

Overview

This standard covers a broad range of basic computer numerical control (CNC) milling competences that will prepare you for entry into the engineering or manufacturing sectors, creating a progression between education and employment, or that will provide a basis for the development of additional skills and occupational competences in the working environment.

In preparing the milling machine, you will be expected to select the appropriate workholding devices, and to mount and secure them to the machine table. You will be required to select the appropriate milling cutters/cutting tools, to mount and secure them to the appropriate tool holding devices and machine spindle, or to place the cutting tools in the relevant positions within the turrets, slides or tool change magazine/carousel, where this is applicable.

You will need to ensure that all the tools have been allocated a relevant tool number, and that the relevant data on their co-ordinates and datum positions is entered into the operating program and machine. This will involve loading and checking component programs, checking for errors/faults, and editing and saving program changes. You will also be required to adjust the machine tool equipment and program, following editing procedures, to achieve component specification. You will be expected to produce components that combine a number of different features, such as flat faces, parallel faces, faces square to each other faces at an angle, steps/shoulders, open and enclosed slots, drilled, bored and reamed holes, internal threads, and special forms/profiles.

During, and on completion of, the milling operations, you will be expected to check the quality of the workpiece, using measuring equipment appropriate to the aspects being checked and the tolerances to be achieved. On completion of the milling activities, you will be expected to remove all cutting tools and workholding devices, and to leave the machine and work area in a safe and tidy condition.

Your responsibilities will require you to comply with health and safety requirements and organisational policy and procedures for the CNC milling activities undertaken. You will need to take account of any potential difficulties or problems that may arise with the milling activities, and to seek appropriate help and advice in determining and implementing a suitable solution. You will work under a high level of supervision, whilst taking responsibility for your own actions and for the quality and accuracy of the work that you produce.

Your underpinning knowledge will provide an understanding of your work, and will enable you to apply appropriate CNC setting and milling techniques safely.

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You will understand the CNC milling process, and its application, and will know about the equipment, workholding devices, tooling, machine operating programs and setting-up procedures, to the required depth to provide a sound basis for carrying out the milling activities to the required specification.

You will understand the safety precautions required when working with the CNC milling machine, and with its associated tools and equipment. You will be required to demonstrate safe working practices throughout, and will understand the responsibility you owe to yourself and others in the workplace.

Specific Standard Requirements

In order to prove your ability to combine different milling operations, at least one of the machined components produced must be of a significant nature, and must have a minimum of **five** of the features listed in scope 5.

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Performance criteria

- You must be able to:*
- P1 work safely at all times, complying with health and safety legislation, regulations and other relevant guidelines
 - P2 plan the CNC machining activities before you start them
 - P3 load/input the program to the machine controller and check the program for errors using the approved procedures
 - P4 mount and set the required workholding devices, workpiece and cutting tools
 - P5 check that all safety mechanisms are in place, and that the equipment is set correctly for the required operations
 - P6 run the operating program, and check and adjust the machine tool speeds, feeds and operating parameters to achieve the component specification
 - P7 measure and check that all dimensional and geometrical aspects of the component are to the specification
 - P8 deal promptly and effectively with problems within your control, and seek help and guidance from the relevant people if you have problems that you cannot resolve
 - P9 shut down the equipment to a safe condition on completion of the machining activities

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Knowledge and understanding

You need to know and understand:

- K1 the safe working practices and procedures to be followed when preparing and using CNC milling machines (such as ensuring the correct isolation of the machine before mounting workholding devices and tooling; fitting and adjusting machine guards; ensuring that the workpiece is secure and that tooling is free from workpiece before starting the machine)
- K2 the hazards associated with the using CNC milling machines (such as automatic machine operations, revolving/moving parts of machinery, airborne and hot metal particles, sharp cutting tools, lifting and handling workholding devices, and burrs and sharp edges on component), and how they can be minimised
- K3 the personal protective equipment (PPE) to be worn for the CNC milling activities (such as correctly fitting overalls and safety glasses; ensuring that, if you have long hair, it is tied back or netted; and removing any jewellery or other items that can become entangled in the machinery)
- K4 the safety mechanisms on the machine (such as emergency stop buttons, emergency brakes), and the procedure for checking that they function correctly
- K5 the correct operation of the various hand and automatic modes of machine control (such as program operating and control buttons)
- K6 how to stop the machine in both normal and emergency situations, and the procedure for restarting after an emergency
- K7 how to use and extract information from engineering drawings or data and related specifications (to include symbols and conventions to appropriate BS or ISO standards) in relation to work undertaken
- K8 how to interpret first and third angle drawings, imperial and metric systems of measurement, absolute and incremental systems, workpiece zero/reference points and system of tolerancing
- K9 the computer coding language used in CNC programs (with regard to machine axes, positional information, machine management and auxiliary functions)
- K10 how to set the machine controller in the program and editing mode, and how to enter or download the prepared program
- K11 how to deal with error messages and faults on the program or equipment
- K12 the range of workholding methods and devices that are used on CNC milling machines
- K13 why it is important to set the workholding device in relationship to the machine axis and reference points
- K14 the methods of setting the workholding devices, and the tools and equipment that can be used
- K15 the range of milling cutters/cutting tools that are used on CNC milling

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- machines, and their typical applications
- K16 how to check that the cutting tools are in a safe and serviceable condition
 - K17 the use of tungsten carbide, ceramic and diamond indexable tips, and the factors which will determine their selection and use (such as the condition of material supplied, hardness of the material, the cutting characteristics of the material, tolerances to be achieved, component surface finish and specifications)
 - K18 the various tool holding devices that are used, and the methods of correctly mounting and securing the cutting tools to the tool holders and machine spindle
 - K19 the advantages of using pre-set tooling, and how to set the tooling by using setting jigs/fixtures
 - K20 the use of tool magazines and carousels, and how to position and identify the tools in relationship to the operating program
 - K21 how to place the machine into the correct operating mode, and how to access the program edit facility in order to enter tooling data (such as tool datums, positions, lengths, offsets and radius compensation)
 - K22 how to conduct trial runs (using single block run, dry run, and feed and speed override controls)
 - K23 the items that you need to check before allowing the machine to operate in full program run mode
 - K24 factors that affect the feeds and speeds that can be used, and why these may need to be adjusted from the program setting (such as type and condition of material, workholding method, tooling used, tolerance and finish to be achieved)
 - K25 the application of cutting fluids with regard to a range of different materials, and why some materials do not require the use of cutting fluids
 - K26 how to save the completed programs in the appropriate format, and the importance of storing programs and storage devices safely and correctly, away from contaminants and possible corruption
 - K27 typical problems that can occur with the CNC milling activities, and what to do if they occur
 - K28 when to act on your own initiative and when to seek help and advice from others
 - K29 the importance of leaving the work area and machine in a safe condition on completion of the activities (such as correctly isolated, operating programs closed or removed, cleaning the machine, and ensuring that any spilt cutting fluids are correctly dealt with and disposing of waste)

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Additional Information

Scope/range related to performance criteria

- You must be able to:*
1. Ensure that you apply **all** of the following checks and practices at all times during the milling activities:
 - 1.1 adhere to procedures or systems in place for risk assessment, COSHH, personal protective equipment (PPE) and other relevant safety regulations
 - 1.2 machine guards are in place and correctly adjusted
 - 1.3 components are held securely (without damage or distortion)
 - 1.4 cutting tools are maintained in a suitable/safe condition
 - 1.5 the work area is maintained and left in a safe and tidy condition
 2. Position and secure workpieces, using **two** of the following workholding methods and devices:
 - 2.1 machine vices
 - 2.2 direct clamping to machine table
 - 2.3 fixtures
 - 2.4 pneumatic or magnetic table
 - 2.5 chucks
 - 2.6 ancillary indexing devices
 - 2.7 angle plate
 - 2.8 other workholding devices
 3. Select and mount **four** of the following types of milling cutters to the appropriate tool holding device:
 - 3.1 face mills
 - 3.2 reamers
 - 3.3 end mills
 - 3.4 slot drills
 - 3.5 twist/core drills
 - 3.6 special profile cutters
 - 3.7 boring tools
 4. Prepare the tooling for operation, by carrying out **all** of the following activities, as applicable to the machine type:
 - 4.1 securing tools to the machine spindle or positioning tools in the correct position in the tool magazine/carousel
 - 4.2 checking that tools have specific tool number in relation to the

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- operating program
- 4.3 entering all relevant tool data to the operating program (such as tool lengths, tool offsets, radius compensation)
- 4.4 pre-setting tooling using setting jigs/fixtures (where appropriate)
- 4.5 setting tool datum
- 4.6 saving changes to the program
- 5. Produce machined components that combine different operations and have features that cover **all** of the following:
 - 5.1 flat faces
 - 5.2 open ended slots
 - 5.3 drilled holes linearly pitched
 - 5.4 steps/shoulders
 - 5.5 enclosed slots/recessesPlus **three** more from the following:
 - 5.6 parallel faces
 - 5.7 external profiles
 - 5.8 tapped holes
 - 5.9 square faces
 - 5.10 drilled holes on pitched circles
 - 5.11 circular/curved profiles
 - 5.12 angular faces
 - 5.13 bored holes
 - 5.14 special forms (such as concave, convex)
 - 5.15 internal profiles
 - 5.16 reamed holes
- 6. Confirm that the machine and program operates safely and correctly, by checking **all** of the following:
 - 6.1 datums for each machine axis are set in relation to all equipment and tooling used
 - 6.2 all operations are carried out to the program co-ordinates
 - 6.3 tool change positions are safe and clear of the workpiece and machine equipment
 - 6.4 the correct tools are selected at the appropriate points in the program
 - 6.5 tool offsets are correctly entered into the machine controller
 - 6.6 tool cutter paths are executed safely and correctly
 - 6.7 auxiliary functions operate at the correct point in the program (such as cutter start/stop, coolant flow)
 - 6.8 programs have been saved in the appropriate format
- 7. Machine components made from **two** of the following types of material:
 - 7.1 low carbon/mild steel
 - 7.2 cast iron
 - 7.3 plastic/nylon/composite
 - 7.4 high carbon steel

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- 7.5 brass/brass alloys
 - 7.6 aluminium/aluminium alloys
 - 7.7 other specific material
8. Carry out the necessary checks for accuracy, to include **all** of the following:
- 8.1 linear dimensions (such as lengths, depths)
 - 8.2 flatness
 - 8.3 slots (such as position, width, depth)
 - 8.4 surface finish
- Plus **four** more from the following:
- 8.5 squareness
 - 8.6 angles
 - 8.7 parallelism
 - 8.8 recesses
 - 8.9 hole size/fit
 - 8.10 thread fit
9. Use **all** of the following measuring equipment during the machining and checking activities:
- 9.1 external micrometers
 - 9.2 dial test indicators (DTI)
 - 9.3 Vernier/digital/dial callipers
 - 9.4 surface finish equipment (such as comparison plates, machines)
- Plus **four** more of the following:
- 9.5 rules
 - 9.6 bore/hole gauges
 - 9.7 internal micrometers
 - 9.8 thread gauges
 - 9.9 depth micrometers
 - 9.10 plug gauges
 - 9.11 depth Verniers
 - 9.12 radius/profile gauges
 - 9.13 slip gauges
 - 9.14 Vernier protractors
 - 9.15 coordinate measuring machine (CMM)
10. Produce components to **all** of the following quality and accuracy standards, as applicable to the operation:
- 10.1 components to be free from false tool cuts, burrs and sharp edges
 - 10.2 general dimensional tolerance $\pm 0.25\text{mm}$ or $\pm 0.010''$
 - 10.3 there must be one or more specific dimensional tolerances within $\pm 0.1\text{mm}$ or $\pm 0.004''$
 - 10.4 surface finish $63\ \mu\text{in}$ or $1.6\ \mu\text{m}$
 - 10.5 reamed holes within H8
 - 10.6 screw threads BS medium fit

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10.7 angles/tapers within +/- 0.5 degree

10.8 flatness and squareness 0.001" per inch or 0.025mm per 25mm

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Developed by	SEMTA
Version number	2
Date approved	December 2011
Indicative review date	December 2016
Validity	Current
Status	Original
Originating organisation	SEMTA
Original URN	16
Relevant occupations	Engineering and manufacturing technologies; Engineering;
Suite	Performing Engineering Operations Suite 2
Key words	engineering, engineering operations, CNC milling machines, manufacturing, machine table, cutting tools, tool holding devices, machine spindle, turrets, tool change