Computer Numerical Control (CNC) Machinist

Provincial Occupational Analysis 2003

ACKNOWLEDGEMENTS

OTHER RELATED OCCUPATIONAL TITLES

In developing this analysis, the Committee consulted National Occupational Analyses prepared by Human Resources Development Canada from the following:

Machinist National Occupational Analysis   1998

Tool and Die Maker National Occupational Analysis   1997

As well, the Committee consulted the existing Essential Skills documented in the Human Resources Development Canada National Occupational Classification. Essential Skills were considered for the following:

Major Group 72-73 TRADES, TRANSPORT AND EQUIPMENT OPERATORS AND RELATED OCCUPATIONS

723   Machinists and Related Occupations
7231   Machinists and Machining and Tooling Inspectors
7232   Tool and Die Makers

Supervisors, Machinists and Related Occupations   NOC 7211
Tool and Die Makers   NOC 7232
Machining Tool Operators   NOC 9511
Metalworking Machine Operators   NOC 9514

TABLE OF CONTENTS

GUIDE TO ANALYSIS

DEVELOPMENT OF ANALYSIS

A draft analysis is developed by a knowledgeable consultant who, with the assistance of a committee of experts in the field, identifies all the tasks performed in the occupation.

STRUCTURE OF ANALYSIS

To facilitate the understanding of the nature of the occupation, the work performed is divided into the following divisions:

A. BLOCK - Is the largest division within the analysis and reflects a distinct operation relevant to the occupation.

B. TASK - Is the distinct activity that, combined with others, makes up the logical and necessary steps the worker is required to perform to complete a specific assignment within a "BLOCK."

C. SUB-TASK - Is the smallest division into which it is practical to subdivide any work activity and, combined with others, fully describes all duties constituting a "TASK."

Supporting Knowledge and Abilities

The element of skill and knowledge that an individual must acquire to adequately perform the task is identified under this heading.

Trends

Any shifts or changes in technology or the working environment which affect the block are identified under this heading.

VALIDATION METHOD

Several CNC Machinists and CNC Tool and Die Makers validated the sub-tasks and applied percentage ratings to blocks and tasks. This method for the validation assisted in the completion of the time weighting section of the position description.

DEFINITIONS

YES: You perform this sub-task.

NO: You do **not** perform this sub-task.

BLOCK %:   The percentage of time you spend on a monthly basis performing this component.

TASK %:   The percentage of time you spend on a monthly basis performing this task.

PIE CHART (APPENDIX "A")

The graph depicts the percentages the CNC Machinists assigned to blocks in the analysis during validation.

DACUM CHART (APPENDIX "B")

The listing of all the blocks, tasks and sub-tasks as established by the sub-committee and validated by several CNC Machinists and CNC Tool and Die Makers.

SCOPE OF THE OCCUPATION

This occupational analysis identifies tasks performed by qualified Computer Numerical Control (CNC) Machinists across Manitoba. A CNC Machinist is a tradesperson who uses a wide variety of occupational knowledge, skills and abilities to program, set up, operate and maintain machines such as Computer Numerical Control (CNC) Lathe, CNC Mill, CNC Electrical Discharge Machine (EDM), and CNC Grinder. CNC machines are used within a controlled manufacturing environment to cut or grind metal and similar materials into parts or products with precise dimensions.

A CNC Machinist must be able to work on new machining projects. This critical aspect of the CNC Machinist's work can be in part, attributed to a working knowledge based on the variety of equipment types and programs available from a wide range of manufacturers.

The CNC Machinist's work is usually, but not exclusively, found in industrial and commercial sectors such as manufacturing, fabrication and assembly plants. CNC Machinists may routinely perform a variety of tasks. To perform his/her work the CNC Machinist relies on his/her knowledge of manufacturing materials; capabilities of the equipment being used; his/her knowledge of codes, engineering drawings, regulations, and laws; his/her experience in a wide variety of work situations and requirements; his/her ability to operate manual and CNC tools; his/her ability to determine the most appropriate means of proceeding with the work and inspection. CNC Machinists must possess mechanical and mathematical aptitudes, above-average spatial ability, and the ability to plan and think sequentially as well as multi-dimensionally.

CNC Machinists are routinely required to work closely with other manufacturing disciplines. It is therefore important that the CNC Machinist have some knowledge and familiarity with the scope of work of these disciplines.

OCCUPATIONAL OBSERVATIONS

Technology continues to contribute to many changes in equipment design and manufacturing processes. Of note are the following: new CNC technology programs such as CAD/CAM, digitizing, probing a part and cutting, use of a CMM machine to scan, canned cycles, inserts and machining accessories. These innovations require constantly changing methods and techniques governed by appropriate attitudes towards the current high standards for CNC programming. Keeping abreast of these changes presents a daily challenge to members of this trade.

Today's equipment may be outfitted with a range of technologically sophisticated features and systems. As equipment becomes more technically complex, accompanying manuals and charts tend to be very specific in terms of factors critical not only to the job at hand, but also to the long-term operation of the system. As well, machined products and parts are increasingly complex as are the applications in which these finished products and parts are used.

The work of a CNC Machinist, by its nature, continues to be challenging. Errors in judgement or in practical application of trade knowledge can be costly, both in terms of injury to workers and damage to equipment or materials. Constant, vigilant attention to the application of safety and accident prevention knowledge must be maintained by workers at all times.

CNC Machinists are more than ever being called on to document and maintain records due to more stringent manufacturing processes. The CNC Machinist's products in industrial and other applications must be appropriately set up, maintained and initiated. This places more responsibility on supervisors, quality control personnel, and on the individuals who perform the tasks. The tremendous variety in equipment and methods means that the CNC Machinist must be more knowledgeable and adaptable than ever before. Coupled with this is the trend of increased and appropriate communication with fellow employees, which seems to be of great importance to the CNC Machinist during the present and future.

ANALYSIS

BLOCK A

Basic work practices and procedures

Trends: *Many of the CNC Machinists have worked for one or more industrial companies for many years and have participated in a number of workplace health and safety practices.*

Task 1   **Participates in workplace health and safety practices.**

Sub-task

1.01   **Maintains a safe**   **<u>Supporting Knowledge and Abilities</u>**
    workplace environment.

1.01.01	knowledge of hoist lifting capacities, slings and chains
1.01.02	knowledge of safe rigging and safe handling procedures
1.01.03	knowledge of potential hazards including fumes, fluids, dust and noise from materials
1.01.04	ability to maintain extraction units (dust or fumes)
1.01.05	ability to identify, address or alter any safety concerns.

Sub-task

1.02   **Uses safety gear and**   **<u>Supporting Knowledge and Abilities</u>**
    protective equipment.

1.02.01	knowledge of types and uses of protective equipment
1.02.02	ability to select, inspect, use and maintain protective equipment

Sub-task

1.03   Follows safety/health Acts   Supporting Knowledge and Abilities
        and regulations.

           1.03.01   knowledge of environmental rules and regulations

           1.03.02   knowledge of procedures to report non-compliance with environmental rules and regulations

           1.03.03   ability to apply industry/environmental rules and regulations

Task 2   Performs general machine maintenance.

Sub-task

2.01   Checks fluids.   Supporting Knowledge and Abilities

           2.01.01   knowledge of lubrication systems

           2.01.02   ability to take PH level readings

           2.01.03   ability to top up levels

           2.01.04   ability to read refractor meters

Sub-task

2.02   Verifies machine   Supporting Knowledge and Abilities
        calibration.

           2.02.01   knowledge of ball bar readings

           2.02.02   knowledge of ceramic cube

Sub-task

**2.03   Completes documentation   Supporting Knowledge and Abilities
records.**

2.03.01   knowledge of documenting procedure
relating to machine maintenance

2.03.02   knowledge of forms to be completed and
information required

2.03.03   ability to perform duties required to obtain
information

2.03.04   ability to take preventative and corrective
measures

Task 3   Applies ergonomics.

Sub-task

**3.01   Organizes an ergonomic   Supporting Knowledge and Abilities
workstation.**

3.01.01   knowledge of ergonomics

3.01.02   ability to identify repetitive motions that
could lead to injury

3.01.03   ability to take corrective actions

Sub-task

**3.02   Develops ergonomic work   Supporting Knowledge and Abilities
procedures.**

3.02.01   knowledge of industry standards

3.02.02   ability to implement procedures

3.02.03   ability to recognize potential problems

3.02.04   ability to develop documentation for
procedures

3.02.05   ability to take corrective measures

Task 4   Trains personnel.

Sub-task

4.01   Conducts orientation for workers.

Supporting Knowledge and Abilities

4.01.01   knowledge of local orientation package, including safety concerns

4.01.02   ability to communicate local orientation package, including safety concerns

4.01.03   ability to communicate ergonomic information

Sub-task

4.02   Provides direction and guidance for workers.

Supporting Knowledge and Abilities

4.02.01   knowledge of relevant training objectives and techniques

4.02.02   ability to explain, demonstrate, and review task at hand

Sub-task

4.03   Supervises and monitors workers.

Supporting Knowledge and Abilities

4.03.01   knowledge of supervisory objectives and techniques

4.03.02   ability to observe performance and provide feedback

BLOCK B

Programming computer numerical control (CNC) machines

Trends: *In an industrial economy, with low unemployment rates, industry has identified a need for CNC Machinists. Increased reliance on CNC Machinists to program machine processes. In a technically advancing economy, the state of technology is such that it provides for more opportunities for companies to grow in a global economy.*

Task 5   **Demonstrates basic programming computer skills.**

Sub-task

5.01   Uses a computer.   **Supporting Knowledge and Abilities**

5.01.01	knowledge of computers
5.01.02	ability to open and close a program
5.01.03	ability to install software and software updates for applications
5.01.04	ability to locate, save a file
5.01.05	knowledge of ways to access internet
5.01.06	knowledge of intranet
5.01.07	knowledge of email protocols
5.01.08	ability to locate information on internet
5.01.09	ability to analyze the information available for its accuracy
5.01.10	ability to locate and download information from intranet
5.01.11	ability to upload files to the intranet
5.01.12	ability to create and send emails with attachments i.e. CAD files
5.01.13	ability to save email attachments

Sub-task

**5.02   Reads and interprets
          machine code files.**

5.02.01	knowledge of machine code file formats
5.02.02	ability to identify appropriate format
5.02.03	ability to open and read the required file using the appropriate program and/or program editor

Task 6   Develops planning.

Sub-task

**6.01   Creates set up sheets and
          operational instructions.**   **Supporting Knowledge and Abilities**

6.01.01	knowledge of processes
6.01.02	knowledge of workholding devices
6.01.03	knowledge of terminology
6.01.04	knowledge of inspection instruments
6.01.05	ability to document order of operations

Sub-task

6.02   Applies ergonomics.   **Supporting Knowledge and Abilities**

6.02.01	knowledge of process flow
6.02.02	knowledge of procedure to evaluate equipment layout
6.02.03	ability to recognize potential problems

Sub-task

6.03   Uses CAD files.   **Supporting Knowledge and Abilities**

6.03.01   knowledge of locating required files

6.03.02   ability to access required files

6.03.03   ability to manipulate CAD files

6.03.04   ability to save CAD files after changes

Sub-task

**6.04   Determines production
         method.**   **Supporting Knowledge and Abilities**

6.04.01   knowledge of one-offs

6.04.02   knowledge of low volume runs

6.04.03   knowledge of high volume runs

6.04.04   knowledge of capabilities

6.04.05   knowledge of current production trends

6.04.06   ability to recognize one-offs

6.04.07   ability to determine low volume runs

6.04.08   ability to determine high volume runs

Sub-task

**6.05   Identifies process
         improvements.**   **Supporting Knowledge and Abilities**

6.05.01   knowledge of process improvements

6.05.02   knowledge of documentation procedures

6.05.03   ability to recognize process improvements

6.05.04   ability to edit program to optimize
                performance

6.05.05   ability to document improvements

Task 7   Creates CAM files.

Sub-task

7.01   Generates a CAM file.   **Supporting Knowledge and Abilities**

        7.01.01   knowledge of CAM packages

        7.01.02   ability to import CAD files into CAM
                package

Sub-task

7.02   Transfers CAD/CAM file.   **Supporting Knowledge and Abilities**

        7.02.01   knowledge of procedures for download of
                data

        7.02.02   knowledge of data storage

        7.02.03   knowledge of Direct Numerical Control
                (DNC)

        7.02.04   ability to input data

Task 8   Uses Electrical Association Industries (EIA) program language.

Sub-task

8.01   Selects tool paths.   **Supporting Knowledge and Abilities**

        8.01.01   knowledge of fixturing

        8.01.02   knowledge of tool holders and cutting
                tools

        8.01.03   knowledge of absolute and incremental
                methodology

        8.01.04   ability to determine tool path(s)

        8.01.05   ability to apply cutter compensation to
                programs

Sub-task

8.02	**Determines speeds and feeds.**	**Supporting Knowledge and Abilities**

	8.02.01	knowledge and the effects of related formulae
	8.02.02	knowledge and the effects of materials
	8.02.03	knowledge and the effects of cutting tools
	8.02.04	knowledge and the effects of constant feed and/or surface speed
	8.02.05	knowledge and the effects of potential cutter deflection
	8.02.06	knowledge and the effects of potential part deflection
	8.02.07	ability to create surface finishes

Sub-task

8.03	**Writes Electrical Industries Association (EIA) programs.**	**Supporting Knowledge and Abilities**

	8.03.01	knowledge of trigonometry functions
	8.03.02	knowledge of programming codes
	8.03.03	knowledge of machine capability
	8.03.04	knowledge of material capability
	8.03.05	knowledge of tooling (cutters)
	8.03.06	knowledge of workholding devices
	8.03.07	ability to apply canned cycles

Sub-task

8.04   Writes macros.   **<u>Supporting Knowledge and Abilities</u>**

                           8.04.01   knowledge of canned cycles

                           8.04.02   ability to create a macro

Sub-task

8.05   Executes macros.   **<u>Supporting Knowledge and Abilities</u>**

                           8.05.01   knowledge of macros

                           8.05.02   ability to use canned cycles

Sub-task

8.06   Verifies program.   **<u>Supporting Knowledge and Abilities</u>**

                           8.06.01   knowledge of programming codes

                           8.06.02   knowledge of program sequences and cycles

                           8.06.03   ability to visually verify program to process/product and/or drawing

Task 9   Determines axis(s).

Sub-task

**9.01   Applies a Cartesian   <u>Supporting Knowledge and Abilities</u>
          coordinate system.**

                           9.01.01   knowledge of trigonometry functions

                           9.01.02   knowledge of procedure to establish part orientation

                           9.01.03   knowledge of quadrants (Cartesian coordinates)

                           9.01.04   ability to differentiate absolute and incremental values

Sub-task

9.02   Determines machining   **Supporting Knowledge and Abilities**
           planes.

                                          9.02.01   knowledge of machining planes

                                          9.02.02   ability to maintain reference plane

                                          9.02.03   ability to relate coordinates to a plane

Sub-task

9.03 Integrates live tooling.   **Supporting Knowledge and Abilities**

                                          9.03.01   knowledge of live tooling systems

                                          9.03.02   ability to relate to part configuration

BLOCK C

CNC lathe

Trends: *The increase from manual lathe to CNC Lathe systems has increased the necessity to acquire specialized knowledge and abilities of CNC Lathe systems.*

Task 10   **Sets up CNC Lathe.**

Sub-task

10.01   **Selects program.**   **Supporting Knowledge and Abilities**

    10.01.01   knowledge of program libraries

    10.01.02   knowledge of the controller(s)

    10.01.03   ability to select the required program

    10.01.04   ability to retrieve program

Sub-task

10.02   **Selects tool holders and cutters.**   **Supporting Knowledge and Abilities**

    10.02.01   knowledge of type of workpiece material to be machined

    10.02.02   knowledge of cutting tools (HSS, carbide, cermets) and their functions

    10.02.03   knowledge of cutting tool identification system

    10.02.04   knowledge of cutting tool performance

    10.02.05   knowledge of tool holders and their functions

    10.02.06   knowledge of cutting tool orientation

    10.02.07   ability to secure cutting tool in tool holder

Sub-task

10.03 Selects work holding devices.

Supporting Knowledge and Abilities

10.03.01   knowledge of modular systems

10.03.02   knowledge of alignment techniques and procedures

10.03.03   knowledge of hoist and slinging procedures and techniques

10.03.04   knowledge of clamping pressures and the effects of clamping pressures

10.03.05   ability to select work holding device to match workpiece requirement

10.03.06   ability to mount, align and secure work holding devices

10.03.07   ability to operate sling and hoist workpiece/work holding devices

Sub-task

10.04 Establishes tool lengths and diameters.

Supporting Knowledge and Abilities

10.04.01   knowledge of different types (tool probe-work probe)

10.04.02   knowledge of how the probe can edit offsets to the program

10.04.03   ability to touch off to establish tool length and diameter

10.04.04   ability to use an electronic probing device

Sub-task

10.05   Establishes workpiece   Supporting Knowledge and Abilities
**   offsets.**

                                   10.05.01   knowledge of workpiece coordinate
                                                 calculations

                                   10.05.02   knowledge of multiple offsets

                                   10.05.03   ability to measure tool length

Sub-task

10.06   Adjusts tool offsets.   Supporting Knowledge and Abilities

                                   10.06.01   knowledge of offset bank system

                                   10.06.02   knowledge of cutter compensation

                                   10.06.03   knowledge of tool length compensation

                                   10.06.04   ability to determine offset distances

                                   10.06.05   ability to enter offset data in specified
                                                 location

Sub-task

10.07   Selects accessories.   Supporting Knowledge and Abilities

                                   10.07.01   knowledge of available accessories

                                   10.07.02   ability to select machine and/or tool
                                                 accessories

Sub-task

10.08   Selects electronic probing   Supporting Knowledge and Abilities
**   systems.**

                                   10.08.01   knowledge of probing systems

Sub-task

10.09   Prove out program.   **Supporting Knowledge and Abilities**

                                                 10.09.01   knowledge of how to prove out program

                                                 10.09.02   ability to prove out program

Task 11   Initiates operations.

Sub-task

11.01   Operates manually.   **Supporting Knowledge and Abilities**

   11.01.01   knowledge of machine controllers and their operation

   11.01.02   knowledge of data input

   11.01.03   knowledge of power feeds (jog and handle)

   11.01.04   ability to create short programs directly on the controller

   11.01.05   ability to operate the machine using the manual controls

Sub-task

11.02   Initiates Manual Data Input **Supporting Knowledge and Abilities**
(MDI).

   11.02.01   knowledge of functions to obtain desired movement
   11.02.01   ability to select functions to obtain desired movement

Sub-task

11.03   Prove out program.   **Supporting Knowledge and Abilities**

   11.03.01   knowledge of dry run and single block control functions

   11.03.02   knowledge of codes for dry run functions

   11.03.03   knowledge of purpose and procedures to conduct dry runs

11.03.04	knowledge of types of controls, such as speed and feed override, emergency stop, cycle start
11.03.05	knowledge of different styles of control units
11.03.06	knowledge to make and recommend edits per company and industry policy
11.03.07	ability to confirm and verify tool path
11.03.08	ability to operate machine control

Sub-task

11.04 Performs editing activities.   **Supporting Knowledge and Abilities**

11.04.01	knowledge of editing activities
11.04.02	ability to make and recommend edits

Sub-task

11.05   Establishes process stability.   **Supporting Knowledge and Abilities**

11.05.01	knowledge of Statistical Process Control (SPC) and how it measures stability
11.05.02	ability to evaluate performance of the program

Task 12   **Maintains CNC Lathe.**

Sub-task

12.01   **Implements tool**   **Supporting Knowledge and Abilities**
            management.

                            12.01.01   knowledge of dedicated tooling

                            12.01.02   knowledge of tool storage and tool
                                            management systems

                            12.01.03   knowledge of maintenance of tooling

                            12.01.04   ability to predict tool failure

                            12.01.05   ability to stage tools

                            12.01.06   ability to create a tool inventory

Sub-task

12.02   **Performs general**   **Supporting Knowledge and Abilities**
            preventative machine
            maintenance.

                            12.02.01   knowledge of equipment preventative
                                            maintenance requirements, techniques
                                            and procedures

                            12.02.02   ability to review schedule and identify
                                            maintenance requirements

                            12.02.03   ability to perform basic preventative
                                            maintenance, such as cleaning, coolants,
                                            lubrication, replacing filters and replacing
                                            slide wipers

Sub-task

12.03   **Troubleshoots CNC**   **Supporting Knowledge and Abilities**
            Lathe.

                            12.03.01   knowledge to recognize alarms

                            12.03.02   ability to recognize and analyze problem

12.03.03	ability to identify general omissions and errors
12.03.04	ability to troubleshoot programs
12.03.05	ability to troubleshoot equipment
12.03.06	ability to troubleshoot tool path interference
12.03.07	ability to troubleshoot fixturing
12.03.08	ability to verify and record problem has been resolved

CNC mill

Trends: *The increase from manual mill to CNC Mill systems has increased the necessity to acquire specialized knowledge and abilities of CNC Mill systems.*

Task 13   **Sets up CNC Mill.**

Sub-task

13.01   **Selects program.**   **Supporting Knowledge and Abilities**

        13.01.01   knowledge of program libraries

        13.01.02   knowledge of the controller(s)

        13.01.03   ability to select the required program

        13.01.04   ability to retrieve program

Sub-task

13.02   **Selects tool holders and cutters.**   **Supporting Knowledge and Abilities**

        13.02.01   knowledge of type of workpiece material to be machined

        13.02.02   knowledge of cutting tools and their functions

        13.02.03   knowledge of cutting tool identification system

        13.02.04   knowledge of cutting tool performance

        13.02.05   knowledge of tool holders, types and their functions

        13.02.06   knowledge of cutting tool orientation

        13.02.07   knowledge of high speed machining techniques

        13.02.08   ability to secure cutting tool in tool holder

Sub-task

**13.03 Establishes tool lengths
and diameters.**

Supporting Knowledge and Abilities

13.03.01 knowledge of different types (tool probe-
work probe)

13.03.02 knowledge of how the probe can edit
offsets to the program

13.03.03 ability to touch off to establish tool length
and diameter

13.03.04 ability to use an electronic probing device

Sub-task

**13.04 Selects work holding
devices.**

Supporting Knowledge and Abilities

13.04.01 knowledge of alignment techniques and
procedures

13.04.02 knowledge of hoist and slinging
procedures and techniques

13.04.03 knowledge of clamping pressures and the
effects of clamping pressures

13.04.04 ability to select work holding device to
match workpiece requirement

13.04.05 ability to mount, align and secure work
holding devices

13.04.06 ability to sling and hoist workpiece/work
holding devices

Sub-task

13.05 Establishes fixture offsets.   **Supporting Knowledge and Abilities**

        13.05.01   knowledge of workpiece coordinate calculations

        13.05.02   knowledge of multiple offsets

        13.05.03   ability to establish fixture offsets

Sub-task

13.06   Selects accessories.   **Supporting Knowledge and Abilities**

        13.06.01   knowledge of available accessories

        13.06.02   ability to select machine and/or tool accessories

Task 14   Initiates operations.

Sub-task

14.01   Operates manually.   **Supporting Knowledge and Abilities**

        14.01.01   knowledge of machine controllers and their operation

        14.01.02   knowledge of data input

        14.01.03   knowledge of power feeds (jog and handle)

        14.01.04   ability to create short programs directly on the controller

        14.01.05   ability to operate the machine using the manual controls

Sub-task

**14.02   Initiates Manual Data   Supporting Knowledge and Abilities
           Input (MDI).**

                                14.02.01   knowledge of functions to obtain desired
                                            movement
                                14.02.02   ability to select functions to obtain desired
                                            movement

Sub-task

14.03   Prove out program.   Supporting Knowledge and Abilities

                                14.03.01   knowledge of dry run and single block
                                            control functions

                                14.03.02   knowledge of codes for dry run functions

                                14.03.03   knowledge of purpose and procedures to
                                            conduct dry runs

                                14.03.04   knowledge of types of controls, such as
                                            speed and feed override, emergency stop,
                                            cycle start

                                14.03.05   knowledge of different styles of control
                                            units

                                14.03.06   ability to confirm and verify tool path

                                14.03.07   ability to operate machine control

Sub-task

**14.04   Performs editing   Supporting Knowledge and Abilities
           activities.**

                                14.04.01   knowledge of editing activities

                                14.04.02   knowledge to make and recommend edit
                                            per company and industry policy

                                14.04.03   ability to make and recommend edits

Sub-task

14.05   Establish process   Supporting Knowledge and Abilities
stability.

14.05.01   knowledge of Statistical Process Control
(SPC) and how it measures stability

14.05.02   ability to evaluate performance of the
program

Task 15   Maintains CNC Mill.

Sub-task

15.01   Implements tool   Supporting Knowledge and Abilities
management.

15.01.01   knowledge of dedicated tooling

15.01.02   knowledge of tool storage and tool
management system

15.01.03   knowledge of maintenance of tooling

15.01.04   ability to predict tool failure

15.01.05   ability to stage tools

15.01.06   ability to create a tool inventory

Sub-task

15.02   Performs general   Supporting Knowledge and Abilities
preventative machine
maintenance.

15.02.01   knowledge of equipment preventative
maintenance requirements, techniques
and procedures

15.02.02   ability to review schedule and identify
maintenance requirements

15.02.03   ability to perform basic preventative
maintenance, such as cleaning, coolants,
lubrication, replacing filters and replacing
slide wipers

Sub-task

15.03   Troubleshoots CNC Mill.   <u>**Supporting Knowledge and Abilities**</u>

15.03.01   knowledge to recognize alarms

15.03.02   ability to recognize and analyze a problem

15.03.03   ability to identify general omissions and errors

15.03.04   ability to troubleshoot programs

15.03.05   ability to troubleshoot equipment

15.03.06   ability to troubleshoot tool interference path

15.03.07   ability to troubleshoot fixturing

15.03.08   ability to verify and record problem has been resolved

BLOCK E

CNC electrical discharge machining (EDM)

Trends: *The increase use of CNC Electrical Discharge Machining (EDM) has increased the necessity to acquire specialized knowledge and abilities of CNC EDM.*

Task 16   **Sets up Electrical Discharge Machining (EDM).**

Sub-task

16.01   **Selects program.**   **Supporting Knowledge and Abilities**

16.01.01	knowledge of program libraries
16.01.02	knowledge of the controller(s)
16.01.03	ability to select the required program
16.01.04	ability to retrieve program

Sub-task

16.02   **Selects electrode material, wire type and material type.**   **Supporting Knowledge and Abilities**

16.02.01	knowledge of type of workpiece material to be machined
16.02.02	knowledge of cutting media and their functions
16.02.03	knowledge of electrode, types, performance and wear
16.02.04	knowledge of tool holders and their functions
16.02.05	knowledge of electrode orientation
16.02.06	ability to secure the electrode in the holder

Sub-task

16.03   Selects flushing devices.   <u>**Supporting Knowledge and Abilities**</u>

16.03.01   knowledge of flushing process

16.03.02   knowledge of indirect and direct flushing devices

Sub-task

16.04   Selects work holding devices.   <u>**Supporting Knowledge and Abilities**</u>

16.04.01   knowledge of modular systems

16.04.02   knowledge of alignment techniques and procedures

16.04.03   knowledge of hoist and slinging procedures and techniques

16.04.04   knowledge of clamping pressures

16.04.05   ability to select work holding device to match workpiece requirement

16.04.06   ability to mount, align and secure work holding devices

16.04.07   ability to sling and hoist workpiece/work holding devices

Sub-task

16.05   Establishes electrode lengths and wire sizes.   <u>**Supporting Knowledge and Abilities**</u>

16.05.01   knowledge of different types (tool probe-work probe)

16.05.02   knowledge of how the probe can edit offsets to the program

16.05.03   ability to touch off to establish electrode length and diameter

Sub-task

16.06 **Establishes fixture offsets.**

Supporting Knowledge and Abilities

16.06.01   knowledge of workpiece coordinate calculations

16.06.02   knowledge of multiple offsets

16.06.03   ability to establish fixture offsets

Sub-task

16.07 **Establishes electrode or wire offsets.**

Supporting Knowledge and Abilities

16.07.01   knowledge of offset bank system

16.07.02   knowledge of electrode length compensation

16.07.03   ability to determine offset distances

16.07.04   ability to enter offset data in specified location

Sub-task

16.08 **Adjust electrode or wire offsets.**

Supporting Knowledge and Abilities

16.08.01   knowledge of adjustment of electrode or wire offsets

16.08.02   ability to adjust electrode or wire offsets

Sub-task

16.09 **Selects accessories.**

Supporting Knowledge and Abilities

16.09.01   knowledge of available accessories

Task 17   Initiates operations.

Sub-task

17.01   Operates manually.   **Supporting Knowledge and Abilities**

17.01.01   knowledge of machine controllers and their operation

17.01.02   knowledge of data input

17.01.03   knowledge of power feeds (jog and handle)

17.01.04   ability to create short programs directly on the controller

17.01.05   ability to operate the machine using the manual controls

Sub-task

17.02   Initiates Manual Data Input (MDI).   **Supporting Knowledge and Abilities**

17.02.01   knowledge of functions to obtain movement
ability to select functions to obtain desired movement

Sub-task

17.03   Prove out program.   **Supporting Knowledge and Abilities**

17.03.01   knowledge of types of controls, such as emergency stop, cycle start

17.03.02   ability to confirm and verify tool path

17.03.03   ability to operate machine control

Sub-task

**17.04   Performs editing   Supporting Knowledge and Abilities
activities.**

17.04.01   knowledge of editing activities

17.04.02   ability to make and recommend edits per
company and industry policy

17.04.03   ability to evaluate performance of the
program

Task 18   Maintains Electrical Discharge Machining (EDM).

Sub-task

**18.01   Implements tool   Supporting Knowledge and Abilities
management.**

18.01.01   knowledge of electrodes and wires

18.01.02   ability to select electrodes and wires

18.01.03   ability to create an electrode and wire
inventory

Sub-task

**18.02   Performs general   Supporting Knowledge and Abilities
preventative machine
maintenance.**

18.02.01   knowledge of equipment preventative
maintenance requirements, techniques
and procedures

18.02.02   ability to review schedule and identify
basic maintenance requirements

18.02.03   ability to perform preventative
maintenance, such as cleaning, coolants,
lubrication, replacing filters and replacing
slide wipers

Sub-task

18.03 Troubleshoots Electrical Discharge Machining (EDM).

Supporting Knowledge and Abilities

18.03.01	knowledge to recognize alarms
18.03.02	ability to identify general omissions and errors
18.03.03	ability to recognize and analyze problem
18.03.04	ability to troubleshoot programs
18.03.05	ability to troubleshoot equipment
18.03.06	ability to troubleshoot tool path interference
18.03.07	ability to troubleshoot fixturing
18.03.08	ability to verify and record problem has been resolved

BLOCK F

CNC grinder

Trends: *The increase from manual grinders to CNC Grinders has increased the necessity to acquire specialized knowledge and abilities of CNC grinders.*

Task 19   **Sets up CNC Grinder.**

Sub-task

19.01	**Selects program.**	**Supporting Knowledge and Abilities**

19.01.01	knowledge of program libraries
19.01.02	knowledge of controller types
19.01.03	ability to select the required program
19.01.04	ability to retrieve program

Sub-task

19.02	**Matches grinding wheel material to workpiece material.**	**Supporting Knowledge and Abilities**

19.02.01	knowledge of type of workpiece material to be ground
19.02.02	knowledge of grinding wheels and their functions
19.02.03	knowledge of grinding wheel performance
19.02.04	knowledge of work holding methods
19.02.05	knowledge of workpiece orientation
19.02.06	knowledge of balancing and wheel dressing
19.02.07	ability to mount grinding wheel

Sub-task

19.03	**Selects work holding devices.**	**Supporting Knowledge and Abilities**

        19.03.01   knowledge of modular systems

        19.03.02   knowledge of alignment techniques and procedures

        19.03.03   knowledge of hoist and slinging procedures and techniques

        19.03.04   knowledge of clamping pressures

        19.03.05   ability to select work holding device to match workpiece requirement

        19.03.06   ability to mount, align and secure work holding devices

        19.03.07   ability to sling and hoist workpiece/work holding devices

Sub-task

19.04	**Establishes workpiece offsets.**	**Supporting Knowledge and Abilities**

        19.04.01   knowledge of workpiece coordinate calculations

        19.04.02   knowledge of multiple offsets

        19.04.03   ability to establish workpiece offsets

Sub-task

19.05	**Establishes wheel offsets.**	**Supporting Knowledge and Abilities**

        19.05.01   knowledge of offset bank system

        19.05.02   ability to determine offset distances

        19.05.03   ability to enter offset data in specified location

Sub-task

19.06   Selects accessories.   **Supporting Knowledge and Abilities**

                                            19.06.01   knowledge of available accessories

Task 20   Initiates operations.

Sub-task

20.01   Operates manually.   **Supporting Knowledge and Abilities**

                                            20.01.01   knowledge of machine controllers and
                                                            their operation

                                            20.01.02   knowledge of data input

                                            20.01.03   knowledge of power feeds (jog and
                                                            handle)

                                            20.01.04   ability to create short programs directly on
                                                            the controller

                                            20.01.05   ability to operate the machine using the
                                                            manual controls

Sub-task

20.02   Initiates Manual Data   **Supporting Knowledge and Abilities**
**   Input (MDI).**

                                            20.02.01   ability to select functions to obtain desired
                                                            movement

Sub-task

20.03   Prove out program.   <u>**Supporting Knowledge and Abilities**</u>

20.03.01   knowledge of Statistical Process Control (SPC) and how it measures stability

20.03.02   knowledge of dry run and single block control functions

20.03.03   knowledge of codes for dry run functions

20.03.04   knowledge of purpose and procedures to conduct dry runs

20.03.05   knowledge of types of controls, such as speed and feed override, emergency stop, cycle start

20.03.06   knowledge of different styles of control units

20.03.07   knowledge to make and recommend edit per company and industry policy

20.03.08   ability to confirm and verify tool path

20.03.09   ability to operate machine control

20.03.10   ability to evaluate performance of the program

Task 21   Maintains CNC Grinder.

Sub-task

21.01   Implements grinding   <u>**Supporting Knowledge and Abilities**</u>
wheel and work holder
devices management.

21.01.01   knowledge of grinding wheel and work holding devices

21.01.02   knowledge of grinding wheel and work holding devices storage

21.01.03   ability to create a grinding wheel and work devices inventory

Sub-task

21.02 **Performs general**
          preventative machine
          maintenance.

Supporting Knowledge and Abilities

21.02.01   knowledge of equipment preventative
            maintenance requirements, techniques
            and procedures

21.02.02   ability to review schedule and identify
            maintenance requirements

21.02.03   ability to perform basic preventative
            maintenance, such as cleaning, coolants,
            lubrication, replacing filters and replacing
            slide wipers

Sub-task

21.03 **Troubleshoots CNC**
          Grinder.

Supporting Knowledge and Abilities

21.03.01   knowledge to recognize alarms

21.03.02   ability to recognize and analyze problem

21.03.03   ability to identify general omissions and
            errors

21.03.04   ability to troubleshoot equipment

21.03.05   ability to troubleshoot tool path
            interference

21.03.06   ability to troubleshoot fixturing

21.03.07   ability to verify and record problem has
            been resolved

APPENDICES

Appendix "A"
Pie Chart

Title of Blocks		**Percentages**
Block A:	Basic Work, Practices and Procedures	5%
Block B:	Programming Computer Numerical Control (CNC) Machines	40%
Block C	CNC Lathe	20%
Block D	CNC Mill	27%
Block E	CNC EDM	4%
Block F	CNC Grinder	4%

Total   **100%**
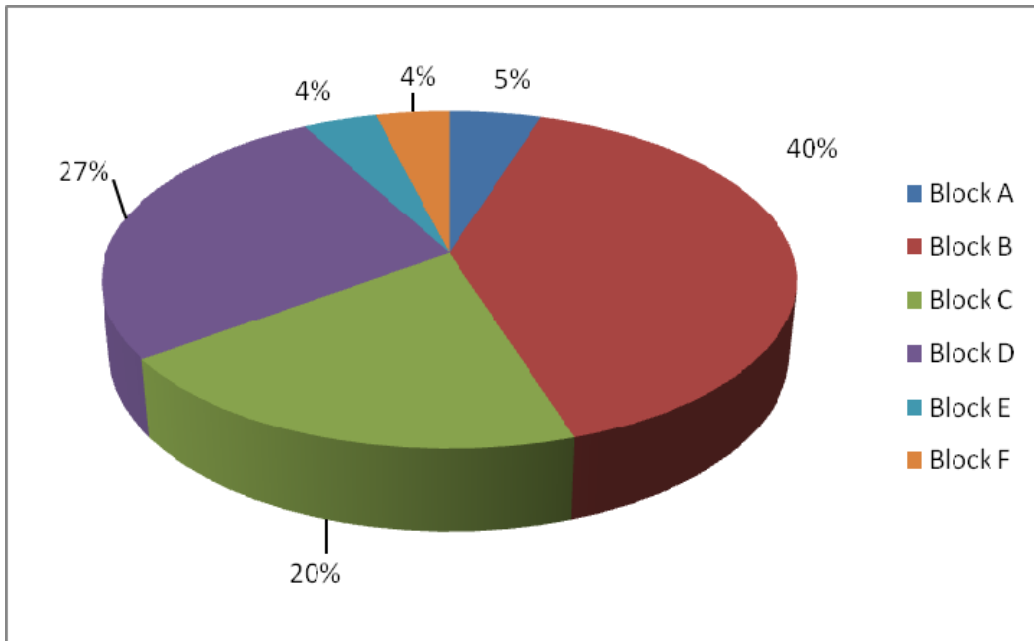
*   The percentages reflect the average amount of time workers within the occupation spend performing these tasks on a yearly basis.

Appendix "B"
Glossary

<u>A</u>

AA Stands for the Aluminum Association. This organization is responsible for issuing identification codes for wrought and cast aluminum alloys.

A-Axis The axis of a circular motion of a machine tool member or slide about the X-axis.

Absolute This is a mode in which tool positions are programmed relative to a stationary zero point. The code for absolute positioning mode is normally G90.

Absolute Dimensioning
A system of specifying part dimensions whereby each new dimension is taken relative to a fixed origin.

Accuracy The difference between a programmed tool position and the actual position achieved by a CNC machine. Thus, a machine with an accuracy of +/-0.001 would respond to a programmed position of X=1, Y=1 by moving the tool somewhere between X=0.999 and 1.001 and Y between 0.999 and 1.001.

Actual Size Refers to the actual or finished production size of a part.

Adaptive Control
A technique for achieving optimum cutting conditions. Adaptive control can be used to automatically adjust feeds and speeds based on the actual cutting conditions. Controls with adaptive control can also sense dull or broken tooling and change to new tooling automatically. It is still rare, but is sure to see increased acceptance and usage.

Address a letter or group of letters or numbers that are used to properly identify to the computer the type of information that follows. Thus, in the instruction X3.5 the address code X signals the computer that 3.5 is a coordinate value that refers to the X axis.

Allowance Is the intentional minimum clearance or maximum interference assigned between mating parts.

Alphanumeric code
A system of entering information using alphabetic characters (A through Z), numeric characters (0 through 9), and special characters (+, -, *, /, etc.).

Analog Refers to a system in which data is gathered continuously from a sensor, which monitors some physical activity. A tachometer is an analog device that produces and output voltage signal in direct proportion to sensed speed.

Annealing Refers to a process whereby a steel part is heated to a point above its critical temperature and allowed to slow cool in a closed furnace. Annealing relieves internal stresses caused by machining.

Anodizing Refers to a process whereby an aluminum part develops a hard ceramic film of aluminum oxide when placed in an electrolyte acid bath.

ANSI Stands for the American national Standards Institute. One of the functions of this governing body is to specify drafting standards for part prints.

APT	Stands for Automatically Programmed Tools. This is a programming language for CNC machines. APT was the first and remains today the most powerful computer-aided part programming language. It runs on large- and medium-sized computers and can be used for four- and five-axis machining of complex part surfaces.

ASCII	Stands for the American Standard Code for Information Interchange. This is a standard format for the exchange of data between systems. Typically seven bits are used. Each bit can be a 0 or a 1. This allows 129 different combinations. Eight-bit ASCII also exists. Eight bits allow 256 different characters to be represented. Each combination is used to represent one character. For example, 1000001 would represent the letter *a*. When you hit the letter *a* on the keyboard of your computer, the ASCII equivalent is sent to the microprocessor. Remember that computers can really only work with ones and zeros. We like to work with characters. ASCII is used to help with the conversion.

ASME	Stands for the American Society of Mechanical Engineers. One of the functions of this organization is to develop and issue standards for indicating dimensions tolerances in part prints.

ASTM	Stands for the American Society of Testing Materials. This organization is responsible for issuing part material identification standards.

Automap	Stands for automatic machining programming. This computer-aided programming language is a subset of APT. It can run on minicomputers and is used for simple profiling and point-to-point machining operations.

Autospot	Stands for automatic system for positioning tools. It is a computer-aided programming language for positioning NC tools and executing straight-line cuts.

Auxiliary Functions
	Additional programmable functions of the machine other than coordinate movement of the tool. These are referred to as M codes in word address format and are used to specify machining parameters such as speeds, feeds, and so on.

Auxiliary Storage
	Refers to the long-time storage of information, which temporarily resides in the computer's memory. Auxiliary storage devices include punched tape, magnetic tape, and magnetic disk.

Auxiliary View
	Is a view that shows the true shape of an inclined face.

Axis	An axis is one of the directions of motion of a machine. In the Cartesian system it is one of the perpendicular lines of the coordinate system. Machines are sometimes classified by the number of axes of motion.

B

B-axis	The axis of a circular motion of a machine tool member or slide about the Y-axis.

Background Editing
	This is the ability to edit a program while another program is running. This helps increase productivity because an operator can be producing a part and writing the program for the next part.

Backlash   Backlash is inaccuracy resulting from play, or slop, between a screw thread and the nut. When the table direction is reversed, the table does not move until the slop is taken up in the opposite direction. Every time direction is reversed, backlash becomes a factor. That is why skilled machinists always work in one direction when machining parts that have to be very accurate.

Backlash Compensation
          This value is added or subtracted every time a CNC machine reverses direction to compensate for backlash. The value can be changed in the software as the machine wears.

Ballscrew   A ballscrew is a special type of screw that is normally found on CNC axes. Ballscrews are used to convert the rotary motion of a motor to linear motion for an axis. Ballscrews are ground to very close tolerances and use ball bearings in the mating nut. The ball bearings circulate through the nut to reduce wear and friction. Ballscrews drastically reduce friction and increase accuracy.

Basic Size, Basic Dimension

Is the theoretical exact size, location, profile, or orientation of a geometrical feature of an object. Tolerance variations are applied to the basic dimension.

BHN Stands for the Brinell hardness Number. This decimal number placed to the right of BHN specifies the hardness the material is to exhibit when indented by the test's hardened steel ball.

Binary-coded Decimal (BCD)

A system of representing numbers using a unique set of four binary bits. Thus, 5=0101

Bit Short for binary digit. It represents on of the two possible electronic states inside a computer's switching circuits – switch on (1) or switch off (0). It is represented as the absence or presence of a hole in punched tape or a magnetized spot on magnetic tape or disk.

Blind Hole Is a hole drilled to a specific depth in a part.

Block One line of a CNC program. A CNC control reads and executes one block of code at a time. Each block is terminated by a special character called an end-of-block character.

Block Delete A slash (/) entered in the front of a block directs the CNC system to ignore the block in a program.

Block Number

This line number in a program is really for the operator's benefit.

Body Refers to the non-threaded portion of a screw shaft.

Boss Is a circular pad extending out from the surface of a casting or forging.

Buffer This is a temporary storage location for CNC program blocks.

Buffer Storage

A location for storing information in a control system or computer for subsequent use when needed. This information can be immediately transferred to active memory and acted upon. Information stored in an auxiliary storage device such as tape or disk takes longer to load than that placed in a buffer.

Bug A small problem in a program or system and is normally hard to find. One small bug can create big problems and headaches.

Byte A sequence of adjacent binary digits that is processed as a unit. A byte is normally shorter than a word, actually 8 bits. A byte can represent numbers from 0 to 255. Half of a byte is a nibble (4 bits).

C

C-axis The axis of a circular motion of a machine tool member or slide about the Z-axis.

CAD Stands for computer-aided design. This is the use of computer software to enter part geometry and specifications. The CAD software is used to help design and produce a blueprint. The CAD data can also be used to help develop a CNC program to produce the parts.

CAM Stands for computer-aided manufacturing. This very broad term means different things to different people. To machinists it generally means the use of a computer and software to generate programs for a CNC machine. To others it means using computers to assist manufacturing in any fashion.

Cancel A command that will discontinue any canned cycle or offset control such as G80, G40, etc.

Canned Cycle

These are machine sequences that are built into CNC controls to make programming easier. One example would be a peck drill cycle. Without the peck drill cycle, a programmer would have to program each individual move. With the peck canned cycle, the programmer inputs only a few values. Typical canned cycles include drill cycles, tap cycles, boring cycles, threading cycles, and roughing cycles.

CAPP Stands for computer-aided part programming. This is the use of a computer to input part geometry, which is then converted (post-processed) to create a part program that will run a CNC machine.

Carburizing (Case Hardening)

Is a process whereby the surface of a soft steel part is hardened by heating it in a carbon-saturated atmosphere and allowing it to cool slowly.

Cartesian Coordinates

A system for defining a point in space relative to a zero position. The point is located by specifying its distance along three mutually perpendicular axes (X,Y,Z) which intersect at a zero point or origin.

CD-ROM Short for Compact Disk-Read Only Memory. This device uses optical technology to retrieve large amounts of data from a 4.75" dia spinning plastic disk. CD disk drives are also available having read as well as write capability.

Chad Pieces of material that are removed when holes are punched in cards or tape.

Chamfer Is a beveled edge machined to break a sharp external corner.

Channels Paths (tracks) that run parallel to the edge of the tape along which information may be stored by the presence or absence of holes or magnetized areas. The EIA standard one-inch tape has eight channels.

Character A number, letter, or symbol that is programmed into the computer.

Chip A single piece of silicon cut from a slice by scribing and breaking. It can contain one or more circuits but is packaged as a unit.

Circular Interpolation

A block of entered information directing the system to cut an arc or circle. On a CNC machine, a circular move is programmed with a G02 or G03 command. A G02 or G03 can be used to program any portion of an arc, from 0 to 360 degrees.

Closed Loop System

A control system whereby the resulting output is measured and fed back for comparison to the input command. The system attempts to adjust itself such that the output closely tracks the corresponding input.

CNC   Stands for computer numerical control. CNC is a system of manufacturing parts by using an on-board computer or machine control unit (MCU) to control an NC machine.

Code   A system describing the formation of characters on a tape for representing information in a language understood by the control system.

Command   A signal or group of signals for initiating a step in the execution of a program.

Command Readout

The display of the table slide position resulting from the control system.

Compact II   A programming language for generating CNC code. English-like commands are used to describe the part geometry, tool path, and machine functions. The compact II code is the post-processed to produce a CNC program that the machine understands.

Compiler   A device that automatically translates an inputted program into a corresponding binary code.

Continuous Path Operation

An operation in which rate and direction of relative movement of machine members is under continuous numerical control. There is no pause for data reading.

Contouring   This is the movement of two or more axes simultaneously to produce a curve.

Contouring Control System

A system that can cut a curve or arc by executing simultaneous motion along two or more axes.

Counterbored Hole

Is a hole whose end has been enlarged to a specific depth. This is done to bury the head of a bolt.

Countersunk Hole

Is a hole having a conical depression at its end. This is done to bury the top of a conical head bolt.

Conversational Programming

This is an English-like programming language. It is different for every brand of CNC control. Conversational systems use graphics and menus to make writing a program easier. The control prompts the programmer to input information such as the operation, material, and geometry and then generates the actual program automatically.

CPU   Stands for Central Processing Unit. This device contains the memory, logic, and arithmetic processing circuits required to execute all inputted instructions, and is known as the brain of the CNC control. It is one or more microprocessors that are used to program and operate the machine.

Crest   Refers to the top of the thread teeth for external threads or the bottom of the teeth for internal threads.

CRT   Stands for cathode ray tube. This device is used for displaying all programmed input and the corresponding output of text and graphics from the MCU. It is similar to a television display.

Cutter Compensation

Cutter compensation is used to offset a tool. There are offsets for length and offsets for diameter.

Cutter Diameter Compensation

A feature of a control system in which the inputted cutter diameter and part profile data are used to automatically place the tool on the part boundary. This feature is most desirable when compensating for tool wear.

Cutter Offset

The distance from the part profile to the center of the cutter.

Cutting Speed

The motion of the tool over the work. It is measured in surface feet per minute and is used to find the desired RPM.

Cycle   A sequence of operations that is repeated regularly.

D

Data   A representation of information in the form of words, symbols, numbers, letters, characters, etc.

Database   A collection of information stored in an auxiliary storage unit such as magnetic disk or tape.

Datum   Is a theoretically exact point, plane or axis from which dimensions are taken. Datums are used for CNC parts to cut down on tolerance errors.

Datum Dimensioning

A system of dimensioning based on a common starting point.

Debug   To detect, locate and remove mistakes from a program. To troubleshoot.

Debugging   This process finds bugs (small problems) in a program or system.

Decimal Code

A code that utilizes base 10 to define magnitude. Decimal code is the standard numbering system for CNC

Delta Dimensioning

A system of specifying part dimensions whereby each new dimension is taken relative to the last dimension given. This is also known as incremental dimensioning.

Diagnostics   Diagnostics are provided on many of the newer machines to help the user troubleshoot and find problems relatively easily. Often the user can call the manufacturer's technician on the phone and be led through a troubleshooting sequence that will identify the most likely source of the problem.

Diagnostic Test

A program run to check for failure or potential failure and to determine its location.

Die   Refers to the cutting tool used to cut external threads.

Digit   A character in any numbering system.

Digital   Refers to the discrete states of a signal (on or off). A value is created by assembling a unique pattern of these signals. Most MCU controllers are digital computers.

Disk   a disk is a storage device. The most common disks now are 3.5 inches. One disk can hold many complex programs.

Display   A visual representation of data.

DNC   Stands for direct numerical control. A DNC system consists of several CNC machines, which are connected to and receive programs from a main or host computer.

Download   This is the process of sending a part program or machine parameters from a computer to a machine.

Dwell   Some canned cycles allow the machine to pause, or dwell, at the bottom of a sequence before it retracts. The dwell is programmable.

E

Edit   The process of modifying an inputted program.

EIA Code   A conventional code that is used for systems that execute straight-cut and contouring operations. EIA code is used in eight-track one-inch punched tape. This standard was established for tape coding. The EIA (Electrical Industries Association) standard is RS-244-B. It is a seven-bit code system based on an eight-channel format. The other standard code system is ASCII (American Standard Code for Information Interchange).

Electroless Plating
> Is a technique for applying a hard nickel coating on part's surface by dipping it in an aqueous solution of sodium hypophosphite and nickel salts.

Electroplating
> Is a method of applying a metallic coating to a base metal by immersing it in a solution of the plating material salts and applying a DC voltage.

Emergency Stop
> These large red buttons on machines let an operator stop all movement immediately. On a CNC machine the emergency stop switch stops all axis motion and cutter rotation immediately. This is different than using the stop switch, which is more like a pause switch. The emergency switch is used for emergency conditions.

Encoder
> This position sensor has three rings with slits that light passes through. These slits provide pulses that are used to generate how far an axis moves. The first two rings of slits have the same number of slits, usually between 500 and 2000. These two rings help determine direction of movement and distance of movement. The third ring generates only on pulse, which is used for homing the axis.

End-of-Block Character
> This special character indicates the end of a line of CNC code. On a computer it is the "return" or "enter" key.

End of Program (EOP)
> This is a code that tells the control the end of the program has been reached.

End of Tape
> A miscellaneous (M30) function that must be placed at the end of a program to indicate the end of the tape. The procedure is reset, coolant off, spindle off, feed off.

Executive Program
> A set of instructions that enables an MCU to behave likes a milling processor or lathe processor, and so on. The executive program is installed by the MCU manufacturer.

F

Feature
> Refers to any surface, angle, line, hole, etc. Which is to be controlled for production accuracy.

Feedback
> This information is provided to the CN control from sensors (transducers) on each machine axis. Position feedback is normally provided from an encoder on each axis, and velocity feedback is provided by a tachometer.

Feedback Override
> A manual switch that enables the operator to alter the programmed feed rate during a cutting operation.

Feed Rate
> The rate of movement of the tool into the work as related to a particular machining operation. Feed is measured in inches per minute for milling and inches per revolution for drilling.

Feed Rate Override
> This lets the operator change the feed rate that was programmed. While the part is running it is sometimes desirable to increase or decrease the feed rate. This is normally accomplished through a dial or push button.

Fillet   is a rounding on an interior corner formed to prevent stress concentration failures.

First Angle Projection

Is a multiview orthographic projection system wherein the object is placed in the first quadrant in front of the projection planes. This technique is used for production prints in the European countries.

Fixed Cycle   these cycles are provided to make programming easier for the programmer. They are also called canned cycles.

Fixture Offsets

These offsets can be programmed to account for multiple fixtures or parts on the table. Only one program is needed. The program is offset to machine the other positions.

Flame Hardening

Is a process whereby the surface of a soft steel part is hardened by first exposing it to heat from an oxy-acetylene torch and then applying a quenching spray.

Flat Taper   Is an inclined face or bevel machined at a sharp corner.

Floating Zero

A feature of a machine control unit that enables the operator to establish a zero or starting point anywhere within the limits permitted by the tool travel.

Format   The manner in which information must be arranged in an instruction.

FPM   Feet per minute.

FRN   Feed rate number.

Full Indicator Movement (FIM)
Refers to open gauging and specifies that the full; movement of the inspection instrument's dial indicator must not exceed the GDT tolerance(s) specified.

Functional Gauging
Refers to a complete gage fixture that is especially designed to inspect a part for compliance with a GDT tolerance specification.

G

Gage Height   A preset height above the work to which the tool retracts after an operation. This safe height, also called the R plane, allows for the tool to be moved parallel to the (XY) table plane without hitting an obstacle. Gauge height is usually set at 0.1 to 0.125 in.

G-Code   A code in word address format that signals for a preparatory function to follow. G codes initiate such operations as drilling, milling, and canned cycle execution.

GDT   Stands for geometric dimensioning and tolerancing. This is a system of specifying tolerances based on how a part is to function.

Geometry Offsets
These are offsets used to compensate for different tools on a CNC lathe. The cutting tip of each tool is at a different position and the machine must know where they are. Geometry offsets are used by the machine to calculate the correct positions. One offset per tool is used. Offsets are normally set by touching the tool to a known diameter or with a tool setting arm, which enters the dimensions automatically.

H

Hardening   Is a process whereby the surface and interior of a soft steel part is changed to a hard martensite structure by first heating it in a furnace and then applying controlled cooling.

Hard Copy   Printed output from the computer.

Hardware   All physical units that make up a computer or control system. This includes the CPU, tape drive, MCU display, and so on.

Home   When a machine is first turned on, it doesn't know where it is. As the operator goes through a home sequence, the machine moves all axes to a known location. This is the position the machine remembers as its home position.

Hot Dipping   Is a method of applying a corrosion-resistant coating to aluminum or steel parts by dipping them into certain types of molten metals.

HRA, HRB or HRC
Stands for Rockwell hardness test A, B, or C. An integer number placed to the right of the abbreviation specifies the hardness the material is to exhibit for a specific test.

I

Incremental   This is a method of programming moves. If the incremental system is used, the programmer gives the distance and direction of the move. If absolute mode is used, the programmer gives the actual position to move to.

Induction hardening
>Is a method of hardening the surface of a soft steel part by inducing heat with the aid of an electric induction coil.

Initial level   The Z height of the spindle at the start of a canned cycle.

Input   all external information entered into the MCU control unit. Input is entered via punched tape, magnetic tape, or disk or from the MCU keyboard.

Integrated Circuit
>A complete miniaturized electronic circuit that has been etched into a small silicon wafer or chip.

Interface   A connecting unit or circuit that allows two pieces of electronic hardware to communicate information to one another.

Interpolation
>The process of determining an intermediate point located between two given data points. CNC systems use interpolation to generate straight-line and arc tool movements.

J

Jog   The jog function is used to move the axes of a machine. By holding the jog button, an axis may be moved in the positive or negative direction.

L

Lay   Refers to the direction of the predominant surface pattern that is caused by the method of production.

Lead   Refers to the distance the thread travels along its axis during one complete revolution.

Leading Zero   The redundant zeros appearing to the left of a number in a program.

Leading Zero suppression
>A feature of a control system that allows for the elimination of leading zeros on input. Thus, Y.0025 can be input as Y25.

Limits   Refers to the largest (upper limit) and the smallest (lower limit) variations permitted from the basic size.

Linear Interpolation
>A feature of a control system to accept two positioning points on a part profile and fit a straight line between the points. The system subsequently moves the tool along the straight line.

LMC or L   Stands for least material condition. Refers to the condition at which an external feature (such as a shaft) is at the smallest size permitted and an internal feature (such as a hole) is at the largest size permitted.

Loop   An instruction or series of instructions that is to be executed repeatedly to produce a desired operation.

M

Machining Center

A CNC machine which at one setup is capable of executing such operations as milling, drilling, boring, tapping, reaming, and so forth, on one or more faces of the part.

Machine Reference (Zero) Point

This is the origin of the machine's axes coordinate system. They are fixed and cannot be changed.

Macro

A complete set of instructions for executing a particular operation. Upon encountering the macro name in a program, the MCU executes all the instructions it contains. The parameters of a macro can be altered to fit a particular programming requirement.

Magnetic Tape

A plastic tape that is coated with magnetic material. Information stored on it in the form of magnetized spots can be fed into the MCU as required.

Major Diameter

The largest diameter on external or internal threads.

Manual data Input

A feature of a control system that allows the operator to manually key in a program or alter the commands of an inputted program.

Manual Part Programming

The preparation of a manuscript in machine control language and format to define a sequence of commands for use on a CNC machine.

Manual Programming

This describes a person writing a word-address style program, called G-code programming. This is in contrast to conversational programming, which is more English-like.

Manuscript

A special form the part programmer uses when writing a program. The form normally contains the machining details such as processing method, tool types, feeds and speeds and so on.

Material Hardness

Refers to the resistance of the material to local penetration, scratching, machining, wear abrasion, and yielding.

M-Code

These codes are used to give commands to a CNC machine. They are also called miscellaneous functions. They are used for functions such as M08-coolant on, M03-spindle on clockwise, and M06-tool change.

MDI

Stands for Manual Data Input. In this method, the operator can input G-codes into the control and run them.

Memory

A unit that is used by a computer to store information. There are two types of memory: short term or active residing within the MCU and long term or auxiliary residing on such media as magnetic disk or tape.

Microinch

Is one millionth of an inch or .000001 in.

Micrometer

Is one millionth of a meter or .000001 m.

Microprocessor

This is the brain of the CNC controller. It is a complete miniaturized circuit that is capable of executing logic and control functions.

Minor Diameter

Refers to the smallest diameter on external or internal threads.

Mirror Imaging

A feature of a control system whereby the computer is capable of taking an inputted profile of part geometry from the first quadrant (+ X, + Y) and automatically mirroring the profile about the Y or X-axis. The system can subsequently drive a tool about the mirror images.

Miscellaneous Functions

This code controls operations such as spindle direction, spindle on/off, coolant, pallet changes, and tool changes.

MMC or M   Stands for maximum material condition. Refers to the condition at which an external feature (such as a shaft) is at the largest size permitted and an internal feature (such as a hole) is at the smallest size permitted.

Modal   Refers to the information that stays in effect until replaced by a cancellation or newer modal information.

N

NC   Stands for numerical control. This is a system of automatically controlling the motion of a tool by acting on numerical inputted data.

Nitriding   Is a method of hardening the surface of a soft steel part by first placing it in a heated nitrogen atmosphere then slow cooling it in a retort.

Nominal Size   Refers to the basic size of an object. Examples include stock size or thread diameter size.

Normalizing   Is a method of improving the machinability of hardened steel parts by first heating to a point above that used for annealing then cooling in still air at room temperature.

O

Off-line programming

This programming is done away from the machine, normally on a microcomputer. One advantage is that the machine can continue to operate while the next part program is being written. Also, it allows a manufacturer to keep skilled operators running machines while a programmer works on a computer generating part programs. Another advantage is that off-line systems allow programmers to use part information that may already exist in the computer. For example, if an engineer designed the part on a CAD system, the part geometry already exists in the computer. The programmer can use that part geometry to generate a part program for the machine.

Offset   Offset is used to change the path of a tool to compensate for wear or tool geometry.

Open Gaging   Is a method of determining compliance with GDT tolerance specifications by using such devices as dial indicators, height gages, surface plates, micrometers, calipers, and coordinate measuring machines (CMM's).

Open Loop   A control system that has no means of comparing the output with the input for control purposes. This means feedback is absent.

Optional Stop

This code can be used in a program. When the program reaches this command, the machine will stop until the operator pushes the start button again.

Orthographic Projection

Is a technique for displaying an object on a projection plane that is oriented perpendicular to the parallel lines of sight.

Overshoot   The amount by which a tool is moved beyond the programmed position. This is, in effect, an error caused by the mechanical and electrical inefficiencies of the control system. Overshoot is affected by part mass, feed rate, and servo motor response.

P

Parity   This bit is attached to the information that is sent using RS-232 asynchronous communications. It is used for error checking. It can be set in to be odd, even, none, mark (1), or space (0).

Parity Check   An extra hole punched in one of the track columns or channels of a tape to make an even number of existing holes odd as required by the RS-244A format. The extra hole would be punched in RS_358B tape to make the existing odd number even.

Part Programmer

A person who prepares the planned sequence of events for the operation of a CNC machine.

Parts Programs

A complete set of instructions written by a part programmer in a programming language (word address, etc.). The MCU allows the part program's instructions in manufacturing the part.

Perforated Tape

Punched tape in which the hole pattern corresponds to the instructions of a part program.

Phosphating   Is a method of applying a protective coating on iron and steel parts by immersing them in or spraying them with a dilute solution of phosphoric acid and other chemicals.

Pitch   Is the distance between the adjacent crests or roots of thread teeth.

Plotter   A device, which will draw a plot or trace from coded CNC data input.

Polar Coordinates

A method of locating a point by specifying the length of a line from an origin to the point and the angle the line makes with the positive X-axis.

Positioning (contouring)

A control system in which the tool can remain in continuous contact with the part as it is moved from point A to point B. Its cutting operations can only be controlled at its destination point B.

Positioning (Point to Point)

A control system in which the tool is not in continuous contact with the part as it is moved from point A to point B. Its cutting operations can only be controlled at its destination point B.

Postprocessor

A program residing insider the MCU, which takes the part program and translates it into a corresponding set of machine control instructions requited to cut the part.

Preparatory Function

A command for changing the mode of operations of the control. In word address format, a preparatory function is given as a G plus a two-digit code appearing at the beginning of a block. Thus, G01 signals for a linear cut.

Preset Tools Preset tooling is a way to increase production. In some shops the tooling for each job will be set to length ahead of time. The operator just needs to put new tools in and make minor offsets to run the job.

Program Reference (Zero) Points

The programmer chooses these points for convenience. In many cases the programmer will choose either the lower left corner as X0, Y0, Z0, the middle of the part, or some feature of the part for a reference.

Program Stop

This is a stop button provided on CNC controls to allow the operator to "pause" the machine operation for non-emergency stops and starts. An E-stop is used to stop the machine immediately in case of an emergency condition.

Prove Out   This is done to test a new program or a program that has been modified. The program is run the first time to check the machine moves and speeds and feeds to be sure the program is safe, efficient, and accurate.

Q

Quadrant   Any of four parts which a plane is divided by rectangular coordinate axes in the plane.

R

Rapid   Positioning the slides at a high rate of speed, usually 150 to 400 inches per minute (IPM) before a cut is started.

Rapid Traverse

This is the rapid movement of an axis.

Repeatability   This is a measure of how closely a machine can repeatedly come back to the same position.

Reset   This key is normally used to reset the control after an error has occurred.

Resolver   This analog device is used on some machines as a position feedback device.

Retrofit   This conversion of a manual machine to computer control normally involves replacing the lead screws with ballscrews and adding motors, drives, and a machine control.

Root   Refers to the bottom of the thread teeth for external threads and the top of the thread teeth for internal threads.

Roughness   Refers to the finer irregularities created on a part's surface by the production process.

Roughness Average (RA)

Refers to the average roughness value over a control distance on a part's surface. Average roughness is expressed in terms of microinches (μin) or micrometers (μm).

Round   Is a rounding at the exterior corner of two surfaces.

Row   A path perpendicular to the edge of a tape along which information may be stored by the presence or absence of holes or magnetized areas. A character is represented by a combination of holes or magnetized spots.

RS-232-C   In this standard for serial communications, each character is sent as its ASCII equivalent one bit at a time. RS-232 has a cable length limitation of about 50 feet. If a cable is longer than 40 feet, there can be occasional transmission problems.

RS-244   This standard has been established for odd-parity punched tape. The standard specifies the width and thickness of the tape and also the size, spacing, and location of the punched holes.

RS-274-D   This standard set of codes was developed for controlling CNC machines.

RS-358   This standard for even-parity punched tape specifies tape characteristics such as thickness, width, location, spacing, and size of the punched holes.

S

SAE   Stands for the Society of Automotive Engineers. This organization is responsible for issuing standards for identifying materials.

Sectional View
    Is a view that shows the internal features of an object.

Sequence Number
    This number is used to identify line numbers in a program, primarily for the programmer's benefit. Sequence numbers begin with an "N" followed by a number. Many programmers increment each line by 5 or 10 in case lines need to be inserted later.

Significant Digit
    A digit that must be retained to ensure a specific accuracy in a command. Thus, in the specification Y0035620 the leading zeroes are taken as insignificant and 35620 are the significant digits.

Skim Cut   This is also called a finish cut. A small amount of material is left for the final pass to achieve more accuracy and a finer finish.

Software   Part programs or instructions that are used to drive the computer's circuits in executing a particular operation.

Source Code This program can be written and understood by a person before it is converted to a machine language program that a microprocessor can understand.

Spherodizing Is a method of improving the machinability of hardened steel parts by first heating to a point below the critical temperature than cooling in still air at room temperature.

Spindle Speed
    The rotational speed or revolutions per minute (rpm) of the machine spindle. In word address, spindle speed is specified by the letter S followed by the rpm value. Thus, S1200 signals for a spindle speed of 1200 rpm.

Spotface   Is an enlargement machined at the end of a hole to a shallow depth. It is intended for seating a washer or the head of a bolt.

Storage   A device that is used to hold information off line until it is needed by the MCU. One or the earlier storage media was paper tape. Now most storage media consist of floppy and hard disks or tapes.

Stress Relieving
    Is a method of lowering internal stresses from machining operations by first heating to a point 100 to 200°F below the critical temperature and then slow cooling in a closed furnace.

Subroutine This is a small program that is called by a main program, usually several times. The intent of the subroutine is to reduce the length of the main program. For example, if there were 25 hole to be center-drilled, drilled, and then bored, their positions would be put in a subroutine. The main program would call the subprogram three times for the hole positions. The tool changes and offsets would be located in the main program.

T

Tab
A series of holes punched into a tape for the purpose of separating words or groups of characters in the tab sequential format.

Tab Sequential
This very rigid format was one of the first formats used for programming NC machines. This format used a five-word block that included sequence number, preparatory function, X dimension, Y dimension, and miscellaneous function. All five words had to be given for each block even if they were unchanged from the previous block. Because the order of each word was fixed there were no letters to identify each word. There were only numbers for each word separated by a tab code.

Tachometer
This feedback device is used for velocity or speed control. A tachometer puts out a voltage that changes with the speed of rotation. The faster it turns, the more voltage it generates. This signal is used by the motor drive to keep the speed constant. There is one tachometer for each axis the machine has.

Tap
Refers to a tapered tool with fluted cutting edges used to cut internal threads.

Tap Drill
Is a drill used to make a hole in a part to accommodate a thread cutting tap.

Tape
Tape was once very prevalent as a storage device. Programs were developed and punched onto paper tape as a series of holes. The hole pattern determines the character. The tapes were then used to lad the program into CNC machines. The earlier NC machines read the tape one ""block"" at a time.

Tempering
Is a method of changing the hardness of steel parts by first heating to a low temperature then slow cooling. Tempering prevents cracking during storage, installation, or use.

Thread Depth
Is the perpendicular distance between the crest and root of thread teeth.

Thread Form
Refers to the shape of the threads cut into a shaft or hole.

Thru Hole
Is a hole drilled through the entire material of the part.

Tolerance
Is the total amount by which a dimension may vary. It may also be defined as the difference between the upper and lower limits for the dimension. Tolerances control the accuracy with which a part is made.

Tolerance Zone
Is the total amount by which a dimension may vary. It may also be defined as the difference between the upper and lower limits for the dimension. Tolerances control the accuracy with which a part is made.

Tool function
A command that identifies a tool and calls for its selection. In word address this is programmed as the letter T followed by the tool register number. Thus, T01 signals for tool 1 to be selected for use.

Tool Length Offset
The distance between the bottom of the fully retracted tool and the part Z_o.

Tool Offset
A correction entered for a tool's position parallel to a tool movement axis. This feature allows for compensation to be applied due to tool wear and for executing finish cuts.

Tool Path   This is the path that the center of a cutting tool takes as it machines a part. If using a single point tool like a turning tool for a lathe, it is the path that the cutting tip takes.

Tool-Nose Radius Compensation

These codes are used on turning centers to adjust the tool path to compensate for the tool tip radius.

Trailing Zero Suppression

A feature of the control system that allows for the elimination of trailing zeros on input. Thus, Y2500 can be input as Y25.

U

U Axis   Some machines, such as wire EDM, have additional linear axes of motion beyond the X, Y, and Z axes. The U axis is parallel to the X axis.

UNS   Refers to a numbering system developed by the SAE and ASTM for identifying materials.

Upload   This term describes sending a part program or machine parameters from the machine up to a computer.

V

V Axis   Some machine, such as wire EDM, have additional linear axes of motion beyond the X, Y, and Z axes. The V axis is parallel to the Y axis.

Virtual Condition

Is referred to as the mating condition of the part. For external features it is the distortion that results when the part's size at M is added to the geometric tolerance at M. For internal features it is the distortion that results when the part's size at M is subtracted from the geometric tolerance at M.

W

W Axis   some machines, such as wire EDM, have additional linear axes of motion beyond the X, Y, and Z axes. The W axis is parallel to the Y axis.

Word   An ordered set of characters used to execute a specific action of a machine tool.

Word Address

This format uses letters to identify each word in a program block. For example, the letter X precedes any X dimension, the letter G precedes all G-codes, and so on.

Word Address Format

A system of coding instructions whereby each word in a block is addressed by using one or more alphabetic characters identifying the meaning of the word.

Work Reference (Zero) Points

These are the origins of the part coordinate system. It is possible to have more than one work reference point on the table. This is useful for setting up multiple parts on the table at one time.

X

X Axis   This is one of the axes perpendicular to the spindle. The X axis is normally the longest axis of motion on a milling machine. On a vertical mill, the X axis moves to the left and right as you face the machine. On a lathe, the cross feed is the X axis.

Y

Y Axis   This axis is perpendicular to the spindle axis. On a vertical mill the Y axis moves in and out.

Z

Z Axis   This axis of motion is parallel to the spindle. Toward the work is a negative Z move.

Zero Offset   A feature of an MCU that allows the programmer to shift the zero or starting point for movements to a new position over a specified rage. The system can be switched back to its old permanent origin if desired.

Zero Shift   Operates in a manner similar to zero offset except that the system cannot be switched back to the origin set prior to the shift.

Zero Suppression

The capability of eliminating zeros either before or after the significant digits entered in an instruction.

Appendix "C"
TOOLS AND EQUIPMENT

The working environment of the CNC Machinist can be very hazardous. Safety is a shared responsibility with implications for management and labour as well as for government, which enforces safe working practices. CNC Machinists generally need boots, coveralls, gloves, protection head gear, eye, ear and all other tools and equipment.

The basic hand tools and equipment, some of the power tools and equipment, and the safety equipment listed below are usually made available on the work site. Management normally supplies resource materials, drawings, manufacturers' manuals and log books.

Machine Tools

Abrasive cut-off saw
Band saw (horizontal and vertical)

Boring machines (horizontal and vertical)

Computer numerical control (CNC) drilling machines
Electrical discharge machine (EDM) (CNC)
Grinders (cylindrical, surface, tool and cutter, centreless, pedestal, tool post, profile, CNC)

Hydraulic press
Lathe (turret, centre, engine, chucker, single and multi spindle, tracer, CNC)
Milling machines (vertical, horizontal, universal milling centres, CNC)
Power hacksaw

Measuring Tools

Angle gauge blocks
Angle plate
Bore gauge
Combination square
Coordinate measuring machine (CMM)
Depth gauge
Dial indicators
Digital readout
Dividers
Drill gauge
Electronic measuring devices
Feeler gauge
Gauge blocks
Gear measuring wire
Go-no-go gauge (threads, diametrical)
Height gauge
Hermaphrodite callipers
Inside callipers
Measuring rods
Measuring tape

Outside callipers
Plug/ring gauge
Precision blocks
Precision level
Protractor (universal, bevel, vernier)
Radius gauge
Scale (steel, rule, hook rule)
Sine bar (compound)
Sine plate (compound)
Small hole gauge
Snap gauge
Square (solid, adjustable, cylindrical)
Surface finish comparator
Surface plate
Telescopic gauge
Three wire thread
Transfer calliper
Transfer calliper
Vernier calliper (dial, digital)
Vernier height gauge

Mechanical comparator
Micrometer (thread, inside, outside, thread comparator, depth, taper)

Power Tools

Air grinder
Bench grinder
Disc grinder

Portable drill
Power hacksaw
Power hacksaw

Cutting Tools

Abrasive cut off wheels
Boring bars

Boring heads (right angle driver)
Broaches

Drills (centre, spade, twist drill, oil hole, straight flute gun drills, hard steel drill, step drill, saw type hole cutter)
Grinding wheels (aluminum oxide, silicon, carbide, boron carbide, cubic boron nitride, diamond)

Knurling tools (straight, diamond)
Milling cutters (dovetail, gear, keyway, end mill, T-slot, woodruff, side and face, slab, plain, chamfer, slitting saws, flycutters, formed, angle face, cemented carbide carbide insert, solid carbide)
Nibblers
Reamers (machine, hand, spiral flute, straight flute, expandable, rose, taper)
Spotfacers

Taps

Hand Tools

Acetylene torch
Allen keys
Arbour press
Bearing extractor
Brushes
Buffing wheels
Chisels
Chuck key
Clamps
Cloths
Deburrers
Die stock
Drill drift
Drill gauge
Emery cloth
File cards
File handles
files

Grease guns
Hacksaws and blades
Hammers/mallets
Honing stones
Lapping plate
Oil cans/guns
Pliers
Scrapers (flat, bearing)
Screwdrivers
Soft jaws
Tap extractors
Tap wrenches
Torch tip lighters
Vices
Wheel dressers (hand held)
Wrenches

Layout Tools

Etchers
Hermaphrodite calipers
Layout fluid
Punches (centre, prick, transfer)

Scribers
Square
Surface gauge

Safety Equipment

Dust mask
Eye wash station
Face shield
Fire extinguishers
Fire hoses
First aid station
Goggles/safety glasses

Hand protection
Hearing protectors
Protective head gear
Respirators
Safety barrier tapes
Safety boots

Set Up Accessories

Adaptors
Angle plates
Arbours
Boring heads (right angle driver)
Centre and edge finders
Centres (dead, half, rotating, spring)
Chucks (3-jaw, 4-jaw, 6-jaw, magnetic)
CNC Probing systems
Colletts
Crane
Cutting tools
Degreasing tanks
Dividing head
Drill chuck
Face plates
Follower/travelling rest
Grinding attachment
Hoists
Lathe dogs

Machine vice
Mandrels
Parallels
Quick change toolpost
Rotary table
Shim stock
Slings
Spacers
Steady rest
Taper sleeves
Tapping head
Tool bits
Tool holders
Turret toolpost
Tool carousel
Vee block
Wheel balancers
Wire feeding device

Appendix "D"
DACUM CHART

BLOCK A Basic work practices and procedures	Task 1 Participates in workplace health and safety practices.	Sub-task 1.01 Maintains a safe workplace environment.	Sub-task 1.02 Uses safety gear and protective equipment.	Sub-task 1.03 Follows safety/health Acts and regulations.
	Task 2 Performs general machine maintenance.	Sub-task 2.01 Checks fluids.	Sub-task 2.02 Verifies machine calibration.	Sub-task 2.03 Completes documentation records.
	Task 3 Applies ergonomics.	Sub-task 3.01 Organizes an ergonomic workstation.	Sub-task 3.02 Develops ergonomic work procedures.	
	Task 4 Trains personnel.	Sub-task 4.01 Conducts orientation for workers.	Sub-task 4.02 Provides direction and guidance for workers.	Sub-task 4.03 Supervises and monitors workers.

BLOCK B Programming Computer Numerical Control (CNC) Machines	Task 5 Demonstrates basic programming computer skills.	Sub-task 5.01 Uses a computer.	Sub-task 5.02 Reads and interprets machine code files.	
	Task 6 Develops planning.	Sub-task 6.01 Creates set up sheets and operational instructions.	Sub-task 6.02 Applies ergonomics.	Sub-task 6.03 Uses CAD files.
	Task 7 Creates CAM files.	Sub-task 7.01 Generates a CAM file.	Sub-task 7.02 Transfers CAD/CAM file.	
	Task 8 Uses Electrical Association Industries (EIA) program language.	Sub-task 8.01 Selects tool paths.	Sub-task 8.02 Determines speeds and feeds.	Sub-task 8.03 Writes Electrical Industries Association (EIA) programs.
		Sub-task 8.06 Verifies program.		

	Task 9 Determines axis(s).	Sub-task 9.01 Applies a Cartesian coordinates system.	Sub-task 9.02 Determines machining planes.	Sub-task 9.03 Intergrates live tooling.	

BLOCK C **CNC Lathe**	**Task 10** Sets up CNC Lathe.	Sub-task 10.01 Selects program.	Sub-task 10.02 Selects tool holders and cutters.	Sub-task 10.03 Selects work holding devices.	Sub-task 10.04 Establishes tool lengths and diameters.	Sub-task 10.05 Establishes workpiece offsets.
		Sub-task 10.06 Adjusts tool offsets.	Sub-task 10.07 Selects accessories.	Sub-task 10.08 Selects electronic probing systems.	Sub-task 10.09 Prove out program.	
	Task 11 Initiates operations.	Sub-task 11.01 Operates manually.	Sub-task 11.02 Initiates Manual Data Input (MDI).	Sub-task 11.03 Prove out program.	Sub-task 11.04 Performs editing activities.	Sub-task 11.05 Establishes process stability.
	Task 12 Maintains CNC Lathe.	Sub-task 12.01 Implements tool management.	Sub-task 12.02 Performs general preventative machine maintenance.	Sub-task 12.03 Troubleshoots CNC Lathe.		

BLOCK D **CNC Mill**	**Task 13** Sets up CNC Mill.	Sub-task 13.01 Selects program.	Sub-task 13.02 Selects tool holders and cutters.	Sub-task 13.03 Establishes tool lengths and diameters.	Sub-task 13.04 Selects work holding devices.	Sub-task 13.05 Establishes fixture offsets.
		Sub-task 13.06 Selects accessories.				
	Task 14 Initiates operations.	Sub-task 14.01 Operates manually.	Sub-task 14.02 Initiates Manual Data Input (MDI).	Sub-task 14.03 Prove out program.	Sub-task 14.04 Performs editing activities.	Sub-task 14.05 Establish process stability.
	Task 15 Maintains CNC Mill.	Sub-task 15.01 Implements tool management.	Sub-task 15.02 Performs general preventative machine maintenance.	Sub-task 15.03 Troubleshoots CNC Mill.		

BLOCK E CNC Electrical Discharge Machining (EDM)	Task 16 Sets up Electrical Discharge Machining (EDM).	Sub-task 16.01 Selects program.	Sub-task 16.02 Selects electrode material, wire type and material type.	Sub-task 16.03 Selects flushing devices.	Sub-task 16.04 Selects work holding devices.	Sub-task 16.05 Establishes electrode lengths and wire sizes.
		Sub-task 16.06 Establishes fixture offsets.	Sub-task 16.07 Establishes electrode or wire offsets.	Sub-task 16.08 Adjust electrode or wire offsets.	Sub-task 16.09 Selects accessories.	
	Task 17 Initiates operations.	Sub-task 17.01 Operates manually.	Sub-task 17.02 Initiates Manual Data Input (MDI).	Sub-task 17.03 Prove out program.	Sub-task 17.04 Performs editing activities.	
	Task 18 Maintains Electrical Discharge Machining (EDM).	Sub-task 18.01 Implements tool management.	Sub-task 18.02 Performs general preventative machine maintenance.	Sub-task 18.03 Troubleshoots Electrical Discharge Machining (EDM).		
BLOCK F CNC Grinder	Task 19 Sets up CNC Grinder.	Sub-task 19.01 Selects program.	Sub-task 19.02 Matches grinding wheel material to workpiece material.	Sub-task 19.03 Selects work holding devices.	Sub-task 19.04 Establishes workpiece offsets.	Sub-task 19.05 Establishes wheel offsets.
		Sub-task 19.06 Selects accessories.				
	Task 20 Initiates operations.	Sub-task 20.01 Operates manually.	Sub-task 20.02 Initiates Manual Data Input (MDI).	Sub-task 20.03 Prove out program.		
	Task 21 Maintains CNC Grinder.	Sub-task 21.01 Implements grinding wheel and work holder devices management.	Sub-task 21.02 Performs general preventative machine maintenance.	Sub-task 21.03 Troubleshoots CNC grinder.		