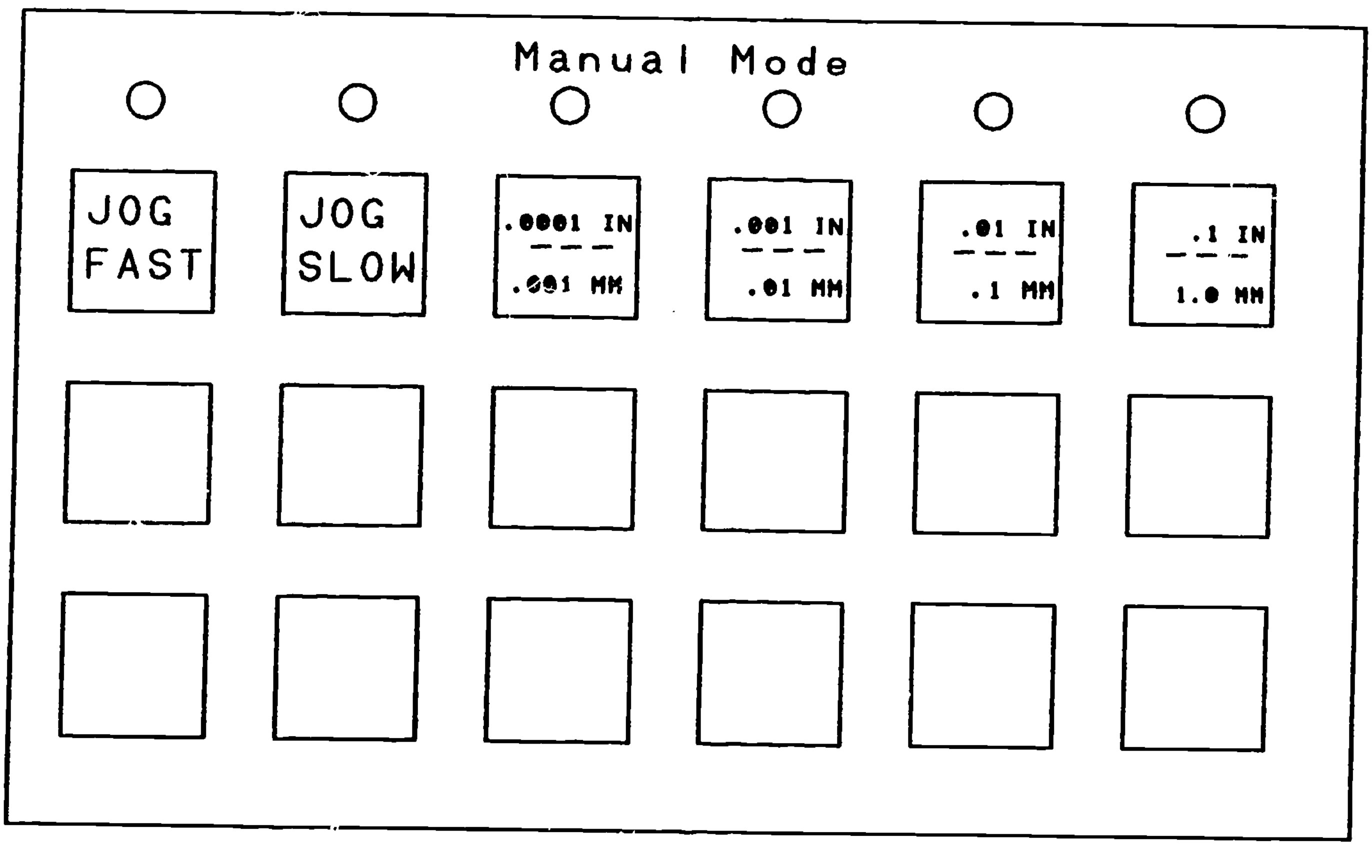
CRITERION-REFERENCED MEASURE:

The student will demonstrate knowledge of conditions requiring the activation of mode control to "manual" mode by written and/or verbal examination, and will demonstrate the ability to activate manual mode in actual hands-on operating conditions to the satisfaction of the instructor.

PERFORMANCE GUIDE:

1. Stop program.
2. Clear entry on control.
3. Select manual mode on control. (Refer to manufacturer's operating/programming manual for codes and program format.)
4. Observe control to verify entry of manual mode.
   Note: Never switch to manual mode while machine is running program.

TYPICAL MANUAL MODE CONTROL



CHECKLIST

DUTY Operating Machine.

TASK Set manual mode control.

ENABLER Activate the manual mode control.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate activation of the manual mode control.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Reviewed manufacturer's operating/ programming manual.	____	____
- Stopped the program.	____	____
- Cleared entry on control.	____	____
- Selected manual mode on control.	____	____
- Selected manual mode while a program was running.	____	____
- Verified manual mode entry at control panel.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #73

TASK: Set cycle modifiers.

STANDARD OF PERFORMANCE OF TASK:

Program operating sequence must reflect all edit entries (cycle modifiers). Modification of machining process must correspond to piece part tolerances and dimensioning specified on blueprint.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tool
Control
Manufacturer's operating manual

ENABLING OBJECTIVES:

1. Identify programming code that will require modification based on the operator's experience, or observation of machining conditions.
2. Enter the modifications into the computer-stored program, or create new input medium (tape) with modifications added to original program.
3. Evaluate subsequent machining operations for further modifying.

*RESOURCES:

1. Machine tool manufacturer's operators manual.
2. Manufacturer's programming manual.
3. Summary of editing commands provided by the manufacturer of the data-entry terminal (if using a remote terminal).
4. Pusztai and Sava. Computer Numerical Control. Reston Publishing Company, Inc., Reston, VA./ 1983.
5. Checklist - Selecting cycle modifiers.

TEACHING ACTIVITIES:

1. Read and interpret operator's and programming manual. (*1 & 2)
2. Present lecture on how to interpret pertinent G-codes and machine cutting motions where modifying may be needed. (*1,2, 3 & 4)
3. Present lecture on how modifications are to be made utilizing the machine tool controller or remote terminal. (*1,2,3 & 4)
4. Demonstrate operation of the editing features of the controller.
5. Demonstrate operation of the editing features of the remote terminal.
6. Assign students hands-on activities that simulate conditions that require modification.
7. Instruct student to select and initiate a cycle modification. (*7)

CRITERION-REFERENCED MEASURE:

The student will demonstrate his knowledge of selecting and entering modifying commands by written and/or verbal examination, and will demonstrate the ability to select and enter modifying commands in actual hands-on operating conditions to the satisfaction of the instructor.

PERFORMANCE GUIDE:

1. Determine program modifications needed for running programs.
2. Enter commands for selected option, mode, or condition. (Use operator's manual from machine tool manufacturer for detailed procedures.)
3. Observe control for edit entries display.

CHECKLIST

DUTY Operating Machine.

TASK Set cycle modifiers.

ENABLER Identify programming code that will require modification based on the operator's experience, or observation of machining conditions.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED __________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate setting cycle modifiers.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Reviewed manufacturer's operating and programming manual.	____	____
- Identified available cycle modifiers.	____	____
- Determined the needed cycle modifiers.	____	____
- Entered commands for selected cycle modifiers.	____	____
- Verified the cycle modifier entry at the control panel.	____	____
- Made the cycle modification of machining process correspond to piece part tolerances and dimensions.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #74

TASK: Set manual feed/jog mode.

STANDARD OF PERFORMANCE OF TASK:

Control must indicate position and distance of axes movement by manual feed/jog mode.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Numerical Control Machining Series.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tool
Control
Basic machining skills

ENABLING OBJECTIVES:

1. Position machine table, or cutting tool, into a predetermined location using manual feed/jog controls.

*RESOURCES:

1. Machine tool manufacturer's operators' manual.
2. American Machinist. Numerical Control Machining Series. Beckworth and Associates, Cleveland, OH. 1978.
3. Visual aids - Utilizing mock-up of control panel, see performance objective 67
4. Checklist - Selecting manual feed/jog.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual. (*1)
2. Present lecture on when to use the manual feed/jog mode during set-up. (*1,2 & 3)
3. Demonstrate the operation of the manual feed/jog feature and system override controls.
4. Assign students hands-on lab activities that require selection and activation of manual feed and jog.
5. Instruct student to select and activate manual feed and jog. (*4)

CRITERION-REFERENCED MEASURE:

The student will demonstrate his knowledge of selecting and activating the manual feed/jog control feature by written and/or verbal examination, and will demonstrate the ability to select and use the manual feed/jog feature in actual hands-on operating conditions to the satisfaction of the instructor.

PERFORMANCE GUIDE:

1. Stop program.
2. Clear entries on control.
3. Position axis to allow manual movement.
4. Turn manual feedrate override switch to desired rate at which axis travel will occur.
5. Observe work area for objects in axis travel path.
6. Move in the direction of axes travel path. (See manufacturer's operating/programming manual for specific instructions.)
7. Operate machine to stop machine when desired location is reached.
8. Make adjustments to feedrate override (if necessary).

CHECKLIST

DUTY Operating Machine.

TASK Select manual feed/jog mode.

ENABLER Position machine table, or cutting tool, into a predetermined location using manual feed/jog control.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate selection of manual feed/jog mode.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Stopped the program.	____	____
- Cleared all entries from control.	____	____
- Positioned axis to allow manual movement.	____	____
- Switched manual feedrate override to desired rate at which axis travel will occur.	____	____
- Checked work area for objects in axis travel pass.	____	____
- Checked movement in the direction of the axis travel path.	____	____
- Used the machine control to stop machine when desired location was reached.	____	____
- Made any necessary adjustments to feedrate override.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #75

TASK: Adjust cutter compensation.

STANDARD OF PERFORMANCE OF TASK:

Programmed center path of cutting tool must allow for the difference between actual and programmed cutter diameter. Program will produce workpiece to meet tolerances and dimensioning specified on blueprint.

SOURCE OF STANDARD:

Principles of Numerical Control.
Customer Information Manual.
1984 NC/CAM Guidebook.
Monarch VMC Three Axis Machining Center Programmer's Guide.
Producer CNC/NC Operator's Guide for Machining Centers.
Producer CNC/NC Programmer's Guide for Machining Centers.

CONDITIONS FOR PERFORMANCE OF TASK:

Control
CNC machine
Part program
Basic machining skills
Manufacturer's operating manual

ENABLING OBJECTIVES:

1. Measure actual cutter and calculate the cutter diameter compensation.
2. Modify programmed center-line location of cutter by entering cutter-compensation data either into the controller or remote terminal.
3. Activate the program, observe finished-piece part dimensions, and further adjust cutter-compensation if necessary.

*RESOURCES:

1. Machine tool manufacturer's operators and programmers manuals.

*RESOURCES: (cont.)

2. William Luggen. Fundamentals of Numerical Control. Delmar Publishing Co., New York, NY. 1984.
3. Pusztai & Sava. Computer Numerical Control. Reston Publishing Co., Reston, VA. 1983.
4. James Childs. Principles of Numerical Control, 3rd Edition. Industrial Press, New York, NY. 1982.
5. Dynapath System. Customer Information Manual. Dynapath Systems, Detroit, MI. 1984.

TEACHING ACTIVITIES:

1. Read and interpret manufacturer's operators and programmers manual. (*1)
2. Present lecture on how to determine if the program contains cutter compensation "turn on" and "turn off" commands (G 40,41,42), and how to modify the program if the feature is not programmed. (*1,2,3, 4 & 5)
3. Present lecture on how the controller calculates and moves the cutter normal to the original programmed centerline. (*1,2,3,4 & 5)
4. Demonstrate how to adjust cutter compensation. (*6)
5. Assign problems requiring calculation of cutter compensation for both under- and over-sized cutters, as well as using cutter compensation for roughing- and trial-cuts.
6. Assign hands-on lab activities that require determination of, enabling of, and measuring the results of cutter compensation.
7. Instruct student to adjust cutter compensation. (*7)

CRITERION-REFERENCED MEASURE:

The student will demonstrate knowledge of cutter compensation by written and/or verbal examination, and will demonstrate the ability to determine, enable, and measure the results of cutter compensation to the satisfaction of the instructor in actual hands-on operating conditions.

PERFORMANCE GUIDE:

1. Define whether cutter path lies to right or left of part.
2. Enter code that describes location of cutter to piece part. (inside cut- outside cut) (See manufacturer's operating/programming manual for specific machine tool control.)
3. Change feedrate for cutter compensation (if necessary).
4. Enter cutter compensation value on machine control.
5. Cancel all cutter compensation values when program is finished (if necessary).

CHECKLIST

DUTY Operating Machine.

TASK Adjust cutter compensation.

ENABLER Modify programmed center-line location of cutter by entering cutter-compensation data either into the controller or remote terminal.

STUDENT'S NAME ______________ DATE ______________

EVALUATOR'S NAME ______________ COURSE ______________

TIME : STARTED ______________ COMPLETED ______________

TOTAL ______________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate adjusting cutter compensation.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Determined whether cutter path lay to the right or left of part.	____	____
- Entered cutter code describing location of cutter to piece part.	____	____
- Changed feedrate for cutter compensation.	____	____
- Entered cutter compensation value on machine control.	____	____
- Cancelled all cutter compensation values after program finished.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #76

TASK: Edit program.

STANDARD OF PERFORMANCE OF TASK:

Verify changes in program on console or with programmed manuscript. For complex program changes, operator may also dry run program through edited portion to visually verify edited program.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Part program
CNC machine
Control
Programmed manuscript
Manufacturer's operating manual

ENABLING OBJECTIVE:

1. Correct or modify part program at C.N.C. control.
2. Create a new part program at C.N.C. control.
3. Run program and verify edited information.
4. Generate a program copy into another storage area of memory, or to a hard copy, or programmed manuscript.

*RESOURCES:

1. Modern Machine Shop 1985 NC/CAM Guidebook. Gardner Publication Inc., Cincinnati, Ohio.
2. Operator's manual.
3. Checklist - Edit part program.

TEACHING ACTIVITIES:

1. Read operator's manual to identify the editing procedure required to correct, modify, or create a part program at the C.N.C. control. (*2)

TEACHING ACTIVITIES: (cont.)

2. Present lecture on editing a part program. (*1 & 2)
3. Instruct students to list three questions they wish answered concerning the different types of editing options.
4. Conduct class discussion on editing, and demonstrate how to edit a part program.
5. Instruct students to practice writing examples of three edited part programs.
6. Instruct students to edit a part program on a C.N.C. control. (*3)

CRITERION-REFERENCED MEASURE:

The student will identify errors in part program which will require editing to correct. The student will edit the items identified as errors, plus add two new lines to part program on the C.N.C. control. The student will also identify when and why editing is required on a C.N.C. control, plus the importance of backing up edited programs on a hard copy.

PERFORMANCE GUIDE:

1. Activate edit mode.
2. Utilize keyboard to create, alter, and or modify program. (See manufacturer's operating manual.)
3. Run program to verify changes (if necessary).
   NOTE: Once editing is complete, hard copy or programmed manuscript should be created and stored.

CHECKLIST

DUTY Operating Machine

TASK Edit program.

ENABLER Edit part program using a C.N.C control.

STUDENT'S NAME ______________ DATE ______

EVALUATOR'S NAME ______________ COURSE ______

TIME : STARTED ______ COMPLETED ______

TOTAL ______

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the editing of part program.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Activated edit mode.	____	____
- Edited errors in part program.	____	____
- Added two new lines to parts program on the C.N.C. control.	____	____
- Identified when and why editing was required.	____	____
- Ran program to verify changes.	____	____
- Backed up edited programs on hard copy.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #77

TASK: Run segment of program.

STANDARD OF PERFORMANCE OF TASK:

Operator must be able to review program by returning to safe start up block, or running program journal to safe start block of next machining sequence.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

C.N.C. machine tool
Control
Manufacturer's operating manual

ENABLING OBJECTIVE:

1. Search N/C tape for a safe start location for a tool.
2. Activate the machine to run a N/C tape and run segment of program.

*RESOURCES:

1. Operator's manual.
2. Simplify C.N.C. Turning Operation. American Machinist Magazine. January, 1981.
3. Programmer's manual.
4. Visual aid - Manufacturing process sheet.
5. Checklist - Safe start location and run program segment

TEACHING ACTIVITIES:

1. Read operator's manual on how to search for sequence block numbers. (*1)
2. Read programming manual to identify what positioning information is required to safely prepare a machine tool to perform the work it is intended to do. (*3 & 4)

TEACHING ACTIVITIES: (cont.)

3. Present lecture on searching and locating safe start locations on N/C tape. (*1,2 & 3)
4. Conduct class discussion on how to locate a safe start location on N/C tape, and why safe start locations are used.
5. Instruct students to conduct a search of a safe start location, and run a segment of a program. (*4)

CRITERION-REFERENCED MEASURE:

The student will identify the safe start locations on the tape for each tool. The student will search the tape for a safe start location. The students will run segments of the program.

PERFORMANCE GUIDE:

1. Turn power unit to on.
2. Search for program using sequence search key or dial. (See manufacturer's specific operation manual for control board commands.)
3. Locate safe start up block number or desired page number.
4. Activate block by block mode.
5. Activate cycle start.

VISUAL AID
Manufacturing Process Sheet
Setup Procedure for K & T 180

Part Number 140-73-828-04
Part Name Support Block
Operation Number 1 I.D. Number 440234

STANDARD TOOLING

USED	TOOL DISCRIPTION	TOOL NUMBER	LOCATION
Yes	#4 Centerdrill	V-34	Pocket #1
Yes	#6 Centerdrill	V-36	Pocket #2
No	#24 Drill	V-10152	Pocket #3
No	3/16" DIA Drill	V-10188	Pocket #4
Yes	#6 Drill	V-10204	Pocket #5
No	"G" Drill	V-10261	Pocket #6
No	9/32" DIA D[illegible]	V-10281	Pocket #7
No	5/16" DIA Drill	V-10313	Pocket #8
No	11/32" DIA Drill	V-10344	Pocket #9
No	13/32" DIA Drill	V-10406	Pocket #10
No	7/16" DIA Drill	V-10438	Pocket #11
No	23/32" DIA Drill	V-10719	Pocket #12
No	10-24 Tap	V-61024	Pocket #13
Yes	1/4"-20 Tap	V-61420	Pocket #14
No	5/16"-18 Tap	V-651618	Pocket #15
No	3/8"-16 Tap	V-63816	Pocket #16
No	1/2"-14 NPT Tap	V-61214	Pocket #17
Yes	90 Degree Chamfering Tool	V-5990	Pocket #18
Yes	3" DIA Face Mill (Rough)	V-23000	Pocket #19
No	Counterbore for 3/8" SHCS	V-50594	Pocket #20

NOTE: These tools must be fitted with valenite retention knob PT-275 and tightened securely in place with loctite #290.

Variable Tool List

Tool Description	Tool Number	Location
27/64" DIA Drill	V-10422	Pocket #21
17/32" DIA Drill	V-10531	Pocket #22
1" DIA. End Mill	V-810001	Pocket #23
1/2"-13 Tap	V-61213	Pocket #24
5/8"-11 Tap	V-65811	Pocket #25

Fixture List

Fixture Description	Tool Number	Location
Universal Vise	KT-180-F-1A	Pallet A
2 3/4" X 1" X 18" Spacer	NONE	Tool Crib
Serrated Hard Jaws	(2) Sets	Tool Crib
(4) Rest Pegs	F-64	Tool Crib
Extra K.T. Vise	KT-180-F-1A	Tool Crib

Gage List

Discription
6" Scale
6" Vernier
Tape Measurer
1/4"-20 Plug Gage
1/2"-13 Plug Gage
5/8"-11 Plug Gage

Set Up Operation

Part Number 140-73-828-04
Part Name Support Block
Operation Number 1
ID Number 440234

1. Measure tools and place in the tool changer. (Make sure they are placed in the correct pocket location.)
2. Place the correct tool number in the tool table.
3. Set any tool length or tool diameter compensation offsets.
4. Attach serrated hard jaws to both sides of the "T" slotted plate.
5. Set the top of both vises at   from the table.
6. Place the 2 3/4" x 1" x 18" spacer on lower jaws. The 1" dimension should be vertical, so part is 1" from lower jaws, the 18" length should be horizontal and located 2" left of left side of fixture.
7. Attach (4) rest pegs (F-64) each to the "T" slotted plate using "T" nuts and 1/2"-13 S.H.C.S.

   A. 1 Rest peg at (HS-1), 3" right of left side of fixture.
   B. 1 Rest peg at (VS-2), 5" up from the lower vise jaw.
   C. 1 Rest peg at (VS-6), 5" up from the lower vise jaw.
   D. 1 Rest peg at (HS-1), 1/2" left of right side of fixture.

   NOTE: Each rest peg should be 1" long.
8. Place ID 440234 in the assigned program index.
9. Place pallet "A" in the work area.
10. Activate the assigned program index number for ID 440234, then the assigned program index number for pallet "B".
11. Turn on alternate enable.
12. Start each program in single block and check to make sure that the ID number corresponds to the job on each pallet.

NOTE: Ts IN

Operation Procedure

Part Number 140-73-828-04
Part Name Support Block
Operation Number 1
ID Number 440234

1. Place one piece in vises. The 5" dimension vertical and 3" left of left edge of fixture. The 19" dimension should be horizontal.
   NOTE: The welded block (2" x 5" x 6" CRS) is on the right side facing the operator.
2. Push the part firmly against the rest pegs (F-64) and lock vises securely.
3. Turn on coolant enable.
4. Start cycle.
5. 3" Face mill (Mill 3 sides to finish dimensions) T-23000
   Pocket #19

   Safe start to load tool....................................5
   Position to mill....................................25
6. #4 Centerdrill (Centerdrill 2 places)
   T-34
   Pocket #1

   Safe start to load tool....................................305
   Position to centerdrill....................................330
7. #6 Centerdrill (Centerdrill 10 places)
   T-36
   Pocket #2

   Safe start to load tool....................................365
   Position to centerdrill....................................390
8. 1" DIA. end mill (Mill 1/2" step 1/2" deep 1 place)
   T-810001
   Pocket #23

   Safe start to load tool....................................505
   Position to mill....................................530
9. #6 Drill (Drill #6 2 places)
   T-10204
   Pocket #5

   Safe start to load tool....................................625
   Position to drill....................................650
10. 1/4"-20 Tap (Tap 1/2" deep 2 places)
    T-61420
    Pocket #14

    Safe start to load tool....................................685
    Position to tap....................................710
11. 27/64" DIA. Drill (Drill 27/64" DIA. 4 places)
    T-10422
    Pocket #21

12. 1/2"-13 Tap (1/2"-13 Tap 4 places)
T-61213
Pocket #24

Safe start to load tool..................................825
Position to tap..850

13. 17/32" DIA. Drill (Drill 6 places)
T-10531
Pocket #22

Safe start to load tool..................................905
Position to drill..930

14. 90 Degree chamfer (Chamfer 6 Places)
T-5990
Pocket #18

Safe start to load tool..................................995
Position to chamfer......................................1020

15. 5/8"-11 Tap (Tap 1 1/4" deep 6 places)
T-65811
Pocket #25

Safe start to load tool..................................1205
Position to tap..1230

NOTE: The operator is responsible for the quality of work.

CHECKLIST

DUTY Operating Machine

TASK Run segment of program.

ENABLER Search for safe start location and run a segment of a program.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE ________

TIME : STARTED __________ COMPLETED ________________

TOTAL ____________

DIRECT: \S TO THE EVALUATOR:

Use the following checklist to evaluate the search for safe start location, and the running of a segment of a program.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Identified the safe start location on the tape for each tool.	____	____
- Conducted a safe start search.	____	____
- Ran a segment of the program.	____	____
- Ran the segment of the program with out errors.	____	____
- Turned the unit on in proper sequence.	____	____
- Activated the block by block mode.	____	____
- Activated the cycle start.	____	____
- Successfully found a safe start location.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #78

TASK: Perform sequence search.

STANDARD OF PERFORMANCE OF TASK:

Operator must locate specific block of information without running entire program or without physical damage to program.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

C.N.C. machine
Control
C.N.C. program
Knowledge of control keyboard
Format classification sheet

ENABLING OBJECTIVE:

1. Students will clear all logic and identify line number or page required.
2. Enter search information format in control.
3. Search N/C tape for line number or page.

*RESOURCES:

1. Operator's manual.
2. Checklist - Sequence search.

TEACHING ACTIVITIES:

1. Read operator's manual to identify the sequence search procedure. (*1)
2. Present lecture on sequence search and why is it used.
3. Instruct students to list three questions they wish answered concerning sequence search.
4. Conduct class discussion on how to scroll forward or backward to desired page or line number.
5. Demonstrate how to perform a sequence search.
6. Instruct students to perform a sequence search. (*2)

CRITERION-REFERENCED MEASURE:

The students will identify and locate the line sequence number on the N/C tape. The students before restarting machine tool must be sure the tool location and the safe start up sequence numbers are correct. The students will run a segment of the program.

PERFORMANCE GUIDE:

1. Turn power unit to on.
2. Clear entry on machine control.
3. Enter and call-up program number.
4. Press page button for program number. (See specific format classification sheet for computer system being used.)
5. Scroll forward or backward to desired page or line.

CHECKLIST

DUTY Operating Machine

TASK Perform sequence search.

ENABLER Identify and locate the lines sequrnce number on a N/C tape and run a program segment.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED ______________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the sequence search.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Identified and located the line sequence number on the N/C tape.	____	____
- Checked the tool location and start up sequence number to insure they were correct before starting up.	____	____
- Ran a segment of the program.	____	____
- Ran the segment of the program without errors.	____	____
- Powered up the unit.	____	____
- Cleared entry on the machine control.	____	____
- Pressed page button for program number.	____	____
- Scrolled forward and backward to desired page or lines.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #79

TASK: Interpret status lights.

STANDARD OF PERFORMANCE OF TASK:

Operator must be capable of maintaining continuous operation of program and machine tool as a result of interpretory lights, indicators, and displays on control unit.

SOURCE OF STANDARD:

Writing team of incumbent workers.
Machining Centers Operator's Training Guide.
Meldas 5100c Numerical Control Programming Instruction Manual.

CONDITIONS FOR PERFORMANCE OF TASK:

C.N.C. machine tool
Control
Basic machining knowledge
Knowledge of control keyboard
Manufacturer's operating manual for machine tool

ENABLING OBJECTIVE:

1. Identify all status lights on control panel.
2. Meet and maintain operating responsibilities.
3. Troubleshoot and determine corrective action required when status lights indicate problems.
4. Enter system command to clear and deactivate status light or lights.

*RESOURCES:

1. Machining Centers Operator's Training Guide. Automation Intelligence. Orlando, Florida. 1984.
2. Meldas 5100 C Numerical Control Programming Instruction. Mitsubishi Electric Corporation. 1978.
3. Operator's manual.
4. Visual aid - control panel showing status lights, see performance objective 67.
5. Checklist - Status lights.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual on control panel status lights. (*3)
2. Present lecture on status lights on control panel. (*1,2,3 & 4)
3. Instruct students to complete a status light identification worksheet. (Will vary depending on machine.)
4. Assign students to write three questions they wish answered concerning status lights.
5. Conduct class discussion on status lights.
6. Present lecture on troubleshooting and identifying problems when status lights indicate there is a problem. (*1,2,3)
7. Demonstrate how to troubleshoot a problem by interpreting status lights.
8. Instruct student to troubleshoot a problem by interpreting status lights. (*5)

CRITERION-REFERENCED MEASURE:

The students will identify and troubleshoot any problem indicated by the status lights. After identifying the problem, and determining corrective action, the student will enter system commands to deactivate light.

PERFORMANCE GUIDE:

1. Identify status lights:
    a. Temperature warning.
    b. Servo fault.
    c. Data error.
    d. Program changes.
    e. Power supply.
    f. Diagnostic.
2. Determine procedure to be followed:
    a. Review manufacturer's operating manual.
    b. Apply corrective measures for machine malfunction or notify maintenance or service personnel.
    c. Enter system commands to deactivate light.
3. Follow procedures to maintain machine tool and continue machine program.

CHECKLIST

DUTY Operating Machine

TASK Interpret status lights.

ENABLER Trouble shoot a machine malfunction using status lights.

STUDENT'S NAME ______________ DATE ______

EVALUATOR'S NAME ______________ COURSE ______

TIME : STARTED ______ COMPLETED ______

TOTAL ______

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the interpretation of status lights.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Reviewed manufacturers operating manual.	____	____
- Identified the following status lights:		
Temperature warning	____	____
Data error	____	____
Servo fault	____	____
Program changes	____	____
Power supply	____	____
Diagnostic	____	____
- Identified all problems by intepreting status lights.	____	____
- Took corrective measures for machine malfunctions.	____	____
- Deactivated status lights after malfuntion was corrected.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #80

TASK: Change Spindle Speed.

STANDARD OF PERFORMANCE OF TASK:

Control or tachometer/gauge must verify change setting for spindle speed in revolutions per minute.

SOURCE OF STANDARD:

Operating Manual for Cincinnati Milacron.
Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

C.N.C. machine tool
Control
C.N.C. program
Spindle motor in operation
Hand-held tachometer
Manufacturer's operating manual for machine tool

ENABLING OBJECTIVE:

1. Set spindle speed (RPM).
2. Verify that corrected or modified spindle speed (RPM) has been changed.

*RESOURCES:

1. Operators Manual For Cincinnati Milacron. Cincinnati Milacron, Worchester, MA. 1984.
2. Operator's manual.
3. Checklist - Spindle speed.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual on correcting procedure on changing spindle speeds. (*2)
2. Present lecture on changing spindle speeds and demonstrate the different methods of changing the spindle speeds:
   a. Speed selector indicators.
   b. Override option. (*1 & 2)
3. Assign students to write how and why spindle speeds should be changed and questions they wish answered in class.

TEACHING ACTIVITIES: (cont.)

4. Conduct demonstration to verify spindle speed changed:
   a. Hand-held tachometer.
   b. Control and/or machine speed selector indicator.
5. Conduct class discussion on changing spindle speeds.
6. Instruct students to perform a spindle speed new selection. (*3)
7. Instruct students to verify new spindle speed. (*3)

CRITERION-REFERENCED MEASURE:

The student should be able to identify how to change a spindle speed. After identifying how to change a spindle speed, the student will select a new spindle speed and verify that the new selection has been satisfied.

PERFORMANCE GUIDE:

1. Determine spindle motor rotation.
2. Start spindle.
   NOTE: Some spindle motors must be in operation in order to change spindle speeds.
3. Position speed increase/decrease control to desired selection or enter data (as required by manufacturer's operating manual for control.)
4. Verify new RPM notation:
   a. Hand-held tachometer.
   b. Speed selector indicator.
   c. CRT screen.

CHECKLIST

DUTY Operating Machine

TASK Change Spindle Speed.

ENABLER Correct or modify spindle speed (RPM).

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate the changing or modification of spindle speed.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Reviewed operator's manual before changing spindle speed.	____	____
- Determined desired spindle speed before startup.	____	____
- Started spindle motor before speed change.	____	____
- Set desired speed using the spindle speed increase/decrease control as required by manufacturer's operating manual.	____	____
- Verified new spindle speed (RPM) using a handheld tachometer, speed selector indicator or C.R.T. screen.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #81

TASK: Initiate program restart from zero (absolute mode).

STANDARD OF PERFORMANCE OF TASK:

When program is interrupted, the operator must complete the program from a safe start-up block to complete workpiece according to specifications.

SOURCE OF STANDARD:

Numerical Control Machining Series.
Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

C.N.C. machine tool
Control
C.N.C. program

ENABLING OBJECTIVE:

1. Students will identity the safe restart positions for the tool and N/C tape.
2. Students will clear all logic and position tool and N/C tape to a safe start location.
3. Activate the machine to run a N/C tape and run segment of program.

*RESOURCES:

1. American Machinist. Numerical Control Machining Series. Beckworth and Associates. Cleveland, OH. 1978.
2. Operator's manual.
3. Visual aid - Axes orientation.
4. Checklist - Program restart.

TEACHING ACTIVITIES:

1. Read operator's manual on how to move a tool safely and how to search for a line sequence number. (*2)
2. Present lecture and demonstration on how to move a tool safely on the machine tool. (*1,2,)

TEACHING ACTIVITIES: (cont.)

3. Present lecture and demonstration on how to identify and locate a safe start line sequence number. (*1,2,& 3)
4. Instruct students to list three questions they wish answered concerning a restart operation.
5. Conduct class discussion on why and how to safely restart a machine tool.
6. Instruct students to move tool safely on the machine tool and search for a safe start block line number. (*4)

CRITERION-REFERENCED MEASURE:

The students will identify and place the tool of the machine tool in a safe position to restart the machine.

NOTE: This location may be a "Home Location." The students will identify and locate the safe start block sequence number. The students will run a segment of the program.

PERFORMANCE GUIDE:

1. Return to original coordinates (using digital readouts if provided).
2. Move machine tool to zero position.
3. Rewind the tape to safe start-up block.
4. Depress cycle start to restart program.

CHECKLIST

DUTY Operating Machine

TASK Initiate program restart from zero (absolute mode).

ENABLER Move tool to safe start up location, identify safe start up block sequence number, restart and run a segment of the program.

STUDENT'S NAME ____________ DATE ________

EVALUATOR'S NAME ____________ COURSE ________

TIME : STARTED ________ COMPLETED ________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate program restart.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Consulted the operator's manual before tool move was made.	____	____
- Identified a safe start up block sequence number.	____	____
- Located the safe start up block on the N/C tape.	____	____
- Moved the tool of the machine tool to a safe location before restart (zero position).	____	____
- Safely restarted the machine tool.	____	____
- Ran a segment of the program.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #82

TASK: Interrupt cycle.

STANDARD OF PERFORMANCE OF TASK:

Machine must stop when stop button is in position.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

C.N.C machine tool
Control
C.N.C. program

ENABLING OBJECTIVE:

1. Students will identify what method should be used to identify an automatic cycle.
2. Students will activate the correct procedure to interrupt an automatic cycle.
3. Students will safely restart automatic cycle, and run a segment of N/C program.

*RESOURCES:

1. Operator's manual.
2. Checklist - Interrupt cycle.

TEACHING ACTIVITIES:

1. Read operator's manual on how to interrupt an automatic cycle. (*1)
2. Present lecture and demonstration on how to interrupt an automatic cycle by switching to single block.
3. Present lecture and demonstration on how to interrupt an automatic cycle by using the feed hold push buttons. (*1)
4. Present lecture and demonstration on how to interrupt an automatic cycle by using the emergency stop push buttons. (*1)

TEACHING ACTIVITIES: (cont.)

5. Instruct students to list three questions they wish answered concerning interrupting an automatic cycle.
6. Conduct class discussion on why an automatic cycle should be interrupted, and how to safely restart an automatic cycle.
7. Instruct students to interrupt an automatic cycle, and restart the cycle safely. (*2)

CRITERION-REFERENCED MEASURE:

Students will identify how to interrupt an automatic cycle, and when that cycle should be interrupted. The students will understand that anytime a cycle is interrupted, and the operator may have to place any portion of their body into the work cutting area, the spindle has to be turned off. The students will restart the cycle, and run a segment of the program.

PERFORMANCE GUIDE:

When machine is in operation:

1. Switch from automatic cycle mode to single block mode. (See manufacturer's operating manual.)
2. Activate feed hold on control. (see manufacturer's operating manual).
3. Execute emergency stop. (See manufacturer's operating manual.)
   NOTE: Operator must consider the machining process to determine which of the above methods will be used to interrupt the automatic cycle mode.

CHECKLIST

DUTY Operating Machine

TASK Interrupt cycle.

ENABLER Interrupt an automatic cycle and restart the cycle safely.

STUDENT'S NAME ______________ DATE ______________

EVALUATOR'S NAME ______________ COURSE ______________

TIME : STARTED __________ COMPLETED __________

TOTAL

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate interrupting a cycle.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Switched automatic cycle mode to a single block mode before interruption.	____	____
- Activated feed hold.	____	____
- Stopped the spindle.	____	____
- Stopped spindle fully before student's body entered the cutting area.	____	____
- Engaged stop button.	____	____
- Made an emergency stop.	____	____
- Made a successful interruption.	____	____
- Successfully restarted.	____	____
- Ran a segment of the program after restart.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #83

TASK: Check cutting fluids.

STANDARD OF PERFORMANCE OF TASK:

Coolant indicator must show level of cutting fluids, and/or spray mist coolant as recommended by manufacturer of machine tool.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Coolant
Manufacturer's maintenance manual
C.N.C. machine tool
Control
Coolant concentration gauge

ENABLING OBJECTIVE:

1. Students will identify what lubricants should be used, and how to check with the manufacturer on different types of lubricants to see if they are approved.
2. Students will identify how to check the machine tool so that it is properly lubricated.
3. Students will understand how to periodically examine the lubricant to determine its physical condition.

*RESOURCES:

1. Operator's manual.
2. Maintenance manual on recommended lubricants.
   State of Illinois. (Environmental Protection Act.) EPA
3. Visual aid - Lubrication.
4. Checklist - Lubrication.

TEACHING ACTIVITIES:

1. Read operator's manual on how to lubricate, and how to check that the machine tool is properly lubricated. (*1)

TEACHING ACTIVITIES: (cont.)

2. Read maintenance manual on approved lubricants. (*2)
3. Present lecture and demonstration on how to lubricate, and where to lubricate the machine tool. (*1,2,& 3)
4. Present lecture on pre-mix lubricants. Stress the use of non-toxic lubricants, and the advantages of using non-toxic lubricants. (*1,2,& 3)
5. Present lecture on periodic examination of the lubricant to determine its physical condition. (1,2,& 3)
6. Instruct students to list three questions they wish answered concerning lubricating machine tools.
7. Conduct class discussion on lubricants.
8. Instruct students to identify where to lubricate, and how to check it. (*4)

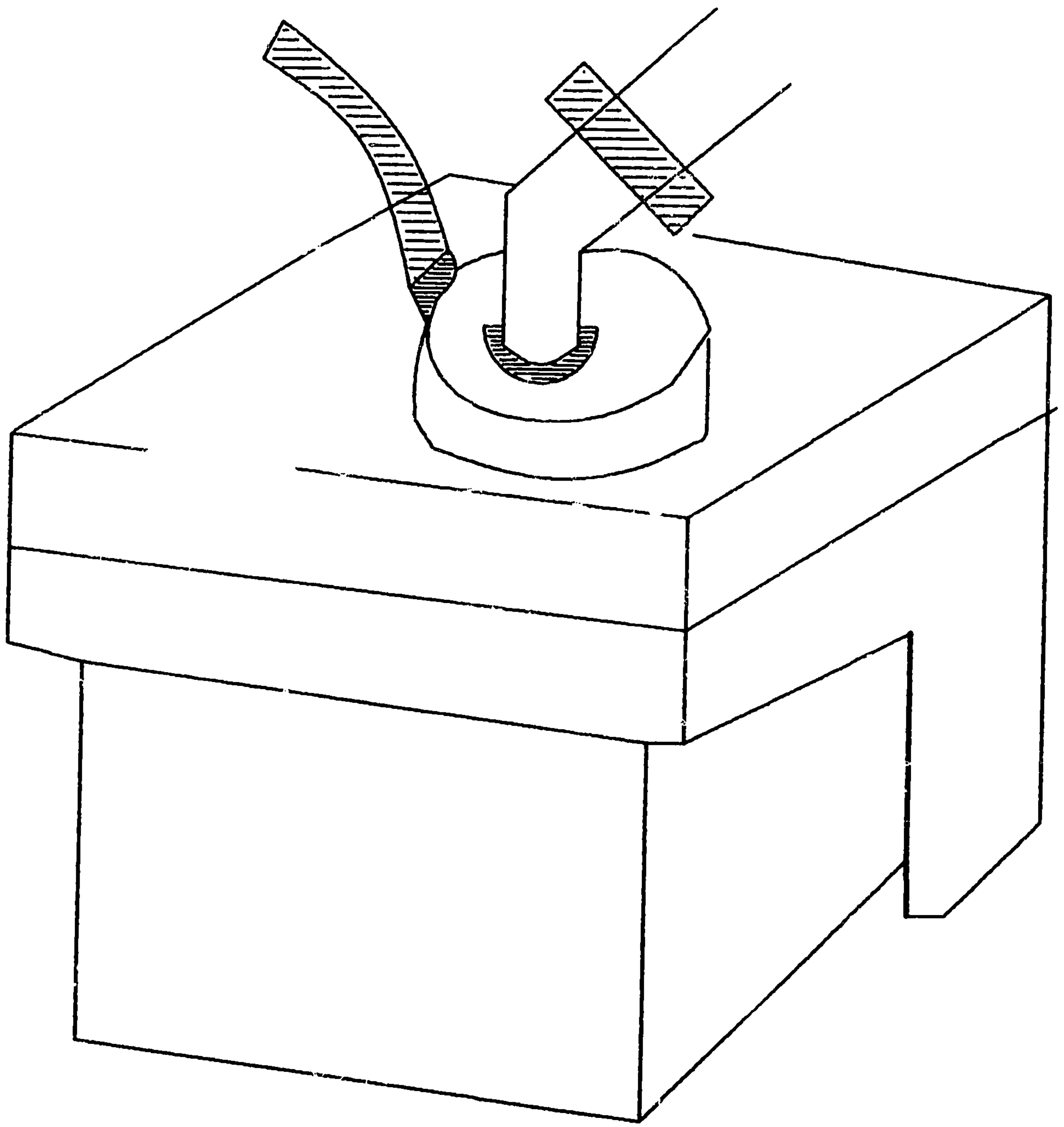
CRITERION-REFERENCED MEASURE:

Students will identify where to lubricate the machine tool. The students will also be able to check if the machine tool is lubricated correctly. The students will know how to correctly mix coolants to the proper ratio. The students will be able to identify lubricants to determine if its physical condition is changing, and what to do to correct that change.

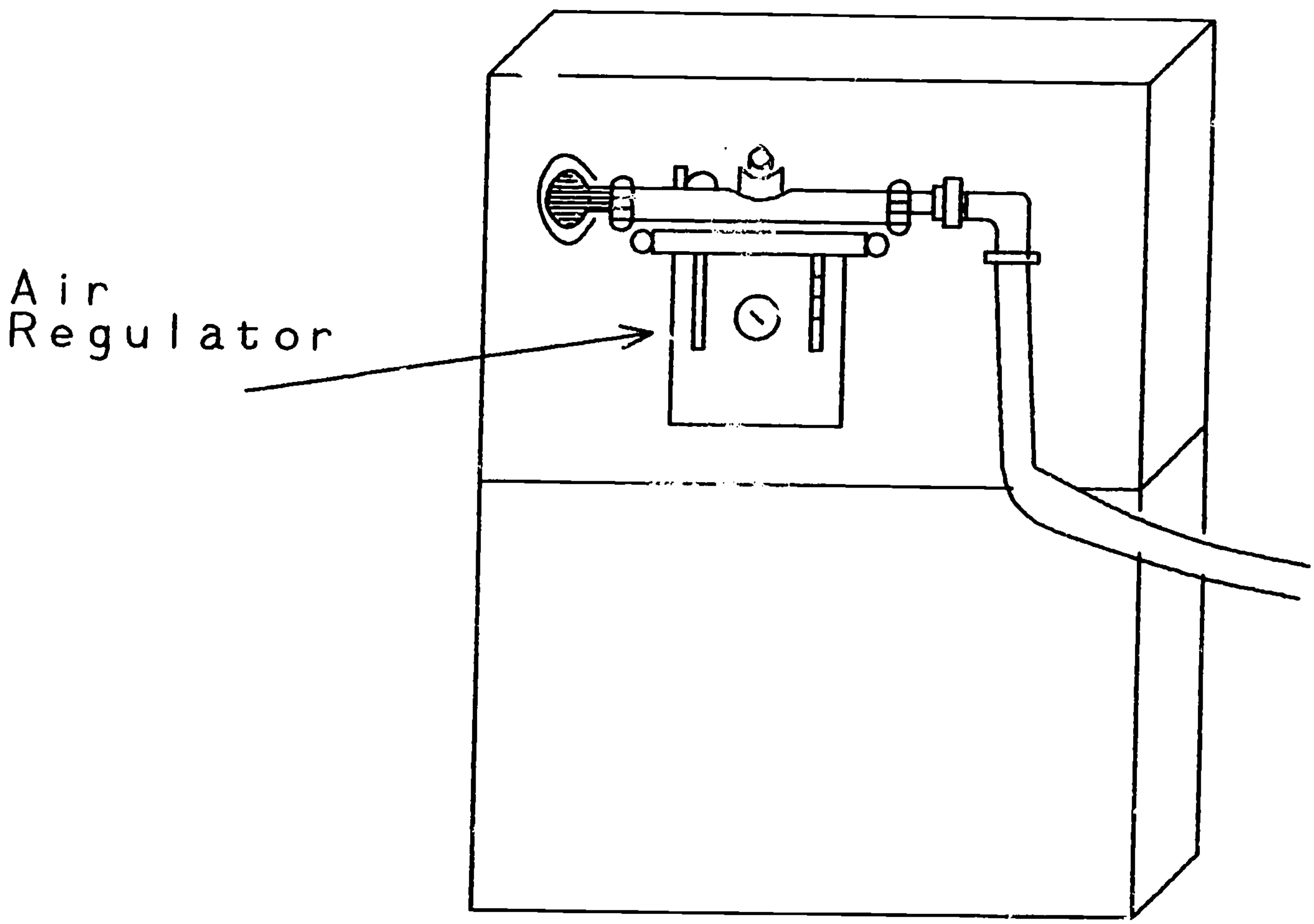
PERFORMANCE GUIDE:

1. Check sight gauge for coolant level.
2. Add coolant amount to level recommended by manufacturer to fill tank.
3. Add pre-mixed coolant recommended by manufacturer:
   a. Use coolant concentration gauge to determine ratio.
   b. Prepare mixture with appropriate ratio of coolant and water.
4. Observe dial indicators on control to verify new fluid levels.

MIST COOLANT RESERVOIR



COOLANT SPINDLE



CHECKLIST

DUTY Operating Machine

TASK Check cutting fluids.

ENABLER Check machine tool lubricant/coolant.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED __________ COMPLETED ______________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the perfomance determinants checklist to evaluate checking of cutting fluids.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Located all lubrication/coolant reservoirs.	____	____
- Identified the correct lubricant/coolant to be used.	____	____
- Mixed the lubricant/coolant to the right ratio.	____	____
- Used a lubricant/coolant concentration gauge to determine ratio.	____	____
- Determined the physical condition of the lubricant/coolant.	____	____
- Corrected any physical change in the lubricant/coolant.	____	____
- Checked the lubricant/coolant sight gauge.	____	____
- Observed dial indicators on the control panel to verify new fluid levels.	____	____
- Filled all reservoirs to a proper level.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #84

TASK: Check surface finish.

STANDARD OF PERFORMANCE OF TASK:

Piece part must measure within surface finish plus or minus range of tolerances as specified on part print.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Piece part
Profilometer
Surface comparator or other appropriate measuring devices

ENABLING OBJECTIVES:

1. Identify differences between surface texture and surface integrity.
2. Identify texture symbols.
3. Understand different methods for checking surface finish.

*RESOURCES:

1. Machining Data Handbook 3rd Edition, Volume. Machining Data Center Metcut Research Associates Inc. Cincinnati, Ohio 45209.
2. Manufacturers Manuals.
3. Visual aid - Surface Texture & Integrity.
4. Checklist - Surface Finish.

TEACHING ACTIVITIES:

1. Read Machining Data Handbook on surface technology. (*1)
2. Read Measuring Manufacturers manuals on measuring instruments to check surface finish. (*2)

TEACHING ACTIVITIES: (cont.)

3. Present lecture on surface finish and how to check surface finish. (*1,2,3)
4. Instruct students to list three questions they would like answered concerning checking surface finish.
5. Conduct class discussion o surface finish and how to check surface finish.
6. Instruct student to check and verify a surface finish. (*4)

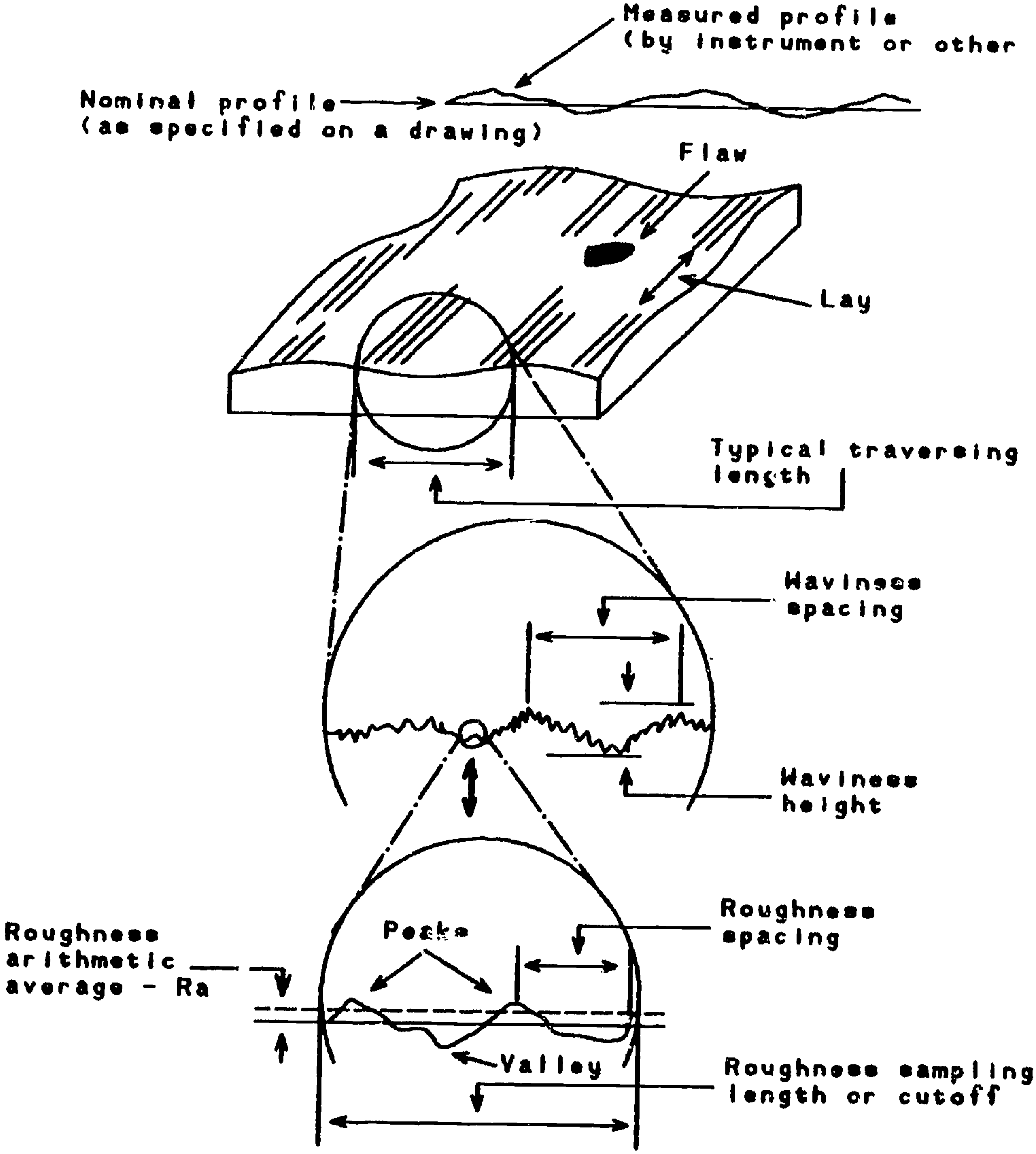
CRITERION-REFERENCED MEASURE:

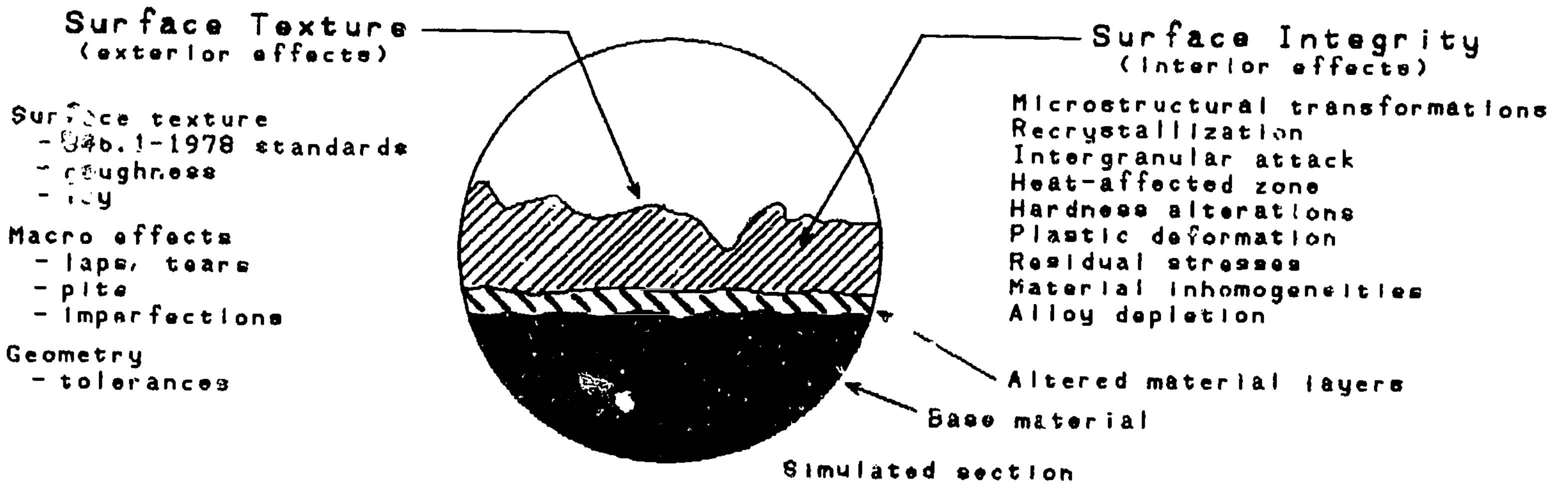
The students will identify differences between surface texture, and surface integrity. The students will know what the surface finish symbols are. The students will be able to demonstrate the use of surface measuring instruments.

PERFORMANCE GUIDE:

1. Remove piece part from fixture.
2. Clean part before inspection.
3. Check surface of piece part.
   a. Compare piece part surface with surface quality of piece part, or
   b. Use profilometer or other appropriate measuring device to determine if piece part finish is within specified tolerance range on part print.

SURFACE TEXTURE AND INTEGRITY





Process Energies
Mechanical
Electrical
Thermal
Chemical

Material Properties
Tensile
Ductility
Hardness

Surface Effects
Roughness
Residual Stresses
Cracks
Phase Changes

↓

Mechanical Properties
High Cycle Fatigue
Stress Rupture
Low Cycle Fatigue
Stress Corrosion

↓

Component Reliability

SURFACE TEXTURE & INTEGRITY

CHECKLIST

DUTY Operating Machine.

TASK Check surface finish.

ENABLER Check and verify a surface finish.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ COURSE __________

TIME : STARTED ______________ COMPLETED ______________

TOTAL ____________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate checking machine surface.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Identified differances between surface texture and surface integrity.	____	____
- Identified surface finish symbols.	____	____
- Removed piece part from fixture.	____	____
- Cleaned part before inspection.	____	____
- Checked part print for specified tolerance.	____	____
- Measured part piece for specific tolerance using a profilometer or other appropriate measuring device.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #85

TASK: Measure cut dimensions.

STANDARD OF PERFORMANCE OF TASK:

Piece part must meet specification tolerances on blueprint.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Blueprint
Measuring device
Finished piece part
Basic machining skills

ENABLING OBJECTIVES:

1. Measure the cut dimension, and determine what is required to machine the part to the correct dimension.
2. Make correction on dimension error to meet and maintain blueprint specifications.

*RESOURCES:

1. Operator's manual.
2. <u>NC/CAM Guidebook - Chapter Two - Machine Tools and Their Control</u>. Modern Machine Shop. Gardner Publications Inc., Cincinnati, OH, 1985.
3. Measuring cut dimension checklist.
4. Visual aid of measuring devices.

TEACHING ACTIVITIES:

1. Read operator's manual to identify the operating procedure required to make a tool cut to the proper dimension, (Tool Offsets) (*1)
2. Present lecture on how to measure a cut dimension or a machine tool part and when to remove the part from the machine tool. (*1 & 2)

TEACHING ACTIVITIES: (cont.)

3. Demonstrate how to measure a cut dimension on a machine tool part.
4. Assign students to write three questions on how to measure a dimension, and with what type of measuring instrument.
5. Conduct class discussion on measuring cut dimensions.
6. Instruct students to measure cut dimensions of machined parts. (*3)

CRITERION-REFERENCED MEASURE:

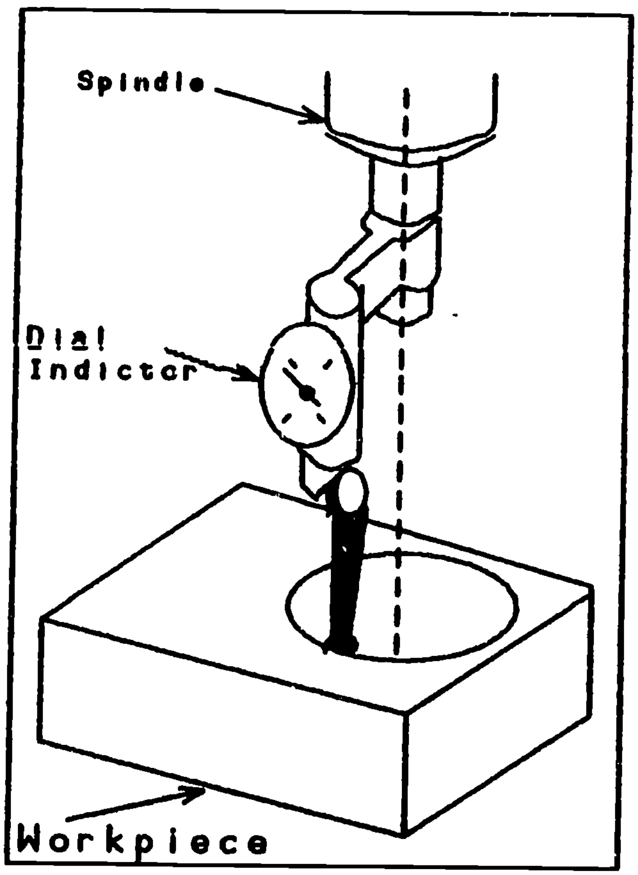
The student will demonstrate when and how to measure a cut dimension. After identifying and adjusting for the correct dimension, the students will conduct a test cut, and verify the correction has been made successfully.

PERFORMANCE GUIDE:

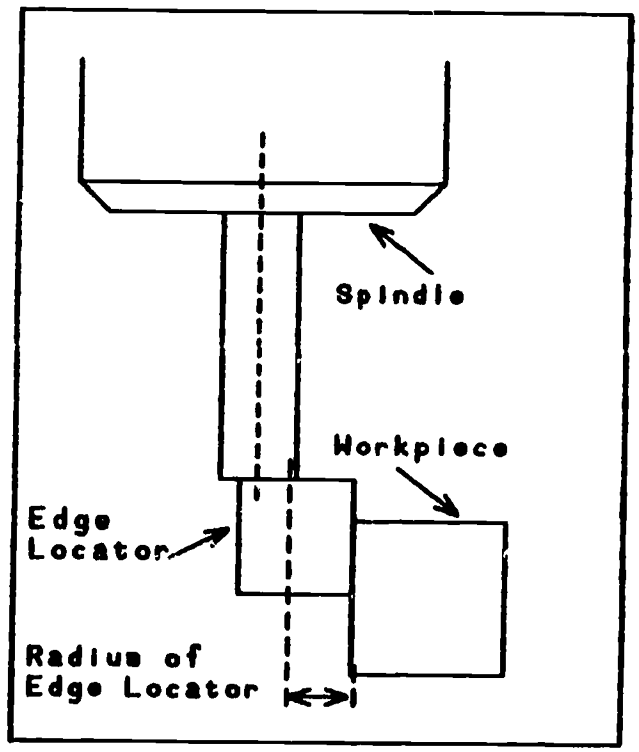
1. Check blueprint for dimension of cut.
2. Remove piece part from fixture vice.
3. Remove burrs.
4. Clean part.
5. Check dimension of part using measuring device.
6. Compare measurements to blueprint specifications.

MACHINE MOUNTED MEASURING DEVICES

Dial Indicator



Edge Locator



CHECKLIST

DUTY Operating Machine

TASK Measure cut dimensions.

ENABLER Measure the cut dimension and determine what is required to machine the part to the correct dimension.

STUDENT'S NAME ______________ DATE ________

EVALUATOR'S NAME ______________ COURSE ________

TIME : STARTED ________ COMPLETED ______________

TOTAL ________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate measuring cut dimensions.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Checked the blueprint for the dimension of the cut.	____	____
- Removed the piece part from the fixture vice.	____	____
- Removed all burrs from part piece.	____	____
- Cleaned piece part.	____	____
- Checked the dimension of the piece part using the appropriate measuring device.	____	____
- Compared piece part measurement to blueprint specifications.	____	____
- Checked machine adjustment for correct dimension.	____	____
- Conducted test cut to verify the correction was successful.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #86

TASK: Index turret.

STANDARD OF PERFORMANCE OF TASK:

When turret is loaded, any tool position can be selected at random.

SOURCE OF STANDARD:

Customer Information Manual, Dynapath Systems AM, Computer Numerical Control.
Dynapath System 10T Computer Numerical Control for Two Axis Lathes.
Miyanomatic Model CNC-7BC Instruction Manual.
Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tool with turret
Tool identification or location number

ENABLING OBJECTIVES:

1. Place correct tools in correct turret location.
2. Index turret in an interference free area.

*RESOURCES:

1. Customer Information Manual, Dynapath System AM, Computer Numerical Control. Dynapath Systems, Detroit, MI. 1984.
2. Dynapath Systems 10T Computer Numerical Control for Two Axis Lathes. Dynapath Systems, Detroit, MI. 1984.
3. Miyanomatic Model CNC-7BC Instruction Manual. Mizano Machinery Simarenjaku Mitoka-shi. Tokoyo 181, Japan, 1982.
4. Operator's manual.
5. Visual aid - Turret.
6. Checklist - Turret index.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual on correct procedure to index a turret via punch tape, or manually. (*4)

TEACHING ACTIVITIES: (cont.)

2. Present lecture on indexing a turret, and stress the importance that this function must be done in an interference free area. (*1,2 & 3)
3. Conduct demonstration on indexing a turret. (*5)
4. Assign students to write how, and why turrets are indexed manually.
5. Instruct students to perform a turret index, and verify the turrets new location. (*6)

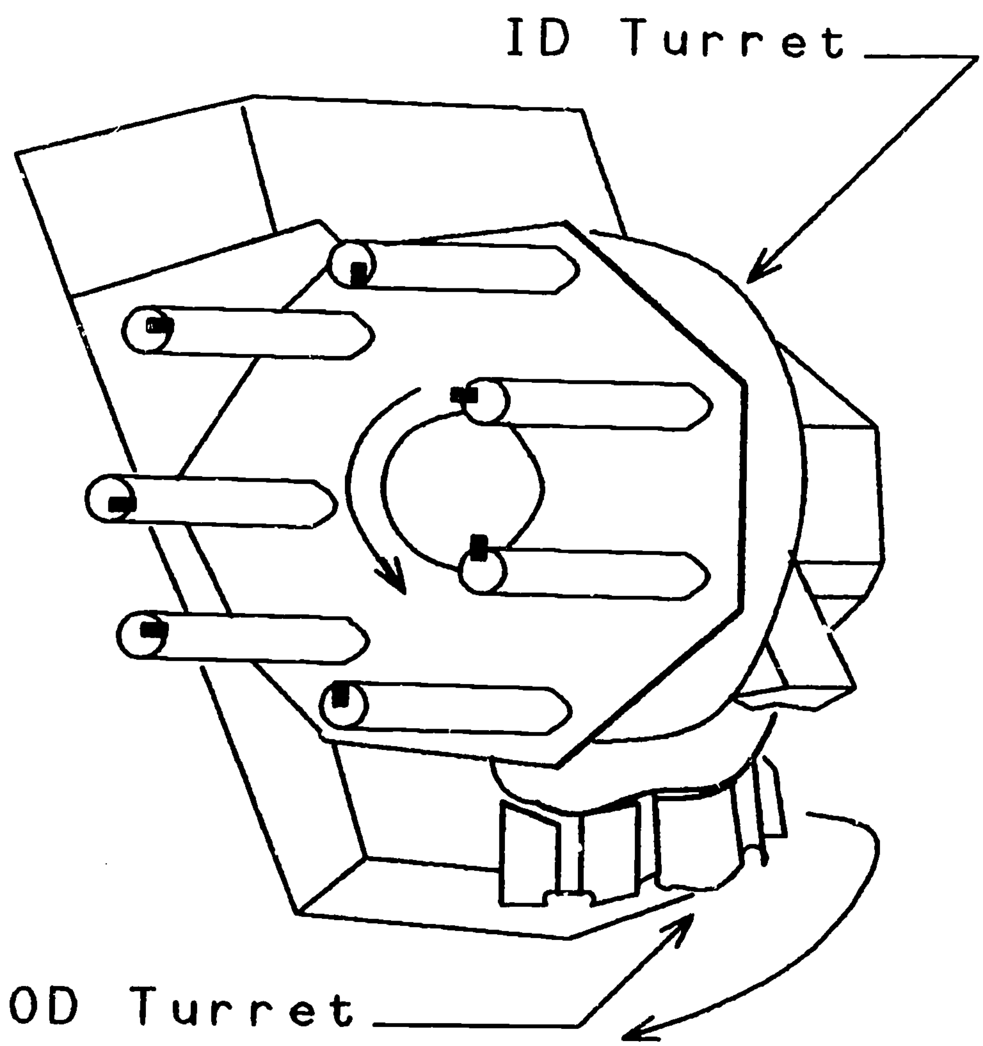
CRITERION-REFERENCED MEASURE:

The students will be able to identify turret locations. The students will also know the direction of the turret index, and the interference free areas. The students will demonstrate how to make a turret index.

PERFORMANCE GUIDE:

1. Select tool position number on turret.
2. Locate desired turret station number.
3. Index turret.
4. Repeat for each turret tool position selected.

TURRET INDEX



CAUTION
Index turrets only when in an interference free area. Failure to follow this instruction could result in damage to tooling, workpiece, and machine.

CHECKLIST

DUTY Operating Machine.

TASK Index Turret.

ENABLER Index turret in an interference free area.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ COURSE __________

TIME : STARTED __________ COMPLETED ____________________

TOTAL __________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate index turret.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Identified all turret locations.	____	____
- Identified the direction of the turret index.	____	____
- Identified interference free areas.	____	____
- Selected tool position number on turret.	____	____
- Located desired turret station number.	____	____
- Selected an interference free location.	____	____
- Indexed turret.	____	____
- Verified new turret location.	____	____
- Used the turret index successfully.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #87

TASK: Differentiate between machine controls.

STANDARD OF PERFORMANCE OF TASK:

Operators must transfer control operating skills to similar machine tools for machining process.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tool
Operator's manual
Presence of qualified operator/instructor
Removal of all tooling, and work holding devices on machine tool (to prevent accidents)

ENABLING OBJECTIVES:

1. Identify difference between controls.
2. Identify difference between machine tools.
3. Meet and maintain operating responsibilities.
4. Troubleshoot and determine corrective action required to maintain operating responsibilities.

*RESOURCES:

1. Operator's manual.
2. Abbreviated operator's manual.
3. Pocket pony operator's notebooks.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual on the control, and the machine tool. (*1 & 2)
2. Present lecture on the different types of machine tools, and highlight why they are so different. (*1,2 & 3)
3. Conduct class discussion on why machine tools and controls are not standardized.
4. Demonstrate why machine tools and controls are not standardized.

TEACHING ACTIVITIES: (cont.)

5. Instruct students to write three questions they would like answered about different machine tools and controls.
6. Instruct students to demonstrate to other students, how to teach an operator the difference between a machine tool and a control.

CRITERION-REFERENCED MEASURE:

The students will identify the difference of C.N.C. machine tools and controls. After they identify the difference, they will be able to explain the differences to a person who hasn't operated this machine tool.

PERFORMANCE GUIDE:

1. Review identification of lights, digital indicators, buttons, dials, switches, and keyboard on previously used machine tool control.
2. Review function of controls with procedure to be initialed.
3. Identify specific control operations.
   a. Identify lights, digital indicators, buttons, dials, switches, and keyboard on new control.
   b. Match function of control to procedure to be followed.
4. Seek additional instruction from qualified machine operator or instructor.

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #88

TASK: Set cycle dwell.

STANDARD OF PERFORMANCE OF TASK:

Machine slide must remain motionless in cut for specified dwell time. (Range of allowable dwell time varies with machine tool and machine control unit).

SOURCE OF STANDARD:

Customer Information Manual, Dynapath Systems AM, Computer Numerical Control.
Machining Centers Operators Training Guide.
Producer CNC/NC Programmers Guide for Machining Centers.
Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tool
Part program
Control
Basic machining skills
Manufacturer operating manual

ENABLING OBJECTIVES:

1. Set the cycle dwell time.
2. Verify that the cycle dwell time is correct, and that the dwell cycle mode has been activated.

*RESOURCES:

1. Operator's Manual.
2. Customer Information Manual, Dynapath Systems AM, Computer Numerical Control. Dynapath Systems, Detroit, MI, 1980.
3. Machining Centers Operator's Training Guide. Automation Intelligence, Orlando, FL, 1984.
4. Producer CNC/NC Programmers Guide for Machining Centers. Automation Intelligence, Orlando, FL, 1984.
5. Checklist - Set cycle dwell.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual for correct procedure on setting the dwell cycle time. (*1)

TEACHING ACTIVITIES: (cont.)

2. Present lecture on setting a dwell cycle time, and demonstrate the method doing that function.
   NOTE: On some of the newer CNC machines the dwell cycle time is programmed, so to change the dwell cycle time, the program would have to be edited. (*1,2,3, & 4)
3. Instruct students to list three questions they wish answered concerning setting a dwell cycle time.
4. Conduct class discussion on why dwell cycles are used.
5. Instruct students to set a dwell cycle time. (*5)

CRITERION-REFERENCED MEASURE:

The students will be able to identify when a dwell cycle time has to be applied. The students will set a dwell cycle time, and verify that time, when that segment of the part program is completed.

PERFORMANCE GUIDE:

1. Start program.
2. Determine needed delay of cutter motion or delayed program time.
3. Enter dwell time (using positive value).
4. Check manufacturer's operating manual for specific procedures on machine tool.
5. Observe control to verify entry of dwell time.

CHECKLIST

DUTY Operating Machine

TASK Set cycle dwell.

ENABLER Set the cycle dwell time.

STUDENT'S NAME ______________ DATE ______________

EVALUATOR'S NAME ______________ COURSE ______________

TIME : STARTED ______________ COMPLETED ______________

TOTAL ______________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate setting cycle dwell time.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Checked manufacturer's operating manual for specific procedures on machine tool.	____	____
- Determined the needed delay of cutter motion or delayed program time.	____	____
- Identified appropriate time for dwell cycle time to be applied.	____	____
- Entered dwell time using a positive value.	____	____
- Observed control to verify entry of dwell time.	____	____
- Completed that segment of the part program successfully.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #89

TASK: Modify manual data input program.

STANDARD OF PERFORMANCE OF TASK:

Revised data must be entered in at machine. Edited or created program must be accepted by machine control unit to produce workpiece that meets the tolerances and dimensions specified on blueprint.

SOURCE OF STANDARD:

1985 NC/CAM Guidebook.
Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Control
CNC machine tool
Manufacturer's operating manual

ENABLING OBJECTIVES:

1. Correct or modify part program at CNC control.
2. Create a new part program at CNC control.
3. Run program and verify manual data input program.

*RESOURCES:

1. <u>1985 NC/CAM Guidebook</u>. Modern Machine Shop, Gardner Publications. Cincinnati, OH. 1985.
2. Operator's manual.
3. Checklist - Manual data input.

TEACHING ACTIVITIES:

1. Read operator's manual to identify the manual data output (M.D.I.) procedure required to correct, modify, or create a part program at the CNC control. (*2)
2. Present lecture on M.D.I. a part program. (*1 & 2)
3. Instruct students to list three questions they wish answered concerning the different types of M.D.I. options.

4. Conduct class discussion on M.D.I. and demonstrate how to M.D.I. a part program.
5. Instruct students to write examples of three M.D.I. part programs.
6. Instruct students to M.D.I. a part program on a CNC control. (*3)

CRITERION-REFERENCED MEASURE:

The students will identify when a part program has to be M.D.I. The students will M.D.I. the items identified. The students will also identify when and why M.D.I. is required on a CNC control.

PERFORMANCE GUIDE:

1. Turn on control.
2. Clean control of all entries.
3. Stop machine.
4. Activate manual data input mode. (See manufacturer's operating manual for specific machine tool).
5. Select single block mode (see manufacturer's operating manual).
6. Edit current program:
   a. Select block in buffer to be edited.
   b. Identify block sequence number to be edited.
   c. Call up desired block sequence.
   d. Revise data using manufacturer's operating manual.
7. Create new program.
   a. Enter manual data input by block or line.
8. Cancel manual data input mode. (see manufacturer's operating manual).

   Note: Manual data input is a feature of the machine control which allows the operator to enter directly to the control, special or revised data or even a complete program, rather than through an outside data source such as punch tape, disk or computer memory.

CHECKLIST

DUTY Operating Machine

TASK Modify manual data input program.

ENABLER Create a new part program by modifying the manual data input.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ COURSE ______________

TIME : STARTED ______________ COMPLETED ______________

TOTAL ______________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate modifing the manual data input.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Turned control on.	____	____
- Cleared control of all entries.	____	____
- Stopped machine.	____	____
- Activated manual data input mode.	____	____
- Selected single block mode.	____	____
- Edited current program.	____	____
- Created new part program by entering manual data input by block or line.	____	____
- Cancelled manual data input mode.	____	____
- Successfully corrected or modified part program at the CNC control.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #90

TASK: Adjust depth of cut.

STANDARD OF PERFORMANCE OF TASK:

Depth of cut on workpiece must meet specifications of part print or blueprint.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

Workpiece
CNC machine tool
CNC program
Measuring device

ENABLING OBJECTIVES:

1. Measure depth of cut on workpiece and determine what is required to machine part correct depth.
2. Make correction on depth of cut to meet and maintain blueprint specifications.

*RESOURCES:

1. <u>1985 NC/CAM Guidebook</u>. Modern Machine Shop, Gardner Publications. Cincinnati, OH. 1985.
2. Operator's manual.
3. Visual aid - Depth of cut.
4. Checklist - Depth of cut.

TEACHING ACTIVITIES:

1. Read operator's manual to identify the operating procedure required to make a tool length compensation. (*2)
2. Present lecture on different methods of adjusting for depth of cut. (*1,2 & 3)
   a. N/C Turning Center.
   b. N/C Machining Center.
3. Assign students to write three questions they wish answered concerning tool length compensation.
4. Conduct class discussion on adjusting the depth of cutting tools.

TEACHING ACTIVITIES: (cont.)

5. Instruct students to complete a worksheet identifying the tool length compensation value and the axis in the direction of compensation.
6. Instruct students to make a correction on a depth of cut to meet blueprint specifications. (*4)

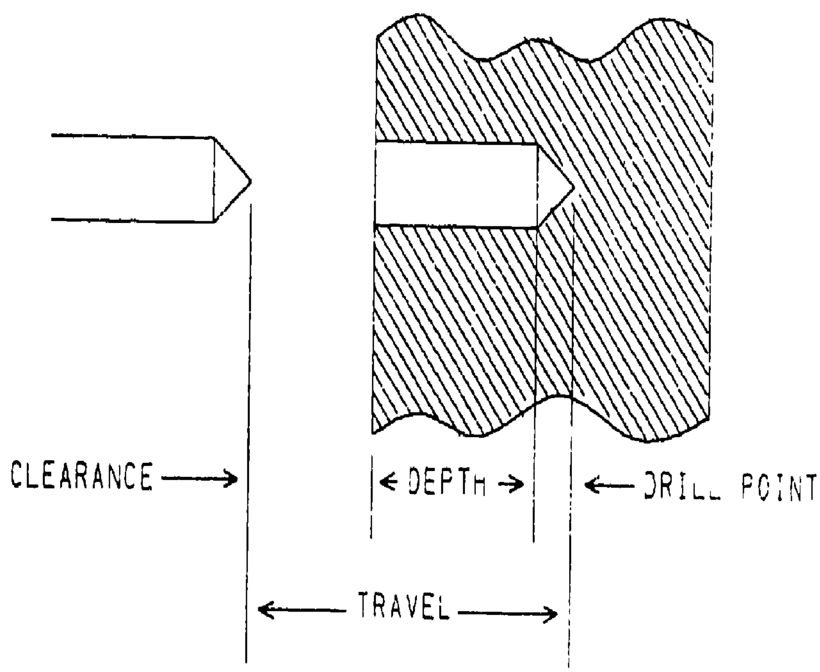
CRITERION-REFERENCED MEASURE:

The students will demonstrate when and how to adjust for depth of cut. There must be two types of machines used for demonstrating. (Turning Center and a Machine Center) After identifying and adjusting for the correct depth of cut, the student will conduct a test cut to verify that the correct tool length compensation has been successful.

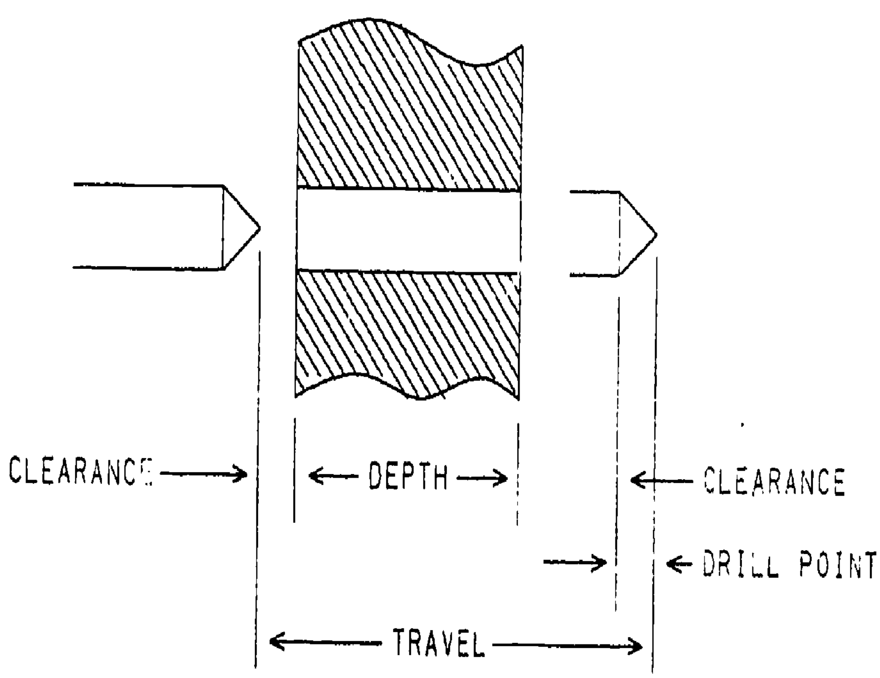
PERFORMANCE GUIDE:

1. Change depth of cut by one of the following:
   a. Raise or lower table and/or tool to change depth of cut.
   b. Change axis depth on program to adjust cutter depth.
2. Measure depth of cut on work piece and compare to blueprint specifications.
3. Repeat steps one and two until part meets desired specifications noted on print.

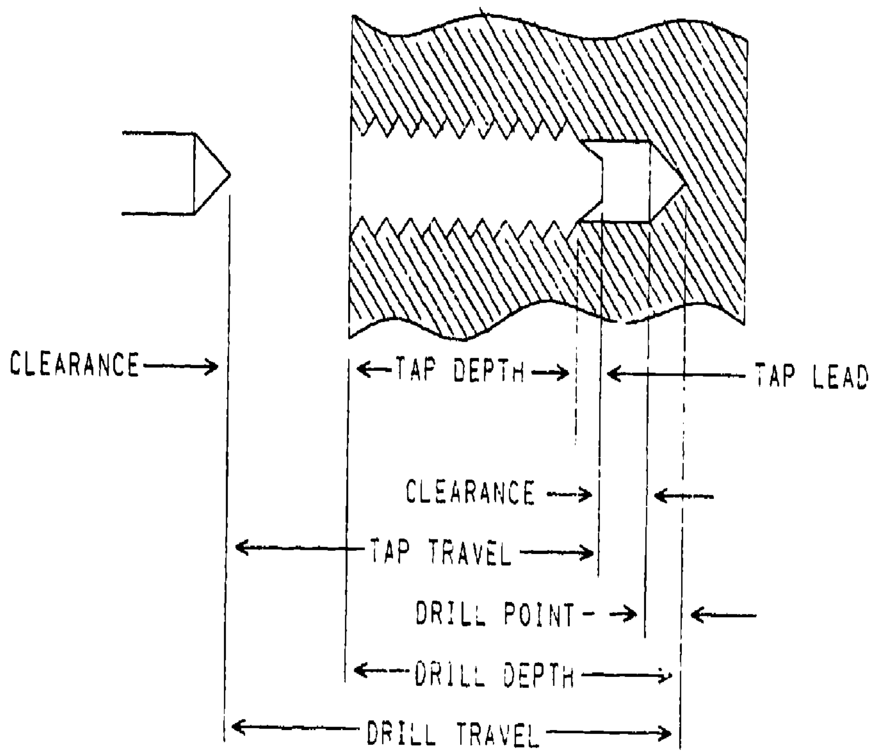
A. Drill travel, blind hole



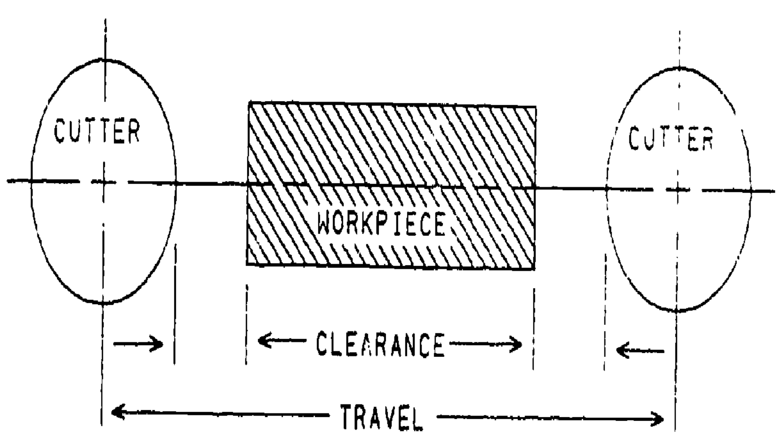
B. Drill travel, through hole



C. Drill and tap travel, blind hole



D. Side cutting travel



CHECKLIST

DUTY Operating Machine

TASK Adjust depth of cut.

ENABLER Make correction on depth of cut to meet and maintain blueprint specifications.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ COURSE ______________

TIME : STARTED ______________ COMPLETED ______________

TOTAL ____________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate adjusting the depth of cut.

PERFORMANCE DETERMINANTS	YES	NO
- Compared depth of cut on workpiece to blueprint specifications.	____	____
- Identified need for a depth of cut adjustment.	____	____
- Made depth of cut adjustment by moving table or tool, or by changing axis depth on program.	____	____
- Made cut on workpiece.	____	____
- Compared the new depth of cut on the workpiece compared to blueprint specifications.	____	____
- Adjusted depth of cut until blueprint specifications were met.	____	____
- Made the final depth of cut on workpiece meet blueprint specifications.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #91

TASK: Reset tool cycle time.

STANDARD OF PERFORMANCE OF TASK:

When tool number and tool location are entered in computer processor, C.R.T. screen must provide tool cycle time with tool number and tool pocket location number.
NOTE: Programming a tool with no time remaining will result in the message "Program Error".

SOURCE OF STANDARD:

Writing team of incumbent workers.
Operating Manual for Cincinnati Milacron.

CONDITIONS FOR PERFORMANCE OF TASK:

Control
Tool numbers
CNC machine
Tool pocket location
Manufacturer's tooling manual.

ENABLING OBJECTIVES:

1. Identify what is "Feed Motion Time".
2. Activate the tool cycle time monitor for each tool.

*RESOURCES:

1. Operating Manual for Cincinnati Milacron. Heald Machine Division, Cincinnati Milacron-Heald Corp., Worchester, MA, 1984.
2. Operator's manual.
3. Checklist - Tool cycle time.

TEACHING ACTIVITIES:

1. Read operator's manual to see if this operation is available on the Machine Tool. (*2)
2. Present lecture on why this option can be important to Tool Management. (*1 & 2)
3. Assign students to write three questions they wish answered concerning the use of tool cycle time.

TEACHING ACTIVITIES: (cont.)

4. Instruct students to define feed motion and give an example how the machine will accumulate the tool performing cycle time.
5. Conduct class discussion on how and why tool cycle time is used.
6. Instruct student to enter new tool cycle time. (*3)

CRITERION-REFERENCED MEASURE:

The students will demonstrate how to input new "Tool Cycle Time". After identifying how to establish and input tool cycle times into the control, they will explain why this is a good tool management option.

PERFORMANCE GUIDE:

1. Measure tool life time (as specified by Manufacturer's Tooling Manual).
2. Reset tool time for each new tool or when a tool is sharpened.
3. Enter tool number or tool pocket location for tool cycle time.
4. Enter predicted tool life (as specified in Manufacturer's Tooling Manual).
5. Continue process for each tool for which tool cycle time is being reset.

CHECKLIST

DUTY Operating Machine

TASK Reset tool cycle time.

ENABLER Enter the correct values in the control to reset cycle time.

STUDENT'S NAME ____________ DATE ____________

EVALUATOR'S NAME ____________ COURSE ____________

TIME : STARTED ____________ COMPLETED ____________

TOTAL ____________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate resetting the tool cycle time.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Identified feed motion time.	____	____
- Measured tool life time.	____	____
- Activated tool cycle time monitor for each tool.	____	____
- Reset tool time for each new or sharpened tool.	____	____
- Entered tool number or tool pocket location for tool cycle time.	____	____
- Entered predicted tool life.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #92

TASK: Remove chips.

STANDARD OF PERFORMANCE OF TASK:

Work location, machine, and floor area around machine must be free of chips and cutting fluids. CAUTION: Chips are sharp, and should not be handled with bare hands or blown from machine with an air hose. Eye protection should be worn during machine clean up.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

"T" slot chip tool
Chip pans
Wet and dry vacuum
Chip containers
Shop towels
CNC machine
Safety glasses
Safety shoes

ENABLING OBJECTIVES:

1. Identify the correct and safe method to remove chips from a machine tool.
2. Identify what safety equipment is necessary.

*RESOURCES:

1. Operating Manual for Cincinnati Milacron. Heald Machine Division, Cincinnati Milacron-Heald Corp., Worchester, MA. 1984.
2. Operator's manual.
3. Checklist - Chip removal.

TEACHING ACTIVITIES:

1. Read and interpret the "Safety Precautions" section of the operator's manual.
2. Present lecture on safety, pointing out the correct method to remove chips from a machine tool.

TEACHING ACTIVITIES: (cont.)

3. Conduct a class discussion on safety equipment and what could happen if the operator wasn't careful.
4. Instruct students to list three reasons why an air hose should not be used to remove chips.
5. Instruct students to complete a worksheet identifying the tool length compensation value and the axis in the direction of compensation.
6. Instruct students to clean chips from work area. (*3).

CRITERION-REFERENCED MEASURE:

The students will identify the safe method of removing chips from a machine tool, know the correct type of equipment to use, and know the importance of keeping the work area clean. The students will remove chips from the work area.

PERFORMANCE GUIDE:

1. Turn off power to all machine axis movements
2. Clean chips and cutting fluids from fixture, table, and chip pan.
3. Clean chips from machine body, base, and floor area around machine.
   NOTE: Air should not be blown into or directly toward spindle.

CHECKLIST

DUTY Operating Machine

TASK Remove chips.

ENABLER Remove chips from the work area.

STUDENT'S NAME ____________ DATE ____________

EVALUATOR'S NAME ____________ COURSE ____________

TIME : STARTED ____________ COMPLETED ____________

TOTAL ____________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate chip removal.
NOTE: Safety equipment must be assembled at all times.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Powered down machine.	____	____
- Locked machine in off position.	____	____
- Assembled needed safety equipment.	____	____
- Used all safety equipment.	____	____
- Used a chip tool/rake to remove chips from the machine.	____	____
- Removed all chips and cutting fluids from machine.	____	____
- Removed all chips and cutting fluids from the floor.	____	____
- Emptied and cleaned chip pan.	____	____
- Disposed of chips properly.	____	____
- Returned safety equipment to storage after chip removal was complete.	____	____

GUIDE SHEET

DUTY: Operating Machine

PERFORMANCE OBJECTIVE #93

TASK: Execute emergency stop.

STANDARD OF PERFORMANCE OF TASK:

All controls must remain inactive while emergency stop button is activated.

SOURCE OF STANDARD:

Writing team of incumbent workers.

CONDITIONS FOR PERFORMANCE OF TASK:

CNC machine tool
Control
CNC program

ENABLING OBJECTIVES:

1. Identify location of "Emergency Stop" buttons on the machine tool and the control.
2. Identify cause of "Emergency Stop Condition" when the machine tool indicates the machine is in an emergency stop condition.
3. Execute an emergency stop.

*RESOURCES:

1. Operating Manual for Cincinnati Milacron. Heald Machine Division, Cincinnati Milacron-Heald Corp., Worchester, MA. 1984.
2. Operator's manual.
3. Visual aid - Emergency stop location. (Will vary with machine.)
4. Checklist - Emergency stop.

TEACHING ACTIVITIES:

1. Read and interpret operator's manual.
2. Present lecture on "Emergency Stop Conditions":
   a. Immediately upon machine start-up.
   b. When the "Emergency Stop" pushbuttons are pressed.
   c. When certain control-sensed situations are encountered such as; axis overturned, motor overloaded etc...
3. Assign students to write five questions they wish answered concerning "Emergency Stop" conditions.

TEACHING ACTIVITIES: (cont.)

4. Conduct class discussion on "Emergency Stop Conditions and Remedies" to correct that condition.
5. Assign students to answer three questions about "Emergency Stop Conditions" and how the machine tool reacts to an "Emergency Stop Condition".

CRITERION-REFERENCED MEASURE:

The students will identify the "Emergency Stop" pushbuttons on the machine tool and control, troubleshoot, and determine remedies on other conditions and execute an emergency stop.

PERFORMANCE GUIDE:

1. Locate emergency stop button on machine and/or control.
2. Press emergency stop button.
3. Observe control for status lights to indicate machine is inactive.

CHECKLIST

DUTY Operating Machine

TASK Execute emergency stop.

ENABLER Execute an emergency stop.

STUDENT'S NAME ____________ DATE ____________

EVALUATOR'S NAME ____________ COURSE ____________

TIME : STARTED ____________ COMPLETED ____________

TOTAL ____________

DIRECTIONS TO THE EVALUATOR:

Use the following checklist to evaluate execution of emergency stop.

PERFORMANCE DETERMINANTS	YES	NO
The preparer		
- Identified and located all emergency stop locations prior to operation.	____	____
- Identified what constitutes an emergency stop.	____	____
- Used closest emergency stop button.	____	____
- Pressed emergency stop button.	____	____
- Observed control status lights to verify that machine was inactive.	____	____
- Observed that the machine remain in active until emergency stop control was released.	____	____
- Successfully executed emergency stop and restart.	____	____

APPENDICES

APPENDIX A

TASK LIST AND JOB TITLES

Computerized Numerical Control
OE: 47.0104

Tool Programmer
DOT:007.167-018

Machine Tool Operator
DOT:609.662-010

DUTIES:

Tasks

A. PROGRAMMING AND PLANNING

Develop programmed instructions from blueprint.
Develop programmed instructions from piece part.
Draw sketch of desired workpiece.
Select program-manual or computer-assosted.
Choose machine tools for part.
Select cutting tools and holders.
Select spindle speed.
Select feedrate for axis-travel.
Position workpiece in relation to machine axis.
Determine absolute or incremental mode.
Compute polar rectangular coordinates.
Compute workpiece geometry.
Verify cutter path.
Plot program.
Graphically depict part.
Define cutter path.
Operate post processor.
Write post processor.
Program tool change procedure.
Prepare operator instructions.
Calculate run time (manually and computer aided).
Prepare tape.
Select canned cycles.
Program restart points.
Design special fixtures for custom job.
Design clamps and holders for custom job.
Write manual program.
Enter tool offset.
Enter tool length.
Repair broken tape.
Up-date programs from engineering changes.
Determine job priorities.
Schedule programs.
Schedule heat treated materials.
Schedule secondary processes.
Schedule plating.

B. SETTING UP

Check tooling sheet.
Transport tools.
Install cutting tools in holders.
Load tools in tool drum.
Mount holder and tool on spindle.
Load automatic tool changer.
Operate drawbar.
Dial cutter compensation.
Mount workpiece.
Set zero.
Dry run program.
Add coolant commands.
Alter speed/feed rates.
Update programs stored in bubble memory.
Complete machine tool safely set-up.
Verify workpiece detail identification number.
Verify type of material of workpiece.
Establish tolerance requirement.
Thread electrical discharge machine.

C. OPERATING MACHINE

Turn on/off power.
Call up program in distributed numerical control.
Place tape in reader.
Key-in program on machine.
Align holding device with machine axis.
Clamp dial indicator to tool holder.
Change tool holder.
Change cutting tool.
Adjust tool offset manually.
Interpret operator related messages on screen.
Control feedrate override.
Activate automatic cycle mode.
Interrupt automatic cycle mode manually.
Set manual mode control.
Select cycle modifiers.
Select manual feed/jog mode.
Adjust cutter compensation.
Edit program.
Run segment of program.
Perform sequence search.
Interpret status lights.
Change spindle speed.
Initiate program restart from zero.
Interrupt cycle.
Check cutting fluids.
Check surface finish.
Check cut dimension.
Index turret.
Differentiate between machine controls.
Set cycle dwell.
Modify manual data input program.
Adjust depth of cut.
Reset tool cycle time.
Remove chips.
Execute emergency stop.

APPENDIX B

DEFINITION OF TERMS

A number of terms frequently used in this manual may be unfamiliar to the reader; others may be familiar but in the context of this manual have been assigned special meanings. To assist the catalog user, the following definitions are provided.

1. Affective. Skills which emphasize an attitude, feeling, emotion, or degree of acceptance and rejection.

2. Checkpoint. A point in the development of the curriculum guide when materials must be sent to V-TECS control office for quality review.

3. Cognitive. Skills which emphasize the recall of knowledge and development of intellectual abilities.

4. Competency. The ability (including knowledge, skills, and/or attitudes) to perform a specific task or duty successfully.

5. Competency-based vocational education. A methodology of instruction that (a) identifies the competencies needed for on-the-job performance; (b) informs students and teachers of the precise and detailed learning objectives required to achieve these competencies; (c) emphasizes high performance standards in testing, course requirements, and/or graduation; and (d) facilitate learning by letting each student master the tasks prior to advancing to another.

6. Criterion-referenced measures. An evaluative procedure used to determine if a student has mastered a performance objective.

7. Domain. A group of related jobs within an occupational area.

8. Duty. One of the distinct, major work activities in an occupational area. A duty is made of numerous tasks. A duty lends itself to the design of units of instruction.

9. Enabling objectives. Objectives identifying support knowledge, and subskills, that are prerequisites to the mastery of a task.

10. Occupational inventory. An instrument used to obtain responses from workers on what duties and tasks are actually performed in an occupational area.

11. Performance checklist. A list of performance steps derived from the performance guide to record acceptable or unacceptable performance of each step of a task.

12. Performance guide. A step-by-step description of how a task is ordinarily performed on the job.

13. Performance objective. A statement of what the learner must do, in observable and measurable terms.

    a. Conditions: "Given what?"
    Describes the situation, including tools and equipment to be used, and limits under which the tasks will be performed.

    b. Task: "Does what?"
    States the observable activity the learner will perform.

    c. Standard: "How well?"
    Indicates performance required of a successful incumbent worker in an actual job environment.

14. Psychomotor. Skills which emphasize manipulation of materials or tools.

15. Quality review. A review of content by V-TECS director or designated representative to examine quality of content format, and style of curriculum guide.

16. Resources. Materials which are used to develop instruction and/or learn specific objectives.

17. State-of-the-art reference. Current materials from which information or resources can be found to facilitate instruction.

18. Task. A unit of work with a beginning and an ending which is measurable and observable.

19. Task list. A list of individual tasks which correspond to a specific job title(s) derived from V-TECS catalogs.

20. Teaching activities. Methods and/or procedures for delivering instructional contents to students.

TOOL AND EQUIPMENT LIST

APPENDIX C

Tool/Equipment

Fixture for holding workpiece
Wrenches
Precision measuring tools
Cutting tools
Hold down bolts and clamps, step blocks
Tape reader
Center drills
End mills
Vises
Reamer
Counter sink
Drill bits
Counter bore
Boring heads
Electronic control console
Spot facer
CNC machining centers
Printer
CNC lathes
CNC vertical milling machines
Plotter
Form-cutter
Microcomputer
CNC lathes
CNC vertical milling machines
Plotter
Form-cutter
Microcomputer
CNC profile and contouring mill
CNC boring machine
Disk drive
Mainframe computer
CNC inspection machine
CNC turret punch press
CNC vertical turret lathe
Cylindrical grinder
Wire electrical discharge machines
CNC punch press
CNC gantry profiler
RAM electrical discharge machine
Flame-cutter
CNC welding machine
CNC wire wrapping machine
RAM wire cutters
CNC grinding fixture

APPENDIX D

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